Abstract

Image segmentation is concerned with decomposing a given image into its constituent regions or objects. It is an important preliminary step in diverse fields of application like object recognition, image compression, medical image processing and biological analysis methods. Among the existing image segmentation algorithms, watershed transformation is deemed to be a powerful tool for image segmentation owing to the simplicity of its formulation and implementation and its ability to identify the important closed contours of a given image. However, the time complexity of the majority of the watershed transform algorithms is quite high, making their real-time application difficult. In particular, real-time processes like moving object segmentation, road traffic monitoring and analysis of steel fracture demand fast computation of watershed transformation for image segmentation. At the same time, a dedicated hardware architecture for implementing watershed algorithms would give rise to faster results as compared to a software program executed on a general purpose processor.

The work embodied in the present thesis is concerned with formulating improved versions of a few standard watershed algorithms and developing appropriate prototype hardware architectures for the same. Following results have emerged in the process.

- An improved algorithm has evolved from Meyer's flooding-based watershed algorithm based on ordered queues. Hardware implementation of Meyer's algorithm, which is based on 256 ordered queues, is very complex and expensive. The proposed algorithm, however, uses a single queu thereby reducing the computational complexity but at the same time showing almost identical performance compared to Meyer's algorithm. Moreover, a prototype architecture has been developed for effective realization of the proposed method.

- A drawback of the above proposed algorithm is that no synchronization is possible in a non-minimum plateau having more than one closely located regional minima. Moga's technique, based on lower complete transformation, can be applied to tide over this problem. However, this would entail time-consuming multiplication by a constant of a gradient image based on geodesic distance. The present work evolves a hillclimbing-based method which improves upon Moga's algorithm by avoiding the computationally expensive lower complete transformation. Moreover, the regional minima detection and labelling is performed in one scan rather than two scans by the use of two queues. The reduced complexity makes the proposed algorithm amenable for hardware

realization. An FPGA-based architecture has been developed to implement the algorithm with moderate hardware complexity.

- The work reported in the present thesis has gone on to develop an efficient immersion-based algorithm based on Vincent and Soillé. Undesired effects like thick watershed lines and isolated minima are not uncommon during the process of flooding of catchment basins and detection of watershed pixels. In the proposed algorithm, flooding starts from pre-determined regional minima, during which the label of the neighbouring pixels are decided on the basis of conditional neighbourhood comparisons and geodesic distance from the outer brim of the nearest plateau. As a result, always continuous watershed lines with a uniform width of a single pixel are produced. A prototype hardware architecture for this algorithm too has been developed.