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Medical Internet-of-Things Based Breast Cancer Diagnosis Using Hyper Parameter-Optimized Neural Networks

[1]Dony Novaliendry, [2]Mansoor Farooq, [3] K.K. Sivakumar, [4]Prasanta Kumar Parida, [5]Bommisetti Yamini Supriya

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Abstract: Breast cancer ranks high among the most lethal forms of the disease in women. Mammograms are widely used by radiologists for the early detection of breast cancer. Low-contrast pictures are common in mammography, which makes it tedious and time-consuming to isolate suspicious areas. Today's healthcare system places a premium on early detection and a precise diagnosis of breast cancer. As time has progressed, the IoT has evolved to the point where we can now analyze both live and historical data with the use of AI and ML techniques. In order to improve medical diagnoses, medical IoT integrates medical devices and AI applications with healthcare infrastructure. The majority of women with breast cancer don't make it because the disease isn't detected early enough with the present standard of care. Therefore, medical practitioners and researchers are confronted with a significant challenge in identifying breast cancer at an early stage. To address the challenge of diagnosing breast cancer at an early stage, we present a medical IoT-based diagnostic system capable of distinguishing between persons with malignant and benign conditions in an IoT setting. While the Support Vector Machine (SVM) and Multilayer Perceptron (MLP) were employed as reference classifiers, artificial neural networks (ANNs) and convolutional neural networks (CNNs) with hyperparameter tuning were used for malignant vs. benign classification. Since hyper parameters have such a direct impact on the behaviors of training algorithms, they are crucial to the success of machine learning algorithms.

Keywords*: Breast cancer, Support Vector Machine (SVM),Multilayer Perceptron (MLP),convolutional neural networks (CNNs),IoT*

1. Introduction

Cancer is a prime public health problem all through the globe, and it is the reason for most of the human deaths. Among different sorts of cancers, Breast Cancer disease is the utmost critical and common one that greatly affect ladies. Breast Cancer is the 5th greatest cause of women death when contrasted against other cancer- types. Early Diagnosis and Treatments are requisite for this notable Breast Cancer. A group of splitting cells that develops into a lump or mass of additional tissues called tumor in the breast region is concerned as Breast Cancer. Major risk aspects are age, family history together with hereditary risk. The Breast Cancer has to be detected as earlier as possible for increasing the likelihood of successful treatment as well as survivability[1-3]. A medical imaging approach termed "Digital mammography" (computerized) generates X-rays of the breasts called mammograms for Breast Cancer screening. The Computer Aided Diagnosis/Detection is developed for performing analysis objectively and quantitatively. The up-gradation of the Internet of Things (IoT) in the medical or Health Care field assists the patients and doctors to precisely predict several diseases and diagnose them centered on the acquired outcomes. The IoT lets smart health objects to remotely manage and sense the data of the smart health devices over the network infrastructure and this would lessen human intervention and elevate efficiency, accuracy, productivity, and economical gain of the devices[4]. Furthermore, the Data Mining approach, with its topmost efficiency in the prediction of the future health scenario, has assisted a lot in medical science. It also aids in attenuating the medical cost and meliorating the people's health and real-time quality which assists in saving people's life. Hence, countless data and information are there for examining and comprehending the process with major researches utilizing Machine Learning strategies. They need historical data associated to patients for effectively predicting their health[5-7]. Numerous Machine Learning approaches were utilized for Health Care applications. The existing standard Machine Learning approaches show the parameter tuning issue and their methodologies still haven't acquired better accuracy and Secure Data Transfer in the IoT environment, and they fail to give the required importance to the Severity

[1]Department of Electronic, Engineering Faculty, Universitas Negeri Padang, Padang, Indonesia
[2]Assistant Professor(IT), Department of Management Studies, University of Kashmir, Hazratbal, Srinagar, Jammu & Kashmir, India, Email: mansoor.msct@uok.edu.in
[3]Associate Professor, School of Liberal Arts and Sciences, Mohan Babu University, Tirupati. AP. India, Email: sivakumarkk@ametuniv.ac.in
[4]Associate Professor, School of Rural Management, KIIT University, Odisha, India, Email: prasanta.parida@ksrm.ac.in
[5]Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation,Vaddeswaram,AP,India, Email: byamini@kluniversity.in

Analysis. The objective is to ensure a security approach for the classificationbased Breast Cancer Prediction system in the IoTenvironment[8].

2. Breast Diseases

Cysts

A group of round tissue masses that might vary in size from millimeters to 5cm in diameter is concerned as Cysts. Its density is equivalent to or somewhat greater than the density of the parenchyma. The patients must do mammograms and ultrasound for assessing the Cysts. Intra-cystic solid components and Cystic masses with thick walls are concerned as complex cysts that might be Malignant Tumor. Here, mostly biopsy is suggested. The cyst might be benign or cancerous and should be further evaluated if its solid components are present. This is often done through repeated imagery to check whether the cyst develops over time[9]. A biopsy is the finest test to check for the benign or malignancy of a cyst or tumor. Cysts could be seen mostly in 30 to 50 years women. The growth of a cyst engenders tenderness along with pain. The symptoms might occur before and at the moment of the menstrual cycle[10].

Fibroadenoma

It is the benign breast tumor characterized by a well-defined mass. It normally appears in adults and women below 30 years (age). In young women, it rapidly grows to a huge size. Ultrasound Scanning is the modality utilized in patients below 30 years and Fine-Needle Aspiration (FNA), FineNeedle Aspiration Cytology (FNAC) test is done for confirmation. A basic, fast and cheap strategy that is utilized to test shallow masses like those found in the neck and is normally acted in the outpatient facility is known as Fine Needle Aspiration Cytology. It makes insignificant injury to the patient and conveys essentially no danger of entanglements. It is utilized to yield cells from unmistakable knobs in organs else tissues. Malignant Fibroadenomas is different as of the benign one[11]. A palpable solid mass that appears like fibroadenoma or a non palpable enlarged mass is biopsied since a welldescribed malignancy might be similar in appearance. In young women, fibroadenomas are among the most frequent noncancerous (benign) breast lumps. Monitoring to identify changes in size or feel, a biopsy to examine the lump, or surgery to remove it may be used as treatment. A fibroadenoma has a well-defined form and may feel solid, smooth, rubbery, or rigid. When inspected, it may feel like a marble in your breast, sliding easily under your skin. Fibroadenomas come in a variety of sizes and can grow or decrease on their own. Normally fibroadenomas are not complicated. A person may getbreast cancer from a fibroadenoma, although it is quite uncommon. Only 0.002-0.125 percent of fibroadenomas are malignant according to studies.[12]

Stages of Breast Cancer

The spread of cancer within the breast or to other regions of the body is found with the staging process. The information attained as of this process deduces the disparate stage of a specific disease. It is vital to recognize about the stage of abnormality for planning the appropriate treatment[13]. Table 1. proffers the definitions of disparate cancer stages. The stage accompanied by an estimation of differentiation is vital for preparing treatment and ascertaining cancer-associated prognosis. The stage, together with an assessment of differentiation, is critical for planning treatment and determining cancer-related prognosis. Different types of stages such as 0, 1 2, etc are taken for typical assignment of cancer cells. An assessment of the probability and outcome of a disease is a forecast[14]. The prognosis of a patient diagnosed with cancer is typically seen as a possibility of effective treatment of the disease and recovery of the patient

Table 1. Typical Assignments of Cancer Stages

Stages	Description
0	The normal anatomical configurations of cells
1	Tumor only in the local anatomical site
2	Ipsilateral regional LNs' involvement
3	A distant site's involvement

Neural Networks in Breast Cancer Detection

For the application of detection of breast cancer, Neural network (NN) plays a significant role. Various medical Neural network techniques are used and published in large numbers, for the algorithm development only few analysis are used for the enhancement of detection techniques with respect to sensitivity and specificity

Convolutional Neural Network

Neurons having learnable weights and biases are used in Convolutional Neural Network. Some inputs are received

by every neuron, and non-linearity is followed for the performance of new dotproduct. Single differentiable score function is expressed in the whole network from the pixels of raw images from one end to other end class scores. The main advantages by using Convolutional Neural Networks are it is very serviceable way by means of input consists of images and architecture constrain[15]. CNN have 3 dimensions neuron namely, height, width and depth. CNN has layers of more combination. Like BCDCNN techniques have 2 hidden layers, input layer and output layer. Input layer consist of pixels data of images. The CNN has the input data in the form of 48 x48 x1 because of grayscale mammograms is used as input in these techniques[16]. Hidden layer consist of rectified linear unit (ReLU) layer, convolutional layer, Fully-connected (Dense) layer and pooling layer. Figure 2.shows the hidden layer explanation in simple format

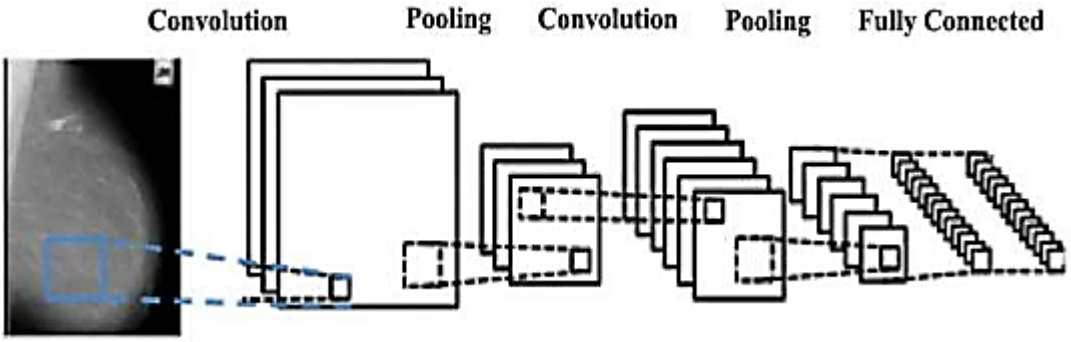

Fig 2. Convolutional Neural Network process

For the input images convolution filters are applied by convolution layers. Set of mathematical operations are performed in every sub region layers to get a single value at the output feature map shown in Figure 1.10. For the nonlinearities introduction in the output of the model ReLU activation function are applied by Convolutional layers. Input image of size 48 x 48 matrix are filtered by using kernel filter into 32 image features of size 5x5 with ReLU activation in BCDCNN model[7].Image down sampling are done by pooling layers. Filter is applied in the matrix of size 2x2 called as 2x2 filter max pooling. Number having bigger value is stored and with remaining values is removed. If the stride value of 2 is given, after that filter will filter the pixels once more by size of 2. Pooling layer is used for the purpose of decreasing the time of processing. Back propagation is used for weight updating the value which is closer in BCDCNN[8]. Once the data is trained, each time new images are passed through the layer and production of loss data occurred compared with output expected. This error is used for increasing the accuracy of the techniques. Fully connected layers are decision making layers. Last hidden layer of size 7 x 7 x 64 are connected by dense layer are classified into 1024 node. The Nodes in the Layer connects with respective logits Layer. Logits layer have 3 possible output namely normal for 0 value, benign for the value of 1 and malignant for the value of 2. For CNN model improvement various parameters and techniques are used, such as data size increment, alteration in the training step, alteration in the rate of learning and increase in the input data pixel, hidden layer and feature number[10]. If the rate of learning and training step is too high, then model is over fitted

Artificial Neural Networks

Features of autocorrelation are used in ANN for breast cancer classification the breast cancer as benign or malignant. The accuracy of malignant classification is high in the system introduced and therefore it can support the operators which is inexpert for diagnosing complicated ultrasound imagesThe main advantage of NN is further optimization is done by supplying ultrasound images with large dataset of as ANN which can be trained well.[11]

3. Healthcare Monitoring System Using IoT

IoT is an authentic innovation embedded by a network of networks. As IoTs has fetched all the things via the web, the associated groups proffer new opportunities for meliorating activities crosswise across assembling, farming, restorative administrations, and economy. Among all, the Health Care services signify the economic and social difficulty that every nation faces. Clinicians, analysts, Human services executives, and certain adepts are the demanding strain for implementing the requisites from both the private division and the general society. The quantity of weak persons, for instance, impaired, seniors and those with unending sicknesses staying in home or distant regions are is exponentially expanding. Hence, the requisite for Remote Health Monitoring is becoming a customary practice. Clinicians and hospitals are increasingly using Remote Health Monitoring systems to remotely monitor and interact with patients while maximizing clinician time, lowering hospital expenses, and enhancing quality of treatment[2][12]. The analyses are chiefly made on how to render quality and pertinent care outside the

condition of the healing facility. Here, the progressed e-Health Care service administrations are requisite to be made accessible for people via a system wherever and whenever feasible. For which, restorative sensor correspondence infrastructure has been proposedwith the IoT which would make usage of distant innovations that authorize the continual information transmission about patients' condition to their caregivers[3][9]. Disparate versatile gadgets are accessible that could differentiate specific medical states—heart rate, breath, liquor level, blood pressure etc. as of a users' touch and exchange those accounts via phones. Here, IoTs with the aid of interlinked sensors utilizing mobile gadgets would accommodate continual checking of patient health state and cope with their treatment as of inaccessible regions. Likewise, it is usual that IoTs would presume a notable part in next – age provisioning of health service

Nevertheless, few difficulties like being excellent information storage and administration, heterogeneous assets- accessibility, interoperability, security, data anomaly, etc happen with this growth and employment of the Health Care scheme via mobile gadgets. Cloud Computing renders some facilities to get closer to the shared assets as well as core foundations in a straightforward and individual way. The objective of cloud computing is to support natural proactivity, fueling virtual administrations instead of actual items & equipment, in addition to, eliminating paper squander, improving energy proficiency, then (given that it permits representatives access from anyplace with a web association) decreasing worker related emanations. As per request over the system, it offers services. It does tasks as per the direction of the progressing requisites. IoT centric Hospital Monitoring Management approach encompasses the internet of wellbeing sensor objects. Hospital Monitoring Management is a computer system that helps to properly manage healthcare information and helps health providers do their jobs. Those things generate copious data that could not be managed by Health Care professionals. The doctor mainly concerns how to make a decision about patients' well-being. For which, the doctors have to separate the data around one specified patient as of the copious health data associated to millions of patients. For transmitting health-associated data into the cloud, an IoT operator would be utilized. The cloud would handle the copious data and render suitability to big data analytics. With this information mining and analytics, continual alarming of the patients' health is strengthened

The body Sensor Nodes compiles the patients' data including blood glucose, blood pressure, temperature, etc. Forbye, the compiled data iscommunicated via IoT agents/mobile gadgets on the cloud network where the data is efficiently processed and saved. Via processing the data and saving the consultations to the cloud, the doctors remotely take requisite actions. For detecting disease capability and executing a service of effectual treatments to patients, a primary project in handling Health Care initiative is the quality of service. Diagnosis is vital but complicated while undertaken needs have to be executed effectually. Grounded on the Health Care-professionals' understanding and experience, the prediction is often done and this may sometimes be erroneous bringing about unwanted effects. Consequently, an automatic medical analysis system is requisite to exploit the compiled information base as well as decision support scheme. The researchers utilized the Health Care information systems handled by the Hospital Management System. On that account, the scheme assists in detecting disorders with a few medical tests before certain signs or symptoms are felt by the patients. Copious data is gathered for extracting hidden information and building an intelligent disease prediction structure that diagnoses disease utilizing a historical database of disparate diseases. For processing copious patient data and considerably extracting inherent, substantially valuable, and formerly hidden information about data effectively in the e-Health Care network, the Machine Learning approaches are employed. The IoT could connect mobile and remote objects or machineries via the utilization of wire-less communications with inexpensive sensors for computing and storing devices. As IoT connects via the web, it could proffer chances of meliorating activities across agriculture, manufacturing, medicinal, and economy services. It holds big data that is hard to manage by the Health Care professionals. Nevertheless, they need historical data associated to patients for effectively predicting their health. Numerous Machine Learning approaches were utilized for Health Care applications. The standard Machine Learning approaches show the issue termed parameter tuning. But, this sort oftuning has the competency of meliorating the prevailing Machine Learning techniques' performance for predicting disparate medical applications like brain tumor, cancer, diabetes, etc. IoT-centric Health Care services are anticipated to lessen costs, elevates the quality of people's lives, and augments the users' experience. As of the view of Health Care providers, the IoT is competent to lessen device downtime via remote provision. Furthermore, the IoT could precisely recognize optimal times for refilling supplies for diverse devices for their continual and smooth operation. The IoT renders the effectual scheduling of limited resources by facilitating their service for numerous patients.

A New Authentication Scheme and XR-DLNN Classifier Based Breast Cancer Prediction and Severity Analysis System InIoT

Breast Cancer is the prime disease amongst females all through the globe, and there are 2 million cases during 2019. Breast Cancer is the 5th greatest death cause for women as analogized against other sorts ofcancers . The cells grow abnormally in Breast Tissue or the increase in the count of affected cells in breast is concerned as Breast Cancer. Breast Cancer is a Malignant Tumor that develops in breast cells. A collection of splitting cells that forms a lump of additional tissues is termed tumors, which may be cancerous or noncancerous. Large attention must be paid to lessen the death rate, and this is only feasible when cancer is recognized in its earlier stage with appropriate monitoring. But it remains a challenge to track the data and to treat cancer at an earlier stage. For rendering an early-stage tracking of Breast Cancer, a health monitoring systems centered on IoT has been developed. The widespread growth of the IoTs and its applications in the medical domain has elevated the Remote Health Monitoring system's effectiveness. This system assists elderly persons or patients who is longing for a long-term personal care. Advanced Health Care monitoring schemes facilitate physicians to virtually review patients' health-associated data anywhere utilizing smart medical apps on theirsmartphones, tablet etc.. Patient's current health attributes could be gained utilizing sensors, and the gauged values could be passed to the patients' primary physician's consent for diagnosis. As when it comes to transmission, data Security and Privacy remains more challenging owing to the existence of countless web users in the internet era and innumerable cloud users. It is essential to carefully cope with countless users' data and as well to render Security and Privacy to their health information.

XR-DLNN Classification

The single-layered Artificial Neural Network is a better one but to elevate the accuracy of the prediction system, the deep layered network renders an excellent result

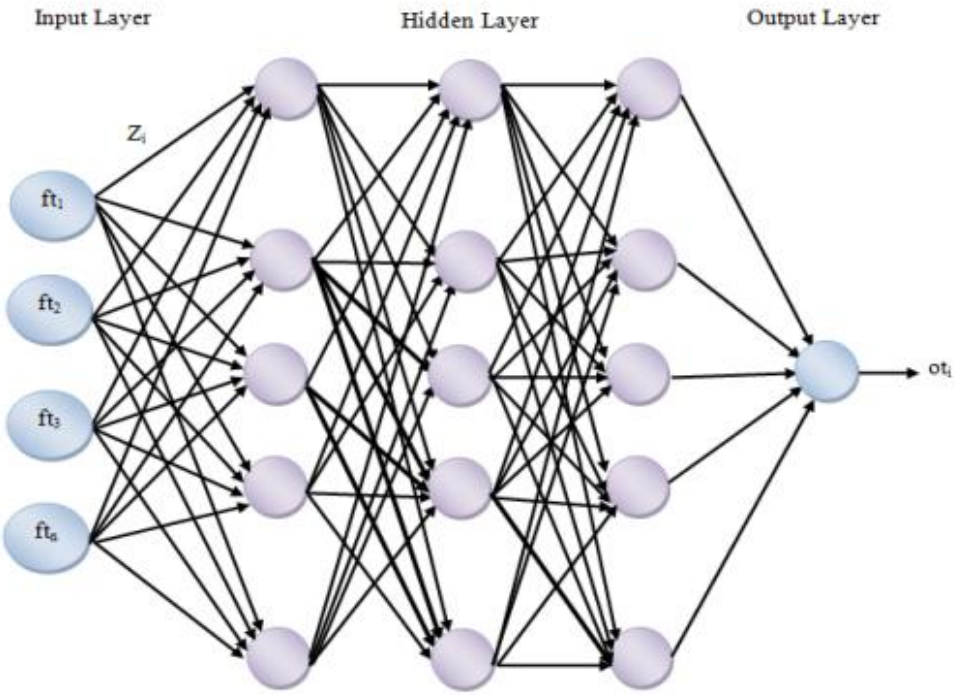

Fig 3. Structure of XR-DLNN

So, here, the Deep Learning Neural Network is considered. A normal Neural Network consists of a single input layer, a single Hidden Layer, and a single output layer. This system considered three Hidden Layers. The Neural Network normally has Weight Initialization to every layer. Basically, the Weight Value (WV) is picked randomly, which traps into a high loss error. So to avoid that, here, XWI method is utilized, which lessens the error and renders higher accuracy. Figure 3.explicates the proposed XRDLNN by showing its structure in detail

4. Dataset Description

This method is evaluated by INbreast dataset. Largest full-digital mammographic publicly available dataset with mammograms exactly marked in current scenario. 410 mammograms for 115 cases are present in this dataset. Totally breast masses of 116 numbers are present in this dataset, [15*mmmm*2, 3689*mmmm*2] is the range

of size of breast masses. The mammogram's pixel size is 70 , and the14-bit is the depth of bit. INbreast is evaluated by using the similar validation data divider for enabling a straight comparison, in this dataset is divided arbitrarily, training uses 60% of dataset and validation uses 20% of dataset and five times of testing uses 20% of dataset.

5. Hyper parameter Optimization

It is possible to classify the key parameters that regulate neural networks' structural structure and learning mechanism as either structural or algorithmic. Number of network layers, number of neurons in each layer, degree of connection, transfer function, etc. are all examples of structural hyper parameters that describe the network's structure and topology. Because of the structural changes they induce, they affect the network's efficiency and computational complexity. The learning process is controlled by a variety of algorithmic factors such as the size of the training set, the algorithm used for training, momentum, learning rate, etc. Although hyper-parameters are external to the neural network model and have no bearing on the network's overall efficacy, they do have a significant impact on training time and accuracy.

When evaluating the efficacy of an ML model, one may look at its hyper parameter settings, which are a collection of predetermined choices that have a direct impact on both the training process and the prediction output. Model training refers to the act of instructing a model to recognize patterns in training data and make predictions about the outcome of fresh data based on these patterns. The length of time needed to train and test a model depends not only on the hyper parameters used, but also on the model's architecture, which represents the model's complexity. Setting has emerged as a crucial and challenging subject in the application of ML algorithms because of its influence on model performance and the fact that the optimal choice of values is uncertain. The literature provides a number of methods for adjusting the hyper parameters.

Below, we detail the procedures for achieving optimal values for various hyper parameters.

When the researcher has a firm understanding of neural network structure and learning data, he or she may use the manual search to estimate the value of the hyper parameter based on intuition or knowledge. The criteria for defining hyper parameters, on the other hand, are nebulous and need a number of trials and errors.

By generating many values for each hyper parameter and averaging them, grid-based search (GS) may determine which one yields the best performance. Using GS is simple and intuitive, and it takes very no training at all. By setting bounds on each hyper parameter and a predetermined step size, GS is able to explore the whole hyper parameter value space and determine the optimal values. Since GS tests every possible permutation, it is exhaustive. A flaw with GS is that the total number of needed runs grows exponentially with the input size. Consequently, GS is time-consuming and expensive to run on modern computers. The nature of some ML techniques, such as ANN and CNN, is that rerunning algorithms with the same parameters may generate different prediction results and, hence, varied performance, which is another drawback of using GS.

6. Conclusion

Timely and accurate diagnoses have become the norm in today's healthcare systems. Through the application of deep learning (DL) models enabled by the Internet of Medical Things (IoMT), the problem of late-stage identification of many illnesses has been solved, and diagnostic accuracy has been improved. Consequently, the late detection of malignant cells in blood tissue has led to the untimely deaths of some cancer patients. The purpose of this research was to present an IoMT-enabled convolutional neural network (CNN) model for distinguishing between cancerous and noncancerous cells in the patient's blood. In this research, we provide hyper-parameter optimization of a convolutional neural network model for BC detection and classification at an early stage. In the IoMT-based healthcare system, which gathers data from a wide variety of sensors and devices, the hyper-parameter-optimized CNN model was employed to detect and categorize Breast Cancer subtypes. Initial analyses of the dataset's acquired data used min-max feature selection and value replacement to determine which characteristics would be most useful.

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