ABSTRACT

Vessel segmentation algorithms for coronary angiogram are the key components of automated radiological diagnostic systems. Segmentation methods vary depending on the imaging modality, application domain, method being automatic or semi-automatic, and other specific factors. There is no single segmentation method that can extract vasculature from any medical image modality.

The first part of this thesis deals with various segmentation methods like Pattern recognition, Neural network classifier, Active contour model and Multi-threshold with Multi-resolution analysis to segment blood vessels.

In Pattern recognition method segmentation using K-means clustering is performed. In this technique, clusters are formed based on the minimum distance criteria with random seed point selection. Different centroids lead to different results. If initial centroids are found which are consistent with the distribution of data, then better clustering can be obtained. Hence, an initial centroid approach is implemented. Moreover, as the dataset scale increases rapidly, it is difficult to use K-means and deal with massive data, so an improved K-means algorithm is proposed. It can avoid getting into locally optimal solution in some degree, and reduce the probability of dividing one big cluster into two or more owing to the adoption of square error criterion. Segmentation so obtained helps in detection of stenosis from the vessel structure by boundary tracking algorithm.
A neural-network classifier that takes the image gray-scale data as direct input is developed to classify blood vessels with minimum of input layers and less number of iterations. The input is given to two network topologies (12-17-2 and 4-3-2 layer configurations) and tested for their performance. The 4-3-2 layer configuration was able to classify blood vessel with less number of iterations comparatively and it could detect even small vessels.

Snakes, or active contours, are used extensively in computer vision and image processing applications, particularly to locate object boundaries. However, most present snake models cannot provide better capture range and evolution - stop mechanism. This thesis presents a model based technique like a new external force for active contours, largely solving both problems. An extension of the gradient vector flow snake (GVF snake) method is presented. First, the adaptive balloon force has been developed to increase the GVF snake’s capture range and convergence speed. Then, a dynamic GVF force is introduced to provide an efficient evolution-stop mechanism. In this way, the snake is prevented from breaking through the correct surface and locking to other salient feature points. The active contour models have been applied on real X-ray coronary angiogram images. The segmentation results demonstrate the potential of improved GVF method in comparison with all previous active contour methods.

The final part of the work among segmentation methods is an automatic segmentation for blood vessel at a comparatively high resolution. This algorithm presents an effective method for automatic segmentation of blood vessels using Multi-resolution Analysis and Multi-threshold Technique.
Also performance analysis of Multi-thresholding with Multi-resolution analysis based segmentation technique with respect to other techniques has been analyzed. This method proved to be an efficient automatic segmentation. This method is analyzed using Multi-observer Gold standard analysis.

The second part in the thesis presents 3D visualization of blood vessels and blood flow velocity determination for stenotic and normal vessels.

Edge detection of the vessel structure has an inherent problem because the gray level difference is minimum between the vessel structure and background. The matched filter does not detect a clear edge when the difference in gray level is minimum. To overcome the above problem a method is proposed in this thesis by taking the intensity profile from the morphologically-processed and contrast-enhanced image to which the matched filter is applied.

3D visualization for the whole coronary tree by using of B-spline basis functions is proposed. A more compact description of the arterial curves is visualized, providing intrinsic smoothness to the curves. The visualizations of blood vessels are important in clinical diagnosis and surgical verification. The 3D visualization provides better information regarding the shape and severity of the lesion.

Determination of blood flow velocity, in order to diagnose coronary disease and detect any reduction of myocardial blood flow that may result from obstructive coronary lesions is designed and analyzed. Thus efficient segmentation, 3D visualization and blood flow velocity determination for coronary angiogram images are analyzed and discussed to help doctors in diagnostics purposes.