CHAPTER 6

CONCLUSIONS AND FURTHER SCOPE

This chapter presents specific conclusions drawn based on observations showing fulfilment of predefined objectives. The work carried out in this thesis can be extended for further research. The chapter also gives avenues of further scope for this research work.

6.1 Conclusions

The work presented in this thesis is a practical framework for achieving perceptual transparency and robustness under high payload scenario with security provision in transform domain. Based on experimental demonstrations, specific conclusions are given below:

i. Arnold transform, modified Arnold transform, Fibonacci-Lucas transform, FLRAT, Harries corner detection method and IPMS effectively provide strong multilevel security for DWT-DFT-SVD and DWT-SVD based image watermarking techniques.
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ii. The proposed watermarking technique in DWT-DCT domain tested with ortho images of size 512x512 give PSNR as 48.53 dBs and NC as 1, when ROI of size 64x64 was preserved.

iii. The experimental results of DWT-DFT-SVD based technique in YUV color space and DWT-FWHT-SVD based technique proved that perceptual quality and robustness are inversely proportional to each other under constant payload.

iv. The imperceptibility and robustness can be effectively optimized under high payload using MEO. With scale factor K1 as 1 and number of generations as 5, we got (PSNR as 51.9741 dBs, NC as 1) for Lena, (PSNR as 55.2266 dBs, NC as 1) for peppers and (PSNR as 59.5709 dBs, NC as 1) for lake images.

v. The proposed DWT-DFT-SVD, DWT-FWHT-SVD and MEO based technique in DWT-SVD domain give better perceptual quality than existing method[23], method[25], method[27], method[85], method[86] and method[87].

vi. The proposed DWT based technique gives PSNR as 41.38 dBs for baboon image, 51.89 dBs for jet plane, 45.44 dBs for peppers, 51.79 dBs for lake and 51.67 dBs for living room. The technique gives NC as 1 showing exact recovery of watermark for all sample candidate images baboon, jet plane, peppers, lake and living room.

vii. The DWT-DCT based technique gives better perceptual quality and robustness for LL, HL and LH sub-bands than DCT domain, keeping payload constant. The 512x512 size color jet plane image in YIQ color space gives (PSNR as 67.56 dBs NC as 0.91) for DWT-DCT-HL, (PSNR as 67.66 dBs, NC as 0.85) for DWT-DCT-LH, (PSNR as 67.57 dBs, NC as 0.97) for DWT-DCT-HH and (PSNR as 54.12 dBs, NC as 0.97) for DCT domain.

viii. The DWT-DFT-SVD based technique shows better performance in LUV color space with compared to YUV, YIQ and YCgCb color spaces. For the set of candidate images Lena, peppers, baboon and splash of size 512x512, we got (PSNR as 86.9609 dBs, NC as 0.9925) for YUV color space, (PSNR as 77.3647 dBs, NC as 0.9924) for YIQ color space, (PSNR 89.9114 as dBs, NC as 0.9925) for YCgCb color space, (PSNR as 95.0650 dBs, NC as 0.9925) for LUV color space, under watermark of size 256x256.
ix. The composition of multiple transforms gives better performance with compared to single DWT based technique. The proposed method in DWT-DCT gives PSNR as 49.46 dBs and NC as 1 for Lena of size 512x512 and watermark of size 256x256. In DWT-DFT-SVD domain with LUV color space, PSNR is found 95.06 dBs with NC as 0.9924, the DWT-FWHT-SVD domain gives PSNR as 75.84 dBs with NC as 0.98.

x. The proposed DWT-DFT-SVD method, DWT-FWHT-SVD method and MEO based method in DWT-SVD domain support more information hiding capacity with compared to existing method[23], method[25], method[27], method[85], method[86] and method[87]. These proposed methods can embed watermark of size 512x512 in cover image of size 512x512 using IPMS giving 100 % embedding capacity.

xi. The experimental results demonstrated that proposed framework efficiently provide security solutions to real world applications such as wavelet biometric based e-voting system, criminal photograph authentication system.

Thus, this research work presents blind, secured, robust and perceptual transparent digital image watermarking system in transform domain by embedding high capacity payload in an image.

The limitations of the thesis are,

i. The small variations in techniques of proposed system are required if cover image size changes.

ii. This framework proposes single watermark embedding. The multiple watermark embedding will be possible at the cost of degradation in imperceptibility of watermarked image.

6.2 Avenues for Future Work

i. As per scope of this work, DWT has been focused as central transform. Instead of DWT, either complex wavelet transform (CWT), Multi wavelet or complex and rotated wavelet transform can be used to make the system more robust and secure.
ii. Many scrambling methods, key generations logics, IPMS, randomization techniques and multiple levels of security provision are proposed in this work. The strong hashing techniques and visual cryptographic techniques can be used for additional security.

iii. The ROI based effective medical image watermarking techniques are proposed in this work. The automated tool can be designed separately incorporating with proposed techniques to speed up the algorithm execution.

iv. The evaluation of grey scale, color and medical images is based on specific parameters such as MSE for grey scale images, MSE for color images, PSNR for grey scale images, PSNR for color images, normalized correlation, color spaces processing and ROI processing. Javier Galbally et al.[18], proposed additional image quality assessment measures such as structural similarity, information theory, distortion and natural scenes statistic. The extension of the work can be done with image watermarking system considering rest of the quality measures and inclusion of multiple watermark hiding capabilities.

vi. The proposed image watermarking system can be extended for video watermarking system.

In summary, this chapter gives complete idea about main contributions as a part of fulfilment of predefined objectives. It also talks about avenues of further scope for this research work.