Chapter 6

Conclusion

Problems related to denoising of the signals in broad and images in particular are of prime importance in Signal or Image Processing. A proper denoising method with all the benefits is very rare. The existing systems are with one or more types of limitations in denoising. In this thesis, hybrid denoising models (using wavelet thresholding and bilateral filter) are addressed. This chapter summarizes the discussion and outlines the main conclusions.

1. Hybridization with Wavelet Soft Thresholding and Bilateral Filter:

   The wavelet based filtering is working very well with different types of noises and images but it faces a problem with smoothening. The edges are not properly retained in this method. Whereas in bilateral filtering the edges are retained properly but cannot work for all types of noises and also not workable in multi resolution environment. The new proposed method is an artifact in this area, where the edges are retained as well as it can work in multi resolution environment.

   The background theories of the work are discussed in chapter 2. The theory of wavelets and its applications on image processing is presented along with its limitations. The bilateral filter is also presented in this chapter. As a parameter to measure the performance, MSE and PSNR is used in first hand and then the IQI is considered as another method. IQI is a different type of measurement parameter that basically checks the structural behavior of the image resulting a good quality of visual perception.
Hybrid denoising models designed through hybridization in different configurations are discussed in chapter 3. The performances of the models that are tested on different types of noisy images are also illustrated. The performance of the models is evaluated in terms of PSNR and IQI and the graphical comparison among the performance is also drawn. Only three models (models 4, 20 and 36) out of 48 are found to be comparatively better than all other models. It is observed that the model 36 is more uniform and consistent in its performance in all the types of images tested with, in terms of PSNR and IQI. It is also observed that application of bilateral filters on wavelet decomposed subbands in any combination with wavelet thresholding deteriorates the performance of the model, whereas, application of bilateral filters before or after or on both before and after decomposition enhances the performance.

2. Performance Optimization (Maximization) using FPGA:

In chapter 4, the parameters of all the filters including hybrid denoising models, developed through hybridization in three apparently best configurations (as discussed in previous chapter), are optimized using FPGA and the performances of the thus GA based optimally designed filters are tested on different types of noisy images. Comparison is drawn in the performance of all the six models with filter parameters optimized using trial and error method with those with filter parameters optimized using FPGA in terms of PSNR and IQI. It has been observed that the performance of all the models improves with FPGA optimized filter parameters even though the amount of improvement in different models is different. This observation is in line with the inference claimed in previous chapter and the same model that is recommended in chapter 3, is also recommended in this chapter as a well competent model for denoising any type of image.

3. Hybridization with Fuzzy Soft Thresholding and Bilateral Filter:

In chapter 5, the hybrid model that is recommended in the previous chapter, is implemented with fuzzy soft thresholding. The parameters of the hybrid model is optimized using FPGA and the performance of the proposed model
is compared in terms of PSNR and IQI with the recommended model of the previous chapter. Results demonstrate that the hybrid model with fuzzy soft thresholding is more efficient in denoising highly noisy images with good perceptual quality in almost all the images. Thus, \textit{the hybrid model with fuzzy soft thresholding and bilateral filter is recommended here, as the ultimate denoising model.}

Generally speaking, the proposed model outperforms other models in terms of PSNR and IQI in all cases. Suggestion to improve the proposed model to overcome the drawbacks is discussed in section 6.1.

\section*{6.1 Scope For Future Work:}

The performance of the hybrid models with wavelet thresholding and bilateral filters, investigated in this thesis works, deteriorates with increase in noise levels. The performance of the hybrid models can be improved further by incorporation of intelligence in choosing the threshold value i.e., making it adaptive to textural variation which can make it more efficient in removing noises. Also, the performance of the hybrid models with fuzzy soft thresholding and bilateral filter can further be improved by incorporation fuzzy logic reasoning together with fuzzy thresholding function.