CHAPTER VII

CONCLUSION

7.1 Conclusion

The main focus of this thesis is to study and analyze various Human Skin Detection Techniques with Application to Human Face Detection. In the course of that goal, a new improved class of Human Skin Detection Techniques got evolved for detecting human faces in color face images with minimal computational work and reduced time complexity which is identified as goals during the literature survey. The three segmentation algorithms, FDTM, FDMP and FDSE are developed to work on color face images, FDMG is a human skin segmentation algorithm designed to detect human skin regions in color images based on Gaussian color models using YCbCr, YUV, YIQ, RGB and a combination of two color based on Gaussian color models, FDPS gives a comparative analysis of skin detection algorithms using sixteen color spaces based on Bayesian, Gaussian and explicitly-defined skin color models.

To evaluate the performance of this proposed novel class of skin segmentation techniques, simulation is carried out on XM2VTS Extended Multimodal Face Database containing more than 100 color images together with manually prepared ground-truth for skin segmentation and face detection are used. In addition, manually prepared ground-truth images are used for skin segmentation and face detection. The other color face databases used are Caltech Face Database, Postech Faces '01, and Indian Face Database. The XM2VTS Extended Multimodal Face Database consists of both frontal view images and side view images. These
images are acquired with our digital cameras and the rest are collected manually from the Web over a period of 46 months starting from 2005 to 2009. The skin types include whitish, brownish, yellowish, and darkish skins. The ground-truth images are meticulously prepared by manually segmenting the face and skin regions. The skin segmented images consist of all exposed skin regions such as facial skin, neck, arms, and hands. The algorithms used to detect human skin workes for both frontal and side view images. The size of this face database is large in number it is difficult to show all the images in the thesis report. The frontal view images are shown in this thesis report.

In conventional explicitly-defined skin cluster methods, the threshold values used to segment the skin region are fixed values which cannot be used for all kinds of skin colors. Therefore, the threshold values are determined using the mean and standard deviation of image pixels. This formed the first human skin detection algorithm used in FDTM.

The detection of skin regions in color images with single color space using explicitly-defined skin cluster methods applied to different types of color face databases produces false positives because the fixed threshold values cannot be used for all types of skin colors. Hence, the threshold values are taken from more than one color space. To overcome these problems, a new explicitly defined skin cluster technique is developed. By deploying these concepts in this research work three more skin detection methods are proposed. First method uses YCbCr and YIQ color spaces to detect human skin in color images. The second method uses the combination of three color spaces YCbCr, YIQ and HSV to segment the skin regions in color images. The third human skin detection uses five color spaces.
namely, normalized RGB, RGB, YCbCr, YIQ and HSV.

The linear decision boundary classifier and Gaussian models have their own shortcomings because the Gaussian model has certain problems as mentioned earlier and it do not produce better results using all commonly used color spaces. The results obtained depends on the selection of proper and appropriate color space and threshold values. The improper selection of color space and threshold values lead to false positives and true negatives. Hence, a statistical model like Bayesian model can be tried to overcome these problems.

Many non-parametric methods have been proposed for skin color modeling. A lot of work has been inspired on color indexing using histogram intersection. Besides histograms often used non-parametric methods are skin probability maps and neural networks. Common for all these methods is that the skin model is estimated from training data without deriving an explicit model of the skin color distribution. The linear decision boundary classifier and Gaussian models have their own shortcomings because the Gaussian model has certain problems as mentioned earlier and it do not produce better results using all commonly used color spaces. The results obtained depends on the selection of proper and appropriate color space and threshold values. The improper selection of color space and threshold values lead to false positives and true negatives. Hence, a statistical model like Bayesian model can be explored to overcome these problems.

Human Face Detection in Color Images using Mixed Gaussian Color Models (FDMG) proposed a skin segmentation approach and gave a comparative analysis of few mixed Gaussian color model using four color spaces. An attempt was made in this research work for the Gaussian color model using YCbCr, YUV, YIQ, YES and other combination of color space, RGB-YUV, RGB-YCbCr, RGB-YIQ, YCbCr-
YUV and YCbCr-YIQ [86]. This new human face detection algorithm involves two stages: applying mixed Gaussian skin color model to segment human skin regions and using template matching technique to detect human face regions in color images. RGB color space will not differentiate the human skin color and the clothes when skin color and clothes color are the same. YIQ color space produces better results than RGB. YCbCr color space produces better results than RGB, YIQ. But YUV color space produces the best results when used to segment skin regions in color images using mixed Gaussian color models. These inferences are derived from the visual effects.

Human Face Detection using Statistical Models and Explicitly-defined Skin Region Classifiers (FDSE) gives a comparative analysis of human skin detection in color images using the commonly used color models like Gaussian, Bayesian and explicitly defined skin cluster classification algorithms in a new derived color space from YCbCr namely YCgCr. The chrominance and luminance information are separated in this the color spaces also as like YCbCr color space. The separation of chrominance and luminance information improves the performance of skin detection results. Experimental results demonstrate successful human skin detection and hence human face detection over a wide range of facial variations in color, position, scale and orientation. The results obtained using the three skin classification algorithms are compared. The Bayesian color model produces good results than Gaussian model. The skin detection method using linear decision boundary classifier in YCgCr color space produce best results than both Gaussian and Bayesian color models. Lip region detection is done to detect facial features using R/G and R/B color models.
Skin Color-Based Human Face Detection using Mixed Piece-wise Linear Decision Boundary and Template Matching Classifiers (FDMP) presents an analysis of the pixel-wise skin segmentation approach that uses color pixel classification using eighteen color spaces. The piecewise linear classifiers applied for HSV and RGB color spaces produces still higher classification rates than all other classifiers for image with good illumination conditions. Earlier research says that no color space can be considered as universal for segmenting the skin regions because color can be interpreted and modeled in different ways. Our findings say that the selection of color space is more important in segmenting the skin regions and hence the face regions in the color images. The color spaces like YIQ, HSV, YCbCr and RGB produces better results when used separately. But when the skin region obtained using different color spaces are combined the best results are achieved.

The experimental results shows that all the (fifty) human skin detection algorithms produced better results when used for XM2VTS face database. But our conclusion is that the same set of algorithms produces much better results than all the other face databases used when used for the CITE face database because the quality of the CITE face database is not good as compared to other face databases.

7.2 Future Scope of the Work

There are good scopes for future improvements in the proposed human skin segmentation techniques. For practical implementation, the computational complexities of the skin segmentation techniques of color images can be further reduced.

The human skin detection approach will not work for the images with bad illumination condition with background containing light focused from backside of
the object. Human skin detection results can be improved if the background is removed from the images or if the image is preprocessed using some illumination improvement techniques.

Another way of improving the skin detection methods are the face detection techniques can be incorporated to the face detection problem. The skin detection technique can be used as preliminary stage for face recognition, face tracking, facial expression recognition, face authentication, content-based image retrieval, human-computer interaction, video conferencing, filtering internet connections for offensive images and video-surveillance.

In all works on “Automatic Human Skin Detection Techniques with Application to Human Face Detection”, need to be fine tuned with regard to the threshold values for the specific database being used to produce better results rather than using the threshold values specified in the developed algorithms. The future researchers can address this open research problem on the ideal threshold values suitable for the database at hand based on the set of estimated parameters from the given database using an ROC (Receiver Operating Characteristics) curve to fine tune the threshold values. This single open research problem is worth doing a full Ph.D work.