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Cytological Detection of Thyroid Cancer by Optical Image Analysis

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Abstract
This research explores the use of features of cells in digital optical images of human thyroid tissue as an important base to diagnose the cancer. It presents some efficient features of cells nuclei for detection of thyroid malignancy such as (radius, smoothness, compactness, expected value and variance). The cytological characteristics are very important and usual method to separate abnormal and normal cases in all diseases. The algorithm of neural network used to detect thyroid cancer successfully with accuracy of 99%.
Keywords: thyroid cancer, neural network, optical images, malignancy

1. Introduction

Thyroid nodules are swells that appear in the thyroid gland and can be due the growth of thyroid cells. The relative frequency of thyroid cancer among all the cancer cases is about 0.1-0.2%. As per this statistics, it is concluded that thyroid related cancer is a serious disease which can lead to death, with increasing incidence rates every year. Hence, early and precise diagnosis is very important for effective treatment. Therefore, some optical image analysis is necessary to increase reliability of diagnosis and reduce the false positive and false negative errors (Zubair & Virginia 2008).

For thyroid and other diseases there are numerous approaches for understanding multiple features in a digital image. These approaches continue to be studied in order to design appropriate systems that can provide precise detection, recognition and classification of abnormalities in medical environment (Blackledge & Dubovitskiy 2008, Blackledge & Dubovitskiy 2009, Deepika et al. 2012, Jean & Benot 1996, Katz 2000, Maroulis et al. 2005, Nikita & Alka 2012, Salim 2012 and Eystratios & Dimitris 2008).

2. Neural network

A first interest in neural networks began after the introduction of simple neurons presented by McCulloch and Pitts in 1943. These neurons represented models are like to biological ones as conceptual components for circuits that could give computational tasks. More scientists contributed with their efforts, the amounts of funds, the number of many conferences, and the number of researches associated with neural networks. Nowadays most institutes have a neural networks group, within their specialties like physics, electrical engineering, computer science psychology, or biology departments. The most important characteristic of Artificial Neural Networks is its ability to learn, generalize, cluster, adapt, or to cluster as 'computational models', and which operation is based on parallel processes (Ben & Patrick 1996).

Neural networks involved simple elements doing in parallel. These elements are similar to biological nervous systems and are inspired of them. The network function - as in nature - is determined mostly by the connections between elements. A neural network can be trained by performing a particular function and adjusting the values of the connections - which called weights - between elements. Usually neural networks are trained or adjusted so that a certain input leads to a particular target output. Such a state is shown below. There, the network is adapted until the network output matches the target according to a comparison between the output and the target (see Figure 8). Many such input/target pairs are typically used based on this supervised learning to form and train a neural network (Howard and Mark 2002).

3. Materials and Methods

Samples of slides contain different benign and malignant thyroid tissues taken by biopsy method are treated with Papanicolaou stain (Pap stain) and imaged by microscope with digital camera connected to computer as a system prepared for this goal (see Figure 2). Then by applying the segmentation technique called adaptive imaging threshold procedure to separate the cells.

Morphological features obtained from images taken from Fine Needle Aspiration samples (FNA) of thyroid cells were used for training and testing the neural networks. A total of 200 cells images were used to analyze. There were 100 images (50%) benign and 100 images (50%) malignant cases.

4. Features

Radius: The radius of nucleus is measured by taking the average length of the radial lines pointed from the center to outer points

Smoothness: the smoothness is a nuclear contour which is measured d by the difference between the length of a radial line and the average length of lines surrounding it (Nick 1993).

Compactness: is a the compactness measure of the cell nucleus.

This dimensionless number gives minimum value by a circular disk and increase with the irregularity of the boundary. The value of this feature increases for elongation of cell nuclei. It is given by equation (1) (Howard and Mark 2002):

$$Compactness = Perimeter^2/Area = P^2/A \text{ ………… } (1)$$

Statistical features: Since probability distributions are the key to statistical inference, it is helpful to study some of their characteristics. Two useful characteristics of a probability distribution are its expected value and its variance. Expected value is a measure of the location of the distribution, while variance is a measure of its spread.

Expected value: That is, the expected value of y is the sum of the values of y times their corresponding probabilities. The expected value E(y) can be thought of as the location, or center, of the probability distribution p(y) (Shirley & Stanley 2004):

$$E(y) = \sum yp(y) \text{ …………………… } (2)$$

Variance: The variance of a probability distribution is the average squared deviation from its expected value, the larger the variance the larger the spread. The formula for the variance is (Shirley & Stanley 2004):

$$V(y) = \sum [y-E(y)]^2 / p(y) \text{ ……………… } (3)$$

5. Result and discussion

The plot of different features explains how these features of both benign and malignant cases overlap with each other results a confusion state. Two kinds of features are used: geometrical features like radius, smoothness and compactness and statistical features like expected value and variance. Figures:3 – 7 which explain the overlap ratios between benign and malignant of radius is 17%, smoothness is 27%, compactness is 36%, and expected value is 13% whereas for variance is 6%.

Feed forward neural network model is applied for diagnosis purpose. It is designed by MATLAB software version 10 as shown algorithm (1). The input data was preprocessed using a principle component analysis and subdivided into three subsets: training 50%, validation 25% and test 25% data sets prior to training of the network.

The performance of Feed Forward Neural Network (FFNN) trained using the numeric data of features is designed as sown in Figure 8. The number of hidden node is 10 (HN) and epoch for network is 12 iterations and Mean Square Error MSE is 8.1992×10^{-13} at epoch 11 and correlation coefficient value R equals 0.998 . It is found that the network investigated was able to give 99% accuracy.

6. Conclusions

The features - in this study - were found to have diagnostic capabilities. The selected features were able to give accurate diagnosis and to indicate aggressive tumor at cells level. The features were able to give high accuracy collectively (99%), although the features were independently insignificant. In other words it was noticed when the features were applied individually; they did not give high classification as expected. When all features are combined with each other, the malignant and benign cases could be classified and identified accurately.

References

Ben Krose & Patrick van der Smagt, (1996), “An introduction to Neural Networks”, The University of Amsterdam, eighth edition.

Blackledge J. M. & Dubovitskiy D. A. (2008), “Object Detection and Classication with Applications to Skin Cancer Screening”, *International Transactions on Intelligent Systems* 1(1), 34-45.

Blackledge J. M. & Dubovitskiy D. A. (2009), “Texture classification using fractal geometry for the diagnosis of skin cancers”, *EG UK Theory and Practice of Computer Graphics*, 1 – 8.

Deepika Koundal1, Savita Gupta & Sukhwinder Singh, (2012), “Computer-Aided Diagnosis of Thyroid Nodule: A Review”, *International Journal of Computer Science & Engineering Survey (IJCSES),* 3(4), 521-516.

Eystratios G. Keramidas & Dimitris K. Iakovidis, (2008), “Thyroid Texture Representation via Noise Resistant Image Features ” ,*IEEE International Symposium on computer – based Medical Systems*, 560-565.

Howard Demuth & Mark Beale, (2002), “Neural Network Toolbox For Use with MATLAB”, The MathWorks,

Inc.
Jean Philippe Thiran & Benot Macq, (1996), "Morphological feature extraction for the classification of digital images of cancerous tissues", *IEEE transactions on biomedical engeneering*, 43(10),.1011-1020.
Katz A. R. (2000), “Image analysis and supervised learning in the automated differentiation of white blood cells from microscopic images by a minor”, M.Sc. thesis, Department of Computer Science, University of RMIT, Australia.
Maroulis D.E, Savelonas M.A, Karkanis S.A, Iakovidis D.K. & Dimitropoulos N., (2005), “Computer- aided thyroid nodule detection in ultrasound images’’, 18th IEEE Symposium on computer based medical system, 271-276.
Nikita Singh & Alka Jindal, (2012), “A Survey of Different types of Characterization Technique in Ultra sonograms of the Thyroid Nodules”, *international journal for computer science and informatics,* 1, 112-115.
Shirley Dowdy & Stanley Weardon, (2004), “Statistics for Research” , third edition, John Wiley & Sons Inc.
Salim J. Attia, “Diagnosis of Breast Cancer Images Using Fuzzy Logic Technique”, (2012), Ph.D. Thesis Submitted to the council of the College of Science, Al-Mustansiriyah University, Iraq.
Nick Street W., William H. Wolberg & O. L. Mangasarian, (1993), "Nuclear feature extraction for breast cancer tumor diagnosis", *science and technology*, 1905, 861-870.
Zubair W. Baloch & Virginia A. Livolsi, “Diagnostic Terminology and Morphologic Criteria for Cytologic Diagnosis of Thyroid Lesions”, *Diagnostic Cytopathology*, 36(6), 425-437.

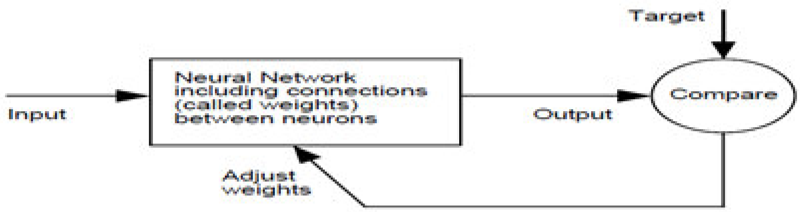
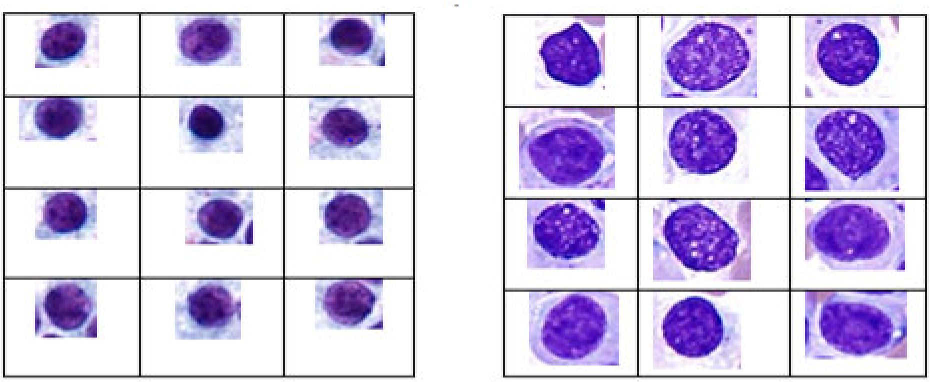


Figure 1, General structure of neural network (Howard and Mark 2002)

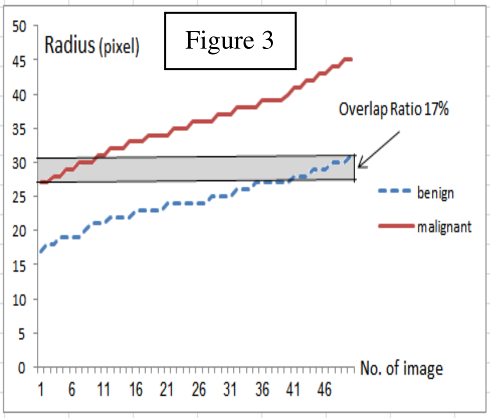


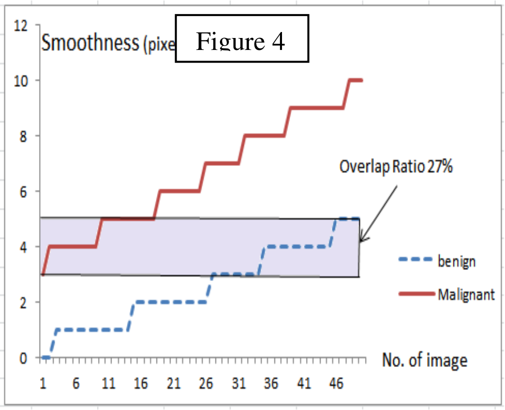
I II

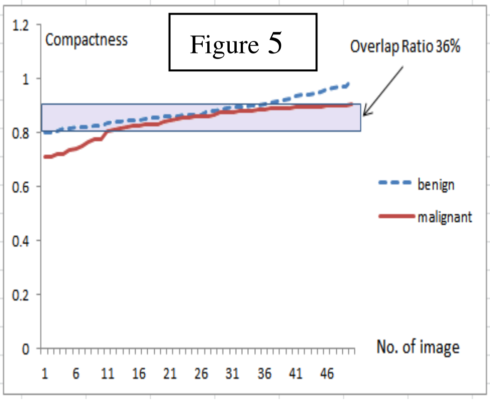
Figure 2, I- Benign and II-Malignant cells images

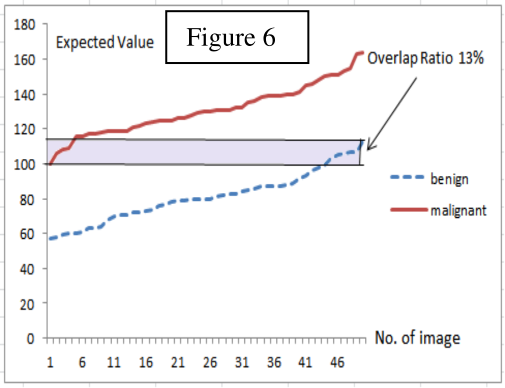
Algorithm 1, The algorithm of neural network

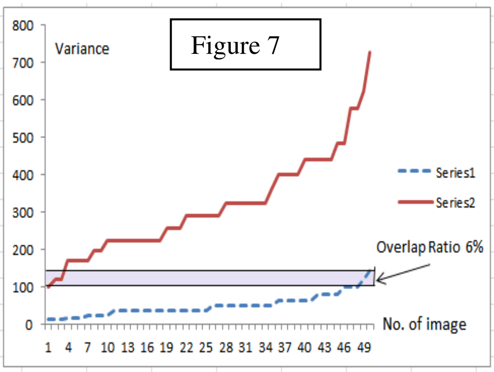
Step one
  Make input values
  Make target value (classes here)
Step two
  Design the network (nodes and layers)
Step two
  Subdivide the input data to 3 ratios training, validating and test
Step three
  Training the network
Step four
  getting output results for samples values and comparing
  with target classes to get accuracy of classification











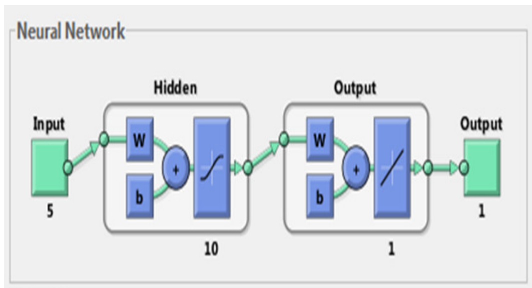


Figure 8, Structure of network