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Detection of parathyroid abnormalities by analysis of optical microscopic images

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Abstract

The study considers the detection of benign and malignant cases of parathyroid tumors by some image analysis techniques. The using of image analysis is a promising approach for distinguishing abnormalities of tumors, but it is rare with parathyroid ones; so it is chosen here with some Euclidian geometric features as a contribution in this field. The Fine Needle Aspiration (FNA) of parathyroid tumors is reliably used to reflect the importance of cytology for the preoperative detection of parathyroid abnormalities and their lesions. Two hundred cells images were taken from normal and abnormal specimens, extracting geometric features like Perimeter, Area, Infill Coefficient, Circularity, Elongation and using Minimum Distance as decision making to distinguish of these images. The combination of geometrical features and the proposed detection algorithm –Minimum Distance - gave good results with an accuracy of 95%.

Keywords: image analysis, minimum distance, geometrical features, benign, malignant

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INTRODUCTION

"(The parathyroid glands are four tiny glands, located in the neck, that control the body's calcium levels. Each gland is about the size of a grain of rice (weighs approximately 30 milligrams and is 3-4 millimeters in diameter)" Henry et al. (1980). The parathyroid secrets Parathyroid Hormone (PTH) that regulates the calcium metabolism in the body, so the parathyroid glands play a significant role in calcium homeostasis Young et al. (2006). Parathyroid tumors include a little ratio of non-palpable neck tumors Kunstman et al. (2013).

The malignancy of the parathyroid is as dangerous as other cancers and the benign tumor of it or what is called adenoma is a rare disease, but it strongly presents prolonged fatigue, bone pain, osteoporosis, multiple fractures without significant trauma and does not associate with age Prihantono et al. (2019). A delay in the diagnosis of parathyroid abnormality results in manifestations that can be avoided by the prognosis of it followed by surgical treatment. It is noticed that there is an increase in the use of image analysis in combination with fine needle aspiration (FNA) for the diagnosis of all kinds of tumors Blackledge et al. (2008); Jelen et al. (2008); Rawal et al. (2020), but, there is a rarity in using this to diagnose the abnormality of parathyroid gland Abati et al. (1995). Some studies had evaluated the usual clinical findings or cytology parameters included "degree of mitosis, amount of cytoplasm, and appearance of nuclear chromatin" and so on Mincione et al. (1986); Halbauer et al. (1991); Yang et al (2001); Calò et al (2013); Agarwal and Kaushal (2016). Some studies have reported US-guided Fine Needle Aspiration because the parathyroid tumors are located in unclear sites and the tumors represent a small part of non-palpable masses of the neck Halbauer et al. (1991); Tsenget al (2002); Dimashkieh and Krishnamurthy (2006). If the parathyroid glands are significantly enlarged, the sonography will be enough to locate them precisely. All these studies have appeared regarding the cytology features and reflected the importance of these features for the determining of parathyroid diseases.

METHODS AND MATERIALS

10 Benign and 10 malignant samples of cervical tissue were taken by Fine Needle Aspiration (FNA) method in which, the samples were prepared on slides and stained by Pap stain. These slides were imaged by digital microscopic camera toped on the optical microscope at 400x magnification to get Benign and Malignant images. The images of cells were segmented to get 200 images as 100 benign images and 100

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malignant images. Five features were extracted: Perimeter, Area, Infill Coefficient, Circularity and Elongation. The Minimum Distance method is used as a classification approach of these images. MATLAB software R2018b is used in calculations of this research.

Segmentation

Segmentation process is a leading step before any detection, diagnosis or differentiation of the medical images or their structure. Image segmentation is the way of separating a whole image into interest parts or objects. The best choice is to get only two regions of whole image: the object of interest and the background one. The basis of this method is formed by knowing the maximum-minimum values of the object of interest and the maximum-minimum values of the background and then the segmentation of objects occurs by ignoring the background values Gonzalez and Woods (2007).

Geometrical features

1. Object Perimeter. The easiest count of perimeter is gotten by summing the number of boundary pixels that surround the object. Perimeter can be obtained by counting every point of the object that has a 1 value with at least one neighboring pixel of 0 value. So the object perimeter can be defined Jelen etal. (2008):

$$P = \sum_{x \in edge} 1(x) \qquad (1)$$

2 Object Area. If the function I_k (i, j) represents a segmented object in the image which has been marked by k during the segmentation process. I_K could be calculated by Qianget al. (2008):

$$I_{k\,(i,j)=} \begin{cases} 1 \; if \; I(i,j) = s^{th} \; object \; number \\ 0 \; otherwise \end{cases} \qquad (2)$$

The area of the s^th object contained N x M pixels and given by:

$$A_s = \sum_{i=1}^{N} \sum_{j=1}^{M} I_s\,(i,j) \qquad (3)$$

This gives the sum of all pixels in a segmented object, or

$$A_s = \sum_{x \in object} 1(x) \qquad (4)$$

1. **Infill Coefficient**: The ratio of cell or object area divided by the surrounded polygon area gives Infill Coefficient.

$$Infill\ Coefficient = A/A_p \qquad (5)$$

2. **Circularity:** Circularity of an object is typically used to define the regularity of an object. There are many applications in which you want to say just how compact or circular an object is. The one common measure by computing the area A and perimeter P of the cell; the range of it (0,1). The Circularity can be defined as Qianget al. (2008):

$$T = 4\pi(A/P^2) \qquad (6)$$

Elongation

Elongation of any shape is one of the shapes characterizing that reflects a very obvious meaning. This is why it can be applied in shape classification assignments:

$$Elongation = L/l \qquad (7)$$

L= longest line along the object

The l = longest line which is perpendicular to L.

A circle takes 1 value and the longer it goes; the higher Elongation it is.

Minimum Distance

Minimum Distance (MD) is used to show the similarity degree of data sets and decides if a set or a vector of features belonged to a certain class or to other. If a class is described by multidimensional space K. Minimum Distance is applied by equations bellows Umbaugh (1998):

$$d(x_g, m_{ig}) = \sqrt{(x_l - m_{il})^2 + \ldots\ldots\ldots\ldots + (x_K - m_{iK})^2} \qquad (8)$$

Or in another form:

$$d(x_g, m_{ig}) = |x_l - m_{il}| + \ldots\ldots\ldots\ldots + |x_K - m_{iK}| \qquad (9)$$

X_h is a point in space K, m_{ig} m_{jg} are two vectors of class i and j respectfully in dimension K.

To verify the Minimum Distance and decide that a vector belongs to i class, the condition for all $j \neq i$ is:

$$d(x_g, m_{ig}) < d(x_g, m_{jg}) \qquad (10)$$

DISCUSSIONS

Five features in Benign and Malignant cases are applied. It is clear that the values of Perimeter and Area are bigger in Malignant than those in Benign and this reflects the bigger size in Malignant comparing with Benign. Infill Coefficient and Circularity features are smaller in Malignant than in Benign, whereas Elongation values are bigger in Malignant than those in Benign; although this difference reflects the irregular nature of Malignant images comparing with Benign images. The overlapped ratio of the values between Benign and Malignant images is 11.6% for perimeter, 8.1% of Area, 14.2% for Infill Coefficient, 12.6% for Circularity and 10.3% for Elongation.

The average values of five features, and Minimum Distance approach required these average values of each feature of Benign and Malignant cases to determine to which class the value is belonged to it. So the Minimum Distance here has 5 weights based on the five features to detect the malignancy of images. One hundred vectors of 5 features as Benign data and another one hundred as Malignant data.

According to average values of features, the minimum distance calculated and the classification occurred. In test process, the percentage of correct testing of benign images or specificity is 95.9% and the percentage of correct testing of malignant images or sensitivity is 94.1%. The accuracy or the percentage of overall correct testing of both benign and malignant is 95%.

CONCLUSION

1. It is noticed that each feature has interference between benign and malignant cases, but the total

features altogether give a better basis to separate them.

2. These geometrical features and Minimum Distance (MS) give good differentiation between benign and malignant cases of parathyroid specimen with high accuracy reached to 95%.

3. Although the sensitivity is more important than specificity in the diagnosis process because the much importance of determining the existence of disease, but there is a little difference between their values.

4. By taking into account the limitations of the research in the diversity and abundance of samples and the quality of imaging, the results are promising, and the study can be improved for prognosis of disease by determining unseen and unusual features and applying different making decision approaches.

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