

# Chapter 1

*"The story was the bushman's most sacred possession. These people knew what we do not; that without a story you have not got a nation, or culture or civilization. Without a story of your own to live, you haven't got a life of your own."*

*Laurens van der Post [42]*

## Introduction

Stories form an integral part of our lives. As children we hear about fables where the prince and princess live happily ever after and we dream of the day that our prince will appear in our lives and take us off into the sunset. Our grandparents tell us stories about their youth and we can see their longing to once again relive old times. We hear stories telling about legends and stories that capture our culture as it is passed along from generation to generation. Indeed, stories have a big influence on our lives.

Interactive storytelling allows people to be actively involved in the story that was created. Imagine a story world where you can pick up an object, open a door and really interactively explore all the mysteries and wonders around you. Imagine a story world that changes according to the person who explores it, where different stories are created out of the same world for different audiences.

By using the interactive storytelling tool, the story can be adapted for different audiences. This adaptability and interactivity can play an important role in making interactive storytelling a powerful tool in education and tourism to teach people more about certain information, e.g. cultural artefacts.

## **Thesis focus**

The work presented in this thesis is a method and software tool that enables users to develop different stories from one virtual world according to the virtual identity through whose eyes the participant experiences the story. It discusses interactive storytelling and virtual environments and then highlights how interactive storytelling can be used in virtual environments. It presents the virtual identity approach and highlights how this approach is different from the traditional approaches that were followed.

## **Thesis layout**

Chapter 2 discusses interactive storytelling and how it is different from traditional media. It highlights the goals and principles that should be followed when an interactive story is created, what a story world is and how these principles can be applied within a story world. It presents the different techniques that are used in interactive storytelling to create animation and other approaches of storytelling such as role-play, comic traditions and interactive mysteries and drama. It then discusses virtual reality and the different virtual reality systems. It presents the elements and issues of virtual environments, authoring tools and the advantages of using authoring tools. It also highlights the application areas of virtual environments. It discusses how interactive storytelling can be used in virtual environments, how virtual characters are used to create interactive stories in virtual environments and how the use of virtual environments can solve some of the problems that are encountered with interactive storytelling.

In chapter 3, the theoretical approach for interactive storytelling using virtual identities is presented. It discusses how interactive storytelling can be used in virtual environments with the use of virtual characters. It presents the virtual identity approach and a taxonomy for defining a virtual identity. It highlights how the taxonomy can be used with the virtual identity approach to create an interactive story and how the virtual identity approach can provide solutions for some of the problems that are experienced with interactive storytelling.

Chapter 4 discusses how the interactive storytelling tool is implemented. It presents the AVANGO framework and highlights how C++ and Scheme are used to create an application. It discusses the modelling that was required for the virtual environment. It presents an overview of the interactive storytelling tool and then discusses the C++ nodes and Scheme scripts that are created. It then highlights how a GUI can be added to the interactive storytelling tool to make it user-friendlier.

Chapter 5 discusses an interactive story that is created with the interactive storytelling tool. It presents information regarding Cato Manor and how the interactive story develops. It highlights the virtual identities that are created and presents the results that are obtained when the application is run on a monitor and in GMD's Cyberstage.

Chapter 6 provides conclusions of the dissertation and discusses future work with regard to the interactive storytelling tool.

Appendix A provides the complete taxonomy that can be used to define a virtual identity. The taxonomy is discussed in chapter 3.

Appendix B provides the code that was used to implement the interactive storytelling tool. The implementation of the interactive storytelling tool is discussed in chapter 4.

## Chapter 2

*"...all of life presents itself as an immense accumulation of spectacles. Everything that was directly lived has moved away into representation."*

*Guy Debord, 1967 [58]*

### Background

The first section of this chapter discusses interactive storytelling and highlights how it differs from traditional media. It highlights the different storytelling approaches and how interactive storytelling can enhance them. It discusses the goals and principles of an interactive story, what a story world is and how these principles can be applied in a story world. A brief overview of virtual reality and different virtual reality systems is presented in the second section of this chapter with the emphasis on authoring tools and their advantages. It also discusses application areas of virtual environments with the emphasis on the educational field.

#### 2.1. Interactive storytelling

Interactive storytelling is a way of telling stories in such a manner that the user is actively involved and can interact with different objects in the story world. The author of the story world doesn't specify the actual events that take place, but only creates the rules under which the characters interact. The player then creates and experiences the events in the story world under the guiding rules of the artist.

Many stories can be created from a single set of external events through a process called "story-morphing". Story-morphing [6] is the semi-automatic generation of stories for use with emotionally intelligent multimedia agents.

One can ask why interactive storytelling is important. Thom feels that interactive storytelling is important and says:

“... I can not imagine a single area of human thought or activity which can not be embodied in a print-based book or magazine and I also can not imagine a single area of human thought or activity which can not be embodied in an interactive storytelling medium. I can imagine many areas which can be better embodied in interactive storytelling than in paper-based print such as science, math, art and music...” [34]

Realism is important for good storytelling, because of the following:

- It provides a familiar context that allows the story to take shortcuts – if the story takes place in a fantasy world, everything about the context would have to be explained
- It is a constant source of variety in the story
- A realistic context inherently limits the character's options – any good plot situation requires limitation to be imposed upon the characters in order to keep the characters interesting
- Many readers look at fiction to inform them about the world
- The more realistic the situation of the story is, the more relevant the theme is going to seem to the reader
- It helps the reader to identify with the portrayal of the character

However, sometimes the freedom of doing things you cannot do in reality and seeing things in a non-realistic way is better than portraying true realism. Therefore, each application should portray the level of realism that is applicable to the specific situation.

To accomplish interactive fiction, the user should be given a sense of existing in a story world and it should be done in such a manner that the user is left with a feeling of free will.

With interactive storytelling, the question is how much interactivity should be allowed in order to still obtain the goal; for example teaching children about culture. Grahame Weinbren proposed that the computer should respond to the user's interaction by saying:

“...I am not interested in an interface which would cause the viewer to believe that he has created the story. Not only is this a false belief, but it also presupposes an invalid esthetic. Art functions to widen one's perception and experience, not to narrow it, to show the viewer a vision of the world, not to make him imagine he has invented one... I believe the requirement that the viewer make choices is not liberation but a burden. My position on this issue goes against the purported link between choice and freedom fundamental to western ideology. The connection between freedom and responsibility for what appears on the screen (without

having chosen it) that interests me. The general paradigm that I propose is that of a machine that answers to a viewers response...” [96]

Usually interactivity and storytelling is directly proportional. In other words, the more interactivity there are, the less storytelling there will be. Therefore, the right balance should be found for the specific application.

The traditional methods of lectures, print, video and audio are *narrative media*, because they require a storyline and put the teacher in the role of *storyteller* and the learner in the role of *listener*.

One of the key benefits of interactive media is the lack of imposed structure that gives much greater freedom of control to the user. According to D. Laurillard [30] learners that work on interactive media with no clear narrative structure display unfocused and inconclusive learning behaviour. Laurillard says: “Narrative structure is one of the most important ways in which the instructional message comes to be understood...” [30].

However, the learner doesn't always know enough to be given full control. Novices cannot be expected to set appropriate goals or plot a reasonable path, for they will under-specify the problem, be distracted by irrelevancies and can fail to meet the objective.

Interactive storytelling can solve this problem, because it allows the user to interactively explore the story world and leads the user by means of a non-sequential narrative. Therefore one could say that interactive storytelling combines the advantages of narrative media with that of interactive media.

However, in order to achieve the goals that are set with the use of interactive storytelling, such as joy and enlightenment, certain principles should be followed.

### **2.1.1. Goals and principles of interactive storytelling**

Certain principles should be followed to achieve the goals that are set with the use of interactive storytelling. According to H. Hirsh [9], the seven principles for a character-based interactive story are the following:

1. The participant should direct the protagonist character's improvisational behaviour and interact directly with other characters in the story. This will draw the participant into an immersive, first person experience.

2. The participant's joy will arise from immersive participation in the story, if the plot has been artfully designed to carry the participant along. Controlling the story outcome and exploring a puzzle, is not enough to ensure joy for the participant.
3. The participant's interaction with other characters should be meaningful and coming from the natural course of events in the story world. This will preserve the participant's illusion of immersion and feelings of active participation.
4. The story world should be densely populated with other characters in order to permit many possible interactions that will not all be discovered during the first visit. This will enable the participant to revisit the story world, finding new joy and enlightenment with every visit.
5. The participant's interactions with other characters should involve mixed initiative. The participant should decide when to and with whom to interact. The other characters should display similar autonomy, approaching the protagonist to offer, suggest and demand interactions.
6. The participant's interactive choices and experiences should shape the detailed story's contours that are constructed around the underlying narrative arc.
7. The participant's story experience should be monitored and orchestrated by an adaptive story master who directs and modulates the behaviour of other characters, to ensure that the experience is joyful, rapturous and enlightens the participant during each visit.

Interactive stories should achieve the following artistic goals for the participant:

- Joy – the interactive story should be created in such a way that the participant experiences feelings of pleasure
- Rapture – the interactive story should captivate the participant and temporarily distract the participant from the real world
- Enlightenment – the interactive story should improve the participant in some aspect of thought, understanding or feeling

In the principles mentioned above, Hirsh often refers to the story world. Therefore, the question arises: what exactly is a story world?

### **2.1.2. Story world**

A story world is a world that is based on a story. It takes actors and actions created by the story world builder and present them to the user for exploration and play.

A story world consists of:

- *Actors* – persons in a story world
- *Verbs* – the actions of the story
- *Stages* – locations where dramatic activity takes place and an actor cannot exist outside the bounds of the stage
- *Objects* – objects in the story world that the user can manipulate and interact with
- *Things* – objects that are transferable between actors and whose ownership can be assigned to an actor

A traditional linear story follows a sequential course that is predetermined by the creator. However, a story world allows interactivity and enables choices within the story that determine how the story develops.

A video game concerns physical or narrowly intellectual challenges and limits its user to choices of a spatial or logical character. On the other hand, a story world concerns actors and human emotions and permits choices of an interpersonal or dramatic nature.

When the story world is created for the use in virtual reality, then we refer to the story world as a virtual world.

In a story world animation is used to present the different events that take place as the story develops. Many animation techniques are used in interactive storytelling, such as flipbooks, key framing, motion capture and procedural animation.

### **2.1.3. Animation in interactive storytelling**

Interactive stories use a wide variety of methods for animation. Some of the methods being used are flipbooks, key framing, motion capture and procedural (computer programmed) animation.

*Flipbooks* [55] consist of a stack of blank pieces of paper or thin cardstock that are stapled to form a book. A slightly different picture is sketched on each page and as the book is rapidly flipped, the sketches appear to move.

With *Key framing* [86] the positions of the moving objects at important times are specified by the animator. Frames could be specified for the animated character crouching down, preparing to jump, then for the character in mid-air and finally for the character absorbing the



shock of landing on the ground. The object attributes for additional frames between the key frames are then calculated by the motion control system. There must be enough additional frames to ensure smooth motion and shape change from one key frame to the next.

*Motion capture* [87] involves measuring an object's position and orientation in physical space and then recording that information in a computer-usable form. Once the data is recorded, animators can use it to control elements in a computer generated scene.

With *Procedural animation* [38] rules are established for a system and an initial state is defined for objects in the system. The object locations or parameters for subsequent frames are computed by applying the forces or behaviours that are defined for the system by the conditions that were established in the previous frame.

Interactive storytelling is used in many areas that we are familiar with, such as role-play. During a role-play the players are actively involved in the story and their actions influence the storyline.

#### **2.1.4. Role-play**

Role-playing is in essence storytelling where the players are the main characters in the story. The players are deeply and actively involved in the story and they influence the direction and resolution of the story. The players aren't resistant or even aware of the information and skills that they are learning.

Role-playing is a form of game that takes the participants into an interactive story. Each player takes on the role of a character in the story and interacts with the other players and the imaginary world around them. The game master creates the story and the other characters that the players will interact with and makes sure that all the players follow the rules of the game.

The Roleplay Workshop uses a game, *Abantey* [31], to teach real life skills in a creative and imaginary setting. The goal of *Abantey* is to use a role-playing game as a teaching tool. The children are actively involved and therefore they learn new life skills through participation.

Comic traditions do not allow the viewer to be actively involved in the story. The different traditions, namely the cartoon tradition, poster tradition and cinematic tradition, do however

have different approaches, features and limitations that should be kept in mind with the creation of an interactive story.

### 2.1.5. Comics traditions

Comic traditions can be categorised in cartoon tradition, poster tradition and cinematic tradition, where each tradition has its own unique features.

#### Cartoon tradition

The cartoon tradition has the following features:

- Emphasises characterisation – exaggerations and caricature of faces are used to portray the character
- The most important stylistic tools are contour line and character design
- Action is portrayed in the following way:
  - The characters are drawn at the same size in successive panels
  - The characters' movements are along a single pane, from left to right
- Text is used for dialog between characters

However, the lack of realism reduces opportunities in the story for suspense and seriousness. The cartoon tradition also encourages the reader to judge the characters by their appearance instead of their actions.

#### Poster tradition

The poster tradition has the following features:

- Spectacle is the most important story value, because of the fact that monsters, disasters, colourful costumes and death-defying stunts have the most potential for creating sensational splash pages
- The most important stylistic tools are the use of colour and the overall page layout
- Action is portrayed in the following way:
  - Action explodes outward from the page into the reader's face
  - All the action happens at once in a single pane
- Text is used in the form of captions to pull the various illustrated spectacles into a coherent narrative

With the poster tradition depicted spectacular events completely take over the story and therefore eliminates characterisation, plot and logic. Poster comics are pretty to look at, but they leave you with an empty feeling.

### Cinematic tradition

The cinematic tradition has the following features:

- Realism is the most important story value
- The most important stylistic factors are the use of light and shade, and the breaking down of the scene into panels
- Action is portrayed in the following way:
  - \* The characters are displayed in close-ups and long shots, from every angle
  - \* The characters move in a variety of directions
  - \* Action is portrayed by montages of panels, where each panel only shows a fragment of the completed action
- Rely on minimal dialog and a few captions, but mostly pictures to convey the story

The cinematic tradition comics are often too complicated and difficult to follow – comic book panels are too small and there aren't enough panels to carry a story on their own, the way a motion picture can.

In film, the viewers cannot pause during different scenes to consider what is taking place, but with interactive storytelling the scene can be illustrated in as much detail as required and the participant is free to explore the virtual environment at length.

Comic traditions do not allow user-interaction and therefore the user doesn't influence the outcome. However, interactive drama and interactive mysteries allow the user to participate and to influence the outcome of the story.

#### **2.1.6. Interactive drama and mysteries**

Interactive drama consists of a fantasy world with exciting characters and the possibility of many adventures. You control your own direction by choosing each action you take, but a master interactive storyteller subtly controls your destiny.

A typical plot (story experience) follows the pattern of a dramatic arc, where an incident leads to rising action, which then builds up to crisis, climax and finally denouement.

Oz [14] is a computer system that was developed to allow authors to create and present interactive dramas. The system's architecture consists of a physical world, several characters, the interactor, a theory of presentation and a drama manager.

Brenda Laurel proposed an "artificial playwright" [22] - an expert system that encodes rules of drama and storytelling. The story is completely rewritten, according to each act that is taken by the player, but still maintains the tension and relaxation, pacing and climax of a real story. The result is total interactivity – the system allows the player to violate the plot, with dramatic rules as the only constraint.

A basic artistic problem with interactive drama is the creation of a structure that provides unity and cohesion, but still permits rich interaction. Therefore, a balance between interactor freedom and author control should be found.

Interactive mysteries are mysteries where the user's choices determine the outcome of the story. *Web of deceit* [33] is a fully interactive mystery thriller where the outcome of the story depends on the choices made by the user. It describes the strange world of Otto the gumshoe and how he battles for survival, self-respect and the woman he loves. It is an experimental game that is based on random chance and audience participation. However, the story is utterly absurd, it has frequent gaps in continuity and it even loops back on itself sometimes.

#### **2.1.7. Summary**

This section discussed interactive storytelling, what interactive storytelling is and how it is different from traditional media. It presented the goals and principles of interactive storytelling and highlighted what a story world is and what a story world consists of. It also discussed other ways of storytelling, such as role-play, comic traditions and interactive drama and mysteries.

The next section discusses virtual reality (VR), VR systems and elements and issues of virtual environments. It highlights authoring tools and their advantages, and the application areas of virtual reality.

## 2.2. Virtual Reality

Imagine representing a world in a way that enables the viewer to be actively involved and to interact with objects in the world. This can be achieved with the use of virtual reality (VR). But what exactly is virtual reality?

Several definitions of virtual reality exist which include:

"...virtual reality makes possible the carrying out of actions which produce, in real time, the corresponding reactions which we are able to experience in real time..." [7].

"Virtual Reality is a way for humans to visualise, manipulate and interact with computers and extremely complex data" [7].

In reality humans interact with the world around them with both their bodies and minds, but in hypermedia interactivity is very minimal. Therefore, an important question comes to mind: what constitutes a continuous interactive representation?

Virtual reality enables users to be fully involved in the digital stories. In a projection-based stereoscopic display the users are both physically and virtually inside a story. Their whole body can therefore function as an interface that receives and sends auditory, visual and tactile signals to the computer and vice versa.

Virtual reality is designed to give the user a type of mediated experience that has never been possible before – one that seems “real” and “natural”, one that seems like it is not mediated and that creates a strong sense of presence [43].

Painting, sculpture, drama, cinema and television separated the audience completely from art. Virtual reality melds the experience and representation, instead of separating them. Virtual reality is therefore simultaneously a picture and bodily experience.

Virtual reality allows new relationships that differ from the dramatic tradition, i.e. one is simultaneously actor and director and one is constructing a narrative, a protagonist of that narrative and its audience.

One could say that virtual reality is the combination of art and science of using computers to create three-dimensional worlds where users can freely explore, be immersed in and interact with the virtual world in real time.

*Battletech* [1] is a VR virtual theme park that existed in Chicago since mid 1991 and it simulates futuristic warfare in which remote users do battle in simulated robotic war machines. Each player is informed that s/he is the righteous vigilante fighting against the forces of evil. These "forces of evil" are the other players, who are labouring under the same illusion.

It is important to note that virtual environments (VEs) and virtual reality (VR) refer to the same thing. In this thesis the term *virtual environments* will be used.

There are many different VE systems that can be categorised with regard to display issues and input devices. Some of the systems are the Window on World Systems (WoW), video mapping, Fish tank virtual environments, immersive systems, telepresence and mixed (Augmented) reality.

Window on World Systems (WoW) is also called Desktop VE and a conventional computer monitor is used to display the visual world. Video Mapping is where a video input of the user's silhouette is merged with a 2D computer graphic and the user watches a monitor that shows his body's interaction with the world. Fish Tank VE is a Canadian VE system that was reported in the 1993 InterCHI proceedings [85], which combines a stereoscopic monitor display using LCD Shutter glasses with a mechanical head tracker. A conventional monitor is used, the head position measured and used to estimate eye position to provide a correct perspective view of a small virtual environment.

Immersive Systems are often equipped with a Head Mounted Display (HMD) and the user's personal viewpoint is completely immersed inside the virtual world. A variation of immersive systems is where multiple large projection displays are used to create a "cave" or room in which the viewer(s) stand, viewing 3d stereoscopic image updated in real-time.

Telepresence links remote sensors in the real world with the senses of a human operator. Mixed (Augmented) Reality or Seamless Simulation Systems is a merge of Telepresence and VE systems.

This thesis focuses on projection-based stereoscopic systems. These systems have a wide variety of input and output devices, which we examine next.

### **2.2.1. VE systems**

VE input and output devices can be divided into the following two sections, namely input devices and visual sensory displays. The input devices that are used fall either under tracking systems or manipulation and control devices.

#### Tracking systems

The tracking system measures position and orientation in the virtual environment. The computer uses the position and orientation of the user's head to determine how to display the virtual world in such a manner that it seems as though you are in the world and not watching it from a distance. When the user turns her/his head the head tracker will sense the change in position and will adjust the displays accordingly.

#### Manipulation and control devices

In a virtual world it is necessary to track the position of a real world object, e.g. a head or a hand, to enable interaction.

A conventional mouse, trackball or joystick is the simplest control hardware. These are 2D devices, but there are 3D and 6D mouse, trackball and joystick devices on the market – these devices have extra buttons and wheels that are used to control the XY translation of a cursor, the Z dimension and rotations in all three directions.

An instrumented glove (data glove), with sensors on the fingers and an overall position/orientation tracker, is also used to manipulate objects in a VE. Full body suits with position and bend sensors are used for capturing motion for character animation and for controlling music synthesizers.

Stereovision is accomplished by creating two different images of a world – one image for each eye. A number of devices are used in VE to create a stereoscopic experience. Some of the devices are:

#### Head Mounted Display (HMD)

A helmet or goggles are used to place small video displays in front of each eye. These devices have special optics to focus and stretch the perceived field of view.

### Projection based systems

Cyberstage [84] is a four-side stereo display system with a 3x3 meter floor on which the virtual space is generated by high performance graphics workstations. It is a CAVE, with a much improved image quality and an eight channel audio display. It has an acoustic floor that allows the generation of a sense of vibrations. It also has eight audio channels and spatialised sound is distributed to its eight speakers located at the lower/upper corners.

The *Responsive Workbench* [84] is a three-dimensional table where the computer screen is changed to a horizontal, enlarged work top version. This view replaces the two-dimensional flat screen and corresponds to actual working surfaces, i.e. in an architect's office, at surgery environments, etc. Objects are displayed as computer-generated stereoscopic images and projected onto the surface of a table. A guide uses the virtual working environment while others can observe through shutter glasses.

There are many elements and issues with regard to virtual environments that relate to interactive storytelling. The next subsection highlights some of these elements and issues by discussing virtual worlds, presence and interaction in a virtual world and the physiological and psychological effects of virtual environments.

## **2.2.2. Elements and issues of virtual environments**

### **Virtual world**

A virtual world is a story world where the user can experience the story world interactively, in other words a story world that is created for a virtual environment.

A virtual world should be worth entering (inviting the user to enter), worth spending time in (captivate the user) and a medium of expression and experience. Best said that virtual worlds should evoke our imagination and not be an exact repetition of the world [73].

This can be accomplished by providing user-friendly tools for people who want to create their own virtual worlds and experiences. Therefore authoring tools (refer to section 2.2.3) can play an important role in the future development of virtual worlds.

A continuous interactive representation is made more complex by the fact that the mind is very willing to restructure itself to compensate for or adapt to a changing reality. According to William Bricken, one comes to accept the polygonal representations as one interacts with a



virtual world and the virtual world becomes just as valid as the real world. This phenomenon is often referred to as *cognitive plasticity* [8].

The design of virtual worlds must include characters that offer many possibilities for interaction or that navigate the user through the virtual experience. In a virtual world, the character should be either controlled or aided in navigating through the environment. Theoretically the user should be able to move anywhere in the virtual world, but in some instances the creator of the virtual world would like to limit them.

Sound can also play an important role in making the virtual world more enjoyable. It can vary in tone, pitch or intensity to reflect a change in conditions, e.g. to warn of the presence of someone or something. The sound can be spatialised to reflect the position of the object or can move around with an external motion signal.

When the virtual world is interactive, the user is an integral part of it and the full progression of the story line isn't known in advance. Elements of the action, such as walk cycles, dances and gestures, can be pre-animated, but they have to be combined dynamically in response to the user.

Within a virtual world three types of interactions can take place:

- Interactions with the *environment* (e.g. navigating around the virtual world)
- Interaction with the *objects* in the environment (e.g. picking up an object)
- Social interaction with *other participants* (e.g. talking to other virtual characters)

Interaction is one of the major advantages of virtual environments. However, a virtual world should create a sense of presence for the participant, to ensure that s/he will experience the virtual environment as believable.

## **Presence**

Lombard and Ditton [43] mentioned six conceptualisations of presence. Some of them are presence as

- Realism
- Transportation,
- Immersion
- Social actor within a medium

### Presence as realism

This conceptualisation concerns the degree to which a medium can produce seemingly accurate representations of events, objects and people, i.e. representations that look, sound, and/or feel like the real thing. There are two key types of realism, namely *social realism* and *perceptual realism*. Social realism refers to which extent a media portrayal reflects events that do or could occur in a non-mediated world, i.e. whether it is plausible or “true to life”.

### Presence as transportation

Three types of transportation can be identified, namely you are there, it is here and we are together.

#### *You are there*

With this type of transportation the user is transported (teleported) to another place. This concept is often used in discussions of virtual reality where users are taken to a VE that leads to a suspension of disbelief that they are in a world other than where their bodies are located.

#### *It is here*

With this type of transportation another place and the objects within it are transported to the user. When we watch a television programme, we don't experience being taken out into the world as much as experiencing that the world is being brought to us.

#### *We are together*

With this type of transportation two or more communicators are transported together to a place that they share, e.g. video conferencing and collaborated virtual environments.

### Presence as immersion

This conceptualisation emphasises the idea of perceptual and psychological immersion. Perceptual immersion is the degree to which a VE submerges the perceptual system of the user. Psychological immersion refers to situations where users feel immersive presence and this results to them being involved, absorbed, engrossed and engaged.

### Presence as social actor within medium

This conceptualisation refers to situations where users' perceptions and the resulting psychological processes lead them to illogically overlook the mediated or even artificial nature of an entity within a medium and they will even attempt to interact with it.

The German word “*umwelt*” is used to express the organised point of view (experience) that is unique to any creature and depends on that particular creature's sensory and cognitive apparatus [79].

In *PlaceHolder* [79] they did the following to experiment with the “umwelt” concept:

- Experimented with approximations of the sensory-motor experiences of non-human creatures
- Experimented with narrative strategies for supporting transformation, locomotion, spatial and temporal discontinuities
- Explored concepts of space and time that underlie representation systems that have been developed by cultures whose views of the world differ dramatically from our own

The virtual identity approach uses the “umwelt” concept since the story world is unique for every virtual identity. The experimentation of the “umwelt” concept in *PlaceHolder* can be applied to virtual identities, since the virtual identities' viewpoint of the story world is not necessarily the same as that of the participant before s/he enters the story world.

According to Best [73] it is easy to become disorientated in an abstract world. Therefore, one of the key aspects to develop a sense of place and to know where you are at all times, is the ability to build an accurate cognitive map.

In order to help the user to build an accurate cognitive map, the virtual world needs to provide an underlying order that gives stability and orientation and allow constant change in response to user actions and information update.

When transfer between different virtual worlds takes place, the user can be warned about change to assist in creating a sense of presence. This can be done in many ways, for example audio cues, building changes in the virtual world (e.g. a change in colour or scale), leading the user with a robot (after being introduced to the robot first) or leaving a trail with a ball of string to create reassurance that the user will be able to find the way back.

Presence is an important element of a VE and the joy of the experience can be enhanced through interaction, because it enables the user to actively explore and participate in the VE.

## **Interaction**

According to Kallman and Thalmann [81] four classes of different interaction-features can be identified:

- *Intrinsic object properties* – e.g. the description of the movements of each object part

- *Interaction information* – information about the positions of interactive parts (knobs, buttons) and the hand shapes and locations to interact with them
- *Object behaviours* – these behaviours are available according to the object's state, e.g. a door has an available behaviour to close itself only if its state is open
- *Expected user behaviours* – these behaviours are associated with the object behaviours in order to indicate where and when the user should put her hand

Best suggested that virtual objects should have sophisticated abilities, i.e. intelligence or additional entities and that this will bring the virtual world alive and give it magical and delightful qualities [73]. The objects can have character, intelligence or give textual or auditory clues.

A virtual object can aid the user by giving clues on how to accomplish a desired interaction task [81]. *Smart Objects* [89] for example have additional functionality defined during the modelling phase by using a graphical interface that enables you to define the behaviour of the object. During the simulation the object knows which interactions can be triggered by the user and then aids the user to choose the desired one.

When virtual environments are used in education, some children find the use of the manipulation devices awkward and even difficult. However, the interaction in virtual environments enables children to learn through participation and it is one of the main advantages of a VE.

Although virtual environments can enable the user to experience joy, rapture and enlightenment, the use of virtual environments can have physiological and psychological effects on the users.

## **Effects of VE**

### Physiological effects of presence as invisible medium

Presence can have physiological effects on the participant. Virtual reality entertainment systems that evoke presence are often designed to be arousing and exhilarating experiences [43]. They can be filled with highly arousing violent or sexual content or highly relaxing content (e.g. a deserted island).

When presence is evoked in virtual reality the users can experience an illusion that they are actually moving through the mediated environment. This phenomenon is referred to as

*vection*. When presence is combined with vection, the user can experience motion sickness with symptoms such as dizziness, disorientation, eyestrain, standing and walking unsteadiness and nausea.

Presence can cause automatic responses such as ducking, flinching and tightly grasping one's chair. According to [46] reduced eye-hand coordination, "flashbacks", illusory sensations of climbing and turning and reduced motor control and even last as long as two weeks after use.

#### Psychological effects of presence as invisible medium

Presence as invisible medium can have psychological effects on the participant. Presence in virtual environments can cause the user to experience enjoyment and delight [43]. Virtual environments that mimic non-mediated experiences can be particularly effective in desensitising users to various stimuli, e.g. VEs has been useful in treating people with a fear of heights [58].

#### Psychological effects of presence as transformed medium

Presence can lead users to perceive a medium (e.g. computer) as a social entity. This can cause at least some of the users' perceptions, emotional responses and thought processes to be similar or identical to those of human-to-human interaction. According to [43] the psychological effects can therefore be potentially as diverse as those that are generated by non-mediated social interaction. Users recognise a computer's personality as submissive or dominant and respond more favourably to one with a personality similar to their own, just as in human-human interaction [48].

Creating virtual environments can become a daunting and difficult task for novices. Many writers don't have any programming skills and don't want to go through the difficulty of creating a VE. Therefore, they seek tools that can make this task easier. Authoring tools provide a solution for this problem and enable novices to create virtual environments much easier.

### **2.2.3. Authoring tools**

An authoring tool can help to bridge the gap between the non-programming author and the computing environment's primitive current state. *CharacterMaker 4.1* [54] [55] helps non-programming authors to focus on behaviour rather than paragraphs of text, for it allows users to create their own Eliza-like characters.

Many writers are interested in writing virtual narratives, but the complex computer coding that is required daunts them. Thom said: "... Other writers in the group also voiced a desire for tools which will allow their words and work to flow through technology rather than being entombed..." [34].

The reason for developing an authoring tool for interactive stories in virtual cultural and educational environments is to make the development of interactive stories available to experts with minimal expertise in the creation of virtual environments and to enable researchers and educators to exploit this technology without relying on expensive production efforts.

When taken into consideration the vast amount of application areas of virtual environments and the power of virtual environments that can be used for education, tourism and training (to name but a few), the eminent need of an authoring tool becomes very clear. Most of the present authoring tools for virtual environments are mostly interface libraries to standard programming languages (CAVE Library, DIVE) or provide minimum support for defining walk-throughs through the virtual world and interaction with the objects in the virtual world. Therefore, an authoring tool that will allow people with the minimum technical background to create interactive stories for different user profiles can have a big impact on many application areas, especially education.

The *choose-your-own-adventure* approach [24] to writing interactive fiction results in a tree structure with an explosion of nodes. An example is illustrated in figure 1. When following this approach the writer must anticipate all possible directions, which is almost impossible.

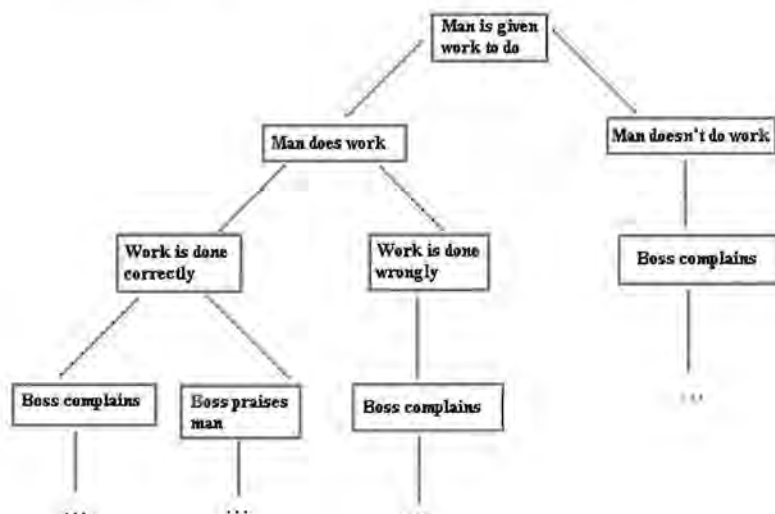


Figure 1: Choose-your-own-adventure approach of writing stories

An authoring tool should provide users with tools for constructing various aspects of an interactive application. These tools should be intuitive to use, allow the creation of rich, compelling content and produce behaviour at run-time that is consistent with the author's vision and content.

Existing VE authoring tools that have some support for generating interactive stories, use metaphors such as paths, scenes and scripts to describe what a user experiences and what interactions with the environment are allowed.

The *Alive* system [56] focuses on self-organising embodied agents that are capable of learning from their experiences and making inferences. The system uses ethological mechanisms that enable the actor to maximise his ability to reorganise his own personality, by taking his own perception and accumulated experience into account.

The *QuickWorlds* [39] program was designed to provide teachers with a mechanism to make virtual models available to their students as part of the regular learning program with very little effort.

In 1998 Crawford said the following:

”There simply isn't anything out there that lets you create interactive storytelling. (And if there were, they'd have to work around my comprehensive patent). There are plenty of text adventure generators, role-playing game systems, Quake level builders, intelligent agent programs, screenwriting tools, and other impressive programs – but if you want to build genuine interactive storytelling, the Erasmatron is The Best by virtue of being The Only.”  
[24]

The *Erasmatron* [24] is an authoring tool that is used to create interactive story worlds. It enables non-technical writers to create interactive stories without worrying about C pointers and memory problems and to address the problem of exploding nodes when following the *choose-your-own-adventure* (refer to figure 1) by using probabilities to anticipate possibilities and still maintain dramatic tension and a compelling storyline.

Authoring tools are required to make the authoring of photo-realistic virtual visits of architectural sites more affordable for use in the fields of architecture, simulation, entertainment, electronic publishing, education, etc. *CyberMonument* [57] provides authoring tools for photo-realistic virtual visits of European heritage and historical architecture.

*CyberCity* [57] provides authoring tools for photo-realistic visits of large 3D urban multimedia databases in a European telematics context.

*XP* [16] is a framework for VE applications that takes care of many of the basic tasks of creating virtual worlds and it is easily extendable. It is based on Performer, the CAVE libraries, a sound library and C++ and was used to build *The Thing Growing* [16].

AVANGO [67][95] is a programming framework for developing distributed interactive virtual environments and is built on top of IRIS Performer. It allows authoring of applications by defining scenes, paths and interaction with the virtual objects in the scene. Camera paths are then created to provide the user with alternative paths through the environment. It is discussed in more detail in section 4.2.

Both artists and cultural workers would like to construct VE narratives and therefore the creation of tools and techniques that will assist them in doing so, become quite important.

VE offers a new way of experiencing fiction. Authoring systems will play an important role in the creation of innovative art projects and moving culturally based VE experiences beyond fly-throughs and reconstructed ruins.

#### **2.2.4. Application areas of VE**

Virtual environments are used in many areas that range from art and entertainment, to medical applications. Virtual environments are an interesting medium for the education and entertainment industry, since they are a novel medium for developing and experiencing content. They are also used in military training and flight simulation, arcade games, architectural and interior design, exercise equipment, virtual sex, underwater exploration and training and assessment of surgical skills [43].

Virtual environments supports a constructivism approach to learning, i.e.

- Knowledge is constructed from the experience the child obtains from the virtual world and processes in which the child engages
- New knowledge is best constructed when users engage in personally meaningful tasks
- Authentic context is pedagogically important



Many applications, such as culture, are dynamic and therefore static representations are not efficient for portraying them. Virtual environments can solve this problem by allowing people to experience the virtual world interactively and dynamically.

One of the application areas where virtual environments can have a big impact is education. Virtual environments will enable children to learn through participation and by interactively exploring the virtual world.

#### **2.2.4.1. Education**

The categories of virtual environments (according to their development platform) that are designed for education are:

- Network text-based virtual environments
- Desktop virtual environments
- Simulations
- Immersive virtual environments

Text-based Virtual Worlds are commonly known as MUDs and MOOs [97] and they support real-time interactive use by allowing a large number of users to share the same virtual world from remotely located computers. However, they lack a specific learning structure, direction and multi-sensory representation and assume literate children (usually English literacy).

Desktop Virtual Environments are virtual environment applications on personal computers. They allow users to walk through simulation environments created via readily available commercial software. However, they are limited in size and complexity, lack immersive qualities and have minimal interaction e.g. through a mouse (2D, 3D, 6 degree).

Immersive Virtual Environments are developed with high-end equipment and are mostly developed especially for head-mounted display systems. However, they are limited to situations with special funding, such as academic and research environments, international companies and museums.

Currently, there are only a few VE-based learning environments designed for young children and even less multi-user virtual educational worlds. Some of the virtual learning systems that are mentioned by Youngblut are the following [70]:

- *Virtual Bicycle* that was developed to train and rehabilitate young bicycle users
- *Virtual Pompeii* that provides insight into Pompeian life and culture

- *Cell Biology* that gives users an “hands-on” experience with the principles of human cell biology
- *Virtual Gorilla Exhibit* that gives instruction in gorilla behaviours and social interactions in a family group and zoo habitat design and layout issues
- *Great Pyramid* to create appreciation of the pyramid structure
- *3D Letter World* to enhance letter recognition
- *Virtual Biplane* to create an appreciation of flight
- *Science Education World* to create conceptual understanding of nature
- *Spatial Relations Worlds* to enhance spatial problem solving abilities
- *NewtonWorld* that allows the user to explore Newton's Laws of Motions and conservation of kinetic energy and linear momentum
- *MaxwellWorld* that enables the user to explore electrostatics that leads to the concepts of electric fields (force), electric potential (energy), superposition and Gauss' Law
- *PaulingWorld* that teaches the user about probability density, wave functions, nuclear charge, atomic orbital shapes for single atoms, bonded of 2 atoms, differences between bonded structures, determinants of bonding angles and length.
- *Makaton World* that teaches Makaton symbols and associated sign language
- *Life Skills Worlds* that supports the development of self-directed activity
- *AVATAR House* that supports the development of concentration skills, improves the attention span and self-confidence
- *Phase World* that provides the user with an understanding (at the molecular level) of what happens when matter changes from solid to liquid to gas and relationships among pressure, temperature and volume
- *Atom World* that reviews the basic atomic and molecular structures
- *Zengo Sayo* that teaches Japanese
- *Global Change* that creates and understanding of the basic relationships among the causes and effects of global change

### **Collaborative Virtual Learning Environment (CVLE)**

In a Collaborative Virtual Learning Environment (CVLE) [60] virtual actors can play two main roles, namely

1. A virtual actor functions as an embodiment or representation of the user in the virtual world and is then known as an *avatar*
2. A virtual actor represents a software agent that specifies the behaviour of the actor

Collaboration can be encouraged through *activity*, i.e. the task of the participant or the subject of the collaboration, and *pedagogy*, i.e. the style of teaching/learning that is used.

A CVLE consists of entities, actions between the entities and the situation of the collaboration. There are four main categories of entities, namely the *environment* (the space in which the collaboration occurs), *objects* (artefacts in the environment that participants can interact with or tools that can be used to communicate with other participants), *participants* (the child and the expert) and *groups* (participants can be divided into groups).

A few of the multi-user virtual educational worlds are:

#### Virtual Physics at the University of Lancaster [70]

The goal of the *Virtual Physics* project [70] was to investigate how collaborative virtual worlds can be designed to provide improved support for conceptual learning of physics. The user can enter a number of scientific worlds from a central space. Current worlds are the *3D Pivot World* where the user has to level the table by moving the objects, the *Friction World* where the user has to adjust the environment so that the world behaves in a “real” manner and identify what exactly the unlabeled controls do and the *Bowls World* where the user builds an understanding of the relationship between friction and weight.

#### NICE (Narrative, Immersive, Constructionist/Collaborative Environments) at the University of Illinois at Chicago [12]

NICE (Narrative Immersive Constructionist/Collaborative Environments) [12] is an exploratory learning environment that was developed for use by children between the ages of 6 and 10 and is set on a virtual fantasy island where the terrain consists of many spaces that can be explored. It is based on *constructionism*, where real and synthetic users, motivated by an underlying narrative, build persisting virtual worlds through collaboration. It blends several learning and pedagogical themes within a single application, namely constructionism, exploratory learning, collaboration and a narrative. NICE succeeded as an engaging social space and as a driver for collaborative virtual environments, but their co-operative learning was unstructured and undirected.

#### Round Earth Project [2]

The *Round Earth Project* [2] is NICE's successor and therefore builds on the experiences gained from NICE and seeks to remedy these deficiencies. To understand a picture of a person on a spherical body, the viewer must project himself or herself into the picture. This cognitive ability is beyond very young children, but with the *Round Earth Project* the

children can be immersed in the experience when they walk on the spherical surface of a small planetary body such as an asteroid in the virtual environment.

#### KidsRoom [28]

The *KidsRoom* guides children through an interactive, imaginative adventure where the story takes place in a real physical space that is transformed into an imaginative play space. During the story, children can interact with objects in the room, one another and virtual creatures projected onto the walls.

The following factors limit the successful integration of advanced technologies in schools:

1. Insufficient resources to support teaching practices
2. Lack of alignment between technology-based materials and the curriculum/goals
3. Lack of authentically motivated preparation and training offerings for teachers
4. Lack of time for teachers to pursue additional training
5. Insufficient technical support for maintaining and upgrading hardware and software systems
6. Providing assistance for operating and understanding the capabilities of the application software
7. Failure to provide mechanisms for assessing the pace and effectiveness of using the technology in the student's learning climate

In Science education [35] many important concepts within the curriculum are acquired through experimentation and manipulation. However, students with severe physical disabilities are often excluded from full participation in regular science classes at the secondary level, because they are unable to perform requisite activities safely and effectively.

The Oregon Research Institute (ORI) Virtual Reality Lab [60] works closely with science teachers at selected secondary schools to explore the feasibility of using virtual environments as a new instructional tool to enable severely orthopedically impaired students to fully participate in science education classes, to identify the necessary support and conditions to accomplish full inclusion using VE technology, to identify underlying principles of using virtual environments for science activities in such a way that meaningful student participation is ensured and to validate that the VE materials ensure adequate student progress.

Cultural artefacts can play an important role in education when they are used to connect children's out-of-school cultural experiences with classroom activities [36]. With the use of cultural artefacts, learning can be intended as a process of mathematical knowledge

construction, by engaging the children in classroom activities that require an extensive use of culturally significant artefacts to encourage them to develop a positive attitude towards school mathematics and to enable children to extend, reflect, generalise and apply their knowledge. In contrast with the traditional classroom curriculum, children are offered endless opportunities to become acquainted with mathematics in a way that they can relate to. This approach enables children to see where mathematical concepts occur in daily life and can therefore help to change their attitude towards mathematics.

Visual representations support learning in numerous ways and in many applications better understanding of specific concepts is obtained through visualisation. Visualisation allows the demonstration of specific concepts without being language specific where translation could be required. Illiterate people can also associate themselves easier with visual representations where reading text is not required.

The ideal learning environment is one that encourages students to question facts and seek challenges. In [80] the following is stated about virtual environments and education: “... the goal of real education means is not just to teach and have students master the content. Real education is to excite students' interest and virtual reality has the possibility to do this.” Virtual environments can become a powerful educational tool, because they allow access to the unreachable or unrealisable, can provide multiple or alternative representations, can help to make abstractions more concrete and are a medium for interactive, collaborative and engaged learning.

Although virtual environments are applied to many educational situations, they are also used for training purposes, cultural applications and art and entertainment.

#### **2.2.4.2. Other application areas**

Virtual environments have the power to make simulation-based learning much closer to real-life experience. Virtual environments have proven to be very valuable, especially in domains where training is expensive or hazardous, e.g. surgery, air combat and control of complex equipment. Virtual reality provides realistic perceptual stimuli and therefore is an adequate simulation for a wide range of situations, for example Steve (Soar Training Expert for Virtual Environments) [13] is a pedagogical agent that was developed to explore the use of virtual environments for an intelligent tutoring system.

The combination of interaction, immersion and the digital computer makes virtual environments an exciting medium for cultural productions [94].

Museums worldwide are becoming aware of the power of using virtual environments to interpret and demonstrate cultural heritage. Maria Roussou and her team have built a reconstruction of the ancient city of Miletus in a VE [62] at the Foundation for the Hellenic World.

Virtual environments can play an important role in many art applications. Kochalka said: “... Art is one of our most basic means for understanding the world around us. We process what we've experienced and recreate it in simplified form. Often this brings revelations that we could not come by through sheer reason.” [33]

Art is a way for the artist to express his/her views and can open our eyes to realise new perspectives. Kochalka said:

“When we encounter a great work of art, the physical world fades away as we step into this new reality. We are alive in a living world. What makes this world so captivating is that it's a reinvention of the actual world, and revelation of the artist's secret self. Art turns us inside out.” [33]

The Multi Mega Book (MMB) [50] [51] in the CAVE (VE application) expands one Maxi-page of the Multi Mega Book multi-media installation. When the user enters the CAVE, the Multi Mega Book is in front of him/her. S/he can then turn the pages and move through the pages into various parts of the worlds within.

Kali [7] is an interactive sculpture of 2 metres that stands on the top of a hill, immersed in a play of shadows. The visitor is able to generate situations (causes within the virtual world) and to see the corresponding consequences (effects) in real time.

*Placeholder* [79] was a research project that enabled two people in head-mounted displays to move around in the environment and to interact with each other and four animated critters, namely Spider, Snake, Crow and Fish. The two persons could also become one of these critters. As the user approached, the critters and sound sources located in the virtual environment told stories about themselves.

*VActor* [5] performance software is used in the Nintendo Super Mario Brothers live presentations and by Broadsword to animate Ratz the Cat. In both cases, they rely on the

skills of their actors, who find the medium liberating. Charles Martinet said: "...when I realized how well it works, all of a sudden I became the character. I wasn't controlling a puppet, I was the puppet." [5] [53]

Virtual environments are applied in many areas. The combination of interactive storytelling and virtual environments can bring many new possibilities and application areas to light.

### **2.2.5. Summary**

This section discussed virtual reality and what virtual environments are. It presented the different VE systems and the elements and issues that are related to virtual environments. It highlighted authoring tools and the advantages of using authoring tools in virtual environments. It discussed the different application areas of virtual environments and in particular education.

The next chapter discusses the theoretical approach that was followed for the interactive storytelling tool. It presents how interactive storytelling is used in virtual environments. It discusses virtual characters and highlights the virtual identity approach and how it can be used in interactive storytelling. It presents how this approach can provide a solution for some of the problems that are experienced with interactive storytelling.

## Chapter 3

*“People create meaning through narrative or stories. They access new learning opportunities and new ways of being through stories...”*

*V. Lalioti and C. Jackson [11]*

### Theoretical approach

In this chapter, the theoretical approach for interactive storytelling using virtual identities is discussed. It discusses how interactive storytelling can be used in virtual environments with the use of virtual characters. It presents the virtual identity approach and a taxonomy for defining a virtual identity. It highlights how the taxonomy can be used with the virtual identity approach to create an interactive story and how the virtual identity approach can provide solutions for some of the problems of interactive storytelling.

#### 3.1. Virtual characters

Interactive storytelling can be a powerful tool for cultural and educational purposes. People create meaning through stories and stories provide a new means of accessing learning opportunities. Therefore, stories can be used to support learning opportunities in a dynamic and fun way [11].

When interactive storytelling is used in virtual environments, there should be a way for the user to identify with some kind of representation while exploring the VE. This can be done with the use of virtual characters.

Virtual characters use a multi-modal approach that includes speech recognition, text-to-speech, real-time morphed schematic faces and music. Virtual characters have varying degrees of freedom, because they can receive explicit instructions (e.g. facial expression), general instructions (e.g. given the emotion and the text to pick their own facial expression) and a degree of freedom (e.g. where they pick the emotion based on their personality).



In order for virtual characters to act like humans, they should be able to use natural language, reason, discuss events and ideas, have knowledge about their world, have memories of their personal histories and have emotions and personalities that fuel their motivations and desires.

Pure physical realism does not ensure believability. To create lifelike characters, the characters must be driven by their thoughts, personality and emotions.

Different approaches exist for creating virtual characters that are acceptable to the user, which include a mixture of the goals, goal-directed states and behaviours, emotional states and behaviours, limited natural language abilities, memory and interface functions. By blending a mixture of these elements, an illusion of reality is created and the user is enabled to suspend disbelief.

The underlying notion of Pixar and Disney animation is that action is driven by the intelligence, personality and emotion of a character. In *Toy Story*, Woody's personality is depicted in his reactions to events [20], i.e. his personality flows through his actions and reactions.

Sophisticated algorithms are used to define the behaviour of the virtual character. The advantage of using these algorithms is that the number of possible outcomes is nearly unlimited, given a rich set of inputs.

With *The Sims* [91] each character has variables to describe and control its behaviour. Each character has needs that lead to motives for a specific action (hunger can lead to getting food), preferences for certain activities, abilities, relationship to other characters, relationship to the environment and personality. Object behaviours are created with Sim-Antics, which is a real-time scripting language. The character attempts to find the best action for every object and each interaction that is possible with that object. The path planning is done with a modified A\* search algorithm, that finds the optimal path to the goal by using either best-first-search (cost of any state is equal to the cost of getting to the state from the start state) or heuristic estimate of the distance from the state to the goal.

Directed improvisation is where characters improvise a course of behaviour in real time by repeatedly generating possible behaviours and constraining their choices among competing behaviours by imposing internally and externally generated directions.

Talin has used Lee's algorithm to control the movement of animated characters in a fantasy environment [21]. The algorithm is a routing algorithm used in electronic CAD programs to plot the optimum pathway for a copper trace on a printed circuit board.

In a virtual world, the virtual character's body image can be constructed in many different ways. The body can be designed with numerous limbs and by attaching additional sensors to the knees and elbows to control the extra limbs, the body can be inhabited with double the regular complement of limbs. This can be used, for example, to construct a giant lobster in the virtual world [8].

Walser and Gulichsen [8] said the following:

“In cyberspace there is no need to move about in a body like the one you possess in physical reality. As you conduct more of your life and affairs in cyberspace, your conditioned notion of a unique and immutable body will give way to a far more liberated notion of “body” as something quite disposable and, generally, limiting. You will find that some bodies work best in some conditions while others work best in others... The ability to radically and compellingly change one's body image is bound to have a deep psychological effect, calling into question just what you consider yourself to be...”

In *Placeholder* [79] the user has to do something (take some action) to obtain a body. In the virtual environment humans are invisible in the world, to themselves and to each other. They cannot use the portals or see the Voiceholders. They can only talk and explore the immediate environment of the cave. From the moment the user enters the virtual environment the Critters talk to them, brag about their qualities and entice the user to move closer. When the user's head intersects with one of the Critters, the user becomes embodied as that Critter. The Critter now functions as a *smart costume* that changes how the user looks, sounds, moves and perceives the world.

Michael Mateus said: “Believable agents are designed to strongly express a personality, not fool the viewer into thinking they are human” [90].

Cognitive modelling is where the mind willingly restructures itself to compensate for or adapt to a changing "reality". It is used to direct autonomous characters to perform specific tasks [8]. Cognitive models govern what a character knows about the world, how the knowledge is acquired and how the knowledge can be used to plan actions. Cognitive empowered

characters only require a behaviour outline (sketch plan) and automatically work out a detailed sequence of actions that satisfy the specification through reasoning.

Cognitive modelling consists of

- *Domain knowledge specification* that involves administering knowledge to the character about its world and how that world can change
- *Character direction* that involves instructing the character to behave in a certain way within its world to achieve specific goals

Behavioural models are reactive and therefore quite limiting. Cognitive models are deliberative and enable an autonomous character to exploit acquired knowledge to formulate appropriate plans of action. Therefore cognitive models are much more powerful and provides the character with more freedom of decisions.

The *VideoAvatar Library* [37] is a collection of functions that can be used for adding static, photo-realistic three-dimensional representations of avatars in virtual reality applications. Views from 360° around the person that is going to be presented should be obtained and then two of the images must be selected, one for each eye, to represent the user in 3D space.

In order to achieve believability, the virtual characters should be consistent and recognisable and respond to each other appropriately at all times. *Improv* [18] is a system that allows you to create real-time behaviour-based animated actors. It provides tools to create actors that respond to users and to each other in real-time, which has personalities and moods and is consistent with the author's goals and intentions. This system enables creative experts who are not primarily programmers to create powerful interactive applications, through the use of an English-style scripting language.

A constraint is a logical relation between several variables that should take values in a specific domain of interest. Therefore, it restricts the possible values that the variables can take and it represents some partial information relating to the objects of interest. Constraint solving is to start reasoning and computing with partial information, ensuring overall consistency and reducing the domains of the unknowns as much as possible.

Codognet proposed to use the power of constraint solving techniques to develop complex and efficient planning modules for autonomous agents integrated in 3D virtual environments [83]. Using constraints as goals in order to describe behaviours is a simple and declarative way of specifying animation of virtual characters.

Interactive storytelling gives the participant more freedom than the traditional media. However, a number of aspects can limit the benefits gained from its use in virtual environments.

### **3.2. General problems of interactive storytelling**

Although interactive storytelling gives the participant more freedom, a number of aspects relating to the character knowledge of the virtual world, narrative flow, the internal consistency of the story, the handling of time and finally the ease of creation can limit the benefits from its use in virtual environments [63] [64]. Taking a closer look at each of the aspects reveals the following:

#### ***Character's Knowledge of the Story World***

In a typical, non-interactive story, the characters understand the world and have knowledge about their world, for example a character knows the contents of the drawers and closets in his/her apartment and there is no need to open them to see what they contain. But in an interactive story world, the user does not have this knowledge and needs to explore the different objects as if s/he was a total stranger to the world. This approach can be used for the creation of interactive stories in certain virtual environments, like in mysteries and heroic quests where the user will engage in new and unfamiliar worlds. However, in many applications of virtual environments it is important to provide more guidance and share some of the character's knowledge with the user. For example, in applications of virtual environments for education and cultural learning, knowledge about the story world should be incorporated in the interactive story so that the user can acquire it through this facilitated interactive experience.

#### ***Internal consistency***

Any story must be coherent; that is, at any point in the story the circumstances at that specific point must be consistent with everything that happened beforehand. This does not mean that stories must be predictable, rather that they should make sense in a satisfying manner. However, the core of interactivity is freedom and therefore a conflict arises between the user's desire to do as s/he chooses and the story world creator's desire to impose a plot and characterisation on the user. The difficulty with using interactive storytelling in virtual environments is to ensure that a high degree of user freedom is combined with the story in a coherent way at every instance of the virtual experience.

### *Narrative flow*

Traditionally, every story consists of an introduction, rising action, a climax, falling action and a conclusion. With non-interactive stories this can be accomplished because the author is in complete control of the story and the characters. With interactive stories the user is outside the control of the author and therefore it is very difficult to ensure that when the dramatic climax takes place in the story, the user is there and ready for it. This is known as the *Problem of Narrative Flow* [63].

Adventure games try to solve this in a number of ways:

- *Limiting the interactivity* by either cutting down the interactivity so that the user cannot stray from the plot or giving the user a lot of interactivity that is not necessarily meaningful and does not affect the plot. This solution is obviously taking away some of the power that interactive storytelling can give to the user.
- *Not taking the user's readiness for the climax into consideration* – the story world is alive and exists around the user, regardless of what s/he is doing. Therefore, in this solution, the user is not allowed to influence the story through any interaction.
- *Advancing the plot along with the user's advances* – the user's actions are linked to the advancement of the plot and therefore this approach absolutely guarantees that the user is ready for the climax. However, this solution is mechanistic and the story only progresses when the user performs the right actions.

### *Time*

In traditional narrative, the story and the discourse are divided. When reading a novel, the storyline is constructed from the discourse that it is presented. Therefore, time of the narrated, time of the narration and time of the reading do not necessarily coincide.

Christian Metz, as quoted in [65], says that:

“Narrative is a ... double temporal sequence... There is a time of the thing told and a time of the narrative (the time of the signified and the time of the signifier). This duality not only renders possible all the temporal distortions that are commonplace in narratives (three years of the hero's life summed up in two sentences of the novel or in a few shots of a “frequentative” montage in film, etc.). More basically, it invites us to consider that one of the functions of narrative is to invent one time scheme in terms of another time scheme.”

It is obvious that presenting time in an interactive story becomes more complex, because of the interactive nature of the story. The representation of time and transitions in time is a particular important challenge in virtual environments where the time of the virtual experience can vary for different users or even for the same user during the repetitive use of the virtual environment.

### ***Ease of creation***

One of the main problems with using interactive storytelling in virtual environments is the difficulty in creating an interactive story. Most writers and storytellers have little or no knowledge of programming. On the other hand, the existing authoring tools for virtual environments are very specialised and require a user experienced in programming. Authoring tools are generally defined as tools for creating computer-based instruction without having to program [66]. Authoring tools for interactive storytelling should allow writers to concentrate on creating the story instead of the details of programming.

Authoring tools (refer to section 2.2.3) use metaphors such as paths, scenes and scripts to describe what the user experiences and what interaction is allowed within the environment. Therefore, authoring tools provide solutions to make the creation of interactive story worlds easier. They provide some internal consistency by defining what interaction is allowed in the story world, and ensure consistency using for example predefined paths. Predefined paths can also provide a solution for the *Problem of Narrative Flow*, but are still limiting the virtual experience. In addition, the problem of time and knowledge about the world remains unsolved and the user experiences the story world from only one angle, that of the specific script and path.

Traditionally with avatars the emphasis was on the external appearance of the user in the VE. However, this can be rather limiting. Virtual identities can provide a solution for this problem.

### **3.3. Virtual identity approach**

The traditional notion of an avatar in virtual environments concentrates on the external appearance of the user in the virtual environment. Therefore, it is rather limiting. To overcome this limitation, the term *virtual identity*, introduced in [11], is used and expanded in this thesis.

A virtual identity is defined by knowledge about itself, its perception of the environment, its virtual embodiment and the physical simulation and kinematics of the virtual embodiment. Virtual identities and their virtual existence relate to their interaction with the environment, their reaction to the environment, their cognition of the environment and their emotional reactions.

The Virtual Identity Approach introduced in [11] allows for the creation of multiple identities/persona, allows users to engage with different cultures, enables users to enter new or challenging cultural experiences in a facilitated (allows the adoption of different identities with regard to age, sex and culture) and different way and allows users the choice of either experiencing the different cultures through the adoption of one of the identities or by freely interacting with the virtual environment.

This approach is extended by providing a taxonomy (framework) to define a virtual identity according to the

- Characteristics that a virtual identity is born with
- Characteristics concerning the virtual identity's background
- Characteristics concerning the virtual identity's values
- Embodiment of the virtual identity
- Behavioural characteristics of the virtual identity

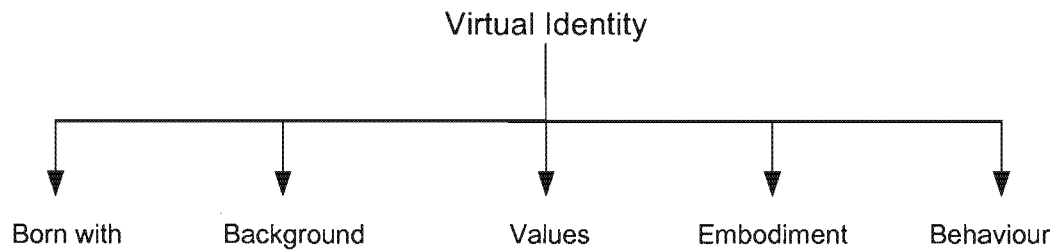
This framework relates real identities to virtual identities, in terms of socio-psychological, gender and embodiment issues [11][99][100], and it is described in more detail in the next section.

### **3.4. Taxonomy for defining virtual identities**

The *multiple identity approach* of social psychology is used, where the identity is negotiated in different contexts. It is by no sociological means a full taxonomy of characteristics of real identities, since the aim is not to completely imitate real identities. A hierarchical framework is defined with several layers that relate to different characteristics of real or virtual identities and is illustrated in Appendix A.

#### Highest level of the taxonomy

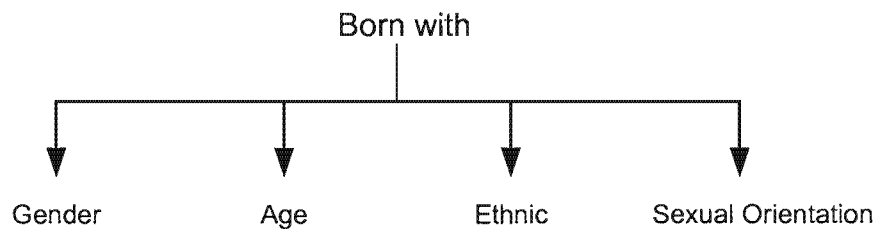
The taxonomy that is used to define a virtual identity consists out of many levels. At the highest level a virtual identity is defined by the characteristics it is born with, its background, values, embodiment and behaviour, as illustrated in figure 2.



*Figure 2: The taxonomy at the highest level*

Characteristics that the virtual identity is born with

Characteristics that the virtual identity is born with are extended into the identity's gender, age, ethnic background and sexual orientation. Many debates are going on whether a person's sexual orientation is a characteristic that a person is born with or if it is a characteristic that is caused by certain things that happened in a person's life or if it is a way of living that a person chooses to follow. In this dissertation it is taken as a characteristic that a person is born with, as illustrated in figure 3.



*Figure 3: The main characteristics that an identity is born with*

The virtual identity's sex can either be female or male and the age can either be young, matured or old. The ethnic background are categorised into American, African, European and Asian. The sexual orientation is expanded into heterosexual, bisexual or homosexual. This is illustrated in figure 4.



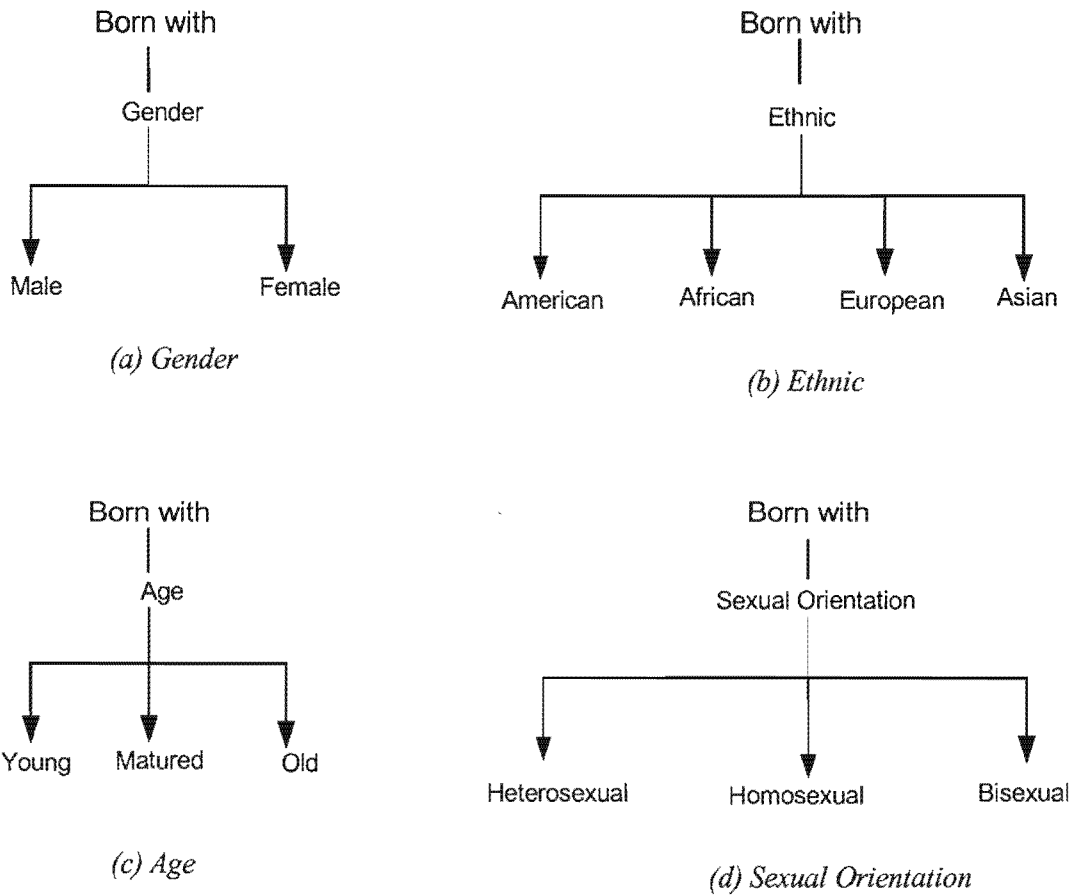


Figure 4: Expanding the characteristics that a virtual identity is born with

#### Characteristics concerning the virtual identity's background

Characteristics concerning the background of the virtual identity are expanded to include the identity's occupation, materialistic power, location where the virtual identity is living, class and language, as illustrated in figure 5.

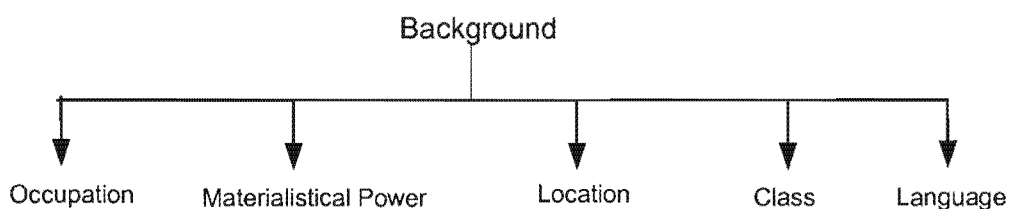


Figure 5: The main characteristics describing the virtual identity's background

The virtual identity's occupation is expanded to the area, status and occupation type. The materialistic power is categorised into below basic, basic, middle, high and rich. The location is expanded to indicate whether it is in the countryside or a residential area and the type of accommodation. The identity's class is expanded by the identity's class that can change (e.g. when the identity marries someone that is rich, s/he may change from a working class to an upper class) and the class that cannot change (e.g. when the identity's class changes from working class to upper class, the identity may still act as someone of the working class and therefore in this aspect the identity's class doesn't change). The language is categorised by the identity's ethnic language and languages that the identity have acquired (see figure 6).

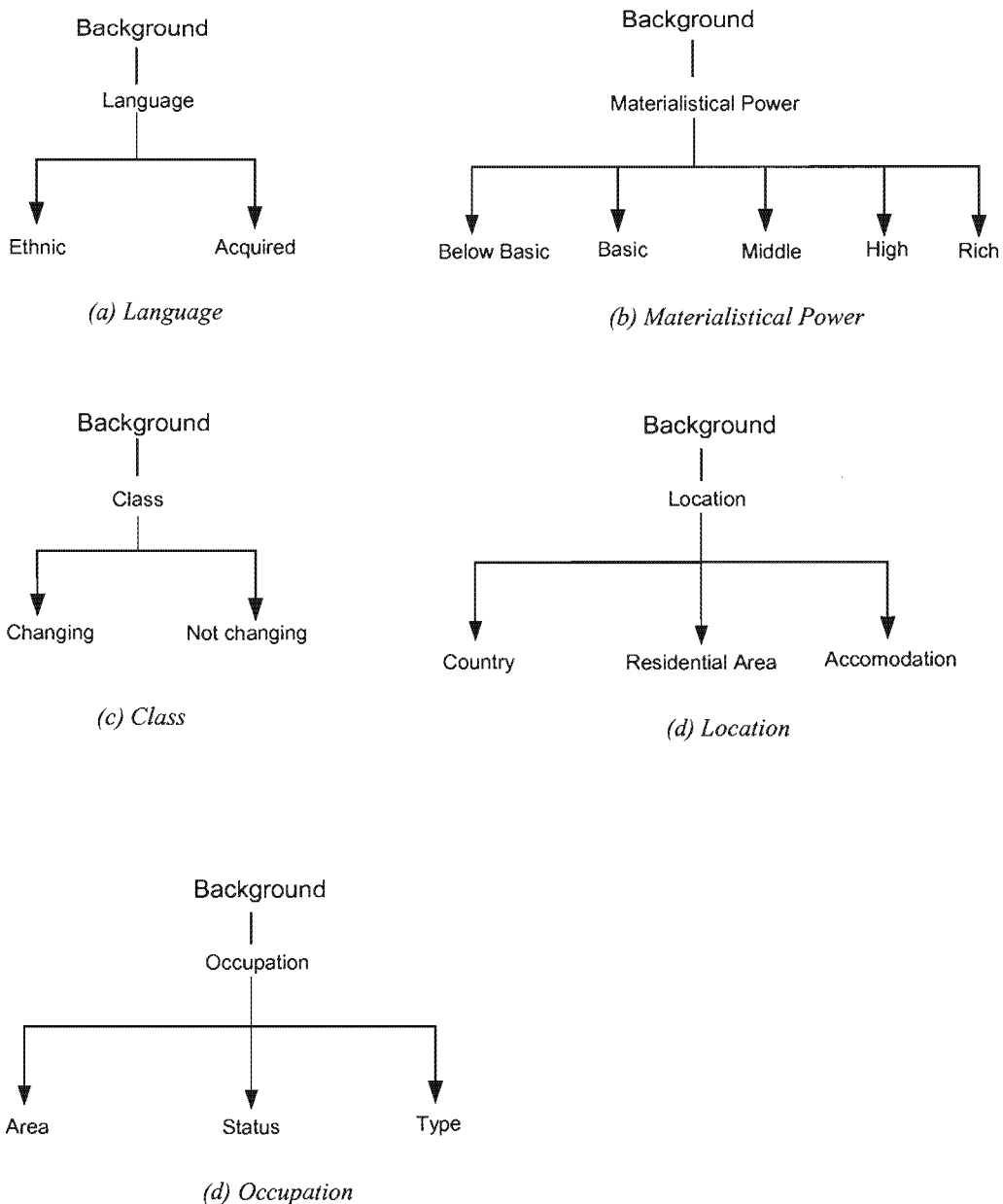


Figure 6: Expanding the characteristics of the virtual identity's background

Characteristics concerning the virtual identity's values

Characteristics concerning the virtual identity's values are expanded to the identity's political affiliation, aesthetic orientation and cultural values, as illustrated in figure 7.

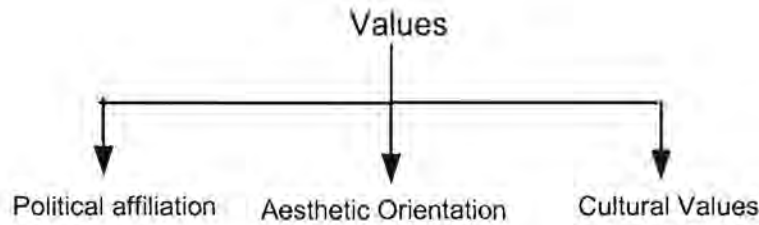
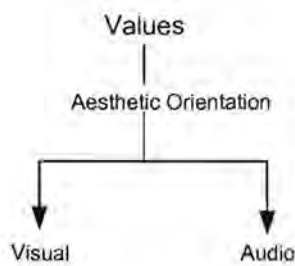
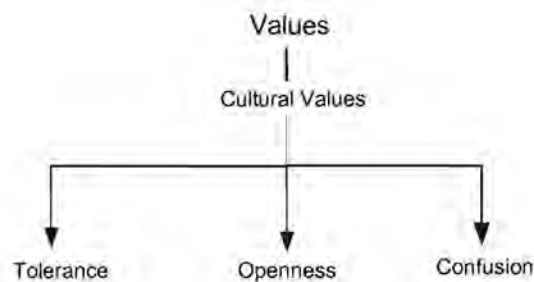


Figure 7: The main characteristics describing the virtual identity's values

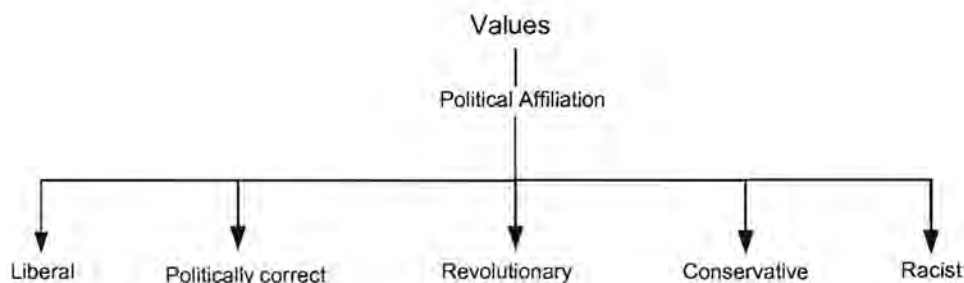
The virtual identity's political affiliation is categorised by liberal, political correct, revolutionary, conservative and racist. The aesthetic orientation is expanded to visual and audio and the virtual identity's cultural values are expanded to tolerance, openness and confusion (see figure 8).



(a) Aesthetic Orientation



(b) Cultural Values

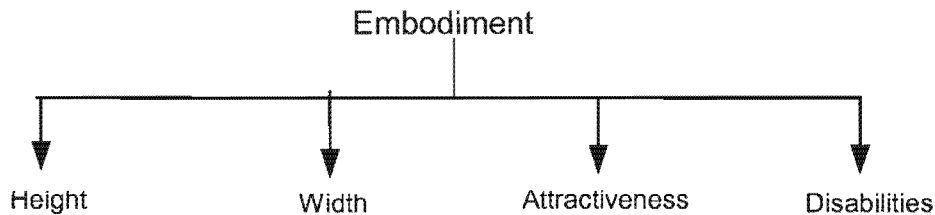


(c) Political Affiliation

Figure 8: Expanding the characteristics of the identity's values

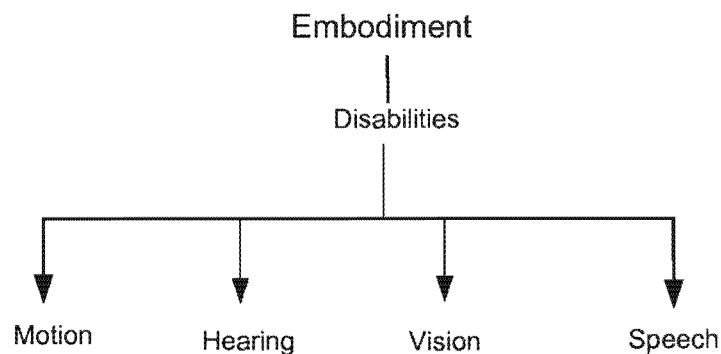
### Characteristics concerning the virtual identity's embodiment

Characteristics that describe the virtual identity's embodiment include the identity's height, width, attractiveness and disabilities. An identity's attractiveness is not a straightforward value that can be computed, because the perception of attractiveness differs from culture to culture and even from person to person. Perhaps it can be defined as how attractive an identity actually feels. These characteristics are illustrated in figure 9.



*Figure 9: The main characteristics describing the virtual identity's embodiment*

The virtual identity's disabilities can be expanded to motion, hearing, visual and speech, as illustrated in figure 10.

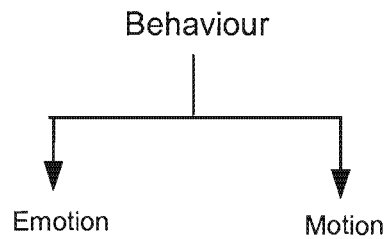


*(a) Disabilities*

*Figure 10: Expanding the characteristics of the virtual identity's embodiment*

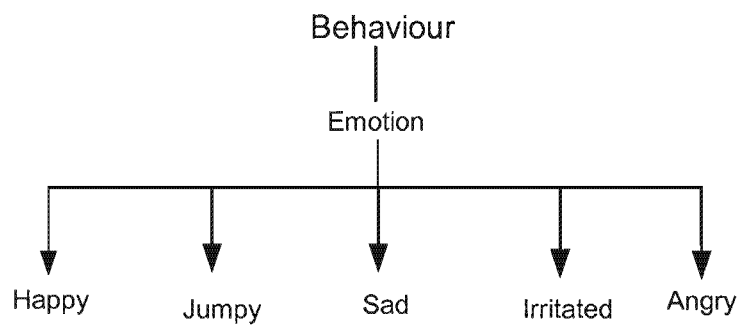
Characteristics describing the virtual identity's behaviour

Characteristics describing the virtual identity's behaviour are expanded to the virtual identity's emotion and motion, as illustrated in figure 11.

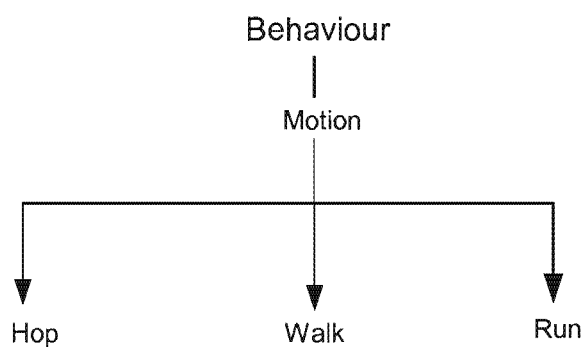


*Figure 11: The main characteristics describing the virtual identity's behaviour*

The virtual identity's emotion can be expanded to the identity's mood and the identity's motion to hopping, walking and running (see figure 12).



*(a) Emotion*



*(b) Motion*

*Figure 12: Expanding the characteristics of the virtual identity's behaviour*

The complete taxonomy is illustrated in Appendix A.

It is important to note that by no means we are saying that the framework is complete, but it is a means of portraying our viewpoint of how a virtual identity can be defined. The virtual identities are not imitating real identities. They are not used to represent a specific identity, but to act as a guided cultural learning experience. Although stereotypes were created and sometimes exaggerated, we should keep in mind how successful cartoon characters can be for learning, e.g. Teletubbies, Barney (the dinosaur) and Pingu (the penguin).

In this section a taxonomy for defining a virtual identity was discussed. The next section presents how the taxonomy can be used with the virtual identity approach.

### **3.5. Using the taxonomy with the Virtual Identity Approach**

This section discusses how the taxonomy can be used with the virtual identity approach.

A virtual identity can be defined by combining one or more characteristics from each category in the framework. For example to create a young girl you can use

- The age and gender characteristics from the characteristics that the identity is born with
- The language characteristic from the characteristics that describe the identity's background
- The tolerance, openness and confusion characteristics from the cultural values characteristics that describe the values of the identity
- The height and attractiveness characteristics from the characteristics that describe the embodiment of the identity

These characteristics are then used to define an interactive story within a virtual environment. The interactive story does not unfold through narrative, but through the exploration of the virtual environment by the virtual identity. We will now discuss the transitions that can occur and how these transitions are influenced by a change in the virtual identity's characteristics.

#### **3.5.1. Viewing the virtual world**

When exploring a VE through the eyes of an identity, one needs to provide the user with a realistic view of the VE. For example the age characteristic will influence the height from which the identity will perceive the virtual environment, i.e. if the user is viewing the VE through the eyes of a child, s/he will view it from a lower viewpoint than when s/he views the VE through the eyes of an adult. This needs to be reflected in the application.

### **3.5.2. Interactions**

Within every virtual environment certain characteristics will influence the interactions that the virtual identity is allowed to do. For example, the ethnic background or age of the virtual identity can cause restrictions with regard to the interactions that s/he can do within the virtual environment. Every time the user perceives the VE through the eyes of a different identity, s/he will be allowed different interactions in the VE. It is important that the interactions are always consistent with the specific virtual identity.

### **3.5.3. Transitions**

Interactive stories normally have a time transition as the story develops. To provide a richer experience for the user we introduced transitions that are from one virtual identity to another, from one characteristic to another, or both.

#### **Time transitions**

A change in the virtual identity's age characteristic can cause an identity to experience a time transition, e.g. when the identity has a memory flashback. When a time transition takes place, it is important that the viewpoint and the interactions of the identity are consistent with the identity at the specific time, e.g. if a man has a flashback of his youth (the age characteristic changes), he must have a lower viewpoint and only be allowed to do the interactions that are defined for a child and when the flashback ends (the age characteristic changes again), he must have a higher viewpoint and only be allowed to do the interactions that are defined for a man. This transition has to be smooth to avoid dizziness or disorientation being experienced by the user.

#### **Class transition**

An identity can experience a class transition when the class characteristic of the virtual identity's background changes, e.g. when the identity is from the working class and marries someone from the upper class or when the identity is from the working class and suddenly inherits money, then the identity's class might change from working class to upper class. Therefore the identity's belongings and clothing can change to reflect this change in class.

#### **Emotional transition**

When a virtual identity's emotion characteristic changes, the identity can experience an emotional transition, e.g. when the identity is in a good mood and very happy, it can see an object that brings back memories and makes the identity sad. To convey the emotions and mood of the identity to the user the motion of the virtual identity can be manipulated, i.e.

making the identity almost walk in a bouncing and hopping manner when s/he is happy and shuffling slowly when s/he is sad.

### **Identity transition**

When a virtual identity's personality changes, the identity can experience an identity transition. For example an experience in the identity's life can cause the identity to change into another identity with a different personality and cause many of the identity's characteristics to change.

### **Materialistic power transition**

When a virtual identity's materialistic power characteristic changes that describes his/her background, an identity can experience a materialistic power transition. For example an identity can receive a promotion at work and might receive a much larger salary that will increase his/her materialistic power. This can also lead to a change in the location characteristics of the virtual identity's background.

### **Accommodation transition**

An identity can experience an accommodation transition when the accommodation characteristic of the virtual identity's location that describes his/her background changes. For example when the identity is living in a shack (informal housing) and the South African government uses the reconstruction and development program (RDP) to build the family a new house.

### **Occupation status transition**

When the occupation characteristics of a virtual identity changes, s/he can experience an occupation status transition, e.g. if the company that the identity is working for is experiencing financial difficulty, the identity can get retrenched and suddenly be unemployed.

### **Political affiliation transition**

A change in the virtual identity's political affiliation characteristic can cause an identity to experience a political affiliation transition. For example if the identity's beliefs and viewpoint change, it will also affect his/her political affiliation.

The virtual identity approach for creating interactive stories in a virtual environment includes transitions to create a richer experience for the user and the story unfolds through the exploration of the virtual environment through the eyes of the virtual identities. It also



provides solutions to some of the problems that are encountered with interactive storytelling, as discussed in the next section.

### **3.6. Solution to problems of interactive storytelling**

In section 3.2 the following problems encountered with using interactive storytelling in virtual environments were discussed:

- Knowledge about the world
- Internal consistency
- Problem of Narrative Flow
- Time
- Ease of creation

The Virtual Identity Authoring approach provides solutions to some of these problems as explained below.

#### **Knowledge about the world**

Each virtual identity is empowered with knowledge about itself, which it uses to perceive and interact with the virtual world. Therefore, although the virtual identity does not have knowledge about the story world, it does have knowledge about itself, for example its cultural background, age and gender. This partially defines its perception of the world and allows different interactions to the virtual world for each identity.

#### **Internal consistency**

Each virtual identity is allowed certain interactions within the virtual world according to its knowledge about itself. Therefore, all the user actions are coherent and go along with the story. By following this approach, internal consistency is maintained.

#### **Problem of Narrative Flow**

In our approach, the story unfolds as the user explores and interacts with the world, through the embodiment of a virtual identity. The interactive story created by this experience is not one with a specific climax and therefore the narrative flow problem is avoided.

#### **Time**

To allow change in time, we introduced transitions, both forward and backward in time. This will result either the change from one identity to another or the change of the age

characteristic of the same identity. When the user interacts with an object in the virtual world that brings back memories, then a temporary change in the age characteristic of the virtual identity will result for example a flashback on its childhood, or the lowering of the height and thus the user's point of view. In the second case, a transition from a child virtual identity to an adult identity results in a first experience through a child's eyes and then through the adult's.

Traditional interactive stories in virtual environments tell a story where the user can explore the virtual environment, but they occur in a rather linear fashion with only a transition in time and one perception of the virtual environment. The virtual identity approach allows things that traditional interactive stories in virtual environments don't. The user can perceive the virtual environment through the eyes of the virtual identity and therefore get a realistic feel for the virtual environment. By exploring the virtual environment as different identities, the user can obtain many different views of the virtual environment and can experience the story from many different angles. This approach also allows the use of many additional transitions as discussed in section 3.2.

### **3.7. Summary**

This section discussed the virtual identity approach and a taxonomy that defines a virtual identity. It presented how the taxonomy are used with the virtual identity approach by highlighting how the viewpoint is changed, how interactions are defined for a specific identity and transitions that the virtual identity experiences. It discussed how this approach solves some of the problems of interactive storytelling and how it provides additional flexibility in facilitated guidance and interactive storytelling in virtual environments.

The next chapter discusses how the interactive storytelling tool is implemented by highlighting the AVANGO framework and AVANGO's Sound Server. It presents the modelling that was required and an overview of the system. It discusses how the nodes are linked and scripts that are used. A possible GUI for the system is also presented.

## Chapter 4

*“There is nothing more that can prevent interactivity from becoming the principle and essence of life itself: I am interactive therefore I am”*

*Pierre Moeglin [98]*

### Implementation

This chapter discusses how the interactive storytelling tool is implemented. It presents the AVANGO framework and how C++ and Scheme are used to create an application. It discusses the modelling that was required for the virtual environment. It presents an overview of the interactive storytelling tool system and then discusses the C++ nodes and Scheme scripts that are created. It highlights how a GUI can be added to the interactive storytelling tool to make it user-friendlier.

#### 4.1. AVANGO

AVANGO [67][95] is a programming framework for developing distributed interactive virtual environments and is built on top of IRIS Performer. It uses C++ *nodes* that are represented in an object-oriented scene-graph API, which allows representation and rendering of complex geometry. AVANGO's interface to the real world and its interaction devices are provided through *sensors*. The AVANGO object is a collection of fields, where each field can be connected to build a data-flow graph orthogonal to the scene graph, which specifies the behaviour and allows for interactive applications. AVANGO also features a complete language binding to the interpreted language Scheme [77] and therefore allows rapid prototype development through *scripting*.

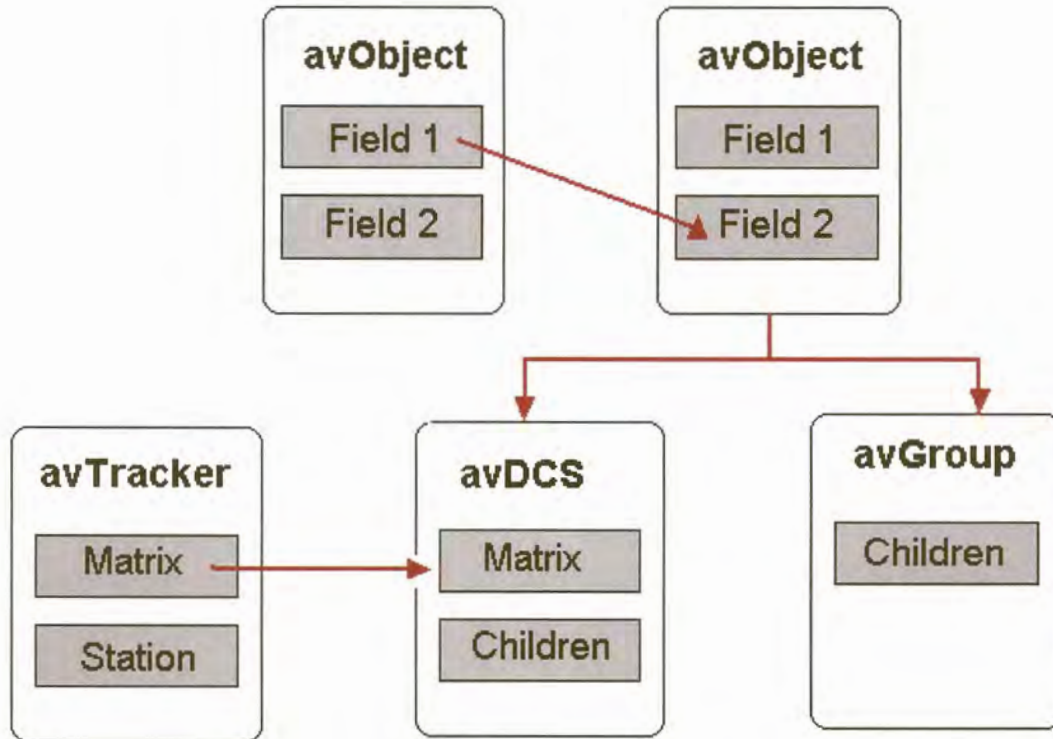


Figure 13: Illustration of AVANGO's scene graph & sensors

The implementation of complex and performance critical functionality is done in C++ by subclassing and extending existing AVANGO classes. The application is therefore only a collection of Scheme scripts that instantiate the required AVANGO objects, call methods on these objects, set their field values and define relationships between them.

AVANGO provides a variety of interaction and navigation techniques that support interactive storytelling. It has been extended to allow authoring of applications by defining scenes, paths and interaction with the virtual objects in the scene. Camera paths are then created to provide the user with alternative paths through the environment.

AVANGO provides draggers that can be defined to allow interaction with objects within a scene. The *fpMatrixDragger* enables you to define that the user can move or rotate the object, according to the value of the *Matrix* field. The *fpScriptDragger* enables you to use a script to describe what should happen if the object is selected.

The AVANGO framework is used for the development of the interactive storytelling tool.

The sound of the application is developed using the AVANGO sound server.

## 4.2. Sound Server

The sound server runs on any SGI machine and supports many audio interfaces, including 8-channel ADAT compatible sound output devices. It is based on IRCAM's Max/FTS real-time sound processing system [67]. FTS is an extensible signal-processing kernel that provides the low-level modules that are required to build sophisticated processing applications and sound synthesis. Max is a graphical programming environment that is used to interactively build FTS programs and allows the control and monitoring of states in a signal-processing program running in FTS.

AVANGO provides a set of scene graph node classes that define auditory scene elements. Different nodes describe the nature of the sound source, the mapping of event to synthesis parameters, the rendering resolution, the radiation pattern and the characteristics of the acoustic environment. These nodes communicate with the sound server, which invokes and controls the corresponding sound synthesis and rendering processes.

The AVANGO node *fpSoundSource* is used to play a sound file in the virtual environment. In our system, the following fields of this node are used:

- *Earnode* – this field identifies the location from where the sound comes from, i.e. the sound's point of origin
- *PlayMode* – this field identifies whether the sound is played only once or continuously
- *SpatMode* – this field identifies whether the sound is ambient, statically spatialised or dynamically spatialised
- *SoundName* - this field identifies which sound file is played

To test the interactive storytelling tool in a virtual environment a model has to be created or an existing model has to be used. We used an existing model, but had to make a few adjustments to the model before we could use it.

## 4.3. Modelling

We used a model of a Cato Manor shebeen (township tavern) that was created by the CSIR<sup>1</sup>. To use the model, a few changes had to be made:

1. The scale of the model had to be changed – the scale was too big and caused problems when the application was tested in GMD's CyberStage. Therefore the scale

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<sup>1</sup>CSIR is the South African Council for Scientific and Industrial Research.

had to be changed into its natural physical proportions to enable a realistic immersed feeling

2. The model had to be exported to \*.obj format with 3D Studio Max. 3D Studio Max then created material files (\*.mtl).
3. The material files were opened with Adobe Photoshop and converted from \*.tga to \*.rgb.
4. The \*.obj file of the model was converted to openflight format (\*.flt).
5. The \*.flt file of the model was opened in Inventor and a hierarchy was added by creating DOF nodes. This was done to create hooks to the objects to enable interaction with the objects.
6. The textures were added to the model in Inventor.

In order to use the audio and video files that were provided by the CSIR, MediaConverter had to be used to convert the audio files to \*.aiff files and the video files to \*.mov.

#### **4.4. Overview of the system**

The interactive storytelling tool provides a means of creating virtual identities that perceive the virtual environment differently and are allowed different interactions according to the specific application. The next section presents an overview of the interactive storytelling tool's system.

The system consists of C++ nodes and Scheme scripts. The C++ nodes are used to define critical functionality. The Scheme scripts instantiate the required nodes, call methods on these nodes, set their field values and define relationships between them.

The *fpVirtualIdentity* node defines a virtual identity. It contains fields that relate to the virtual identity's characteristics, fields that relate to the way the identity perceives the virtual environment, fields that relate to the movement of the virtual identity and fields that trigger a specific event.

The fields that relate to the characteristics of the virtual identity are the characteristics that are defined in section 3.4, i.e. characteristics that the virtual identity is born with and characteristics that describe the virtual identity's background, values, embodiment and behaviour.

The fields that relate to the way the identity perceives the virtual environment are UserHeight and UserBelly that are linked to the viewpoint of the virtual identity.

The fields that relate to the movement of the virtual identity are the Speed and Sensitivity fields. The Speed field influences the speed with which the identity moves, and the sensitivity field influences the speed of change of direction.

The fields related to the movement of the virtual identity are the Amplitude and Frequency fields. The fields related to collision detection are UserHeight and UserBelly. These fields influence whether an identity can for example walk under a table or is blocked by the table.

The fields that trigger an event will depend on the application being developed. If certain objects are selected it can trigger an event, for example a sound can be played.

#### 4.5. Linking of nodes and scripts

According to the Age the Userheight and UserBelly values are changed to reflect a realistic height of the virtual identity. According to the UserHeight the virtual identity's viewpoint is changed.

When the virtual identity's age changes, the identity's UserHeight and UserBelly changes. The change in the UserHeight causes a change in the matrix of the *fpFlyer*, which is an AVANGO node that determines the way that the identity perceives the virtual environment and moves in the virtual environment.

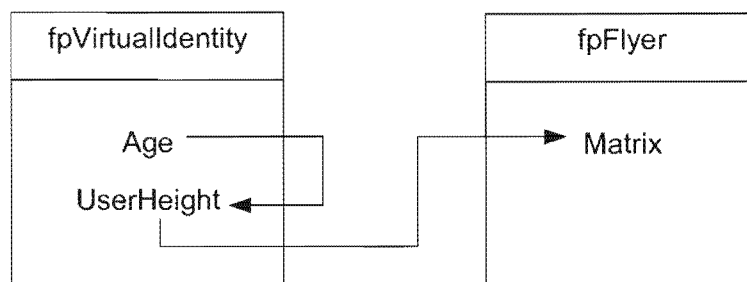


Figure 14: A change in Age, influences a change in the UserHeight, which in turn influences the Matrix of the *fpFlyer*

When the Speed or Sensitivity of the virtual identity changes, it causes a change in the Speed and Sensitivity of the *fpFlyer* node, which influences the speed and sensitivity of the identity, as s/he is moving around the virtual environment.

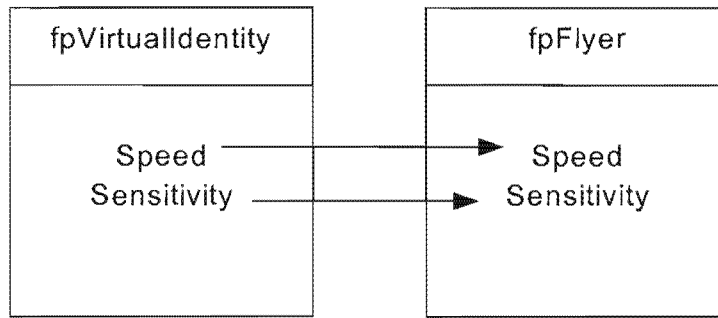


Figure 15: A change in a virtual identity's Speed or Sensitivity causes a change in the fpFlyer's Speed or Sensitivity

The Amplitude and Frequency fields influence the swaying effect while the identity is moving. When the Amplitude and Frequency fields are changed, it influences the matrix of the fpFlyer node.

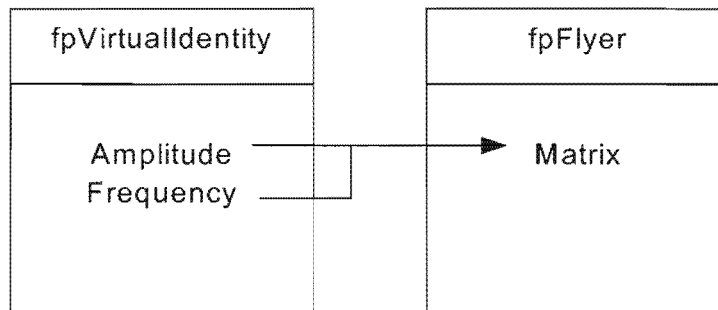


Figure 16: A change in the Amplitude or Frequency influences the Matrix of the fpFlyer node

The UserHeight and UserBelly fields are linked to the fpFlyer node that is one of the AVANGO nodes that is used to define the way that the identity is moving through the virtual environment.

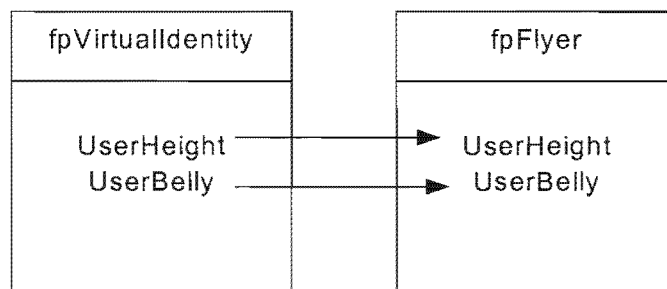


Figure 17: A change in the identity's UserHeight and UserBelly influences the UserHeight and UserBelly of the fpFlyer node.



The fields that trigger an event will depend on the specific application. The events will be defined in the Scheme scripts that are used for the specific application. This is done with the use of the *fpScriptDragger* node that is discussed in section 4.1.

Each virtual identity is associated with a script in which

1. The model is defined and added to the scene-graph
2. An object of *fpVirtualIdentity* is created and the field values are set accordingly
3. The virtual identity is connected to the viewer
4. The virtual identity is connected to the mover
5. The hooks to the objects of the virtual environment are loaded
6. Interactions and events are defined

The complete code of the interactive storytelling tool can be viewed in Appendix B.

The interactive storytelling tool enables users to create interactive virtual environments that are perceived through the eyes of the virtual identities. A graphical user interface (GUI) will make the system user-friendlier and therefore easier to create various virtual identities and stories.

#### **4.6. GUI**

A GUI is not created for the system, but can easily be added to make the system user-friendlier. The functionality that should be supported by the GUI are selecting the characteristics of the virtual identity, providing the user with a list of the objects in the scene and allowing the user to specify which objects can be moved by the identity and which objects triggers an event when selected. If the object triggers an event, a list of possible events should be displayed. A possible GUI for the interactive storytelling tool is illustrated below.

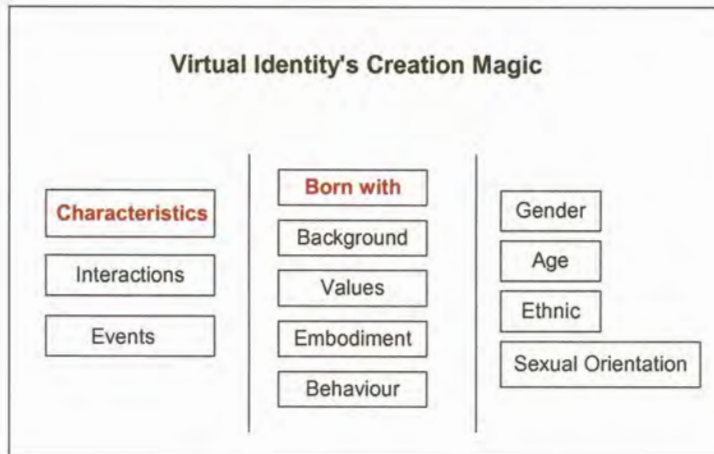


Figure 18: The GUI for selecting the characteristics that the virtual identity is born with

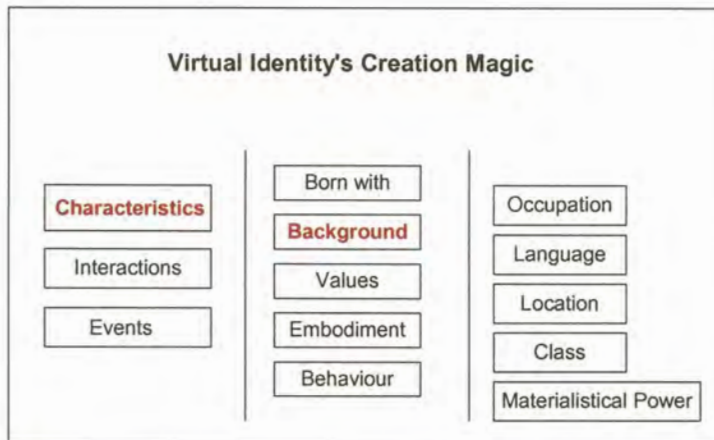


Figure 19: The GUI for selecting the characteristics that relate to the virtual identity's background

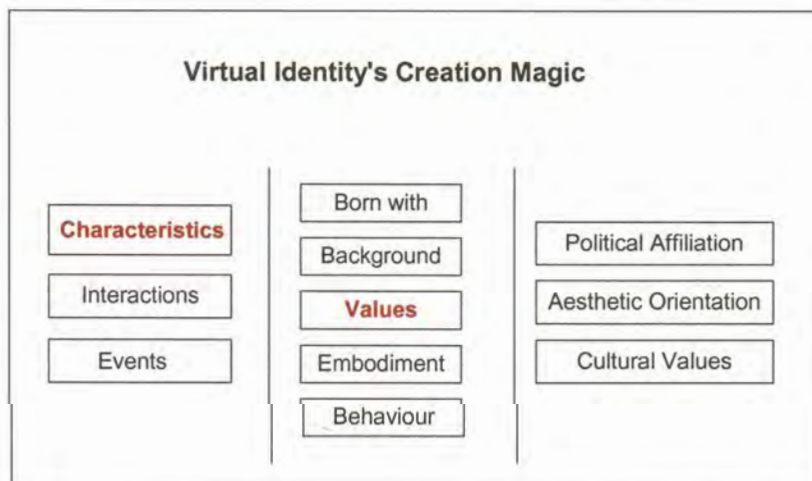


Figure 20: The GUI for selecting the characteristics that relate to the virtual identity's values

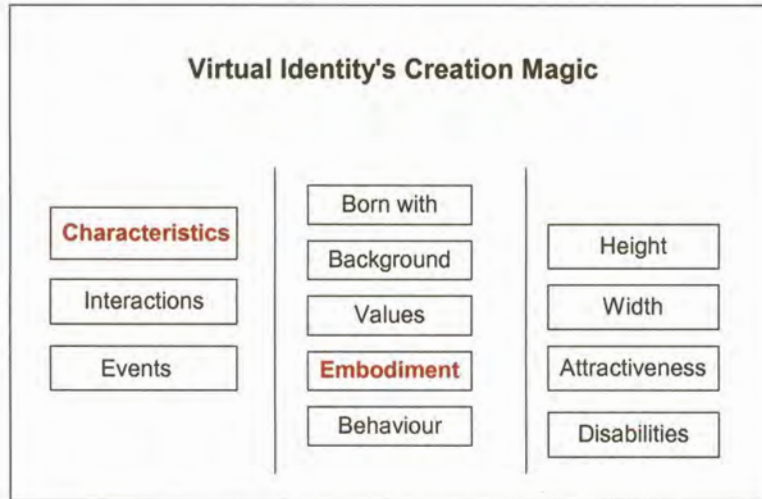


Figure 21: The GUI for selecting the characteristics that relate to the virtual identity's embodiment

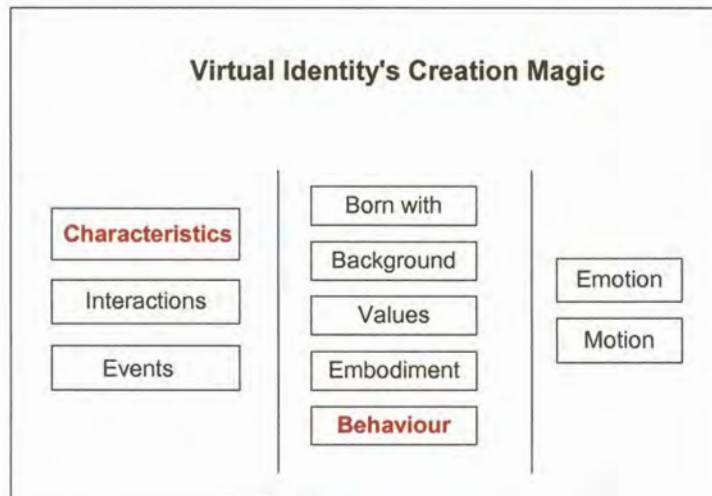


Figure 22: The GUI for selecting the characteristics that relate to the virtual identity's behaviour

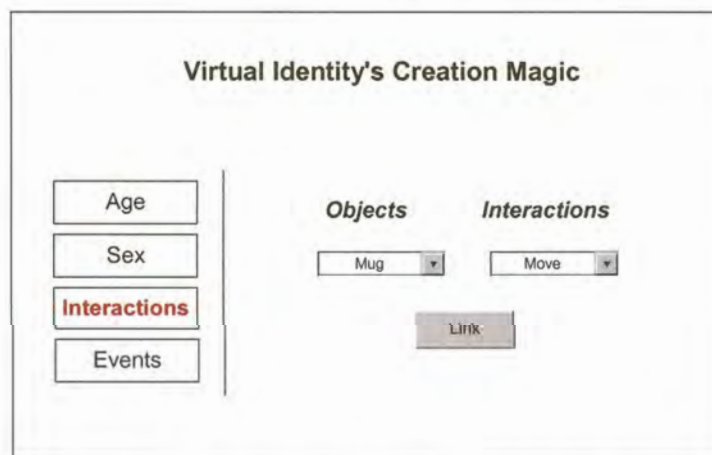
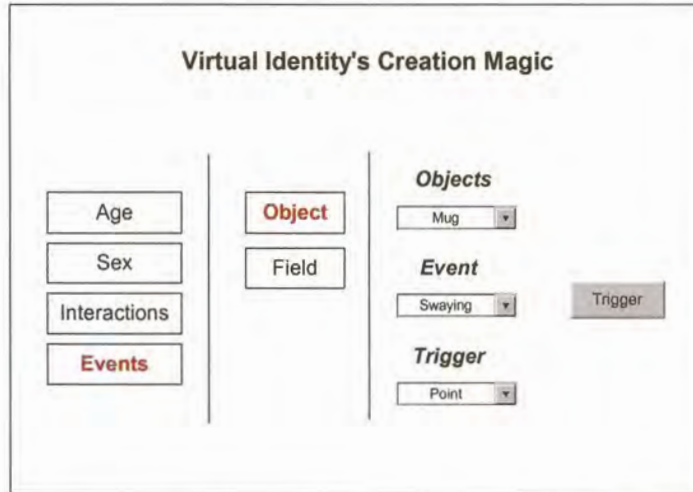


Figure 23: The GUI for selecting the interactions that the virtual identity is allowed to do within the virtual environment



*Figure 24: The GUI for selecting the events that can be triggered when the identity interacts with an object*

The GUI illustrated above is only a possible GUI for the interactive storytelling tool. The GUI will enable the user of the tool to create interactive stories with virtual identities much easier.

#### **4.7. Summary**

This section discussed the implementation of the interactive storytelling tool. It highlighted the AVANGO framework and Sound Server and the modelling that is required for the virtual environment. It presented an overview of the interactive storytelling tool system and the C++ nodes and Scheme scripts that were used to develop the system. It discussed how the C++ nodes are linked and how a GUI can be added to the system to make the interactive storytelling tool user-friendlier.

The next chapter discusses an interactive story that was authored with the interactive storytelling tool. It presents the background of the Cultural Heritage application and how the interactive story develops. It highlights the virtual identities that were created and presents the results that were obtained with the demonstration of the application.

## Chapter 5

*“Cato Manor was once a melting pot of Indian and African cultures, a vibrant, makeshift community of 100,000 people who wrote their own rules and survived and thrived for half a century in the shadow of the city that excluded them”*

*B. Lynch [68]*

### Authoring an interactive story

This chapter discusses an interactive story that is created with the interactive storytelling tool. It presents information about the background of Cato Manor and how the interactive story develops. It highlights the virtual identities that are created and presents the results that are obtained when the application is running on a monitor and in GMD's Cyberstage.

#### 5.1. Cato Manor

In 1845 Durban's first mayor, George Cato, was granted land in Cato Manor in compensation for a beachfront property that had been expropriated for military purposes. Cato and his descendants farmed on this land until the turn of the century, after which the land was subdivided into a number of smaller farms. During the next thirty years the landowners hired out or sold plots of land to Indian market gardeners. Isolated clusters of shacks that were occupied by Africans began to appear along the banks of the Umkhumbane River. At that time Africans were prohibited from owning land or building homes in an urban area and were regarded as temporary sojourners. In 1932 Cato Manor was incorporated into the municipality of Durban and therefore the shack settlements became illegal. The authorities turned a blind eye and people continued to come to the area. In 1943 the squatter population had swelled to 17 000.

In 1949 the “Durban Riots” broke out after an Indian man near Durban's Indian market allegedly assaulted a 14-year-old African boy. This led to two days of anti-Indian violence,

spreading to Cato Manor, where Indian-owned shops and houses were razed and most of the Indian residents fled the area. By 1950 there were 6 000 shacks in the Cato Manor area, housing between 45 000 and 50 000 people.



*Figure 25: The Cato Manor shack settlement in 1950 [taken from 68 with permission]*



*Figure 26: A Cato Manor shack area prior to the establishment of a Controlled Emergency Camp [taken from 68 with permission]*

In 1957 the government instructed the municipality to begin developing a new housing scheme for Africans at KwaMashu and to set up a temporary transit camp in Cato Manor. In 1959 attempts to move people to KwaMashu were met with resistance and tensions began to rise in Cato Manor. In 1960 nine policemen were killed by a mob in the Emergency Camp. This incident created negativity towards Cato Manor and rapid clearance of the area began.



*Figure 27: Flames arising from the Native Administrative Offices that were set alight by angry demonstrators in June 1959 [taken from 68 with permission]*

In 1968 Cato Manor was left largely vacant and only a few scattered houses, shops, the beer hall and several Hindu temples remained. In 1979 the few remaining residents formed the Cato Manor Residents' Association to resist further removals and racially based housing

developments. During the mid 1980's major portions of Cato Manor were officially identified for development for Indian people and some formal houses were built at Wiggins.

## **5.2. Interactive story**

The interactive storytelling tool is tested in a Cultural Heritage application. The story world is a shebeen (township tavern) in Cato Manor. The story develops through exploration of the shebeen by the user. The user experiences the shebeen through the eyes of the specific virtual identity. According to the chosen identity, the user is allowed only certain interactions that are appropriate for the specific identity. This enables the user to view the shebeen from different perspectives and angles and to get a true reflection of the culture.

## **5.3. Virtual identities**

Three virtual identities were created, namely a Zulu boy, a Zulu man and a shebeen owner. Each identity is allowed certain interactions in the shebeen. A shebeen was a gathering place where alcohol (illegal during apartheid) was served, and ideas and goods were exchanged.

The virtual environment is a shebeen (township tavern) within Cato Manor and contains a radio that plays music of that time, photo's of a soccer match, a boxing match and a jazz singer, mugs for drinking beer, chairs and crates to sit down and extra beds and crates that can be used when more places to sit are required.

The photo's in the shebeen resembles the culture of the people at that time. The soccer photo portrays their love for soccer and attending soccer matches. The boxing photo reflects their love for boxing matches and the photo of the jazz singer reflects the music that the people liked to listen to in those days.

When the user perceives the virtual environment through the eyes of the Zulu boy, the viewpoint is lowered. The user is not allowed to enter the shebeen, but if s/he clicks on the shebeen's front wall the virtual identity is transformed from a Zulu boy to a Zulu man and is allowed to enter the shebeen and to do the interactions that are allowed for a Zulu man.

When the user perceives the virtual environment through the eyes of the Zulu man, the viewpoint is higher than that of the boy. The user is allowed to enter the shebeen and can do the following interactions within the shebeen:

- Click on the soccer photo that will trigger a transition to a soccer match that is reflected with a sound file being played that resembles a crowd at a soccer match

- Click on the boxing photo that will trigger a transition to a boxing match that is reflected with a sound file being played that resembles commentators at a boxing match
- Click on the jazz photo that will trigger a sound file to be played that represents a jazz song that is typical of the jazz music that the people listened to during those days
- Click on a cup in the shebeen that will cause the identity to sway when he is walking, indicating that he is drunk
- Move crates around to position them where s/he wants to sit down

When the user perceives the virtual environment through the eyes of the shebeen owner, the viewpoint is higher than that of the boy. The user is allowed to enter the shebeen and can do the following interactions within the shebeen:

- Click on the radio to switch it on, that will trigger a sound file to be played that represents a radio station of that time
- Move tables around in the shebeen
- Move spare crates around in the shebeen
- Move beds around in the shebeen to create more place to sit down or to put them away to create more space for the people in the shebeen

The user perceives the shebeen through the eyes of the virtual identity and therefore experiences the shebeen from different perspectives. The application was demonstrated on a monitor and in the Cyberstage and the results are discussed in the next section.

## 5.4. Results

This section presents the results that were obtained when the application was tested on a monitor and in the CyberStage. The results are highlighted with images that are obtained from either the monitor or from a video recording that was made while the application was tested in the CyberStage.

### Monitor

Although the Zulu boy is not allowed to enter the shebeen, for testing purposes he was allowed to enter to enable the results to indicate the lowering in viewpoint when the boy enters the shebeen. Figures 28, 29 and 30 indicate the difference in the viewpoint of the boy and man from the same angle.





(a) Zulu boy's viewpoint



(b) Zulu man's viewpoint

Figure 28: Illustration of the difference in viewpoint between the Zulu boy and the Zulu man as the identity walks to the table in the shebeen



(a) Zulu boy's viewpoint



(b) Zulu man's viewpoint

Figure 29: Illustration of the difference in viewpoint between the Zulu boy and the Zulu man as the identity stands close to the table in the shebeen



(a) Zulu boy's viewpoint



(b) Zulu man's viewpoint

Figure 30: Illustration of the difference in viewpoint between the Zulu boy and the Zulu man as the identity stands in front of the cups in the shebeen

Figure 31 illustrates what the shebeen looks like when the application is run on the monitor.



Figure 31: A view of the shebeen when the application is run on a monitor

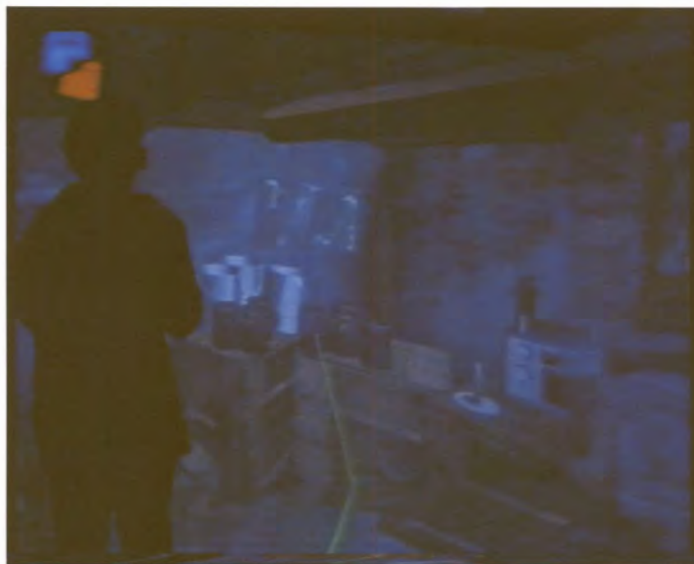
## Cyberstage

The Zulu boy can move the cups around, but is not allowed to do anything else in the shebeen.



*Figure 32: Illustration of the Zulu boy's interaction with a cup in the shebeen*

The Zulu man can drink from the cups, which causes a swaying action while he walks. This interaction is illustrated in figure 33.



*Figure 33: Illustration of the Zulu man's interaction with a cup in the shebeen*

The Zulu man can click on one of the photos in the shebeen, which then triggers a soundfile to be played. This is a transition in time that doesn't involve a change in the virtual identity, i.e. a soccer match that the man watched in the past and when the identity sees the photo of the soccer match it reminds him of a match that he has seen in the past. This memory flashback is created with the soundfile that simulates the crowd at a soccer match.



*Figure 34: Illustration of the Zulu man's interaction with a photo in the shebeen*

The shebeen owner is allowed to switch on the shebeen radio, which then triggers a radio station of that time to be played.



*Figure 35: Illustration of the shebeen owner switching on the radio*

The shebeen owner can move a crate with all the cups on top of the crate. When the shebeen owner moves the crate, the crate with all the cups is moved to make more space for the customers.



*Figure 36: Illustration of the shebeen owner moving a crate with all the cups on top of the crate*

The shebeen owner is also allowed to move spare tables around in the shebeen to create more space for the customers or to provide the customers with more tables to put their mugs of beer on.



*Figure 37: Illustration of the shebeen owner moving a spare table*

## 5.5. Summary

This chapter discussed an interactive experience of three identities in a shebeen (township tavern) that was created with the interactive storytelling tool, using the virtual identity approach. It discussed the background of Cato Manor and how the story evolves through exploration of the story world. It highlighted the virtual identities that were created and explained how the virtual environment is perceived through their eyes. It presented the results that were obtained when the application was demonstrated on a monitor and in the Cyberstage.

The next chapter discusses future work that can be done to improve and expand on the virtual identity approach and the interactive storytelling tool. It highlights the different aspects that were discussed in the thesis and presents final conclusions.

## Chapter 6

*“...We shall not cease from exploration  
And the end of all our exploring  
Will be to arrive where we started  
And know the place for the first time...”*

*T. S. Eliot [61]*

## Conclusions and Future work

This chapter provides conclusions of the thesis and discusses future work with regard to the interactive storytelling tool.

### 6.1. Conclusions

Since our childhood we are exposed to stories in many different forms. The story metaphor has been used in multimedia and virtual environments to create interactive stories. Virtual environments are much richer both in terms of freedom of navigation and ease of creation. In projection-based systems in particular, the user is not bound to predefined paths and can have a hands-on experience through immersion and interaction with the virtual world. However guidance is needed to support the user during the exploration and facilitate the understanding of the purpose and intention of the particular virtual environment.

Interactive stories have already been used in virtual environments and allow users to be actively involved in the story. Although interactive storytelling gives the participant a richer experience, a number of aspects are missing from today's approaches, such as the problem of narrative flow, the character's knowledge of the world, internal consistency of the story, the representation of time and the ease of creation.

The virtual identity approach enables the participant to experience the interactive story through the eyes of the identity and provides solutions to some of these problems. A virtual identity is defined by knowledge about itself, its perception about the environment and its virtual embodiment. We extended this approach by providing a taxonomy (framework) to define a virtual identity through characteristics that a virtual identity is born with, characteristics concerning the virtual identity's background, the virtual identity's values, the embodiment of the virtual identity and behavioural characteristics of the virtual identity.

To allow change in time, we introduced transitions, both forward and backward in time. This results in either the change from one identity to another or the change of a characteristic of a virtual identity.

An interactive storytelling tool enables users to create interactive stories. With our approach the user of the interactive storytelling tool is able to create many different experiences with the use of a single virtual model.

We developed the interactive storytelling tool with the AVANGO [2] framework that has been under development at GMD since 1996. The system consists of C++ nodes and Scheme scripts. The C++ nodes are used to define critical functionality of the system. The Scheme scripts instantiate the required nodes, call methods on these nodes, set their field values and define relationships between the fields.

Each virtual identity is associated with a script where the model is defined and interactions and events for the virtual environment are defined.

We tested our approach in a Cultural Heritage application. The story world is a shebeen (township tavern) in Cato Manor, a once vibrant South African community that was torn down during apartheid to enforce racial segregation and to open up a prime piece of real estate for white occupation. We demonstrated the application both on a monitor and GMD's Cyberstage, with very promising results. A number of publications have resulted from the work in this thesis [92][93][94].

The interactive storytelling tool can be extended and improved by adding functionality that doesn't yet exist.



## 6.2. Future work

The framework presented to define a virtual identity covers many characteristics of an identity, but is by no means complete. Therefore the framework can be extended to include other characteristics that are not yet covered.

The user experiences the virtual environment through the eyes of the identity. The story unfolds through exploration. The approach can be extended to enable the user of the interactive storytelling tool to include some narrative in the experience through the use of a narrator or voice artist that tells a story as the user explores the virtual world.

The interactive storytelling tool doesn't have a GUI at this stage. To make it easier for the user to use the system, a GUI can be added. This will make the system user-friendlier.

We tested the system with a Cultural Heritage application. The interactive storytelling tool can be applied in many different application areas, such as education and art. Therefore, it should be applied to other application areas and tested to see how effective it can be applied to a wide range of application areas.