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A HYBRID DEEP LEARNING ALGORITHMS FOR DIABETES MELLITUS PREDICTION USING THERMAL FOOT IMAGES

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Abstract- Diabetes mellitus, frequently known as diabetes, is a disease that affects a vast majority of people globally. Diabetes cannot be cured; it can only be kept under control. In this paper, diabetes is diagnosed by the analysis of foot Variability obtained from thermal images. We employed deep learning networks of the Convolutional neural network (CNN) and CNN-SVM (SVM-Support Vector Machine) combination to mechanically sense the anomaly. Unlike the conventional analysis methods so far followed, deep learning techniques do not require any feature extraction. We performed classification splitting the database into separate training and testing data. The maximum accuracy obtained for test data is 97.9% using CVM(Integration of Convolutional Neural networks with Support vector machines). Using CNN+SVM gave an of 93.6% of sensitivity while CNN-SVM combination gave the maximum specificity of 90.3%. As per our best knowledge, this is the first paper in which deep learning techniques are employed in distinguishing diabetes and normal. The accuracy obtained using cross-validation is the maximum value achieved so far for the automated detection of diabetes using thermal footpaths.

Index terms- Classification, Diabetes, CNN-SVM, Footpaths, Thermal images

Introduction

Diabetes is an ailment which asects the ability of the body in producing the hormone insulin, which in turn makes the metabolism of carbohydrate abnormal and raise the levels of glucose in the blood. In Diabetes a person generally suffers from high blood sugar. More than 45% of new born infants are affected by diabetic mellitus in all over the universe, 65% of middle-age peoples and 88% of geriatrics are affected by the same [1]. Early detection of such abnormality improves the patient's lifetime. In recent days, machine and deep learning classifiers are widely adopted for these medical illness detection. Diabetic mellitus detection using tongue, foot, blood sugar level are considered for analysis [2]. Especially, footpath complications are high which leads to early amputations. Many complications occur if diabetes remains untouched.

Diabetes is considered to be a very important health problem during which the sugar level cannot be controlled. Diabetes is not only affected by various factors like height, weight, hereditary factor and insulin but the major reason considered is sugar concentration among all factors. The early identification is the only remedy to stay away from the complications [3].

Many researchers are conducting experiments for diagnosing the diseases using various classification algorithms of machine learning approaches like J48, SVM, Naive Bayes, Decision Tree, Decision Table etc. as researches have proved that machine-learning algorithms [4],[5],[6] works better in diagnosing different diseases.

Data Mining [7], and Machine learning algorithms gain its strength due to the capability of managing a large amount of data to combine data from several different sources and integrating the background information in the study [8].

This research work focuses on pregnant women suffering from diabetes. In this work, SVM, and Convolutional neural network deep learning classification algorithms are used and evaluated on the thermal footpaths dataset to find the prediction of diabetes in a patient. Experimental performance of all the three algorithms is compared on various measures and achieved good accuracy, recall, specificity.

The remaining of the research discussion is organized as follows: Section-II briefs Related Work of various classification techniques for prediction of diabetes, Section-III describes the Methodology and brief discussion of Dataset used, Section-IV discusses evaluated Results, and Section-V determines the Conclusion of the research work.

2 Related Works

In this section, few recent works relevant to the proposed objectives are elaborated in detail. Machine learning and deep learning networks become trendy in both classification and prediction problems especially in medical environment.

Likewise, harleen et.al [9] proposed mechanized prediction network for diabetic mellitus patients. Support vector machine, nearest neighbor algortihms are trained with raw data's and tested for unknown records. Only 82% of accuracy attained through the proposed model. Dataset description, feature selection strategy is not mentioned in this work.

Maldonado et.al [10] developed a mask-RCNN system for the regular monitoring scheme of diabetic foot. The proposed system classifies the temperature deviations in foot zones as ulcerous or necrotic conditions. This proposed algorithm segmented the visible spectrum foot images using R-CNN models. Deepti et.al [11] adapted three machine learning classifiers such as SVM, decision tree, and naïve baiyes for diabetic detection. Various features are trained and tested with PIMA datasets.

Selvarani et.al [12] proposed an tongue heat variations analyze with a dyadic wavelet transform (DyWT) for polygenic disease detection. The warmth expelled from the tongue varies for the diabetic persons and traditional person. The thermal image of the tongue acquires and processes to guage heat regions within the tongue. The limitation of the proposed technique is targeted only the mid-age persons (35 - 45).

Chanjuan Liu et.al developed a segementation technique for detecting foot difficulties of diabetic patients. The proposed algorithm is a two feet technique which includes clustering such as KNN and expectation maximization (EM). EM-linear and quadratic are deployed for identifying the temperature differences between left and right foot. The limitations are less significant for single feet amputation patients [13].

The authors in [14] proposed Predictive model construction is based upon supervised machine learning algorithms: Naive Bayes, Decision Tree, Random Forest, Gradient Boosted Tree, and Tree Ensemble. Farther, the analytical patterns about these predictive models have been presented based on various performance parameters which include accuracy, precision, recall, and F-measure.

Swapna et.al developed an CNN trianed with LSTM algortihm for diabetes detection using the ECG signals. LSTM is a memory based structure which has high computational overhead at runitme [15].

To address this, we proposed a hybrid deep learning neural network such CNN-SVM algorithm for diabetic prediction at early stage. Thermo foot paths are collected as images fom both normal and affected persons. The proposed algorithm achieved extreme ccuracy within minimal time. CNN-SVM achieved prediction exactness upto 98% , recall upto 95%, specificity as 92.3% with minimal loss.

3 Proposed Methodology

In this paper, a convolutional neural network (CNN) is developed for detection of foot snags on diabetic patients. Diabetic mellitus is the complex issue in all over world, which become a common illness nowadays. Infants to geriatrics are easily affected by this devastating disease. Early recognition techniques are very essential for medical environment. Foot and tongue are the major part get affected easily and leads to amputation. This proposal targeted the foot complications of patients at different ages. Figure.1 illustrates the working procedure of the proposed system

3.1 Dataset Pre-processing

In this paper, we evaluated our proposed CNN-SVM model with both benchmark and real-time dataset which is oberserved through DITI thermal camera. Footpath depictions are observed form different diabetic patients and normal persons. Benchmark footpath images are observed from DFU 2020 dataset [16-17] which includes more than 4500 depictions. These images are used for training and testing the proposed Convolutional neural network.

3.2. SVM training algorithm

In this paper, proposed deep neural network is trained using support vector machine algorithm. SVM is the standard ML algorithm for classification or regression issues. The SVM parallely limit the experiential category blunders and exploits the geometric margins. It is most suitable for non-linear problems and the kernel functions are modified during the training phase. The kernel permits to construct the classifier for unknown feature space. NLP,speech recognition, obstacle detection applications are widely adopted this SVM training algorithm.

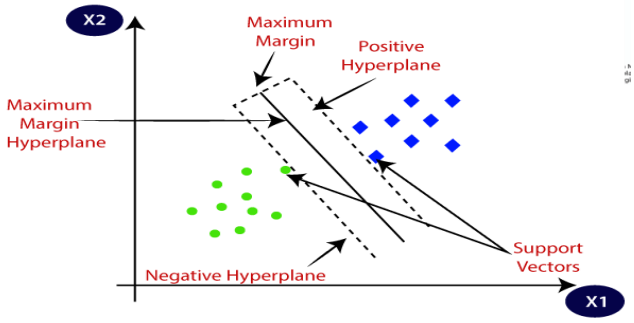

Fig.1. SVM training Algorithm basic structure.

3.3. Convolutional neural network (CNN)

Convolutional neural network (CNN) is a special type of deep learning neural network. CNN architecture comprises of synapses, weights, biases with diverse set of neurons. The proposed network is similar to multilayer perception which includes series of concealed layers, max pooling, fully connected layer with sigmoid activation function. Weights and bias values are generated randomly. Thermal images are collected from datasets which are utilized to train the proposed CNN classifier. Raw pixels are extracted through the convolution layer as a dot product and feed-forwarded into concealed layers in terms max polling, FC etc.

Table.1. Parameters of CNN+SVM algorithm

Parameters	Architecture
No.of.neurons	50
Activation function	Sigmoid
No.of.hidden nodes	20 nodes on each layer

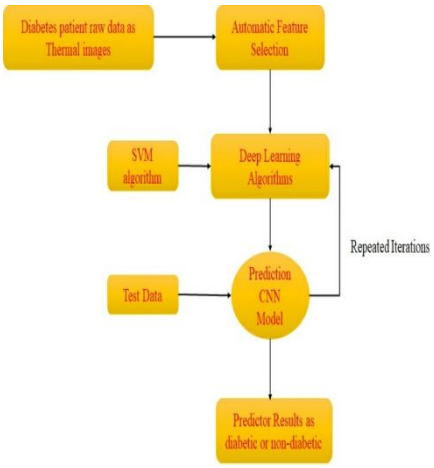

Fig.2. Layout of the Proposed Scheme

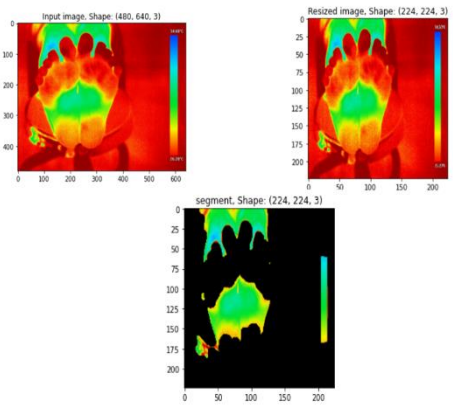

Fig.3. Segemented footpaths utilized for training and testing

4. Experimental set-up

To evaluate and validate the proposed diabetic detection system using the proposed CNN+SVM deeep learning framework, we have used different parameters such as Accuracy, Sensitivity Selectivity, Specificity and compared with the other existing classifiers such as Random Forest,(RF) Decision Tress(DT),KNN algorithms and Artificial Intelligence . In case of identifying the different attacks at various levels were given by the mathematical expression

$$Accuracy = \frac{DR}{TNI}\ x100 \quad (1)$$

$$Sensitivity = \frac{TP}{TP+TN}\ \text{x100} \quad (2)$$

$$Specificity = \frac{TN}{TP+TN}\text{x100} \quad (3)$$

Where TP and TN Represents True Positive and True Negative values and

DR & TNI Represents Number of Detected Results and Total number of Iterations

True positive values are the detected images which are predicted as abnormal when they indeed to be abnormal. True negative are the images which are predicted as normal when they indeed to be normal. The proposed classification algorithm has been implemented using Sci-kit learn along with Tensorflow API . Nearly 4500 images were collected from the above experimentation in which 70% were taken as training and 30% were taken as testing. With this the following parameters were evaluated and compared with the other existing algorithms

4.1 Accuracy Analysis

For accuracy evaluation, the proposed algorithm has been executed for the 100 trials and used 10 cross validation matrix to find the final accuracy for the classification/prediction of different attacks The accuracy of the proposed algorithm has been evaluated using the different learning algorithms.

The sensitivity and secificity metrics also calculated using above equations. Figures. 4 and 5 illustrates the proposed system performance.

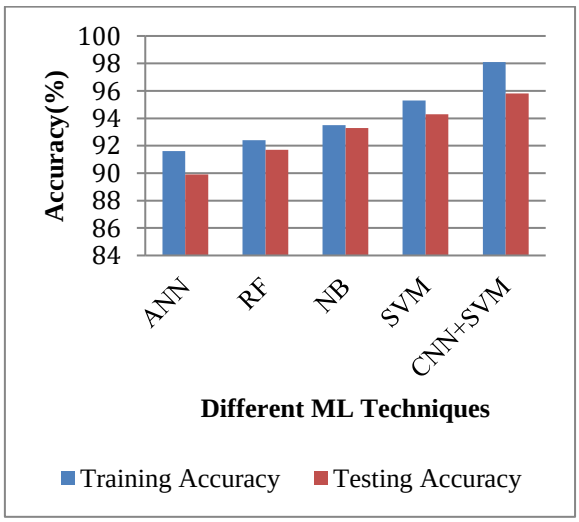

Fig.4. Diabetic Detection Accuracy

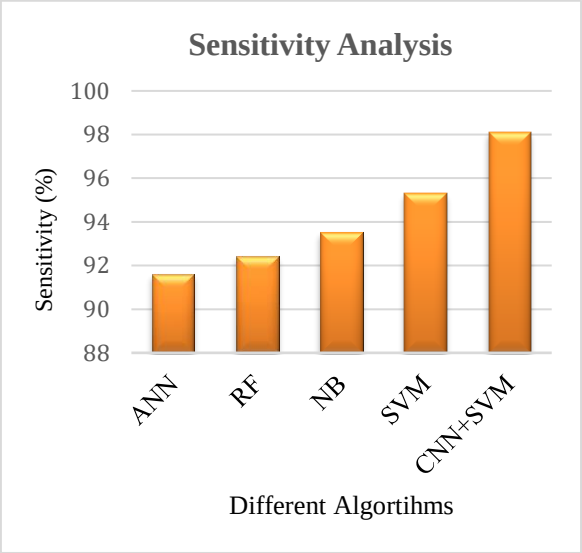

Fig.5 Sensitivity analysis for Diabetic Detection

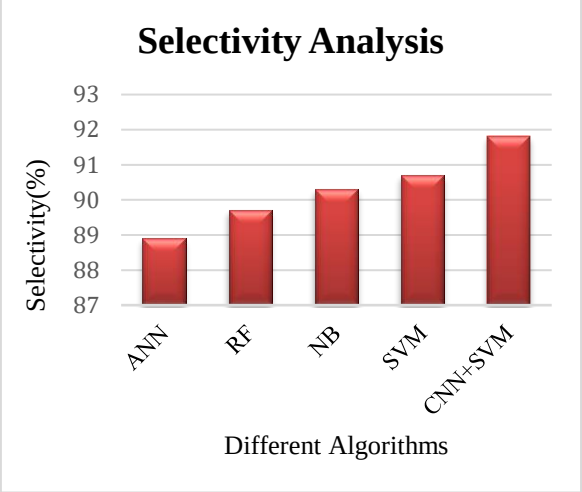

Fig.6.Selectivity metric analysis of proposed system

5. Conclusion

In this paper, we developed a convolution neural network is trained with SVM learning algorithm in order to detect the diabetic image footpaths abnormalities. The proposed algorithm is trained with segmented footpaths. Various parameters are analysed for the proposed algorithm. Exactness, specificity and sensitivity are observed using the calculations. The accuracy achieved as 97% for the proposed algorithm, 93% for specificity and 94% for sensitivity in an average when compared with ANN, SVM, RF, NB algorithms

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