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Non-Invasive Method for Diabetes Detection using CNN and SVM Classifier

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Abstract:

The diabetes is one of the common disease that many people suffer. Diabetes can be described as a group of metabolic disease where the blood glucose level in the body is higher than the normal prescribed parameters. Traditional way to detect the blood glucose level is by drawing blood samples which is painful and inconvenient. Investigation shows that urine, sweat, saliva, tears and breath contain traces of glucose and these traces vary with the levels of the glucose in the blood. This research shows that breath is a good alternative to monitor and diagnose glucose levels as acetone in the breath shown good correlation to Blood Glucose Level (BGL).

This method converts the diabetes detection from Invasive to non-Invasive method by using breath samples which emerges as a promising option with acetone levels in breath. In Present there are certain techniques which provides the analysis of breath for acetone detection. Gas chromatography mass spectroscopy, selected ion flow tube mass spectroscopy and cavity ringdown. These methods have measure drawbacks of each and it faces many constraints, such as high computational cost and less accuracy. To overcome this issue, we had used Deep Learning Approaches, such as the convolutional neural network. By using this approach calculation of automated features from raw signal and classifying the derived features. Motive of this project is to develop a modified deep learning convolution neural network algorithm integrated with support vector machines to follow up the drawbacks of current methods and algorithm.

The system is coordinated on real-time breath signals for non-invasive detection of diabetes. Multiple Metal Oxide Gas Sensors in array form are used to detect the acetone level. Sensors shows change in conductivity when exposed to acetone concentration. This property is useful for overcome the presently costly methods.

Keywords **—CNN, SVM, Acetone Level, Non-Invasive.**

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I. INTRODUCTION

Pattern recognition algorithms have been widely used to quantitatively analyse raw data obtained from sensors for detection of various chronic diseases. In order to effectively detect these diseases a reliable sensory system is essential [1]-[5]. Consequently several hybrid methods have been developed by combining feature extraction techniques and classification algorithms which have successfully applied for predictions in nonlinear processes. Diabetes can be described as a group of metabolic diseases where the blood glucose level in the body is higher than the normal prescribed parameter .When a person suffers from diabetes, it is seen that their body is either unable to secrete enough insulin or their body is notable to use the insulin produced by the liver .This causes sugar to buildup in the blood thus leading to diabetes. There are two major types of diabetes which include type1 and type2 .Type1 diabetes is the result of the body's failure to produce enough insulin. While type2 is a condition in which cells fail to respond to the insulin produced in the body properly. It is seen that the prescribed parameter of blood glucose levels (BGL) in healthy subjects before meals is around 70 to 80 mg/dL. Sugar less than 100mg/dL while fasting is considered normal by today's standards and after meals 140mg/dL .Any BGL higher than normal is considered unhealthy. Feedforward neural network or Multilayer Perceptron with multiple hidden layers in artificial neural networks is usually known as Deep Neural Networks (DNNs). Convolutional Neural Networks (CNN) is one kind of feedforward neural network.

II. RELATED WORKS

An machine learning algorithms employ two main techniques which include feature extraction and data classification. Various algorithms have evolved and have been proposed for detection and classification of data samples. Feature extraction techniques include Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA) which are some common used feature extraction techniques. While algorithms such as decision tree [9], k-nearest neighbourhood [10], Artificial neural network [10], Support Vector Machine [11] are some of the commonly used classifiers. Deep neural network algorithm have gained popularity in image, text, speech, and language processing systems. These techniques although have merits, pose as a challenge inn real-time detection system. The selection of proper feature extraction technique specific to a particular set of data is one of challenging factor [13].

Naïve bayes and decision tree has played main role in previous methods for diabetes detection, as naïve bayes is simple probabilistic classifier based on bayes theorem with strong independence assumption. Decision tree is a tree structure, which is form of flow chart. Using nodes and internodes classification and prediction are done. Roots and internodes are used as test cases that separate the instances with different features. Internal nodes are result of attribute cases. Leaf nodes denote the class variable. Class variable determine if person has diabetes or not. Output of decision tree gives either tested positive or tested negative. Hence both these algorithms works on small amount of training data but it shows lack of transparency of result.

Among these algorithms, the Convolution Neural Network (CNN) has emerged as a popular pattern recognition technique. CNN architecture has emerged as an promising result in optimizing the performance and have reduced the computational time of the classifier.

In this paper CNN algorithm is proposed to be integrated with SVM architecture to predict diabetes and its type from raw acetone level samples.

III. BACKGROUND

In this section, the concept of Deep learning approach for optimal and reduced feature sets through CNN and fully connected MLP architecture as well as SVM classifier are explained.

A. Deep Learning Approach

This architecture mainly comprises of convolution neural network and max-pooling layers which are primarily used to extract features from signals.

Deep learning approach comprises of mainly two layers as given below

1) Convolution Layer :-

It is an deep feed-forward artificial neural network. Convolution layers defines the feature maps by transforming the input signal through the mathematical operation of convolution. Convolution is defined as dot product of two function after one function is reversed, where two functions are x(n) as input data signal and k(n) as kernel weights.

2) Max- pooling Layer :-

Pooling layers are used to reduce the dimensions of the feature maps. Thus, it reduces the number of parameters to learn and the amount of computation performed in the network.Max pooling is a pooling operation that selects the maximum element from the region of the feature map covered by the filter. Thus, the output after max-pooling layer would be a feature map containing the most prominent features of the previous feature map. The feature maps are segmented using a non-overlapped windowing technique.

B. Fully Connected MLP Layer

In multilayer perceptron, there are more than one linear layer. For example if we take three layer network, first layer will be input layer and last will be output layer and middle layer will be hidden layer.

MLP layer classifies data through supervised training. This is achieved by adopting back-propagation and stochastic gradient descent methods.

The activation function ranges in between [-1,1].The weights are biased and initialized randomly. In this algorithm mean square is calculated by summation of difference between desired output and estimated output.

Fully connected MLP layer of CNN iterates itself in forward and backward propagations till minimum error is achieved.

C. SVM Classifier

The main purpose of SVM algorithm is to construct a hyper-plane which can discriminate data points of a given feature set. SVM algorithm selects the optimal hyper-plane which as largest margin so as to achieve maximum separation of data points. Considering the training sample data mi the input feature set and τi is the target or the class label such the τ ∈{+1 or−1}. The decision function f(x) to construct the optimal hyper-plane is given by,

$$f(x) = \sum_{i=1}^{N} \omega_i \cdot m_i + b \qquad (1)$$

D. Figures and Tables

Fig.1 shows a hardware architecture of kit used for testing acetone level including array of sensors.

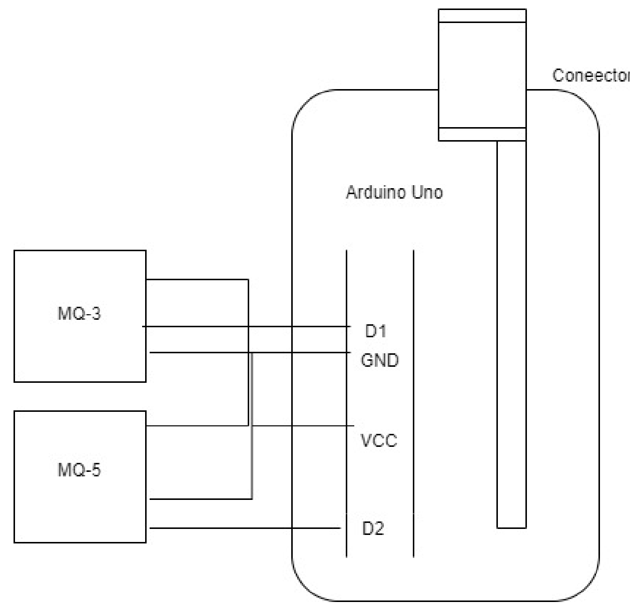

Fig. 1Sensors Connected To Arduino Uno (MQ3 – Figaro TGS822, MQ5 – Figaro TGS2611

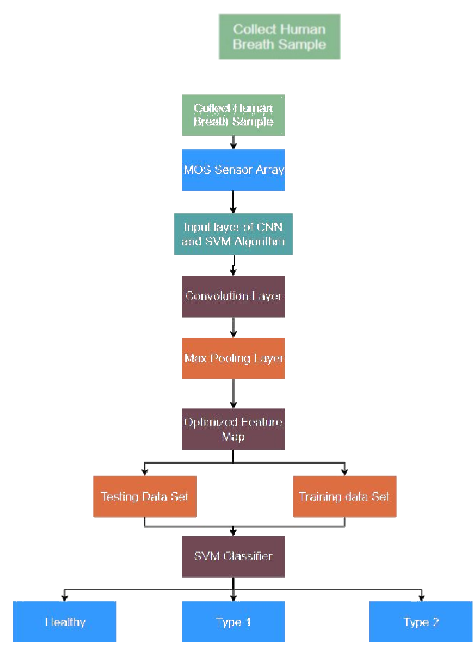

Fig. 2 Flow chart of the procedure.

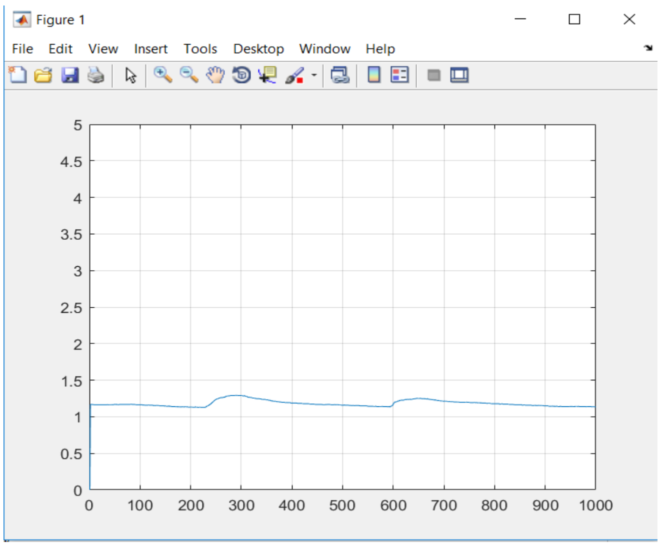

Fig. 3 shows an example of an non-diabetic patient using MQ-3 sensor.

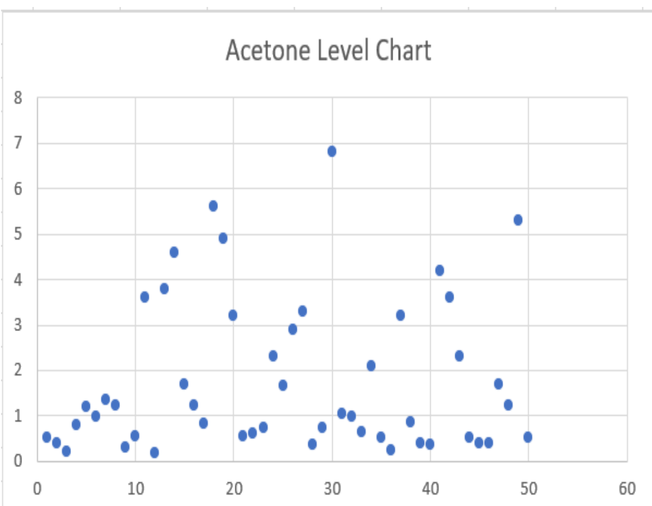

Fig. 4 Acetone level detection from breathesamples.

E. Experimental Results.

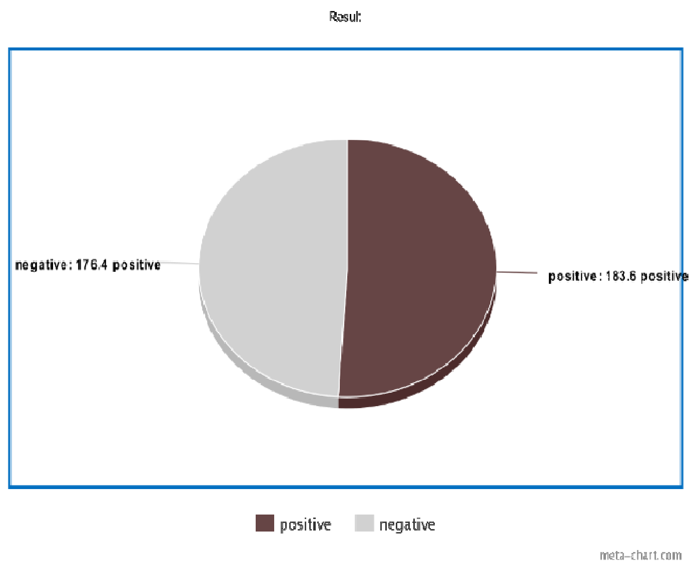

Fig. 1 Classification of negative and positive patients.

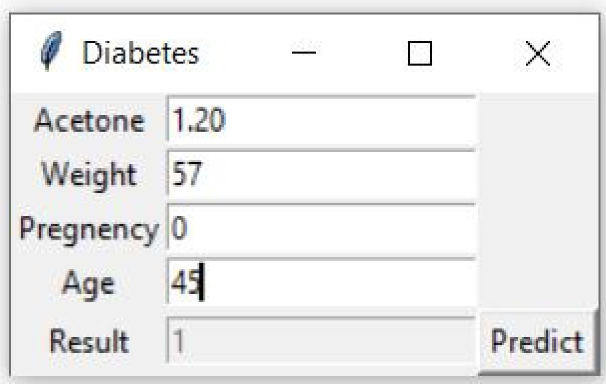

Fig. 2 Result for Diabetic patient.

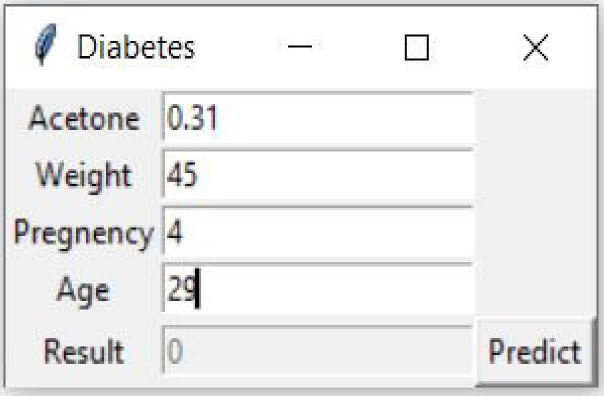

Fig. 3 Result for Non-Diabetic patient.

IV. CONCLUSIONS

The implementation involved developing a deep learning convolutional neural network by integrating support vector machine algorithm for classification of diabetic patient dataset. To overcome the drawback of MLP algorithms for non-linear datasets the proposed architecture integrates the concept of CNN feature extraction technique with SVM classifier.The feature sets from raw signals are calculated by mathematically convoluting these signals with Gaussian kernel weights.These optimized feature maps are further classified with the help of the SVM with kernel functions for non-linear data classification. In order to validate the system, the performance measures and overall computational time will be compared with the already existing technique. The developed system is tested on the acquired breath signals to quantitatively measure acetone gas concentrations present in them and hence to detect diabetes. The proposed system optimizes the overall performance of the detection system and effectively reduces the computational complexity of the classifier. Since, this will pertain to be the best application system to detect diabetes for type 1 and type 2 diabetes prediction by gaining best accuracy.

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