Detection of Carcinoma with the Fuzzy ARTMAP NN

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According to statistics from NIH (National Institute of Health), cervical cancer is the third most common reproductive tract malignancy (ranking behind endometrium and ovary cancers) with about 13000 new case seen annually in the U.S., and resulting in about 4500 deaths annually. However, data from NIH indicate that the incidence and mortality rates have decreased by 50% since 1947. This has been largely due to preventive test, called *smear or Pap test*. The objective of smear or Pap test is to detect early morphological cell changes called **CIN** (*Cervical Intra-eptical Neoplasia*) before they develop into cancer. This is commonly known as *Cervical Screening*. When morphological changes are detected, the patient is submitted to other test (Colposcopy, Cone Biopsy, or Large Loop Excision of the Transformation Zone) to confirm the existence of cervical cancer.

Cervical cancer can exist in two main types: Squamous Cell Carcinoma and Adenocarcinoma. These names indicate the type of cervical cells that exhibit abnormal growing. Normal cervical cells are composed of a cytoplasm and a nucleus, the shape of each is almost circular and the size of the nucleus is much smaller than that of the cytoplasm. Morphological cell changes, as far as cervical cancer is concerned, occur in the form of elongated shape, of both the cytoplasm and the nucleus, and bigger size of the nucleus. When the ratio of the size of nucleus to that of the cytoplasm is bigger than normal, the changes may lead to carcinoma.

Cervical screening is performed by examining a sample of cervical cells with the aid of a microscope. The process starts by looking into the microscope, focusing, and searching for cells with abnormal morphological changes. This process may take 10 to 15 minutes or even more, depending on the density of the sample and the psychological state of the cytologist. With the aid of modern technology, a CCD camera could be coupled to the microscope and the microscopic image would be visualized by a video monitor. This will reduce the eyestrain that the cytologist may experience. Nevertheless, the cytologist would still have to perform some task such as focusing/refocusing and moving the slide from one direction to another. With every such task the cytologist will have to look at the monitor and analyze the focused cells. These repetitive tasks require an intensive amount of concentration from the cytologist during a single working day. Considering human factors, there are an average number of samples that a cytologist can examine and give confident results. In Brazil this number is between 45 and 50. Without any doubt an automated cervical screening process will reduce the strain on the cytologist and will allow more samples to be examined thus, reducing the incidence rate of cervical cancer.

In this paper we will describe a computer-based method for cervical screening with the purpose of detecting morphological changes that lead to squamous cell carcinoma. It is part of a long-term project that aims at developing an automated system for cytological diagnosis of cervical cancer. The computer-based method consists in analyzing a microscopic image of cervical cells and detecting any morphological changes. The whole process starts by taking as input a gray-level image of the microscopic sample and then transforming it to binary form. Thereafter, a set of morphological operations is applied in order to measure the area of both the nucleus and the cytoplasm. These two features and the ratio between them form the feature vector, which is applied to a Fuzzy ARTMAP neural network for classification. The output of the process is an image that contains cells with morphological changes. The Fuzzy ARTMAP was trained with features from squamous cell carcinoma only. This is based on the one-class problem approach proposed by the author for signature verification and detection of breast cancer. This approach is logical and a natural one. If the purpose is to detect squamous cell carcinoma, then why the Fuzzy ARTMAP should also be trained with features of other cells. In terms of system development, when adopting this approach, the amount of time required for data preparation, training and testing is less than that when adopting the two-class problem approach. The Fuzzy ARTMAP was trained with 43 feature vectors and tested with 15 microscopic images that contain normal cells and squamous cell carcinoma taken from different patients. The parameters for the Fuzzy ARTMAP were $\rho = 0.95$, $\beta = 0.6$, and $\alpha = 1.0$. The epoch size and training iteration were, respectively, 16 and 200.

The test results show 100% detection rate of squamous cell carcinoma and 98.25% rejection rate of normal cells. According to cytologists, these results are very satisfactory because perfect detection of squamous cell carcinoma is important in order to avoid false diagnosis. On the other hand, perfect rejection of normal cells is not required since this will not alter the decision of the diagnosis.

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