CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 CONCLUSION

Texture segmentation is one of the most challenging works in a comprehensive vision system. Segmentation of a given scene is essential for any further processing and the precise perception of a real world scene is not possible without segmenting the textured objects. The performance of the vision system depends upon the performance of the texture segmentation algorithm as an error at this stage will be propagated to its higher levels. It is therefore, not surprising to see the attention of researchers on this topic for the last thirty years and one can find a whole surfeit of methods for segmentation of textured regions in the literature.

Our objective in this thesis has been the discussion of color texture segmentation of images using wavelet derived features. The segmentation algorithms developed have been restricted to a framework of pixel-based representations. Let us now briefly recall the main contributions of this thesis.

We have presented algorithms to show how wavelet theory can be applied in the domain of color imagery for the segmentation of textured regions. Texture and color are two properties that coexist at the images and their interrelations can be more or less strong depending on the images. In this sense, we have explored four wavelet detection transformation techniques in which this interrelation has different weight and then some spatial–chromatic
features are more important than others. These transformations refer to how
texture in each channel relates to texture of the other ones.

In most papers related to texture segmentation, the feature
extraction step yields a lot of information that must be reduced. This
reduction should be performed by classic methods of dimensionality
reduction without any knowledge about the data. In this work, a simple and
elegant method is devised to create the feature space using i) wavelet
coefficients and ii) wavelet statistical features, by suitably combining the
approximation sub image with the significant detail sub images. The resultant
feature space is quite consistent for characterizing the color texture features
present in an image. It also holds good for all types of wavelet transforms
irrespective of the number of sub images obtained after any level of
decompositions. This idea has been supported by actual results showing that
selecting the right features achieves the better segmented output.

Three segmentation algorithms have been developed and
implemented in our work: i) Wavelet Based Homogeneity Histogram
Analysis by Thresholding; ii) Wavelet Based EM with Cost Spatial
Refinement and iii) Wavelet Based 2D Histogram Clustering.

The general processing scheme in which our algorithms are
enclosed is divided in two stages: in the first stage, wavelet derived
coefficient feature space and wavelet derived statistical feature space are
created, whereas in the second stage, the proposed segmentation algorithms
are applied on the derived feature spaces and analyzed to study how textured
images are discriminated.

We have opted to select images which are rich in color and texture
with a relatively limited number of regions and in which human segmentation
from different persons could present small divergences. This does not mean that these images are easy to segment, in fact texture segmentation is never an easy task and the evaluation can be more “objective” according to the similar segmentation different humans would obtain.

The performance of the proposed wavelet based homogeneity histogram thresholding is compared with the Otsu multithresholding algorithm and Mean shift algorithm. The experimental results indicate that the proposed approach, which utilizes both local and global information, displays an improvement in accuracy over the traditional methods. These improvements can be visualized qualitatively in the real and synthesized textured images in chapter 4 and most clearly quantitatively in terms of evaluation function, average color error and execution time in chapter 6.

A new clustering approach is proposed by combining partitional, hierarchical and probabilistic clustering techniques to overcome the limitations and to take advantage of their merits. The proposed EM with cost spatial refinement algorithm produces more meaningful segmentation results. However, the spatial refinement in Fuzzy C means and K-means allows identification of regions but the problem of over segmentation is present in regions with a textured behaviour. The superiority of the proposed clustering method is proved qualitatively in chapter 5 for various kinds of textured images. Especially, this method is highly suitable for multi spectral images. This fact is also due to the robustness of the multi resolution approach which has shown to be able to get correct segmentation results, independent of noise and its parameters. The obtained results encouraged us to continue the work. The parameters deviation ratio, average dispersion degree and execution time are used as the performance measures for carrying out the quantitative evaluation of the clustering algorithms which have been elaborated in chapter 6.
It is observed from the results that Wavelet based EM with cost spatial refinement algorithm produces accurate segmentation only at the expense of execution time. To reduce the computational time, clustering problem can be imposed on the histogram of the created feature space. So, wavelet based 2D Histogram clustering algorithm is developed and implemented. Some color texture segmentation results obtained using this proposal is qualitatively proved and shown in chapter 5. The meaningful regions are successfully detected and the usefulness of color texture segmentation is demonstrated. Furthermore, the quantitative analysis is dealt in detail in chapter 6.

Color images not only have information about the brightness of each pixel but also have additional information such as hue and saturation compared with monochrome images. In the experiments, the effect of using different color spaces is examined. RGB, HSV, YC_bC_r, XYZ and LAB color spaces are used in our experiments. The segmentation results in these color spaces are qualitatively seen from the results presented in chapter 4 and 5. The quantitative analysis is carried out in chapter 6.

Analysing the experimentation results, it is observed that Dual tree complex wavelet transform derived coefficient feature space is found to be more suitable for discriminating the highly textured regions. This is due to the fact that the limited redundancy introduced in the structure allows a significant reduction of aliasing terms and also shift invariant translations cause large changes to the phase of the wavelet coefficients, but the magnitude, and hence the energy, is much more stable. The Intermediate maximum overlap wavelet transform derived statistical feature space is turned to perform well for smooth textured images. The reason for the superiority of this method is due to the smoothing effect on neighborhood pixels which works well for smooth textured images. And also, RGB color space produces
the best results for both types of the images. The HSV space produces the worst results because of the singularity problem inherent to this space. The XYZ space provides better results for smooth textured images.

In addition, we want to emphasize some aspects of the shown results that are considered by us as very positive. We believe that the segmentation performed by our proposals is correct as it distinguishes regions with different color textures without any initial knowledge on their characteristics. Moreover, Texture segmentation is especially difficult at boundaries and great errors are often produced at them. But, using our algorithms, we can experimentally prove that accurate segmentation results are obtained considering not only the correct detection of regions, but also the precise localization of boundaries between adjacent textures.

7.2 FUTURE WORK

The development of new representation tools for images that can both capture various features and be implemented by fast algorithms is one of the most active research areas in the image processing community. The multiresolution filter bank approach in this thesis is very promising and leads to a variety of possible extensions. In the following, we give an overview of ongoing and future research directions.

From the wavelet point of view, a fast algorithm is required for applying the segmentation algorithm. Like other signal processing tools such as the FFT and fast wavelet transform, it could be possible to improve the speed of this transform algorithmically. The work can further be extended to recently developed wavelet transforms to investigate the suitability of effective segmentation of high dimensional images. Algorithms can be designed to efficiently exploit information across scales and resolutions.
From the texture point of view, a comprehensive mathematical model for textures is highly desirable. More elaborate models for combining color composition and spatial texture features could be used to improve segmentation performance. Future research will address the estimation of other features with a high level of interrelation among channels and levels of decomposition.

An important routine is that of foreground and background segmentation, which would be extremely helpful in order to focus the attention onto some object in the whole scene depending on the tasks scheduled to be carried out. A good direction would be to include shape or motion information to the segmentation algorithm.

Automated systems can be developed to analyze, understand, classify and index the color texture image data sets.