Wavelet Based Image Texture Segmentation using a Modified K-means Algorithm

by

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B.E. (First Class Honours), B.Sc. (Ma. & Comp. Sc.)

Thesis submitted for the degree of

Doctor of Philosophy

in

Department of Electrical and Electronic Engineering,

Faculty of Engineering,

Computer and Mathematical Sciences

University of Adelaide, Australia

August, 2003

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Abstract

In the field of computer vision, texture analysis has historically been an important topic of study. Texture is one of the major primary visual cues to image understanding. The human visual system relies on texture, among other types of cues, to effectively interpret the information contained in an image. Therefore, it is imperative that a fully functional artificial vision system must perform texture analysis. However, effective texture analysis has proved to be a difficult problem. This is mainly due to fundamental difficulties with texture - it is more of a concept than a well-defined object or property. Without an unambiguous definition of texture, researchers have to resort to various models and techniques, all of which have their own advantages and disadvantages. Traditionally, there have been three main approaches to texture analysis: statistical, structural and filter-based. While statistical and structural approaches have been favoured by early researchers, more modern techniques are typically filter-based. This thesis presents a type of filter-based technique. There are two main areas within texture analysis: classification and segmentation, but this thesis only covers the segmentation problem.

Wavelet transforms are a relatively new analytical tool in the scientific community. It is commonly accepted that wavelet theory grew out of classic Fourier analysis. Despite its widespread usefulness, Fourier analysis has several deficiencies; wavelet theory is among many others that attempt to address such problems. Primarily, wavelet transforms decompose signals into joint time-frequency bases, instead of harmonic ones. The inherent multiresolution property associated with joint time-frequency representations makes wavelet transforms far more suitable for analysing non-stationary signals. As a result, wavelets have been used in many different applications in the relatively short period of time since its introduction.

In this thesis, wavelet transforms are chosen as the primary analytical tool for texture analysis. In particular, a recent advancement in wavelet transforms, called the Dual-Tree Complex Wavelet Transform, is applied to the texture segmentation problem. While the wavelet transform is believed to be a suitable analytical tool, there are other problems to be overcome before a texture segmentation system can be built. Specifically, the feature extraction and feature clustering methods need to be investigated. This thesis examines several possibilities for feature extraction and clustering steps. In particular, novel feature extraction and clustering schemes are introduced and compared to other known techniques. An extensive range of experiments are performed on the texture mosaics, to verify the effectiveness of the proposed feature extraction and clustering methods. The set of inputs to the experiments are carefully chosen as to allow direct comparison with existing methods, so a meaningful indication of the quality of the proposed segmentation system can be obtained. It has been found that the proposed system is capable of producing accurate, highly consistent segmentations on the test mosaics. With the success on the test mosaics, the segmentation system is then applied to several real-world applications. In the real examples, it is found that the system produces more erratic results, often as a consequence of the lack of any problem-specific input to assist the segmentation process. Overall, the proposed system, using wavelet based features, compares well with existing schemes for basic texture segmentation tasks.