Chapter 16
Classification of Thyroid Carcinoma in FNAB Cytological Microscopic Images

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ABSTRACT
This paper investigates an image classification method performing thyroid carcinoma classification in Fine Needle Aspiration Biopsy cytological images of thyroid nodules under noise conditions and varying staining conditions. The segmentation method combines the image processing techniques thresholding and mathematical morphology. Feature extraction and classification are carried out by discrete wavelet transform and Euclidean distance based on k-nearest neighbor classifier, respectively. The classification methodology is successfully tested for Papillary carcinoma and Medullary carcinoma cytological images of thyroid nodules, showing promising results, encouraging future research work. The maximum classification rate of 95.84% and minimum classification rate of 79.17% have been reported for various testing sets of FNAB cytological images of thyroid nodules.

1. INTRODUCTION
The thyroid is one of the largest glands in the body that regulates the rate of metabolism by producing thyroid hormones. The unwanted growth of cells on the thyroid can form a mass of tissue that is called as thyroid nodules. Most of these thyroid nodules are benign and not cancerous. Only 10-15% of all thyroid nodules are discovered to be thyroid cancer i.e. malignant. There are four main varieties of thyroid cancer namely Papillary carcinoma, Follicular carcinoma, Medullary carcinoma and Anaplastic carcinoma (Mahar, Husain, & Islam, 2006; Kumar, Aqil, & Dahar, 2008).

Thyroid cytology deals with study of microscopic cytological images of thyroid nodules. Thyroid cytopathology is used as screening tool to detect cancer in its early stage by studying the cytological features of cancer affected cells. Although screening may lead to an earlier diagnosis, over-diagnosis and misdiagnosis are the unwanted negative effects of screening. Sometimes, cell
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boundaries are not well distinguishable due to poor dye quality and parts of the same tissue are not equally stained and two or more cells may overlap which mislead the segmentation. While examining such samples under microscope, a pathologist examines the changes in the distribution of the cells across the sample. Classification of medical images by a clinician may vary from person to person based on the experience and research efforts have been directed in the field of medical image analysis to assist in diagnosis of diseases (Hrebien, Stec, Nieczkowski, & Obuchowicz, 2008; Sarkar & Leong, 2009; Schneider, 2007).

To overcome these problems and improve the reliability of diagnosis, it is necessary to develop efficient automated methods for performing the segmentation of cancer cells from the FNAB microscopic images and classifying benign and malignant state using image processing techniques. The researchers are very much interested in the Computer Aided Diagnosis (CAD) system for the classification of pattern in medical images to improve the decision made by the pathologists in the analysis of medical images.

Segmentation algorithms for gray scale images are based on discontinuity and similarity of image intensity values. In the first category, the approach is to partition an image based on abrupt change in intensity, such as edge. The principal approach in the second category is based on portioning an image into regions that are similar according to a set of predefined criteria. Thresholding, Mathematical Morphology, Watershed algorithms, Region Growing and Clustering are the few methodologies in region-based approaches. Discontinuities detection algorithms are based on point detection, line detection and edge detection. The other segmentation methods in automated medical image processing are classifiers, Fuzzy-neural based approaches, Image transforms, Model based approaches and Wavelet based approaches (Adawy, Shehab, Keshk, & Shourbagy, 2006; Arivazhagan & Ganesan, 2003; Duanggate, Uyyanonvara, & Koanantakul, 2008; Gonzalez & Woods, 2002; Hrebien, Stec, Nieczkowski, & Obuchowicz, 2008).

The proposed research work aims to extract the cancer cells in FNAB microscopic cytological images of papillary carcinoma and medullary carcinoma of thyroid nodules in order to classify cell types with the help of Discrete Wavelet Transform based texture feature extraction and Euclidean distance based k-nearest neighbor classifier.

In training phase, five papillary carcinoma and five medullary carcinoma images have been used for feature extraction. Since each image is cropped into four sub-images before feature extraction, the total number of images for training set becomes 40. After feature extraction, the total number of features becomes 120 among which mean, standard deviation and variance are 40 each. The maximum classification rate of 95.84% and minimum classification rate of 79.17% are obtained for various testing sets of FNAB cytological images of thyroid nodules.

We begin with introduction of Fine Needle Aspiration Biopsy in Section 2. The Mathematical morphology based segmentation method is described in Section 3. Section 4 describes the two-level wavelet decomposition of images for feature extraction and the image classification method. The feature extraction and classification results are presented in Section 5 and Section 6. Finally, the results and conclusion are summarised in Section 7 and Section 8.

2. INTRODUCTION OF FINE NEEDLE ASPIRATION BIOPSY

Fine-Needle Aspiration Biopsy (FNAB) is the non-surgical method of determining benign or malignant state of the thyroid nodule. Thyroid FNAB can be performed effectively in a general hospital or outpatient department by a doctor. The doctor who performs the aspiration must have proper training and experience in this method. Our research work focuses on effective findings