International Journal for the Application of Wireless and Mobile Computing
(IJFAWMC), Volume 4 (October – December, 2018) ISSN: 2141-0720.

ADAPTIVE NEURO FUZZY INFERENCE SYSTEM (ANFIS) BASED DETECTION OF CERVICAL CANCER

[1]Ronke S. Babatunde, [2] S. Muhammad-Thani
[1]Department of Computer Science, Kwara State University, Malete Nigeria
ronke.babatunde@kwasu.edu.ng
[2]Kwara State College of Education, Ilorin. Nigeria
safinah2012@gmail.com

Abstract

Cancer occurs when cells in an area of the body grows abnormally. Cervical cancer is a cancer that is known to be the second most deadly cancer affecting women worldwide which emerges from the cervix of a woman. The normal cervix has two main types of cells: squamous cells, that protect the outside of the cervix and glandular cells. Cervical cancer is caused by abnormal changes in either of these cell types in the cervix. Pap smear screening is the most successful attempt of medical science and practice for the early detection of cervical cancer. However, the manual analysis of the cervical cells (pap smear) is time consuming, laborious and error prone.

In this research, detection of cervical cancer was done using Adaptive Neuro-Fuzzy Inference System (ANFIS), a hybrid intelligent system which combines the fuzzy logic qualitative approach and adaptive neural network capabilities. The system was modelled to predict the probability of cervical cancer as either high probability or low probability based on the input risk factors of cervical cancer as contained in the dataset used.

The efficiency of the ANFIS in predicting cervical cancer was tested using a dataset collected from Leah Foundation, a non-governmental organization in Nigeria, having a total of 250 patient's data. The dataset contains eight risk factors of cervical cancer, which serves as the input variables. The output is the classified risk factors each patient is prone to. A patient with low level (represented as 1) is classified to be of no or less probability of having cervical cancer, while a patient with high level (represented as 2) is classified to be a victim of high probability of having cervical cancer.

The result of this system shows that the system can be adopted by medical practitioners as well as for individual use.

Keywords**: Neuro fuzzy, Cancer, Cervical, Risk factor.**

1.0 INTRODUCTION

Cervical cancer is a malignancy of the passage of the uterus, which happens normally in ladies beyond 30 years of age (Nordqvist, 2015). This cancer is the second form of cancer after breast cancer influencing ladies worldwide yet it is preventable and treatable if detected early. It begins with pre-malignant changes and grows gradually. Research has shown that up to 90% of cervical growths might be forestalled if cell changes are distinguished and treated early (Sarbortova, 2013)

This cancer is highly connected with human papillomavirus (HPV) infection, and is a preventable human cancer due to its moderate progression, cytological identifiable forerunners, and treatments if recognized early. Early finding of cervical malignancy cells plays an imperative part in the curing process. A common symptoms associated with cervical cancer is severe bleeding from the vagina, yet now and again there might be no seen manifestations until the growth has advanced to a high stage. (Quteishat, Al-batah, Al-mofleh, and Alnabelsi, 2013).

Cervical cancer takes numerous years to grow from normal stage to high or advanced stage. Hence, the mortality identified with this cancer can be altogether lessened through early recognition and appropriate treatment (Al-batah, Ashidi, Isa, Klaib, and Al-betar, 2014).There are wide varieties of screening techniques for cervical cancer. Pap smear test is a notable screening technique yet because of rare number of talented and experienced cytologists the screening strategies becomes tedious and highly inclined to human mistakes that could lead to mistakes in results or loss in results. Nowadays, detection systems in light of artificial intelligence could be a promising system to create a more precise and quicker prediction result for cancer patients. Cervical cancer early detection can decrease the rate at which people die from the disease.

Currently, Pap smear is being used to detect cervical cancer in hospitals and in few health community settings. Considering the number of population and illiteracy situation of this country this technique has certain limitations like unavailability of skilled manpower, lack of equipment and limited acceptability. PAP smear test is a proficient and simple strategy to identify any anomaly in cervical cells. In any case, human observation is not always satisfying and it is a difficult task to physically

analyze countless number of PAP smear images. Since known factors are recognized to be associated with cancer of the cervix; an alternative to universal screening by Pap smear can be the development of an expert system for diagnosing cancer of the cervix for early detection and treatment.
The development of Computer has prompted the improvement of many algorithms and models to guarantee exactness and accuracy and this has significantly diminished the number of patients that die day by day in the clinics and hospitals and one of such model is Adaptive Neuro-Fuzzy Inference System (ANFIS).(Awotunde, Matiluko, & Fatai, 2014)

Adaptive Neuro-Fuzzy Inference System, a kind of artificial intelligence which incorporates both neural systems and fuzzy logic standards and principles. ANFIS uses either back propagation or hybrid algorithm to adjust the membership functions of a Sugeno-type fuzzy inference system (FIS).The hybrid optimization method is a combination of both the back propagation and leas-square gradient descent scale which trains the membership function of the fuzzy system to emulate the training data set. The pros of the fuzzy inference system is that it can bring justice to semantic expressions and the benefit of a neural system is that it can be trained to learn thus can self-learn and self-move forward. A wise man named Jang took both focal points, joining the two techniques, and proposed the Adaptive Neuro-Fuzzy Inference System. The thought behind neural system and fuzzy system is to outline system that uses a fuzzy to represent information in an interpretable way and has the learning capacity got from a neural system that can tune the values of the fuzzy system called membership function in order to make the system perform better Hamdan, 2013)

The risk factors of cervical cancer (factors that places a lady at a high risk of having cervical cancer according to Nordqvist (2015) include: Illiteracy, Poverty, Weak immune system, early age of having sex, different sexual accomplices or an accomplice who has numerous accomplices, viral contaminations, for example, genital warts and herpes, Smoking cigarettes, Using Oral contraceptives often, being overweight, having a family history of cervical cancer.

Furthermore, ladies with early cervical cancer when in doubt have no signs. The signs frequently don't show up until the cancer gets to be obtrusive and develops into close-by tissue. Some of the signs according to Al-batah et. al., (2014) are:

I. An abnormal secretion from the vagina − the secretion happens between their periods or after menopause and it also contains blood.
II. Irregular vaginal bleeding, for example, bleeding after having sexual intercourse, draining and spotting amongst periods, and having (menstrual) periods that are longer or heavier than common or even bleeding subsequent to douching or after a pelvic examination.
III. Pain in the vagina when having sex

These signs and symptoms can in like manner be realized by conditions other than cervical cancer. For instance, a contamination can bring about bleeding

2.0 RELATED WORKS

There exist a vast number of researchers contributing to this field of research. Mutgi, Murthy, and V, (2015) developed an automated system created for analysis of cervical cancer utilizing image processing procedures and neural systems. MATLAB an image processing tool was utilized to extract features from cytology images that are utilized for separating different phases of cervical cancer. The features extracted were used to train the neural network. The system was able to classify the images as non-cancerous, low- grade and high-grade cancer cells.

Odeh (2011) developed a system for detection of skin cancer. The work used a Hybrid gradient descent optimization method to train the ANFIS algorithm. The detection system comprised of three different types of skin lesions. The performance evaluation of the ANFIS model was based on accuracy of the classification and the performance of the training. The outcomes affirmed that the proposed ANFIS model has potential in classifying the skin cancer.

Considering the work of (Hernández, Lasserre, Gómez, Guzmán, and Sánchez, 2013). An expert system was developed with image interpretation and fuzzy. In the work, the data obtained from the specialists for decision was modeled by the expert system in the first stage. In a second stage, the system plays out an examination by fragmenting the prepared images to demonstrate the interest parameters in the image. The system gave good recommendation and conclusion.

According to the work of (Mahanta, Nath,&Nath, 2012), a methodology for analysis of PAP smear images of cervical region taking into account cell cores circulation and shape and size examination was proposed. The work automated the screening procedure and provided particular factual information which will be useful for distinguishing variations from the norm in cervical area. The MATLAB Image Processing Toolbox was utilized to section the advanced images and compute different

factual information. By looking at cell cores conveyance and checking the shape and size elements MATLAB can be customized to recognize ordinary cervical cell to sketchy ones.

Quteishat, (2013) developed a Neural Network (NN) based system for grouping cervical cells as ordinary, poor quality squamous, intra-epithelial sore and high-review squamous. The system comprises of three stages. In the first stage, cervical cells are sectioned utilizing the Adaptive Fuzzy Moving K-implies (AFMKM) grouping calculation. In the second stage, the component extraction procedure is performed. In the third stage, the separated information is grouped utilizing Fuzzy Min-Max (FMM) NN. The observational results demonstrate that the proposed strategy can accomplish adequate results.

According to the work of (Al-daoud, 2016) a model to analyze the malignancy infections by utilizing fuzzy rules with moderately little number of linguistic labels was developed . The model was actualized and contrasted with ANFIS. Both models were evaluated on "Wisconsin Breast Cancer" data set. The outcomes demonstrate that the latter model was more precise than the former.

3.0 METHODOLOGY

The set of data collected is within one health center which is Leah Foundation, Kwara State, a non-governmental organization. A total of 250 patient's data was collected. The data contains eight input risk factors of cervical cancer that will be used to develop the cervical cancer detection system to predict the possibility of a patient having cervical cancer using the given factors. The whole data was divided into 75% that is 188 data samples for training and 25% that is a total of 62 data samples for testing. The testing data set was used to evaluate how efficient the ANFIS can be in predicting cervical cancer.

The risk factor for the cervical cancer dataset was grouped by the experts into 8 attributes and two classes namely; Output and Status.

The cervical cancer status conclusion was grouped into High and Low

The Eight Attributes of the datasets are as follows and shown in Table 1; Risk of HPV, Multiple sex partner, Young age at first sexual act, Husband's extra marital affair, Low socio economic status, Oral contraceptive pill, Parity and Genetic factor.

Table 1: Sample Dataset

RISK OF HPV 1	MULTIPLE SEX PARTNER 1	Young age at first sexual act 1	Husbands extra marital affair 1	Low socio economic status 1	Oral contraceptive pill 1	Parity 2	GENETIC FACTOR 2	OUTPUT	GRADES
1	1	1	1	1	1	1	1	9	2
0	1	1	1	1	1	1	1	9	2
1	0	1	1	1	1	1	1	9	2
1	1	0	1	1	1	1	1	9	2
1	1	1	0	1	1	1	1	9	2
1	1	1	1	0	1	1	1	9	2
1	1	1	1	1	1	0	1	7	2
1	1	1	1	1	0	1	1	9	2
1	1	1	1	1	1	1	0	7	2
0	0	1	1	1	1	1	1	8	2
1	1	0	0	1	1	1	1	8	2
1	1	1	1	0	1	0	1	7	2
1	1	1	1	1	0	1	0	7	2
0	0	0	1	1	0	1	0	4	1
1	1	1	0	0	1	0	1	6	2
1	1	1	1	1	0	1	0	7	2
0	0	0	0	1	1	1	1	6	2
0	0	0	0	0	1	1	1	5	2
0	0	0	0	0	0	1	1	4	1
0	0	0	0	0	0	0	1	2	1
0	0	0	0	0	0	0	0	0	1
0	1	0	0	0	0	0	0	1	1
0	0	1	0	0	0	0	0	1	1
0	0	0	1	0	0	0	0	1	1
0	0	0	0	1	0	0	0	1	1
0	0	0	0	0	1	0	0	1	1
0	0	0	0	0	0	1	0	2	1
0	0	0	0	0	0	0	1	2	1
0	0	0	0	0	0	1	1	4	1
0	0	0	1	1	1	0	0	3	1
1	1	1	1	0	0	0	0	4	1
0	1	1	1	1	0	0	0	4	1
1	1	1	1	1	1	1	1	10	2

Input variable

The input variables are those risk factors which put a lady at a higher risk of having cervical cancer. The inputs as earlier stated are: Risk of human papilloma virus (HPV), multiple sex partner, young age at first sexual act, husbands extra marital affair (if married), low socio economic status, Parity (minimum of four pregnancies), Oral contraceptive pill, Genetic history. This and their values are shown in Table 2.

Table 2: Input Variable Transformation

S/NO	INPUT VARIABLE	VALUES	
1	Risk of HPV	Yes = 1	No = 0
2	Multiple sex partner	Yes = 1	No = 0
3	Young age at first sexual act	Yes = 1	No = 0
4	Husbands extra marital affair (if married)	Yes = 1	No = 0
5	Low socio economic status	Yes = 1	No = 0
6	Parity(minimum of four pregnancies)	Yes=1	No=0
7	Oral contraceptive pills	yes = 1	No=0
8	Genetic Factor	Yes = 1	No= 0

Output data (target)

The output data are classified based on the risk factors each patient is prone to. A patient with low level (represented as 1) is classified to be a victim of no or less probability of having cervical cancer, a patient with high level (represented as 2) is classified to be a victim of high probability of having cervical cancer.

Training the ANFIS Model

The above symptoms were used to train the ANFIS model. The training involves adjusting the weight between the input layer and output layer. After the training, the results are fed into a fuzzy logic knowledge base. Figure 3.2 shows the model of an Adaptive Neuro-Fuzzy system, indicating how the input, in this case, the cervical cancer symptoms must be feed into the neural network so that it can be trained to yield a particular output and thereafter fed into the knowledge base which acts as the database. The risk factors of cervical cancer Inference System includes; Risk of human papilloma virus (HPV),Multiple sex partner, Young age at first sexual act, Husbands extra marital affair (if married), Low socio economic status, Parity(minimum of four pregnancies), Oral contraceptive pill and Genetic history. A hybrid learning process which brings together least square gradient descent optimization methods and back propagation is used by ANFIS to adjust the parameters of a sugeno-type fuzzy inference system, so as to emulate the model. The model can be tested using a testing data set to see the performance of the model. Figure 1 shows the structure of the ANFIS:

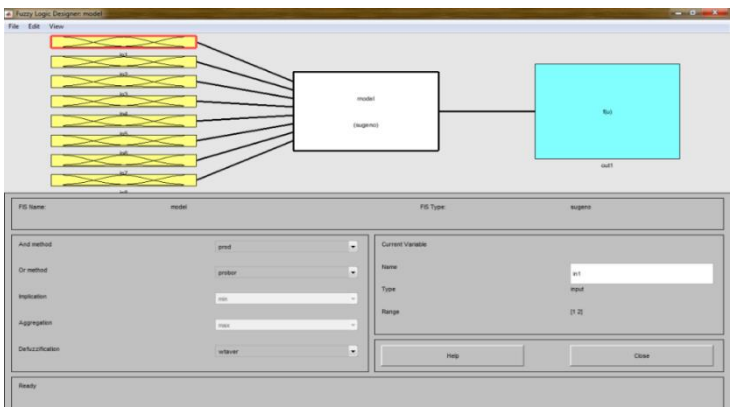

Figure 1: ANFIS Structure

The Fuzzification Interface

Fuzzification is the first step in the fuzzy inference process. It involves data transformation where inputs variables are transformed into fuzzy inputs. For the developed system, the data variable was based on the cervical cancer domain expert's knowledge, the input and output parameters selected were described with two linguistic variables (high and low) as shown in Table 3. The data variables were evaluated using the triangular membership function.

Table 3: Table showing the Linguistic Variables Used

Data Variables	Fuzzy Values
Low	$0.1 \leq x \leq 0.50$
High	$0.50 \geq x \leq 1.0$

Fuzzy Reasoning

The second layer forms a major part of the fuzzy reasoning phase, which generates the Yes strength. The Yes strength combines the degree of compatibility with respect to the antecedent membership functions in a rule using fuzzy AND or OR operators to form a Yes strength that indicates the degree to which the antecedent part of the rule is satisfied. The degree of compatibility is comparing known facts with the antecedents of fuzzy rules to find closeness with respect to each antecedent membership function. In this research work the AND operator was chosen to form a firing strength to indicate the degree to which the antecedent part is satisfied.

The Inference Mechanism (Fuzzy Inference System)

The Inference Mechanism forms the third layer of the ANFIS architecture. In this research the fuzzy control rules were formulated using the expert experience. The cervical cancer Inference system uses the rules in the knowledge base to derive conclusions by using a forward chaining mechanism to search the symptoms by looking up the membership values in the condition of each rule. The membership functions are trained in order to adjust the weight to the desired target output. Fuzzy inputs are mapped out in their respective weighting factors and their associated variables to determine their degree of membership. The membership functions are then trained in order to adjust the weight to the desired target output. A rule is said to be Yes, if any of the precedence parameter is (1) otherwise, if all the parameters evaluate to No it is (0). The Fourth Layer calculates the consequents based on the consequent parameters, by applying the Yes strength to the consequent membership function of a rule to generate a qualified consequent membership function.

The Defuzzification Interface

The fifth layer of the ANFIS architecture forms the overall output of the ANFIS system, by using the process of defuzzification to transform each fuzzy results into a non-fuzzy (crisp output). The weighted average method of defuzification was employed in this research because all output membership functions must be the same type which is either linear or constant in ANFIS architecture. In this research the output membership functions was chosen as constant.

4.0 RESULTS AND DISCUSSION

The application program has two major modules which can either be prompted from both administration and user ends. The User Login interface at runtime is shown in Figure 2. The administrative end has the ability to moderate users of the system and also carry outs a back-end experiment set up to create a well generalized experimental knowledge for the fuzzy inference system. This can help to formulate a well-defined and acceptable standard for any user of the software at any point in time.

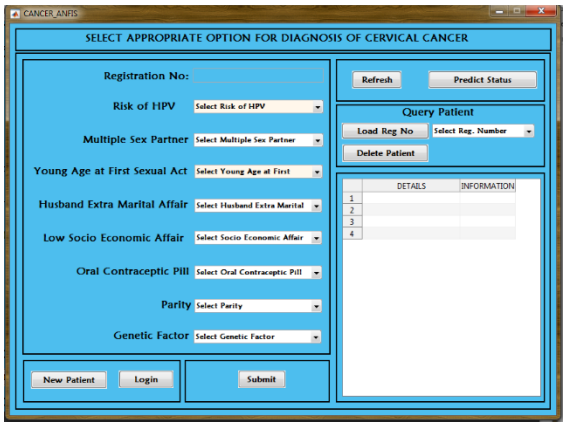

Figure 2: User Interface at Initial Runtime (User start-up page)

Once a user/patient is able to successfully login, the user can enter the personal information (Bio data) and specific symptoms as shown in Figure 3, which is saved into the MySQL database.

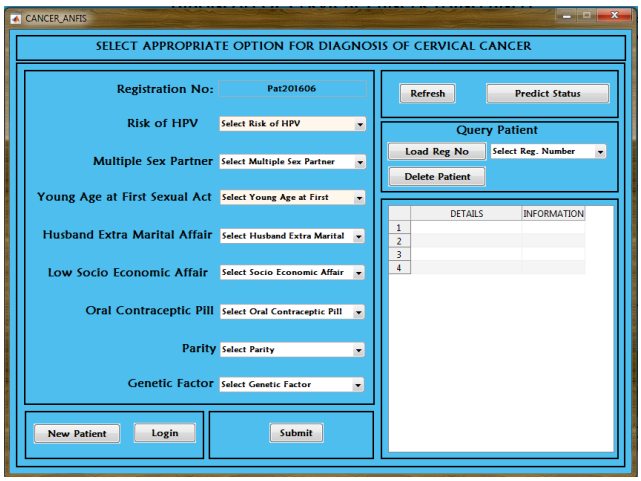

Figure 3: Entry of Patients symptoms

An existing patient's data can be queried as shown in Figure 4. This can be done by entering the patient's registration number and clicking on the search button to retrieve his or her personal information.

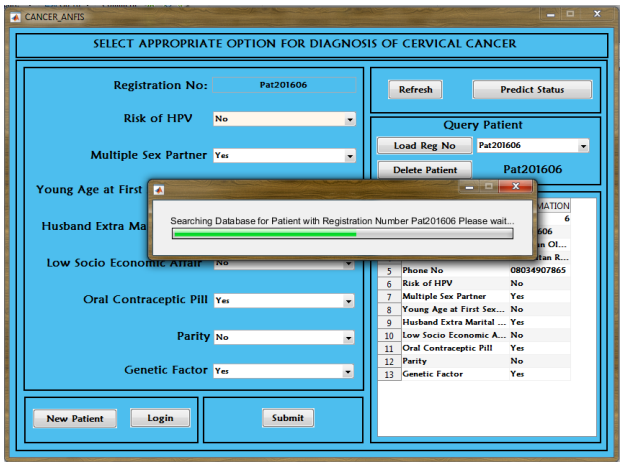

Figure 4: Querying of Patient's existing data

Once the queried patient data has been retrieved from the database, the patient cancer status can be checked by clicking on the "Predict status" button, the status is displayed as shown in Figure 5 to give the result of the status of the patient in question.

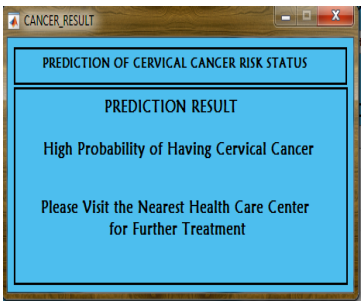

Figure 5: Outcome of Patient's Status Check

The result obtained by the ANFIS model, showing the Predicted Output (PO) and the Expected Output (EO) is shown in Table 4. The result indicated that there were 4 misclassified samples out of the 62 positive samples that were tested by the ANFIS model. Also, the predicted output which indicates the true positive result was 58. The system realized a 93.54% correct classification and a 6.45% incorrect classification.

Table 4: Classification Result of the ANFIS model

Expected Output	Predicted Output	Misclassification	% Correct Classification	% misclassification
62	58	4	93.54	6.45

5.0 CONCLUSION

One of the major challenges faced today in under developed country is access to quality and fast health facilities which poses a big threat to the health conditions of patients. Accurate medical diagnosis is one of the major ways to sustain good health and live long. In this paper, neuro-expert system was developed using advanced neuro-fuzzy inference system taking into consideration the combination of eight attributes (risk factors) and one output for the prediction of cervical cancer. Future direction includes training on larger dataset with more data points (attributes) and most importantly, comparative analysis of the ANFIS model's performance with other classification algorithm.

REFERENCES

Al-batah, M. S., Ashidi, N., Isa, M., Klaib, M. F., & Al-betar, M. A. (2014). Multiple Adaptive Neuro-Fuzzy Inference System with Automatic Features Extraction Algorithm for Cervical Cancer Recognition,

Hernández, K. R. D., Lasserre, A. A. A., Gómez, R. P., Guzmán, J. A. P., & Sánchez, B. E. G. (2013). Development of an Expert System as a Diagnostic Support of Cervical Cancer in Atypical Glandular Cells , Based on Fuzzy Logics and Image Interpretation.

Hamdan, H. (2013). An Exploration of the Adaptive Neuro-Fuzzy Inference System (ANFIS) in Modelling Survival Thesis submitted to The University of Nottingham for the Degree of Doctor of Philosophy An Exploration of the Adaptive Neuro-Fuzzy Inference System (ANFIS) in Modelling Survival.

Al-daoud, E. (2016). Cancer Diagnosis Using Modified Fuzzy Network.

Lynch, K. (2013). " The womb people " : detection , treatment , and prevention of cervical cancer with the khayelitsha cervical cancer screening project in khayelitsha , south africa Kirsten Lynch Advisor : Professor Lynette Denny , Principle Investigator Khayelitsha Cervi. *Detection and Prevention of Cervical Cancer*, 1–69.

Mutgi, m. A., Murthy, M. R. P., & V, M. T. (2015). neural network based automated system for the diagnosis of cervical cancer project REFERENCE NO .: 38S1497, 3–5.Andries, P.E. (2002). Computational intelligence. John Wiley & Sons, Ltd.

Awotunde, J. B., Matiluko, O. E., & Fatai, O. W. (2014). Medical Diagnosis System Using Fuzzy Logic, *7*(2), 0–7.

Cancer, W. I. (2014). Cervical Cancer What is cervical cancer ? *American Cancer Society*.

Jang, J.S.R. (1993). Anfis adaptive-network-based fuzzy inference system. Systems,Man and Cybernetics, IEEE Transactions on, 23, 665–685.

Mahanta J. B., Nath D. C, Nath C. K, Majumdar D. D., Karan S., Sharma J. D. Cervical Cell Classification.

Nordqvist, C. (2015, August 25). "Cervical Cancer: Causes, Symptoms and Treatments." *Medical News Today*. Retrieved from http://www.medicalnewstoday.com/articles/159821.php.

Negnevitsky, M. (2005). Artificial Intelligence: a guide to intelligent systems. PearsonEducation Limited, Essex, England.

Odeh, S. M. (2011). Using an Adaptive Neuro-Fuzzy Inference System (ANFIS) Algorithm for Automatic Diagnosis of Skin Cancer, *8*, 751–755.

Quteishat, A., Al-batah, M., Al-mofleh, A., & Alnabelsi, S. H. (2013). cervical cancer diagnostic system using adaptive fuzzy moving k-means algorithm and fuzzy min-max neural network, *57*(1).

Sarbortova, H. (2013). Final Project Report Detection of Cervical Cancer in Pap Smear Images, 1–13.

Schneider, J. (2004). Independent Study Project (ISP) Collection Cervical Cancer Screening in Rural South Africa : An Analysis of the Awareness , Attitudes , and Practices of Women Served by the Masincedane Clinic Clinic.

Singh, R.P., Rawat, V., Pawar, M. & Mishra, R.K. (2012). Design of an optimalmulti-layer neural network for eigenfaces based face recognition. Recent Research inScience and Technology, 4(1), 24–32.

Simon, D. (2012). Introduction to neural network. URL:http://itee.uq.edu.au/ cogs2010/cmc/chapters/Introduction/ [01/06/2012].