DESIGN AND IMPLEMENTATION OF A FUZZY EXPERT SYSTEM FOR DIAGNOSING BREAST CANCER

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ABSTRACT

The death rate is caused by breast cancer in women is increasingly high and growing. A number of people are getting to lose this part of their body due to late diagnosis of this disease. This therefore requires the development of an efficient and accurate diagnosis approach that will aid providing the knowledge of the type of breast cancer type and severity in order to reduce the mortality rate through the disease. This need serves as the major motivation for this work. In this paper, we proposed a fuzzy expert system for diagnosis of and treatment recommendation of breast cancer problems which provide physicians and patients with information of the cancer type and treatment recommendation. The application was designed using JAVA programming language, MATLAB and SQLite database engine. This application permits update of new information as a means of knowledge. The evaluation showed that the inclusion of the fuzzy inference system improved the accuracy and precision of the system from 0.8 to 0.9. The system is user-friendly and has high level of acceptability from the validation conducted at the end of the research.

Keywords: Breast cancer, Fuzzy, Expert System, Diagnosis, Treatment recommendation.

1. INTRODUCTION

The lives of a number of women have been threatened by breast cancer disease (Abdelwahed et al., 2015). It is the major common cancer amidst women both in developing and developed nations with a report that the breast cancer cases numbered globally was estimated at 14.1 million new cases and 8.2 million women died in 2012 (Boughorbel et al., 2016). To be more precise, it is the second leading cause of death globally, and was responsible for 8.8 million deaths in 2015 (WHO 2017).Every woman is exposed to facing the risk of breast cancer (Bhardwaj and Tiwari, 2015). Researchers predict that every woman is likely to have a 12% chance of having this cancer before 85 years of age. As a woman ages, her risk of developing breast cancer rises dramatically regardless of her family history. The causes and treatment approach for breast cancer still has a wide gap in terms of research with no

widely available preventive measure (Christoyianni et al.., 2000, Rodrigues et al., 2006). Hence, detecting and effectively treating the disease early is the only preventive action to reduce the mortality caused by breast cancer. This will make localized tumors treated successfully before the spread of the cancer (Daliri, 2012; Polat and Gunes, 2008). Thus, the accuracy of the diagnosis is essential and an urgent issue in medical science community. Diagnosing the disease early will bring about a better treatment of patients and aid crucial decision making by medical experts (Alzubaidi et al, 2016).A number of approaches have been employed in detecting cancer in patients ranging from blood tests, X-ray, CT scan, biopsy to patient examinations (Daliri, 2012). The data gotten from each of the test is able to hold crucial information that can be used for better diagnosing cancer and inform clinical decision-making. Factors such as mammography which is a common employed technique accomplish a vital role in this field (Feng et. al, 2012). It is only limited in its dependence on the composition of mammary parenchyma and tumor tissue (Lu et al., 2014).Mammography and fine needle aspiration cytology (FNAC), are discovered to be void of being capable of high diagnostic ability (Chen et al., 2011). It is absolutely necessary therefore to develop a better technique of diagnosis. In other to address the need, the introduction of expert systems and machine learning techniques were brought into existence for improving diagnostic capability. An automated diagnostic system will aid the avoidance of likely errors medical experts make while diagnosing diseases. This will bring about a faster, easier and detailed examination with the medical identified.

This study aims to generally reduce the rate of mortality especially amongst women by presenting a fuzzy expert system for diagnosing breast cancer. The expert system technique is employed for easier and accurate diagnosis while the fuzzy logic is to aid the cancer rate of on a patient. The objectives of this study are to design and implement a breast cancer diagnosis application that medical personnel cause at any point in time to diagnose the type of breast cancer a person has. The system also will provide a means of recommendation of how the breast cancer can be treated. The study as well validated the diagnosis system as a means of ascertaining its level of acceptability and usability.

The rest of this paper is organized as follows: Section 2 discusses the motivations, approaches, results and limitations of past researches carried out on breast cancer diagnosis. Section3 explains the research methodology describing the techniques, architecture and algorithm. The implementation and result is described in Section4. Section 5 gives the usability evaluation and discussion of the proposed system. The conclusion and recommendation is stated in Section 6.

2. RELATED WORKS

A number of researches have been conducted to address the issue of automated diagnosis of different cancer types previously. An automatic diagnosis system to diagnose cancer of the lung was proposed in Polat and Gunes (2008). The Principal Component Analysis (PCA) was employed in the system to carry out a reduction of the feature space dimensionality with a scheme for weighting fuzzy employed before the classification phase. The classification of the data was done using Artificial Immune Recognition System. A combined automated system for cancer diagnosis foundational on Genetic Algorithm and Fuzzy Extreme Learning machines (ELM) was presented by Daliri (2012), such that

Genetic Algorithm was employed for developing the dimensionality of the feature space. The resulting features were input to ELM for performing the classification task.

Abdelwahed et al., (2015) propose a Computer Aided Diagnosis (CAD) system for segmenting and classifying the cancer of the breast in ultrasound images. This they did as a means of aiding the decision of radiologist. The system employed a marker controlled watershed transformation approach for identifying the interest region. The wavelet transform is then applied for extracting the set of features with a combination of texture and statistical features. The phase for classifying determined if the interest region is a normal or focal lesion. The focal lesion finally was classified as either benign or malignant. The classification activity was carried out using Support vector machine (SVM), K-nearest neighbor (KNN) and classification & regression trees (CART). 10 folds cross validation was employed for validating the proposed method which revealed it was encouraging. From the results returned, CART gave 83.75% classification rate by employing statistical and texture features in case of classify benign and malignant tumor performing better than SVM and KNN. In differentiating between normal and abnormal classes SVM and CART obtained 100% classification rate by employing the texture feature.

Alzubaidi et al., (2016) proposes a hybrid feature selection approach for diagnosing breast cancer which has a combination of Genetic Algorithm (GA) and Mutual Information (MI) to select the best cancer predictor combination. The features that were selected features inputted into a classifier for predicting the presence of breast cancer in a patient. They made use of an available public breast cancer dataset to perform experiments and evaluate the performance of the Genetic Algorithm based on the Mutual Information approach with two different machine learning classifiers, namely the k-Nearest Neighbor (KNN), and Support vector machine (SVM).The outcome showed that the hybrid approach that was proposed was so accurate to predict breast cancer, and promise to do same for other cancers using clinical data.

Bhardwaj and Tiwari (2015) propose a Genetically Optimized Neural Network (GONN) algorithm, to solve the problem of classifying breast cancer. They evolve a neural network genetically for optimizing its architecture to classify. They included an introduction of new crossover and mutation operators contrary to the standard operators for reducing the destructive nature of these operators. The GONN algorithm was used for classifying breast cancer tumors as either benign or malignant. The result demonstrated using the WBCD database from UCI Machine Learning repository for comparing how accurate, sensitive, specific the classification was. They also measured the confusion matrix, ROC curves and AUC under ROC curves of GONN with classical model and classical. The results proved the positive performance of the approach which worked well with the breast cancer database.

Zheng et al., (2014) propose a hybrid technique for diagnosing breast cancer depending on the tumor features that are extracted. The extraction and selection of feature are very important to the quality of classifiers based on the data mining methods. They developed a hybrid k-means and support vector machine algorithm for extracting important information and diagnosing the tumor. The K-means algorithm is employed for recognizing hidden patterns of the benign and malignant tumors separately. The membership of each tumor to these patterns is calculated and treated as a new

feature in the training model. Then, a support vector machine (SVM) is employed for obtaining the new classifier and differentiate the incoming tumors. Based on 10-fold cross validation, the proposed methodology improves the accuracy to 97.38%.

Hassanien et al., (2014) introduces a hybrid approach with a combination of the benefits of fuzzy sets, ant-based clustering and multilayer perception neural networks (MLPNN) classifier, in conjunction with statistical-based feature extraction technique. They developed a system with an algorithm that was based on type-II fuzzy sets for enhancing the contrast of the input images. An improved version of the classical ant-based clustering algorithm is followed by an improved version for identifying the target objects through an optimization methodology that maintains the optimum result during iterations. Then, over twenty statistical-based features are extracted and normalized. The result of the experiment that was obtained showed that the adaptive ant-based segmentation is superior to the classical ant-based clustering technique and the overall accuracy offered by the employed hybrid technique confirmed that the effectiveness and performance of the proposed hybrid system is high.

A number of the approached did not diagnose to know the type of breast cancer that a patient had but instead the level of malignity. Also, it was deduced that the recommendation of treating the disease was not considered in many studies which this study will be addressing.

3. RESEARCH METHODOLOGY

The techniques employed in this research work are described in this section. The description of the proposed system is stated also consisting of the architecture. It entails the software development approach and all system requirements. It as well describes the software development approach and all system requirements.

3.1 Data Collection

The data used in this study were gathered based on information obtained from various sources which include our primary source of information, interview. Interviews were conducted with some medical practitioners to get their individual perspectives on breast cancer diagnosis. Secondary research approach used is the online information sources. The internet was used to obtain sufficient, adequate and accurate information on breast cancer diagnosis, journals that presented related works of various authors. The breast cancer diseases considered in the study are ductal carcinoma, invasive ductal carcinoma, invasive lobular carcinoma, mucinous carcinoma, inflammatory breast cancer, triple negative breast cancer, paget's disease of the nipple, adenoid cystic carcinoma and lobular carcinoma in situ. These several breast cancer type have their different recommendations peculiar to them which needs to be diagnose appropriately.

3.2 Proposed System Architecture

The process of system modeling is the architectural make-up of the system. It is the process of defining the architecture, component, modules, interfaces and data for the system to satisfy specified requirements. As this application is designed to be used by medical doctors, who may not be advanced computer users, we aimed to develop the user interface of the breast cancer as user friendly. The program was designed with Java and MySQL was used as a database platform. The diagnosis system runs on windows environment. This involves the detailed specification of data objects, input data to be captured, and the storage formats, the output provided by the system, the system interface to users and finally the specification of various data manipulation procedures that would be implemented as codes. Figure 1 shows the architecture and the operations of the proposed system.

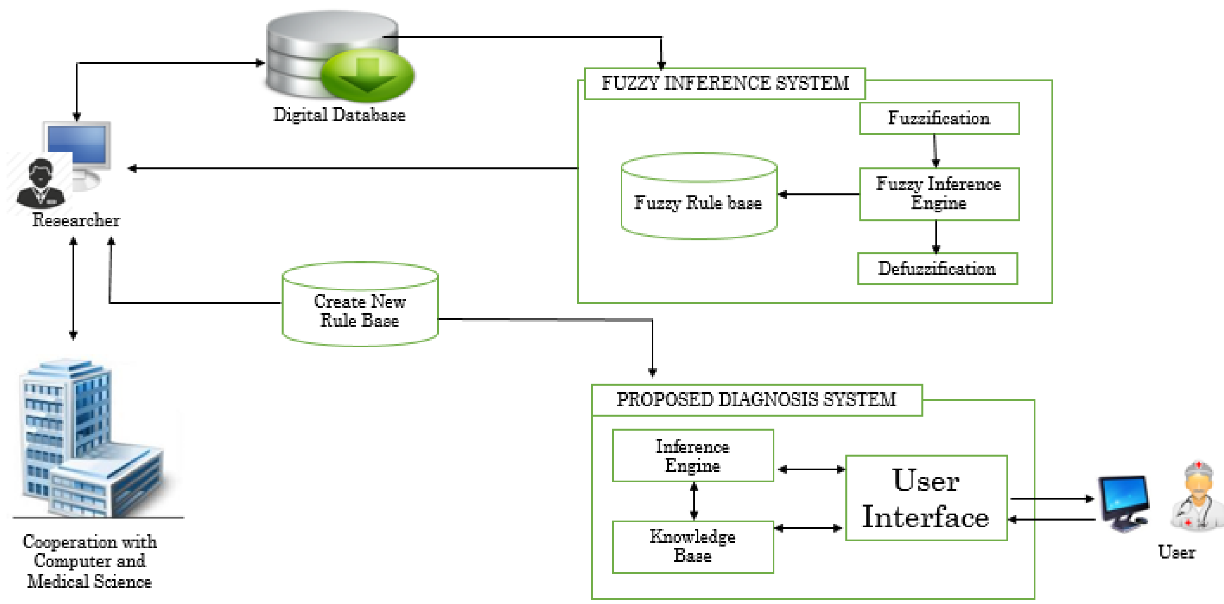

Figure 1: Architecture of the Proposed Breast Cancer Diagnosis System.

3.3 Proposed Breast Cancer Diagnosis System Phase

3.3.1 User Interface

Here is the phase of the application that enables users to interact with the system. The user to the system can either be an administrator or physician. Also, there is an access control necessary to manage the type of user that can carry out operation on the system in order not to manipulate the rules or information. An administrator is able to manage and monitor the usage of the system. He manages the access information to the application. The physician does the diagnosis based on certain symptoms and gives the report back to the patient. Although the computer aids in decision making process, the computer will only manipulate the supplied data to assist the decision maker in reaching a solid decision. The type of input to design depends largely on how data will be processed and also depends on the required output. As can be seen from the architecture, the expert system technique is employed in this aspect of the entire system.

3.3.2 Inference Engine

The inference engine has to do with the rules that guide the decision of the system. Based on the information gathered from experts, the IF THEN rule technique was employed in the development of the system to carry out the process. About 14 symptoms, the major breast cancer types and different recommendations for treatments were used for developing the rules of the expert system aspect of the research work.

3.3.3 Expert Knowledge Base

This is the knowledge database where the data got from the medical experts were stored and new ones updated so as to be able to utilize for the diagnoses process. This makes the information reusable and accessible at any given period of time. The information in the knowledge base could updated, deleted and queried.

3.3.4 Fuzzy Inference System Phase

The fuzzy inference system (FIS) phase is employed to manage uncertainties and help determine the level at which the cancer has get to in a patient. A disease could be present but not gotten to an intense point which might not need rigorous treatment recommendation. The aspect of the fuzzy included will help the system guide on the necessity and urgency of treating a particular breast cancer type. The FIS employs fuzzy logic technique to relate inputs which are fuzzy classification features to outputs which are fuzzy classification classes. The mamdani fuzzy inference is employed here because of its ability to provide fuzzy set output which is what is needed in this research work. The membership function considered the following features: age, pain on breast and size of lump. The age membership function considered the young, mid-age and old states. The young age range is considered from 0-20, mid-age from 21-40, and above 41 as old. The breast pain membership function considered the mild and severe classes. The lump size function is classified into small, medium and large. The output function which is the cancer rate is classified into low and high. The membership functions will be determined by using the following ranges;

$$\boldsymbol{Age, A_i} = \begin{cases} \mathbf{0.4} > x \;\; Old \\ \mathbf{0.2} < x \leq 0.4 \;\; Mid - age \\ \boldsymbol{x \leq 0.2 \;\; Young} \end{cases} \quad \textbf{(1)}$$

$$\boldsymbol{Breast\ Pain, B_i} = \begin{cases} \mathbf{0.67} < x \leq 1 \;\; very\ severe \\ \mathbf{0.33} < x \leq 0.67 \;\; slightly\ severe \\ \boldsymbol{x \leq 0.33 \;\; mild} \end{cases} \quad \textbf{(2)}$$

$$\boldsymbol{Lump\ Size, L_i} = \begin{cases} \mathbf{0.67} < x \leq 1 \;\; large \\ \mathbf{0.33} < x \leq 0.67 \; medium \\ \boldsymbol{x \leq 0.33 \;\; small} \end{cases} \quad \textbf{(3)}$$

$$\boldsymbol{Cancer\ Rate, C} = \begin{cases} \mathbf{0.5} > x \geq 1 \;\; High \\ \mathbf{0} > x \geq 0.5 \;\; Low \end{cases} \quad \textbf{(4)}$$

3.3.5 Fuzzy Inference rules

The inference rules guiding the fuzzy logic operations are as follows

IF Age is Young AND Breast Pain is Mild AND lump size is Small, THEN Cancer Rate is Low

IF Age is Young AND Breast Pain is Mild AND lump size is Medium, THEN Cancer Rate is Low

IF Age is Young AND Breast Pain is Mild AND lump size is Large, THEN Cancer Rate is Low

IF Age is Young AND Breast Pain is Slightly severe AND lump size is Small, THEN Cancer Rate is Low

IF Age is Young AND Breast Pain is Slightly severe AND lump size is Medium, THEN Cancer Rate is Low

IF Age is Young AND Breast Pain is Slightly severe AND lump size is Large, THEN Cancer Rate is High

IF Age is Young AND Breast Pain is Severe AND lump size is Small, THEN Cancer Rate is Low

IF Age is Young AND Breast Pain is Severe AND lump size is Medium, THEN Cancer Rate is High

IF Age is Young AND Breast Pain is Severe AND lump size is Large, THEN Cancer Rate is High

IF Age is Mid-age AND Breast Pain is Mild AND lump size is Small, THEN Cancer Rate is Low

IF Age is Mid-age AND Breast Pain is Mild AND lump size is Medium, THEN Cancer Rate is Low

IF Age is Mid-age AND Breast Pain is Mild AND lump size is Large, THEN Cancer Rate is High

IF Age is Mid-age AND Breast Pain is Slightly severe AND lump size is Small, THEN Cancer Rate is Low

IF Age is Mid-age AND Breast Pain is Slightly severe AND lump size is Medium, THEN Cancer Rate is High

IF Age is Mid-age AND Breast Pain is Slightly severe AND lump size is Large, THEN Cancer Rate is High

IF Age is Mid-age AND Breast Pain is Severe AND lump size is Small, THEN Cancer Rate is Low

IF Age is Mid-age AND Breast Pain is Severe AND lump size is Medium, THEN Cancer Rate is High

IF Age is Mid-age AND Breast Pain is Severe AND lump size is Large, THEN Cancer Rate is High

IF Age is Old AND Breast Pain is Mild AND lump size is Small, THEN Cancer Rate is Low

IF Age is Old AND Breast Pain is Mild AND lump size is Medium, THEN Cancer Rate is High

IF Age is Old AND Breast Pain is Mild AND lump size is Large, THEN Cancer Rate is High

IF Age is Old AND Breast Pain is Slightly severe AND lump size is Small, THEN Cancer Rate is High

IF Age is Old AND Breast Pain is Slightly severe AND lump size is Medium, THEN Cancer Rate is High

IF Age is Old AND Breast Pain is Slightly severe AND lump size is Large, THEN Cancer Rate is High

IF Age is Old AND Breast Pain is Severe AND lump size is Small, THEN Cancer Rate is High

IF Age is Old AND Breast Pain is Severe AND lump size is Medium, THEN Cancer Rate is High

IF Age is Old AND Breast Pain is Severe AND lump size is Large, THEN Cancer Rate is High

4. IMPLEMENTATION AND RESULTS

The proposed system was implemented using JAVA programming language and MySQL database. The implementation approach used in the deployment of this system is directchange over. In this case, the traditional way of diagnosis will be overtaken by this proposed system. Although it poses as the riskiest form of system change over, it is the cheapest, quickest and easiest amongst other forms of system change over. In order to attain a successful deployment of the application, the hardware and software specifications discussed in the different sections below must be achieved to access the application. The front-end part of the system was designed with Java which is a general-purpose computer programming language that is concurrent, class-based, object-oriented and specifically designed to have a few implementation dependencies as possible.

The implementation phase of this project is divided into three major modules which are the Access control, physician and admin modules.

Access Control Module: This module has to do with managing who can access the system and what part of the system can be accessed. This is the platform where the authorized admin and physician would be able to utilize the system. Figure 2 below shows this module.

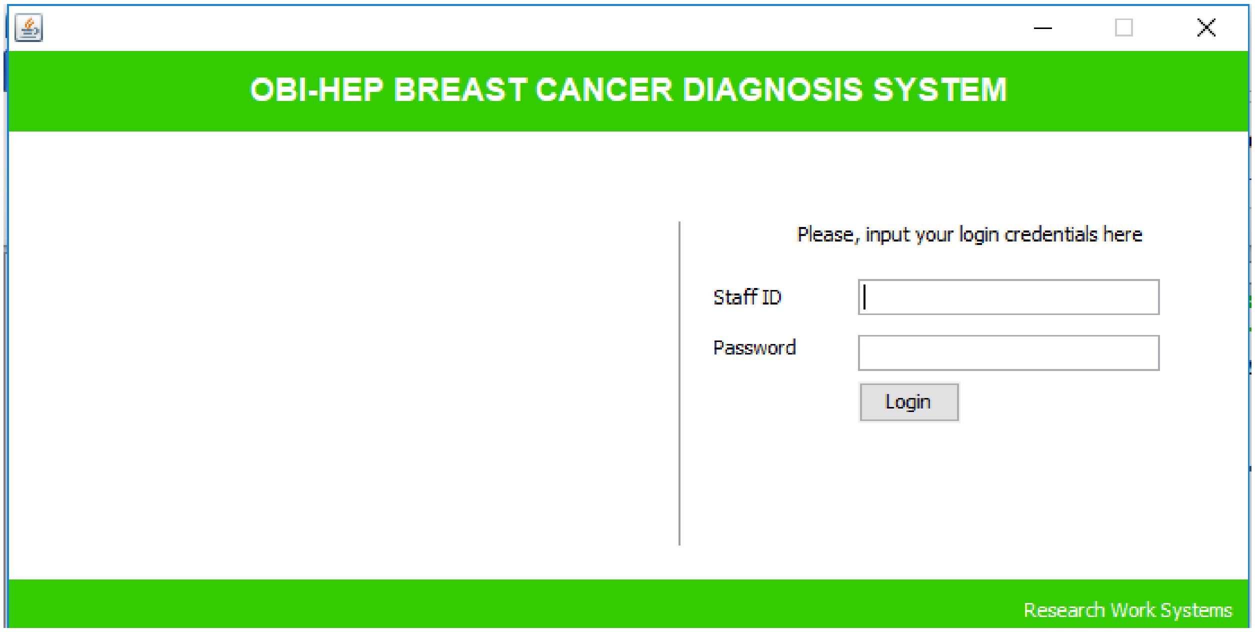

Figure 2: Screenshot of the login phase of the proposed system

Physician Module: The physician logs in with his or her staff ID and password. He or she can diagnose a patient by selecting the number of symptoms as showcased by the patient from the list of symptoms and then click the diagnose button at the bottom of the diagnosis page. A result page showing the selected symptoms, the breast cancer type as well as recommendations, are viewed. Figure 3 shows the diagnosis operation phase of the proposed system. The result phase is shown in Figure 4.

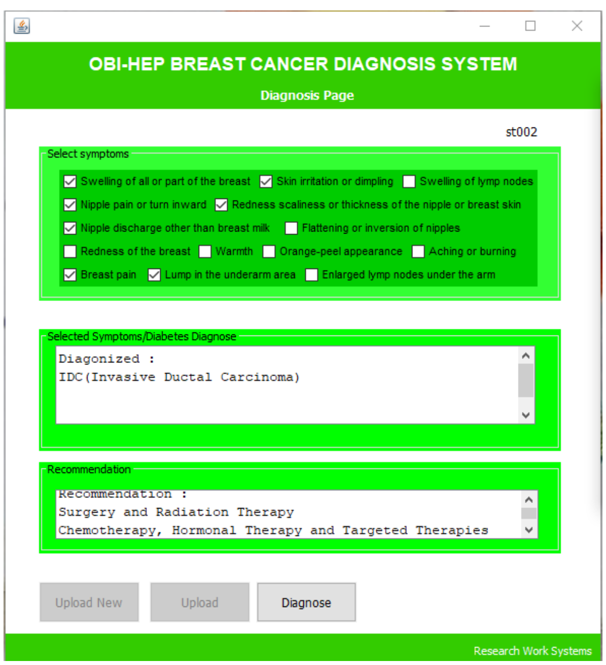

Figure 3: Diagnosis phase of the proposed system

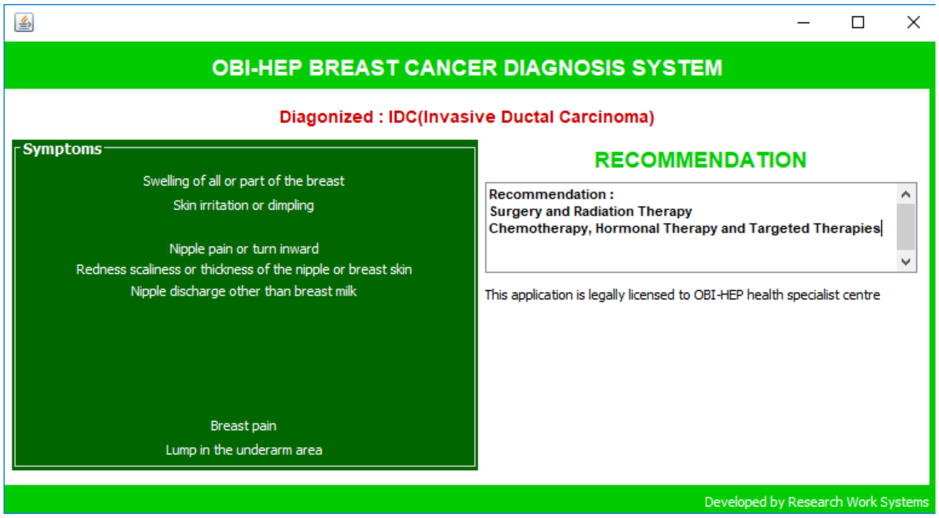

Figure 4: Diagnosis Result of the proposed system

Admin Module: This module comprises of services provided by the application and update of necessary information, for example, update of new symptoms and their recommendations. In order to update symptoms and recommendations, the admin clicks on the user option on the top left corner of the page which shows a list. Then he or she clicks on upload diagnosis to carry out the update operation. The admin is able to monitor activities and manage accessibility to the proposed system. Figure 5 shows the admin dashboard of the proposed system. Figure 6 shows a screenshot of the MySQL.

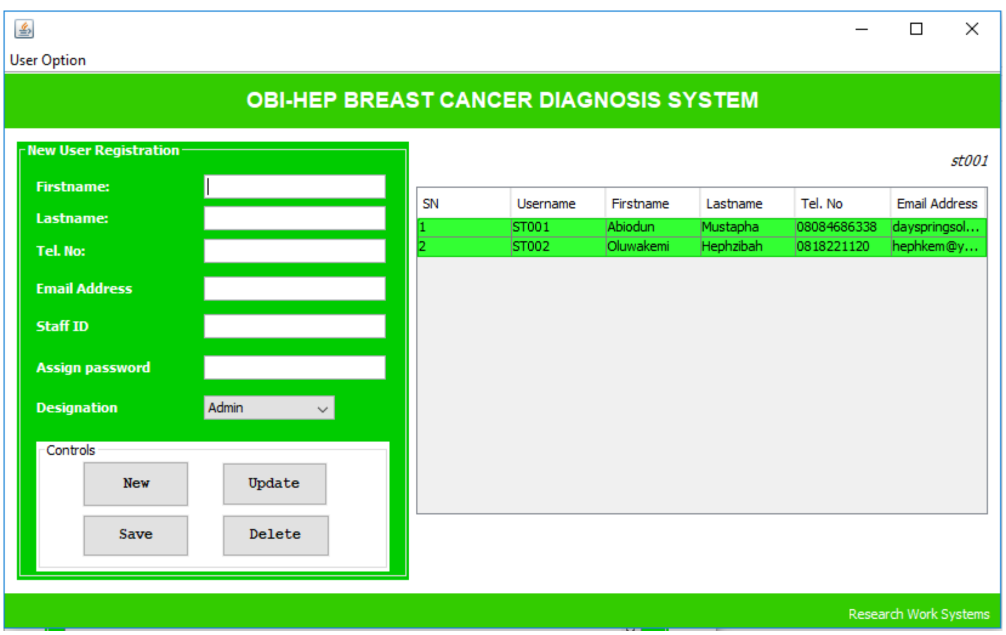

Figure 5: Admin module of the proposed system.

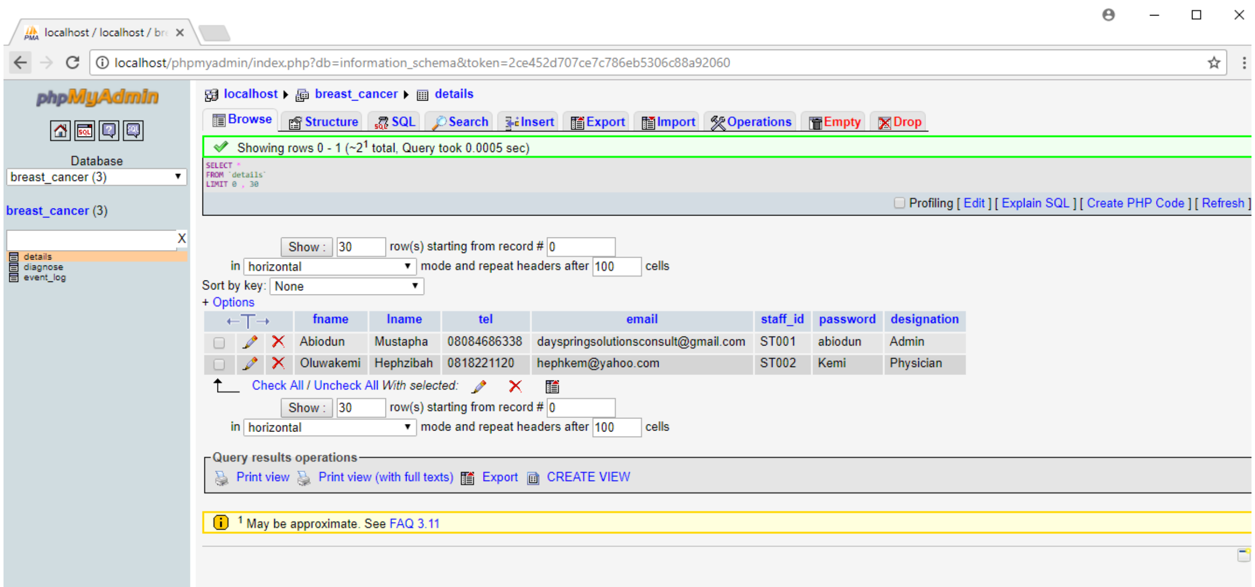

Figure 5: Screenshot of the database server of the proposed system.

Figures 6,7 and 8 shows screenshots of the fuzzy inference system phase of the proposition.

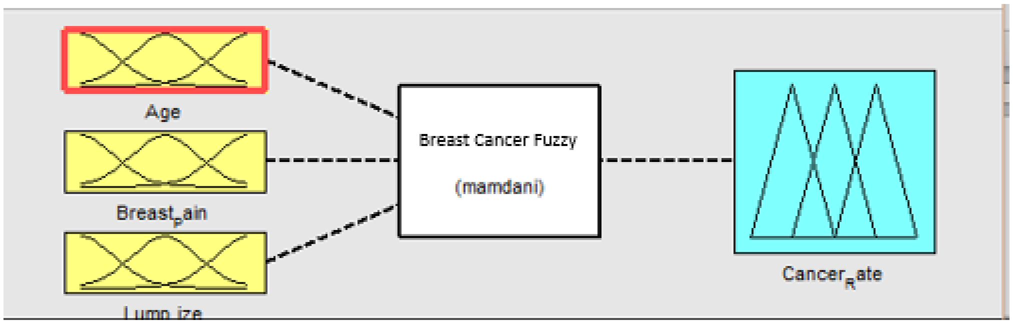

Figure 6: Screenshot of the fuzzy inference system

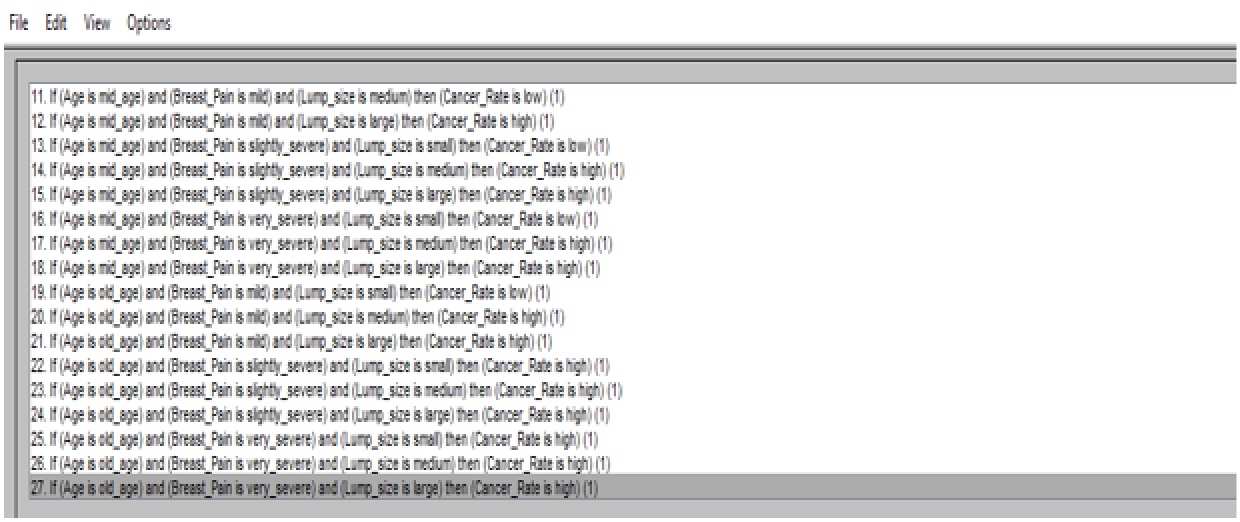

Figure 7: Screenshot of the fuzzy rules

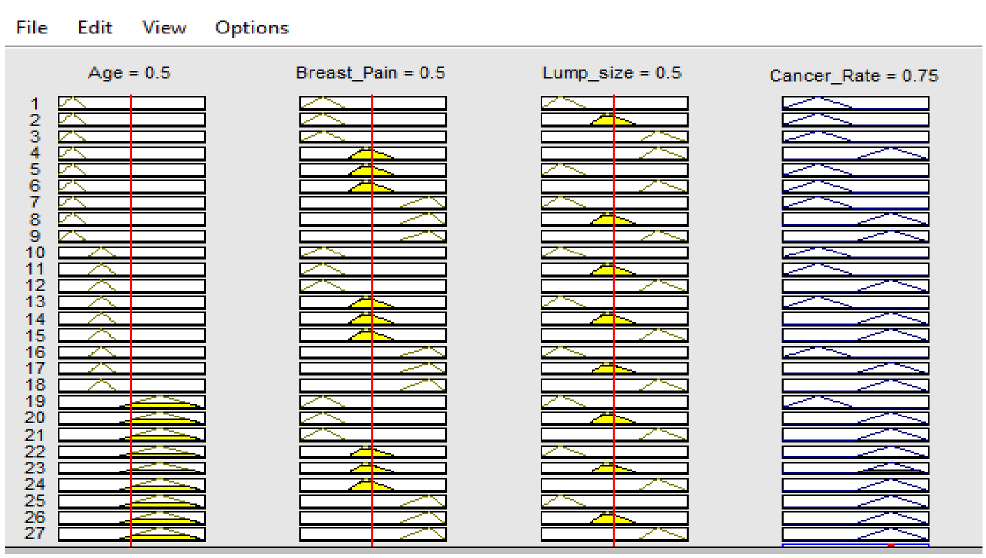

Figure 8: Rule viewer of the fuzzy inference system

5. EVALUTION AND DISCUSSION

The breast cancer diagnosis system was evaluated by comparing the accuracy and precision results when it is implemented alone (BCD-SYS) along side when fuzzy inference system is employed (BCD-SYS + F). The True Positive(TP), True Negative(TN), False Positive(FP) and False Negative(FN) values were employed in finding these values.

TP = the number of times an expected output was returned

TN = the number of times an unexpected output was returned

FP = the number of times the wrong output was returned for an expected output.

FN = the number of times the worng output was returned for an unexpected output.

Table 1 and Table 2 show the estimated output of the accuracy values.

Table 1: Estimated evaluation output

	TP	TN	FP	FN
BCD-SYS	8	0	2	0
BCD-SYS + F	9	0	1	0

Accuracy = (TP + TN)/(TP + TN + FP + FN)

Precision = TP / (TP + FP)

Accuracy (BCD-SYS) = (8 + 0)/(8 + 0 + 2 + 0) = 8/10 = 0.8

Accuracy (BCD-SYS + F) = (9 + 0)/(9 + 0 + 1+ 0) = 9/10 = 0.9

Precision (BCD-SYS) = 8/(8+2) = 8/10 = 0.8

Precision (BCD-SYS + F) = 9/(9+1) = 9/10 = 0.9

Table 2: Precision and Accuracy comparison of the two appraoches

	Precision	**Accuracy**
BCD-SYS	**0.8**	**0.8**
BCD-SYS + F	**0.9**	**0.9**

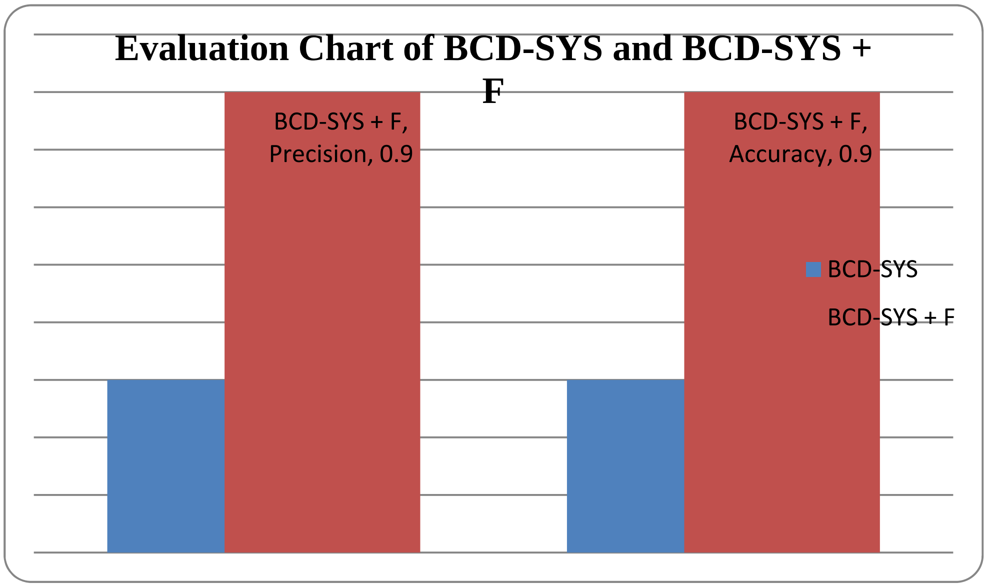

Figure 9: Chart showing the evaluation chart of BCD-SYS and BCD-SYS + F

The usability evaluation of the proposed system was conducted by employing the Technology Acceptance Model (TAM) (Venkatesh and Bala 2008), a major information systems theory that is globally acceptable for evaluating systems and comprehending user's acceptance. In this paper, we made use of four of the TAM factors: Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Perception of External Control (PEC) and Job Relevance (REL) explained explicitly by Abdullah et al. (2016).

(1) PEOU is employed for determining the level to which users find the proposed system easy to use.

(2) PU is employed for determining the level of believe the user have that the proposed system would aid enhancing his or her performance in diagnosing breast cancer problems.

(3) PEC is employed for determining the level of believe the user has that organizational resources and technical facilities exist to enable the implementation of the proposed system;

(4) REL is employed for determining the level to which an individual agree to the proposed system being important to his or her job.

After developing the breast cancer diagnosis system, a pilot study was conducted to carry out a validation using ten (10) participants to determine the usability. So as to develop a health-centered software, the understanding the quality alone is not sufficient. This is due to the fact that the quality of an application is not equivalent to the usability to the target users. The responses got from usability evaluation (conducted with cancer physician summarized in table 3) are crucial to determine the perception of users about the system to provide insight to the future usage of the application. Table 3 gives a summary of the overall level of usability. This response gotten from the users proved and

evidence of perception by the mean score of 4.15 for perceived ease of use, 4.40 mean score for perceived usefulness, 4.30 mean score for PEC and 4.33 mean score of job relevance. All construct were measured on a Likert scale of 5-points by making use of different set of questions.

Table 3: Usability evaluation results

Statements	Mean
Perceived Ease of Use (PEOU)	4.15
Perceived Usefulness (PU)	4.40
Perceived External Control (PEC)	4.30
Job Relevance (REL)	4.33

Apart from finding the mean rating for the different user per usability construct, we as well computed the median score per construct, through all the construct responses that were gathered. Specifically, it was found out that concerning the 80 responses gotten for the Perceived Ease Of Use attribute (that was evaluated using 8 questions, as highlighted in Table 4, which were responded to by 10), the overall PEOU median score is 5. The outcome further proves the high level of agreement users have based on PEOU, which was affirmed also by the 4.15 overall mean score from the validation. This finding shows the agreement of the participants on the easy usage of the application. Exploring further on the evaluation of PEOU for the application proves that PEOU3, PEOU4, PEOU5, PEOU6, PEOU7 had the highest mean score i.e.(see table 4). These scores reveal the participants' agreeing that "Users will understand this application with little effort", "I find it easy to use the application to diagnose breast cancer", "I find the mobile application flexible to use", "Learning to use the mobile application is easy for me" and "The mobile application is presented in a way that allows me to easily diagnose breast cancer" followed by PEOU2 with mean score of 4.60which shows that the participants agreed that "Users will understand this application with little effort". PEOU1 had a mean score of 4.10 indicating that participants agree that the background knowledge of computing devices is essential to use the application effectively. PEOU9 was a revere scale question. The low score for this question indicates that the respondents do not consider that the application is unnecessarily complex (PEOU9).

Table 4: Perceived ease of use (PEOU) responses

Statements	Mean
PEOU1. Background knowledge of computing devices is essential to effectively use this application	4.1
PEOU2. Users will understand this application with little effort	4.6

PEOU3. I can easily master the use of the mobile application	**4.7**
PEOU4. I find it easy to use the application to diagnose breast cancer	**4.7**
PEOU5. I find the mobile application flexible to use	**4.7**
PEOU6. Learning to use the mobile application is easy for me	**4.7**
PEOU8. The mobile application is presented in a way that allows me to easily diagnose breast cancer	**4.7**
PEOU9.The mobile application is unnecessarily complex	**1.0**

Three (3) statements were employed for measuring the Perceived Usefulness attribute, as revealed in Table 5. By investigating the participants further, the responses indicated that the application is useful diagnosing breast cancer problems. The high mean score for PU1, PU2 and PU3 with 4.4, 4.4and 4.44 respectively supported this fact. From the accumulation of feedbacks, the median score gotten was 4, proving the overall affirmation to the usefulness of the application by the health experts' perception.

Table 5: Perceived usefulness responses

Statements	**Mean**
PU1. I find this mobile application useful for helping individuals/physicians diagnose breast cancer	**4.4**
PU2. I need to ask less questions before I could start using this application	**4.4**
PU3. I find the application useful for my job	**4.4**

The two questions PEC1 and PEC2 were used for measuring users' perception of external control as seen in Table 6. From the evaluation, it was discoverd that participants attest to being willing to ready to possess every resources needed and knowledge required to implement the application. In particular, the participants agree that they have the knowledge necessary to use the application (The mean score of PEC1 at 4.3) and to a lower, yet, acceptable level, the necessary resources needed for the application usage (The mean score of PEC2 at 4.3). The medium score for the PEC was gotten as 4.0 showing a high level of perception of necessary resources had.

Table 6: Perception of external control responses

Statements	**Mean**
PEC1. I have the knowledge necessary to use the application	**4.3**

PEC2. I have the resources necessary to use the application	**4.3**

Job Relevance of the application based on the responses got from the participant was evaluated using three statements, REl1, REL2, and REL3 as shown in Table 7. Based on the REL construct, there was a high mean score for REL3. The users proved having an agreement to the fact that the application is in adherence to current practices, which can be seen from the mean score of 4.4. Also, REL1 showed a mean score of 4.3 which was slightly higher, proving that the arrangement of the operation of the application is helpful. REL2 gave a mean score of 4.2 indicating that the application being able to address the entire symptoms necessary (i.e. "The application is able to address the entire symptoms necessary").

Table 7: Job relevance responses

Statements	Mean
REL1.The arrangement of the operation of the application is helpful	**4.3**
REL2. The application is able to address the entire symptoms necessary	**4.2**
REL3. The application is in adherence to current practices	**4.4**

6. CONCLUSION AND RECOMMENDATION

This research paper presented the implementation of a fuzzy expert application for diagnosing the type of breast cancer and rate of the disease in a patient. It was developed for addressing urgent and crucial need in the medical domain as the rate at which women suffer from the disease is intense. The application is an outcome of a study that has progressed through various aspects of problem identification, feasibility study, information gathering, system design and implementation, expert feedback and the usability evaluation, has positioned the application as software providing needful solution in the medical domain. The experts indicate their consideration of the application as highly useful and effective in diagnosing breast cancer. This will be of great advantage to easing the diagnoses and recommendation of treatment to a cancer patient. In addition, feedbacks that are unsolicited from the experts has also demonstrated the potential of this application. Finally, a comprehensive approach for the diagnosis system usability evaluation was provided using the Technology Acceptance Model.

As pervasive technologies become a more integral part of everyday life, attention is now being paid to how these ubiquitous computing systems can be used to monitor and contribute to breast cancer diagnosis services. This paper diagnosed breast cancer problem, prescribing medical recommendation to treat the disease. We intend carrying out further research by enabling users input their symptoms so as to diagnose result, which may be more efficient and reliable.

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