ORAL

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TITLE: A Model Framework for Cervical Lesions (CL) Screening Using Adaptive Neuro-fuzzy Inference Systems (ANFIS): A Study on Commercial Sex Workers (CSWs) Predict Diagnosis

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INTRODUCTION

The commercial sex workers CSWs are group of women that gives sex in an exchange for monetary gains and use the illicit act as a major source of livelihood. They are increasingly at risk of acquiring infections, which could influence cervical lesions (CL) (Odigie and Achukwu, 2015). CL, however, is all pathological abnormalities seen in cells and/or tissues taken from the cervix (Obaseki and Nwafor, 2015). The current widely used methods [(Pap smear by Ayres spatula and the liquid based cytology (LBC)] for screening CL are time-consuming and dependent on the skill of the pathologist/ cytologist (Mohammad *et al.,* 2014). These methods are invasive, which has led to the growing concerns for the formulation of a diagnostic model especially for the screening of CSWs who scarcely present in hospitals for checkup. From the foregoing, the Adaptive Neuro-Fuzzy Inference Systems (ANFIS) could be used for CL screening in CSWs as pre-diagnosis. ANFIS is a hybrid system that comprises of Neural Network (NN) and Fuzzy Logic (FL). ANFIS combines the computational capability of neural network and explanative power of fuzzy logics (Ubeyli, 2009). ANFIS has shown to be an excellent function approximation tool, implementing a first order sugeno-style fuzzy systems in the diagnosis of some health related challenges (Suhail, 2011). The basic idea behind ANFIS is very simple; it provides a method for the fuzzy model to acquire information about a dataset in order to compute the membership function parameters that best allow the associated fuzzy inference systems, to track the given input/ output data respectively (Suhail, 2011). Earlier studies showed that ANFIS has been used for numerous biomedical and

medical conditions like: breast cancers when nine features defining the indications were used as inputs with an accuracy of 98.25% and analysis of liver cancer and brain tumors (Ubeyli, 2009; Bekaddour and Chikh, 2012; Hosseini and Zekri, 2012; Rajamani and Rathika, 2015).

Against this background, there is a gap in literature in the existing methods for CL screening in this part of the world. It may be blocked-up by formulating an ANFIS model that will assist the pathologists in overcoming cumbersome diagnosis and, consequently, produce more accurate results. To the best of our knowledge, this study may be the first ANFIS model for CL diagnosis. Hence, our aims were to formulate a model that is understandable, practicable and able to predict CL correctly and assess the accuracy of the ANFIS model by screening CSWs in Edo State.

METHODOLOGY

The present study was a preliminary report from a mega ongoing research in the design of an ANFIS model for CL. The experimental study was approved by the Edo State Ministry of Health (Protocol number: HA.577/VOL.16/065). The CSWs who participated in the ANFIS screening exercise were adequately briefed on the safety of ANFIS and for participants requiring LBC, the risk involved in the procedure was explained prior to written informed consent, which was voluntarily signed by participants. Matrix Laboratory (MATLAB) version 7.5.0 (R2007b) was used to implement the ANFIS systems. The dataset was collected from the field work conducted on CSWs and further pre-processed to the format required for this study. ANFIS was used to formulate a model system that predicts CL using the most valid signs and symptoms represented by (PA, PB, PC and PC). Where PA represents- symptom 1 (smelly or blood tinged cervical discharge), PB-symptom 2 (pus on cervical swabs), PC- symptom 3 (bleeding after sampling) and PD-symptom 4 (inflammatory cervix). To avoid the presence of large numbers of symptoms as input, the feature selections used a limited task of (4 valid CL symptoms) selecting a small subset of these features that is sufficient to predict the target class. Again, there is the need for feature selections to avoid the presence of a large number of weakly relevant and redundant features in the dataset (Suhail, 2011). A total of 259 CSWs participated within the confines of 76 brothels in Edo State, and was used in testing the accuracy, reliability and efficiency of the ANFIS model.

RESULTS AND DISCUSSION

The ANFIS architecture comprises of six layers and were all put to use (Figure 1A). The layers involve: an input layer 1, membership function layer 2, rule layer 3, normalization layer 4, defuzzification layer 5, and an output layer 6; with their specific functions. The dataset used in

training the ANFIS classifier consists of 259 member cases resulting in 60% (154 cases) of the entire dataset used in training the system and 40% (105 cases) used in testing the system.

In this study, ANFIS model was designed using a bell membership function using a hybrid optimization method with an error tolerance of 0.05. The training dataset was passed through the ANFIS for 20 epochs. At the end of the simulation the system had a training error of 1.1652 at epoch 20 on the training dataset and an average testing error 1.255, which means the system was able to classify approximately 98.75% of the testing dataset accurately. The ANFIS architecture, training dataset, training process fuzzy inference engine, and the system testing are shown in (Figure 1 A to E). The diagnostic outcome of 20 patients is shown in the Graph plot diagram, which represents the diagnostic values against the diagnostics outcome (Figure 2). At the end of the simulation, the surface view diagrams were generated by MatLab, which shows the relationship between any two inputs (symptoms) to output (diagnosis) (Figure 3 A to E).

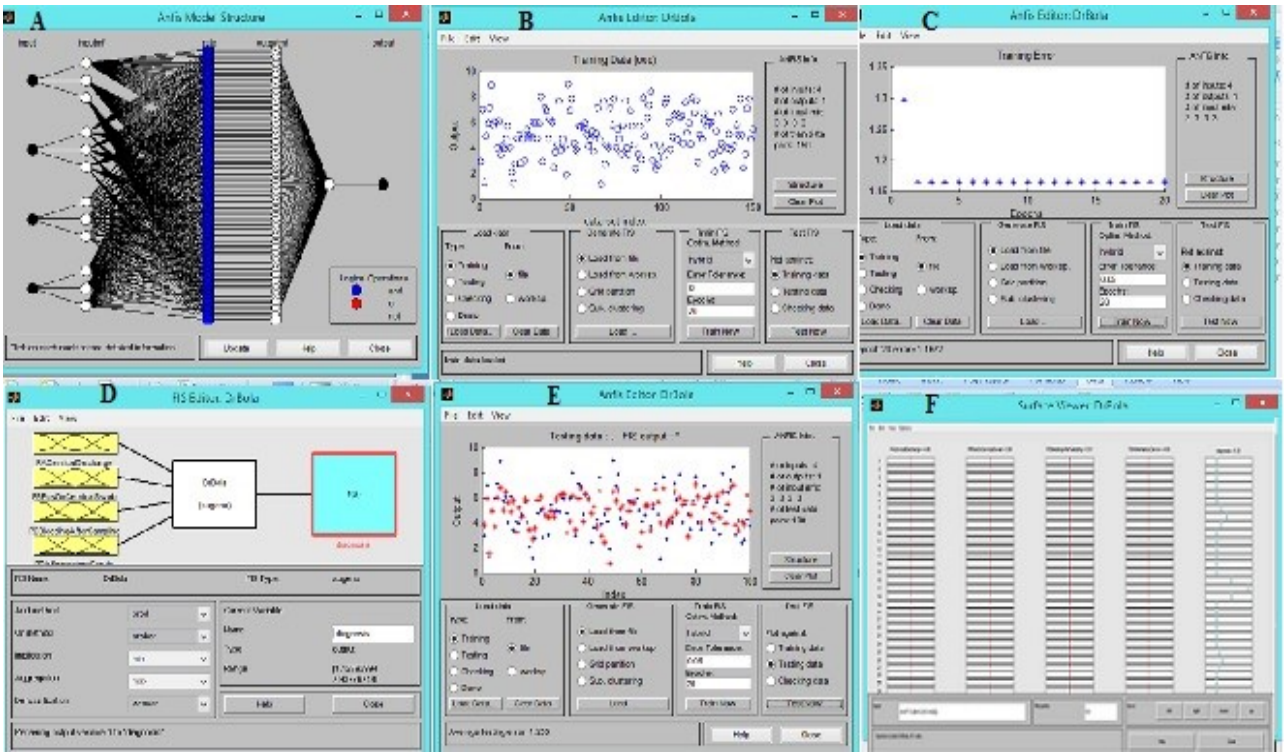

Figure 1: (A) shows ANFIS Architecture. (B) Training Dataset (C) System Training. (D) Fuzzy Inference Engine. (E) System Testing. (F) ANFIS rule viewer.

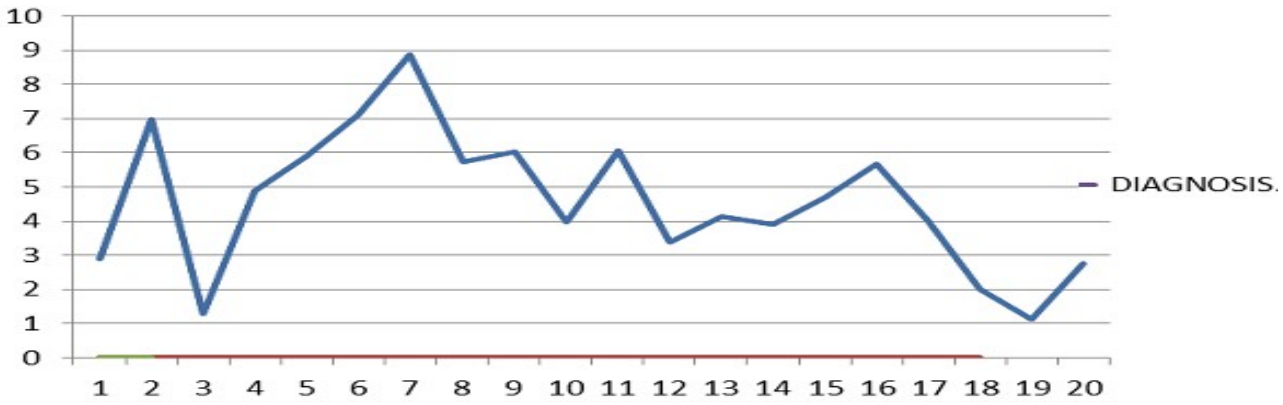

Figure 2: shows the predict diagnosis outcome for 20 Patients

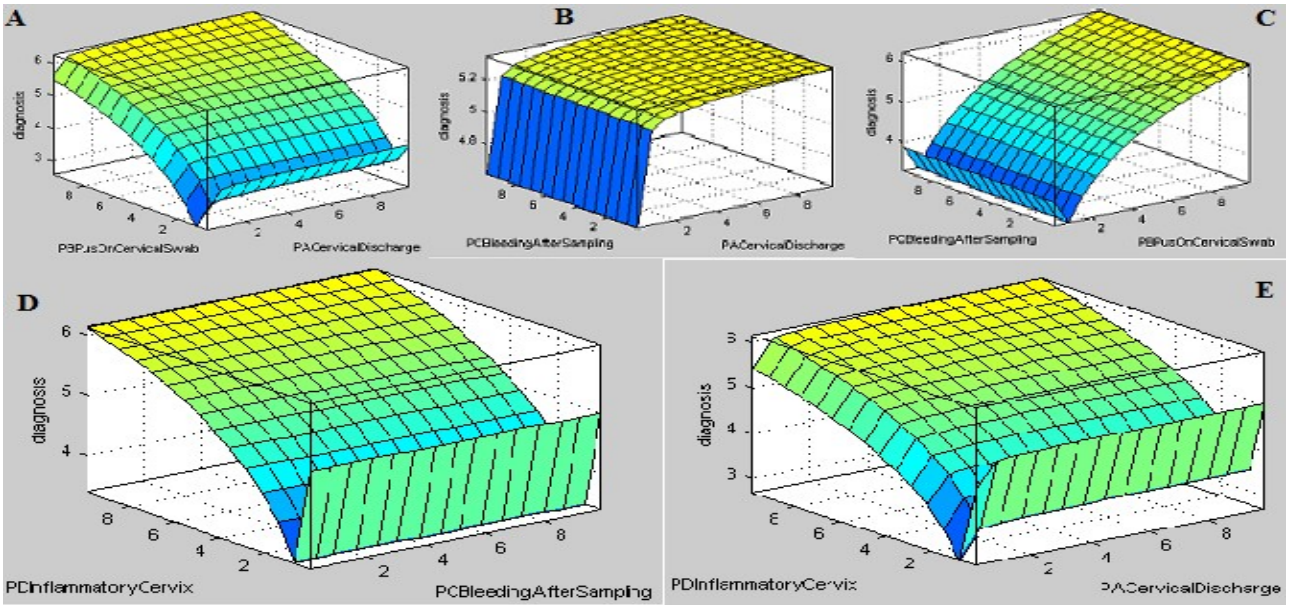

Figure 3: ANFIS surface viewer shows the surface view of the relationship between (A) pus on cervical swab and cervical discharge- PB vs. PA. (B) bleeding after sampling and cervical discharge- PC vs. PA (C) bleeding after sampling and Pus on cervical swab- PC vs. PB (D) bleeding after sampling and inflammatory cervix PD vs. PC (E) cervical discharge and inflammatory cervix- PD vs.PA and the extent, in which CL could be diagnosed in the patient.

A considerable number of researches have been conducted specifically to automate both the Pap smear and the LBC classification based on artificial intelligence (Jusman et al., 2012). In the case of CL, which is similar to the cervical cancer ANFIS classifier, the classification requires CL features to be determined manually by human experts from the Pap smear and pre-clinical data or LBC images as input data (Mustafa et al., 2008). The automated diagnostic systems may not only reduce the time required for cancer screening, but also, it will reduce the misdiagnosis due to eye fatigue or human errors (Mat-Isa et al., 2008). This has been demonstrated in this study, where model for CL pre-diagnosis has been developed. Our claim is in line with the study by Mat-Isa et al. (2008); who earlier formulated an automated cervical pre-cancerous diagnostic system, which is similar in operation to the ANFIS model in this study. The present study corroborates the claim by Mustafa et al., (2008); in which cervical cancer diagnostic system was developed using hierarchical

neural network. This study also agrees with Bekaddour and Chikh, (2012), in which 98.25% precision was achieved. However, the present claim disagrees with Mohammad et al. (2014) on extraction algorithm of cervical cancer recognition with classifier performance of 94.2% accuracy compared to the 98.75% in this study. The disparity may be due in part to the nature of classifiers and ailments engaged upon. Where our study employed ANFIS for CL, the former (Mohammad et al.) used Multiple-ANFIS (MANFIS) for cervical cancers. Type of classifiers as a factor for poor performance by classifying models has been reported (Suhail, 2011). While, nature of ailments is yet unclear. However our model has the limitation of not having a totally non-invasive performance for CL compared to a similar model for cervical cancer screening (Mustafa et al., 2008).

CONCLUSION AND RECOMMENDATION

The present ANFIS framework has an excellent accuracy for predict-diagnosis of CL in CSWs. It may however, assist the pathologist in making fast decisions in women with similar ailments.

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