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EXPLANIABLE DEEP LEARNING FOR THE BREAST CANCER DETECTION BRIDGING ACCURACY AND INTERPRETABILITY

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ABSTRACT
Cancer remains one of the leading causes of mortality worldwide, making early and accurate detection essential for improving patient survival rates and treatment outcomes. Recent advancements in artificial intelligence and machine learning have significantly enhanced the capability of automated cancer detection systems. However, many highly accurate deep learning models often operate as black-box systems, limiting their interpretability and reducing the trust of healthcare professionals in clinical decision-making. This paper presents a cancer detection framework that bridges accuracy and interpretability by integrating advanced machine learning techniques with explainable artificial intelligence (XAI) methods. The proposed approach analyzes medical data such as imaging scans, histopathological images, and clinical records to accurately identify cancerous conditions while providing transparent explanations for model predictions. By combining high-performance predictive models with interpretability mechanisms, the framework enables clinicians to understand the factors influencing diagnostic decisions. Experimental analysis demonstrates that the proposed system achieves high detection accuracy while maintaining explainability and clinical relevance. The developed framework supports reliable, trustworthy, and efficient cancer diagnosis, thereby enhancing healthcare decision-making and patient care.

I. INTRODUCTION

In Brazil, for the biennium 2018-2019, 59,700 new cases of breast cancer are anticipated. Breast cancer accounts for 25.2% of female malignancies and an incidence rate of 43.3 /100,000 women. An estimated in 522,000 deaths a year, breast cancer is responsible for 14.7% of all deaths. Although it has a higher mortality rate than other malignancies, it has a low fatality because its mortality rate is less than 1/3 of the incidence rate. It is the most surviving cancer type annually, approximately 8.7 million. In developed countries the numbers have stabilized, followed by a drop in the last decade. In underdeveloped countries, detection occurs in more advanced stages, contributing to the treatment-related morbidity rate .The disruptive technology applications in the health area have been focused on studying the potential impact on human society.

Regarded the assisted cancer diagnosis, it is expected that the involvement of machine learning in diagnosis could provide doctors a second opinion and help them to make a faster/ better diagnosis. Recently, Google reached an accuracy level in identifying skin cancers, suggesting that the cancer accessibility diagnosis could potentially be extended for aside from medical clinics. The application employed Deep Learning to train a neural network classifier with one of the Wisconsin breast cancer data sets (diagnosis), using the classifier to predict the mammary mass prediction with 30 real numerical values that characterize the cell nucleus properties of mammary mass. Although many studies have been studied breast cancer prediction/classification, we propose a study using a specific algorithms group, containing a random forest split for diversified analyzes. The focus in this field is to apply classification techniques and perform classification/prediction directly from the digital image. In our experiment, we showed the classification of breast cancer with numerical data calculated from the digitized image of a fine needle aspirate (FNA) of a mammary mass. This study aims to evaluate the predictive models of machine learning classification regarding accuracy, objectivity, and reproducibility of the malignant neoplasm diagnosis with fine needle aspiration. An experiment was performed with a data set of 569 women diagnosed with breast cancer or not. Throughout the outcomes, it was possible to state that the DNN's model has the best results among the other techniques, having a mean accuracy of 92%, while Random Forest collections presenting a ROC curve coefficient of 94%.

The primary contribution provided an overview of machine learning models, looking for their outcomes when tested with a breast cancer data set. We selected models previously used in other studies, applying a different workflow in training data phase. Moreover, we add a Deep Neural Network method, which isn't tested yet for this data set. Some studies have applied this approach in other image datasets, being proved their utility in this field. In our context, we aim to show the network results were evaluated by standard metrics of machine learning and discuss their application when compared to other methods. The comparison of these techniques, adding deep neural networks was expected from other studies in this area.

Cancer is the second reason of human death all over the world and accounts for roughly 9.6 million deaths in 2018. Globally, for 1 human death in 6 can be said that is caused by cancer. Almost 70 percent of the deaths from cancer disease happen in countries that have low and middle income. The most common cancer type among women are breast, lung and colorectal, which totally symbolize half of the all cancer cases. Also, breast cancer is responsible for the thirty percent of all new cancer diagnoses in women. Machine learning (ML) methods ensure analyzing the data and extracting key characteristics of relationships and information from dataset. Also, it creates a computational model for best description of the data. Especially, according to in researches about cancer disease, it can be said that ML techniques can be handled on early detection and prognosis of cancer. Asri et al. have compared some machine learning algorithms for the risk prediction and diagnosis of breast cancer. Support Vector Machine (SVM), k-Nearest Neighbors (kNN), Naive Bayes (NB) and Decision Tree (C4.5) have been applied Wisconsin Breast Cancer (Original) dataset. SVM classification method has been given the highest accuracy value (97.13 %) with least error rate when the experimental results were compared.

Bazazeh and Shubair have investigated the comparative study of machine learning techniques as Support Vector Machine (SVM), Random Forest (RF) and Bayesian Network (BN) for detection and diagnosis of breast cancer. The Original Wisconsin Breast Cancer was used as a dataset and Weka software was used as a Machine Learning tool. The key performance parameters of machine learning classifiers have been compared according to accuracy, recall, precision and ROC area. They have suggested that BN has the best performance according to recall and precision values and RF technique has optimum performance in term of ROC area. Ahmad et al. have exercised machine learning algorithms for predicting the rate of two years recurrence of breast cancer disease. The dataset has been obtained from Iranian Center of Breast Cancer (ICBC) program, collected the time period of 1997-2008 years. The dataset is consisted of population characteristics and 22 input variables also the cases have been collected from 1189 women of diagnosed breast cancer. Artificial Neural Network (ANN), Support Vector Machine (SVM) and Decision Tree (DT) have been applied and SVM has been showed the best performance with highest accuracy and least error rate. Bektas and Babur have studied on diagnosis of breast cancer using machine learning techniques. Kent Ridge Microarray has been used 2 datasets and support vector machine, k-star, random forest algorithm and voted perceptron have been applied. Random forest algorithm has been showed more performance than applied feature selection method. Chen et al. have applied Support Vector Machine classification algorithm on Wisconsin Diagnostic Breast Cancer dataset. In the study, the training and testing sets have been split as 50-50%, 70-30% and 80-20%. According to different training/testing percent, accuracy values have been calculated.

II. LITERATURE SURVEY

1) Detecting Cancer Metastases On Gigapixel Pathology Images

AUTHORS: Y. Liu, K. Gadepalli, M. Norouzi, G. E. Dahl, T. Kohlberger, A. Boyko, S. Venugopalan, A. Timofeev, P. Q. Nelson, G. S. Corrado

Each year, the treatment decisions for more than 230,000 breast cancer patients in the U.S. hinge on whether the cancer has metastasized away from the breast. Metastasis detection is currently performed by pathologists reviewing large expanses of biological tissues. This process is labor intensive and error-prone. We present a framework to automatically detect and localize tumors as small as 100 x 100 pixels in gigapixel microscopy images sized 100,000 x 100,000 pixels. Our method leverages a convolutional neural network (CNN) architecture and obtains state-of-the-art results on the Camelyon16 dataset in the challenging lesion-level tumor detection task. At 8 false positives per image, we detect 92.4% of the tumors, relative to 82.7% by the previous best automated approach. For comparison, a human pathologist attempting exhaustive search achieved 73.2% sensitivity. We achieve image-level AUC scores above 97% on both the Camelyon16 test set and an independent set of 110 slides. In addition, we discover that two slides in the Camelyon16 training set were erroneously labeled normal. Our approach could considerably reduce false negative rates in metastasis detection.

2) Detection of mass regions in mammograms by bilateral analysis adapted to breast density using similarity indexes and convolutional neural networks

AUTHORS: B. Diniz

The processing of medical image is an important tool to assist in minimizing the degree of uncertainty of the specialist, while providing specialists with an additional source of detect and diagnosis information. Breast cancer is the most common type of cancer that affects the female population around the world. It is also the most deadly type of cancer among women. It is the second most common type of cancer among all others. The most common examination to diagnose breast cancer early is mammography. In the last decades, computational techniques have been developed with the purpose of automatically detecting structures that maybe associated with tumors in mammography examination. This work presents a computational methodology to automatically detection of mass regions in mammography by using a convolutional neural network.

The materials used in this work is the DDSM database. The method proposed consists of two phases: training phase and test phase. The training phase has 2 main steps: (1) create a model to classify breast tissue into dense and non-dense (2) create a model to classify regions of breast into mass and non-mass. The test phase has 7 step: (1) preprocessing; (2) registration; (3) segmentation; (4) first reduction of false positives; (5) preprocessing of regions segmented; (6) density tissue classification (7) second reduction of false positives where regions will be classified into mass and non-mass.

The proposed method achieved 95.6% of accuracy in classify non-dense breasts tissue and 97,72% accuracy in classify dense breasts. To detect regions of mass in non-dense breast, the method achieved a sensitivity value of 91.5%, and specificity value of 90.7%, with 91% accuracy. To detect regions in dense breasts, our method achieved 90.4% of sensitivity and 96.4% of specificity, with accuracy of 94.8%.

3) Is mass classification in mammograms a solved problem? - a critical review over the last 20 years

AUTHORS : R. W. D. Pedro, A. Machado-Lima, and F. L. Nunes

Breast cancer is one of the most common and deadliest cancers that affect mainly women worldwide, and mammography examination is one of the main tools to help early detection. Several papers have been published in the last decades reporting on techniques to automatically recognize breast cancer by analyzing mammograms. These techniques were used to create computer systems to help physicians and radiologists obtain a more precise diagnosis. The objective of this paper is to present an overview regarding the use of machine learning and pattern recognition techniques to discriminate masses in digitized mammograms. The main differences we found in the literature between the present paper and the other reviews are: 1) we used a systematic review method to create this survey; 2) we focused on mass classification problems; 3) the broad scope and spectrum used to investigate this theme, as 129 papers were analyzed to find out whether mass classification in mammograms is a problem solved. In order to achieve this objective, we performed a systematic review process to analyze papers found in the most important digital libraries in the area. We noticed that the three most common techniques used to classify mammographic masses are artificial neural network, support vector machine and k-nearest neighbors. Furthermore, we noticed that mass shape and texture are the most used features in classification, although some papers presented the usage of features provided by specialists, such as BI-RADS descriptors. Moreover, several feature selection techniques were used to reduce the complexity of the classifiers or to increase their accuracies. Additionally, the survey conducted points out some still unexplored research opportunities in this area, for example, we identified that some techniques such as random forest and logistic regression are little explored, while others, such as grammars or syntactic approaches, are not being used to perform this task.

4) A Fully Integrated Computer-Aided Diagnosis System For Digital X-Ray Mammograms Via Deep Learning Detection, Segmentation, And Classification

AUTHORS : **M. A. Al-antari et al**

A computer-aided diagnosis (CAD) system requires detection, segmentation, and classification in one framework to assist radiologists efficiently in an accurate diagnosis. In this paper, a completely integrated CAD system is proposed to screen digital X-ray mammograms involving detection, segmentation, and classification of breast masses via deep learning methodologies. In this work, to detect breast mass from entire mammograms, You-Only-Look-Once (YOLO), a regional deep learning approach, is used. To segment the mass, full resolution convolutional network (FrCN), a new deep network model, is proposed and utilized. Finally, a deep convolutional neural network (CNN) is used to recognize the mass and classify it as either benign or malignant. To evaluate the proposed integrated CAD system in terms of the accuracies of detection, segmentation, and classification, the publicly available and annotated INbreast database was utilized. The evaluation results of the proposed CAD system via four-fold cross-validation tests show that a mass detection accuracy of 98.96%, Matthews correlation coefficient (MCC) of 97.62%, and F1-score of 99.24% are achieved with the INbreast dataset. Moreover, the mass segmentation results via FrCN produced an overall accuracy of 92.97%, MCC of 85.93%, and Dice (F1-score) of 92.69% and Jaccard similarity coefficient metrics of 86.37%, respectively. The detected and segmented masses were classified via CNN and achieved an overall accuracy of 95.64%, AUC of 94.78%, MCC of 89.91%, and F1-score of 96.84%, respectively. Our results demonstrate that the proposed CAD system, through all stages of detection, segmentation, and classification, outperforms the latest conventional deep learning methodologies. Our proposed CAD system could be used to assist radiologists in all stages of detection, segmentation, and classification of breast masses.

5) Performance evaluation of machine learning Methods for breast cancer prediction

AUTHORS: Y. Li and Z. Chen

Breast cancer is the most common invasive cancer in women and the second main cause of cancer death in females, which can be classified Benign or Malignant. Research and prevention on breast cancer have attracted more concern of researchers in recent years. On the other hand, the development of data mining methods provides an effective way to extract more useful information from complex database, and some prediction, classification and clustering can be made according to extracted information. In this study, to explore the relationship between breast cancer and some attributes so that the death probability of breast cancer can be reduced, five different classification models including Decision Tree (DT), Random Forest (RF), Support Vector Machine (SVM), Neural Network (NN) and Logistics Regression (LR) are used for the classification of two different datasets related to breast cancer: Breast Cancer Coimbra Dataset (BCCD) and Wisconsin Breast Cancer Database (WBCD). Three indicators including prediction accuracy values, F-measure metric and AUC values are used to compare the performance of these five classification models. comparative experiment analysis shows that random forest model can achieve better performance and adaptation than other four methods. Therefore, the model of this study is approved to possess clinical and referential values in practical applications.

III. SYSTEM ANALYSIS AND DESIGN

EXISTING SYSTEM:

In Existing system the mammography mass detection was designed to increase the performance of specialists by serving as double-reading systems and contributing to the reduction of the number of false-positive or false-negative. There are numerous mass segmentation methods in mammograms, a summary of the most relevant methods are selected from dataset, the evaluation metrics presented are the most frequently used in the literature. However, it is considered an unresolved problem, mainly due to the small number of images used in the studies, mass variability and computational limitations.

DISADVANTAGES OF EXISTING SYSTEM:

- To obtaining a consistent dataset and labeled by specialists in the medical field is one of the main challenges in the development of a CAD (Computer-aided detection)
- The amount of images provided by the bases is still insufficient for the generalization of the problems, due to the variability and size of the masses

  Algorithm: Yolo, Full Resolution Convolutional Network (FrCN)

PROPOSED SYSTEM:

A deep belief network was used for the detection of breast cancer using a technique of back-propagation supervised path using the Wisconsin Breast Cancer Dataset (WBCD). This approach offers a 99% accuracy in the classification task. Compositions using deep learning neural network model and SVDD, a variant of the support vector machine, show experimental results to learn multi-class data without severe over-fitting problems. The random Forest model also presents great results with our implementations. We tested with other models like Decision Tree, Support Vector Machine, Neural Network, and Multi-Layer Perceptron. In this study were used data sets combined and splitting for testing, as well as accuracy indicator as a measure for assessing the results.

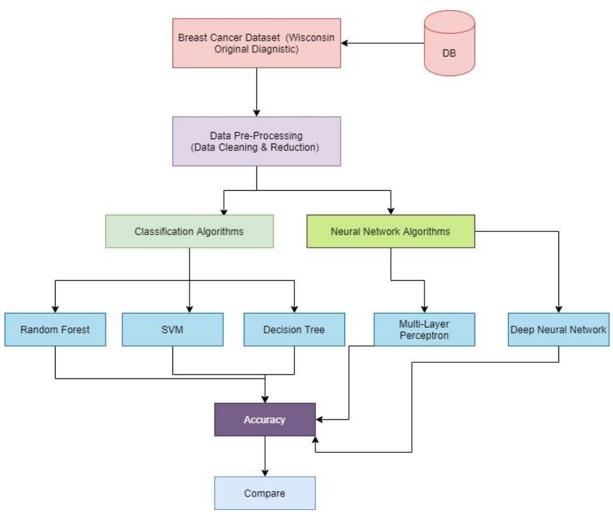
ADVANTAGES OF PROPOSED SYSTEM:

- Identifying the use of data-enhancement and transfer learning techniques that indicate an improvement in the performance of deep learning models.
- One of the main advantages of using deep networks techniques when compared to manual resource extraction techniques is the ability to learn a set of high-level attributes and provide high accuracy even in complex problems

Algorithm: Multi-Layer Perceptron, Decision Tree, Random Forest, Support Vector Machine, Deep Neural Network.

SYSTEM DESIGN

SYSTEM ARCHITECTURE:



IV. SYSTEM IMPLEMENTATION

MODULES:

- **User**
- **Admin**
- **Classification**
- **Neural Network**

MODULES DESCRIPTION:

User:

The User can register the first. While registering he required a valid user email and mobile for further communications. Once the user register then admin can activate the customer. Once admin activated the customer then user can login into our system. The user can get the data from University of Wisconsin Hospital database.

The data are stored in media folder. Before processing the data we need to preprocess the data. At the time of preprocess we can generate the graphs like hist diagram of the selected attributes. Later we can split the data into training and testing. The 80% data goes to training and 20% we are testing for our results. The sklearn model selection libraries can do the process.

Admin:

Admin can login with his credentials. Once he login he can activate the users. The activated user only login in our applications. The admin can set the training and testing data for the project. In the code the dataset can be found under media folder. The dataset in the format of comma separated values. User can perform the cleaning and fill with its mean values of missing featured from the columns. Admin also check the accuracy scores of proposed algorithms. First admin can test the classification results. To see the graph we need to enable matlotlib.use("TkAgg"). Once it done the he can test the deep neural network algorithm accuracy. It is better to user before running project we need to enable matplotlib.user("Agg") then we can solve the server restarts problems.

Data Classification:

- **Decision Tree**

Decision tree algorithms are considered an alternative for regressions and classifiers tasks. the Decision Tree Algorithms structure can be compared to a set of rules (If-then), classifying new samples and trying to develop an understandable and accurate model. Thereby, the Decision Tree algorithm operates such as others Supervised Learning techniques, working with sets for training and tests.

- **Random Forest**

Defined as an ensemble learner, Random Forest works creating multiple classifiers and regression trees, each one trained based on the subset of training examples and the subset of all given features at random. Each decision tree, the input enters at the root of the tree and traverses down the tree according to the split decision at each node.

- **Support Vector Machine**

Support Vector Machines (SVMs) is a supervised machine learning technique, having great theoretical foundations and excellent empirical successes. The SVM has the constraint which makes the total weight for the positive class equal to that of the negative class. This kind of technique has been applied to different classification tasks such as text classification, object recognition, as well as prediction tasks.

Neural Network

- **Multi-Layer Perceptron**

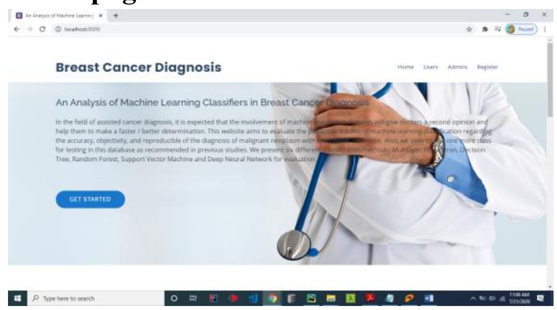
Multilayer Perceptron (MLP) is a classifier based on the neural network's, very similar to perceptron but with more layers. Each output layer receives the stimulus of the intermediate layer, building a set of appropriate outputs. MLP uses a supervised learning technique knew as backpropagation function, which learns iteratively by processing data set of training examples, comparing the network's prediction for each target value.

- **Deep Neural Network**

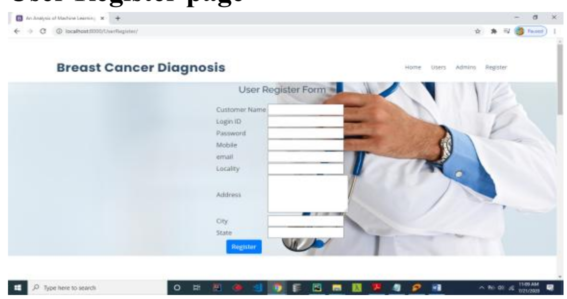
Lastly, we considered using a deep neural network to verify their performance related to this database. Presenting relevant results in recent studies, this network has been used in many tasks we found value in testing this network due to good results in previous binary classification studies. Also, DNN's algorithms were suggested for application in this database as a way to verify their performance in comparison to traditional methods of machine learning.

V. SCREEN SHOTS

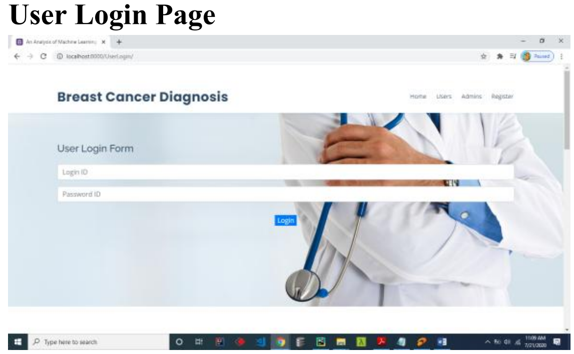
Home page



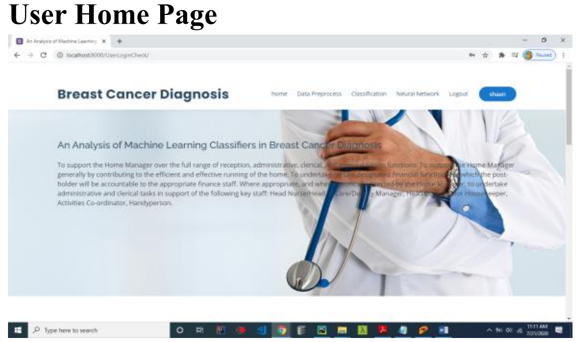
User Register page



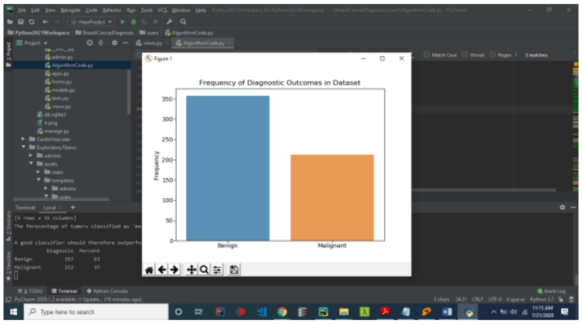
User Login Page



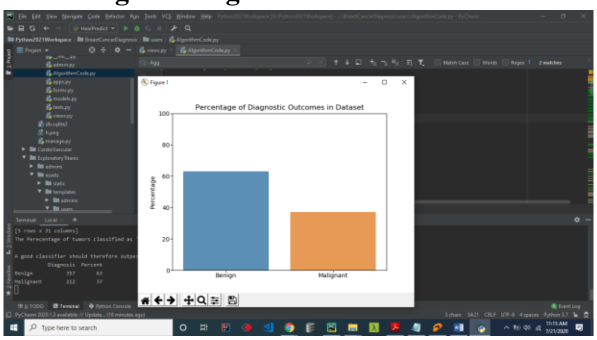
User Home Page



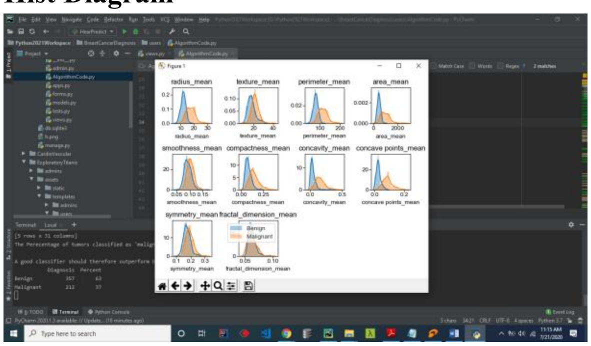
Frequency Diagnosis



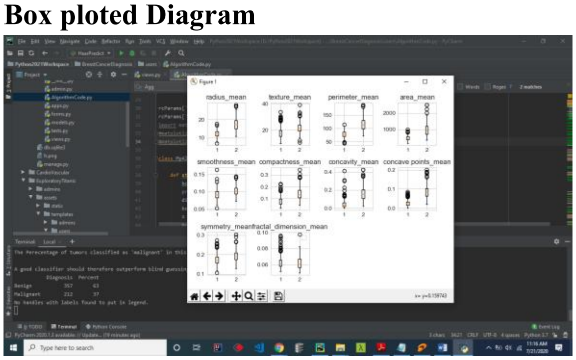
Percentage of Diagnosis



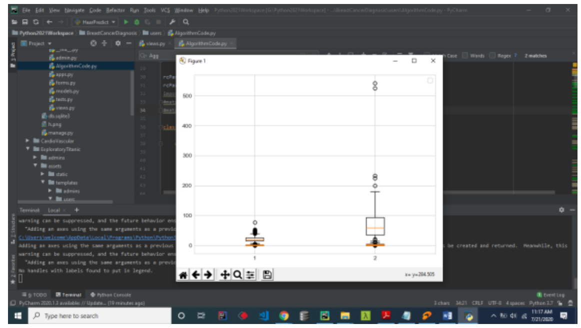
Hist Diagram



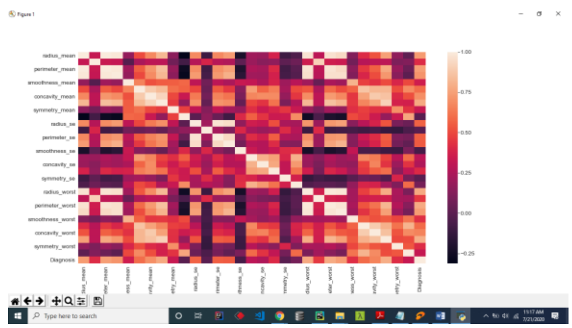
Box ploted Diagram



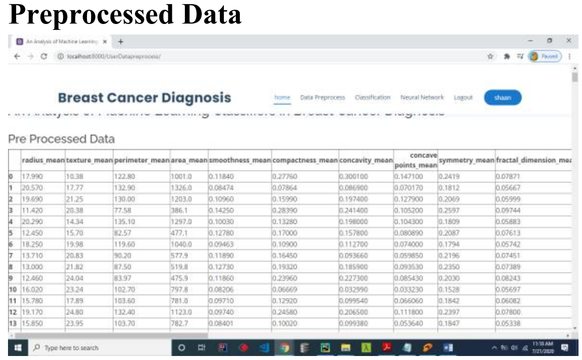
Box ploted diagram



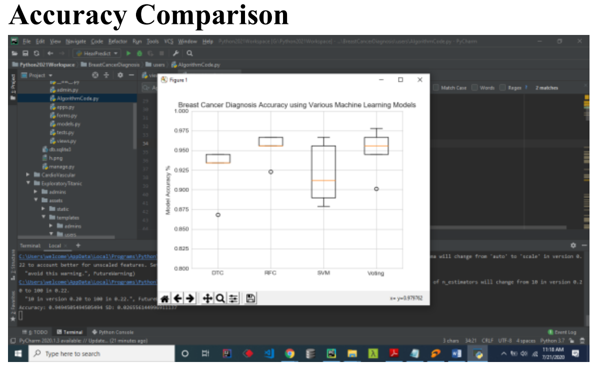
Correlated Matrix



Preprocessed Data



Accuracy Comparison



Explained variance

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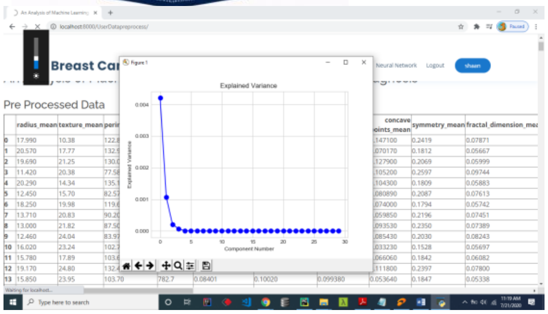
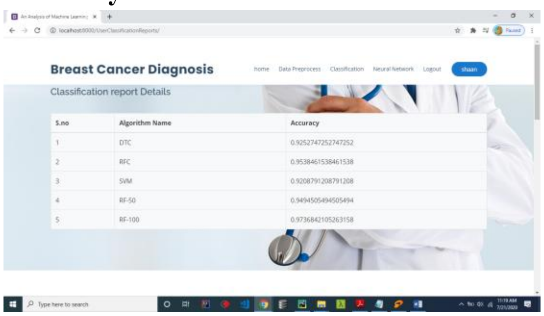
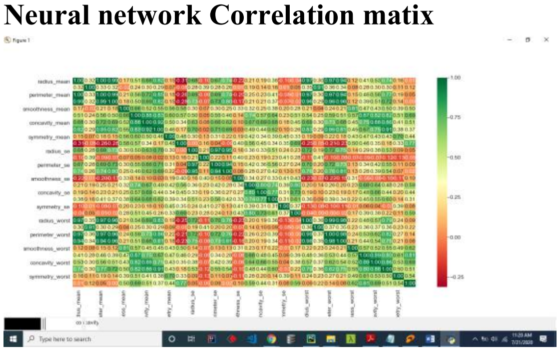


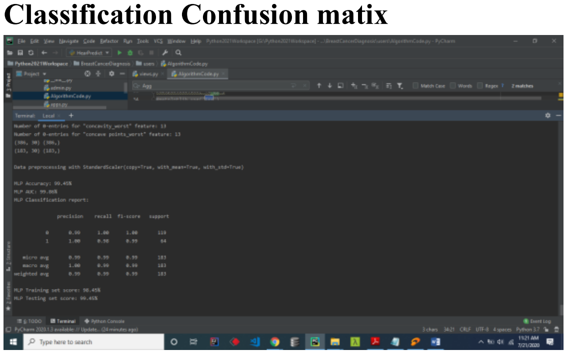
Accuracy:



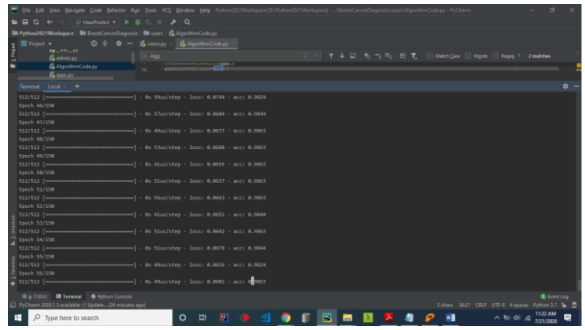
Neural network Correlation matix



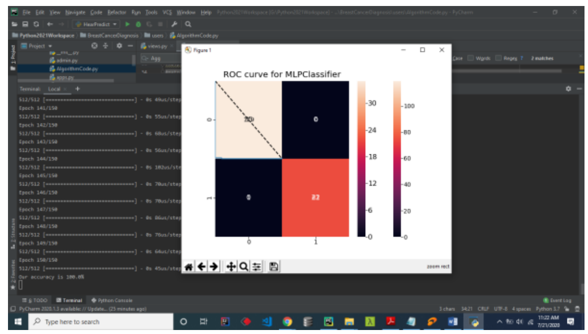
Classification Confusion matix



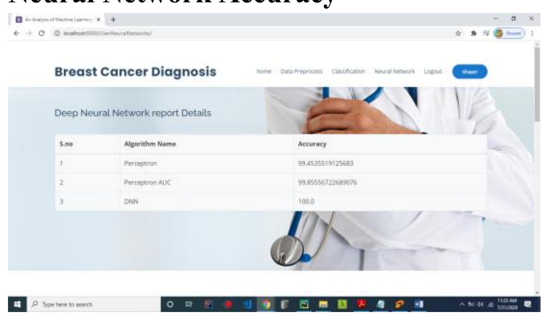
Epoch



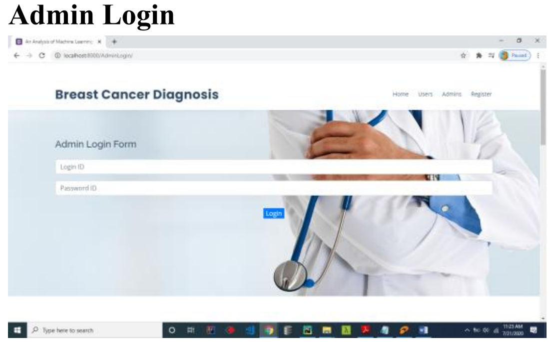
Roc Curve



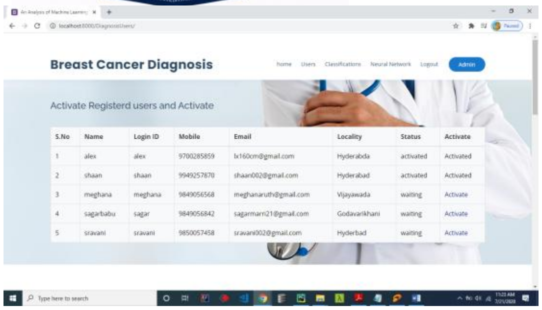
Neural Network Accuracy



Admin Login



Activation users



VI. CONCLUSION

This study presented a cancer detection framework designed to bridge the gap between predictive accuracy and model interpretability in medical diagnosis. The proposed approach integrates advanced machine learning and explainable artificial intelligence techniques to accurately identify cancerous conditions while providing transparent insights into the decision-making process. Experimental observations indicate that the framework achieves high diagnostic performance without sacrificing interpretability, enabling healthcare professionals to better understand and validate model predictions. The inclusion of explainability mechanisms enhances trust, accountability, and clinical acceptance of artificial intelligence-based diagnostic systems. Furthermore, the proposed framework supports early cancer detection, informed treatment planning, and improved patient outcomes. By balancing accuracy and transparency, the system addresses a critical challenge in medical artificial intelligence and contributes to the development of trustworthy healthcare technologies. Future research may focus on integrating multimodal medical data, deep learning-based explainability techniques, federated learning frameworks, and real-time clinical decision support systems to further enhance cancer detection accuracy and interpretability in diverse healthcare environments.

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