X. Combined Algorithm

In this section the results from the other sections will be integrated into one algorithm. The algorithm basically consists of a visually-adaptive lapped-transform encoder with optimised quantisation. The transform section will consist of a LOT transform for reducing the block-effect. The quantisation step will consist of a uniform quantiser followed by source coding, since this type of coding took better advantage of correlation between coefficients and blocks. The HVS is introduced in the determination of the step size of the uniform quantiser. The structure of the final algorithm is shown in figure 45.

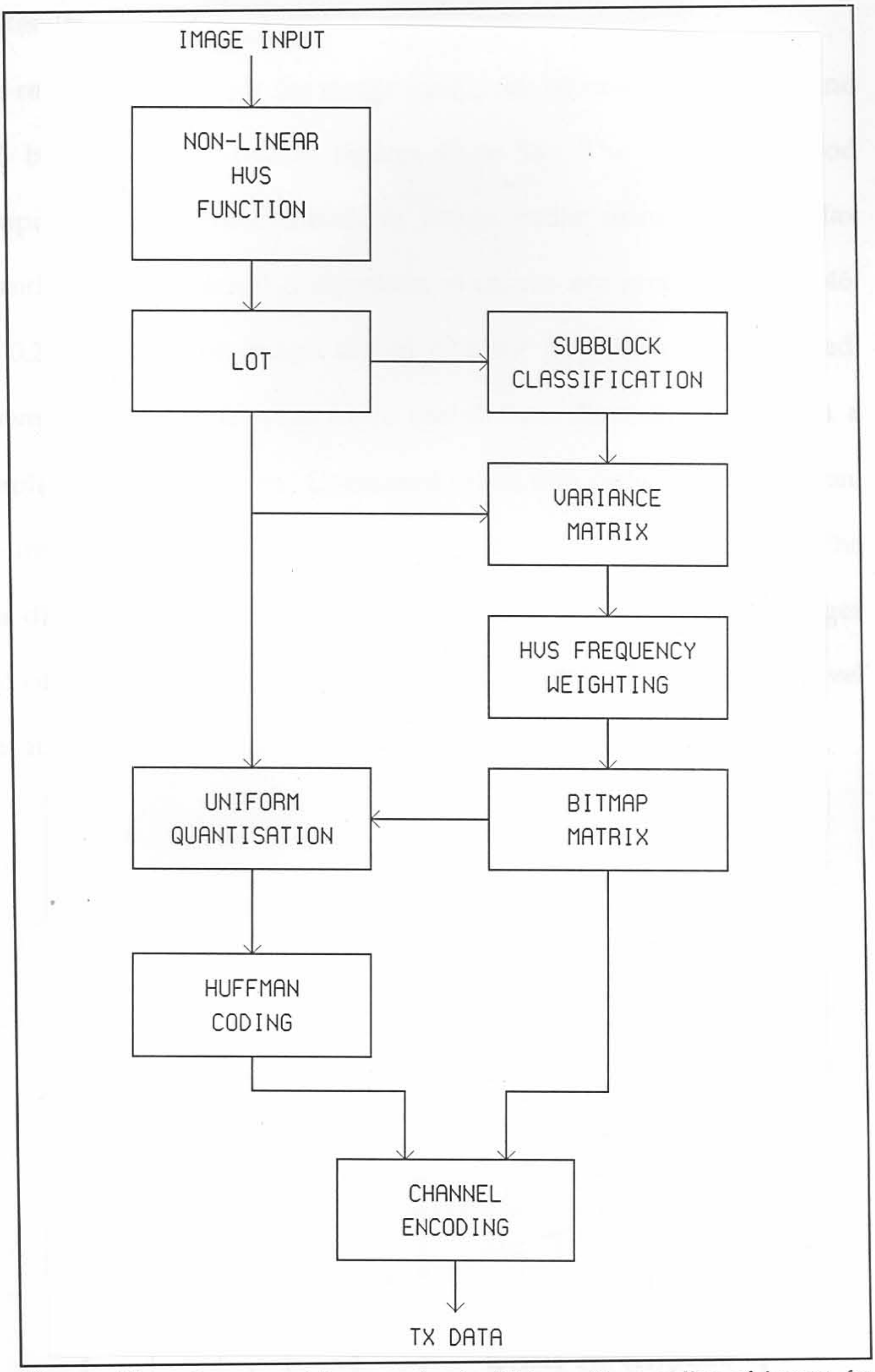

Figure 45 Structure of image codec for high quality encoding of images for transmission.

A. Results

The results achieved for the image codec, for bit rates between 2.0 and 0.25 bits/pel, is shown in figures 47 to 58. The results are good compared to the basic transform image codec using a Lloyd-Max quantiser. A numerical comparison of results are given in figure 46. At 0.25 bits/pel the image lacked contrast and were a bit blurred. However, the results were more useful than those achieved with a simple DCT based codec. Compared to the rate distortion simulation, the images coded to 1.0 and 0.5 bits performed slightly inferior. The rate distorted images appeared slightly sharper than the coded images and contained less artifacts. The block-effect was reduced up to a level that it only became visible for low bit rates.

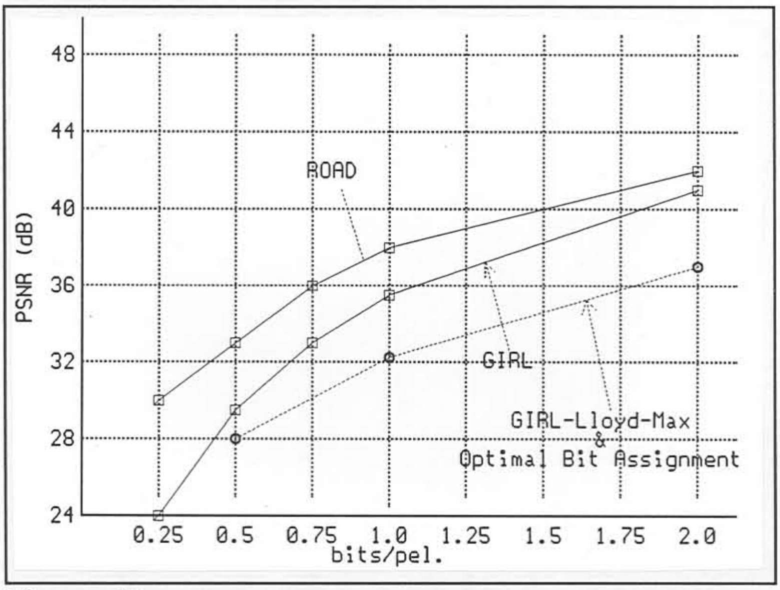

Figure 46 Numerical Results for Images Coded with the Combined Algorithm.

Figure 47 Original Image: GIRL (256x256x8)

Figure 48 LOT Coded Image: GIRL 2.0 bits/pel.

Figure 49 LOT Coded Image: GIRL 1.0 bits/pel.

Figure 50 LOT Coded Image: GIRL 0.75 bit/pel.

Figure 51 LOT Coded Image: GIRL 0.5 bit/pel.

Figure 52 LOT Coded Image: GIRL 0.25 bits/pel.

Figure 53 Original Image: ROAD (256x256x8)

Figure 54 LOT Coded Image: ROAD 2.0 bits/pel.

Figure 55 LOT Coded Image: ROAD 1.0 bits/pel.

Figure 56 LOT Coded Image: ROAD 0.75 bits/pel.

Figure 57 LOT Coded Image: ROAD 0.5 bits/pel.

Figure 58 LOT Coded Image: ROAD 0.25 bits/pel.

B. Channel Error Simulation

For the channel error simulation random errors were made in the coefficients of the coded data. For the experiments the bit rate was chosen to be 1 bit/pel. Errors in the quantisation information are considered critical, thus it is assumed that this information will be sufficiently protected with an error correction scheme. For a picture coded to one bit per pixel the total number of bits is 65536, which makes simulation of channel errors difficult for error probability less than 10^{-5}. The influence of errors in the range 10^{-5} to 10^{-3} was investigated on images coded with both the DCT and the LOT. Results are shown graphically in figure 59 and images for error probability of 10^{-4} are shown in figures 60 to 61. The results show that the LOT is superior in its ability to compensate for channel errors, since each block is reconstructed from the overlapping of four blocks.

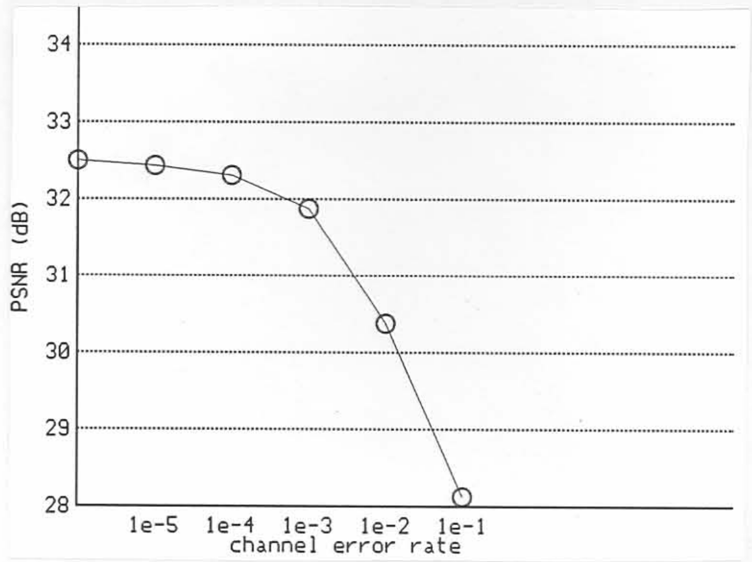

Figure 59 Signal to Noise Ratios for different channel error rates.

Figure 60 DCT (8x8) Coded Image: GIRL @ 1.0 bits/pel, 10^{-4} Error probability.

Figure 61 LOT Coded Image: GIRL 1.0 bits/pel, 8x8 block size, 10^{-4} Probability of Error.

XI. Conclusion

The thesis started by stating the information theory guidelines for image coding. Next the image spatial statistics was investigated and the Markov image model was presented. The thesis continued with a discussion of the human visual system and its application in transform image coding. The use of the rate distortion theory was also presented in this section. The next step was to define the quality criteria that were used to measure the codec's performance.

The basic transform coder structure was given and the different subsections were discussed. In this discussion the use of the DCT, as choice of transform, was substantiated. The different sources of errors in the basic transform coder structure were inspected and presented. The quantisation of the coefficients was investigated next. Three models for quantisation were presented, the compander, the Lloyd-Max quantiser, and the uniform quantiser followed by source coding. The last method outperformed the others as a result of its ability to adjust to the specific statistics of the coefficients as well as an ability to take advantage of inter-block as well as inter-coefficient correlations.

Next the optimal assignment of bits to the different coefficients were presented. It was shown that the marginal analysis bit assignment provides better results than the rate distortion theoretic approach (RDTA), as a result of several shortcomings of the RDTA.

The bit assignment was then made spatially adaptive, i.e. the image was classified into different regions of similar statistics. This improved the coding of detail in the images, especially when a Lloyd-Max quantiser was used, and to a lesser extend when source coding was used.

The focus then moved to the elimination of the block-effect, and four methods were presented that attempted to reduce the blocking effect. These included filtering, overlap and add method, visual error minimisation, and lapped orthogonal transforms (LOT). Of these the LOT was found to be the most successful in reducing the block-effect while at the same time increasing the coding gain.

The best results of each section were then integrated to form the final algorithm. This algorithm was tested for bit rates between 2.0 and 0.25 bits/pixel. Good results were achieved throughout the rate range with 2.0 bits/pel virtually indistinguishable from the original and 0.25 bits/pixel very usable. The algorithm was then tested for sensitivity to channel errors for error probability between 10^{-3} and 10^{-5}. Here, it was seen that the overlapping nature of the LOT is desirable for image reconstruction in the presence of channel errors.

It was found that the final algorithm performed close to that of the rate distortion simulation with some improvement still possible. The improvement could possibly be achieved by further improvements in the coefficient quantisation. These improvements could take the form of direction adaptive masks, to better group blocks of similar statistics.