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Machine Learning Based Approach to Identify Neuro-Degenarative Disease using Gait Analysis

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Abstract- Personal mobility is primarily affected by neurodegenerative diseases. Characteristics of the disease are stiffness of the muscle and abnormal gait movement. Impairment of motor activity is a common characteristic indicative of patients with neurodegenerative (ND) disease, which can disrupt the pathway from the cerebrum to the muscle and thereby cause movement disorders.In order to differentiate normal gait from normal gait, we proposed a machine learning based approach. Where we analysed various classification algorithms and achieved an overall accuracy of 86.35% with 10 features. Conventional methods including high tech lab setup cameras sensors can be avoided since the proposed system is effective and wearable. Using manually labeled features, for algorithms such as K-nearest neighbour, Support Vector Machines, and Decision Trees, multiple feature sets are used to classify, and the performance of these algorithms is then recorded. This research introduces a real-time method for the mentioned disorders with an accuracy of more than 85%.

1. INTRODUCTION

Generative disease conditions are making life difficult, on the other hand, healthy subjects are happy because they can do simple activities like sports walking very easily. In most of the neurodegenerative diseases, there is reduced production of dopamine. In neurodegenerative diseases, symptoms are related to both motor and non-motor activities. “Clinical gait analysis is a way of documenting the biomechanical motion carried out while a subject walks, enabling physicians to determine the condition of a patient in the event of gait dysfunction. Due to specific neurological skeletal or muscular pathology, there is always a fluctuation in the human gait from healthy subjects.”[1][2] As there are large fluctuations and different variabilities, identification of abnormal gait, and diagnosis of specific neurodegenerative diseases can be achieved smoothly. Many authors [5][6][7][8] addressed the same challenging task using different technologies like Force sensors, electromagnetic, flexible goniometers, magnetoresistive sensors, tracking systems, sensing fabrics, electromyography, and accelerometers, gyroscopes, and are examples of technologies previously reported[3][4]. All technologies used expensive hi-tech lab setup, camera, sensors

and recording software, to make gait analysis wearable and affordable in this proposed system we have used force resistive sensor from which continuous signals are embedded to the various classification-based machine learning algorithm to achieve quick and easy identification of abnormal gait and diagnosis of specific neurodegenerative diseases. The components used in this proposed system are few force resistive sensors, NodeMcu Esp8266 microcontroller wifi module. The advantage of using a post resistive sensor is that the output is a continuous voltage which can be directly fed to the motherboard. The reason for using NodeMcu is it can be easily connected to the server or cloud to store or access and use the data from the sensor along with the easily achieved server or cloud system the reason for introducing MQTT-S transmission of data can be easily accessed since MQTT has publish-subscribe along with the broker methods[9]. The collected data is then fed to a classification based machine learning algorithm to identify abnormal gait. The overview of the proposed system is explained in section 2, specification of the proposed system is explained in section 3, data collection preprocessing is explained in Section 4, the algorithm used and the codes written are explained in section 5, section 6 result conclusion is discussed.

2. PROPOSED SYSTEM

Force resistive sensor outputs more voltage when the pressure is more and outputs less voltage when the pressure is less[10]. The sensor is placed in between the shoe and the foot which in turn connected to the microcontroller from there easy processes like digital visualization, cloud server transmission can be achieved. The generated output from the sensor is then published to the web or app where machine learning embedded framework code is present which will classify the normal and abnormal gait data. ESP8266 module publishes the data from the sensor to the MQTT-s server which includes
,publish-subscribe technics[12]. Along with the help of the two databases, several classification-based machine learning algorithms were analyzed, and then for the given for the taken data set SVM established 86.7% accuracy, which was highest among the analyzed data[13].

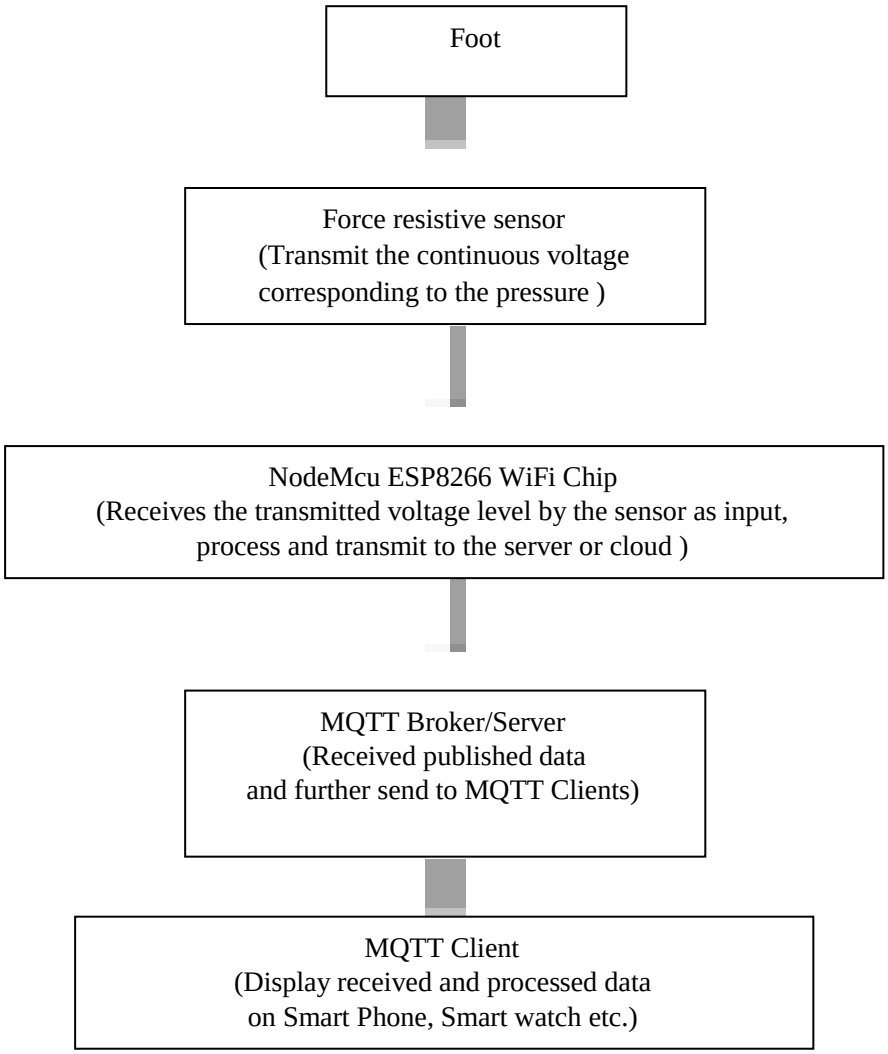

Fig 1 Process of the proposed system

2. SYSTEM SPECIFICATION

In the proposed system, the data from this which is fed to and machine learning algorithm which classifies is the normal and abnormal gait data with the help of the databases in this section each component used is explained in detail.

1). Force Resistive Sensor: A force sensitive resistor (FSR) is a material that, when a force or pressure is applied, alters its resistance[15]. An example of such force resistance material is conductive film. In other words, the force-sensitive resistor is a sensor that allows physical strain, pressing and weight to be sensed.

2). NodeMcu ESP8266 : is one of the low-cost, Wi-Fi-embedded and commonly used microcontrollers. It helps us to very easily programme the ESP8266 wi-Fi module. It combines the microcontroller and Wi-Fi features, which is an added bonus of simple and

accessible performance. The ESP8266 WIFI module has been designed in such a way as to relay the data to the server where the machine learning code is embedded[16]. Processed data is released with the aid of the MQTT-S communication protocol. The broker then receives the released message and then transmits it to the end user, such as smartphones , computers, etc.

3). MQTT-S The topic-based publish / subscribe techniques are a low-cost , low-power, lightweight protocol specifically designed for IoT purposes and protocol. One point functions as the client in this paradigm, which in turn is linked to the broker, where the client can receive messages from the broker or subscribe to them. The ultimate contact is to the broker and then to the client from the NodeMcu module. Since we are using a topic-based MQTT server, a unique topic ID identifies each topic-based client.

a). Mqtt-S Broker - The MQTT-S broker serves as a mediator who can accept the message and forward it to the free subscriber in the subject ID when esp8266 publishes the data to the certain topic ID. The broker manages both the publishing and subscribing methods and the buffering of the messages carried out so that the message can be accessed offline by the consumer.

b). MQTT-S Publisher/subscriber: NodeMcu along with the force resistive sensor act as a MQTT-S publisher, which will publish a message at specific voltage change according to the algorithm return which is completely based on the pressure. On the other end MOTT-S act as a subscriber who can receive the data by subscribing to the pre-register topic ID. Subscription to a particular topic-id is done with the help of the broker.We have considered a machine as the intermediary which can deal with the two distributors and supporters and is additionally ready to cushion the presently distributed messages. Buffering of distributed messages is helpful for disconnected customers who can later peruse that missed messages once they wake up.

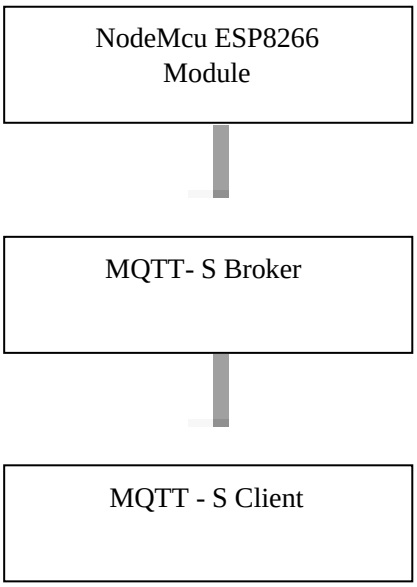

Fig 2 Asynchronous publishing of message

c). Supervised Machine learning: Supervised learning is the task of machine learning to learn a feature that maps an input based on example input-output pairs to an output. It includes a feature consisting of a collection of training examples from labelled training data. Supervised machine learning produces a model that, in the presence of uncertainty, classifies or predicts based on evidence[17]. A supervised learning algorithm takes a known set of data inputs and known data (output) responses and trains a model to make accurate predictions for the response to new data.

3. CLINICAL GAIT DATA

The way in which we walk and the manner in which human legs more is referred to as human Gait. The factors which are influencing the gate data are bodyweight, age, sex, height, diseases, and geography, etc In order to achieve more generalized and specific approach consider to databases that the raw data is directly proportional to the force which is similar to the data obtained from the sensor. The first database consists of 48 neurodegenerative disease patient records and 16 healthy patient records.Data was obtained from 'The National Institutes of Health-sponsored Research Resource for complex physiological signals' [10]. The second data consists of 40 healthy patients gait records obtained from [11]. Not all features were used specific feature correlation to the neurodegenerative disease was selected and then was used in the proposed system basic, preprocessing are used to make the data ready to implement machine learning algorithm finally 10 features are used in the proposed system to facilitate machine learning algorithm[14]

4. SUPPORT VECTOR MACHINE

Support vector Machine (SVM) is a non-probabilistic binary classifier that assigns new examples to classes. It is a supervised process kernel-based algorithm in which a collection of data is evaluated with first of all, known groups and then identify unknown test samples. Linear SVM is the basic form of an SVM classifier where examples are laid out in space as points and then separated a clear gap in two, maximising the width of the gap. In an infinite dimensional feature space that is used for classification or regression, an SVM builds a hyperplane. A maximum separation hyperplane with the nearest training data points has the least classifier error. The data points that help to construct this hyperplane are called support Vectors. They are those that are closest to the hyperplane. It is possible to conduct SVM linearly or nonlinearly. Non-linear SVM gives better results when the hyperplane of the linear margin does A good fit is not made. Non-Linear SVM uses a kernel trick to transform feature space, thus optimising hyperspace. The Gaussian radial basis function (rbf) kernel is used for classification in this work If a data set of n points is provided, such as (x1, y1) ... (xn, yn). In which x is the data, and yj is the binary identifier (1 or -1) reflecting the class to which xj belongs, and φ(x) is the morphed data point of a new linear SVM space. The transform function of the kernel is connected by equations: $k(xi, xj) = \varphi(xi).\varphi(xj)$ Where the kernel equation is k(xi, xj), φ(xi) is the transformed equation, The data set and the standard vector for that hyperspace is φ(xj). For-For
The kernel equation of the Gaussian rbf kernel is given as Where $|x-x'|$ is the Euclidean distance,
squared. And σ is a parameter that is free. C and σ were selected using the grid search

method in this work, and C= 1000 and σ= 10 showed the least classification error. Using Python, with the assistance of pandas , numpy and Sklearn, SVM was implemented. The observations are as computed below.

Parameter	Value(%)
Accuracy	86.35%
Error Rate	14.75%
Positive Predictive Value	92.31%
Negative Predictive Value	60%
Sensitivity	85.23%

5. CONCLUSION

In this paper, we have proposed a practical brilliant accpoch in which gait characteristics are used to differentiate between normal and abnormal gait which facilities to identify Neuro degenerative diseases . Gate analysis is a valuable method that can help physicians make choices for patients with neurodegenerative disorders and prepare treatments. We have used the MQTT-S protocol as it is efficient and makes data transmission easy between the publisher and subscriber. The Buffering technique is used to read the message in offline mode. As an add on advantage to the smart Healthcare service, we believe that the developed system can remotely monitor the gait data of the patient. The results shown in this paper indicate that for particular diseases, different algorithms would have better results and, as such, a multi-model prediction scheme might have better overall efficiency.

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