A Novel Approach For Breast Cancer Detection Using Multi-Phase Machine Learning Techniques

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Abstract:

Breast cancer has risen to prominence as one of the leading causes of death during the last ten years. Researchers in the field of cancer have developed algorithms that are capable of detecting Breast cancer disease in its early stages using a number of machine learning approaches. This work proposes and evaluates a novel brain MRI-based extraction method. This suggested research offers a unique method for diagnosing Breast cancer using MRI images. We used multi-phase feature selection approaches to improve performance. In order to pick more ideal features, we segmented the images using FBSO feature selection approach and defined three standard datasets S1, S2, and S3 and analysed them using deep learning and machine learning methods. In our study, we achieved 98.9% classifier optimality and 96.7% accuracy. In compared to earlier studies, the novel method showed the greatest level of reliability and had the most efficient classifier system

Keywords: Breast cancer disease, Feature extraction and selection, Fuzzy PSO, Deep Learning, Classification.

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1. Introduction

Breast cancer is the primary cause of mortality among women worldwide. The levels of incidence in developed countries are higher in comparison to those in developing and underdeveloped nations. Breast cancer incidence is observed to be elevated among women of reproductive age, whereas it is comparatively lower among women who have reached menopause [1].

This paper provides a summary of breast cancer infectious diseases, highlighting key factors and methods for diagnosing it. The categorization of breast cancer within the medical domain presents a complex challenge. The focus of this paper is to address the obstacles encountered during this process and the methodologies employed to surmount them. Neural networks with image-preprocessing, segmentation, feature extraction, and classification are a novel approach for categorizing images in breast cancer analysis [2].

Breast cancer is a prevalent ailment characterised by the unbridled proliferation of anomalous cells in the mammary gland. Breast anomalies possess certain characteristics that, in conjunction with the inherent limitations of human visual perception, can result in occasional oversight or misclassification of abnormalities. Consequently, biopsies are performed that are not deemed necessary. A system for Computer Aided Diagnosis (CAD) has been devised to tackle this matter [3]. The present thesis work involves the implementation of a CAD system that integrates image processing techniques and Machine Learning algorithms. Computer-aided detection (CAD) aims to identify and precisely locate anomalies in their initial stages, thereby impeding their progression [4-8].

1.1 Breast Cancer Diagnosis

Multiple medical imaging techniques are utilized in the diagnosis of breast cancer [6]. Medical imaging techniques such as ultrasound, magnetic resonance imaging (MRI), and X-ray are utilized in the detection of early-stage breast cancer. The aforementioned imaging methods are utilized in the diagnosis of breast cancer within the medical field. Basic techniques in Breast Cancer disease are below:

1.1.1 Ultrasound Imaging

The ultrasound image produced exhibits a real-time frame rate of around twenty-five frames. The ultrasound visualization technique is capable of detecting breast cancers of a very small size, specifically those measuring 3mm, owing to the transducers utilized. The amalgamation of ultrasound imaging and mammography has yielded a predictive efficacy of 98% for the identification of invasive lobular carcinoma, with a value of 11. Ultrasound imaging is the primary modality for detecting the majority of invasive lobular carcinomas.

1.1.2 Magnetic Resonance Imaging (MRI)

Prior to the surgical procedure, the localization of breast cancer is ascertained via Magnetic Resonance Imaging (MRI). The advancements in temporal and spatial resolution of breast MRI have facilitated the identification of ductal carcinoma in situ and small invasive cancers. Magnetic resonance imaging (MRI) is utilized as an adjunct to ultrasound imaging in lieu of the former for women who are deemed high-risk. Magnetic Resonance Imaging (MRI) is a relatively advanced diagnostic imaging modality that requires the administration of gadolinium via intravenous injection. The administration of this injection has been found to result in the development of nephrogenic systemic fibrosis in certain patients who exhibit impurities in renal function. Breast magnetic resonance imaging (MRI) is contraindicated for patients with renal disorders. The utilization of MRI technology for breast cancer diagnosis is contraindicated for individuals who have received pacemaker or other metallic implants due to the presence of strong magnetic fields [7-8].

1.1.3 X-Ray

X-rays are employed for the purpose of acquiring two-dimensional images or cross-sectional views of the organs that are being visualized. Subsequently, a range of algorithms are employed to produce coherent three-dimensional (3D) visuals, which are furnished with anatomical data such as the location of lesions. Intravenous administration of iodinated contrast media is utilized to enhance the CT image contrasts. The injection facilitates high sensitivity visualization of tumors. The study involved the examination of a patient presenting with inflammatory and enlarged axillary lymph nodes, with suspected metastatic differentiation. The diagnostic accuracy of CT perfusion was evaluated in this case. The CT perfusion technique efficiently diagnoses breast cancer patients who exhibit improved axillary lymph nodes. The CT image depicted in Figure 2 illustrates the detection of breast cancer.

1.2 Computer Aided System (CAD)

Computer-aided detection (CAD) is a highly advanced technique that assists radiologists in accurately detecting diseases through the interpretation of medical images, including mammograms. Consequently, the health concerns have been addressed. The utilisation of CAD algorithms facilitates the precise categorization of patients into either normal or abnormal groups. The complexity of breast cancer, coupled with the vast amount of data obtainable from breast cancer examinations, has spurred the emergence of computer-aided detection (CAD) [9]. The purpose of computer-aided detection (CAD) is to decrease the occurrence of erroneous positive and negative results in mammography screening by detecting concerning mass lesions and micro calcifications. Consequently, Computer-Aided Diagnosis (CAD) was developed to aid radiologists in accurately identifying potential pathological lesions. The development of a CAD system involves several stages, including digitization of mammography images, pre-processing of images, and enhancement of pictures.

The utilization of computer-aided detection (CAD) is believed to have the potential to aid in the detection and diagnosis of breast cancer. As a result, medical practitioners, including radiologists, are keen to leverage the successful clinical applications of breast cancer detection to enhance the efficacy of available treatment options and decision-making [10]. Conversely, it is widely acknowledged that numerous countries endorse expeditious screening methods for the timely detection of primary symptoms of breast cancer. Numerous techniques have been suggested to enhance the image processing approach in light of the inherent difficulties associated with imaging methodologies. Conversely, a significant number of researchers are motivated by the imperative to develop efficacious and accurate techniques for timely detection of breast cancers, with the aim of optimizing the possibility of successful treatment.

1.3 MACHINE LEARNING

Machine learning algorithms refer to a collection of mathematical methods and rules that can be employed to identify and comprehend the fundamental patterns present in extensive datasets. There is a widespread consensus that the utilization of machine learning algorithms is indispensable in constructing any predictive model aimed at forecasting illnesses. The machine learning algorithm instructs the model to identify patterns within the training data, and subsequently evaluates its efficacy through testing against separate data. In order to develop a prognostic model capable of effectively processing intricate data and furnishing dependable outcomes, it is imperative to employ machine learning algorithms. Developing a disease prediction model utilizing machine learning algorithms is a viable approach to addressing the matter at hand. The acquisition, preprocessing, analysis, optimization, and classification of data are all integral components of the illness prognostication framework. The field of machine learning encompasses various subfields, including supervised learning, unsupervised learning, and reinforcement learning [11-12].

1.4.1 Deep Neural Network

Deep Neural Network is a subfield of machine learning that centers on the development and application of artificially intelligent neural network algorithms. These networks are designed based on the structural and functional characteristics of the human brain. It emulates the cognitive processes of the human brain. Currently, there exists a notable level of enthusiasm towards deep learning across various domains, with a particular emphasis on the examination of medical data. The utilization of deep learning involves the utilization of models based on the deep neural system, which is a variant of the neural network that approximates the human brain to a greater extent through the implementation of more sophisticated mechanisms than those used in the basic neural network [13].

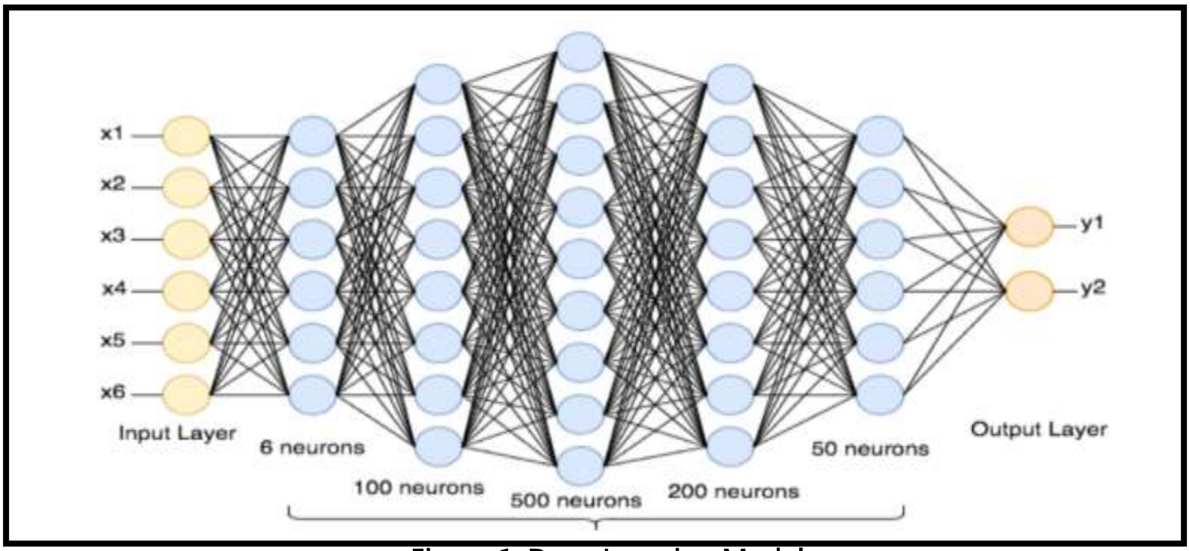

Figure 1: Deep Learning Model

As shown in Figure 3, Deep Learning models are structured in a hierarchical manner, consisting of multiple layers. A standard model typically comprises a minimum of three tiers. Each stratum facilitates the reception and transmission of data from the antecedent stratum. Classification involves the categorization of input data, which may take the form of visual, quantitative, or signal data, with the ultimate goal of predicting the corresponding label. The deep learning process involves the conversion of quantitative methods into matrix format, which can then be transformed into real data format as required for the categorization of medical information.

1.5 Problem Statement

The advent of the information technology era has facilitated enhanced storage and analysis capabilities for vast quantities of data. The utilisation of advanced computational technology and the creation of novel and efficient algorithms play a crucial role in the implementation of information technology to address complex challenges across various fields of study. A vast number of databases and publications house extensive quantities of data pertaining to various drugs, encompassing biological, chemical, and clinical information.

The availability of data plays a crucial role in addressing problems through computational approaches, and in the majority of cases, the utilisation and creation of machine learning models necessitate the use of clean data. This method can be applied to molecules or compounds for identifying the breast cancer disease. The primary objective of this study is to develop intelligent and expert diagnostic systems that are computer-aided and employ soft computing and Machine Learning techniques to analyse and diagnose breast cancer. These systems are crucial instruments for the detection and diagnosis of the disease.

2. Literature Survey

The investigation of concerns related to breast cancer is associated with unpredictability and fuzziness arising from imprecise input actions and insufficient data from experts. Although there exist several technology-focused studies pertaining to breast cancer analysis, only a limited number of studies have been initiated for the purpose of breast cancer prognosis.

Lin, H et al. (2023) discussed an unclear expert system is proposed for the purpose of providing supplementary assistance in the process of breast cancer diagnosis. The system is designed to aid in the prediction of breast cancer outcomes. This methodology is sufficiently effective in capturing ambiguous and imprecise data commonly encountered in the classification of breast cancer. This paper employed a fuzzy reasoning model that exhibits a high level of interpretability and enables early diagnosis of the system's precision. The results indicate an average accuracy of 95%, which highlights the system's superiority over other related works in the forecasting process. The analysis and prediction of breast cancer posed a significant challenge to medical researchers.

The utilization of machine learning and data mining techniques has revolutionized the field of breast cancer. Conduct a diagnosis and make a forecast. Breast cancer is a malignant neoplasm that arises from the cells of the breast tissue. The process of diagnosing breast cancer involves analyzing the presence of a breast lump and forecasting the potential for cancerous growth. This analysis ultimately informs the design of an appropriate treatment plan. According to the Breast Cancer Forecast, there is a likelihood of recurrence of Breast Cancer in patients who have undergone cancer removal. Hence, the aforementioned issues primarily fell within the purview of organizational challenges. This research paper comprises a comprehensive analysis of multiple evaluations and technical literature pertaining to the diagnosis and prognosis of breast cancer.

Abunasser et al. (2022) this study aims to enhance the accuracy of breast cancer detection and prognosis. The aim of our investigation is to elucidate the utilisation of Bayesian Belief Networks (BBN) in the implementation of an automatic assistance tool for the identification of breast cancer. The utilisation of Bayesian Belief Network is an insightful approach for disease detection, as it involves the examination of the interplay between clinical judgements, physical findings, and specialised research centres at a standard level. A concise computational tool and its corresponding stages were identified. It has been demonstrated that the utilisation of conditionindependent requirements through impact chains enables the incorporation of a large-scale example into a Bayesian system that utilises limited space. This approach is often capable of producing probabilistic implications among the features or highlights within a reasonable timeframe. The subsequent stages for implementing the Bayesian Belief Network are outlined. The Bayesian network possesses a significant advantage in that it can effectively leverage the explicit structure of the domain model to generate a visual representation of the learning process. The propagation of self-sufficiency through network topology reveals the development of effective strategies for performing computations across networks. The researcher aims to facilitate the application of computer network-based detection in mammography by establishing an interface between the Bayesian machine learning algorithm and radiologists. This would enable radiologists to interact with the system by providing only a limited number of informative images, which can be processed by the powerful learning algorithm.

Abdar et al. (2019) the proposal entails the development of an automated diagnostic system for the detection of breast cancer, which is based on the utilisation of Association Rules (AR) and Neural Network (NN) techniques. In this context, augmented reality (AR) is utilised to facilitate the process of measuring intelligent classification. The performance of the AR+NN scheme, which combines two approaches, is compared to that of the NN model. The application of AR has resulted in the reduction of the initial space for features from 9 to 4. During the testing phase, a 3-fold cross-validation method was utilised on the WBC database to evaluate the efficacy of the proposed system, resulting in an accuracy rate of 95.6%. The researcher demonstrated the potential utility of augmented reality (AR) in reducing feature-length and offered an AR+NN model for the development of an automated diagnostic system for various diseases. In areas focused on restoration, where research is strongly linked to information and analysis, novel research directions have been identified to further advance the field and its environment.

The proposal entails the development of an automated diagnostic system for the detection of breast cancer, which is based on the utilisation of Association Rules (AR) and Neural Network (NN) techniques. In this context, augmented reality (AR) is utilised to facilitate the process of measuring intelligent classification. The performance of the AR+NN scheme, which combines two approaches, is compared to that of the NN model. The present literature review provides a comprehensive survey of the existing methods for detecting breast cancer and their associated constraints. The identification of a novel automated and streamlined approach for detecting AD is beneficial.

3. Methodology

The following section will provide a comprehensive analysis of the multiple phases learning approach that was developed. Figure 4 depicts the comprehensive design of the model building. Prior to choosing features from the datasets, the organisation of these datasets was carried out using the fuzzy particle swarm optimisation (FPSO) algorithm. The outcomes of a feature selection process, which relied on probabilistic techniques, were utilised as input for the FPSO algorithm [17]. The feature selection methodology was integrated into the FPSO algorithm to facilitate the identification of attributes that enhance the predictive capabilities of the classifiers. The effectiveness values in the FBSO technique were determined by computing the mean of a stratified 10-fold cross-validation. The subsequent sections will provide further details on the different components of the proposed framework.

3.1 Dataset Collection

The machine learning and deep learning algorithms underwent training in order to identify instances of breast cancer by utilising the Wisconsin Diagnostic Breast Cancer (WDBC) dataset. As stated in reference [18], the dataset comprises of characteristics that were derived from a digitised image of a fine needle aspirate (FNA) obtained from a breast mass. The aforementioned features delineate the attributes of the cellular nuclei observed in the image [. The dataset consists of 569 data points, with 212 classified as malignant and 357 classified as benign.

3.3 Fuzzy Particle Swarm Optimisation

The process of selecting appropriate characteristics from a dataset is typically conducted based on domain knowledge, and is recognised as a crucial step known as feature selection [19]. Multiple studies are currently being conducted on the topic of feature selection in generate predictions. The utilisation of Fuzzy Particle Swarm Optimisation (FPSO) for feature selection is extensively employed in this research study. The FPSO algorithm demonstrates a high level of effectiveness in extracting a subset of 23 features from a larger set of 49 features in the initial dataset. This is achieved through the utilisation of information gain and accuracy measures.

3.3.1 FPSO (Feature Selection Algorithm)

Input: Benchmark or Streaming Dataset

Output: Dataset with the Selected Feature

```
Begin
FPSO (a,b,c)
  Initiate 'b' ideas with the intended representation modified to fit the proposed
   architecture.        Use a  Fuzzy c-means clustering algorithm
   Repeat
     With the suggested fitness function, assess the fitness of ideas.
     Use probability p1, p2, and p3 to create new ideas.
     Swap out the bad ideas with better ones till cancellation (c) requirements
  Return to the best suggestion
End
```

3.4 Classification Algorithm

This study investigates the performance of three classifier algorithms, namely Support Vector Machine (SVM), Decision Tree (DT), and Deep Belief Network (DBN), in terms of their ability to achieve test accuracy. The classifiers chosen for this research were chosen based on their reliability and precision, as determined through experimental evaluation [20].

3.3. Working Mechanism

The working mechanism of work is described as follows:

Input: Take Images for process

Output: Obtain the output score and make predictions.

Step-1: The first step involves the collection of images, which are subsequently saved as data objects.

Step-2: Transforming data into numerical format to facilitate quantitative analysis.

Step-4: Employ a multi-phase approach to select features. The proposed fuzzy particle swarm optimisation (FPSO) techniques incorporate a correlated feature.

Step-5: the process involves clustering each individual concept into a specified number of clusters. The fitness value is then used to determine the cluster centre within each cluster.

Step-6: Compare each newly generated concept to an existing idea. Perform this procedure iteratively until the maximum allowable number of iterations has been reached.

Step-7: Choose 100, 200, and 500 feature sets labelled as S1, S2, and S3 from Wisconsin Diagnostic Breast Cancer datasets.
Step-8: Perform classification and prediction.

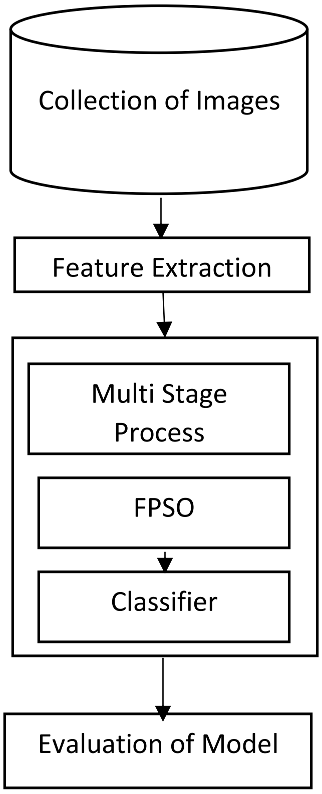

Figure 2: Working Mechanism

4. Result and Discussion

The utilisation of sMRI images is currently being extensively assessed for its diagnostic potential in detecting breast cancer. The proposed building design will encompass both essential and discipline-specific characteristics. In order to enhance precision, the entire dataset undergoes a random reordering process prior to clustering. Classifiers undergo training by utilising clustered feature output images obtained through our multi-phase feature selection techniques. The extracted features were subjected to the FPSO feature selection method. The dataset was primarily classified into three distinct categories, denoted as S1, S2, and S3. The suggested structure and procedures of each classification are illustrated in Figure 2.

In order to assess the outcomes of the simulation, efficiency metrics such as accuracy, sensitivity, specificity, precision, F-1 score, and mean AUROC values were chosen. Furthermore, the utilisation of a rule base has the capacity to significantly enhance the precision of the system that is suggested. The efficacy of the suggested strategy is further substantiated through the metrics of specificity and sensitivity. Table 1 displays the outcomes of the proposed experiment utilizing Wisconsin Diagnostic Breast Cancer datasets.

Table 1 presents a comparative analysis of the proposed system for three different machine learning algorithms: (a) Support Vector Machine (SVM) (b) Random Forest, and (c) Deep Belief Network (DBM).

Model	Parameter (%)	S1	S2	S3
Support Vector Machine	Accuracy	90.0	90.6	90.9
	Sensitivity	91.7	92.0	92.5
	Specificity	76.4	76.9	77.2
	Precision	92.6	92.8	93.1
	F1 – Score	93.0	93.5	93.9
	AUROC	93.1	93.7	94.2
Decision Tree	Accuracy	91.5	92.1	92.7
	Sensitivity	93.4	93.8	94.5
	Specificity	80.8	85	87.8
	Precision	95.5	96.7	97.5
	F1 – Score	94.9	95.9	97
	AUROC	95.3	94.9	95.6
Deep Belief Network (DBN)	Accuracy	93.9	95.4	96.7
	Sensitivity	96.6	97	98.8
	Specificity	85.9	88.1	91.5
	Precision	97	97.7	98.7
	F1 – Score	96.6	97.4	98.8
	AUROC	97.9	98.6	98.9

Our suggested framework is open to the inclusion of various machine learning and deep learning algorithms. However, it has been observed that the Deep Belief Network (DBN) performs particularly effectively compared to the aforementioned learning techniques. It is evident that increasing the overall number of features yielded significantly enhanced outcomes for our study. Optimal outcomes for S3 were achieved through the utilisation of 500 features. The figures below illustrate the collective performance of the datasets suggested in this study.

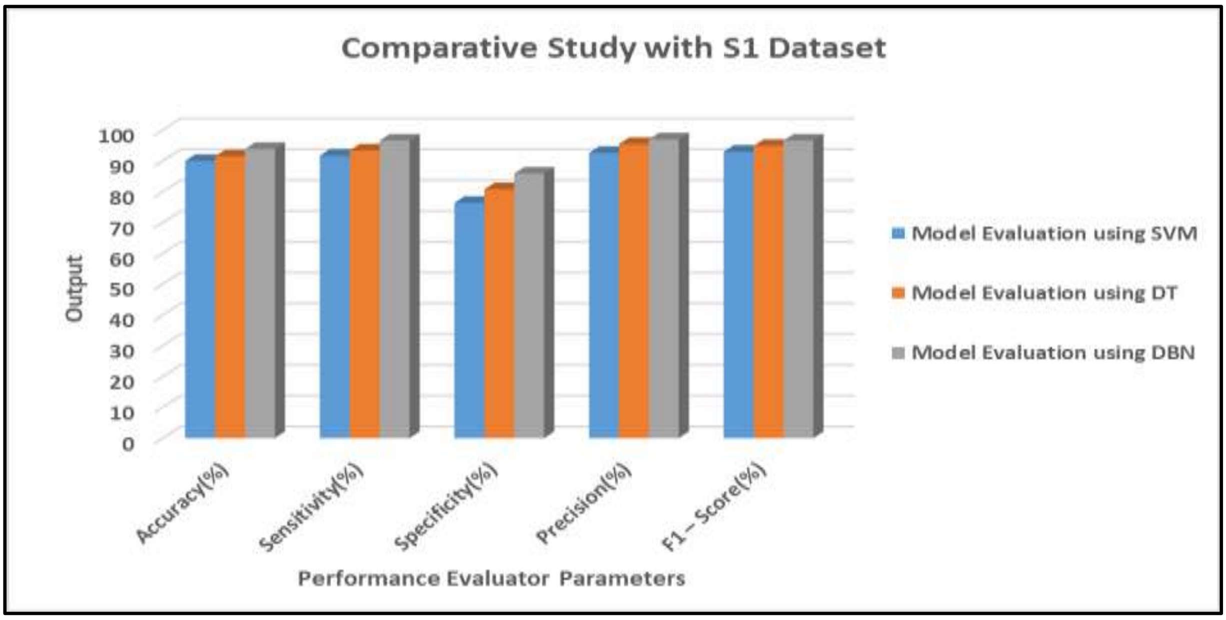

Figure 3: Comparison with S1 dataset using proposed models

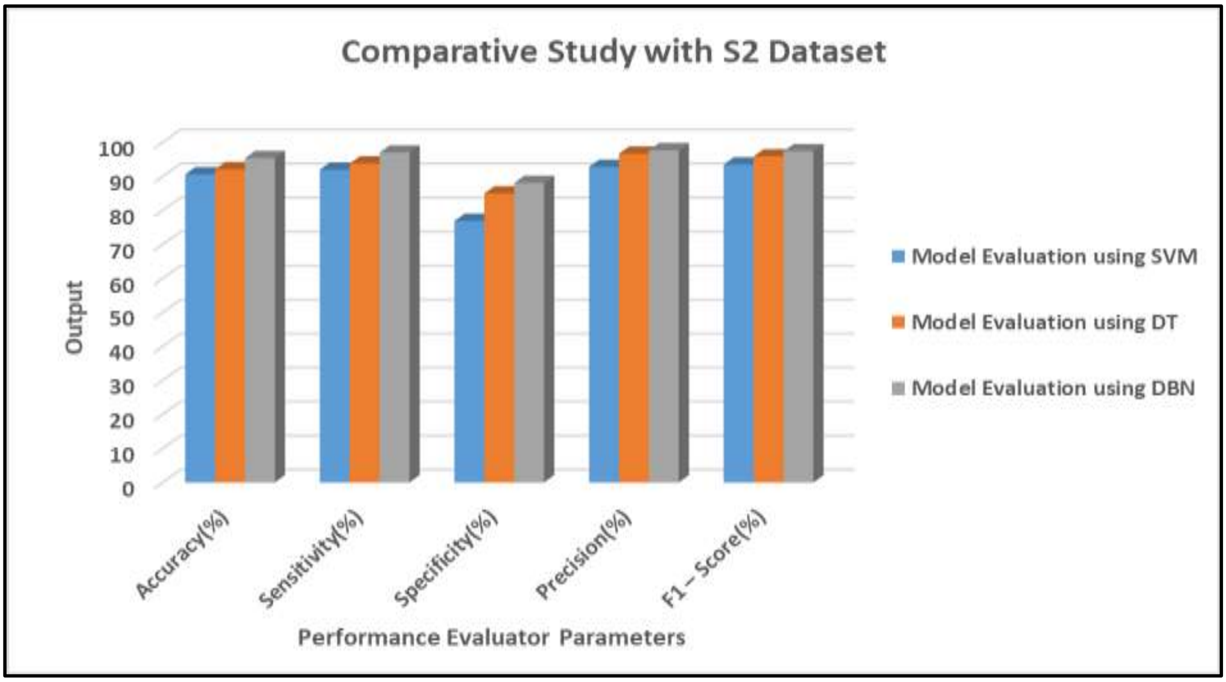

Figure 4: Comparison with S2 dataset using proposed models

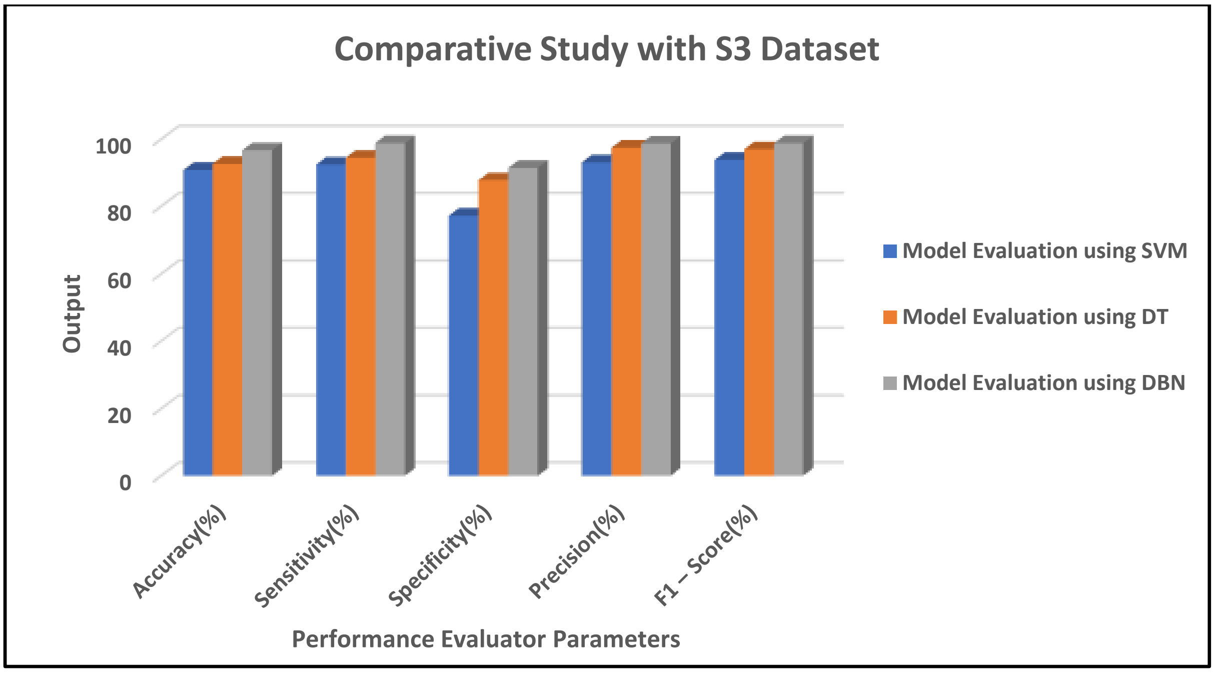

Figure 5: Comparison with S3 dataset using proposed models

The best classifier is determined using the mean AUROC for DBN classifier that is the most optimal model for this research. Figure 6 illustrates how DBN provides the best results out of the three classifiers.

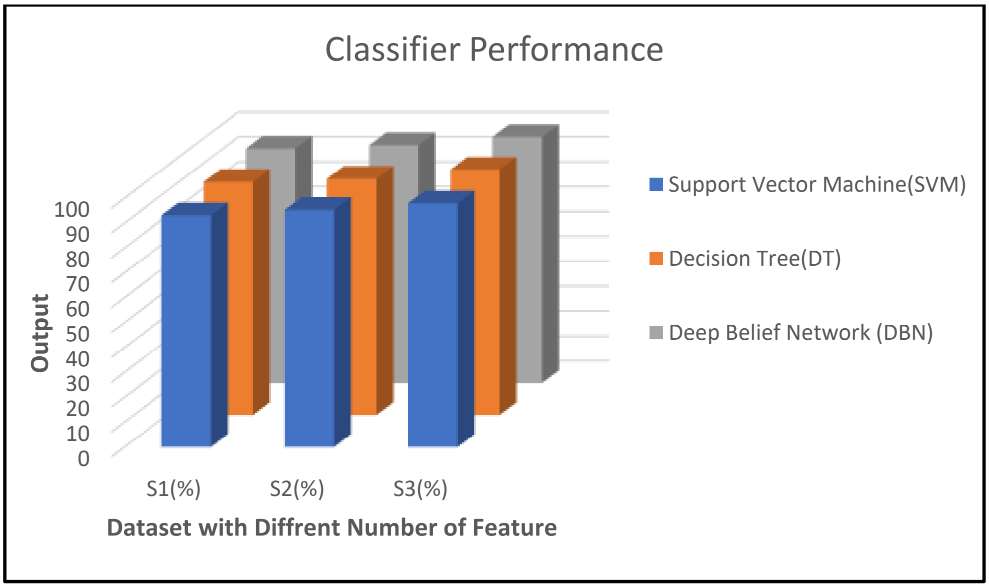

Figure 6: Depict Optimality of classifier for Proposed System

5. Conclusion and Future Scope

For Breast cancer diseases, a completely novel disease forecasting system has been created. The design and implementation of a method for choosing features using a deep learning model is the main finding of the research. It is utilised to select the most important characteristics to boost the deep learning model's performance in classification. Breast cancer disease detection system may be classified into many classes using the FPSO feature selection method and Deep Belief Network model. Three standard datasets—S1 with 100 features, S2 with 200 features, and S3 with 500 features—are utilised for training and assessment. The recommended method improves efficiency on accuracy of predictions to over 95%. The recommended disease prediction model outperforms previous attempts in terms of prediction accuracy. For the S1, S2, and S3 datasets, the multi-stage DBN classifier's accuracy was 93.9%, 95.4%, and 96.7%, respectively. Future research may potentially incorporate an integrated approach of neural network that uses to categorise Breast cancer disease.

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