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A Cuffless BP measurement using ECG and PPG sensors

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Abstract: The current lifestyle of people even though it is fascinating with respect to technologies, health is constantly getting worse day by day. Because of commuting, pollution, or working lifestyle there induces immerse stress on one's life. One of the major health concern with respect to stress is the changes in blood pressure, heart rate and the saturation level in one's blood. Hence this paper concentrate on development of a cost effective health monitoring system to measure blood pressure (BP), using Electrocardiogram (ECG), Photoplethysmography (PPG) along with the detection of arterial stiffness.

Keywords: Machine Learning; Digital Signal Processing; Arterial Stiffness; Blood Pressure

I. INTRODUCTION

For a country to be tagged as developed, along with meeting its basic amenities for citizen such as food, shelter, stable economy, healthcare should also be looking fine. However the ratio of doctor and the parametric staff to the population of India is very less. In the recent years many death happen due to cardiovascular problems or due to high blood pressure variation. According to National Institute of Health (NIT) two third of the people in world suffer from high blood pressure, which can lead to fatal disease such as stroke, cardiac failure, arterial stiffness etc. Frequently monitoring the blood pressure in elderly people, pregnant women, and all other patients can help them to stay from fatal. Hence here it focuses on a development of an embedded system that can measure electrocardiogram (ECG) and photoplethysmography (PPG) of the patient. An analysis of machine learning algorithm will be made to calculate blood pressure of him/ her with the help of ECG and PPG value.

A. Machine Learning

In previous decade medical data were stored using software, which have made the accuracy of data limited. But in recent days there is a huge amount data that is generated day by day which becomes difficult for a human to analyse these data. An alternative method which is being come into existence is machine learning, which will give out a prediction based on the dataset.

Machine learning, which a subset of artificial intelligence, came into existence in the year 1959 by Arthur Samuel. When a computer is provided with data and then recognized those with help of an algorithm, it is called as machine learning, the process by which it learn is called as training and output processed is the model. The objective of a learner is that to generalize from its experience. Generalization means the ability of a machine to perform accurately on unseen or new data. The computational analysis of algorithm in machine learning is known as computational learning theory. There are a number of applications in machine learning such as healthcare industry, agriculture, marketing, economics, general game playing etc

Machine learning in healthcare industry is recently come up. Google have identified that machine learning algorithms can be used to identify cancerous tumours on mammograms. Machine learning algorithms provide reproductive or standardized benefits to disciplines. Machine learning is trained to observe images that are provided and hence find out the abnormalities and point to that area which needs attention, hence increase the efficiency. At a health catalyst, proprietary platforms are used to analyse data and use it in clinical decision making. When a physician check a patient and enter the symptoms, data, and test results to the EMR a machine learning will happen throughout the data hence give the useful information to doctor for making diagnosis. There are limitless advantages of machine learning in healthcare industry which can be described as follows:

- Reduce readmission: Doctors can get guidance on patience as in who are more likely to get admitted again through machine learning in an efficient and patient centred manner and hence reduce the risk.
- Reduce long stay in hospital: long stay in hospital can be reduced by analysing patient condition and improve patient satisfaction.
- Predict chronic diseases: Machine learning can be used to predict the likelihood that the patient will develop chronic disease.
- Reduce 1 year morality: It can reduce the morality rate by predicting the likelihood of death in a year.
- Predict propensity to pay: Health system can give assistance to patients for their financial support

- Predict no shows: health system can give accurate models to asses to scheduled appointment thus improve patient care.

B. Case Based Reasoning

Earlier in 1970's and 1980's the developments in artificial intelligence research was based on rule based expert system (RBES). This was applied to most of the problem that had emerged during that time. Rule based expert system was based upon deep and explicit knowledge. Even though rule based expert system was successful in many sectors over the period there were a few disadvantages which can be summarized as follows:

- It was time consuming and hard due to complex expert knowledge elicitation.
- RBES usually deals with problems, when the built in knowledge is well established, formalized and stable.
- If the RBES system is not provided with a learning facility then any addition to the existing system will requires help of a programmer.

Solution to these problems was found using new and improved technique and tools. A problem solving and new reasoning method was found that was case based reasoning (CBR). The origin of CBR was the work of Rogen Schank.

- CBR is a solution which comes out through remembrance, it uses previously solved problem. 4 assumptions that represent the basis of CBR are:
- Regularity: same actions performed for same condition will have same outcome.
- Typicality: experiences which will repeat themselves
- Consistency: small changes in situation require small changes in interpretation and in the solution.
- Adaptability: when things repeat the differences tend to be small and the small differences are easy to compensate for.

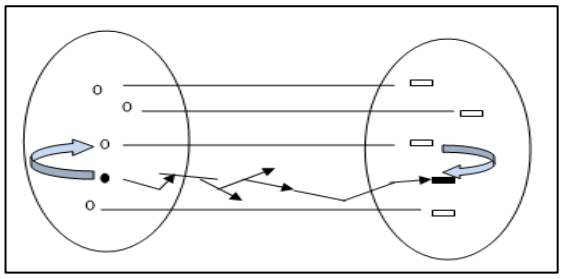

Fig 1. Problem solving using CBR

The figure illustrates how the 4 assumptions are used to solve the problem in CBR. If a new problem arises and if it is described according to the previously solved, then solution to this problem can be applied to current problem. Once if solution is formed then a link between it and description of problem will be created such that new problem can be solved in future. CBR can be described in the following 4 stages;

- Case Retrieval: Once the problem is assessed, best matching case is searched and then approximate solution is retrieved.
- Case Adaptation: the retrieved solution is adapted to fit better the new problem.
- Solution Evaluation: The adapted solution is evaluated either before or after the solution is applied.
- Case Updating: If solution is verified as correct then new case may be added to case base.

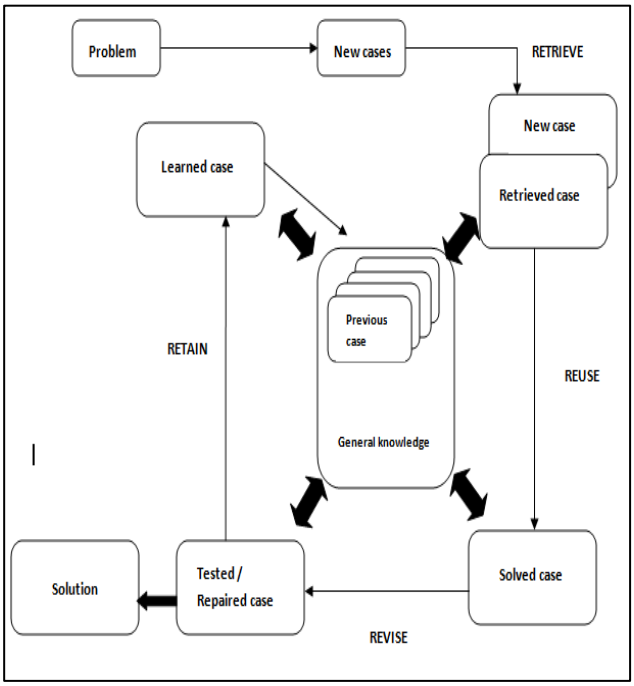

Fig 2. CBR working cycle

C. Digital Signal Processing

Digital signal processing is used for processing various signal, the processed signal are a sequence of numbers that represent samples of continuous variable such as time, frequency, space. Digital signal processing and analog signal processing are subfield of signal process. To analyze signal digitally it must be digitized using analog digital converter.

Signals can be sampled in 2 ways i.e. discretization and quantization. Discretization is a method where the signal is divided into equal interval. Quantization is the approximation of value from the finite set. Usually digital signals are studied in one of the following domains such as time domain, frequency domain, and wavelet domain. Sequence of sample from measuring device produce temporal or spatial domain. Application of digital signal processing includes audio, sonar, radio signals etc.

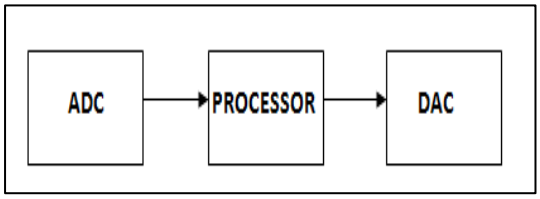

Fig 3. Digital signal Processing

II. RELATED WORK

Artificial neural network, initially live data were collected from hospitals and those data were sampled to train and test using Multilayer perceptron (MLP) and Gaussian mixture mode (GMM). The data records were derived from 2 set of experiment. The first set was a healthy and second type was consisted of pathologies. An algorithm was run over this data and found to be satisfactory. But as a conclusion it is said that PPG signal are varying from person to person and time to time. The MLP can be used for very small data such that it provides accurate and effective result is proposed in [1].

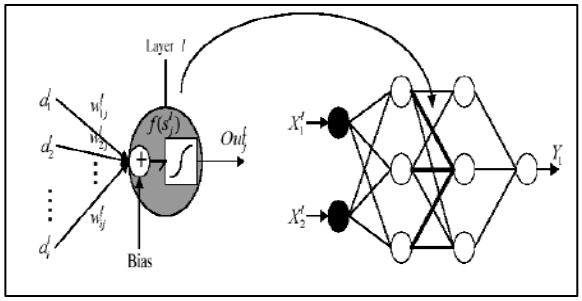

Fig 4. Architecture of multilayer perceptron neural network

Method to measure BP based on the pulse transmit time (PTT). Least square regression model is used to estimate BP in the first and repeated after 6 months. The development of PTT based blood pressure measurement enable to trace the change of BP after a period and provides accuracy and hence reduce frequent calibration of cuffless technique [2].

People with no history of cardio vascular problem of age ranging between18-25 were studied in order to come up with the pulse transmit time from the ECG. Studies were performed at a normal temperature, and have allowed a light consumption of food before 4 hours of diagnosis. Studies have resulted that all the non smoking men were healthier than the smoking men [3].

An overview of approaches that are used to measure blood pressure using non invasive methods. Such that this method can be categorized as pure PPG-based only on the basis of PPG signals. It also describes the challenges that can occur while using wearable blood pressure measurement and wireless blood sensor networks (BSN). It is found that wearable BP measurement is challenging in both technological and standardized perspective.

Wireless BSN face issues in measuring BP because of its small dimensionality, optimal placement, low energy consumption and in-node processing measuring to save the bandwidth to transmit the raw data is provided in [4]. Using impedance technique [5] in this paper a new approach is being used to measure blood pressure i.e. impedance plethymography which would be used to measure cuff less blood pressure. Hardware was designed for the impedance plethymography technique as shown in the figure.

Blood flow is measured in IPG technique based on the impedance blood volume caused due to cardio stroke. A multi channel measurement system is used to measure ECG, PPG, and IPG signals. Different measurement was collected from many samples and analyzed, hence have plotted different graphs and found that impedance methodology was better than the other related work.

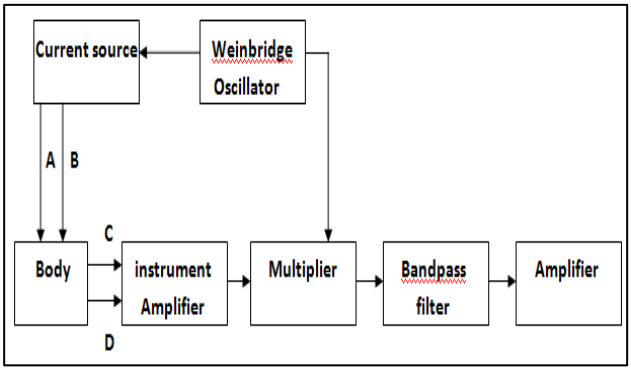

Fig 5. Circuit for Impedance plethymography technique

Blood vessels are responsible for circulating blood throughout the body. The pressure exerted by circulating blood on walls of blood vessels is called as blood pressure, it is measured in terms of systolic over diastolic. Low blood pressure is termed as hypotension and high blood pressure is termed as hypertension, both can get adverse effect on human hence a continuous monitoring is needed for blood pressure. Using sphygmomanometer is the traditional method, and some non-invasive method for measuring blood pressure. In paper [6] it proposes a method to predict diastolic blood pressure and systolic blood pressure, here features were extracted from some few samples which were analyzed under 3 different conditions.

As shown in the diagram paper [7] proposes a model in which a tunneling piezoresistive sensor is immersed to a wristband of a smart watch and which could continuously measure the blood pressure variation in a human body. These varying signals are captured by the sensor and have stored in the cloud hence anyone could access it. A health monitoring organization can analyze the varying signal values that are accessed from cloud for the further diagnosis, hence they can find if anyone need an emergent assistance and could provide better treatment such that his/her life can be saved from cardiovascular problems.

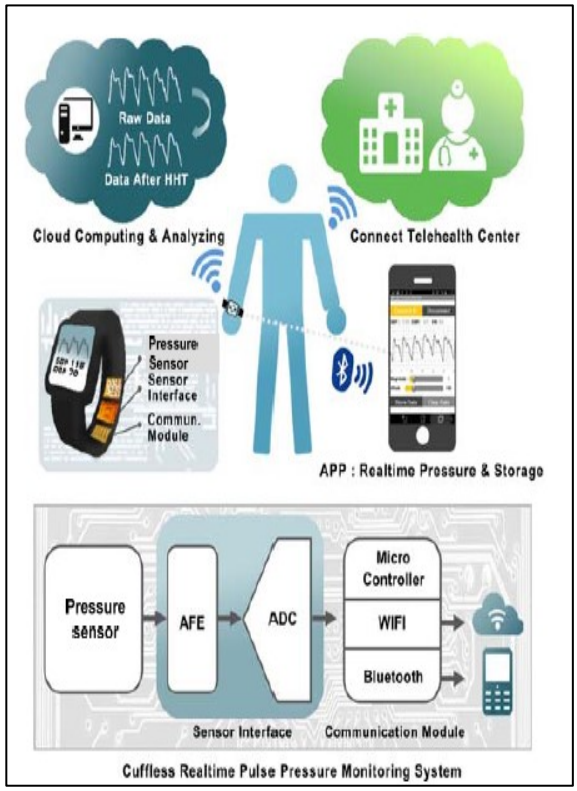

Fig 6. Pressure sensing system scenario

III. CONCLUSION

The paper explained in the earlier section concentrates on cuffless blood pressure detecting method. However, the complexity involved in the process is high. Moreover, the pressure sensor has been directly incorporated in the design, which may not provide accurate results all the time. The future scope of the work would be to develop a machine learning based method to calculate BP using ECG and PPG sensors.

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