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Applications of Artificial Intelligence Techniques in Polycystic ovarian syndrome Diagnosis

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Abstract— **Artificial intelligence (AI) is defined as a field of science and engineering concerned with the intelligent behavior. It is the subfield of computer science as it has enhanced the human life in many areas. AI has recently bested human performance in several domains, and there is a great hope in healthcare. The healthcare system handles very huge amount of data which is very hard to analyze through traditional methods. The success of AI in healthcare promises better prevention, detection, diagnosis, and treatment of diseases. Polycystic ovarian syndrome (PCOS) is a hormonal disorder for women menstrual cycle at the stage of reproductive age. Women with PCOS find their menstrual cycle comes every 21 days or more often. Sometimes have fewer periods (fewer than eight in a year) or women with PCOS stop having menstrual period. This can leads to infertility and development of cysts in the ovaries. Symptoms of PCOS include Irregular menstrual cycle, weight gain, darkening of skin, Thinning hair on the scalp, Diabetes and High blood pressure. Early diagnosis and treatment are recommended. AI is capable of "learning" features from very large amount through clinical practice to diagnosis this diseases. AI has the capability to increase its accuracy by self-correct aspects. In this paper, applications of AI in the detection of PCOS, segmentation and classification are presented.**

Keywords— Artificial intelligence, polycystic ovarian syndrome (PCOS), detection of PCOS, segmentation and classification.

I. INTRODUCTION

The most common gynecological endocrine disorder that proffers the consequence in health issues of women is PCOS (polycystic ovarian syndrome). Usually it occurs in reproductive aging women. [1] PCOS featurized by Irregular menstrual cycle, weight gain, darkening of skin, hypertension, Diabetes, metabolic abnormalities/dysfunction and also infertility. In humans, infertility is an unsuccessful ovulation to get pregnant. Many women are diagnosed of having PCOS when they reach age 20-30. PCOS leads to abnormal growth of follicle in the ovaries. Inside the ovaries, many small fluid-filled sac that contains small cysts and the clusters of pearl-sized follicles, each one containing an immature eggs. The cysts lead to hormone lopsided characteristics. Doctors typically study the medical history and recommended to perform pelvic tests, Blood tests, ultra sound waves to look the appearance of ovaries and the thickness of the lining of your uterus. [2]. In the modern days, transvaginal ultrasound is an internal examination to look at a woman's uterus, ovaries, tubes, cervix and pelvic for the recognition of PCOS.

For decision making aspects of PCOS phenotype (i.e., to discover the primary cause of PCOS with some attributes (tests)). In the October 2012, National Institute of Health criteria noticed that Rotterdam criteria to detect PCOS, and Endocrine Society Guideline also supporting these criteria. [3]. The criteria is to find out the PCOS in at least one of the ovary have volume equal or more than 10cm3, diameter with 2-9 mm, still doctors need to analyze, store and manipulate the ultrasound image for predicting the PCOS. [3]. Perfect finding of the PCOS is important for the treatment. Anyhow, manual classification of follicles' identification may affect women's health seriously because of inter and intra-observer inconsistency. Due to the improvement of modern technologies like Artificial Intelligence try to classify the ultrasound images to determine PCOS class or nonPCOS class.

Artificial Intelligence is a combination of Reasoning, learning, problem-solving perception, language understanding, etc. A general introduction to the subject of Artificial Intelligence, creates a new revolution in the world and creates a great scope in future to describe machines that mimic humans nature in association with "cognitive" functions of human mind, such as "learning" and "problem solving".[4] Many applications on Artificial Intelligence is now all around us. With the belief of AI, real world problems can solve very easily and provides high accuracy. [5] Now, Healthcare Industries are applying AI to make a better and faster diagnosis than humans.

Many researchers used Artificial Intelligence to classify ultrasound images automatically. AI is capable of "learning" features from very large amount of data through clinical practice to diagnosis the diseases. AI has the capability to remove unwanted data and to detect the disease with high accuracy and precision. In this paper, applications of AI in the detection of PCOS such as segmentation of ultra sound images and classification are presented. By diagnosis the PCOS, AI has been proved as a best technology in the automated disease diagnosis of PCOS.

II. POLYCYSTIC OVARIAN SYNDROME

PCOS, Polycystic ovarian syndrome is a predominant type and affects the women a lot in reproductive age. Nearly 1 in 10 and 1 in 20 women are affected with this abnormality. [6] Most women with PCOS lead to growth of multiple cysts in ovaries that are filled with fluid. Hormone imbalances are taken place. The symptoms and signs of PCOS are weight gain, irregular menstrual cycle, oily skin, hypertension, Diabetes and metabolic abnormalities. Based on these symptoms to determine PCOS are still changing.

In the Ovaries, the fluid-filled forms of the immature eggs are contained by the cystic. These cystic are small and the clusters of pearl-sized are formed. The PCOS are contributed to the large number of male hormones productions by the Androgen, [7] these follicles have termed as cysts. They are arranged peripherally inside the ovary of a PCOS patient.

To diagnosis the PCOS, A pelvic exam, blood tests, and ultrasound scans are conducted to find out the abnormality in ovaries.

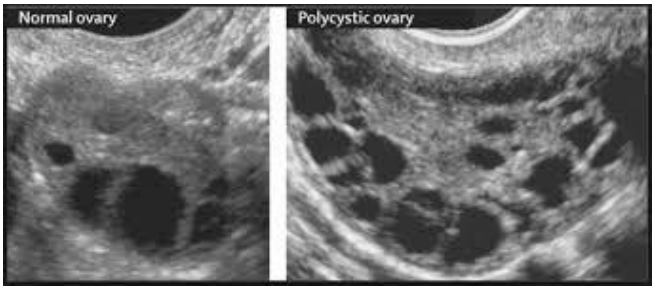

***Fig 1**. Polycystic Ovarian Syndrome [8]*

The ultrasound images in fig1 shows the differences between the normal follicles and polycystic follicles in the ovary. Because of the ultrasound images are useful to detect the PCOS.

Ovarian ultrasound imaging plays a vital role to suspect PCOS in the women. Ultrasound scan can perform in between the cycle days 2 and 7 with a Transvaginal transducer of 7MHz. To examine the scan, the image should be grayscale colored data with JPG format indicates right and left ovaries. The report of the images should be specific and includes ovaries volumes and follicles count. Based on the amount of follicles count, position, size, and also response to the hormonal stimulation are categorized as PCOS class or non PCOS class. The ultrasound images will save the physician time to detect the follicles in PCOS. [1]

To enhance the quality and clarity of images by applying the Histogram equalization is needed to perform image brightness to detect the PCOS. [3] The current ultrasonographic images are considered by several authors, including ourselves for the recognition forms of PCOS. [9] In sometimes, a thresholding function is utilized to denoisfy the image in the wavelet form before the segmentation procedure. The clustering algorithm potency is depends upon the value of Mean Square Error (MSE) and Peak Signal for Noise Ratio (PSNR). [10]

III. IMAGE SEGMENTATION OF ULTRA SOUND IMAGES TO DETECT PCOS USING AI

Ultrasound images are important to detect the follicles in the PCOS. Manual detection of follicles is more time consuming and may cause several problems like inter and intra-observer inconsistency which affect women's health [1]. Hence, computerized techniques are necessary to enhance the detection of follicles from the loaded images of ovary. Many researchers pre-processed and segmented the ultrasound images of ovary to identify the severity of the PCOS. Some of the studies related to the image pre-processing and segmentation of ultrasound images of ovary using AI techniques to detect PCOS are presented in this section.

Palvi Soni et. al [3], proposed a method in which they provided a grayscale colored ultrasound image as input. The input image is enhanced using Histogram equalization for better quality and brightness level. Two different types of threshold methods such as Global Basic Threshold and Otsu Threshold are applied to separate the

background class and object class. To separate the background image and foreground image, Binarization of image is performed. Region based and watershed algorithms are applied to separate the foreground and background of image. Finally Convolution Neural Network (CNN) is used to classify the image in to PCOS and nonPCOS class. The preprocessed images of this study are presented in figure 2.

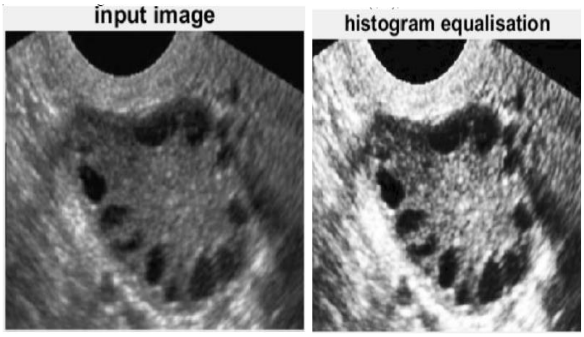

Fig 2*. Input image and histogram equalization [3]*

Potocnik et al. [11], proposed a method on Cellular Neural Network (CNN). This method consists of four successive steps. In the first step of CNN, rough position of the follicle is determined. In the second CNN, follicles are expanded to the border position. In the third CNN, it determines the position of the recessive follicles. Finally, in the last step of CNN, a real and phantoms follicles are merged to distinguish the affected follicles.

Kiruthika and Ramya et al. [12], proposed a method for the automated follicle detection in the ovary. To measure the visual difference, the ultra sound image was transformed into L*a*b* colour space. The images are converted into discrete wavelet transform. K-means algorithm was used to segment the ultrasound images. Further, Gaussian edge operator was used to detect the potential follicles edges. The texture parameters were suggested to minimize the classification error. The resultant images in this study are presented in figure 3 for better analysis of the work.

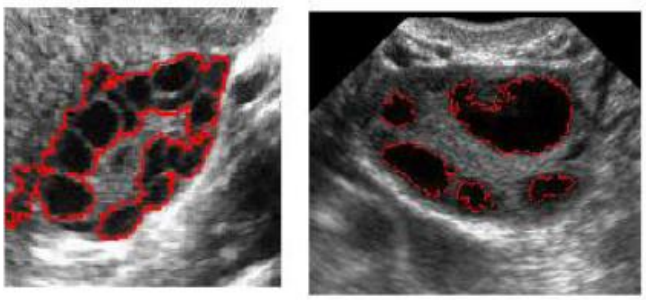

Fig 3*. Follicle Detection images*

IV. CLASSIFICATION OF PCOS DATA

Classification of data related to PCOS is necessary to identify the PCOS affected cases and not affected cases accurately. In the literature, many AI based classifiers are used for the classification of follicles and Polycystic Ovarian Syndrome (PCOS) diagnoses. Some of the studies are related to that are presented in this section.

Palak Mehrotra et al. [13], proposed an algorithm to formulate the vector features based on the normal and PCOS groups. Selected vector features are classified using Bayesian and Logistic Regression (LR) classifiers. An automated system was examined to reduce the delay in diagnosing the risk of PCOS. In this study, the

performance of Bayesian classifier is better than the logistic regression. The accuracy of Bayesian classifier is 93.93% as compared with logistic regression i.e. 91.04%.

Lawrence et al., [14] proposed a method to distinguish the normal ovary and polycystic ovary. By using region growing algorithm, the images are extracted form segmented region by the following five stereological features: Surface Density (SD), Volume Density (VD), number of follicle regions per image (Profile), Mean follicle Diameter (meanD), and Maximum follicle Diameter (maxD). Then the extracted features are constructed a vector feature for classifying the follicles present in the ultrasound image. In this study, the extracted features are classified with Linear discriminant, K Nearest Neighbour (KNN) and Support Vector Machine (SVM). Their accuracies were 92.86%, 91.43% and 91.43%, respectively.

The authors in the paper [15], composed an application to classify Polycystic Ovary Syndrome. The first stage of classification is preprocessing to extracts the paired follicle images on low pass filter, balance histogram, Binarization, and morphological processes. The stage is highlight with edge detection, marking, and cropping the follicle images by utilizing Gabor wavelet. The extracted follicle images are gathered into two groups (1) Mean, (2) Mean, Entropy, Kurtosis, Skewness, and Variance. The outcome of two process are (1) Dataset A has 40 images that consist of 26 ordinary images, and 14 PCOS images. They are counted by Mean surface element and got 275 follicle images. (2) Dataset B has 40 images consist of 34 normal images and 6 PCOS images, which counted by Mean, Entropy, Kurtosis, Skewness, and Variance surface highlights at that point acquired 339 follicle images. Classification is the last stage to recognize the PCO and non-PCO follicles. In Classification, three scenarios based on Neural Network-Learning Vector Quantization (LVQ) strategy, KNN - Euclidean distance, and Support Vector Machine (SVM) RBF Kernel are considered. The best accuracy picked up from SVM - RBF Kernel on C=40. It demonstrates that dataset A reaches 82.55% while dataset B that got from KNN-Euclidean distance classification on K=5 reach 78.81%.

V. CONCLUSIONS

Artificial Intelligence (AI) has been proved as a best technology to detect the polycystic ovarian syndrome (PCOS) using segmentation and classification of ultra sound images of ovary. PCOS is a hormonal disorder in women menstrual cycle which leads to infertility and development of cysts in the ovaries. To overcome PCOS, Early diagnosis and treatment are recommended. AI is capable to diagnosis PCOS by learning features in self-correct aspects.

Various research studies are conducted to detect and diagnose the PCOS using AI techniques such as Neural Networks (NN), Convolution Neural Networks (CNN), Support Vector Machines (SVM), Bayesian Classifier, Logistic Regression (LR), k-Nearest Neighbour (kNN) and etc. In study, how the ultrasound images of ovaries pre-processed and segmented using various techniques are analysed. In addition, how the various AI techniques classified the feature vector space extracted from the ultrasound images of ovaries are also studied. AI techniques are able to classify the PCOS data with highest accuracy.

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