THE DIGITISATION OF PHOTOGRAPHIC COLLECTIONS

by

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ABSTRACT

The management of photographic collections present certain unique problems due to their heterogeneous nature. The purpose of this study is to analyse these potential problem areas and to determine how these can be resolved through the digitisation of photographic collections. The following areas are addressed: the capturing and enhancement of photographic images; data formats and storage; metadata and the retrieval of photographic images. In order to determine to what extent the principles and findings set out in the study are applied in practice, a case study was done of the Digitisation Project of the MuseumAfrica. This was followed by an evaluation of the findings of the case study as well as recommendations with regard to elements of the Museum's project that could possibly be improved upon or done differently. In conclusion a summarised overview is presented of the findings of the study as well as some remarks on possible future developments regarding the management of photographic collections within a digital environment.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The management of photographic collections present certain unique problems. Due to their heterogeneous nature and distinctive characteristics, they need to be handled differently from documents or books. Any photographic collection is collected for conservation, collection, reproduction or information value.

A photographic collection can only succeed in its objectives if the photographs are properly appraised, preserved, stored, indexed and retrieved. Each of these procedures presents certain problems. Photographs are difficult to store and handle, and using them tends to accelerate deterioration. Finding the appropriate photograph can be an arduous task, and browsing is almost impossible. (Besser, 1990: 788)

Due to their fragile nature photographs require specialized storage and preservation methods. It is also important to take into account that photographs are available in many different formats. Although it is not the purpose of this study to delve into the specific requirements of physical storage and preservation, it is important to realise the difficulties presented hereby. An effective system must be able to accommodate these problems.

What is needed is to minimize physical handling of the original photographs, but at the same time to facilitate quick and direct access to the collection. Although this contradiction in terms, modern technology does present certain solutions. Electronic imaging makes it possible to minimize handling by storing surrogate images of the original photographs in an electronic format. Access is gained through a computerized retrieval database, which may or may not be an integral part of the image database. Retrieval is made possible by indexing each photograph in the database using pre-determined fields. On face value, this whole process seems quite simple. This, however, is misleading. There are many different and complex processes involved.

Electronic imaging has not yet emerged as a discipline. Many branches of engineering, computer science, and information science are involved - no existing academic field of study offers the overall perspective that is really needed in the development of electronic imaging applications. There are very few, if any, librarians or system designers who fit this profile presented by Lynch (1991: 578). As photographic collections are usually part of, or independent library or museum collections, this arduous responsibility usually falls on the shoulders of the picture librarians or curators. This requires an in-depth knowledge of many different and mostly technical, complex procedures. Although studies in information science do prepare librarians concerning indexing and retrieval principles, and the computerization of these principles, few have the necessary in-depth knowledge of imaging technology and the processes involved needed in the development of an integrated image database.

Image databases are computationally intensive, which is a good indication of the cost involved. To be able to make intelligent choices, persuade top management to invest in such projects, communicate with computer and technical personnel, and to responsibly represent their clients' needs, librarians must acquire in-depth knowledge of concepts such as capturing devices, image enhancement software, compression ratios, image formats, storage media and all the other issues involved in the digitisation of photographic collections.

Photographic or image collections have until recently, been the black sheep of libraries, archives and museums. Their management have always been so time-consuming and labour-intensive, that it was easier to rather concentrate on textual documents, which were better suited to the systems ideally designed for them. The importance of photographs as sources of information cannot be denied. The reality, therefore, is that these collections do exist, they have to be managed and this responsibility largely falls on the librarian or information professional. Librarians cannot afford to be ignorant of the newest technological developments. The field of imaging technology is developing at an almost daily basis with far-reaching, and very positive consequences for all aspects photographic collection management. The opportunities are there - they only need to be seized.

1.2 THE PROBLEM

How can a photographic collection effectively be digitised, taking into consideration the capturing, enhancement, storage, metadata and retrieval of the photographs, in order to enhance the preservation and accessibility of the collection?

In essence the problem that needs to be addressed is to determine how a photographic collection can be digitised in order to enhance the preservation and accessibility of the collection

1.2.1 The sub-problems

- What considerations need to be taken into account during the process of capturing and enhancement of photographic images?

- What considerations need to be taken into account in terms of storage solutions and data formats?

- What considerations need to be taken into account in terms of the allocation of metadata to photographic images?

- What considerations need to be taken into account when deciding on an information retrieval system for a photographic collection?

1.3 THE HYPOTHESES

Photographic collections exist because of certain purposes. In order to effectively exploit these purposes, photographic collections need to be effectively managed. Before the most recent advances in computer technology, and more specifically imaging technology, this ideal was almost impossible to realise. Today there is a selection of choices available. Armed with a good knowledge of the different processes involved, it is possible to create an image database that can solve most of the traditional problems associated with photographic collections.

1.4 DELIMITATION OF THE FIELD

The point of departure for this study has been that of Library and Information Science. There are, however, many academic disciplines involved in the field of imaging technology, which cannot be disregarded. These areas, of which many are related to the field of Information Technology, have therefore been included where applicable.

This study has been limited to the study of photographs, although the same principles and findings could be applicable to other types of graphic materials.

1.5 DEFINITION OF TERMS

Terms have been defined as required and where relevant in the body of the thesis and were not attached as a separate appendix.

1.6 OBJECTIVES OF THE STUDY

The objectives of this study were:

- To determine how photographs can be digitally captured and enhanced.
- To determine what data formats apply to the digitisation of photographic images as well as the various storage options available.
- To determine the scope of metadata that needs to be considered in order to effectively describe photographic images in a digitised collection.
- To determine the various issues that need to be taken into consideration to ensure the effective retrieval of photographic images in a digitised collection.
- To determine how the principles and findings as set out in this study are applied in practice by doing a case study of a "real life" digitisation project.
- In summary the main purpose of this study is to determine how one should go about to effectively digitise a photographic collection in order to enhance preservation and accessibility of the collection.

1.7 RESEARCH METHOD

A variety of research methods have been used in this study:

- A review of the related literature:

This study covered a wide and varying range of topics with the theme of the digitisation of photographic collections as the only central common denominator. It was therefore necessary to sift through the literature and only use that information which can contribute to the solution of the problem and the purpose of the study.

The purpose of the review of the related literature will be to determine what information is available, what the views of different authors are concerning the various subjects to be studied and to integrate these views into a streamlined argument and motivation.

- Case study and evaluation:

A case study has been done of a real life digitisation project to determine how the various aspects relevant to the digitisation of photographic collections are applied in practice. The findings of the case study were then evaluated to determine to what extent the principles and findings set out in this study have been applied by the specific institution in their digitisation project. On the basis thereof certain recommendations were made with regard to aspects that could be improved upon or done differently.

The following key issues have been considered in the case study:

- Capturing:

How will the images be captured? What methods of optimalisation will be used?

- Storage:
  What storage options were applied? Has sufficient provision been made for the preservation and longevity of the collection?

- Metadata:
  What kind of indexing system will be used? Does the allocated metadata ensure sufficient access to images in the collection?

- Retrieval
  What retrieval system will be used? Does it adequately provide in the retrieval needs of the system's potential users?

1.8 STUDY FRAMEWORK

This study has been presented according to the following framework:

CHAPTER 1	The Problem and its Setting
CHAPTER 2:	Capturing and Enhancement
CHAPTER 3:	Data Formats and Storage of Photographic Collections
CHAPTER 4:	Metadata and Photographic Collections
CHAPTER 5:	Retrieval of Photographic Images
CHAPTER 6:	Case Study: Digitisation Project of the MuseumAfrica

1.9 CONCLUSION

From the problem and sub-problems a preliminary conclusion was drawn that this would be a comprehensive study as the subject matter is quite diverse. It would be interesting to observe how such a potentially problematic issue such as the management of a photographic collection is handled in practice.

The next chapter will attempt to address the first phase in the digitisation process, namely that of the capturing and enhancement of photographic images.

CHAPTER 2

CAPTURING AND ENHANCEMENT OF PHOTOGRAPHIC IMAGES

2.1 INTRODUCTION

This chapter will focus on the first step in the digitisation process, in which images are digitised via a capturing device, such as a scanner, video camera, digital camera or specialised proprietary workstation and enhanced to meet predefined quality criteria.

The quality of the capturing process will have a determining influence on the success of the total digitisation process. For this reason the capturing and enhancement process should not be dealt with in isolation as each decision may have reverberations on later steps that are to follow. Poor judgement in terms of scanning resolution, scanning device and level of enhancement could influence the potential future use of the digitised images.

The following questions highlight some of the issues to take into consideration when making decisions in terms of the various capturing options available:

- *Will the digitised image act as a surrogate for the original?*
  If so, the surrogate image will have to be of a quality that equals the original photograph: high-resolution capturing and optimal enhancement.

- *How big will the image be that will be viewed on-screen? Only a thumb print or full screens?*
  If only a thumb print capturing resolution need not be very high. If larger, capturing resolution will need to be much higher.

- *Will output also be to paper?*
  Paper output as a substitute for prints made from original source material would require images captured at a high resolution.

- *What degree of enhancement will be required to be performed on the digitised image?*
  If a high degree of enhancement needs to be done it would be preferable to capture the images at the highest resolution possible to enable maximum enhancement.

- *How many images need to be digitised? Are the original photographs in good condition? How frequently will the database need to be updated?*
  The above questions reflect on the choice between the use of a service bureau and in-house capturing. (See also par. 2.)

- *What range of photographic formats (prints, negatives, slides, size formats) is found in the original collection?*
  The different formats to be captured will determine the choice of capturing device(s) to be used, as not all capturing devices are able to cater for all photographic formats.

As can be concluded from the above issues the capturing and enhancement phase of a digitisation project needs careful consideration and planning. Of all the phases, the outlay in terms of cost, personnel and time are the greatest for the capturing phase. No organisation can afford costly mistakes at this point of the digitisation process, as it will negatively influence the whole project. It is therefore imperative that a thorough study be undertaken of the nature of the source collection as well as all capturing options available.

2.1.1 Basic Concepts

Before the various issues concerning capturing and enhancement of photographic images be considered, it is necessary to understand certain basic concepts which will govern digital image quality at point of capture:

- **Scan resolution**

  Scan resolution is determined by the number of pixels used to represent the image. Increasing the number of pixels used will result in a higher resolution and a greater ability to record fine detail. During the scanning process, the key is to determine the point at which sufficient resolution has been used to capture all significant detail present in the source document, without unnecessarily increasing the file size (Bone 1997).

- **Pixel depth**

  Pixel depth (also known as bit resolution or colour depth) is a measurement of the number of bits of stored information assigned to each pixel in an image. Bit resolution determines how much colour information is available for each pixel in the file. Greater pixel depth means more available colours and more accurate colour representation in the digital image (Adobe Systems Incorporated, 1994). According to Curtin (1998) "...the best scanners use 36 bits (12 for each colour red, green and blue) to produce 6.8 trillion colours. When these files are processed down to 24-bit files, they contain images with more subtle gradations of colour and more colour accuracy". In addition to 24-bit, there are now also 32- and 24-bit colour options available (Boss, 2001).

- **Dynamic range**

  Dynamic range indicates the range of tonal difference between the lightest and darkest areas of an image (Reilly, 1996: 152). The dynamic range of a capturing device such as a scanner depends on its ability to register tonal values from pure white to pure black. A device's dynamic range can be measured and given a numeric value between 0.0 (white) and 4.0 (black) that indicates its ability to capture all values within the full dynamic range (Curtin, 1998). Most flatbed scanners typically register values from about 0.0 to 2.4. According to Curtin (1998) new 30- or 36-bit scanners claim a dynamic range up to 3.0, making them "...more adept at pulling out detail of shadow areas within images".

- **Gamma correction**

  Gamma correction enables one to modify the contrast level within different levels of brightness of the image (Bone, 1997).

- **Colour models**

  The properties of colour are mathematically defined according to colour models. The four most common models are: hue, saturation and brightness (HSB); red, green and blue (RGB); cyan, magenta, yellow and black (CMYK); and CIE L*a*b* (Adobe Systems, 1994).

- **Colour balance and accuracy**

  Colour balance refers to the ability to capture neutral colours, such as black and white, in neutral form and as closely matched to the original as possible (Stone, 1997a).

- **Scanning and file size**

  During the scanning process the aim is to acquire a digital image file that contains all of the detail needed without the file being too large to work with (Curtin, 1998). If scanning is performed at too low a resolution detail will be lost. If it is performed at too a high a resolution, the file will be too large. When scanning, file size depends on a number of factors, including the area being scanned, the resolution of the scanner and the pixel depth.

- **TWAIN**

  TWAIN is a set of standards developed to enable hardware and software to communicate with one another (Curtin, 1998). Before the development of TWAIN each scanner manufacturer had its own proprietary set of protocols that made scanning possible with their hardware and software and a few other products that they chose to support. The problem with this approach was that scanners from different manufacturers were incompatible with many application programs. TWAIN standards are embedded in a device driver that is installed in one's system, which makes it possible to directly acquire images from external sources while working within an application such as Adobe Photoshop.

2.2 IN-HOUSE CAPTURING VERSUS SERVICE BUREAUS

After the decision has been taken to start with a digitisation project, the first step would be to make a choice between in-house capturing and the use of a service bureau. Although this choice may initially seem fairly clear cut, there are various pitfalls concerning both options that need to be carefully considered.

2.2.1 Service Bureaus

When confronted with a large collection of images to be digitised the easiest option could be to simply turn over the source materials to a service bureau and let it convert the images (Danziger, 1990:16). Not only may this be the easiest method, it may also be the most cost-effective, especially if the source materials are in good condition, well organised, either very large or very small, and subject to infrequent updating. Service bureaus are equipped to handle large volumes of materials, provided that they are in good condition. That means files must be weeded, restored, if necessary, and otherwise in ready-to-scan condition before being sent to a service bureau. Since few archives or libraries can claim to have all files in such condition, a fair amount of work may be necessary to prepare the files before they can be digitised.

2.2.2 In-house Capturing

According to Danziger (1990:16) in-house capturing may be preferred if source material were in good-to-poor condition, of moderate volume and subject to frequent updating. Although it may seem easier to use a service bureau to handle legacy data, having an in-house recording capability is much more convenient. New images are immediately retrievable. New technologies in the field of digital imaging are also becoming more affordable and therefore make in-house capturing more attainable. One issue which, however, still remains to be carefully considered is personnel, specifically in respect of available numbers, time and training.

2.2.3 Comparative Overview

The following table provides a comparative overview of the two options:

Table 1: Service Bureaus versus In-house Capturing: A Comparative Study

SERVICE BUREAU	IN-HOUSE CAPTURING
▪ Preferable for large once-off digitisation projects.	▪ Preferable for medium to small collections that are frequently updated. The long-term workload should justify the initial expenditure.
▪ Source material need to be in good, ready-to-film condition.	▪ Weeding and repairing of damaged material can be an integral part of the digitisation process.

▪ No initial or ongoing layout in terms of equipment.	▪ A big initial layout in terms of equipment; equipment needs to keep abreast of new technological developments which are very rapid in this field.
▪ Little investment in personnel and personnel development.	▪ A digitisation project requires major investment in personnel time and development.
▪ Little control over the process. Reliant on an external service provider.	▪ Full control over the process. Much more convenient than having to rely on an external partner.

Although it may seem that there are more advantages to the use of a service bureau, in-house capturing has the big advantage of being more convenient, especially on the longer term. The final choice will, however, be determined by the nature of the photographic collection to be digitised as well as the culture and financial sponsorship of the institution.

2.3 CAPTURING DEVICES

There are a wide range of capturing devices available that are able to convert images from various photographic formats to a digital format. The choice between devices will depend upon the specific environment: the type and format of the source material that needs to be digitised. An overview will be given of the various capturing devices available, divided according to the following types:

- Scanners
- Video cameras

- Digital cameras
- Proprietary digitisation workstations.

2.3.1 Scanners

Scanning is the most popular capturing option. Scanners have become very affordable and are easy to set up and use. Little training is necessary to use a scanner. It has become standard equipment in most businesses - from the small office home office market to that of big corporations.

A scanner can be defined as:
"A system for converting the electro-magnetic radiation emanating in specific spectral bands from an object or scene into digital representation of the object or scene which can then be manipulated by a computer" (Sturt, 1990: 99).

The scanner is therefore a device that is used for the conversion of images into digital characters. It captures information from source material, which, such as a photograph. The photograph is then electronically represented by a collection of dots or pixels in a computer readable format.

Most scanners come with proprietary software that can handle all typical tasks and the most common file formats - PICT, TIFF, JPEG, BMP. The scanning process can also be controlled through software, which forms part of the image enhancement program, such as Adobe Photoshop. The software works with any scanner that has a compatible plug-in module.

2.3.1.1 Types of Scanning:

When choosing a scanner it is important to identify the right scanner for the specific application. Scanning can be divided into the following types:

- Line art or bitonal scanning
- Halftone scanning
- Greyscale or continuous tone scanning
- Colour scanning.

An overview will be provided of each type of scanning for the purpose of determining the scanning types relevant to the digitisation of photographic images.

- *Line art scanning* transfers pen and ink style drawings, clip art and pencil sketches into a computer readable format. Bone (1997) describes line art as having no shading nor colour other than black. It is one-bit scanning in which the computer sees the image as either black or white. Line art scans, since they can only be black or white, are prone to having jagged edges around curves when scanned at lower resolutions than the final output device. Therefore, line art scanning is not suitable for the scanning of photographs.

- *Halftone scanning* is the process whereby the original document is an already screened source such as a magazine, coffee table book, newspaper, etc. Scanning these images often creates interference patterns called moiré patterns, which need specialized filters to reduce the effect (Curtin, 1998). Halftone scanners are unable to produce continuous tones, as they are unable to create a pixel in different shades of grey as the scanner sees them. Instead they use a very complicated screening pattern to simulate shades of grey to the naked eye (Bone, 1997). At higher magnifications it is possible to discern that a halftone image is not really a photo, but is a series of variable sized dots.

- *Greyscale scanning* is often used for original photographs. Grey-scale scanners are scanners with CCDs (charge coupled devices / light sensitive integrated circuits) that can differentiate between levels of light falling on them, rather than just being on or off (Bone, 1997). A greyscale scanner can therefore determine whether the pixel should be any number of shades of grey. Greyscale scanning is suitable for the scanning of black and white photographs.

- *Colour scanning* is similar to greyscale scanning. Colour scanners differ in that they have filtration (most commonly Red, Green, and Blue) and make multiple passes to generate 256 levels of each RGB component. The software then recombines the three passes to create full colour. Higher quality scanners perform all three scans in one pass at the same time (Bone, 1997). Colour scanning is the type of scanning most used for the scanning of photographic material.

2.3.1.2 Types of Scanners

There are various types of scanners that have been developed to cater for specific applications. The following have been identified as potentially relevant to the digitisation of photographic images:

- Handheld scanners
- Flatbed scanners
- Slide scanners
- Drum scanners

A short description will be provided of each type, indicating possible areas of application.

- *Handheld scanners:*

  As indicated by its name, a handheld scanner fits in the palm of one's hand. The device is slowly rolled across a piece of paper and an array of photo sensors in the scanner records the image. Handheld scanners are the least expensive but are difficult to control and require some practice to master (Boss, 2001). In the scanning process one must hold down the scan button, move the scanner at a suitably slow pace, and keep the scanner rolling in a straight line. According to Bone (1997) handheld scanners work best for draft quality half tones or line drawings. Handheld scanners are also limited to the scanning of small images no wider than their CCDs, as the re-alignment or 'stitching' of graphics is a cumbersome process.

- *Flatbed scanners*:

  A flatbed scanner works in the manner of a photocopying machine. A sheet of paper is laid on a platen, after which the scanner moves the photo sensor array past the page (Bone, 1997). A flatbed scanner consists of a series of CCDs mounted in a stationary row so that light reflected from a piece of flat art is allowed to pass over. These CCDs register presence or absence of light (ON/OFF) thus producing a pixel electronically. Since they are mounted in a single row that is also the way the electronic file is created, row-by-row. Essentially the CCDs are reflected one row of the flat art at a time until the image is completely built (Bone, 1997).

  Resolution or the number of pixels written based on what is reflected is controlled in two ways. The number of pixels horizontally is controlled by how closely the CCDs are placed next to each other along the single row. The number of pixels vertically is controlled by how slowly the light bar and mirror move along the length of the flat art thus reflecting onto the CCDs (Bone, 1997). Therefore, the more CCDs and the smaller the steps of the advancing light bar the greater the resolution.

  According to Bone (1997) the major scanner engine manufacturers all build their systems essentially the same way. The highest resolution flat bed scanning system is physically limited to 600 pixels per linear inch. The 600dpi physical limitation has been breached by what is known as interpolation. Interpolation is a software/firmware process whereby the scanner essentially samples two pixels and averages (using more complex formulas) the two pixels together to form an extra pixel (or more) in the middle. Better scanners can do this in hardware, but some still rely on their scanning software to do it (often uninvolving the user). This higher resolution is however, only pseudo-data, or data being created by averaging and not by actually sampling it from the original art (Bone, 1997).

Scanner manufacturers do not always indicate their resolutions in uniform terms. For instance, some indicate that their scanners are 600x1200 dpi. This can be misleading, as explained by Bone (1997): "Traditionally pixel resolution reflects how much data the scanner can acquire in a square inch, or X x Y. Scanners that have non-uniform resolutions do not actually give one the ability to acquire image data at this non-uniform resolution, they instead interpolate one dimension. At 600x600 they interpolate the 1200dpi dimension down to 600dpi (usually done by merely running the stepper motor that moves the light bar at twice its minimum rate), or at 1200x1200 they interpolate the X dimension".

Many flatbed scanners are equipped with additional transparency units that enable the scanning of slides (Curtin, 1998). A transparency adapter is a scanner cover that diffuses light evenly through the transparent media. It replaces the copy board cover that is included with the scanner. Generally the resolution of these units is below that of slide scanners.

Colour flatbed scanners are becoming more appealing, both in price and capabilities. Until recently flatbed scanners tended to be limited to 600 dpi. From 1998 flatbed scanners were available that offered resolution as high as 3200 dpi (Boss, 2001). A flatbed scanner is, however, no substitute for the costly slide scanners and even more costly drum scanners used in high-end publishing.

- *Slide scanners:*

  Slide scanners (also called film or transparency scanners) are the best tool for inexpensively capturing high-resolution data directly from slides and film.

Slide scanners are an efficient and inexpensive way to capture film for high-quality digital production. According to Curtin (1998) the highest quality scans are from slides or negatives because they have much higher dynamic range than prints. Virtually all slide scanners offer resolutions of at least 1,950-dpi, because slides and negatives are so small and must be enlarged so much. Many slide scanners feature batch processing functions, which can dramatically speed up the scanning process. Specifications for colour depth, density range, image processing hardware accessories, scanning method, and bundled software are all-important features to be considered when comparing slide scanners. According to Weibel (1997: 83) many high-end slide scanners are being discontinued, as prices for flat-bed and drum scanners fall. Low-to-mid-range scanners continue to be successful.

- *Drum scanners:*

  Drum scanners are mainly used in commercial environments requiring output of very high-end graphics. They are the most expensive type of scanner and have high resolutions of 2,750 - to 12,000 dpi (Stone, 1997b: 1).

  Curtin (1998) provides the following description of the working of a drum scanner:

  "On these scanners the transparency or print is affixed to a glass drum. As the drum spins, the image is read a line at a time by a photomultiplier tube instead of a CCD. A bright pinpoint of light is focused on the image and its reflection (prints) or transmission (transparencies) is measured by the tube. These tubes provide the highest quality of RGB and CMYK scan with greatly improved highlight and shadow detail. Their dynamic range is so high they can capture detail both in shadows and bright highlights and they also capture subtle differences in shading. Resolutions range up to 12 000 dpi and higher and these scanners have very large scanning areas".

  A drum scanner scans one pixel at a time, which means that it is less prone to stray light. In contrast, a flatbed scanner, using a CCD to look at the image line-by-line, can lead to stray light, producing faults in the scanned image. There are, however, some disadvantages to drum scanning. It is generally more time consuming as an operator has to mount artwork onto a cylinder in order to scan it, and a higher level of expertise is needed to operate a drum scanner (Photoplan, 1997: 3). The quality of CCD technology is, however, advancing rapidly and the gap between flatbed and drum-scanner quality is narrowing. Currently though, if the highest quality scans are required, a drum scanner is the best option: "...although drum scanners have given much ground to flatbed units, they are still popular for high-end work" (Toth, 2001).

2.3.1.3 Scanning Software

The software - proprietary or otherwise - bundled with scanners is almost as important as the hardware. To be effective, the software needs to offer more than just high-end features; it must be easy to use too. To get the perfect image, software must correct the data it is presented. It is possible to do most of the colour correcting in a program such as Adobe Photoshop, but manual colour correcting can be very time consuming.

Many scanners are able, through software, to automatically adjust and correct the colours of a scan. This makes the process of scanning less painful for the operator. However, it's not a fail-safe option. Automatic adjustment of hue, saturation and contrast are satisfactory with most images, but there are exceptions that require manual input. For example, a photograph that appears very dark may be a result of the photographer's attempt to portray mood and atmosphere. The scanner's software, however, might assume otherwise and lighten the picture to what it believes is wanted (Fanning, 1997:3).

Software is also important for managing workflow. Some of the scanners have an A3-size scanning area, which is almost a necessity for the handling of large originals as well as batch scanning. Batch scanning involves placing a number of originals on the scanning area and setting the scanner to scan them individually. If using a template as many as 32 slides (35mm) can be mounted on some scanners (Fanning, 1997: 3).

2.3.1.4 Determining Scan Resolution

Before scanning is started time should be taken to calculate how much detail needs to be captured for the intended use of the images.

Scanning resolution refers to the number of samples a scanner takes in a particular area of the original. Measured in dpi (dots per inch), the more dpi the scanner can see, the more accurate and detailed the image will be (Bone, 1997). If a 4-x-5-inch transparency were being scanned, then 300 dpi would be suitable, as long as the final output is the same size. If an image needs to be printed that is much larger than the original, it needs to be scanned at a higher resolution. This is particularly important when dealing with 35mm film.

One of the resulting problems of scanning at a higher resolution than needed is that it places unnecessary pressure on the output device. This causes delay in downloading time when displaying an image on-screen and overloading the raster image processor (RIP) of the laser printer or image setter, resulting in a possible crash of the RIP (Bone, 1997).

The correct resolution for a scan is determined by the capability of the output device. If the image resolution is too low, the enhancement software may use the colour value of a single pixel to create several halftone dots when printing. This results in idealisation, or jagged-edged output. If the resolution is too high, the file contains more information than the printer needs. The file size directly affects the length of time required for the printer to process the image. The size of the file is proportional to its image resolution. The size of the final image compared to the size of the original image should also be considered when setting the scan resolution. Should the image need to be made larger than the original more data is needed to produce the final image with the correct image resolution. Should one be unsure of the file size needed most image enhancement software allows for the creation of a dummy file that tells you what size you need (Bone, 1997).

2.3.2 Video Capturing

Video capturing is a process whereby the output of an analogue video signal from a video camera, frame grabber or VCR, is converted to a digital, computer readable format.

"A frame grabber bridges the analogue world of traditional video technology and the world of digital imaging" (Boss, 2001). A video camera captures an image in much the same way as a digital camera. The difference is that instead of immediately converting the image to digital format it is instantly saved in analogue form. The analogue data is then converted to digital format via a video digitiser or frame grabber (Grotta & Grotta, 1996: 145).

The fact that the image is initially saved in an analogue format, enables the captured image to be viewed 'live' on the computer screen, which in turn enables adjustment of the colour balance and focus prior to freezing the picture on the screen (Rowland & Seeley, 1991: 218).

According to Anderson (1991:598) the general claim that images can easily be captured into the system via an inexpensive video camera can be somewhat misleading. In the university of Maryland Historic Textile Database digitisation project, four video cameras from three different manufacturers were tested with unsatisfactory results. Finally the project team came to the conclusion that only a dedicated camera and lens would be satisfactory.

Another problem that should be taken into account when using a video camera is that the broadcast video signal has inherent limitations in dynamic range which cause the loss of information in images with a large dynamic range such as colour transparencies (Reilly, 1996: 152).

Video has the advantage over other capturing devices that images can immediately be displayed on a television set or computer monitor

2.3.3 Digital Cameras

Digital filmless cameras allow users to quickly and easily capture images directly to a computer. Digital cameras are very similar to traditional cameras (Photoplan, 1997:2). Both types have a lens, shutter and diaphragm. The difference lies in the medium on which the image is captured. Traditional cameras focus their images on film coated with light-sensitive silver halide crystals. In a darkroom the film is then immersed in a series of chemicals to develop and permanently fix the recorded image. Digital cameras focus their images on a photo-sensitive semi-conductor chip or CCD, which converts the image into pixels.

Should the original source be an existing photographic print, it can be photographed using a digital camera and then transferred for manipulation.

Even with recent advances in digital cameras "...they have far less capacity than a digital scanner. Until recently their advantage was the 32- to 42-bit color they offered, but that advantage has disappeared now that many flatbed scanners also offer that" (Boss, 2001). One of their main advantages is that digital cameras greatly simplify the digitisation process. They plug directly into the computer to transfer the images for manipulation (Photoplan, 1997: 2).

2.3.4 Proprietary Image Capturing Platforms

Proprietary image capturing platforms are systems which integrate all the steps in the digitisation process, from the point of capture to the point of output, whether on screen or in hard copy. The most well known systems are the Kodak Photo Digital Conversion System 1200 and the Apple Macintosh Image-Capture (IC) Platform (Newby, 1996).

Apple's system functions on the basis of specialised software to be added to the digitisation process to enhance it. The IC platform consists of two main components: a comprehensive set of QuickTime IC application programming interfaces and a multitasking, real-time embedded operating system, which runs inside digital cameras and other similar devices. Apple's system provides a bridge between digital imaging hardware and software applications, making it easier for software developers to build image-related features into new and existing products (Apple Macintosh, 1996; Newby, 1996).

The KODAK Digital Conversion System 1200 converts negatives, slides, prints and flat artwork to either Photo CD, TIFF RGB or FlashPix format (Kodak, 1997). It is a complete image-authoring station for producing Kodak Photo CD discs: "Photo CD technology is multifaceted, combining scanning technique, storage medium, image format and compression algorithm, and color management system for digitising and presenting images" (Kenney & Rieger, 1998).

The Kodak system consists of the following components: a film scanner, a print scanner, a data manager workstation, CD-ROM XA drive, a compact disc writer, and a digital thermal printer and system software (Kenney & Rieger, 1998).

Kodak Professional Photo CD film scanner is capable of digitising colour negatives, colour transparencies, and black-and-white negatives in formats of up to 4 x 5 inches (Kodak, 1997). With 12-bit sampling and resolutions as high as 4K x 6K, the scanner generates 24-bit image files containing the fine detail required by professionals. The Kodak system has built-in enhancement controls that allow automatic colour balance, density saturation and contrast (Kodak, 1997).

The Kodak Digital Conversion System 1200 also has the capability to protect on-disc images against unauthorized use through copyright identifiers, watermarks and encryption (Kodak, 1997).

2.3.5 Summarised Overview of Capturing Devices

There are various capturing options available, making a decision in terms of the right device for a specific application, quite confusing. By providing a summarised overview of the available options, the following table will aim to make this decision a little clearer.

Table 2: Image Capturing Devices

IMAGE CAPTURING DEVICES			
Scanner	**Video**	**Digital Camera**	**Imaging Workstation**
• Scanners have become an integral part of the business environment and are familiar and easy to use. • Scanners have the drawback that they cannot deal with the whole range of photographic formats found in large, diverse collections. • Handheld scanners are limited to scanning small low-resolution images. • High-end colour flatbed scanners are suitable for a wide range of photographic formats, especially if equipped with transparency units. • Colour flatbed scanners are becoming more appealing, both in price and capabilities.	• Video cameras are fairly easy to use. • Video is flexible in the sense that a camera can be pointed at any photographic format - either a print or a transparency on a light box. • Video cameras are fairly inexpensive. • Images can be viewed and evaluated on a video screen before final capture. • Video cannot capture at very high resolutions. • Loss of information from images with a large dynamic range such as colour transparencies is caused because the broadcast video signal	• Fairly easy to use for those familiar with traditional photography. Requires technical knowledge of photography and cameras. • Although low-end cameras provide poor resolution, they are an easy, quick and cost-effective method of capturing images, which do not require high resolution. • High-end cameras that provide good resolution are costly. • Higher resolution capturing is fairly slow.	• Imaging workstations are specialised to produce high quality images. • The hardware and software are proprietary to one system, thereby eliminating any compatibility problems that may arise from 'mix-and-match' systems. • Proprietary imaging workstations are very costly and therefore only suitable for applications requiring intensive capturing.

IMAGE CAPTURING DEVICES			
Scanner	**Video**	**Digital Camera**	**Imaging Workstation**
• Slide scanners are an efficient and inexpensive way to capture high-resolution data directly from film or slides. • Drum scanners provide highest resolution capturing, but are also the most expensive type of scanner.	because the broadcast video signal has inherent limitations in dynamic range.		

2.4 DIGITAL IMAGE ENHANCEMENT

2.4.1 Image Enhancement

Image enhancement deals with the upgrading and optimalisation of digitised images of which the quality is not satisfactory. Poor image quality could be the result of originals that are in poor condition as a result of their age, handling or neglect. Image quality can also be influenced by the digitisation process. Low resolution scanning will result in a low quality, low-resolution digital image. Poor image quality can be enhanced by specially developed image editing software that contains specialised tools to automatically correct image imperfections.

2.4.2 Image Editing Software

After being captured by a digital capturing device such as a scanner, and converted to a digital file format, images often need to be enhanced for better output on screen or paper. Digital enhancement is done through the use of specially developed software. Image editing software is either published as standalone packages or included as part of the capturing device.

There is a wide range of image editing software available, which can be divided according to three levels: basic, intermediate and professional (Boss, 2001). The first level is usually inexpensive, easy to use, but many lack important features such as "...the ability to remove tears and scratches from the image" (Boss, 2001). (Example: Microsoft Picture It 99). These basic tools should be avoided by libraries and archives. Intermediate tools have more advanced capabilities, do not "...require users to take a class to learn it", but also lack some important features required by libraries and archives. (Example: Jasc Paint Shop Pro 5). Professional editing tools are developed for professional photographers. They are usually expensive and require training to ensure effective use. Although these products may have more features than libraries or archives may need, at least one is assured that everything needed is there. (Examples: Adobe Photoshop and Corel Photo / Paint) (Boss, 2001).

The following table provides an overview of the typical enhancement features found in image editing software. The basis for the information contained within this table was obtained from the Adobe Systems Web site: Photoshop Key Features (Adobe Systems, 1998). Adobe Photoshop is widely acclaimed as a comprehensive image and professional image editing and production package. For this reason its features were summarised in the following table to illustrate the typical enhancement features found in most state of the art image editing packages.

Table 3: Typical Image Enhancement Features

TYPICAL IMAGE ENHANCEMENT FEATURES	
FEATURE	**DESCRIPTION**
Painting Tools	• Painting tools are the tools most used in image enhancement as they focus on sharpness and retouching of imperfections. They include the following features: - Exposure correction - Colour saturation correction - Drawing and painting tools - Retouching tools (image sharpening, cloning)
Selection Tools	• Selection tools are used to select a specific feature or area of an image on which to use a specific tool. The following features are included: - 'Lasso' and 'pen' tools for automatic tracing of elements

TYPICAL IMAGE ENHANCEMENT FEATURES	
FEATURE	**DESCRIPTION**
	- Feather-edge selections for blending backgrounds and combining foreground and background images - Automatic colour range selection
Filters	• Many image editing packages include special effects filters that allow for automatic: - Image sharpening - Image softening - Stylising - Lighting - Removal of dust, scratches and hairline cracks
Colour Correction Tools	• Colour management is a very important aspect of image quality management. Image colour is one of the features most affected by the digitisation process. Colour correction tools include: - Adjustments for brightness, contrast and mid-tones (gamma) - Adjustable tonal curves and control points - Variations to adjust image colour and brightness by previewing a range of modified images simultaneously - Controls for selectively adjusting hue, saturation and brightness of any range of colour in an image - Replacing colour in a selected area - Adjustment of the dynamic range of an image

TYPICAL IMAGE ENHANCEMENT FEATURES	
FEATURE	**DESCRIPTION**
	- Information palette with densitometry readings.
Colour Separations	• Colour separations are needed to adjust the printed output for paper stock and printing devices. Colour separation includes calibration features.
Colour Support	• Most image editing packages allow for flexibility to convert between Bitmap, Greyscale, CIE LAB, RGB and CMYK editing modes.
Digital Watermarking	• Digital watermarking is the ability to embed an imperceptible digital copyright signature that proprietary software such as Photoshop can detect and display, even after an image is printed and scanned.
File format and cross platform compatibility	• Most image editing packages are cross-platform compatible and support the more widely used file formats such as Encapsulated PostScript (EPS), Kodak Photo CD, TIFF, JPEG, PCX, BMP, MacPaint, Targa (TGA), and GIF. • Most packages also support TWAIN interface for a wide variety of image capturing devices, such as scanners and digital cameras.

2.4.3 Enhancement Philosophy

When digitising large collections of photographs for research or other professional use, enhancement is an important part of the process. If the digitised image were to act as surrogate to the original image it is important that high image quality be maintained. This can only be achieved by editing each captured image for quality in terms of sharpness, brightness and colour representation.

The integrity of the surrogate image as an accurate representation of the original image can become a contentious issue within the context of image enhancement. The philosophy in terms of level of enhancement may vary according to both institution and librarian / archivist. Some librarians / archivists may want the image to look as much as possible like the source document, leaving all defects of the source document in place for users to see what they would see if the source document were to be examined. Other librarians / archivists emphasise readability of the images and "...enhance the contrast, remove markings that affect readability, and otherwise improve the images" (Boss, 2001).

In order to formulate an organisational philosophy on the level of image editing that will be applied, the following questions should be considered:

- Should damaged photographs be repaired digitally?
- Will the original photograph be misrepresented if certain imperfections, such as hairline cracks, were to be repaired?
- If it were possible to enhance a photograph to bring out detail that was lost due to fading, should it be regarded as changing of the original or as enhancement to its former, original state?
- If the policy were not to enhance an image beyond its current state, will it continue to be an accurate representation in five years' time when further deterioration of the original had taken place?
- If part of a photograph were lost due to a tear, can it be replaced with the use of the cloning tool in image editing software?
- Where does enhancement end and changing of the original begin?

2.5 CONCLUSION

The process of image capturing and enhancement can be misleading in that it seems simpler than it really is. As the foregoing study has proved, there are many pitfalls that await the unsuspecting and uninformed user. With good basic knowledge of all the possibilities and the advantages and disadvantages of each option, capturing can be successful and be the starting point of a very productive and effective digitisation project.

No specific capturing method can be recommended above another - the choice is very much dependent on the specific application. Each application will prescribe certain criteria in terms of capturing requirements. These requirements will include issues such as:

- the size of the collection;
- the formats to be digitised;
- the planned usage of the digitised images;
- the output resolution required, and
- the degree of manipulation to be performed on the images.

Choice in terms of capturing hardware and software is also determined by the amount of money an organisation is willing to spend on its digitisation project. The best, state of the art hardware and software may perhaps produce the highest quality image, but that may not necessarily be what is required. Expenditure must also take into account whether the equipment will have ongoing value for the organisation - will it be a once-off major project with little future development, or will it be an ongoing project with long-term usage of the equipment.

The tremendous potential of a digitised photographic collection compared to traditional photographic formats, definitely make the learning curve, cost and labour required by the capturing and enhancement phase of a digitisation project, worthwhile. Once this hurdle has been crossed, the rest of the digitisation process may seem easy in comparison.

After the images have been captured they need to be stored in a specific file format and in a specific storage medium. The next chapter will discuss the various data formats and storage options available for digitised images.

CHAPTER 3

DATA FORMATS AND STORAGE OF PHOTOGRAPHIC IMAGES

3.1 INTRODUCTION

Traditionally one of the major problem areas of any photographic collection has been its storage and preservation. This is due to various reasons. Photographs damage very easily - even fingerprints can affect the chemicals in a photographic print or negative. Photographs come in numerous formats, in terms of both physical format (slides, prints, negatives) and size (35mm to 8x10 inches and bigger). In a photographic archive special provision has to be made for each format. For these reasons archives prefer that only personnel handle the photographs. This, however, greatly limits accessibility to the collection and places a big burden on personnel.

Modern technology fortunately presents some solutions to these problems. As discussed in the previous chapter, it is possible to capture photographs electronically and convert them to a digital format, no matter what the original formats were. Once digitised a new world of possibilities are open to photographic collections. The electronic format could replace the original photograph; act as a working substitute, or as a key to the original. For historical reasons many archives prefer to store the original photograph and only make the digital format available for use by end-users, thereby ensuring its preservation.

After digitisation the next step is to decide in what format the photograph will be stored, what compression method will be used and on what medium it will be stored. The purpose of this chapter is to identify the various image file formats, compression techniques and electronic storage media available for photographic images.

3.1.1 Imaging Standards

Electronic storage is one of the areas in the computing worlds in which developments are the greatest. Each year sees the introduction of better and bigger storage and compression capabilities. It is a world driven primarily by user demand and the competition among vendors to meet the demand and make the greatest profit. This phenomenon naturally is very advantageous for the user, but it also presents certain problems. In their race to be the first in the discovery of new storage solutions, each vendor follows its own route, only focussing on compatibility with its own product range. This results in problems with backward and cross-platform compatibility. For this reason the consumer market recognized the need for standards, which today defines the total imaging process. This includes the capturing process, image file formats, compression algorithms and various storage media.

As the USA has been the leaders in the development of the imaging industry they have also played a central role in the development of imaging standards. Imaging standards can be divided according to those that affect only the USA (as overseen by the American National Standards Institute / ANSI), those that are international (as overseen by the International Organization for Standards / ISO, the International Electrochemical Committee/IEC and the International Telecommunications Union / ITU - formerly known as CCITT) (Anson, 1993a: 16.).

The different standards applicable to data formats, image compression and storage media will be discussed in the relevant subdivisions of this chapter.

3.1.2 Criteria for the Evaluation of Image Data Format and Storage Options

When making decisions on the different aspects of file formats, image compression and storage media, it is of the utmost importance that the purpose of the specific project always be kept in mind - the means must suit the purpose. To be able to make the *most suitable* choice, one has to know the exact nature of the specific application. Different photographic collections may have different specifications to consider. The following are the main considerations/criteria that need to be taken into account (Anson, 1993a: 16):

3.1.2.1 Size of the collection

Here aspects such as the importance of the collection, as well as the amount of money an organization is willing to spend, should be taken into account. If a collection is very small it is not cost-efficient to spend a large amount of money on it. But if it were a very rare or frequently used collection it may well justify the cost. The size of the collection will also determine the amount of storage space needed, which in turn will determine the type of storage medium (must be able to handle large volumes of images) and compression technique (the bigger the compression rate the less storage space will be needed) that will be used. Future expansion of the collection must also be taken into account.

3.1.2.2 Preservation and permanence

In rare and sometimes already fragile collections it is important to reduce physical handling of the original photographs to a minimum. This specification demands that photographs be stored in such a way that the end-user will be able to satisfy his research needs by the image shown on the screen and in many cases be able to make a satisfactory copy of an image directly from the system. Here an aspect such as the compression technique chosen and the resolution at which the image is stored is important. The hardware must obviously also be able to produce a copy of the image, either on screen or in print, at the same satisfactory resolution.

3.1.2.3 Cost

As mentioned before, the amount an organization is willing to spend will determine what storage medium will be chosen. The different storage mediums vary quite widely in terms of cost. The hardware and image capturing requirements of the different storage mediums are the aspects, which can be the most costly of any system.

3.1.2.4 Computer-generated copies

Will the user need the original photograph? Or will a copy suffice? How good and true to the original should the copy be? If the original print is in colour, must the copy also be in colour? Should it be a hard copy (i.e. a print from a printer) or in an electronic format, e.g. loaded on a floppy disk? The answers to these questions will determine the format, compression and decompression techniques and storage media needed to ensure the quickest and most efficient access to the photographic images.

3.1.2.5 Manipulation

It must be determined beforehand whether users will want to manipulate images. Certain collections should not be able to be manipulated due to legal reasons. Not all storage mediums allow manipulation capabilities. Users wanting to manipulate images will want their output to be in a digitised format. The system should then also support various image formats to suit the needs of its various users.

3.1.2.6 Ease of use

The storage medium chosen must be easily accessible to all its users - even those with limited computer literacy. Here the retrieval method, which will be described in a later chapter, will have an almost overriding effect on the system's user-friendliness.

3.1.2.7 Distribution

If the collection or parts of the collection need to be distributed to remote workstations, the storage medium must allow for this. A collection stored on hard disk, for example, will be problematic to distribute. Optical disk, on the other hand, lends itself excellently to distribution.

3.1.2.8 Compatibility

If the system being developed by an organisation must be incorporated with an existing system and its hardware infrastructure, the limitations of the existing system must obviously be taken into account. Such a situation can be very restricting on the development of an "ideal" system, but is unfortunately unavoidable in some cases.

3.1.2.9 Future developments

In the area of imaging technology the developments are *very* rapid. Any good system must be able to keep pace with future developments in hardware and software imaging capabilities. An aspect, which comes to mind here, is resolution dependence. The resolution capabilities of visual display units (VDU's), scanners and printers are improving at an almost daily rate. If an application is resolution dependant it will not be able to use the new developments to its own advantage, as its resolution rate is fixed the moment the image is captured. Resolution independence allows for output at the best resolution available at that specific moment.

3.2 IMAGE FILE FORMATS

From the point of capture images are compressed, distributed, stored and displayed in specific image file formats. The file format chosen depends on various factors such as the software used to manipulate or display the images and the compression technique and storage medium used. As the question of image formats will necessarily pop up when working with electronic images, it is important to know what formats are available, where they are applicable and what possible effect they may have on the functioning of your image database.

3.2.1 Overview of Image File Formats

The following tables provide an overview of a selection of various image file formats available. A short description as well as advantages and disadvantages of each file format are provided. It is however important to note that advantages and disadvantages of the different file formats depend largely on the application - what may be a disadvantage in one environment may be an advantage in another environment. A good example of this principle is lossy and lossless compression. Losslessness has the advantage of protecting the integrity of the data, but the disadvantage of not being able to reach high compression ratios.

Information from a selection of authors have been collated in the compilation of the following table (Bethoney (1997: 42); Boss (2001); Goodman (1996: 462); Graves (1993: 594); Hirshon (2000); Kenney & Rieger, (2000); Prosise (1996:1-5); Roth (1996: 1); Rowb (2001)):

3.2.1.1 Graphic File Formats

Table 4: Graphic File Formats

GRAPHIC FILE FORMATS			
Format	**Extension**	**Type/Description**	**Advantages & Disadvantages**
BMP	.bmp	**BitMaP Graphic File** - Bmp is the native bitmap file format for Windows (closely matches the format in which Windows stores bitmaps internally) and OS/2. - A bitmap file stores the binary information a computer needs to re-create a picture. - Encodes colour information using 1, 4, 8, 16, or 24 bits per pixel (bpp). - Compression is lossless.	**Advantages:** -Compression is lossless. **Disadvantages:** - This format is platform dependent, limiting its usability. - Although BMP supports basic compression, most image applications do not generate compressed BMP files, therefore files are very large.
RLE	.rle	**Run Length Encoding**	**Advantages:**

GRAPHIC FILE FORMATS			
Format	**Extension**	**Type/Description**	**Advantages & Disadvantages**
		- CompuServe and Windows graphic file format. - A type of bitmap file in which the bitmap data is compressed using the RLE compression method. - The RLE algorithm replaces runs of identical pixels in the image with tokens specifying the number of pixels in the run and their colour.	- RLE is a very powerful and reliable compression method. - Compression is lossless. **Disadvantages:** - This format is platform dependent, limiting its usability. - Cannot obtain the high compression ratios of JPEG.
Macintosh	**.pct**	**PICT: Macintosh Picture** - A versatile format in wide use in Macintosh applications using graphics. - PICT was primarily developed as support for QuickDraw, the native graphics drawing protocol on the Macintosh.	**Advantages:** - A very versatile format - Supported by all graphics programs to be used with Macintosh computers. **Disadvantages:** - Seldom supported on other platforms because of its complexity.
GIF	**.gif**	**Graphics Interchange Format** - A very popular inter-platform bitmap file format created by CompuServe.	**Advantages:** - GIF has widespread popularity. - GIF is very compact, requiring less storage space than TIFF.

GRAPHIC FILE FORMATS			
Format	**Extension**	**Type/Description**	**Advantages & Disadvantages**
		- There are two versions of GIF files, GIF87a and GIF89a. - GIF allows more than one image to be encoded in a single file.	- Supports excellent image compression via a Lempel-Ziff-Welch algorithm similar to the one used by TIFF files. - Compression is lossless. - GIF is widely used to exchange bitmaps across platforms. **Disadvantages:** - Images stored in GIF files are limited to a maximum of 256 colours, 8 bpp. - Compression ratios are not as high as JPEG. - Supports online communications as the digital nature of GIF files enable them to be communicated over a range of communication lines or links.

GRAPHIC FILE FORMATS			
Format	**Extension**	**Type/Description**	**Advantages & Disadvantages**
PNG	**.png**	**Portable Network Graphic** - PNG is not a proprietary file format but was rather developed as a replacement for GIF to circumvent the legal issues surrounding the use of GIF files. - PNG inherited many of the GIF features and also supports true-colour images.	**Advantages:** - It compresses bitmap data using a variation of the highly regarded LZ77 compression algorithm that everyone is free to use. - Allows true-colour support up to 48 bits and gamma correction across platforms. - Compression is lossless. - Provides a useful format for the storage of intermediate stages of editing. **Disadvantages:** - Compression ratios are not as high as JPEG. - Not suitable for transmission of finished true-colour photographic images.
Kodak Photo CD	**.pcd**	**Kodak Photo CD ImagePac** - A proprietary image format of the Kodak Photo CD system. - Allows images to be captured at five different resolutions.	**Advantages:** - The Photo CD format is widely supported and highly compatible. - The different resolution levels allow a variety of applications from

GRAPHIC FILE FORMATS			
Format	**Extension**	**Type/Description**	**Advantages & Disadvantages**
			low resolution viewing to high resolution of images. **Disadvantages:** - PhotoCD is not considered a good choice for oversize documents that include fine detail as the fine detail (such as small print on an image) becomes illegible.
PostScript	**.eps**	**Encapsulated PostScript Graphic File** - EPS files can contain Adobe PostScript language statements and a TIFF bitmap image. The bitmap is useful for previewing the EPS file on a screen, while the PostScript statements are typically executed by printers to produce high-quality, scalable images.	**Advantages:** - Offers fast import. **Disadvantages:** EPS support is limited.

GRAPHIC FILE FORMATS			
Format	**Extension**	**Type/Description**	**Advantages & Disadvantages**
TIFF	.tif	**Tagged Image File Format** - TIFF defines more than 70 different types of tags. - Although TIFF is not an official imaging standard it became the de facto standard to help users transport imaging files easily between different platforms. - An image encoded in a TIFF file is wholly defined by its tags. - This file format is highly extensible because additional features can be added simply by defining additional tag types. - A TIFF file can contain multiple images, each with its own set of tags, which can complicate the reading of the image.	**Advantages:** - Despite its complexities, the TIFF file format is one of the best for transferring bitmaps across platforms. - It is platform independent. - It is flexible enough to allow almost any image to be encoded in binary form without losing any of its attributes, visual or otherwise. - When compressed, no information is lost. **Disadvantages:** - One of the most complicated of all the bitmap file formats to decode - software has to be written to understand all the different tag types. - As most TIFF readers implement only a subset of the full range of tags, a TIFF file created by one application sometimes cannot be read by another. Programs that create TIFF files can also define private tag types that are meaningful only to them. TIFF readers can skip tags they do not understand, but run the risk of affecting the appearance of the image.

GRAPHIC FILE FORMATS			
Format	**Extension**	**Type/Description**	**Advantages & Disadvantages**
JPEG	.jpg or .jpeg	**Joint Photographic Experts Group Compressed Graphic File Format** - Was developed to provide an efficient method for storing images such as photographs which are characterized by numerous subtle variations in colour. - JPEG is an ISO/IEC standard called Digital Compression and Coding of Continuous-Tone Still Images. - The greatest difference between JPEG and the other file formats discussed is that JPEG uses a lossy, and not lossless, compression algorithm.	**Advantages:** - Achieves high compression ratios, which is especially important in supporting the use of colour images, as they require large amounts of storage space. - Well-suited to storing true-colour photographic images. - Popular for use as service copies. **Disadvantages:** -A decompressed JPEG image rarely matches the original exactly, but as the differences are mostly so minor they are not easily detectable. - Not popular for archiving due to lossy compression technique. - In the Macintosh environment a JPEG file needs to be decompressed every time the image is printed. - JPEG does not support pixel transparency as does PNG and within limits, also GIF.
Fractal	.fif	**Fractal Image File**	**Advantages:**

GRAPHIC FILE FORMATS			
Format	**Extension**	**Type/Description**	**Advantages & Disadvantages**
		- Mostly used for colour images. - Provides a natural way to handle image data. - Uses an asymmetrical approach in which decompression takes less computation than compression. - Can attain compression ratios of up to 100-to-1.	- Not resolution dependent - as is JPEG. - Achieves high compression ratios - Supports scalability. **Disadvantages:** - Compression is lossy

3.2.2 Image File Formats: Concluding Remarks

Even though the above tables only represent the most commonly used image file formats, the options are already overwhelming and confusing. What is, however, apparent is that there seems to be a suitable format for each imaging application. The choice of format will largely depend on the working environment and potential use of the image. Understanding of what formats are available and the advantages and disadvantages of each within specific environments, is important to enable effective storage, retrieval and manipulation of images.

3.3 IMAGE COMPRESSION

One of the major obstacles in the creation of image databases is the large size of the image files needed for true-colour, high-quality images. A single 800- by 600-pixel true-colour image requires 1.44MB of disk space - one image will completely fill a high-density 3.5" diskette. Larger images need even more disk space, more memory, more time and are more troublesome to use. This effectively equates to a high cost to build and use applications, which use images. (Anson, 1993a: 16 & Anson, 1993b: 195). Data compression is important because storage space and bandwidth required for the transmission of images are costly. This is especially relevant in terms of the escalation in the popularity and use of the Internet (Copeland & Kay, 2000b).

Compression is "...the process by which the storage space consumed by image data is condensed by encoding the documents/images so that they may be efficiently stored, transmitted and processed" (Kaebnick, 1993:18).

Decompression is the process whereby the compression algorithm is decoded and the original data is reconstructed for output of the image on screen or printer. A decompressor can therefore operate only by using knowledge of the compression algorithm used to convert the original data into its compressed form. Compression algorithms are used to re-encode data into different, more compact representations conveying the same information. They are important for condensing the storage space consumed by image data and for making transmission of images feasible (Kaebnick, 1993: 18). Compression algorithms are subject to a high degree of standardisation, which is fortunate, as it simplifies the decoding process.

3.3.1 Lossy and Lossless Compression

Data compression algorithms can basically be divided into two categories: lossless and lossy (Copeland & Kay, 2000a).

Lossless compression compress data "...without destroying or losing anything during the process" (Copeland & Kay, 2000a). Lossless compression guarantees that the data produced after decompression will be identical to the data before compression (Anson, 1993a: 17).

A *lossy compression* method eliminates redundant data with the result that the decompressed image will not be identical to the image before compression. It is however, possible to control the amount of "loss" - in other words to limit the amount by which the original data and the decompressed data will differ.

According to Boss (2001), lossy compression is more cost-effective as it can reduce images too much smaller sizes, "...but inherent in the economy is the potential for loss of detail". Nevertheless, lossy compression is frequently the best option for images, because lossy methods can achieve larger compression ratios while introducing only small differences into the decompressed images. According to Anson (1993a: 17) even with a method specifically designed for images, lossless compression would be unlikely to even achieve a 3 to 1 compression ratio on full-colour images. As digital image files are so huge, much larger compression ratios are needed. As a result most research into image compression has been applied to lossy compression schemes.

All compression techniques rely on the assumption that most data sets contain redundant elements. Compression can be achieved by identifying and encoding such redundancies. A lossy image compression scheme needs to take into account the characteristics of the human eye/brain system. Since the decompressed images are going to be different, the scheme should try and ensure that the differences are less noticeable. Anson (1993a.18) emphasises that this is not as simple as it sounds because the interaction between the eye, the brain and the imagination is not well understood. There are, nevertheless, some "rules of thumb". For example the eye is far more sensitive to fine details in brightness (luminance) than in colour (chrominance). As a result the colour component of an image can be encoded, that is compressed, into fewer bytes than the equivalent luminance component.

3.3.2 Symmetric and Asymmetric Compression

Compression algorithms can be divided into two categories: *symmetric* and *asymmetric.* A *symmetric compression* method uses roughly the same algorithms, and performs the same amount of work, for compression as it does for decompression (O'Reilly & Associates, 1997: 3).

Asymmetric compression methods require substantially more work to go in one direction than they require in the other. Usually, the compression step takes far more time and system resources than the decompression step. In the real world this makes sense. For example, if one is developing an image database in which an image will be compressed once for storage, but decompressed many times for viewing, a much longer time can be tolerated for compression than for decompression. An asymmetric algorithm that uses much CPU time for compression, but is quick to decode, would work well in this case.

Algorithms that are asymmetric in the other direction are less common but have some applications. In making routine backup files, for example, it can be expected that many of the backup files will never be read. A fast compression algorithm that is expensive to decompress might be useful in this case.

3.3.4 Image Compression Methods

Only a few different compression schemes are in common use throughout the imaging industry. The most common of these schemes are variants of the following methods, which are listed below (O'Reilly & Associates, 1996):

- **Pixel packing**

  Not a method of data compression per se, but an efficient way to store data in continuous bytes of memory. This method is used by the Macintosh PICT format and other formats that are capable of storing multiple 1-, 2-, or 4-bit pixels per byte of memory or disk space.

- **Run-length encoding (RLE)**

  A very common compression algorithm used by such bitmap formats as BMP, TIFF, and PCX to reduce the amount of redundant graphics data.

- **Lempel-Ziv-Welch (LZW)**

  Used by GIF and TIFF, this algorithm is also a part of the v.42bis modem compression standard and PostScript Level 2.

- **Discrete Cosine Transform (DCT)**

  DCT breaks an image into 8- by 8-pixel blocks and then uses mathematical "tricks" to decide what image information can be thrown away without damaging the appearance of the image too much. With JPEG/DCT the algorithm is symmetrical: compression and decompression take roughly the same amount of time. Since DCT was chosen as the basis for the JPEG standard it has become a benchmark by which other compression methods are measured.

- **Joint Photographic Experts Group (JPEG)**

  A toolkit of compression methods used particularly for continuous-tone image data and multimedia. The baseline JPEG implementation uses an encoding scheme based on the Discrete Cosine Transform (DCT) algorithm.

- **Fractal**

  A mathematical process used to encode bitmaps containing a real-world image as a set of mathematical data that describes the fractal (similar, repeating patterns) properties of the image.

- **Wavelet Scalar Quantization (WSQ)**

  A lossy compression algorithm allowing less of a trade off between compression ratios and image detail, than DCT/JPEG.

3.3.4 Image Compression Standards

Standards for compressed image formats are extremely useful in reducing problems of file format incompatibility between image processing systems from different suppliers. The following are standards most commonly used in the compression of photographic images. Although only JPEG is an internationally accepted (ISO) standard, Fractal and Wavelet compression are generally accepted as de fact industry standards.

3.3.4.1 JPEG

The most important widely used compression standard for still images is JPEG (Boss, 2001). JPEG is a high-performance, general purpose compression technique for continuous-tone colour or black-and-white photographs.

During the 1980's, various organisations wanted a standard for still, compressed continuous tone images. A group, called the *Joint Photographic Experts Group* or *JPEG*, was founded in 1986 to define such a standard. The JPEG standard describes ways of taking bit-mapped data for colour or grey-scale continuous-tone images and storing it in a smaller number of bytes. The JPEG recommendation is based on the DCT method.

The goal of JPEG was to find the best method for image compression and to get it adopted as an international standard. By November 1993 the JPEG recommendations *(ISO 10918-1 JPEG Draft International standard (DIS) / CCITT Recommendation T.8)* had formally been adopted by the International Telegraph Consultative Committee (CCITT), and shortly afterwards accepted also by the International Standards Organisation (ISO) (Kaebnick, 1993: 20).

The JPEG standard had to meet the following requirements (Kaebnick, 1993: 20):

- To be applicable to any kind of continuous tone image with no artificial restrictions on resolution, colour, aspect ratios, content, etc.
- To allow the compression ratio to be traded-off against the decompressed image quality.
- To be symmetric - with compression and decompression requiring approximately the same amount of computation.

Although JPEG met its original goals and can achieve compression ratios of 30-to-1 or 40-to-1 with good quality output images, this is not good enough for many applications. For example if the input file is 2.4MB a compression ratio of 40-to-1 will only reduce it to 61,440 bytes, which will still be too big for many practical purposes (Kaebnick, 1993: 20).

As a result the JPEG group is continuing to work towards a next generation standard which will not only improve compression ratios, but will also provide true *scalability*. Scalability, also referred to as resolution independence, enables a computer to output an image at any resolution. The next JPEG standard should achieve a level of functionality with which a one source image file will be able to be displayed at the best possible resolution the particular output device being used is capable of.

Although the DCT method that JPEG is based on, is effective at low compression ratios - up to about 25-to-1 - it has serious problems at higher ratios. Since the image is broken into 8 x 8 pixel blocks, the compressed file is roughly proportional to the number of these blocks. Therefore, as uncompressed files increase in resolution, JPEG/DCT files either increase in size or decrease in image quality. JPEG/DCT images are also characterised by their blocky nature. A rippling effect spreading out from the edges of an image, called *Gibb's Phenomenon*, is an unavoidable aspect of DCT, and most noticeable around edges and textures.

The most serious problem caused by long-term use of JPEG/DCT compressed images, is according to Anson (1993a: 24), that the images are resolution dependent. Attempts to display the decompressed images at a higher resolution than the original would result in a blockiness that results from pixel replication. Since graphics cards and printers are increasing in resolution every year, resolution dependence results in this year's images having to be rescanned and recompressed to take full advantage of the latest technology

3.3.4.2 Fractal Transform Image Compression

A *fractal* is "...an infinitely magnifiable picture that can be produced by typically small, finite sets of instructions such as you would find in a computer program" (Anson, 1993a: 24). Fractal Transform Image Compression consists of complicated mathematical and technical processes into which detail this study will not delve. It suffices to note that a fractal differs from a bit-mapped image in that the more you zoom in on a fractal image the more detail you see, but with a bit-mapped image, however, you will eventually only see big blocks of the same colour. Fractal image compression was developed to provide a natural way to handle image data in a digital environment. It provides resolution independence, which as mentioned before, is essential if the images will be stored over a long period of time.

Unlike JPEG/DCT, Fractal Transform is an asymmetrical approach in which decompression takes much less computation than compression: "...although decompression and rendering are fast, compression takes a lot of computation" (Dyson, 1998). This is, however, ideal for applications where data is compressed once and accessed many times, as in digitised photographic collections. Another advantage is that image data in a FIF (Fractal Image Format) file is resolution independent - the reason is mainly because no pixel data is stored in a FIF file, only affine maps and some header information. Unlike DCT, fractal image compression provides improved performance as the original image increases in size. The last possible advantage, mostly upheld by people in the "high art world", is that a FIF presentation of a picture is a more true presentation of the original than a "raster scanned" bit-mapped image - it fits more naturally into the way the human brain and eye looks at an image (Anson, 1993a: 29).

Fractal image compression has developed from an academic research topic in 1987 to a low-cost mass market product as early as 1992. It is not part of the JPEG standard, mainly because it did not exist when the standard was being drafted (Anson, 1993a: 29).

3.3.4.3 Discrete Wavelet Transform Image Compression

Several vendors are, from the middle of 1996, promoting alternative compression schemes as potential replacements for the *Discrete Cosine Transform* (DCT) technology used in JPEG. These are based on a technology known as *wavelet scalar quantization* (WSQ), originally developed at Los Alamos National

Laboratory for the FBI as a method of storing and transmitting fingerprint data (Beale, 1996: 36).

Like DCT, WSQ is a lossy technique, but there is generally less of a trade-off between the compression ratio and image detail. Wavelet vendors advocate that an image can be compressed by about twice as much as with JPEG to get the same level of quality (Beale, 1996: 36).

DCT compression requires an averaging of the detail in every 64-bit block of pixels. Wavelets, on the other hand, compress pixels in a continuous stream, reducing data loss and providing greater detail upon decompression.

WSQ is popular on the World Wide Web as it allows Web hosts to compress images as bulky as 1.2 megabytes down to 4 kilobytes, which makes transmission virtually instantaneous. On the other end, images can be decompressed within a second or two. The result is much faster and higher-quality compression than can be achieved by DCT technology. WSQ compression ratios compare even better than JPEG: Wavelet technology enables between 20-to-1 to 300-to-1 ratios compared to JPEG technology's compression from 20-to-1 to 30-to-1. Wavelet technology also maintains compressed image's original form and transmits larger images more efficiently than JPEG (Lavilla, 1997: 46).

The primary obstacle, agreed to by all cited authors on this subject, to acceptance of wavelet compression, is a lack of standards: images compressed with one vendor's product cannot be decompressed with software from competing companies (Dyson, 1998). None of the wavelet vendors are big enough to establish its technology as a de facto standard, leaving them with two choices: get a major vendor like Apple or Adobe Systems to endorse their format, or get a standard-setting body such as the ISO to establish wavelets as an accredited industry standard. WSQ is seen as the most likely successor to JPEG (Technologic Partners, 1997: 3).

3.3.4.3.1 Comparison Between JPEG, Fractal and Wavelet Compression

The information contained in the following table was collated from the work of the following authors: Anson (1993a); Lavilla (1997); Dyson (1998); (O'Reilly & Associates, 1997).

Table 5: Comparison Between JPEG, Fractal and Wavelet Compression

JPEG	FRACTAL	WAVELET
• Accepted as an international standard. • A lossy compression technique. • Complicated to implement. • Symmetrical compression. • Not supported by all file formats. • Resolution dependent. • More effective at low compression ratios - as uncompressed files increase in resolution, JPEG images either increase in size or decrease in image quality. • Based on an averaging of detail in every 64-bit block of pixels, resulting in data loss.	• Not an international standard. • The size of the original image has no effect on compression performance. • Asymmetrical compression in which the decompression rate is much faster than the compression rate. • Resolution independent. • Performance at higher compression ratios is better than with JPEG.	• Lack of standardisation in applications by different vendors, resulting in incompatibility problems. • Can achieve higher compression ratios than JPEG. • Although a lossy technique, there is generally less of a trade-off between compression ratio and image detail. • Pixels are compressed in a continuous stream, reducing data loss and providing greater detail.

3.4 STORAGE MEDIA

The increase in storage requirements during the past decade has been paced by increases in storage capacity, both in terms of the more traditional storage media such as hard drives and tape and the more recently developed optical media such as compact disc. (Eggleston, 1997:38). According to Bucholtz (2000) "...the turnabout came as the Internet became a transforming force for business; data has never before been generated in such volume or valued as such a critically important asset".

There is no technical difference between storing digital images and any other type of electronic media. The difference rather lies in the capacity requirements for digital images: "...an uncompressed, monochrome image of an 8.5- by 1-inch page at 600 dots per inch requires about 2 MB of storage; an uncompressed 24-bits-per-pixel color image of a similar-sized photograph requires 24 MB" (Boss, 2001).

When considering storage options a choice can be made between either fixed storage media such as hard disks or removable storage media. Removable storage in this context means any form of read/write storage that can be removed from the computer. Until recently, the only removable storage choices for most computer users were the floppy disk and the tape drive. But floppy disks lacked the capacity users needed, and tape drives lacked the flexibility to do more than back up files. Other options such as the Bernoulli Box and the SyQuest cartridge system found only a limited following among project managers who had to lock up files at night, and among graphic artists sending files to service bureaus. This category of drive was moved into the mainstream by the advent of Iomega's affordable, easy-to-use Zip Drive, introduced in 1995. The cartridges are basically floppy disks (that is, flexible magnetic media) in a case. The biggest strength of the removable storage category is however also its weakness: there are so many competing, non-interchangeable choices (Egglestone, 1997).

According to Egglestone (1997): "Disk-based drives are by far the more appropriate choice for most purposes, since they will let you read and save files directly from any program and even run programs from the disks. They also make up for their higher cost per megabyte (relative to tape drives) with added convenience. For example, you can back up files by copying them; you don't have to use backup and restore utilities".

An overview of the various storage options available will be provided, divided in the following categories: hard drives, tape, and optical media (including magneto-optical, CD-ROM, WORM, DVD and others). The storage industry is one of the fastest moving industries within the computer world. The current situation as recorded within this document may be outdated within a few months' time. Storage has become a race among the various big contenders. This has resulted in phenomenal advances in storage capacity. The downside however, is that so many proprietary standards have evolved, which in the end has a limiting effect on the open to users caught within a specific environment.

3.4.1 Hard Drives

Hard drives are cheap, reliable, fast, and therefore well-suited to holding a computer's operating system, applications, and dynamic data - the files created using spreadsheets, word processors, databases, graphics, and other application programs. But with the trend towards image databases, the need for *secondary* storage has become acute (Starret, 1997:37). Within the hard drive category, this means secondary hard drives.

Secondary hard drives present the option of adding terabytes of storage capacity by piling on thousands of multi-gigabyte hard drives; however, even with the swift 9 to 12ms access times today's leading hard drives deliver, their efficient interfaces, and relatively crash-proof performance, hard drives are not ideal secondary storage devices. The main reason for this is that they are still not big enough to handle the storage requirements of large image databases.

In 1991 Rowland and Seeley (1991:218) recommended that a large disk space should be sufficient for a smallish photographic collection and rather be considered even if the more expensive optical storage techniques are affordable - it would be a much more cost efficient solution. They also recommended going for the largest disk you can afford in order to take into account expansion of the collection with the option to upgrade disks as required. This advice could still be relevant today for very small low-resolution collections, but it would rather be the exception than the rule. Today optical storage is also much cheaper than it was in 1992 which makes optical a much more attractive solution.

3.4.2 Tape Drives

For many users needing additional storage, the best removable storage solution may still be an old standard: the tape drive. Tape's obvious advantage is its large capacity (up to 4 GB) and low cost per megabyte. But tape has one serious drawback: slow speed. Throughput is inherently slower for tape technologies than for disks, and one has to wait for the tape to wind through the tape to find a file (Brown, 1998).

Given its, sequential nature (rather than the random-access capabilities of disk-based storage media), tape is best suited to backup or archiving where data-retrieval speed is not critical. Tape drives are highly limited for other kinds of applications. Even though some software lets one treat tape drives as if they were disk drives, the time it takes to wind through the tape and find the right file makes them difficult to use for loading an image, viewing it or working on it, and saving it back to tape (Stone, 1997c; Celi, 1996). For these reasons tape is still not very popular with end users.

3.4.3 Optical Storage Media

Removable optical disc systems, while slower than their magnetic counterparts at any given capacity-point, offer the random access to files that tape cannot, lower cost-per-megabyte than hard drives, and arguably the highest level of physical stability. Both write-once and rewritable optical media can maintain data intact for decades. From 3.5-inch magneto-optical (MO) drives to 14-inch write-once/read many (WORM) units, and the various flavors of CD and DVD in between, even in the face of environmental hazards, it's very hard to spoil an optical disc, which only adds to the already compelling arguments for optical media devices as the optimum choices for secondary data storage (Starret, 1997:38).

During the 1980s the optical storage market was primarily focused on large 12-inch and 14-inch drives, but in the 1990s the emphasis has changed to smaller products, such as the 5.25-inch compact disc. This emphasis has also led the formulation and acceptance of various standards for 5.25-inch optical media. These standards have contributed to the wide acceptance of the media - users were given guarantees regarding compatibility, durability and reliability. Due to the importance of these standards a brief overview will be given of the internationally accepted standards (Nordgren, 1993; nelson, 1993).

Optical storage media encompass a whole range of technologies - MO (Magneto-Optical), CD-ROM (Compact-Disc-Read-Only-Memory), WORM (Wrote-Once-Read-Many), CD-I (Compact-Disc-Interactive), CD-R (Compact-Disc-Recordable), CD-RW (Compact-Disc-Rewritable), PD-CD (Phase Change-Dual-Compact Disc), and DVD (Digital-Video-Interactive).

3.4.3.1 Optical Disc Standards

The following standards refer to standards for both the physical formats as well as volume and file structure. 5.25-inch optical disks stand out from other optical media because of the existence of standards and compatibility.

The following table outlines the various standards that exist for 5.25-inch optical media (Humes, 1997: 1); (Parker, 1993:151-154), (Kaebnick, 1993: 20):

Table 6: Optical Disc Standards

Standard	Type	Description
ISO 9660	CD-ROM	This is the international standard for the logical format of CD-ROM. ISO 9660 supports data that can be read across the DOS/Macintosh/UNIX platforms - i.e. it ensures cross-platform compatibility of a CD-ROM disc.
ISO 10149	CD-ROM	This is the international standard for the recording format of CD-ROM.
Red Book	CD-DA	All other standards are based on the Red Book standard for audio CD.
Yellow Book	CD-ROM	CD-ROM discs are recorded to the Yellow Book standard. The Yellow Book defines the physical properties of the disc, such as pits and lands, their arrangement in a spiral, the speed at which they are read, error correction and sector size. Yellow Book specifies two kinds of tracks, Mode 1 and Mode 2. Mode 1 is for text and computer data and Mode 2 is for video and audio data.
MPC	Multimedia Personal Computer	MPC is the standard for multimedia set by vendors who joined together to form the Multimedia PC Marketing Council. This group defined a minimum configuration for a PC to be multimedia compliant. MPC discs are just CD-ROM applications that include files that require the multimedia capabilities of Windows.
Green Book	CD-I, CD-ROM XA, PHOTO CD	The Green Book standard is defined only as CD-I, but CD-ROM XA uses part of the Green Book specification. Photo CD also borrows from the green Book, but is recorded under the Orange Book standard.
Orange Book	Part I: CD-MO (Magneto-Optical) Part II: CD-WO (Write-Once; includes hybrid specifications for Photo CD) Part III: CD-RW (CD-(Re-Writeable)	Photo CD stores digitised 35mm photographs on recordable compact discs. Photo CD is recorded in Mode 2 of the Yellow Book, and based on the Orange Book specification, Part II that defines CD-WO appendable media.
Blue Book	CD Extra	CD Extra is a method of making mixed media CDs that play as standard audio CDs, but also has computer data to function as a CD-ROM.

3.4.3.2 Optical Disc Formats

3.4.3.2.1 Magneto-optical Media

Magneto-optical (MO) technology had its advent in the early 1980's and was hailed as the removable storage medium of choice. MO made it possible to expand available storage capacity by means of durable and reliable media which took relatively little space: a shiny round platter holding gigabytes of data. Today MO still holds many advantages, the foremost of which is durability. The reasons for this can be understood by explaining the methods by which the MO recording process takes place (Starret, 1997: 39).

Magneto-optical recording is really magnetic, but the drive uses a laser to heat a spot on the surface of the disk to its "Curie point," at which the polarity of the magnetic particles in that spot can be changed by an electromagnet. Below the Curie point - especially at room temperature - a magnet cannot affect MO data at all; this is why MO disks are so valuable as archival media (Starret, 1997: 39).

When a lower-powered laser is shined on the spot, its light is polarized in one of two directions, depending on the magnetic polarity of the spot it illuminates. This is how the drive distinguishes logical ones and zeros that represent data. These spots are considerably smaller than those on a magnetic disk, so the media's capacity (expressed in bits-per-inch or tracks-per-inch) is much greater (Starret, 1997: 39).

On the down side, the write speed is slower than magnetic disk recording because the laser head must pass twice over a spot to be written, requiring two rotations of the disk platter. The first pass resets the spot to a single orientation, effectively erasing the old data, and then the second pass reorients the polarity to record the new data (Starret, 1997: 39).

Recently however, MO drive manufacturers have begun to offer one-pass writing, which speeds up data transfer and encoding considerably. Called direct-overwrite (DOW), the process uses an external bias magnet to switch the polarity of magnetic domains that are bonded into the disk itself, below the recording layer. The external magnets, instead of the electromagnetic head, can then reset or erase the polarity before recording. The light intensity modulation method of direct overwrite (LIMDOW) is the current standard, and is available in both 3 1/2-inch and 5 1/4-inch MO systems, such as Plasmon's new DW260 2.6GB MO drive. With LIMDOW, the bias field is switched at the fastest rate achievable with the laser, and consequently there is no need for the disk to rotate a second time around (Starret, 1997: 39).

The unique characteristics of MO technologies still afford it several advantages over other types of storage media (Rosch, 1998; Boss, 2001) :

- **Capacity:**
  MO allows reasonably high-areal densities, hence good capacity. Currently the 5.25-inch media can store up to 5.2GB per double-sided cartridge. (A note on capacity: MO figures are optimistic. As the cartridges are double-sided, one has to eject and flip the media to access the full capacity.)

- **Performance:**
  Because the drives use magnetic technology to read data, transfer rates for MO drives rival those of a standard hard disk. Writing takes a little longer than on a hard disk because of the laser technology, but performance is fine for primary or near-line storage. MO drives are not subject to head crashes "...because the media and heads no not contact one another" (Boss, 2001).

- **Durability:**
  Because the bits are written and erased optically, normal magnetic fields don't affect your data. Also, the disks are permanently fixed in rugged cartridge

shells that manufacturers have made to demanding shock-tolerance standards. MO vendors rate the useful life of the data stored on the media in excess of 30 years.

- **Compatibility:**

  Most MO vendors have agreed to keep newer drives backward-compatible within at least two previous generations of MO capacity points. For example, a 3.5-inch 640MB MO drive can accept the older 530MB, 230MB, and 128MB cartridges. Also, most capacity levels follow ISO file-format standards, so cartridges can be exchanged between drives of different manufacturers.

Unfortunately this long list of advantages is counterbalanced by just one drawback: cost. Relatively to other secondary storage media available, MO is quite expensive. Both in terms of the media and the drives. For this reason MO most popular for use within fairly big applications where cost is secondary to the advantages presented. This includes markets such as medical imaging, digital video editing and storage and near-line database storage.

3.4.3.2.2 WORM (Write Once Read Many)

Although a popular storage medium in high-end document imaging systems, the 5.25-inch write-once/read-many (WORM) drives never gained wide support in the consumer market. Their limitations are considerable: high-cost hardware; middling access speeds; and the inability to erase or rewrite data. For some applications - particularly those that have legal or regulatory requirements for data permanence - WORM systems are still manufactured and deemed indispensable by users for whom security and permanence are paramount (Starret, 1997: 44).

3.4.3.2.3 CD-ROM (Compact Disc Read Only Memory)

CD-ROM introduced a whole range of new storage possibilities. The consumer market was already familiar with audio CD when introduced to CD-ROM. Up to that stage the personal computer secondary storage market only had a choice between 1.2 and 1.44 MB floppy discs. Suddenly CD-ROM came on the market with a capacity of 650 MB. The possibilities seemed endless. Large amounts of data could be distributed, either in-house or commercially. Today all new PCs have standard multimedia capabilities of which the core component is a CD-ROM drive. In the 3.5-inch optical media industry CD-ROM and its accompanying standards have set the benchmark against which all later developments were to be measured (Bennet, 1996:29).

Conventional CD-ROMs, like audio compact discs, are made up of three basic layers. The mass of the disc consists of an injection-molded polycarbonate plastic substrate, which includes a spiral track of variable-length pits and lands encoding all the data contained in the disc. Over the substrate is a thin aluminum (or gold in premium products) reflective layer, which in turn is covered by an outer protective lacquer coating (Bennett, 1996: 29).

Information is retrieved by a CD-ROM drive focusing a low-powered (0.5mw) infrared (780nm) laser beam onto the spiral track of pits and lands in the disc's substrate. The height difference between the pits and the adjacent lands creates a phase shift causing destructive interference in the reflected beam (Bennet, 1996:29).

CD-ROM is still a good option for the storage and distribution of digital photographic collections. Stacked in a jukebox the capacity can be almost endless. Its one drawback is that it is 'read-only'. Each CD-ROM has to be pressed by a service bureau - the equipment needed not falling within the budget of most museums, archives and libraries that have to manage photographic collections (Bennet, 1996:29).

3.4.3.2.4 CD-R (Compact Disc-Recordable)

CD-R was developed in answer to the limitations of CD-ROM. CD-R encompasses the recordable CD media as well as the equipment and software used to make recordable discs. CD-R presents the possibility of authoring one's own CDs in a small, relatively low-budget environment. As with CD-ROM, CD-R is also subject to international standards as defined in the Orange Book standard Part II (see "Optical Disc Standards" table).

CD-R discs have a different construction and operate under a different principle than moulded CD-ROM. Unlike a conventional CD, the substrate of a CD-R disc does not contain a track of pits and lands. Instead, the substrate contains a slightly wobbled spiral pre-groove. When the disc is rotated at the correct speed under the focused laser beam, the reflected light returned to the photodetector from the pregroove generates a carrier frequency in the photocurrent providing the critical tracking, motor control, and focus signal for the recorder to stay on course (Zimmer, 1993b: 31).

The most important difference between a CD-R disc and a CD-ROM is the inclusion of a sensitive dye layer to accept the data to be recorded. Rather than having the data molded into the substrate as pits and lands at the factory, data is written to the CD-R disc on demand in a permanent and irreversible way by a CD recorder which employs a power laser that alters the sensitive dye layer in the pregroove to create areas of decreased "reflectivity." This is accomplished by the dye's absorption of the light of the laser beam and converting its energy into heat (250 degrees to 400 degrees Celsius), which alters the dye. Although the difference in the reflecting layers is clear, both types of media perform identically within a CD-ROM drive. Writable CD media adheres to the ISO 9660 file and volume structure, the core CD-ROM format, and can be read in standard CD-ROM devices. Writable CDs are "write once" discs, meaning that data cannot be erased once it has been written to the disc. But, unlike pressed CD-ROMs, writable CD media is appendable, which means that data can be added to a disc in different recording sessions (Zimmer, 1993b:31).

Different capacities of CD-R discs are created by rotating at different speeds. A 63-minute disc (containing 540MB) is spun at a real-time Constant Linear Velocity (CLV) of 1.4m/s while 74-minute discs rotate at a slower 1.2m/s CLV, creating smaller marks and lands and thereby increasing the capacity to 650MB (Bennett, 1996).

CD-R is a popular alternative to magnetic media for two reasons: it is fairly inexpensive and can retain data for much longer than magnetic media: "…a minimum of 20 years and as long as 100 years" (Boss, 2001).

3.4.3.2.4.1 Kodak Photo CD

During 1992 Eastman Kodak Company introduced a product, the Kodak Photo CD system has made it possible to "…digitise slides and transparencies, and to store images on PhotoCD disks" (Kenney & Rieger, 2000). Photographs are scanned, at an extremely high resolution onto special, write-once, compact discs. Each Photo CD can store about 100 images and is appendable, which means that new photographs can be added to the disc at different times. Kodak Photo CD is a family of CD-recordable formats for storage and retrieval of photographic images. Photo CD was developed to handle high-resolution photographic images in an electronic environment. It delivers rapid access to vast amounts of information at a low cost (Beiser, 1993a:16).

Photo CD has become a proprietary standard within the imaging industry. It was developed specifically for the management of photographic images, and therefore cater for photo-specific requirements such as high resolution, preservation requirements, ease of use, size of image data, and the need for an universally compatible image format (Zimmer, 1993a: 23).

- **Photo CD Characteristics**

Photo CD has some very unique characteristics, which have made it a market leader in this specific field:

- Disc permanence:
The problem of disc permanence has aroused many questions and reservations. Information stability varies widely in different manufacturers' media and can be linked to different types of dyes used in their discs. Kodak writable CD media that carries the InfoGuard Protection System trademark, is specially designed and tested to provide secure long-term storage. The data recording layer Kodak uses is a carefully selected, laser-sensitive dye that does not change significantly over time, even when exposed to extreme light, heat, and humidity conditions. In company tests, equivalent to more than 100 years of exposure to indirect indoor sunlight, no significant changes in any performance characteristics of Kodak writable CD media occurred (Zimmer, 1993b, 32).

- Scratch-resistant surface:
Kodak writable CD with the InfoGuard protection system has been specially treated to minimise damage caused by handling. Its scratch tolerant surface resists damage even when subjected to forces twice as great as those that would cause data loss on conventional CDs, and five times greater than those that would cause data loss on some other recordable CD media (Zimmer, 1993b, 32).

- Identification numbers and handling:
Another innovation Kodak developed for its writable CD media is an identification number printed in readable form (with a corresponding bar code) on each disc. A bar code reader is built into each Kodak PCD Writer 200. The 12-digit number functioning as a disc serial number, can also be used to in databases and indices to identify specific discs on which requested information is located. Another benefit is customised labelling, which allows even small-scale publishers to provide their customers with a professional labelled appearance. Fields are left open on the disc surface for company

logos, product names, or other unique publisher information (Zimmer, 1993b, 32).

- **Photo CD Formats**

Kodak Photo CD images are stored at five different resolutions "...from Base/16 images at 128 x 192 pixels (for thumbnail views), to 16 Base full-resolution images at 2,048 x 3,072 pixels. The Pro photo CD disk adds a sixth level of resolution (64 Base) that provides high-resolution images (4,096 x 6,144 pixels)" (Kenney and Rieger, 2000).

- Photo CD Master Disc:

Up to 100 images - four 24-exposure rolls of 35mm colour or black-and-white film - can be scanned at high resolution and placed on a Photo CD. The work is done by photo processing laboratories or service bureaus that have the necessary equipment. Images can be added again and again until the disc is full. Existing negatives and slides can also be photographically scanned and placed on the disc. Images are recorded at a maximum resolution of 2048 x 3072 pixels. Five different versions of each photograph are stored as an "image pack" on the disc, ranging from 128 x 192 pixels to 2048 x 3072 pixels. The Master Disc can also function as a "digital negative," which means consumers can take the disc to their photofinisher to have prints made. (Beiser, 1993a:16 & Zimmer, 1993b: 33)

- Pro Photo CD Master Disc:

This format was designed for the larger film formats of professional photographers, including 120mm, 70mm, 4 x 5-inch as well as 35mm. A disc will hold from 25 to 100 images at up to 4096 x 6144 pixels.

- Photo CD Portfolio Disc:

This a system for creating discs that mix photo images with audio, graphics and text with a degree of interactivity. The purpose is to use it as a presentation medium. (Beiser, 1993a: 16)

- Photo CD Catalog Disc:

The Catalog Disc format allows storage of up to 6 000 images at "video resolution" for soft display on television sets and computer monitors. The images stored on the Catalog Disc cannot be used to make photo-quality prints as with the Kodak Photo CD Master Disc. A simple database management utility is included for searching of index terms and retrieval of images. The format was designed for applications where thousands of images are required, but high-resolution is not essential. It provides a low-cost way to store and distribute images in digital form. (Beiser, 1993a: 16 & Zimmer, Ibid.)

To view multisession discs the CD-ROM drive must follow the CD-ROM XA Mode 2 specification. The device driver supplied with the drive must also support this specification. According to Beiser (1993b: 99) Photo CD's ability to support images created in multisession is crucial to its success and flexibility. It is also the cause of its incompatibility with the vast majority of currently installed CD-ROM-drives. The original CD-ROM specifications to which CD-ROM equipment was designed do not support multiple sessions. To add that feature requires changes in the device driver software for the drive and changes to the software stored in Read-Only Memory (ROM) chips on the drive and/or interface card itself.

Beiser (1993a: 16) motivates that the Photo CD is the only approach to electronically handling images "that combines the virtues of broad software support, high resolution, relatively inexpensive hardware requirements for image users ... and quick and easy transfer of images from negative or slide to the medium." One of Photo CD's biggest advantages is that makes it possible to more widely disseminate information about an image collection.

3.4.3.2.4.2 PD-CD (Phase Change Dual CD)

One of the most interesting and versatile but least-understood storage solutions is Matsushita's Phase Change Dual (PD) drive. Branded by Panasonic, Plasmon, NEC, and Toray, PD-CD reads and writes proprietary 640MB disks that are the same size as CDs; and it also reads (but does not write) CD-ROM, and CD-R media. Prospective users were initially confused by PD-CD's similarity to other optical systems, especially CD-R, but the vendors did not adequately explain the difference or market it aggressively (Starret, 1997: 45).

PD-CD uses phase-change optical technology, which differs from MO in that it doesn't employ magnetics at all: both the reading and the writing are done with laser light. Whereas CD-R is a write-once system, PD-CD is rewritable. PD-CD drives are slower in their seek times and data transfer rates than are hard drives: 165ms and 900KB/sec are typical benchmarks for PD-CD drives, which makes them less than a tenth as fast as today's common hard drives (Starret, 1997: 46).

3.4.3.2.5 CD-RW (Compact Disc Rewritable)

CD-RW used to be called CD-Erasable (CD-E), but "...was changed from a marketing viewpoint so that it wouldn't sound as if important data could get erased on a whim. The difference between CD-RW and CD-R is that CD-RW discs can be erased and rewritten, while CD-R discs are write-once" (McFadden, 1997: 9).

CD-RW drives use phase-change technology. "Instead of creating "bubbles" and deformations in the recording dye layer, the state of material on the disc changes from crystalline to amorphous form. These discs are not writable by current CD-R drives, nor readable by many existing CD readers (the reflectivity of CD-RW is far below silver CDs and CD-R, so an Automatic Gain Control circuit is needed)" (McFadden, 1997: 9).

CD-RW discs use the CD-UDF write-once file system, which means that they won't be readable under some operating systems even if the hardware is compatible. Because of the way the media is constructed, it may be easier for a DVD drive to read CD-RW discs than CD-R discs. All current CD-RW drives can write CD-R discs as well (Parker, 1998).

A major software-related drawback of CD-RW lies in the file deleting process. When a file is deleted, the disc's directory reflects the change, but the file remains on the disc. If a lot of files are "erased" enough times, the disc will eventually be filled (Sengstack, 1997: 68).

3.4.4 DVD (Digital Video Disc / Digital Versatile Disc)

A DVD disc is the same physical size as a CD-ROM, but incorporates more pits and lands by making them smaller and closer together, allowing for a capacity of up to 17GB on a double-sided, dual-layer disc. Unlike CD-ROM, which was based on a medium originally designed to play audio, DVD was designed with audio, video, and computer applications in mind. Thus, there are several types of DVD available. DVD-ROM, DVD-R, and DVD-RAM are the most applicable to the computer user, DVD-ROM being the equivalent of pressed CD-ROM and DVD-R the recordable version. The first production versions of DVD-RAM, accepted standard for rewritable high-density CD, were provided on the market at the end of 1997 (Starret, 1997: 3; Glatzer, 1998; Shatz-Akin, 1997).

According to Boss (2001) DVD-R is "...increasingly competing with CD-R because the capacity is as high as 8.7 GB per DVD-R. Although the discs are a minimum of five times as costly as CD-R, their capacity is 14.5 times greater".

The increased storage capacity of DVD make it a definite storage option for digitised photographic collections. The one drawback is that there is various formats and not all formats are compatible, although DVD is backward compatible. With so many companies involved in the DVD race a lack of standards present problems when needing to decide on a specific system to standardise on. The market is ripe for DVD, especially in terms of video storage and hopefully, with enough consumer pressure, these problems will be sorted out in the near future.

3.4.5 Preservation and Longevity of Optical Storage Media

The extremely low cost per megabyte, small size, and convenient handling of CD-ROM and CD Recordable (CD-R) discs has resulted in the explosive growth of their use as a data storage and distribution medium. With disc capacities around 680 MB, the user has a significant investment in the data on each disc, and wants assurance that the data will be retrievable in the future.

According to Electronic News (1997: 38) "The media is as reliable as are your safeguards to insure proper handling and storage of the media. Media manufacturers estimate the shelf life of unrecorded CD-R media to be between 5 and 10 years. For recorded media, the CD-R media manufacturers have performed extensive media longevity studies using industry-defined tests and mathematical modeling techniques, with results claiming longevity from 70 years to over 200 years. With proper handling and storage, your CD-Rs will outlive you".

Eckman (2000) does not, however agree with the above statement. He states that "...Digital information does not remain stable forever, even under climate and temperature storage conditions that are usually regarded as favourable".

In addition to the physical durability of storage media, an area of major concern is that of backward compatibility, both in terms of hardware and software: "the hardware and software required to read electronic records have even less life expectancy than the media on which they are recorded" (Stephens, 2001).

According to Gould & Varlamoff (2000) a co-ordinated strategy is required within every organisation to address the above-mentioned issues. Pace (2000) suggests the following strategies to ensure longevity of records:

- *Refreshing:* Involves the transferring of digital materials to a new medium, e.g. CD-ROM to DVD.

- *Migration:* Involves the migration of new formats of software, e.g. saving a WordPerfect 7 document as a new Word 97 file.

- *Technology preservation:* Involves the preservation of hardware that required to read the stored information. Although ideal, this is almost impossible to attain

- *Emulation:* Involves retaining information about how a digital collection was created and accessed so that future access can be accurately reproduced. This type of information can be stored as metadata and will also be addressed in the next chapter on Metadata for Photographic Images.

There is, however, no ideal once-off solution to permanent preservation of electronic archives. It is, however, important that librarians and archivists take note of the problem in order to address it in the best manner suited to a specific organisation.

3.5 CONCLUSION

What has become apparent from this study on image data format and storage options is that if one does not know what your exact requirements are even before evaluating the available options, you will find it very difficult to navigate you way through the maze of acronyms out there. This is a field where development is only limited by imagination and market forces. It is an industry for the future and everyone who has something to offer is trying to climb on and stay on, the bandwagon. Although overwhelming for the consumer, the escalating storage capacities open up new worlds of possibilities. Total photographic collections can be stored on one disc.

An understanding of the range of options available will ensure that an educated choice can be made, tailored to the requirements of each specific application - choices regarding file formats into which to capture, distribute and store images; the best compression method; and the best storage medium. These choices will be influenced by the criteria as spelled out in the beginning of this chapter: size of collection; preservation requirements; budget; manipulation needs; ease of use; distribution needs; compatibility issues and future planning and developments.

It is an ideal period in the imaging industry to start with a photographic digitisation project. Technically the capabilities are available.

After a decision has been made in terms of the data format an image is to be created in and the medium on which it is to be stored, the problem of uniquely identifying the image, has to be addressed. The next chapter will address the issue of metadata for digitised photographic images.

CHAPTER 4

METADATA AND PHOTOGRAPHIC COLLECTIONS

4.1 INTRODUCTION

Metadata has become a buzzword in the information business. Although the term may be fairly new, the concept is familiar to information professionals. Librarians and indexers have, through indexing, cataloguing and classification, been producing metadata for a very long time. Traditionally the purpose of the catalogue was to enable access to information. With the advent of computerized catalogues, online databases and the Internet, this fundamental principle has not changed, but has rather been emphasized. With the boom in accessibility of electronic information, metadata has become an important concept to both the authors and seekers of information - metadata provides pointers to information, which would otherwise have been lost in cyberspace. In instances where such electronic information is photographic images, metadata as finding aid becomes even more important. Without proper description it is very difficult and almost impossible to locate a specific image.

A photographic collection only has value if the photographs are properly appraised and described in such a manner as to make future retrieval possible. The user value of a photographic collection is determined by the ease and effectiveness with which specific, relevant images can be located. Traditionally these processes have presented certain problems. Cataloguing and indexing of photographs are labour-intensive processes, requiring much more input in terms of time and effort than traditional book description. Although digitisation presents many advantages to the handling and preservation of photographic collections, it does not replace the need for description of individual images. An advantage to describing digitised images rather than traditional hard copy images is that the image can easily and quickly be recalled and displayed to determine its relevance. Description need therefore not be as specific as in manual collections in which the description serves as a surrogate to the original image - the image has to physically be retrieved from an archive to determine relevance.

With the escalation of the Internet as a means of communication and distribution of information, Library and Information Professionals have become increasingly interested and involved in metadata initiatives to organize, access and preserve electronic, networked information, such as digitised photographic collections.

Various formalized discussions by international associations, institutes and organizations have taken place on the issue of metadata since about 1994. These include, among others, the Coalition for Networked Information, the Consortium for the Computer Interchange of Museum Information (CIMI), OCLC and the Visual Resources Association. Various frameworks have been presented, addressing questions such as: What information should be recorded about digital image files? Where and how should image files be documented? What information must be placed in the image header, and what can be placed in an accompanying text record? How should that text record be fielded? How should the relationships between image files and their accompanying text records be managed? (Trant, 1995).

The purpose of this chapter is to provide an overview of different metadata systems and standards in order to identify those metadata elements of photographic images that will enable effective access to the collection and the information contained therein.

4.1.1 Defining Metadata

According to Miller (1998) the concept of metadata predates the World Wide Web, having purportedly been coined by Jack Myers in the 1960's to describe data sets effectively. The following three definitions are fairly representative of the view on metadata within the library and information science environment:

"Metadata is data *about* data, and therefore provides basic information on the attributes and content of a work, such as the author, the date of creation, subject, links to any related works, *etc.* One recognizable form of metadata is the card index catalogue in a library; the information on that card is metadata *about* a book" (Miller, 1998).

Cathro (1997) emphasises the association between metadata and the information resource and defines metadata as follows: "an element of metadata describes an information resource, or helps provide access to an information resource. A collection of such metadata elements may describe one or many information resources".

"Metadata can be defined as data about data or the contents of a surrogate record that characterizes an object, such as a photograph" (Weibel & Miller, 1997).

Metadata is created through the cataloguing and subject indexing processes. Cataloguing is the practice of identifying the main bibliographic descriptive elements of an information resource in order to facilitate its identification, location, access and use. A catalogue is an information source in itself in the sense that it consists of a collection of surrogates to the primary collection (Levy, 1995). Subject indexing is the practice of identifying the subject content of an information resource and describing it with the use of descriptive terminology and codes.

In view of the above, metadata can be described as descriptive information about an information resource to enable its future retrieval, location and access. An information resource is seen as any work or object that may have future retrieval value, in this instance photographic images.

4.1.2 Approaches to Metadata

Traditionally photographic collections have been indexed using card indexes. These indexes usually provided basic and fairly effective access to a collection. The biggest problem in almost all cases was the sheer volume of material that had to be indexed. Card indexes are very labour and time intensive, especially when taking the many cross-reference cards and filing processes into account. The effectiveness of a card catalogue depends on the quality and detail of its cross-references. Due to staff limitations many collections have only been partially indexed and are therefore only partially accessible.

With the advent of computerized libraries and online public access catalogues, the cataloguing, classification and indexing processes of photographic collections were also computerized in many libraries. Online catalogues were less labour intensive in terms of the creation of cross-references and the filing that was involved in the compilation and maintenance of card catalogues. The earlier online systems only served as indexes or references to the physical photographic collection. The drawback with these systems was that the index created by the indexer had to act as a surrogate to the original image. There was no online image available to determine whether the reference was correct and the image relevant - the original image had to be obtained physically. The result was that the reference had to be complete and very descriptive to ensure that the correct image was located.

The next step has been the development of integrated databases consisting of textual references and digitised images. Retrieval is done by way of a textual reference and relevance checking done simultaneously by matching the reference to a digitised image of the photograph. Indexes now need to be less descriptive - it is possible to browse through a collection of hits fairly quickly.

Currently the most advanced developments are automatic indexing schemes whereby a computer automatically indexes an image according to physical content characteristics such as object dimensions, colour and texture. Although automatic indexing and browsing systems play an increasingly important role in retrieval of images, they do not replace the need for metadata. After retrieval users need information about the image in order "... to cite it, confirm its evidence or illustration or determine whether permission is needed to reproduce it" (Arms 1999). Further information on automatic schemes will be provided in the next chapter on Retrieval of Photographic Images.

4.1.3 Problems Inherent to the Description of Images

The essential problem with respect to the description of photographic images lies within the nature of photographic images themselves: " Photographic materials, in general, differ from standard print materials in several very important respects. Perhaps the most fundamental difference is that for most photographic materials the great bulk of the information they convey resides in the image, itself, rather than in words. The physical artefact embodies the information content and cannot be separated from it" (Ralph, 1994). Textual documents "speak for themselves" - they are almost always accompanied by bibliographical details and subject matter can be deducted from the text of the document. This is not true of photographs. The descriptive process often encompasses research into the origin and context of the image. Description is also open to subjectivity - each image is viewed and appraised from the personal perspective and framework of the cataloguer. This unique nature of photographic images is also one of the main causes of lack of standardization - it is almost impossible to find one, standard system or methodology to suit the needs of all photographic collections and their potential users.

Although much has been written on the cataloguing and indexing of photographic collections, there is no one, generally accepted standard as in the cataloguing and indexing of books. Although standard cataloguing methods and codes have been adapted to photographic collections, the interpretation and application of these rules differ. Traditional systems such the Anglo American Cataloguing Rules (AACR) are complex and cumbersome to apply. More recent attempts towards standardization, such as the Dublin Core Elements are very limited and allow for unstandardised extensions, which defeat the purpose of standardization.

Within the digital environment, the issue of metadata becomes even more complex. Trant (1995) states that documenting digital images requires recording information both about the work, and about the digital representation of the work. This includes the characteristics of the digitisation process, e.g. scanning, as it will have an impact on the resulting quality of the digital image, and should be documented as well. The same is true if an image were derived or sub-sampled from another digital image file. Currently there are no standards to guide this process in terms of the specific data elements to be captured and it is left to each individual/institution to make choices in terms of completeness of cataloguing.

4.1.4 The Need for Metadata

With advances in modern technology regarding the electronic processing, storage, distribution and retrieval of information, the question is raised whether the assigning of metadata is really necessary, taking the time, effort and skill required into account. The answer to this question is yes. Modern technology has excelled in making large amounts of information available electronically, but has not been able to keep abreast in terms of means to accurately and quickly access specific required information. The exponential developments in both hardware and software has also resulted in information not being accessible over time due to incompatibility between newer and older versions of both the hardware and software involved.

According to Graham (1994) the traditional purpose of catalogues was to:

- provide access to locally owned materials;
- provide access to artifactual materials
- provide access in the form of pointers to locations, and
- to serve as a stand-alone bibliographic tool.

With the emphasis on digital networked environments, the purpose of catalogues are changing to:

- provide access to materials local and elsewhere, owned and not owned;
- provide access to electronic information;
- provide electronic information itself, not only locations;
- be presented as a tool integrated with other workstation tools, and
- provide in itself, a variety of tools in addition to the bibliographic function (Graham, 1994).

In short, the main reasons for the use of metadata are to facilitate:

- retrieval of information; and
- preservation and longevity of digital records.

4.1.4.1 Retrieval of information

According to Cathro (1997) the key purpose of metadata, whether in the traditional or Internet context, is to "facilitate and improve the retrieval of information". Metadata can improve both retrieval precision and recall, ensuring that only the most relevant information is retrieved, without missing important information. In a photographic environment this is even more applicable. Although there are automated image retrieval systems available, their application is limited. Photographs do not speak for themselves. They need to be described textually to place them in the right context and fully reveal their subject matter.

4.1.4.2 Preservation and longevity of digital records

There is great concern within the Library and Museum fields over the preservation of digital records, of which photographic images is an important component. Currently the emphasis seems to be on the provision of online digital access to collections. Little attention is paid to ensuring that these collections will be accessible in future when currently used software and hardware become obsolete (Day, 1997).

To ensure the longevity of digital data, records should be encapsulated along with explanatory metadata sufficient to allow accessing and deciphering the encapsulated information in the future. Records should be encapsulated along with whatever application and system software is required to view them, as well as metadata describing the hardware environment needed to run the required software, to allow future emulation of the required system. Explanatory metadata must be attached to this collection to explain how to use the emulated system and encapsulated software to view the encapsulated record, while indexing and other descriptive metadata should be included to enable the record to be found by search queries and managed intelligently. The surface of an encapsulated record must be annotated in a transparent form to ensure that future readers will be able to interpret the encapsulated record with a minimum of effort (Rothenberg, 1996).

Rothenberg (1996) has also identified categories of metadata required to support data quality evaluation and improvement. These are divided into three distinct levels: the database level, the data element (or data dictionary) level, and the data value (or instance data) level. All of the categories are necessary for either evaluating or recording data quality.

Research has proved that metadata can play a very useful role in the preservation of electronic records, but, as Day (1997) points out, there are several questions that remain to be answered satisfactorily:

- Who will define what preservation metadata are needed?
- Who will decide what needs to be preserved?
- Who will archive the preserved information?
- Who will create the metadata?
- Who will pay for it?

4.2 METADATA PRINCIPLES FOR THE DESCRIPTION OF PHOTOGRAPHIC IMAGES

When considering the assignment of metadata to image collection there are various aspects that need to be taken into account:

- Will each separate image be described or will related images be described as sub-collections?
- How detailed will the description of the images be?
- What information should be recorded on each image?
- Will a controlled vocabulary be used? What controlled vocabularies exist to record the specific collection?
- Can existing standards be used or do they need to be adapted to suit the needs of the collection?

The above questions highlight some of the principles that need to be considered when discussing metadata. These issues will now be debated further in an attempt to facilitate decisions on each.

4.2.1 Potential Use and Users

The more clearly the area of application and the interest of users can be defined the better the metadata created to describe the collection will facilitate effective retrieval and location of photographic images. According to Leung, et. al. (1992) it is not the range of subject matter that determines the difficulty of cataloguing the collection; it is the fact that the nature of the application and its potential users are unknown.

4.2.2 Chief Source of Information

Book cataloguing is based on the transcription of data from the published item itself or the "chief source of information", into the format of a catalogue record - all the information required to describe the book adequately can be found in the text of the book itself (Arms, 1996). This is rarely true of graphic images. The chief source of information - the photograph - cannot provide all the necessary information. Information must be extracted, interpreted and extrapolated from the visual content and context of the material, as well as from secondary sources (Arms, 1996). For the benefit of both the user and the cataloguer it is necessary that a catalogue make a distinction among transcribed, supplied and conjectural data, in order to avoid confusion and incorrect assumptions.

4.2.3 Item Cataloguing Versus Group Cataloguing

Photographic collections can either be catalogued at item level or at group/collection-level (Arms: 1996). Item level refers to the cataloguing of an individual photograph, whereas group level refers to the cataloguing of a homogeneous group of photographs by the same photographer, depicting similar subject matter. Each photograph in the "group" will have a unique identifier, but will be linked to a single cataloguing record. Although it may be desirable to decide on item level cataloguing, few institutions have the resources to cope with this demand. It is much more practical to follow a group-level approach, especially if the subject matter of the "group" is very similar.

4.2.4 Multiple Documentation Levels

Besser & Trant (1995) distinguish among three levels of image documentation:

- *'Work of art' description points*: information that refers to the original work;
- *'Surrogate image' description points*: photographic representations of that work;
- *'Digital image' technical documentation*: the technical characteristics of a digital image, "that may have been captured from the original or a photographic representation, or derived from an existing digital image file" (Besser & Trant, 1995).

The issue raised by Besser and Trant (1995) does not concern the different categories of metadata, but rather the different representations reflected within one digitised image. Each of these representations may therefore have its own set of metadata. If viewed from this perspective, metadata becomes a very complex issue. Few institutions have the resources to document each of these representation levels. What is, however, important to note is that during the metadata documentation process, the different levels of representation not be confused. If referring to more than one level of representation it should be indicated as such in the documentation.

4.2.5 Exhaustivity

Exhaustivity refers to the detail of indexing and classification, i.e. the number of terms assigned or the number of classes in which an entity may be placed (Anderson, 1989: 71).

Although one would assume that institutions would aim for the highest possible level of exhaustivity, the level of description for a collection is dependent on institutional priorities and available resources (Arms, 1996).

4.2.6 Specificity

The specificity of a system is the "...extent to which the system permits the indexer to be precise about the subject of a document" (Rowley, 1992). The most complete form of indexing of a textual document would be the text itself. Within photographic collections, the potential level of specificity is reliant on the complexity of the subject matter, the knowledge of the indexer of the subject matter and the scope of available documentation on an image collection.

4.2.7 Metadata Standards

Besser and Trant (1995) emphasize the importance of documentation standards that "...incorporate expertise both in formatting database records for storage or interchange and in using structured vocabularies to represent data values for description and retrieval". Standards for data structure provide "...a framework for data that allows precision, exchange, and re-use of data for multiple purposes. Adherence to common standards will allow information to be shared with other institutions. Standards may even save cataloguing and indexing time by making it possible to incorporate portions of documentation records from other institutions into local record" (Besser & Trant, 1995). A lack of standardization therefore results in negatively affecting usability of the collection, especially if it is meant to be shared across the borders of a specific institution.

4.2.8 Storage of metadata

As mentioned previously there are various types or categories of metadata linked to a specific image. It is important to make a decision at the onset of a digitisation project as to where the different categories of metadata will be stored. Arms (1996) identifies the following options for storing metadata:

- in the items themselves, for those formats that support descriptive headers;

- in linked items, for example by creating a sub-document listing details about the digitisation process, such as equipment used and special instructions for conversion;
- in external catalogues or finding aids, to support the identification of relevant items by searching or browsing; or
- integrated with the digital object in the repository structure, to support retrieval of an identified item.

Decisions on the above options are important and should be made on the basis of user requirements. General descriptive and subject metadata will be required by general users to retrieve an image and determine its relevancy - these types of metadata should therefore be stored in the item or linked to a thumbnail of the item. The technical and administrative types of metadata will mostly be required by more specialized users and not retrieved as frequently - the user can therefore be linked to sub-documents.

4.2.9 Metadata Categories

Metadata elements can be divided into two main categories: Bibliographic description and Subject/Content description. Bibliographic description is the description of an object according to a set of pre-defined characteristics, such as author, title, publisher, date of publication and physical description. Subject/content description refers to the identification of the subject of the object through the allocation of indexing terms (standardized or free text), an abstract or classification code. In addition to bibliographic and subject elements, the following metadata categories have also been identified are also of relevance to digitised collections of images:

- **Metadata for administrative purposes** (Van Wyk, 1998: 3)

  This category of metadata primarily serves the purpose of administrating items of information. The content of these fields could be automatically system generated, or taken from administrative processes or systems. Typical fields would be:

- Record number
- Order number
- Accession number
- Invoice number
- Filing location/ shelf number
- Date the record was created"

- **Metadata for access or location** (Van Wyk, 1998: 3)

  These fields have the purpose of "... enabling the user to locate the information item". Typical fields would be:

  - Location
  - URL
  - Online databases
  - Files

4.3 METADATA STANDARDS

With the new emphasis on metadata for the description of electronic resources, the issue of standardization has been further complicated. There are numerous initiatives in process for the development of metadata standards, but there seems to be a lack of cooperation as stated by Milstead and Feldman (1999: 25): "Different systems are being developed for different - and sometimes the same - kinds of information, resulting in a chaotic atmosphere of clashing standards. Probably the biggest stumbling block in the way of orderly development of metadata is the sheer number of different metadata projects". Although there seems to be a degree of cooperation among the larger, more influential groups (such as the developers of the Dublin core and the World Wide Web's RDF effort), any group may define its own metadata standard. These standards may be as wide or narrow as the developers choose - often the standards only apply to very specific areas of interest (Milstead & Feldman, 1999: 30).

Another problem area in terms of standardization is the application of vocabulary to the defined elements: "...even if common metadata elements are used, there is no guarantee that the vocabularies, the content of the elements, will be compatible" (Milstead & Feldman, 1999:30). As most metadata standards focus on specific types of data, it can result in users of metadata having to learn different sets of conventions for each kind of data.

In an attempt to provide some clarification on available standards, a brief overview will be given of those standards and projects that are in some way relevant to the description of photographic images. Each standard will be discussed in terms of its description, elements identified for resource description and comments on its main strong and weak points and its applicability to photographic images.

In the following overview, the standards were divided into two categories: communication or structure formats and content standards. According to Miller (1998) structure standards relate to the systematic arrangement of data elements for machine-processing, which facilitates the exchange and use of metadata among multiple applications. Content standards determine what elements are required to describe an information resource.

Not all of the following are internationally accepted standards. All are, however, regarded as standards within specific communities. For the purposes of the following table, the term "standard" will be used to identify the different formats available that are being used within the graphics environment.

4.3.1 Metadata Structure Standards

Table 7: METADATA STRUCTURE STANDARDS		
Standard	**Description**	**Comments**
Machine Readable Cataloguing (MARC)	MARC is a data structure standard, defining the structure in which the descriptive metadata elements should be formatted to enable them to be machine-readable and shareable between various applications. MARC has been customized according the specific needs of different countries, for example: USMARC, UKMARC, SAMARC and UNIMARC (Day & Powell, 2000). The descriptions proscribed by the Anglo American Cataloging Rules (Second Revision) (AACR2) are reflected in specific MARC fields, ensuring that the catalogue record of a photographic image can be interpreted by computer. MARC therefore does not change the AACR2R record; it just ensures that the information is in a standardized machine-readable format - it creates a structure for metadata (Arms, 1999).	**Advantages:** The MARC standard, ISO 2709 Format for bibliographic information interchange on magnetic tape, is internationally accepted and widely used within the library and archives environment. Its use therefore presupposes compatibility with collections available worldwide (Arms, 1999). It promotes greater interoperability among content descriptors and systems (Lagoze, 1996). **Disadvantages:** The creation of high quality MARC records requires training and experience in the use of cataloguing rules. Although the input of data to a record can be automated, the cataloguer needs to view the resource in some detail, and then interpret

Table 7: METADATA STRUCTURE STANDARDS		
Standard	**Description**	**Comments**
		cataloguing rules before formatting the required information correctly in the MARC record (Dempsey & Heery, 1997).
Resource Description Framework (RDF)	The RDF, developed under the auspices of the World Wide Web Consortium (W3C), is an infrastructure that enables encoding, exchange and reuse of structured metadata. RDF is an application of XML that imposes needed structural constraints to provide unambiguous methods for expressing semantics for the consistent encoding, exchange and machine processing of metadata. The RDF enables metadata interoperability through the design of mechanisms that support common conventions of semantics, syntax and structure. RDF provides the ability for resource description communities to define semantics (Miller, 1998). The Dublin Core community is working closely with the RDF community to develop a common architecture to support generalized metadata (Weibel & Hakala, 1998).	**Advantages:** RDF provides interoperability between applications that exchange metadata (Ianella, 1998). RDF allows descriptions of WWW resources to be made available in machine-readable form (Ianella, 1998). RDF allows for the re-use, extendibility and refinement of established resource description standards since such standards will be available in machine-readable form (Ianella, 1998). RDF improves access to electronic information through the establishment of common conventions about semantics, syntax and structure (Miller,

Table 7: METADATA STRUCTURE STANDARDS		
Standard	**Description**	**Comments**
		1998). **Disadvantages:** RDF is a complex structure of which various aspects are still in the process of being clarified (Brickley, 2000).

4.3.2 Metadata Content Standards

Table 8: METADATA CONTENT STANDARDS			
Standard	**Description**	**Elements**	**Comments**
Anglo American Cataloguing Rules 2 (AACR2)	AACR2 is a set of rules for descriptive cataloguing of all types of materials likely to be found in general library collections. Individual chapters cover books, pamphlets and printed sheets, graphic materials, etc. Rules guide cataloguers in constructing descriptors to identify and represent bibliographic works in catalogues and constructing uniform headings (for persons, corporate bodies, geographic places, titles) (Society of American Archivists, 1994). AACR2, Chapter 8, focuses on the description of commercially produced audio-visual materials, published and/or documented artists' prints and photographs, portfolios and reproductions accompanied by printed information. These rules are mainly aimed at describing the physical attributes of graphic material and include aspects	*Title, Statement of Responsibility, General Material Designation, Edition, File Characteristics, Serials Statement, Publication, Distribution; Physical Description, Series, Notes (incl system requirements, mode of access, edition and history of the file) (OCLC, 1999)*	**Advantages:** AACR2 has widely been accepted as a definitive standard for the bibliographic description of library material. This enables cooperation initiatives between libraries. (Society of American Archivists, 1994). **Disadvantages:** Although provision is made for the description of graphic materials in terms of physical attributes, it is very generic and does not provide for unique elements in terms of description of the digitisation process of surrogate images, required in digital collections (Ralph, 1994).

Table 8: METADATA CONTENT STANDARDS

Standard	Description	Elements	Comments
	such as type (for example slides, lithographs), colour designators (for example colour (col.) or black and white (b&w)) and dimensions where image size is not standard (Ralph, 1994).		1994).
Graphic Materials - Rules for Describing Original Items and Historical Collections (GIHC)	GIHC is a manual based on AACR2 and compiled by the Library of Congress (LC). GIHC contain rules for description of two-dimensional pictorial works, both single items and collections. Repositories that wish to provide more extensive information on the physical nature, visual content or historical context of creation (< biblio >) may use it instead of AACR2, Chapter 8 (Society of American Archivists, 1994). . AACR2, Chapters 21-25 must be used in conjunction with GIHC to select and formulate headings for personal names, corporate names and uniform titles (Society of American	Title & Statement of Responsibility; General Material Designation; Publication and distribution; Physical Description; Series; Note (US Library of Congress, 1995).	**Advantages:** As for AACR2. **Disadvantages:** As for AACR2.

Table 8: METADATA CONTENT STANDARDS

Standard	Description	Elements	Comments
	Archivists, 1994).		
Dublin Core Metadata Elements Initiative	The Dublin Core Initiative is an international and interdisciplinary effort to define a core set of elements for more effective "resource discovery" on the Internet. It resulted in consensus concerning a base set of elements for descriptive metadata. This set of elements was developed through a series of annual invitational workshops, of which the first was held in 1995 (Weibel & Hakala, 1998). According to Milstead & Feldman (1999:35) it appears as if the Dublin Core will, on a basic level, become the international metadata standard for electronic resource description. If applied by specialised groups, customised lists may need to be developed to extend the Core.	**Content:** Title, Subject, Description, Source, Language, Relation (to another resource), Coverage (spatial or temporal characteristics of intellectual content) **Intellectual Property:** Creator, Publisher, Contributor, Rights **Instantiation:** Date, Type (such as home page, note, working paper), Format (of data, to identify software and	**Advantages:** - Easy and simple to use; provides a basic structured record that promotes interoperatibility with other metadata formats. It can be enhanced or mapped to more complex records depending on field of application (Miller, 1996; Day, 1997). - Developed to allow the same elements to be applied to both text and images (Weibel & Miller, 1997). - The Dublin Core has achieved wide international recognition as the primary candidate for interdisciplinary resource description (Weibel & Miller, 1997).

Table 8: METADATA CONTENT STANDARDS

Standard	Description	Elements	Comments
	The Dublin Core Metadata Elements fall into three groups which roughly indicate the class or scope of information stored in them: (1) elements related mainly to the Content of the resource, (2) elements related mainly to the resource when viewed as Intellectual Property, and (3) elements related mainly to Instantiation of the resource (Weibel & Miller, 1997)	hardware required for use), Identifier (such as URL or ISBN).	description (Weibel & Miller, 1997). **Disadvantages:** - Its simplicity is also a drawback as it conflicts with the need to adequately capture and encode the richer descriptors for original capturing, image formats and variant forms of the image content (Weibel & Miller, 1997). - It does not offer the same degree of precision and organization that characterizes library cataloguing (Lagoze, 1996). - Milstead & Feldman (1999) identify the following additional disadvantages: - Lack of formal responsibility for maintenance: development takes place in

Table 8: METADATA CONTENT STANDARDS

Standard	Description	Elements	Comments
			the informal Dublin Core workshop series. ongoing basis. - Unstable: changes are made on - No guidelines for use: differing interpretations.
Categories for the Description of Works of Art (CDWA)	The CDWA was developed by the Art Information Task Force (AITF) and sponsored by the Getty Art History Program and the College Art Association. It was released in 1996. CDWA provides a structure for information used to describe works of art and images of them (UKOLN Metadata Group, 1998). The CDWA has been developed independently from software and hardware and serve as a model to which existing art information systems can be	Object/work; Classification; Orientation/arrangement; Titles or names; State; Edition; Measurements; Materials and techniques; Facture; Physical description; Inscription/marks; Condition/examination history; Conservation/treatment history; Creation; Ownership/collecting history; Copyright/restriction; Styles; Subject matter; Context;	**Advantages:** Enhances the compatibility between diverse systems and enable the sharing of art information (Dempsey & Heery, 1997). **Disadvantages:** The CDWA has not yet been adopted as a standard. It has not been widely implemented either and its applicability

Table 8: METADATA CONTENT STANDARDS			
Standard	**Description**	**Elements**	**Comments**
	mapped (UKOLN Metadata Group, 1998).	Styles; Subject matter; Context; Exhibition/loan history; Related visual documentation; Related textual reference; Critical responses; Cataloguing history; Current location (Dempsey & Heery, 1997).	implemented either and its applicability and compatibility is still being tested by libraries (UKOLN Metadata Group, 1998).
Standards Framework for the Computer Interchange of Museum Information (CIMI)	The CIMI Committee, an initiative of the Museum Computer Network (MCN) produced a framework in 1993 for the description of museum information. The framework encompasses interchange protocols, interchange information, lower level network and telecommunications building blocks and content data standards (Dempsey & Heery, 1997). The framework can be implemented at two levels. The first is specification of hardware and software so that it supports the standards defined	Basic descriptive *elements (record summary, dates, object title name, document title, editor, person name, organization name, place, record type)*; Subject description *(classification, concept, event, material, mark, object, object identifier, occupation, role, style/movement, subject, topic)*; URIs; Resource format and technical characteristics; Host administrative details;	**Advantages:** It provides a non-academic approach suited to the level of the average museum visitor (UKOLN Metadata Group, 1998). **Disadvantages:** According the UKOLN Metadata Group (1998) CIMI is complex in terms of its ease of creation.

Table 8: METADATA CONTENT STANDARDS

Standard	Description	Elements	Comments
	software so that it supports the standards defined in the framework - to ensure data interchangeability. The second level addresses standardization of data content (information fields) and data values on what goes on in the fields (Dempsey & Heery, 1997).	administrative details; Administrative metadata *(record type, document source)*; Provenance/source; Terms of availability/copyright (Dempsey & Heery, 1997)	It has not been adopted as a standard. Research in terms of practical application is still required before adoption can be considered (UKOLN Metadata Group, 1998).
Coalition for Networked Information (CNI) & the Consortium for the Computer Interchange Museum Information (CCIMI) Framework	The CNI and CCIMI have compiled a joint framework identifying a number of general kinds of information about a digital image (Besser & Trant, 1994).	**Information identified**: - to view the image *(type, format, compression scheme, pixel dimensions)* - about the quality and accuracy of the image *(source digitised, source image type)* - about the scanning process *(light source, resolution, scanner, date of scan, image manipulation, digital signatures)*	**Advantages:** Provides a very comprehensive list of elements that ensures a fairly complete description of digital images (Besser & Trant, 1994). Emphasis is placed on standard description for purposes of archival integrity and transfer of image files over networks (Besser & Trant, 1994). **Disadvantages:**

Table 8: METADATA CONTENT STANDARDS			
Standard	**Description**	**Elements**	**Comments**
		- how an original is depicted in a surrogate image *(perspective, position, orientation, linking various views of the same image)* - rights and reproduction information *(copyright details)* - how to locate an authentic copy of the original *(Universal Resource Number or Universal Resource Locator).* (Besser &Trant, 1994)	Due to its comprehensiveness it would be very time and labour intensive to apply to a large collection (Besser & Trant, 1994). The capturing method is limited to scanning (Besser & Trant, 1994). Refinement is still required in terms of vocabulary standards of elements (Besser & Trant, 1994).
Visual Resources Association (VRA)	The VRA Data Standards Committee was established in 1993 to promote the use of standard descriptive practices in visual resources collections. The committee compiled the "Data Standards for Visual Resources" in 1996, which includes a list of data elements used in image	**VRA Core Categories:** Object Categories: *Object Type, Technique, Materials, Dimensions, Titles, Larger Entity.*	**Advantages:** The VRA core categories were developed so that they reference the corresponding MARC cataloguing fields and so that they correspond to the CDWA (Sandore & Lewis, 1997).

Table 8: METADATA CONTENT STANDARDS			
Standard	**Description**	**Elements**	**Comments**
	collections, a brief description of each field, the AITF category number and MARC tag equivalent (Visual Resources Association, 1999). The VRA has endorsed the work of the Computer Interchange of Museum Information (CIMI) Consortium and has contributed its data for use in CIMI's Model Project (Visual Resources Association, 1999).	Creator Categories: *Creator, Nationality, Culture.* Surrogate Categories: *View Description, Image Type, Image Owner, Number, Source.*	CDWA (Sandore & Lewis, 1997). The VRA take into account the use of controlled vocabulary subject and name terms (Sandore & Lewis, 1997). **Disadvantages:** Although the VRA standard covers the most crucial elements required for image description, it lacks in terms of elements describing the digitisation process, required for future reproduction and preservation purposes (Sandore & Lewis, 1997.

4.4 SUBJECT CLASSIFICATION AND INDEXING

Much has been written about subject indexing and classification of photographic images, mainly because it is such a potentially problematic and contentious issue.

Leung, et. al. (1992: 112) differentiate between two levels of content description. At the primary level the physical image is described - that which the indexer sees in the image. The secondary level involves an interpretation of the objects seen in the image and is based on "knowledge acquired from familiarity with the customs and cultural traditions of a particular civilization". The primary level therefore offers a more objective, factual description, while the secondary level, depending on the background and perception of the viewer can be highly subjective. To ensure retrieval effectiveness it is important that both levels of description are catered for in subject indexing.

Fraser (1981: 141) has identified the following questions to assist in determining the subject of a photograph:

WHO?	- names and titles of person/s and their dates if known;
WHAT?	- the occasion for the photograph;
WHY?	- the circumstances, reasons for the event, why it is noteworthy;
WHEN?	- the date or approximate date when the photograph was taken;
WHERE?	- the town, building or location.

After identifying the subject, it should be paraphrased in such a way as to be logical to the potential user. This can be done using various methods, which Leung, et. al. (1992: 113) divide into three classes:

- Classification systems
- Keyword systems
- Free text systems.

4.4.1 Classification Systems

The importance of classification schemes for the improvement of subject access to information has long since been recognized by classification experts and librarians (Vizine-Goetz, 1996). As early as 1983 Svenonius (1983) describes several uses for classification in online retrieval systems, including improvement of precision and recall; to enable browsing; to provide context for search terms and to serve as a mechanism for switching between languages.

In essence the primary purpose of classification schemes is to group documents into a hierarchical structure of subject categories. Traditionally classification schemes indicated the shelf position of a document. In an electronic collection this is not a core criterion. The DESIRE (Development of a European Service for Information on Research and Education) project has done extensive research in the role of classification schemes in Internet resource description and discovery. One of its main findings has been that classification schemes have not outlived their usefulness and have a role in aiding retrieval in a network environment, especially for providing browsing structures for subject-based information gateways on the Internet (Koch & Day, 1996).

Classification schemes can be defined by several categories, but can be broadly divided into the following (Koch & Day, 1996):

- Universal schemes - examples include the Dewey Decimal Classification (DDC), the Universal Decimal Classification (UDC) and the Library of Congress Classification (LCC);
- National general schemes - universal in subject coverage but usually designed for use in a single country. Examples include the Nederlandse Basis Classificatie (BC) and the Sveriges Allmäma Biblioteksförening (SAB);
- Subject specific schemes - designed for use by a particular subject community. Examples include ICONCLASS for art resources and the National Library of Medicine (NLM) scheme for medicine;

- Home-grown schemes - schemes devised for use in a particular organization.

Photographic collections are not characteristically classified using general classification schemes. According to Ralph (1994) the reason for this is that "...the information contained in the images is almost always too specific to be accommodated by general classification schemes. The purpose of general classification schemes, after all, is the orderly distribution of the universe into groups of main subjects or classes or concepts". Locally developed systems have the advantage that they can focus on the specific needs of the patron population (Ralph, 1994).

In view of the above, most institutions have developed, or would have preferred to develop, their own customized classification schemes to accommodate their specific needs and required level of detail. For practical reasons this is not always possible. In instances where photographic collections form part of a greater traditional library or archival collection, the same classification scheme used for the primary collections will be used. Although not ideal, general classification schemes are therefore often used for photographic collections. Another reason for this trend is cross-institutional compatibility - by using a general scheme the collection will be accessible to other collecting organizations and can even be integrated into their collections. Classification schemes for images of natural objects generally follow existing classification schemes for the branch of science represented. Ralph (1994) summarizes the reason for this trend as follows: "The exact nature of the thing pictured is the basis for the classification and the key to location in the collection".

A brief overview will be given of two classification systems: a general scheme (Dewey Decimal Classification / DDC) and a subject specific scheme (ICONCLASS).

4.4.1.1 Dewey Decimal Classification (DDC)

The DDC is a general knowledge classification system, first published in 1876 and continually revised - the 21st edition being the most current. It is the most widely used classification system in the world. In the DDC basic classes are organized by disciplines or fields of study (OCLC, 1999). At the broadest level it is divided into ten main classes, with the assumption that it covers the entire world of knowledge. Each main class is further divided into ten divisions and each division into ten sections. Arabic numerals are used to represent each class in the DDC. Hierarchy is expressed through structure and notation. The following are the ten broad categories of the DDC (Moshell, 1996):

000 - Generalities
100 - Philosophy and Psychology
200 - Religion
300 - Social Sciences
400 - Language
500 - Natural Sciences and Mathematics
600 - Technology and Applied Sciences
700 - The Arts
800 - Literature and Rhetoric
900 - Geography and History

DDC numbers are incorporated in MARC bibliographic records at the Library of Congress and distributed to libraries.

Since Dewey is not being used to locate a document in a physical place, but to assign a document to a location within the DDC topic structure, more than one number may be applied if appropriate. Care must still be taken to apply numbers consistently to like topics so that users are not confronted with the situation that the same topic is entered under different numbers at different times. Consistency in number application also ensures that the DDC's hierarchical structure and established relationships can be used to maximum benefit when leading users to related subjects (Vizine-Goetz, 1996).

Suggestions for enhancements to online classification schemes, such as DDC, have been made, including (Vizine-Goetz, 1996):

- Developing end user interfaces that employ adaptive methods for displaying classification hierarchy structures,
- Transforming selected DDC and LCC captions to end user language especially in terms of expressiveness and accuracy, and
- Using links to other subject thesauri, language versions, and full and abridged forms of classifications to provided custom views of online classification data.
- Expansion of definitions of literary warrant to include Internet Resources.

By enacting enhancements of this type, library classifications systems will significantly moved forward in the effort to ensure that classifiers will be provided with advanced classifying tools and that library classification will play a major role in organizing existing and future document-like object collections (OCLC, 1999).

4.4.1.2 ICONCLASS

ICONCLASS is a "hierarchical notation-based system for the indexing and organization of subject matter of art works and their surrogate images" (Bower & Roberts, 1999). ICONCLASS was developed in the Netherlands and translated into English. It is currently being used in many European and American museums, photographic archives and documentation centres.

ICONCLASS consists of approximately 24 000 definitions of objects, persons, events, situations and abstract ideas, used to describe the subjects of visual documents. It also includes 13 000 unique keywords to index pictures (ICONCLASS Research & Development Group, 1999). The schedules of

ICONCLASS are organized into ten basic classes in which the themes and subjects are ordered hierarchically. The notation is alphanumeric:

0 - Abstract, Non-representational Art
1 - Religion and Magic
2 - Nature
3 - Human being, Man in general
4 - Society, Civilization, Culture
5 - Abstract Ideas and Concepts
6 - History
7 - Bible
8 - Literature
9 - Classical Mythology and Ancient History

ICONCLASS is a flexible system, allowing for the classification and indexing of visual materials from various perspectives, thereby ensuring more effective retrieval of images. As with most classification systems, however, the drawback of ICONCLASS is that it requires a degree of knowledge of the system to enable users to use the system and fully benefit from its advantages.

4.4.2 Keyword Systems

Subject indexing by assignment of keywords entails the choice of a number of words to describe the subject matter of an image. The descriptions may be at either primary or secondary level. The vocabulary is not necessarily controlled, although it often is (Leung, et. al., 1992: 114). More sophisticated keyword system may have hierarchical structures. In such systems the indexer first chooses a term or heading from a specified list of subject headings and then assigns more specific terms under the chosen heading. Keyword lists can either be according to subject or alphabetical, as is found in the construction of thesauri.

According to Besser and Trant (1995) "...structured vocabularies ensure the consistency necessary for precise retrieval of information ...sources such as the Art and Architecture thesaurus, the Thesaurus of geographic Names, the Union List of artist names, ICONCLASS, and the Library of Congress subject Headings provide a wide range of controlled terminology to describe people, places, things, events, and themes depicted by images".

4.4.2.1 Subject Headings

According to Daily (1985b: 256) subject headings "...provide a standardized guide to the subject content of a book by giving it a heading that would be appropriate and recognizable by the public". One of the most generally used subject lists is the Library of Congress Subject Headings (LCSH), which is meant to "...supply topical headings in the interest of uniformity in libraries" (Daily, 1985b: 257).

According to Daily (1985b: 268) subject headings have the most use for novices in a subject area - "The novice must have some place to begin, which is provided by the subject access to the material".

An overview of the Library of Congress Subject Headings will be given as an example of an internationally accepted standard for subject headings.

4.4.2.1.1 Library of Congress Subject Headings (LCSH)

LCSH is the most widely used source of terms for subject cataloguing in the United States of America. The 16th edition (1993) contains approximately 198 000 headings. Staff at the Library of Congress began compiling an authority list of subject headings in 1898, although the first printed version only appeared in 1909 (Society of American Archivists, 1994). The LCSH has various limitations. For most of its existence, its scope was limited in that it only reflected those materials accessioned and held at the Library of Congress. In addition it was developed without a specific code or body of rules, resulting in many inconsistencies and irregularities. Despite these limitations, LCSH has become a central cataloguing tool in many libraries primarily because of the Library of Congress' printed catalogue card distribution programme. The main attraction of LCSH as a resource descriptor is "...probably determined more by the fact that it is there, broad in scope and available for use, rather that its inherent quality" (Milstead & Feldman, 1999).

Archivists have resisted using the LCSH because it is too general and therefore difficult to apply to archival materials. The integration of the LCSH into the MARC format has, however, lead to its use by many archivists to catalogue non-book material: "Many archivists have conceded that using LCSH is one of the compromises that must be made to gain the larger benefits of participating in the networks of local integrated online catalogues" (Society of American Archivists, 1994).

According to Milstead & Feldman (1999) LCSH is not specifically suitable for electronic searching due to its use of bound terms, which makes it less useful for searching.

4.4.2.2 Thesauri

A thesaurus is defined in the ANSI Z39.19-1980 standard, Guidelines for Thesaurus Structure, Construction and Use, as "... a compilation of words and phrases showing synonymous, hierarchical and other relationships and dependencies, the function of which is to provide a standardized vocabulary for information storage and retrieval systems" (Society of Archivists, 1994).

A thesaurus provides a level of control on natural language through linkage of synonyms and near-synonyms and by identification of relationships among terms (Brenner, 1989: 64). Its main advantage is to improve retrieval (Arms, 1999). To retain its usability, thesauri need to be maintained and updated to reflect changes in natural language. Although keyword systems offer greater flexibility and are easier to use by inexperienced users, Leung et. al. (1992: 115) concede that there are certain drawbacks. The systems separate subjects, although this can be overcome to a certain extent by the use of cross references. Descriptions of terminology are usually fairly basic and the system relies on the user's understanding and use of a term to be the same as that of the indexer, to ensure retrieval recall and precision. Brenner (1989:65) adds that thesauri are often not well maintained and thereby become redundant.

The LC Thesaurus for Graphic Materials (LCTGM) and the Art and Architecture Thesaurus will be briefly discussed as examples of thesauri relevant to the indexing of photographic images.

4.4.2.2.1 Library of Congress Thesaurus For Graphic Materials: Topical Terms for Subject Access ((LCTGM)

The LCTGM was developed in the Prints and Photographs Division of the Library of Congress. It provides a "...substantial body of terms for subject indexing of pictures, particularly large general collections of historical images which are found in many libraries, historical societies, archives and museums" (Parker, 1994). It is authorized for use in MARC records. LCTGM is a controlled vocabulary used for describing a broad range of subjects, including activities, objects and types of people, events, and places depicted in still images. It includes subject categories only (Parker, 1994).

The LCTGM contains more than 6000 terms and cross references for use in the indexing of two-dimensional pictorial materials. Entries for each term contains links (broader, narrower and related) to related terms. According to the Society for American Archivists (1994) the LCTGM is considered a primary tool for the description of archival collections of graphics material.

4.4.2.2.2 Art and Architecture Thesaurus (AAT) Art and Architecture Thesaurus (AAT)

The Art and Architecture Thesaurus (AAT) is defined by Bower & Roberts (2000) as follows:
"A standards project of the Getty Art History Information Program (AHIP), the AAT is a thesaurus of art-historical terminology, arranged both hierarchically by concept and alphabetically, reflecting the common usage of scholars and catalogers".

The AAT began in 1979 and has since become a substantial (nearly 40 000 terms) controlled vocabulary, focussing on the fields of art and architecture, although its application can easily extend to other fields. It does not include music, legal, literary, religious or oriental art vocabularies; personal, corporate or geographic names (Society of American Archivists, 1994). The AAT is a post-coordinated, hierarchically structured thesaurus organised into 40 hierarchies within seven broad categories called facets: associated concepts, physical attributes, styles and periods, agents, activities, materials and objects (Society of American Archivists, 1994).

The AAT has proved to be quite successful within the archival community primarily because it sought active participation from all stakeholders throughout its compilation. The AAT has also incorporated several independent vocabulary lists in its structure and has provided an infrastructure for their maintenance (Society for American Archivists, 1994).

4.4.3 Free Text Systems

The main difference between free text systems and classificatory and keyword systems is that no control is placed on free text systems. The indexer is given the freedom to describe an image using any word or phrase deemed best to represent the subject matter. According to Leung, et. al. (1992: 115) those who maintain that the subject matter of their collections does not conform to any structure that can be imposed or that a specific vocabulary can be pre-determined to represent the image content, often advocate this approach.

Free text systems have the advantage of not being inhibited by preset structures and vocabulary. New terminology can be assigned as it appears in the world; there is no waiting period for updates of thesauri or classification systems. The obvious drawback is that it is not possible for the user to consult a list to determine what terminology has been used - should the language of description of the indexer differ much from that of the user, recall and precision will be poor.

4.4.4 Summary

Subject indexing is a complex and time-consuming process. The primary objective is to describe the subject matter of a photographic image in such a way as to optimally facilitate its retrieval by a potential user. The fulfilling of this seemingly simple objective is complicated by the fact that images are rarely accompanied by text to "speak" on their behalf. They have to rely on the interpretation of an indexer to make their content accessible. Should the perspective of the indexer and the user differ, a potentially relevant image may be completely lost to that user.

Three types of systems have been identified: classificatory, keyword and free text. None of these systems provide a complete solution in itself. The best option would seem to be a combination of all three. The more access points created the greater the possibility of an image being retrieved at a later stage.

4.5 METADATA ELEMENTS FOR THE DESCRIPTION OF PHOTOGRAPHIC IMAGES

Taking into account the various elements relating to the bibliographic and cubject description of photographic images, the following metadata elements have been identified as necessary for the effective description of images. Although there may be additional elements as determined by the various and diverse metadata standards that are currently available, the following table presents a list of elements that are critical to the effective description of photographic images.

Table 9: Metadata Elements for the Description of Photographic Images

ELEMENT (Category)	DESCRIPTION
Title / Caption	The title or caption provided either by the creator of the original image or the cataloguer / indexer.
Statement of Responsibility	Information about those responsible for the creation of the image, e.g. photographer, graphic artist, stylist.
Ownership	Information about past and present owners of the original.
Subject	Classification, concept, event, keywords, subject heading.
Physical Description	Information describing the original image, including sub-elements such as image format of original (e.g. black and white print; transparency, polaroid) (4"x5", 35mm), measurements, condition, conservation/treatment history.
Publication and Distribution	Relevant should the image (original or surrogate) be published.
Provenance / Source	Source digitised, source image type, current location.

ELEMENT (Category)	DESCRIPTION
Copyright / Restriction	Rights and reproduction information / terms of availability.
Unique Identifier	Unique number or name whereby the image can be identified and located in an electronic system, e.g. URIs, Universal Resource Locator (URL)
Capturing Process	Information about the capturing process needed for purposes of preservation. Sub-elements would include: light source, resolution, scanner, date captured, image manipulation, digital signatures, operator judgment / decisions, hardware, software
Viewing Requirements	Information to view the image, including type, format, compression scheme, pixel dimensions, hardware and software requirements
Administrative Metadata	Record number, order number, accession number. Filing location / shelf number, date the metadata record was created.

4.6 CONCLUSION

As mentioned in the introduction to this chapter, metadata has become a buzzword within the information professional community. The main reason for this has been the phenomenal growth in the availability of electronic information including electronic images. This has, in turn, triggered interest in the issue of metadata: the more images that are available the more difficult it is to locate the "right" image. It has led to discussions among various role players, brought together experts from a wide range of fields and sparked interest in an aspect of information management that has commonly been regarded as "administrative" and better left to little old ladies in the musty corners of the big traditional libraries.

Although cataloguing and indexing have moved into the realm of electronic resource description, the basic principles of traditional cataloguing and indexing remain the same. An item, in this instance an image, needs to be described in such a manner that a potential user will be able to find and positively identify it. The description has to be such that it can act as a surrogate to the original image.

These principles and ideals are much more difficult to attain when dealing with images than when dealing with traditional textual information. The reason is twofold: (1) images do not "speak" for themselves, but rely on the interpretation of the indexer; and (2) the cataloguing and indexing processes have always been the most labour and time intensive processes in the management of photographic collections.

The many projects, working groups and proposals that have been established to provide a solution to the dilemma of how best to provide access to digitised image collections emphasize one fact: there is no clear and perfect solution available. This dilemma is compounded by the fact that each collection is unique with unique subject matter and unique requirements (Weibel & Hakala, 1998).

The primary purpose of metadata is to facilitate effective retrieval. The better and more comprehensive the metadata, the more effective the retrieval will be. Tools that facilitate retrieval have become even more essential within an electronic environment, as stated by Cathro (1997):

"As the quantity of information on the World Wide Web multiplies rapidly, it will become increasingly difficult to retrieve information, with reasonable precision and recall, using the major search and harvesting engines. The use of metadata, combined with the use of improved harvesting processes, has the potential to improve retrieval of these information resources".

The next chapter will focus on the retrieval of photographic images and address the relationship between metadata and image retrieval.

CHAPTER 5

RETRIEVAL OF PHOTOGRAPHIC IMAGES

5.1 INTRODUCTION

The success of any digitisation project is measured by the effectiveness of the retrieval system. Archived information, such as a collection of digitised images, has very little use if it cannot be retrieved (Halfhill, 1994). The bigger the collection of images the more essential it is to have an effective retrieval system. With the advent of the Internet and the resulting increase in available digital images, greater emphasis has been shown in research in the fields of image retrieval systems. Although traditional photographic systems have relied on text retrieval of keywords, new systems are looking towards automated, content-based indexing and retrieval of images as a solution to the time- and labour intensity of manual indexing. Research in the field of image retrieval is increasingly focussing on image-recognition technology. Research is driven by practical applications, such as industrial, military and law-enforcement needs, as well as business applications (Halfhill, 1994; Chang, et. al. 1997).

The type and format of information has a definite influence on its retrievability. The simplest kind of information to retrieve is textual: documents that either originated in machine-readable format or were converted to ASCII text by an OCR scanning process. A more difficult challenge is to retrieve image files or compound documents in which the target of a search is an image.

This chapter will provide and overview of the various retrieval principles that have to be taken into account in the development and evaluation of an image retrieval system. The relationship between metadata and image retrieval will also be highlighted.

5.1.1 Defining Information Retrieval

In the field of information retrieval research various approaches to defining information retrieval can be found:

- Lancaster and Warner (1993: 11) take a fairly simplistic approach, defining information retrieval as "...the process of searching a collection of documents (using the term document in its widest sense) to identify those that deal with a particular subject".

- Anderson (1998) bases her description on the traditional communications theory approach: "Information retrieval is viewed as a communication process in which judgements of relevance are made".

- Tague-Sutcliffe (1996: 1) has a similar viewpoint to that of Anderson (1998), also defining information retrieval as a process: "Information retrieval is a process in which sets of records or documents are searched to find items which may help to satisfy the information need or interest of an individual or group". In addition to identifying the process, Tague-Sutcliffe (1996:1) also identifies the major components of this process: "...the set of records or documents (document set); the indexing or access method for the documents set (access method); the information need of the user (user need); the verbalisation of this need in a sequence of search statements or menu selections (the search strategy); the sequence of items presented as a result of the search strategy (the retrieved set or sequence), and the degree to which the retrieved set satisfies the user's need (relevance judgements)".

- Rowley (1998) takes a cognitive approach to information retrieval theory, which is concerned with "...the way in which the brain processes information". Fundamental to this approach is the emphasis placed on the user and his/her perceptions. The perceptions and prior knowledge of the user has an impact on the meaning and relevance derived from retrieved information (Rowley, 1998).

- Ingwersen (2000: 205) summarised the various approaches to information retrieval and identifies three main approaches to information retrieval research: "1) the algorithmic mainstream approach ... 2) the user-oriented approach and 3) the cognitive perspective". The algorithmic approach regards information as "...meaningful signs... information gives meaning...". The user-oriented approach emphasises the need to "...contextualise the information need by means of supplementary information on intent, purpose and goals". The cognitive theory "...signifies an attempt to globalise information retrieval by regarding all of its components as representing cognitive structures of varying origin and degrees of complexity that co-operate in an interactive communication process".

From the above it is clear that there is no one generally accepted, "right" or "wrong" definition to information retrieval. There are many factors that can potentially impact on the process of retrieving information Depending on a specific approach taken, a different element or concept relating to IR, is emphasised.

5.2 RETRIEVAL PRINCIPLES

There are certain basic retrieval principles that apply to any retrieval system, irrespective of the format of the information. It is imperative that these principles be taken into account in the development and/or evaluation of a retrieval system.

5.2.1 Retrieval Needs

Information retrieval systems are designed to satisfy the information needs of a known or unknown group of potential users. In order to ensure retrieval effectiveness it is imperative that system designers be aware of the possible retrieval needs of potential users of the system.

According to Chen and Rasmussen (1999) little information is currently available on users' need for image information:
"Unfortunately, to date, very little information has been available on why users search for images, how they intend to use them, as well as how they pose their queries, though this situation is being remedied as a body of research begins to accumulate."

The general move towards digitisation of images has complicated the issue of categorisation of user needs even further. Traditional analogue image collections were usually limited to a specific, clearly defined user group of which the retrieval needs were easy to define and categorise. In contrast, with digital collections "...one of our overriding principles ... is to extend access, not to restrict it" (Stephenson, 1999).

An effective retrieval system should be designed in such a way as to accommodate these diverse needs. According to Stephenson (1999) this is easier said than done:
"At least in the short term, it is unlikely that systems can be built that serve all user groups equally effectively. Ideally, good system design would isolate digital objects in a repository, and any number of front-ends could be customised for specialised user groups" (Stephenson, 1999).

If that is not possible to cater for all needs, it should be determined what needs are critical to ensure the success of the system. For this reason Tang (2000) advocates participatory design in which users play a pivotal role in the design process. Participatory design "...suggests that system design should be a collaborative process in which both design team members from different fields and potential users take an active role" (Tang, 2000).

Christie (1999) also supports this point of view and states that collaboration between system designers and end users is critical in ensuring the success of an image retrieval system: "Although the creation of image rich digital resources certainly represents a series of technological challenges, it is critical to give adequate attention as well to the fundamental questions of audience, user behaviour, and use". This user-based approach is captured in the following broad questions:

- "For whom are we building our image delivery system?
- What is it that we are building and for what purpose do those users want to use it?
- What functionality do our users need to use what we build?" (Christie, 1999).

In the area of image retrieval the identification and categorisation of the retrieval needs of users, presents a challenge, as stated by Chen and Rasmussen (1999): "While there begins to be a body of research addressing the question of image information needs, the studies are fragmented".

5.2.2 Relevance

According to Anderson (1998) relevance is one of the fundamental concepts of information science "...which, despite more than forty years of debate, is still not fully understood". One of the reasons for this is inconsistency in the use of terminology to define relevance (Mizzaro, 1998). Different terms are either used as synonyms or ambiguously, using the same term for two or more concepts. In addition to this problem, Anderson also states that "...notions such as topicality, pertinence, or situational relevance have appeared in the literature over time, but support for one view has often meant excluding all others". It can therefore be concluded that the issue of relevance is one that is still to be debated for some time to come before agreement can be reached on what exactly relevance is.

Considerable research has been done on the issue of relevance within the field of information retrieval (Cosijn and Ingwersen, 2000: 533; Mizzaro, 1998). By analysing some of the main research that has been done on the issue, Mizzaro reaches the conclusion that there are many kinds of relevance, contributing to the problem of finding one all-encompassing, generally accepted definition of relevance.

In simple terms, the term relevance is used to express the appropriateness of a document for a particular user (Lancaster & Warner, 1993: 47), within the context of a specific query (Croft, 1998).

Historically research focussed on either a systems-centred or a user-centred approach to information retrieval. More recent studies on relevance have focussed on "...the interaction between human and computer" (Cosijn and Ingwersen, 2000: 534).

In an attempt to determine what relevance is, Cosijn and Ingwersen (2000) have plotted the attributes of relevance (relation, intention, context, inference and interaction), as defined by Saracevic (1996), against the manifestations of relevance (algorithmic, topical, cognitive, situational and affective). In doing so it was found that "...the attributes of relevance function in different dimensions for the various manifestations of relevance" (Cosijn and Ingwersen: 548, 2000). In essence a distinction can be made between algorithmic relevance and motivational or affective relevance: "...the manifestation of motivational/affective relevance should not be viewed as a discrete category or as part of a linear scale of relevances, instead, motivational relevance may essentially be included in the attribute of intention, and affective relevance acts as a different dimension altogether, influencing all the other subjective relevance types".

In view of the above it is clear that no one, generally accepted definition of relevance exists within the field of information retrieval. Although this is true, users of systems intuitively understand what relevance is (Saracevic, 1996:215), even though they may not be able to precisely define on what they based a specific relevance judgement.

5.2.3 Recall and Precision

Recall and precision are measures used to determine the effectiveness of a retrieval system. Wallis and Thom (1996: 274) provides the following general definition for recall and precision: "For a given query and information retrieval system, *precision* measures the number of relevant documents retrieved as a proportion (of) all relevant documents, and *recall* measures the number of relevant documents retrieved as a proportion (of) all documents retrieved". The recall ratio of a retrieval system is determined by dividing the number of relevant documents retrieved into the total number of relevant documents in the system. Precision ratio is determined by dividing the number of relevant documents retrieved into the total number of documents retrieved (Rowley, 1992).

As can be deducted form the above-mentioned definitions, determining the relevance of a set of documents is critical to determining either recall or precision. As discussed in paragraph 5.2.3, determining relevance is not as straightforward as one would assume, as it is a subjective measure and there are various types of relevance to take into account. In addition, Wallis and Thom (1996: 274) also argue that the fact that one would assume that the user knows what he or she wants and is therefore the best person to make a relevance judgement is not necessarily a good means of assessing the effectiveness of a retrieval system: "...what a user wants may not always be what he or she describes". As a solution to this problem certain researchers have either just ignored it as it does not have a significant affect on the comparison of the retrieval effectiveness of two systems. Others, as in the TIPSTER and TREC projects, have tried to formally define relevance and employ specially trained relevance assessors in their research (Wallis & Thom, 1996: 274).

High recall of a system is associated with lower specificity, but higher exhaustivity of the indexing language: the more themes that have been identified the more likely it will be that a document will be retrieved. A high exhaustivity of indexing is therefore beneficial where a thorough search is required (Rowley, 1992). In contrast to recall, precision is increased by higher specificity and less exhaustivity of the indexing language.

A perfect system, providing both 100% recall and 100% precision, would return a set of documents containing all relevant documents in the system as well as no irrelevant documents (Wallis & Thom, 1996:274). In practice, and especially in the case of large databases, this is not feasible. In practice it is difficult to determine recall. Without scanning the entire database it is impossible to determine the exact number of relevant documents available in the database. According to Wildemuth et al (1993:533) precision measures can also not always be relied on to be a true reflection of the system's retrieval effectiveness: "...lack of precision may simply reflect the searcher's unwillingness to expend further effort in narrowing a search."

Precision and recall are two conflicting objectives that are present in any search. Ideally one would want to both maximise recall, and the number of relevant documents retrieved, and at the same time ensure that the documents retrieved all remain relevant. In practice, however, it is not possible to simultaneously achieve these twin objectives (Rowley, 1992).

5.3 APPROACHES TO IMAGE RETRIEVAL

The representation of images in an image database will have a determining effect on the approach(es) that can be followed to retrieve the images. Images can be represented by textual references or metadata about the images, the images themselves, or a combination of metadata and images. Based on these representations three main approaches to image retrieval can be identified:

- Text-based retrieval
- Content-based retrieval
- An integrated approach

Each of these approaches has specific characteristics and present specific advantages and disadvantages to the user of an image database. Each approach will now be discussed in more detail.

5.3.1 Text-based Image Retrieval

Traditionally image databases have relied on text-based descriptions for cataloguing and search purposes (Romer, 1995). The image is represented by a textual description and therefore requires a retrieval system with textual retrieval capabilities: the words used by a user to search for a specific image have to be matched to the words present in the database, either pre-defined by an indexer or in free text.

According to Chang et. al. (1997) the use of comprehensive textual annotations provides "… the most direct, accurate and efficient methods for finding 'unconstrained' images". The problem, however, is that images present specific challenges with regard to the creation of representative metadata. The text accompanying an image is usually fairly limited, as all text needs to be manually added to an image, which is a very time- and labour-intensive process (Srihari &

Zhang, 1999). (See Chapter 4 for more information on the issue of image metadata).

In image databases relying on retrieval of textual references, the same principles apply as for any text-based system. Most text retrieval systems work on the basis of creating a digital index of the contents of the database. Such an index allows the search software to perform all searches on abstracts of the documents contained in the database. According to Joss and Wszola (1996: 33) even the most advanced searching strategies employ a pre-generated and stored index. A digital index entry consists of a heading and a locator, where the heading is a specific term and the locator a pointer back to the location(s) of the word in the database. Such headings can either be created through the selection of keywords or by creating a full-text index. In a full-text index every important word in the database is indexed, while unimportant, unnecessary words, known as "stop words" are ignored (Joss & Wszola, 1996:33). In text-based image retrieval systems, retrieval is primarily done on keywords allocated by an indexer. In instances where text accompanies images, such as in some newspaper archives, full text retrieval can be done on this text (usually in addition to keywords).

In his classification of retrieval systems, Hildreth (1995) distinguishes between query-oriented and non-query oriented systems. Non-query oriented systems are exploratory and rely on browsing and hypertext links for information retrieval. Query-oriented systems are classified as conventional or non-conventional systems. Conventional retrieval systems are also known as exact-match systems and are based on Boolean logic. In contrast, non-conventional information retrieval systems use a closest of best-match strategy where "…degree of closeness or similarity of a candidate item's content description to the textual query is taken into account" (Hildreth, 1995).

A short overview will be given of exact-match, best-match and browsing and exploratory retrieval techniques.

5.3.1.1 Exact-Match Retrieval Techniques

According to Hildreth (1995), exact-match techniques "...require that the specifications of the query (e.g. the search terms and their specified logical or textual relationships) be satisfied precisely by any and all document representations that make up the retrieval set". Exact-match techniques, which are primarily based on Boolean retrieval mechanisms, therefore specifically cater for precision and is preferred by information professionals as it provides them with the tools to precisely translate a user's or their own information need into a search query. One of the criticisms against exact-match techniques is that end-users have difficulty in using Boolean retrieval techniques. Another criticism is that Boolean retrieval systems usually do not provide a ranked output of the retrieved set of documents and neither does it provide for the assignment of weights to search terms (Hildreth, 1995).

Some of the attempts to overcome the difficulties experienced by end-users include the creation of menus that provide for command selection wherein a user only had to enter relevant search terms and optionally specify a type of search or targeted field. These type of search forms can, however, create even greater confusion to the user as the user is rarely aware of the functioning of the term combinational logic, truncation and matching functions that the systems automatically employ. The result is that the users then do not understand why their searches fail or why they retrieve large numbers of irrelevant documents. System feedback on these reasons is rarely provided (Hildreth, 1995).

The following provide an overview of best-match retrieval techniques (Joss & Wszola, 1996:36; Blacharski, 1997):

- Single term searching

  Most users, especially novice users, begin a search by entering a single term, usually a noun. This term is matched against the words in the index. This method can provide relevant results if the user has chosen the right search term. If not, the search may result in either no information or less than the complete set of relevant information available.

- Phrase searching

  This option allows users to input multiple terms and request the system to search on those terms in the precise order that they are given.

- Boolean searching

  Boolean searching is one of the most common and traditional methods of online searching. It uses inclusive operators (OR) and exclusive operators (AND, NOT) to restrict retrieval of items. This allows skilled users to conduct very precise searches. Although Boolean searching can be very effective, it is not intuitive and requires training of users.

- Truncation

  This search tactic allows for the use of special characters or "wild cards" to search for a core portion of a word and all its possible variants. Retrieval programmes can allow for pre-, middle- and post-truncation of a word stem. Truncation is a method of increasing recall by expanding the retrieval possibilities of a search.

- Proximity searching

  Proximity searching allows users to constrain word combinations by searching the text around the search term for second or third search term variants. Proximity searching functionalities include:

  - two words adjacent to one another
  - two words within *n* words of one another
  - specified words appearing in the same sentence
  - specified words appearing in the same paragraph.

Proximity searching increases retrieval precision as it restricts the number of documents to be retrieved.

- Expanded recall

  In expanded recall the database automatically searches the index for all related variants of a search term, for example: love, loved, loving, lovely. As the name suggests, this function increases recall by increasing the possible terms that can be searched for.

- Thesauri

  The database developer creates a thesaurus of terms relevant to a specific database, indicating the relationships between terms. When a searcher performs a thesaurus-based search the system automatically looks up all search terms that the database developer has deemed related to the term entered. Related to thesauri are word lists or look-up tables where the searcher is presented with a list of words from the index and is allowed to choose from among them. Thesauri and word lists are useful in instances where the searcher is not familiar with the content of the database and needs guidance in the selection of search terms.

- Phonetic look-up tables and fuzzy matching

  In instances where the searcher is unsure of the correct spelling or where errors are possible in a database, a fuzzy match will accept words as hits is they are close to the spelling of the desired word. The system therefore attempts to interpret the spelling of a word.

- Natural language syntax

  The user is allowed to enter sentences or questions in natural language and the system then scans through them and selects the search terms. When employing this function, the system may use other tactics such as phonetic look-up tables, expanded recall or thesauri. This search strategy is especially useful for novice users. Its obvious drawback is that the user has little control over the outcome of the search, especially if he/she does not understand the tactics underlying the function and employed by a specific system.

- Query by example

  Query by example allows a searcher to use a previously successful query to create a new, similar query. A searcher can also select a document, paragraph or phrase and use that to search without having to create a formal query.

5.3.1.2 Best-Match Retrieval Techniques

Best match or ranked-output systems differ from exact match systems in that they do not accept that there will necessarily be an exact match to a query, but rather strive to obtain a "...degree of closeness or similarity of a candidate item's content description to the textual query" (Hildreth, 1995). Best match systems employ various retrieval strategies such as vector space processing, fuzzy matching and probabilistic techniques. Vector-based systems "...treats each index term as a co-ordinate in an information space, so that both document and query become represented as vectors (perhaps weighted) of term values between which a similarity is computed, using a measure such as the cosine law" (Sanfilippo et al, 1998). Probabilistic techniques "...typically employ weighted term searching, ranked output, and automatic or interactive relevance feedback" (Hildreth, 1995).

Hildreth (1995) provides the following description of a probabilistic retrieval system:

"A probabilistic retrieval system ... retrieves all documents that match a query in any degree, even if the match occurs on only one word or word root (stem), infers (computes) the probability of relevance of these documents to that specific query and ranks them accordingly. The ranking algorithm orders the set or retrieved documents according to their decreasing similarity to the query".

The precise methods that different retrieval systems use to determine relevance are closely guarded trade secrets. There are, however, some general principles or ranking criteria that are followed by most systems (Notess, 1999). These include term frequency, positioning, weighting and proximity:

- Term frequency

  Although term frequency can prove very useful, it can also be misleading. Pages that contain a term many times will rank higher, but using only this approach may artificially raise the ranking of very long pages that contain many words. A more helpful approach is where the frequency of a term is compared to the total number of words in a document (Notess, 1999).

- Term positioning

  Term positioning refers to the relevance ranking a search engine places on a term in relation to its position in a document, e.g. in the title or caption, author field or metadata. Some search engines will ignore some of these areas, while other will place greater emphasis on them (Notess, 1999).

- Term weighting

  Term weighting refers to the practice of making some words more important than others. Very common words are likely to have very low weight and may even be classified as stop terms that receive no weight. Infrequently used terms will receive more weight (Notess, 1999).

- Proximity

  Proximity refers to the relative distance (number of terms in between two desired terms) between terms (Notess, 1999). It can be surmised that the closer the terms are to one another the more relevant a document will be.

As relevance can be determined by various factors, the user should be able to play an important role in guiding the system towards documents that are relevant in "the eyes of the user". Relevance feedback by the user is an important aspect of probabilistic retrieval systems as it promotes effective system performance:

"Relevance feedback may lead to a refinement or expansion of the user's query and 'fuel' the system for even better performance" (Hildreth, 1995).

5.3.1.3 Browsing And Exploratory Searching

According to Hildreth (1995) neither exact-match or best match retrieval systems takes into account "...information seeking that is not query-based ...for example many kinds of browsing or exploratory searching. Modern inter-active systems have the ability to support the kind of non-linear, trial and error thinking process found in browsing" (Hildreth, 1995). These include facilities such as hyperlinking.

Although browsing can refer to haphazard scanning of a collection it can also be a purposeful activity driven by an information need, which although ill-defined, is real (Hildreth, 1995).

Hildreth (1995) identifies three types of browsing:

- General browsing: "...random, unstructured, undirected activity".
- General purposive browsing: "...the browser does not know in advance where relevant information may turn up, but selects and scans a specific publication or set of publications on a regular basis ...to insure that nothing of likely interest goes unnoticed".
- Specific browsing: "...the searcher has a specific end in mind" but "...specifically assumes a state of mind that is open to clues and suggestions". The searcher follows clues and pointers of the system to identify information relevant to his information need.

"A good browsing tool, source or system exploits the human ability to recognise items of interest, a cognitive ability that is faster and easier that juggling concepts to specify a need and describing relevant items in advance" (Hildreth, 1995).

In conclusion, it is clear that text-based retrieval systems have very powerful search and retrieval capabilities. The main reason for this is that text-based systems have been in use for a long time and as a result have benefited from the extensive research that has been done in this field. In image retrieval system, the main drawback of text-based systems is that they have to rely solely on the metadata assigned to an image, which is often very limited. This fact again emphasises the crucial relationship between metadata and image retrieval.

5.3.2 Content-Based Image Retrieval

According to Smith & Chang (1996) the growth of digital image and video archives have increased the need for tools that effectively filter and efficiently search through large amounts of non-textual information. Due to the overhead of manual cataloguing and indexing of images, alternative options have to be considered for retrieval in large image databases.

Content-based retrieval operates in a totally different way than keyword or textual retrieval (Eakins & Graham, 1999). Content-based image retrieval refers to the creation of descriptions from the image file itself, based on the recognition and description of statistical image properties such as colour, texture, shape, spatial location, regions of interest and facial characteristics (Romer, 1995; Srihari et. al., 1999). Users search these systems by giving examples, drawing sketches, selecting visual features (e.g. colour and texture), arranging spatial structure of features, or requesting the system to find more items that are similar to previously returned items (Chang et. al., 1997; Encinas, et. al., 1999: 14).

A brief overview will be given of colour, texture and shape as primary properties for describing image content.

- Colour

Colour is an important cue for extracting information from images. Colour histograms are commonly used in content-based retrieval systems, but according to Belongie et. al. (1998) the global characterisation is poor at, for example, "distinguishing between a field of orange flowers and a tiger" because it lacks information about how the colour is distributed spatially.

Systems relying on colour indexing, often specify not only the colour content of images, but also the spatial relationships and composition of colour regions (Smith & Chang, 1996). This ensures that a greater range of image queries can be handled by a system.

There are two classes of techniques for colour indexing: (1) global colour distribution and (2) local or region colour. The distinction between these two techniques is that indexing by global distribution enables only whole images to be compared while regional indexing enables matching between localised regions within images. Both techniques are very useful for retrieval of images, but are suited for different types of queries. Global distribution is more useful when a user provides a sample image for the query. Colour indexing by localised or regional colour provides for partial or sub-image matching between images (Smith & Chang, 1996).

Although there are application areas for the recognition of colour or colour regions, these are limited. Colour identification will not assist the general and most common queries for a specific object or event in an image.

- Texture:

According to Picard (1996) texture eludes precise definition, but is usually distinguished by being tactile, patterned, rhythmic or noisy.

Examples of texture images include photographs of water, sand, a brick wall or aerial photographs of agricultural regions. Queries are performed by presenting sample textures to the system, which are then compared to texture regions in images in the system. Texture images are difficult to describe as they do not have "good structure" (Manjunath, 1995).

As with colour recognition, texture identification does have specific, limited applications areas, but will not greatly assist in common queries for specific objects.

- Shape:

The recognition of shape is an important criterion for the identification of specific objects in an image. Potential applications would include face-recognition, fingerprint-recognition, recognition of easily definable technical objects and recognition of plants and animals. The techniques for shape recognition include template matching and edge abstraction matching. In template matching the system is provided with sample objects for which templates are created. When presented with an example image in a user query, the system then compares the example to the pre-defined templates. Edge abstraction matching the system attempts to match the example shape by segmenting the edge of the image into straight-line segments. These segments are then normalised for scale, rotation and translation. The normalisation serves to enable the algorithm that has been created, match human expectations, but the "...establishment of a start location and break points for the segmentation is problematic" (Heiddorn, 1999).

Shape recognition approaches are "...weak in that they are not well matched to human performance or expectations. They do not break objects into parts or other psychologically relevant features" (Heidorn, 1999). The main problems with most shape recognition techniques are that they produce two-dimensional

> projections of three-dimensional objects and suffer from perspective dependence. The system has difficulty in matching an image not viewed from exactly the same perspective. Rotation and variations in the scale of the object can cause mismatches (Heidorn, 1999). The applicability of shape recognition systems are therefore very limited and only suitable to controlled environments in which the perspective of each image is controlled both in terms of the system template and the query formulation.

The goal of content-based retrieval is to provide algorithms that can automatically recognise the important features contained in the image without human intervention in the process (Romer, 1995). As manual cataloguing and indexing processes are so time and labour-intensive and therefore costly, content-based retrieval holds a promise for reducing time and cost. An additional advantage is that content-based methods create tools for intelligent browsing of image data.

A disadvantage of content-based retrieval is that it "...provides a relatively low level of interpretation of the image except in fairly narrow and applied domains" (Chen and Rasmussen, 1999). Content-based research is still in its early stages, therefore little is known about the actual usefulness of images accessed via content-based systems. According to Chen and Rasmussen (1999) further research is required in terms of user needs and the degree of satisfaction provided by content-based systems. There is a lack of standardisation between different systems. Each system is based on different research models. This makes browsing across systems almost impossible.

Heidorn (1999) effectively summarises the limitations of content-based image retrieval indexing:

> "Ideally, content-based algorithms that define shape similarity should behave in a manner consistent with human expectations and with the techniques that people use to define shape. The problem with content-based indexing is that current computational techniques do not have all of these properties. They tend to be effective at finding individual visual features, but the features

frequently are not the same ones that people would recognise. They also tend to be poor at integrating the features to classify or recognise more complex objects".

Various content-based image retrieval systems have been developed in the commercial and academic domains. In the commercial domain some of the more widely known systems include:

- **QBIC**

The QBIC (Query By Image Content) system is generally accepted as the best-known content-based system (Chen & Rasmussen, 1999). QBIC was developed by the IBM Corporation. It provides for the retrieval of images by colour, texture and shape. It supports both global and local classes of colour content. Because of the problems in automatically outlining objects, the extraction of local regions is handled manually by requiring a person to draw region boundaries using a mouse. Both the global and local colour information is represented by mean colour and colour histogram. It also uses a quadratic distance metric for comparing histograms, but because this is very computationally intensive, the mean colour distance is used as a pre-filter for colour queries (Chen & Rasmussen, 1999; IBM Home Page, 2000; Smith, 1996). QBIC was not designed to replace traditional keyword queries, but to complement them when keywords are insufficient when looking for images in a database. The content-based queries can be combined with keyword queries to ensure greater retrieval precision (IBM Home Page, 2000).

- **Excalibur Visual RetrievalWare**

Excalibur Visual RetrievalWare provides content-based, high-performance retrieval for multiple types of digital visual media. The system provides feature extraction, analysis, indexing and retrieval of digital images based on their colour, shape and texture. The system also allows for both the matching of sample images as well as the intelligent retrieval of images that are matched natively and not by description (Excalibur Home Page, 2000). Excalibur Visual

RetrievalWare is marketed primarily as an applications development tool rather than as a standalone retrieval package. One of its best-known applications is the Yahoo! Image Surfer which enables content-based image retrieval from the World Wide Web (Eakins & Graham, 1999).

- **Virage VIR Image Engine**

The VIR Image Engine is "...a set of libraries for analysing and comparing the visual content of images" (Compass, 2001). It uses content-based features to enable users to perform meaningful searches against "thousands of images" (Compass, 2000). The Virage system consists of a series of modules that system developers can build into their own systems allowing them to extend and customise the system. Alternatively the system can also be added onto existing database management systems (Eakins & Graham, 1999). One of the outstanding features of the VIR Image Engine system is that it "...provides a level of intuitiveness and ease of use that has long been lacking in systems set up to store and retrieve digital images (Compass, 2001).

In the academic domain research has been quite active and various systems have been developed as test beds for research initiatives. Examples include:

- **VisualSEEK**

The VisualSEEK system is the first of a group of experimental systems developed at Columbia University, USA (Eakins & Graham, 1999). It supports queries by colour, texture and spatial layout. The system provides the user with a highly functional and platform independent Java user-interface which collects the user's query. The goals of the system are automated extraction of localised regions and features, efficient representation of features, preservation of spatial properties, extraction of compressed data and fast indexing and retrieval. The user may search for images using both global and local features. The user indicates locations of colour using a query grid. The system also provides for sample matching – "give me more of the same" (Smith, 1996).

- **MARS**

The Multimedia Analysis and Retrieval System (MARS) is a project developed at the University of Illinois and is aimed at developing image retrieval systems that provide the user with a high degree of control through the use of relevance feedback. It is based on the assumption that relevance feedback is "...the only way at present of capturing individual human similarity judgements" (Eakins & Graham, 1999). Each object in the system is characterised by a variety of features. A range of different similarity measures is used to compare queries to stored objects. User feedback is then applied to adjust the weighting of features (Eakins & Graham, 1999).

- **Photobook**

The Photobook system was developed at the Massachusetts Institute of Technology (MIT) and "...has proved to be one of the most influential of the early CBIR systems" (Eakins & Graham, 1999). As in the case of most other content-based systems it aims to characterise images using features such as shape and texture. It differs from other systems in that it "...aims to calculate information-preserving features, from which all essential aspects of the original image can in theory be reconstructed. This allows features relevant to a particular type of search to be computed at search time, giving greater flexibility at the expense of speed" (Eakins & Graham, 1999). The success of the Photobook system is illustrated by the fact that its face recognition technology has been incorporated into the FaceID package from Visage Technology, used by several USA police departments (Eakins & Graham, 1999).

Some of the research areas that remain unresolved are, according to Encinas et. al. (1999: 14), deciding:

- "What visual features are the best;
- How they should be extracted, coded and compared, and
- What are the appropriate searching techniques and indexing structures"?

In conclusion it is clear that although content-based image retrieval holds promise for the future, image retrieval is a very complex issue that remains largely unresolved and therefore not yet suitable as a sole method of retrieval for image collections, especially in large general image databases.

5.3.3 Integrated Retrieval Methods

When viewed independently both text-based and content-based image retrieval approaches have several limitations. Text-based retrieval provides for access to concepts and contextual information, but is not as powerful in the provision of access to image content. Content-based retrieval can compute general similarity between images and thereby provide access to the image's content, but cannot provide access to concepts (Srihari et. al., 1999). A solution to the limitations of these approaches would be a combination of both, thereby allowing the searcher much more scope and flexibility in searching. The one system would therefore complement the capabilities of the other (Chang & Smith, 1997; Chen & Rasmussen, 1999).

In an integrated system the user would have the option of using the retrieval approach that would best suit his needs. An integrated system will be able to handle requests for images based either on subject content or on their visual content.

In an attempt to integrate the two approaches, but at the same time limit the manual indexing effort, some systems use the information in the captions to photographs to assist in the interpretation of the images. Successful research in this regard has been done in the retrieval of captioned newspaper photographs (Chen & Rasmussen, 1999): "Captions place constraints on the photographs, which help in identifying their content and the location in the image of the objects or individuals; however this information can often be interpreted in the context of world knowledge, since human viewers are expected to recognise, for instance, President Clinton or differentiate between Mr. and Mrs. Smith without spatial information".

Similar research has been done by Paek et. al. (1999) that has proven that an integrated approach that combines image-based and text-based approaches for scene classification, achieves much higher classification accuracy than any individual approach. They have also determined that subject navigation and browsing are the most popular searching techniques of users of interactive retrieval systems: "Users usually first browse through the subject hierarchy to get general ideas about the collection and then issue specific queries using keywords, visual features, or a combination of both."

As substantial research is still required in the field of content-based retrieval, an integrated system would be an ideal option. Such a system would be able to provide the basic visual retrieval capabilities of content-based retrieval, but would also be able to rely on text-based retrieval as an approach that has been tried and tested over many years.

5.4 EVALUATION OF RETRIEVAL SYSTEMS

An information retrieval system is most commonly evaluated for the purpose of determining its capabilities and weaknesses, in order "...to lead to improvements in the information retrieval process, both at a particular installation and more generally" (Tague-Sutcliffe, 1996:1).

According to Lancaster and Warner (1993: 162) an evaluation of the effectiveness of an information retrieval system is a study of the extent to which a system meets the expressed needs of its users. Tague-Sutcliffe (1996:1) takes this viewpoint further by stating that evaluation of retrieval systems is concerned not only with the needs of actual users but also potential users, and not only in individual cases, but also collectively, in the community.

The evaluation of information retrieval systems has been the topic of active research for more than forty years. During this time one major issue that has come to light, has been the lack of agreement about the characteristics of the information retrieval process (Tague-Sutcliffe, 1996:1). In addition to this, Tague-Sutcliffe (1996:1) has also identified six issues, which he poses as questions, most important to research in information retrieval evaluation:

- Should information retrieval experiments involve real users with real information needs?
- Must information retrieval evaluation involve actual retrieval processes?
- What kind of aggregation is appropriate in evaluating different retrieval systems?
- What can analysis, as opposed to the experimental or qualitative collection of data tell us about information retrieval systems?
- How can interactive retrieval systems be evaluated?
- How generalisable are the results of information retrieval test?

From the above questions it is clear that there are various aspects that need to be taken into account and debated before the evaluation of a retrieval system can even begin. Without clearly defining the point of departure, scope and criteria to be applied, the results of an evaluation will have limited use for the system evaluator (which can vary from an individual or group of users, the system developer(s) or an academic researcher).

5.4.1 Criteria for the Evaluation of Retrieval Systems

Information retrieval systems can either be evaluated by themselves or in relation to "...the people involved in creating and operating it" (Lancaster & Warner, 1993: 171). Evaluation is also usually comparative in the sense that the performance of two or more systems is compared to one another against a set of pre-defined criteria.

When evaluating retrieval systems, there are various aspects that can be highlighted such as the degree of assistance in formulating queries, the speed of retrieval, the presentation of documents and the ability to find relevant documents (Croft, 1998).

Table 10: Criteria for the Evaluation of Image Retrieval Systems

CRITERIA FOR THE EVALUATION OF IMAGE RETRIEVAL SYSTEMS	
CRITERIA	**DESCRIPTION / MOTIVATION**
User Needs	▪ To successfully design an image retrieval system, it should be based on the user requirements of the target group. According to Danziger (1990) emphasis should be placed on the unique system requirements of each target group. Should needs differ considerably, the varying needs should be given relative priority. No system could be expected to meet all user needs. ▪ Both current users and uses and anticipated future users and uses should be considered when completing an analysis of user requirements (Besser & Trant, 1995). The inability of an organisation to forecast their future requirements accurately will result in costly changes to an existing system in future (Miller, 1985). ▪ The role of the system designer or analyst is to "...strike a balance between many end-user needs to find a system solution that satisfies the most important needs at a cost the organisation is willing to pay" (Danziger, 1990).
Recall and Precision	▪ Retrieval effectiveness is mainly measured by determining the precision and recall ratio of systems. As recall is problematic to measure, system evaluators do not attempt to measure total recall, but rather use recall to compare two different systems by defining relative recall. Relative recall is determined by comparing the number of documents retrieved in system A to the number of

CRITERIA FOR THE EVALUATION OF IMAGE RETRIEVAL SYSTEMS	
CRITERIA	**DESCRIPTION / MOTIVATION**
	documents retrieved in system B (Rowley, 1992). It is therefore not required to determine the total number of relevant records in a system. To effectively compare the retrieval effectiveness of two systems, it is important that the content of the databases be identical. If not, relative recall will be measured in terms of the database content and not retrieval capabilities of each system.
Search Strategy	▪ The preparation of a search strategy is a fairly complex process, involving conceptual analysis and translation. The first step involves the analysis of a request to determine what a user is really looking for and the second step involves the translation of the conceptual analysis into the vocabulary of the system. This second step is the search strategy, which can be regarded as a "request representation" (Lancaster & Warner, 1993: 9). ▪ The ability of a retrieval system to translate a user's request into a search strategy is a very critical measure of the system's retrieval effectiveness. During the evaluation process it is therefore important to determine the extent to which search strategies can be devised in a specific system to meet the requirements for either high recall or high precision. ▪ The search facilities should provide for a broad spectrum of information seeking behaviour needs - not all users seek information in the same way. Some users such as information specialists, prefer a system with advanced Boolean search capabilities enabling them to precisely define their information need. On the other end of the spectrum certain users will not be in a position to exactly define their information need and will therefore prefer to browse through broad categories of information and follow the clues provided by the system in the hope that they will find something useful. ▪ Search strategy formulation is the main gateway to the content of a database. The more powerful the search capabilities the more flexibility the user will have to provide for either a broad (high recall) or very specific (high precision) query.

CRITERIA FOR THE EVALUATION OF IMAGE RETRIEVAL SYSTEMS	
CRITERIA	**DESCRIPTION / MOTIVATION**
Text Retrieval	▪ An image retrieval system based on textual representation of the images, will be evaluated in terms of the sophistication and flexibility of its textual retrieval capabilities. A good text retrieval system should provide for exact-match, best-match, as well as exploratory retrieval techniques. (See the overview of these techniques under paragraph 5.3.1: Text-based Image Retrieval).
Content-Based Image Retrieval (CBIR)	▪ A sophisticate image retrieval system should provide content-based image retrieval capabilities. Specialised databases requiring the identification and extraction of specific image features, such as texture, can rely on retrieval capabilities based solely on content-based image retrieval techniques. General databases consisting of diverse categories of images and catering for the information needs of a diverse client group, should preferably combine textual and content-based techniques. ▪ The basic retrieval techniques that a content-based system should provide for is discussed in paragraph 5.3.2: Content-based Image retrieval.
Display of Search Results	▪ Rappoport (2000:75) emphasises the importance of the display of search results to enable browsing: "Displaying the search results and the order in which your search engine ranks its results, is critical to a good search experience". In text-based systems the display of search results includes both the browsing of indexes, for example authors and subjects, as well as result lists. The user should be given the option of determining the detail in which results are displayed. ▪ A good search engine should provide customisation features that will allow a searcher to arrange results in a clear and useful manner. Result lists should provide sufficient information that will enable the searcher to determine relevancy. According to Van House et. al. (1996) only non-redundant

CRITERIA FOR THE EVALUATION OF IMAGE RETRIEVAL SYSTEMS	
CRITERIA	**DESCRIPTION / MOTIVATION**
	information should be displayed: only the metadata that provides the most useful information to the user. ▪ In content-based systems, result lists are displayed graphically. The size of image files tends to be extremely large. Even with access to very high-speed networks it is often impractical to transmit images at their highest resolution and therefore in their largest file size. A simple solution is to maintain low resolution, small file-sized thumbnail images. While thumbnails consume storage space, this overhead is insignificant compared to the advantages obtained from their use (Manjunath, 1995). Thumbnails allow fast browsing of search query results to determine relevance. The provision of a facility for thumbnail browsing can reduce the need for in-depth indexing of small collections (Baxter & Anderson, 1996). ▪ When developing a retrieval system it is important to consider in what format the information will need to be presented (Blacharski, 1997). This is especially important in image retrieval systems, as a search engine will have to cater for all possible image formats that could be accessed via the system. The user should have the option to specify in what format images are to be displayed. This option can be exercised either before defining a search query or when presented with the search results. ▪ In integrated systems, browsing should provide the option of browsing textually, graphically or as a combination of images and textual description. The last option allows for the greatest level of specificity in determining relevance of search results.
Relevance Ranking	▪ Although relevance ranking forms part of the display of search results, it plays such an important role in determining retrieval effectiveness, that it is justified to identify it as specific criteria for evaluation.

CRITERIA FOR THE EVALUATION OF IMAGE RETRIEVAL SYSTEMS	
CRITERIA	**DESCRIPTION / MOTIVATION**
	▪ As most search engines order their results according to relevance, it is important that the user knows what criteria were used to determine the relevance ranking. Search engines should therefore provide information on the relevance algorithms that they use to enable the searcher to correctly interpret the results (Rappoport, 2000: 75). The user should also be provided with the flexibility to manipulate the ranking order of results.
System Feedback	▪ With image queries it is not always clear why queries produce irrelevant results. Unlike with text searches in which the user can see the features (words) in a document, content-based image retrieval systems do not allow the user to see exactly what the system is looking for in a response to a similarity-based query. Without realising that the input image was not properly processed, "…the user can only wonder what went wrong" (Belongie, et al, 1998). In content-based systems, system feedback could be enhanced through the display of the system's representation of the submitted image with the returned image.
Browsing	▪ An effective retrieval system should provide for browsing. There will be many occasions where a user will approach a system without any specific need in mind, but wishing only to be able to select items at random. According to Foskett (1982:29) a user should be able "…to follow a casual train of thought as well as a planned search". This is true for both text-based and content-based systems. In content-based systems, the provision of graphical clues and comparative image links, could greatly assist the user in his search process". ▪ The advent of the Internet have familiarised even inexperienced users to the potential of hypertext and related record searching. Even without being able to precisely define their information need users expect a retrieval system to provide them with possible clues and options that will enable them to investigate various options and through this process also identify information that could be of use and relevance to their need, no matter how vaguely defined.

CRITERIA FOR THE EVALUATION OF IMAGE RETRIEVAL SYSTEMS	
CRITERIA	**DESCRIPTION / MOTIVATION**
User Interface	▪ The user interface provides the link between the user and the system. According to Philip, et. al. (1994) users evaluate retrieval systems judged mainly on the "perfection" of the user interface. ▪ There are basically three types of user interfaces: command-driven, menu-driven and graphical user interface (GUI) (Hildreth, 1995). GUI's use image to represent certain options or functions. In addition, windows divide the screen into functional sections and point and click devices provide for manipulation (Hildreth, 1995). Although it is widely accepted that GUI's are easier to use and enhance access, Hildreth (1995) warns that too much graphical detail can result in complexity that "...may place unreasonable demands on the user". ▪ Retrieval software should provide users with an intuitive, easy to use interface and conveniences such as query-by-example (Blacharski, 1997). The utilisation of tools that aid simplicity and user-friendliness, such as menus, buttons, and a Windows or World Wide Web browser interface, should be considered when evaluating a retrieval system. As much keying by users as possible should be eliminated to prevent typing errors and resulting retrieval ineffectiveness (Van House, et. al., 1996). ▪ A single user interface will rarely satisfy the entire range of users (Arms, 1996). Retrieval systems should provide for the needs of both novice and advanced users. Novice users may require more guidance and should not be confused by too many options (e.g. query fields). Advanced users who are familiar with the content of the collection and possess advanced retrieval skills, will require the ability to formulate their own queries and would not want to be limited to specific fields (Van House, et. al., 1996).
Ease of Use	▪ The user's perception of a system plays a very important role in the evaluation of a system. If a user is frustrated or has difficulty in using a system, he will prefer not to use the system. According to Joss and Wszola (1996: 48) the best

CRITERIA FOR THE EVALUATION OF IMAGE RETRIEVAL SYSTEMS	
CRITERIA	**DESCRIPTION / MOTIVATION**
	retrieval system is one that provides "...quick, complete, and relevant information retrieval with a minimum of frustration to the user". ▪ A user-oriented system should provide online assistance through both a general and a function-specific help function. The user, and especially the novice user, should be guided in using the system (Anderson, 1991).
Cost-effectiveness	▪ Cost-effectiveness refers to the relation between a level of performance of a system and the costs involved in achieving it. When evaluating cost-effectiveness, both fixed costs and variable costs need to be considered. Fixed costs include aspects such as computer hardware purchase or rental, developmental costs, and costs involved in the acquisition and indexing of the present database (Lancaster & Warner, 1993: 189). ▪ There are also other, less tangible cost considerations such as the effort involved in learning how to use a system; the effort involved in the actual use of the system and the effort involved in retrieving images (directly from the database or via document-delivery systems) (Lancaster & Warner, 1993: 161). ▪ According to Foskett (1982: 29) cost-effectiveness can be improved by improving the relevance of a system: reducing the number of unwanted documents revealed by a search will also reduce the time and effort needed to scan through them to identify relevant documents. However, if it costs more to develop a very sophisticated and advanced system than scanning through an unsophisticated system, there would be no point in developing the advanced system.

5.5 CONCLUSION

Retrieval is the final and crucial step in the process of providing electronic access to photographic collections: "The challenge of providing online access to visual materials goes far beyond the process of digitisation" (Arms, 1999). It is of little use if a collection is digitised, but no effective mechanism exists for the retrieval of specific relevant images. Although any electronic access is better than none, the demand for images is increasing and becoming more sophisticated. Basic retrieval functionality is not good enough - accessing images via a few pre-defined keywords is not sufficient. Additional facilities such as "image browsing, free text retrieval and basic content-based retrieval mechanisms" are becoming pre-requisites for effective image retrieval (Arms, 1999).

As users become more computer- and information-literate, they become more demanding in their requirements. Where in the past retrieval systems were evaluated by information professionals, end-users are starting to play a much more active and informed role in the retrieval process - both on a formal and informal level. As a result acceptance of image databases will depend on their convenience, speed of access and degree of user control (Kenny, 1995).

A study of the principles of information retrieval and specifically image retrieval clearly indicated that there is a very definitive relationship between retrieval and metadata. The more in depth the metadata process the more access points are created, providing for more effective retrieval. The role of metadata as a key to retrieval will continue to be critical for many years to come.

Although the need for content-based image retrieval is widely recognised, research is still required in this field before content-based retrieval will be a viable option: it would seem that currently the best solution would be to combine content-based and text-based approaches into an integrated system, thereby ensuring that the inadequacies of the one will be complemented by the advantages of the other.

In the ensuing two chapters, the principles found in this and preceding chapters will be compared to practice through a case study and evaluation of the digitisation project of the MuseumAfrica.

CHAPTER 6

CASE STUDY: DIGITISATION PROJECT OF THE MUSEUMAFRICA

6.1 INTRODUCTION

The purpose of this case study is to determine how the various aspects involved in the digitisation of photographic collections are applied in practice. In the next chapter the applications as detailed in this chapter will be evaluated.

MuseumAfrica (hereafter referred to as the Museum) was chosen as the subject of the case study for various reasons. It contains one of the largest photographic collections in Africa. In 1995 the Museum launched a project to digitise their photographic collection and computerise the collection management and documentation processes. The fact that it is a very current project was an indication that the Museum would possibly utilise recent technological developments in the field of imaging.

6.2 METHODOLOGY

A personal interview was conducted with the Curator Documentation at the Museum, who is primarily responsible for the digitisation project of the Museum. The interview was structured according to a pre-defined questionnaire (attached as Appendix A). The questionnaire was compiled according to the following broad categories:

- Project planning and definition

- Capturing and enhancement
- Storage and file formats
- Metadata
- Retrieval

As the purpose of the questionnaire was to elicit as much information as possible about the Museum's digitisation project, most questions were phrased as open-ended questions.

During the interview the questionnaire proved to be very useful, serving to direct the interview in such a manner as to ensure that all-important aspects were covered.

In addition to the questionnaire the Curator also provided documentation compiled during the planning process of the project, which detailed issues such as user specifications and system criteria.

6.3 BACKGROUND TO THE DIGITIZATION PROJECT OF THE MUSEUM

6.3.1 Historical Perspective to the Collection

The collection consists of a total of approximately 750 000 records. Of these the photographic collection comprises approximately 350 000 images. All other objects, however, need to be photographed (often from various angles) for documentation purposes, resulting in a collection of more than a million images.

Traditionally the accessibility of the photographic collection has been very limited. Because each photograph can only be in one physical place with one subject classification number, many images, which might prove to be of crucial interest in one field, are not retrievable because they have been classified as pertinent to something else. This unsatisfactory arrangement of what is one of the most significant photographic collections in Africa, is the result of insufficient staff and insufficient time to follow the whole manual documentation procedure for each of several hundreds of thousands of photographs.

6.3.2 Origin of the Digitisation Project

In 1995 it was established that the Museum urgently needed a computerised documentation system. The main reasons were:

- The Museum owns collections which are very large (documentation involves 750 000 records plus images), varied (objects, photographs, works of art, documents, etc.), valuable and which are consulted by researchers, publishers, universities, film and televisions companies world wide.
- All documentation, including the indexing, was done manually with a card catalogue that referred the searcher to original photographs. This resulted in slow generation of records, slow access to records, searches that involved a very great deal of professional time and records, which were not user-friendly to the broader public user.

These problems led to the formulation of the following vision:
"We have a vision of a digital system which will impact on all the traditional museum functions of preservation, research, publishing, education and exhibition making, and take museum documentation far beyond just record keeping and collections management. We anticipate a much broader user base, both researchers and the browsing public, able to help themselves to information, in both standard and stimulating new multimedia formats" (De Wet, 1997:1).

A strategic planning decision was taken by the curators of the Museum during 1995 that top priority was to be given to the establishment of a computerised system for the digitisation and documentation of the Museum collection. A further decision was taken that all available funds for computerisation should be applied to the acquisition of the most powerful, thesaurus-assisted database management software available.

6.3.3 Scope of the Project

The project consisted of two dimensions:

- The establishment of a database for management and retrieval purposes, and
- The digitisation of the collection, including both photographs and objects.

The project was divided into three phases:

- Research: Determining user requirements and system specifications and evaluating available commercial systems.
- Digitisation of the collection.
- Establishment of the database and creating records in the database (including the transfer of legacy data).

The second and third phases are running concurrently and their completion is seen as long-term objectives.

6.4 THE DATABASE

The first phase of the project was to investigate relevant database software. As a point of departure the following guiding principles were established:

- The choice of the software must be driven by the Museum's documentation needs and not by any other consideration, and
- The software chosen must have proven itself over years in museums in South Africa and/or overseas.

6.4.1 Database Requirements

Taking the above principles into account, the following specific criteria were identified that would meet the diverse needs of the Museum and its clients:

- It had to be a leading edge product that was tried and proven in the museum environment;
- The manufacturer had to have a commitment to ongoing software development;
- The product should have local support;
- The system should be customisable and easy to maintain by non-technical staff;
- The system should be able to handle large volumes of data, including images;
- It should be able to support international museum standards;
- It should be easy to learn, use and administer by the public and professionals alike;
- A graphical user interface was essential;
- It should be stable with good security levels;
- It should be capable of networking on PCs and over the Internet;
- The system should be capable of working with the large storage system that will be necessary to store images of the Museum's total collection (estimate - 360 gigabytes).

6.4.2 System Choice

Various software packages were evaluated against the list of pre-defined criteria. One of the major limiting factors in the identification of suitable software was the size of the Museum's collection. Many popular packages such as DataEase and InMagic could not handle records of this scope. Most GUI packages were severely limited in field length and in the amount of tailoring that could be done to input screens. After evaluation it was concluded that Cuadra STAR met the defined criteria far better than any other system. The main reasons were:

- Cuadra Associates has been in successful operation since 1978 and due to their specialised focus on database management software are regarded as leaders in the field.

- STAR is widely used by museums and archives world-wide. Various large South African users were also identified. Internationally users included the Museum of Modern Art, the New York Public Library and various Getty Foundation projects.

- The software is excellently supported locally - the quality of the support was attested to by local users.

The Museum purchased the STAR/Museums module, which is a set of applications specifically, designed for museum collections management. It consists of various sub-modules or applications that cover the whole range of museum management processes, such as accessioning, inventory management, cataloguing support, conservation management, and exhibits management and disposal control. It also allows for descriptive data records to be linked to related images, objects text files, etc.

The STAR system has a graphical user interface, and although sophisticated in its collection management capabilities, is easy to use and maintain. It is possible for Museum staff to customise screens, fields and reports without the assistance of computer programmers.

6.5 CAPTURING AND ENHANCEMENT

The goal of the imaging part of the project was to create "...small on-line images for searching on in the database, a high quality image for stable preservation and suitable images for the variety of requests we get from the public for reproductions" (De Wet, 1997: 2).

It was important that the digitisation process would be able to capture an image in such a manner as to match the original or even improve on the quality of the original object, whether photograph, painting or artefact. There were various issues that therefore needed to be considered, such as the matching of the colour on a painting, clearly reproducing small identifying marks on objects, etc.

6.5.1 Digitisation Requirements

The following requirements were pre-defined for an imaging system that would meet the needs of the Museum, its collection and the potential users. The imaging system should be able to:

- Handle input of variable formats (photographs, paintings and 3D objects);
- Provide a true image that matches the original;
- Provide for both low and high resolution images;
- Automatically identify each image by including identification text (accession number) on each captured image;
- Be loadable to UNIX hard drive for access via the STAR system;
- Link to the STAR database for searching;
- Be as simple and quick as possible to capture;
- Be able to capture a watermark on captured images;
- Be written to archival storage media for preservation purposes.

6.5.2 System and Process Choices

After investigation a decision was made to purchase the Kodak Digital Conversion System 1200, backed by a digital camera.

The system includes a film scanner for 35mm film and slides and a flatbed scanner to convert larger format film, prints and artwork. The scanner, which is standard with the system, scanned at too low a resolution for the needs of the Museum and was replaced with an Agfa Duoscan scanner, with a dpi of 2000x1000. A Kodak DCS 460 digital camera is used take photographs of objects. In total, this equipment has proven to be a solution to the Museum for fast, high quality input.

Image management and enhancement to scanned images are done, if need be, in the PhotoShop software. The main aim of enhancement is to achieve a close match to the original or in instances where the quality of an original photograph has deteriorated, to improve on the original, by "...recovering detail in faded sepia prints, removing tears and scratches, cloning lost areas and improving on colour quality" (De Wet, 1997: 3).

6.5.3 Lessons Learnt

The capturing and enhancement aspects proved to be the most daunting of the whole digitisation project, for the following reasons:

- The Museum was the first implementation of the Kodak system in South Africa. Although indicating that they were at the forefront of technology in the field, it also had its drawback as no local expertise could be borrowed from other institutions that had experienced similar problems.

- The staff had very little technical experience and it took them almost a year to fully master the technology and streamline the process.

- Available training in terms of the enhancement (Photoshop) was aimed at graphic designers and not at archivists. The terminology and concepts relating to scanning and enhancement were unfamiliar to the personnel of the Museum. A whole new field of expertise had to be mastered by the personnel involved in the project.

- The colour management proved to be quite problematic and had to be solved on a trial and error basis, wasting valuable time and effort.

- Personnel also had to learn the basics of digital photography and the crucial effect of correct lighting on the captured images.

In addition to the above, the Museum had, and still has, serious staff shortages. Although an easy solution would have been outsourcing, this was not an option due to budgetary constraints. The Museum, therefore, had to accept the fact that the digitisation process would be a long-term project. They have managed this drawback by prioritising the collection to be captured according to criteria such as collections required for exhibitions, collections that have the greatest historical significance and collections most frequently requested by users.

6.6 STORAGE AND DATA FORMATS

6.6.1 Storage and Data Format Requirements

As the images of the museum are used for diverse needs, this has to be accommodated at the point of capturing the images. A chosen system would have to provide for the storage of images in various data formats and resolutions:
"No one pixel-per-inch (ppi) count is suitable for all uses to which an image may be put and better quality is achieved if one makes provision at the inputting stage for eventual output need e.g. a thumbnail on a database must be a small file size for easy loading, and need be no more than 72 ppi, as this is needed to avoid pixellation" (De Wet, 1997: 3).

The storage media would have to be stable and suitable for archival purposes, ensuring the longevity of the images. One of the aims of the digitisation project has been to ensure that original artefacts need never have to be accessed for purposes of research or copying. The digital image that is retrieved as a result of a search on the database should be sufficient for the needs of the user.

6.6.2 System Choices

The Kodak Digital Conversion system 1200, chosen as the solution for the digitisation process, includes a disk writer that writes images to Kodak Portfolio II Photo CD disks. This fact was one of the major attractions of the system for the Museum as it "...automatically saves in a hugely compressed format in five visually lossless resolutions, with good colour control, accessible across computer platforms. The final file, with its 'image pack' of five resolutions, is saved in a file of only 4.5 MB" (De Wet, 1997: 3). It was therefore a logical decision that PhotoCD would be used for the storage of the images. One CD can store up to 100 images. The disks allow for multi-session capturing. According to research done by the Museum, this file format is widely endorsed by compact disk writers and imaging software worldwide.

Photo CD disks are suitable for archival storage. The Photo CD disks include properties not found on ordinary writable disks, such as coatings to protect against damage from light, temperature, humidity and fingerprints. Each disk also has a unique, machine-readable identification number.

6.6.3 Lessons Learnt

Original photographs and images now require much less handling as requesters are supplied with either an image on compact disk, in a choice of five resolutions, or a hard copy print made on a dye-sublimation printer. These options are much faster and cheaper than using a photographer and almost no quality is lost in the process.

6.7 METADATA

6.7.1 Historical Approach to Metadata

The historical connection between the Museum and the Johannesburg Public Library has benefited the Museum in terms of guidance in the allocation of metadata: "Our close connection with the Johannesburg Public Library and its trained librarians benefited the Museum: at a time when museums paid little attention to cataloguing their collections, the Africana Museum was guided into very systematic record keeping, along library lines" (De Wet, 1997: 1).

Traditionally the Museum has used a manual documentation system, which consisted, in addition to the accessions registers, of a Dewey Decimal Classification (DDC) subject card catalogue, subject index, location card catalogue and an additional notes file by accession number. In the case of more recently acquired items, a visual, black and white contact print image of each object was stapled to its subject card. Three branch museums maintained independent but similar systems. The photographic collection was not stocked and has therefore not been accessioned. Photographs were only classified according to DDC and stored in DDC number order. There is no record of each individual item, nor can they be retrieved by donor. Each item can only receive one subject classification.

Although the Museum has had a very workable system, no records are suitable for automatic copying into the new system. In all instances the collection will have to be re-catalogued.

Regarding the photographic collection the main purpose of the computerisation process was to improve access to the collection.

6.7.2 Metadata System Requirements

The Museum had a need to deal not only with object description, but to also combine many different types of data, such as contextual and associated information about people, places and events and also enable links to other artefacts, photographs, text, etc. This data needed to be combined into one consolidated, detailed record, with a large number of fields of unlimited length. A suitable system was also needed that would cater for both structured and free text. All this had to be displayed on one screen and also had to include a digitised image of the original. Data also had to be validated instantly and checked against authority lists.

In short, the following requirements were identified as crucial for a system that would meet the Museum's metadata needs:

- A large number of input fields must be available;
- Input fields must not be limited in length;
- Free text entry in some fields must be possible;
- There must be a variety of image storage and retrieval capabilities;
- There must be thesaurus support and the capability of checking input against a large number of authority files;
- The input process should not be cumbersome and overly time-consuming;
- The system should guide less experienced personnel in the creation of standardised metadata records.

6.7.3 System and Process Solutions

The Cuadra STAR system, chosen as the Museum's database solution, easily met all their metadata management needs.

STAR/Museums makes provision for the allocation of metadata according to twelve broad categories:

- Identification

Record type; object summary; curator responsible; museum collection; credit line; title; title notes (e.g. "identified by donor"); series; assigned number.

- Production

  Searchable dates of production; geographical production location; information about artist/maker; cultural information.

- Acquisition sources and rights:

  Details of the acquisition of the photograph; usage restrictions; reproduction rights; etc.

- Subject description:

  Index terms; a narrative subject description (context); an iconographic description (a description of that which is seen in the image) and an object summary (short descriptive title).

  Index terms are categorised according to subject type: identity, describe and interpret. The system also allows for the allocation of AAT Thesaurus terms.

- Physical description:

  Materials and/or techniques used; a general physical description; dimensions/size and marks.

- Associations/use:

  Personal associations; historical and/or military associations and collector/site associations.

- Reference/exhibition

  Exhibition details.

- Provenance:

  Details of current and previous owners.

- Acquisition Sources/Rights:

  Acquisition details; credit line information; reproduction rights.

- Finance:

  Details of all costs involved in the acquisition of the artefact.

- Inventory control:

  Location of object.

- STAR housekeeping:

  Administrative information.

6.7.4 Example of Applied Metadata Principles

In order to illustrate how metadata principles are applied in the Museum, an example is provided of a photograph with its supporting metadata.

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Number PH1999/83

Table 11: Case Study: Example of Metadata

METADATA Example: Picture, Portrait of Captain Jamadar Naweb Khan in uniform		
Category	**Field**	**Metadata Entry**
Identification:		
Department/Name/Type	Object Summary	Picture, Portrait of Captain Jamadar Naweb Khan in uniform
	Curator Responsible	Photographic Archive
	Credit Line	MuseumAfrica, Johannesburg
	Object Name	Picture
Title/Series/Patent	Object Title	Portrait of Captain Jamadar Naweb Khan in uniform
	Title Type	Iconographic
	Title Language	English
	Title Notes	Identified by donor
Assigned Number	Object Number	PH1999/83
	Number Type	Accession
	ID Number	E1995: 476
	Number Type	Entry
Object Production/Dates:		
Searchable Dates	Century/Time Period	Early 20^{th} C.
	Date Range for Production	1900/00/00 - 1925/12/31

METADATA Example: Picture, Portrait of Captain Jamadar Naweb Khan in uniform		
Category	**Field**	**Metadata Entry**
Artist/Maker	Production Role	Photographer
	Name/Group/Collaborative	Unknown
	Continent	Africa
	Country	South Africa
	State/Province	Gauteng
	City/Municipality	Johannesburg
Subject Description:		
Index Terms	Subject Type & Museum Subject Term	Identify: Khan, Jamadar Naweb Describe: Uniform, Indian army Interpret: South African War 1882-1885
Description	Subject Description/ Narrative	Captain Jamadar Naweb Khan was born about 1859 and died on 11/8/1939 at his home at 384 Main street, Fordsburg, Johannesburg. He is buried at the Braamfontein cemetery. He joined the Indian army at 13. He served …
	Iconography	Frontal three-quarter view, dressed in the uniform of the Indian army: tunic and riding breeches…
Physical Description:		
Material/Technique	Category/Descriptor	Technique: Photography Medium: Print Colour: Black and white

METADATA Example: Picture, Portrait of Captain Jamadar Naweb Khan in uniform		
Category	**Field**	**Metadata Entry**
General Description	General Physical Descriptor	Yellowed with age, some scratches and torn edges
	Facture	Black and white silver nitrate photographic print
Dimensions	Dimension	Height: 140 mm Width: 95 mm
Marks	Marking on Object	Cpt J H Khan
	Mark Type	Inscription
	Technique	Handwritten in pencil
	Position on Object	Back
Associations/Use: **Personal Associations**	Association	Sitter/subject
	Name/Group	Khan, Jamadar Naweb
	Unique ID	ADAM
	Continent/Country/ State/Province/ City/Municipality	Africa: South Africa: Gauteng: Johannesburg
	Date/Time Period	19^{th}-20^{th} C; c.1859 - 11/8/1939
Provenance: **Owners**	Owner	MuseumAfrica

METADATA **Example: Picture, Portrait of Captain Jamadar Naweb Khan in uniform**		
Category	**Field**	**Metadata Entry**
	Unique ID	Khan1
	% Owned	100%
	Owned From/To	1989/05/08 -
Previous Owners	Previous Owner	Khan, Mr A
	Unique ID	Khan1
	% Owned	100%
	Owned From/To	1939/08/11 - 1989/05/08
	Note/Remarks	Son of sitter JH Khan
Acquisition Sources/Rights: **Acquisition**	Acquisition Method	Gift
	Date	1989/0508
	Authority	Acq. Committee
	Primary Acquisition Source	Khan, Mr A
	Source Note/ Remarks	Son of sitter JH Khan
Entry/Credit	Entry Reason	Gift

METADATA Example: Picture, Portrait of Captain Jamadar Naweb Khan in uniform		
Category	**Field**	**Metadata Entry**
	Date	1989/05/08
	Authority	Curator
	Deposited by…	Khan, Mr A
	Credit Line	MuseumAfrica, Johannesburg
	Restrictions on Use	None
Reproduction Rights	Reproduction Rights Owner	MuseumAfrica
	Unique ID	Muse1
	% Owned	100%
	Credit Line for Reproductions	MuseumAfrica, Johannesburg
Inventory Control (Object Only): **Normal Location**	Date	2001/03/29
	Building	MuseumAfrica
	Storage Room/ Gallery/Area	Photo Store

6.7.5 Lessons Learnt

The new system heralded a whole new approach to metadata in the Museum. The aim of the indexing process has shifted from creating at least a catalogue entry to a photograph or collection of photographs, to providing a full metadata record for each image. The result of this has emphasised the need for a customised thesaurus that would cater for localised subject matter. The decision was made that an international thesaurus such as the AAT would have to be customised by personnel of the Museum.

Although the system did not improve the process in terms of the time and labour needed for the analysis of each photograph in order to be able to describe it, it does save a lot of time and effort in terms of manual processes such as the creation, referencing and filing of catalogue cards.

The system also provides an immense benefit to the Museum in making the collection more accessible and user-friendly.

6.8 RETRIEVAL OF IMAGES

The retrieval aspect of the system has to cater for the varying needs of a diverse user group: Museum personnel (documentation staff, curators and in-house researchers) and the public (academic researchers, ad hoc researchers, the media, etc.). The system, therefore, had to make provision for the retrieval needs of both novice and experienced users.

6.8.1 Retrieval Requirements

The most important requirements were the following:

- The system must be able to develop and run a number of interlinked, extremely large, relational databases.

- The system must support sophisticated and varied search techniques via a graphical user interface.

- Free text fields must be fully searchable.

- The software must support image storage and retrieval together with the text record.

- Search interfaces should be provided for both novice and expert users.

- Online help should be available to users.

6.8.2 System Choices

The retrieval capabilities of the STAR system proved to meet the requirements of the Museum adequately and it was therefore not necessary to consider the purchasing of a separate retrieval system.

The interface of the STAR system is windows-based with a navigation bar for retrieval that includes links to search; browse; view a record; show terms (thesaurus) and online help.

The retrieval system provides for both novice and experienced users by providing search options for either an "assisted search" or and "expert search". The assisted search is based on a template that can be customised by the system administrator. The assisted search template provides for retrieval based on basic bibliographic information such as Object Name; Object Title; Subject; Artist/Maker; Style/Period/Group/Movement; Production Location and Production Dates. The expert search allows the user to enter his/her own search fields and Boolean operators and to also combine various search strings with one another.

6.8.3 Lessons Learnt

As the process of populating the database has only recently started and only a limited number of records have been created, Museum personnel cannot as yet make an evaluation of the retrieval effectiveness of the system in terms of large volumes of data.

Personnel who have used the system for retrieval purposes find it to be user-friendly and especially like the option of being able to choose between a novice and expert search mode. Unfortunately as the system has not yet been launched for use by the public, a broader based assessment of usability by persons who are unfamiliar with the collection and system could not yet be obtained.

6.9 CONCLUSION

As with any new system, it can be expected that there will some stumbling blocks that have to be overcome. In the case of a digitisation project such as the one undertaken by the Museum, this is even truer: they have entered a new era of collection management and have had to master a range of new technologies and processes along the way. Some of the stumbling blocks that were, and to certain extent are still being experienced by the Museum in the implementation of their digitisation project, include:

- Lack of local expertise
  The digitisation project of the Museum was one of the first large digitisation projects to be launched in South Africa. This was a major drawback as there was little local expertise to borrow from in either the planning or

implementation phases of the project. Expertise was mostly obtained from similar international institutions although at the point of implementation, most problems were identified and solved through a trial and error process - an effective, but unfortunately very time-consuming way of obtaining expertise.

- Non-technical staff

  Although staff were experienced in museum collections management, they did not have previous technical experience of either the hardware and software involved in the digitisation process. The learning curve needed was a very integral part of the planning and especially the implementation phases of the project.

- Size of collection

  The size of the collection limited the technical solutions available to the Museum, e.g. database software packages that could handle large volumes of data. The size of the collection also proved extremely daunting in terms of the digitisation process - all involved had to come to the realisation that it would take an enormous amount of time and effort to complete the process.

- Lack of fully indexed legacy data

  As the legacy records were either incomplete or non-existent it was necessary to re-catalogue all records. This is a huge task that would require an enormous amount of time and effort.

- Staff shortages

  The limited number of staff available to assist in the digitisation process of the collection, compounds the problem of ever completing the capturing and metadata processes of the Museum's legacy data.

- Budgetary constraints

  Although funds were available to purchase a state of the art system (as a result of donations), funds were not available to either appoint additional staff or to outsource the digitisation process.

In conclusion it was found that on the whole, the Museum personnel were satisfied with the progress of their project and did not regret any choices made in terms of systems, including both hardware and software.

In the next chapter the digitisation project of the Museum will be evaluated, measured against the findings and recommendations of this study.

CHAPTER 7

EVALUATION: DIGITISATION PROJECT OF THE MUSEUMAFRICA

7.1 INTRODUCTION

The purpose of this chapter is to evaluate the success of the digitisation project of the MuseumAfrica (hereafter referred to as the Museum), measured against the principles and findings of this study.

The objectives are:

- To determine to what extent the principles and findings set out in this study have been applied by the Museum in their digitisation project;
- To make certain recommendations with regard to elements of the project that can possibly be improved upon or done differently.

7.2 CAPTURING AND ENHANCEMENT

As stated in Chapter 2 of this study, the quality of the capturing process will have a determining influence on the success of the total digitisation process. For this reason it is important that careful planning be done before the start of the project in terms of the nature of the source collection as well as the capturing options available. According to the case study it would seem that ample attention was given to the planning phases of the project and that the Museum personnel had obtained a good understanding of its users and their information needs thorough years of experience.

The following issues, as highlighted in the introductory paragraph (2.1) of Chapter 2 that need to be taken into consideration in terms of decisions on the various capturing options available, have also been included in the detailed digitisation requirements of the Museum:

- the digitised images will act as surrogates to the originals;
- viewing requirements of images during retrieval;
- output, which will be both on paper and on screen;
- the degree of enhancement that will be required;
- the volume of images to be digitised;
- photographic formats.

No criticism can be made against the Museum's system choice, the Kodak Digital Conversion System 1200. It is a turnkey solution that integrates all the steps in the digitisation process. It is well known system that has been widely acknowledged. Should a system have been chosen that consisted of independent hardware and software packages, this would have been especially problematic as the Museum did not have ready access to qualified technical staff who could have taken responsibility for the integration of the various components.

The fact that the Museum opted for a system that included various capturing devices, illustrates their understanding of the nature of their collection and its diverse capturing requirements. By including a flatbed scanner, film scanner and digital camera in their range of capturing devices, they have ensured that they are able to capture photographs as well as all other types of artefacts that form part of the Museum's collection.

The nature of the Museum's collection demands good image enhancement capabilities. The usability of many damaged images could be greatly improved if the quality of the images is enhanced and the images restored to their original former state. The Museum will, however, have to consider the adoption of an image enhancement policy in order to set clear guidelines for itself in terms of the acceptable extent that an image may be edited before the historical value of the image is compromised.

The Adobe PhotoShop software, chosen as the solution to the Museum's image enhancement needs, is widely regarded as the most comprehensive image editing and production package available.

The lessons learnt by the Museum during the implementation of the digitisation phase confirm the statement made in the introductory paragraph of Chapter 2 that of all the phases of a digitisation project, the outlay in terms of cost, personnel and time are the greatest for the capturing phase. The Museum personnel quite openly admit that it took them at least a year to fully understand the whole digitisation process and all the technicalities involved. Even after they had reached a point where they have streamlined their digitisation processes, they still acknowledge that it is a very time-consuming process, especially taking the time involved in the enhancement process into account. There are no easy solutions to this problem. Although a service bureau would have been a solution, even had the Museum had the funds, this would not really have been an option as their implementation of the Kodak system was the first in South Africa and no service bureaus existed that could assist them.

The Kodak system does have the capability of protecting on-disc images against unauthorised use through copyright identifying watermarks and encryption. It is unfortunate that the Museum was not able to implement this functionality as part of their digitisation process (the capturing of watermarks was part of the Museum's list of digitisation criteria). Especially when entering the domain of the Internet, enforcement of adherence to the Museum's copyright prescriptions may become problematic.

Through careful planning the Museum has ensured that the end-user's needs have been taken into account in terms of aspects such as scanning resolution, scanning devices and level of enhancement, as these could influence the potential future use of the digitised images.

7.3 STORAGE AND DATA FORMATS

One of the aims of the Museum's digitisation project has been that of preservation: by limited physical handling of original photographs, damage caused by, for example, fingerprints, will be limited. Even should images deteriorate after digitisation, the Museum will at least have a record of the original photograph in its former state. For this reason it was important that the Museum carefully considered its storage and preservation needs during the planning stage of the project. In addition the Museum also had to provide for the potential future use of the images. The system therefore had to cater for the storage of images in various data formats and resolutions.

The Kodak Digital Conversion System 1200 and the Kodak Portfolio II Photo CD disks that the captured images are written to, provides for these needs. The fact that images are automatically saved in five different resolutions makes provision for future usage needs, whether as a thumbnail image displayed during retrieval, or as a high-resolution image that needs to serve as a surrogate to the original image. The Photo CD file format in which the images are stored is also available across most of the major computer platforms, minimising potential compatibility problems. This is especially relevant when considering the fact that the Museum aims to provide access to its collections via the Internet.

Kodak writable CD media that carries the InfoGuard Protection System trademark, is specially designed and tested to provide secure long-term storage (Zimmer, 1993b: 31). According to tests done by Kodak the data recording layer used by Kodak does not significantly change over time, even when exposed to extreme light, heat and humid conditions. These disks are also specially treated to minimise damage caused by handling.

From the above, it can be concluded that the Museum had carefully considered their own, and their clients' needs in terms of data formats and storage and that they have succeeded through their system choices, in successfully providing for these needs.

7.4 METADATA

Traditionally the Museum had only assigned the minimum metadata to photographs. With the implementation of the new Cuadra STAR system, this has changed quite dramatically. The metadata fields pre-defined in the system are extensive and cater for almost all potential metadata needs.

An in-house thesaurus that is still in the process of being developed is used by the Museum for the purpose of standardised assigning of indexing terms. Although the STAR system supports the Arts and Architecture Thesaurus (AAT), the Museum has opted for the development of an in-house thesaurus as no internationally-based thesaurus makes sufficient provision for South African- and African-based terminology.

In order to evaluate metadata assigned by the Museum, the elements determined by the Museum will be compared to the summarised list of minimum metadata elements for photographic description as identified in Chapter 4:

Table 12: Minimum Metadata Elements For Photographic Description

MINIMUM METADATA ELEMENTS FOR PHOTOGRAPHIC DESCRIPTION	
ELEMENT	**APPLIED BY MUSEUMAFRICA**
Title/Caption	**Yes** Titles are provided by the curators. Provision is also made for title type, language and notes. In addition an object summary is

MINIMUM METADATA ELEMENTS FOR PHOTOGRAPHIC DESCRIPTION	
ELEMENT	**APPLIED BY MUSEUMAFRICA**
	provided for each image in a standardised format and appears on all following input and display screens.
Statement of Responsibility	**Yes** Provides for full details of the artist or maker of the image or object.
Ownership	**Yes** Provides for full details/history of previous and current ownership.
Subject	**Yes** Provides for in-depth subject indexing. Index terms are divided according to three categories or levels: identification, description and interpretation. Text fields are provided for a subject description (what the image is about) as well as a description of object depicted in the image (what the image is of).
Physical Description	**Yes** Provides for the physical description of the original photograph or artefact: material or technique used, general description, dimensions and marks.
Copyright/ Restriction	**Yes** Provides full details of the reproduction rights. Also includes acquisition details.
Unique Identifier	**Yes** A unique object/accession number as well as and a system number is generated for each image.
Capturing Process	**No**
Viewing Requirements	**No**

MINIMUM METADATA ELEMENTS FOR PHOTOGRAPHIC DESCRIPTION	
ELEMENT	**APPLIED BY MUSEUMAFRICA**
Administrative Metadata	**Yes** Provides for all the relevant administrative metadata.

From the above table it can be concluded that although the Museum does not follow a specific metadata standard such as the Dublin Core, the metadata elements defined by the Museum are comprehensive. The main area that is, however, lacking is that of metadata on the capturing process and required viewing details. This is important for future reference to ensure the longevity of records.

7.5 RETRIEVAL OF IMAGES

As the potential users of the retrieval system were identified to be quite diverse with diverse retrieval needs, it was important that, whatever system was chosen, it would cater for these needs. The Museum personnel required a sophisticated retrieval system that would not cause frustration through continuous online guidance. The general public required a system that would lead them in terms of the nature of the collection as well as the command language and retrieval logic of the system.

The Cuadra STAR system seems to adequately cater for these diverse needs. The expert searcher is given the leeway to enter and combine search terms through the use of Boolean commands and to also combine search strings. The novice user is assisted through a template, which includes input boxes for those fields in the database that would be relevant to the general public.

In addition to the user interface being user-friendly, the system also provides online help facilities. A user can also request guidance in terms of the thesaurus terms used for indexing. Although this facility is not currently active, the Museum is in the process of compiling its in-house thesaurus.

As the process of populating the database has only recently started, retrieval issues such as recall and precision, as measures for retrieval effectiveness, could not be tested. The exhaustivity and specificity of the Museum's indexing processes, however, give and indication of the system's potential effectiveness in this regard. The indexing is fairly exhaustive in the sense that the indexing terms are allocated on three levels (identification, description and interpretation) and that summaries are provided of the background and context of the subject matter of the image. One could therefore assume that the system should provide for fairly high recall as many potential access points are provided. On the other hand, the indexing terms used are quite specific and through the effective use of Boolean logic, especially by the expert user, high levels of precision should also be obtained.

The retrieval system is an exact-match text retrieval system based on Boolean logic. This fact is also an indication that the system itself is more geared towards achieving high precision ratios than high recall rations.

The system provides no content-based retrieval. Although not a serious drawback, the addition of content-based retrieval could be advantageous in that it would complement the text retrieval capabilities of the system. Although the policy of the Museum may be to index each image in depth, the size of the collection may force the Museum to follow a more general, less time-consuming approach to indexing resulting in less access points per image. In such an instance content-based retrieval could provide additional retrieval possibilities. It could also be useful in instances where users have identified possibly relevant images and want to determine whether similar images are available in the database ("more like this").

Although it may not be possible to evaluate the effectiveness of the Museum's retrieval system in depth, it can be concluded from both the perspectives of the Museum's metadata policy and the design of the system, that it will more than adequately meet the retrieval needs of the personnel and public users.

7.6 CONCLUSION

On the whole it can be concluded that the digitisation project of the MuseumAfrica has been a success. The planning phase, especially, was done very thoroughly, with the result that the system criteria for all the resulting phases were complete, making it fairly simple to determine the best solution available for each phase.

After evaluating the digitisation project of the Museum the following recommendations are made:

- That the Museum keeps abreast of developments in the field of content-based retrieval in order to consider it as a complimentary addition to the retrieval system and also as a means of obtaining access to images that either could not be indexed exhaustively or could not be indexed at all due to the volume of the collection and the staff shortages.

- That the Museum further investigates the possibility of making use of a service bureau to speed up the capturing process.

- That the Museum further investigates the possibility of including digital watermarks on the digitised images in order to protect images from unauthorised use, especially when the collection is made accessible via the Internet.

- That the metadata be expanded to include information about the capturing process and the viewing requirements of the images.

- That the Museum undertake a survey, as soon as the system is fully operational, to determine user acceptance of and satisfaction with the system. Although the Museum personnel have, through years' of experience, come to know the needs of their users, these needs may differ when presented with all the additional and different options that are offered in an electronic environment.

In conclusion the Museum is to be congratulated on a successful, well-planned and well-executed digitisation project. Although it may take years to complete the project, the Museum can feel secure in the knowledge that they have made good choices in terms of both systems and processes and that the basis for the continued deployment of the digitisation project is sound.

In the next and final chapter conclusions will be drawn from the work done in this study to determine whether the objectives set out in the first, introductory chapter have been met.

CHAPTER 8

CONCLUSION

8.1 INTRODUCTION:

The various issues covered in this study have proven to be quite diverse. Although all the issues were directly relevant to the digitisation of photographic collections, each issue has proven to be an independent study with its own range of sub-issues.

The purpose of this chapter is:

- To provide a summarised overview of the findings of the study.

- To determine whether:
  - the problem and sub-problem statements as presented in the first chapter have been addressed, and
  - the hypothesis as stated in the first chapter, has been proven true.

- To provide some remarks on possible future developments regarding the various issues addressed in this study.

8.2 PROBLEM STATEMENT AND HYPOTHESIS

In Chapter 1 the problem of this study was stated as:

"In essence the problem that needs to be addressed is to determine how a photographic collection can be digitised in order to enhance the preservation and accessibility of the collection."

Various sub-problems were also stated and related to the issues that need to be considered in order to effectively digitise a photographic collection.

Investigation into the issue of the digitisation of photographic collections have proven that there are a diverse range of aspects that need to be taken into consideration in both the planning and implementation of a digitisation project. These issues were addressed and the various options relating to each issue were discussed. From these investigations it became clear that photographs are indeed unique in nature and therefore need to be managed differently to textual objects. This is true for all phases of the digitisation process, namely:

- Capturing and enhancement of the images.
- Storage and data formats.
- Allocation of metadata.
- Retrieval of photographic images.

The hypothesis, which was based on the problem statement, was stated as:

"Today there are a selection of choices available. Armed with a good knowledge of the different processes involved, it is possible to effectively utilize available imaging technology in order to create an image database that can solve most of the traditional problems associated with the management of photographic collections."

As is clear from this study the digitisation of photographic collections covers a vast and diverse range of issues that need to be considered. It is therefore true that there is a selection of choices available. It is, however, also true that in-depth knowledge is needed of each issue in order to make the right choices and effectively plan and implement such a project.

The case study conducted at the MuseumAfrica also illustrated that through the discerning use of modern imaging technology it is possible to solve many of the problems associated with the management of photographic collections and in the process enhance accessibility and usability of the collection.

8.3 OVERVIEW

In an attempt to bring together all the issues covered in this study an overview will be provided of each. Chapter 1 will be addressed in the next section of this chapter when discussing the problem statement and hypothesis of the study.

8.3.1 Chapter 2: Capturing and Enhancement

Of all the phases in a digitisation project the capturing and enhancement phase is the most resource intensive in terms of cost, personnel and time. It is therefore important that careful planning be done to determine the nature of the images to be digitised as well as the potential future use of the digitised images. Technical expertise is also required for both the planning and implementation phases. Skills acquisition is an especially problematic issue in instances where information/imaging technology experts are not primarily responsible for the project or readily available for the duration of the project. To ensure the effective capturing and enhancement of images a fairly high level of expertise is required of a range of technical aspects such as scanning resolution, pixel depth, dynamic range, gamma correction, colour models, colour balance and accuracy, file size, and TWAIN.

Should an institution not have the necessary resources available to capture images in-house, they can consider using service bureaus for this. Before committing to such a decision the advantages and disadvantages of each option need to be carefully considered. A final choice will depend on the nature of the collection as well as the culture and financial sponsorship of the institution.

There are various capturing options available, which makes the decision in terms of the right device for a specific application, quite confusing. The summarised overview of the capturing options available provides clarity on the differences and applicability of each device.

An integral part of the capturing process is the enhancement of the digitised images. As this is also a specialised and technical field there are again a number of concepts that need to be mastered by those involved in the capturing process.

The advantages of a digitised collection compared to traditional photographic formats, however, make the learning curve, cost and labour required by the capturing and enhancement phase, worthwhile.

8.3.2 Chapter 3: Data Formats and Storage

After photographs have been digitised, the next step is to decide in what format an image will be stored, what compression method will be used and in what medium it will be stored.

There are various imaging standards relating to data formats, image compression and storage media that the manager of a digitisation project needs to be aware of and make provision for. An overview is provided of these issues in par. 3.4.3.1.

The developments are very rapid in this field and although overwhelming to the consumer, the escalating storage capacities open up new possibilities for the effective storage and preservation of photographic collections.

An understanding of the range of options available will ensure that an educated choice can be made, tailored to the requirements of each specific application. An overview is provided of the various capturing methods as well as capturing devices that are available.

8.3.3 Chapter 4: Metadata

This chapter provides an overview of different metadata systems and standards relevant to the description of photographic images. The essential problem to the description of photographic images lies in the nature of photographs themselves: the information that they convey resides in the images themselves and not in text. Bibliographical and subject description details have to be allocated by an indexer with rarely any accompanying detail to assist him/her, which also opens debate in terms of the subjectivity of the indexer.

The escalation of the Internet as a means of communication and distribution of information, has led to the proliferation of available digitised images. This, in turn, has resulted in various international initiatives to reach consensus on the standardisation of metadata for electronic resources, such as digital images.

An overview is provided of the various metadata standards relevant to the description of photographic images, including the possible advantages and disadvantages of each. The standards reviewed include MARC, RDF, AACR2, GIHC, Dublin Core Metadata Elements Initiative, CDWA, CIMI, Coalition for CNI and CCIMI and VRA.

Subject indexing and classification of photographic images present various problems. Numerous systems have been developed or customised to cater for this field. These are divided according to classificatory systems (e.g. DDC and ICONCLASS), Keyword systems (e.g. LCSH, LCTGM and AAT) and free text systems.

In summary a list of metadata elements have been identified as the essential elements for the description of photographic images.

8.3.4 Chapter 5: Retrieval of Photographic Images

The success of any digitisation project is measured by the effectiveness of the retrieval system. A collection of images has little use if it cannot be retrieved.

Various retrieval principles such as retrieval needs, relevance, recall and precision that need to be taken into account in the development and evaluation of retrieval systems, have been discussed.

Three main approaches to image retrieval have been identified, namely text-based retrieval, content-based retrieval and an integrated approach to retrieval. Image databases have traditionally relied only on text-based retrieval techniques. Modern imaging technology has opened up possibilities for content-based retrieval that automatically extracts specified image features. Both text-based and content-based retrieval present specific advantages that are complimentary to one another. For this reason it is concluded that the ideal option would be a retrieval system in which both text- and content-based techniques are integrated.

The evaluation of retrieval systems is discussed in terms of various criteria that could have an effect on the retrieval effectiveness of a system, such as user needs, recall and precision, search strategy, display of search results, system feedback and ease of use. These issues are especially important when having to compare and make a choice between various retrieval systems.

8.3.5 Chapter 6: Case Study: Digitisation Project of the MuseumAfrica

A case study of the digitisation project of the MuseumAfrica was done in order to determine how the various aspects involved in the digitisation of photographic collections are applied in practice.

The Museum has a collection of approximately 750 000 records which needed to be captured, enhanced, stored electronically, referenced in a database through the allocation of metadata and made accessible via a retrieval system. The scope of the project was daunting, but careful planning was done of each phase and the relevant criteria were pre-defined to enable objective evaluation of the various products available.

The main lesson learnt was that all personnel involved had to undertake a learning curve, as the project required in-depth technical skills. It took almost a year before the personnel involved in the capturing and enhancement processes were fully trained and the processes streamlined.

The case study proved that knowledge of the various and diverse range of issues covered in this study is required to ensure that informed decisions are made in each phase and that the project is a success.

8.3.6 Chapter 7: Evaluation: Digitisation Project of the MuseumAfrica

In this chapter the findings of the case study were evaluated. In general the project was considered a success as illustrated by the following:

- The project was well planned. All phases were well researched and the Museum's requirements were clearly specified according to pre-defined criteria.

- The system choices in all instances illustrated the Museum's understanding of their collection and its digitisation needs as well as the needs of their users.

- The metadata allocated to each image was comprehensive. The only limitations were the lack of metadata relating to the capturing process and viewing requirements of the images.

- The retrieval system made provision for the retrieval needs of both the expert and novice users through specifically designed user interfaces.

In conclusion the following recommendations were made:

- That the Museum keep abreast developments in the field of content-based retrieval for future consideration;

- That the possibility of using a service bureau for the capturing of the images be considered;

- That the metadata be expanded to include information on the capturing process and viewing requirements;

- That the possibility of including digital watermarks on digitised images be further investigated;

- That a survey be undertaken as soon as the system is fully functional to determine the users' satisfaction of the system.

8.4 CONCLUDING REMARKS

The digitisation of photographic collections has proven to be a very comprehensive, diverse and technically advanced field of study. Each of the main areas that were investigated presented a range of options that needed to be considered and compared to one another in order to make choices that are right for a specific application, user group, collection and institution.

In retrospect the following concluding remarks can be made on the digitisation of photographic collections:

It covers a diverse range of issues.

- Many of the issues are of a very technical nature and require technical skills in order to effectively apply the relevant solutions.

- A digitised collection presents so many advantages compared to a traditional photographic collection, that the time, effort and learning curve involved are well worth it.

- Digitisation enables a collection to fulfil its purpose whether it is historical, informative or aesthetical.

- Accessibility is tremendously increased by digitisation and especially by an effective image retrieval system based on comprehensive metadata.

At the conclusion of this study one also needs to look ahead at what the future may hold. The digitisation of photographic images is an interesting and fast developing field that requires focused effort to keep abreast of new possibilities. By using the developments in this field over the past few years as a guideline, a few generalised predictions can be made in terms of possible future research and development areas:

- Capturing devices will increase in quality and at the same time become more affordable to consumers. Devices such as scanners and digital cameras will increase in general popularity resulting in an increase in skills in this field.

- Digital storage devices will continue to increase in capacity and also become more affordable. Greater standardisation and compatibility will be achieved in terms of data formats – as a result of pressure by ever-demanding Internet users.

- Metadata interest groups will move towards greater standardisation in the description of electronic resources of which photographic images will increasingly form an important part.

- Research in the field of content-based retrieval will lead to more commercially viable products that have more general applicability.

- Research will be required in terms of the information retrieval needs of users within the digital environment. As users become more familiar with the usage and potential of electronic resources, their needs and expectations will change accordingly.

Through the use of modern imaging technology it has become possible for institutions to effectively manage their photographic collections. In contrast to the past where access to collections was limited, full access can now be provided to all users. By using the Internet as distribution medium access can now even be given to international users. The full potential of each photograph in a collection can now be realised in terms of its value for specific users.

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APPENDIX A

CASE STUDY: DIGITISATION PROJECT OF THE MUSEUMAFRICA: QUESTIONNAIRE

SECTION A: Organisation and Interviewee Details	
Name of Organisation	
Name and Position of Interviewee	
Date of Interview	

SECTION B: The Digitisation Project
1. Project title
2. When did the project start?
3. How many people involved in the project?
4. What were the purpose and objectives of the project?

5.	**How big is the image collection?**
6.	**Describe the collection.**
7.	**What is the condition of the photographs?**
8.	**What system had been used prior to digitisation?**
9.	**How was the project approached? In phases? What was the pilot phase?**
10.	**How many different systems were initially evaluated?**
11.	**Why was the decision made to standardise on the specific chosen system?**
12.	**Briefly describe the system and its components.**
13.	**How much training did the personnel require before they were adept in using the system?**
14.	**What did the capturing process entail?**
15.	**In what medium are the digitised images stored?**

16.	**What is the life expectancy of this storage medium in terms of preservation of images?**
17.	**Storage formats?**
18.	**Were any problems encountered with the digitisation process?**
19.	**What metadata is provided for each image?**
20.	**What is envisaged for the future in terms of indexing?**
22.	**How are images retrieved?**
23.	**Search screen?**
24.	**Display of results?**
25.	**What are the levels of recall and precision?**
26.	**What output does the system provide / printing capabilities?**
27.	**Who are the users of the system? How many users of the system are there?**

28.	**How accessible is the system to users? Interoperability of the system?**
29.	**Ease of use of the system?**
30.	**How much training is required to use the system?**
31.	**Can the overall project be rated as a success? What were the problems/frustrations experienced with the overall project/system?**
32.	**In hindsight, would the same system be chosen?**
33.	**What plans are envisaged for the future?**
34.	**What are the constraints limiting expansion of the project?**
35.	**Any additional comments?**