Chapter 5

Conclusion and Future Work

This thesis provides an overview and comprehensive evaluation of fingerprint image enhancement techniques. In this research work the presented fingerprint image enhancement techniques are based on SWT, Frequency and spatial domain techniques and the combination of various general purpose image enhancement techniques such as mathematical morphology, contrast enhancement, intensity mapping, filtering, normalization, Quick mask. Finally, we have presented the feature extraction algorithm using mathematical morphology to remove the superfluous information and performance of this proposed algorithm is measured in terms of specificity and sensitivity.

In the preliminary study of the overview of fingerprint image enhancement, we had observed, studied and analyze the various techniques used to perform analysis and strategies of fingerprint enhancement techniques. We have also focused on few another techniques like binarization, thinning, morphological approach, ridge
reconstruction, singular point extraction etc. and their results and limitations for
fingerprint image analysis and enhancement. The main difficulty of researchers is to
choose the good combination of techniques or methods for effective and capable
fingerprint image enhancement to improving the performance of the fingerprint
recognition system and also reduce the computation efforts. Hence, in this research
work we have presented three different methods by using Mathematical Morphology,
Fourier transform based composite method and SWT based composite method.

In the first experiment the original fingerprint images rely on quantities measurement
of inspection, but they can provide a natural representation of fingerprint
imperfections such as noise and broken ridges. The experimental result shows that,
this algorithm can effectively increase the contrast, reduce the noise and
morphological transform (top-hat) is used to connect or fill the gaps between the
broken ridges. It is necessary to choose the appropriate structuring element as per the
problem requirement. The gap between the ridges can remove two false ridge ending
minutiae i.e. automatically reduce the false accept rate (FAR). The resultant image of
this algorithm can be directly used to extract the genuine features. The results of this
algorithm can be further extends to convert resultant image into binary image. But to
convert image into binary form the appropriate threshold value must be select to avoid
image losses. This algorithm may fail for heavy noisy fingerprint image.

In second experiment, we have presented the composite algorithm for noisy or
corrupted fingerprint image enhancement in three terms namely intensity mapping,
Fourier spectrum analysis, and connecting broken ridges. Intensity mapping function
map the intensities from low to high and high to low, due to this we just increase the
contrast of the image and it doesn’t affect on structure of the fingerprint image. Fast
Fourier Transform (FFT) in frequency spectrum shows prominent features of
fingerprint that could not be extracted by other enhancement techniques. Frequency
spectral analysis techniques use to highlight very weak fingerprint information from
variety of background patterns. Where as, because of applying of quick mask broken
ridges of fingerprint has been connected. This mask connects broken ridges of all
eight directions within one convolution operation, hence it saves computational
efforts. This proposed composite algorithm shows the batter performance for
enhancement and connecting the broken ridges in noisy images. However it may not show the desired result where the broken or cut ridges are at very high level.

In third experiment, we present a novel SWT based Composite method (described in chapter 3) to deal with fingerprint image enhancement. The new approach adopts the denoising by SWT. The SWT based composite method provided better results on low contrast and noisy fingerprint images. Morphological operations eliminate superfluous details, smaller than the structuring element, without affecting its universal features of fingerprint. Further the quick mask is applied on processed data and found more useful to connect broken ridges of all eight directions within one convolution operation, hence it saves computational efforts and finally the some obtained result has compared using texture descriptor, before and after enhancement. This approach has an obvious advantage, in time invariance and useful in recognizing the noises in fingerprint images and also useful for improving the recognition performance.

Finally, in this research work, we have introduced a method for removing superfluous information for genuine fingerprint feature extraction using mathematical morphological operation. This algorithm removes the spikes, spurs and dots very effectively and extracts a clear and reliable ridge map structure from input fingerprint image. We have also compared the performance of before and after of this morphological algorithm by extracting features in terms of sensitivity and specificity. This result also reflects the average sensitivity that was 89% and 95% before and after post processing respectively. Similarly, for specificity, we got high specificity after preprocessing i.e. 89% as compare to before i.e. 78%. This result shows the better enhancement ratios in comparison with reported work and hence found suitable for robustness of fingerprint recognition system; specifically for low noise fingerprint images. However, heavily distorted or high cut or broken ridges may not show the desired result under this environment and hence for automatic recognition multi-biometrics or multimodal approach is required.
Future Work

Our future work is to extend the work of this area by using the Multiwavelet or wavelet packet rather than FFT and redesign quick mask to connect the high broken ridges. Also for feature extraction work may be extended for the other database and reduce the number of missed minutiae by improving the performance of feature extraction algorithm for better performance of automatic fingerprint recognition system.

In spite of the performed work, our plan is to develop the new techniques and algorithms for matching of fingerprint recognition for the automatic fingerprint recognition system.