International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Issue 03, Volume 6 (March 2019) - Special Issue www.ijirae.com
SPECIAL ISSUE - 5th Inter National Level Conference - "MEEMIC – 2019"

IOT BASED EARLIER STROKE PREDICTION

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Manuscript History
Number: **IJIRAE/RS/Vol.06/Issue03/Special Issue/SI.MRAE10104**
Received: 20, February 2019
Final Correction: 05, March 2019
Final Accepted: 20, March 2019
Published: **March 2019**
Editor: Dr.A.Arul L.S, Chief Editor, IJIRAE, AM Publications, India

Abstract - Stroke onset during night-time sleep referred as wake-up stroke, where a patient awakens with stroke symptoms that were not present before falling asleep. The symptoms of wake-up stroke are not clearly known; it is only noticed upon waking. Without knowledge of the stroke onset time, this large group of patients is excluded from treatment with tissue plasminogen (tPA) activator. This research studies stroke risk prediction during sleep, i.e., wake-up stroke prediction using Internet of Things (IoT). Stroke prediction through intelligence technology and prediction algorithms which controlled by hyper-connected self-machine learning engine. The idea achieved through building a knowledge base including physiological data, motion data, bio signal, risk factors and electronic health record. The physiological, biosignal, and motion data will be measured through wearable and embedded sensors. This paper focused on briefly explaining the conceptual idea and related information of the elderly stroke prediction while sleeping using IoT.

Keywords: Wake- up stroke; Internet of Things; Wearable devices; Physical and Physiological variations;

I. INTRODUCTION

The Korean population is constantly evolving. The elderly population is the one particular demographic has grown considerably over the years. Korea is one of the most rapidly aging countries in the world. In the year 2000, Korea turns out to be an aging society with the elderly over 65 years old was 7.2 %. Moreover, it is rapidly moving into an aged society in 2018 and a super-aged society in 2026. For Korea, it will take only 26 years to transform from aging to super-aged society. According to the Korea national statistical office, people over 65 years old will account for 37.4 % of Korea's population in 2050 and Korea is expected to become the most aged country by the mid-21st century [1-3]. A stroke occurs when the sudden disturbance of blood supply to the brain due to either the blood supply suddenly interrupted to part of the brain, or blood vessel ruptures and blood invades the surrounding area. Stroke is an important health burden in Korea as well as worldwide. The stroke population, as well as world population, is aging Stroke is the second leading cause of death above the age of 60 years. Stroke is the third most common cause of death in developed countries.

Wake-up stroke defined as stroke onset during night-time sleep, where a patient awakens with stroke symptoms that were not present before falling asleep. Several studies indicated that the percentage of wake-up stroke between 8 to 28 % of all ischemic strokes. The stroke affects the individual depend on serves factors, including the side of the brain and amount of brain tissue damage. Some of these effects may be experienced: sudden loss of vision in one or both eyes, face drooping, arm weakness or arm drift down, speech difficulty, movement, and sensation or paralysis, eating and swallowing, sudden loss of balance, cognitive ability, emotion control, and severe headache. The chances of surviving from stroke are much higher if the victim gets emergency medical assistance within a few hours of occurrence.

However, the symptoms of wake-up stroke are not clearly known; it is only noticed upon waking consequently, without the time data of the stroke onset, it is difficult to treat a patient with wake-up stroke. Also, those patients are excluded from the treatment with tissue plasminogen activator. The tissue plasminogen activator remains the only FDA-approved nonsurgical reperfusion therapy. Recent advances in brain imaging used to decide whether wake-up stroke started within 4.5 hours window. The current standard technologies for stroke diagnosis are ultrasound, magnetic resonance imaging, and computer tomography. For example, the magnetic resonance imaging carries the potential to identify patients like to be within a time-window for reperfusion therapy by a specific magnetic resonance image pattern. It involves analysing the mismatch between a visible lesion on diffusion-weighted imaging and a normal fluid-attenuated inversion recovery image. However, those techniques are expensive and can only be done by medical doctors under hospital settings. Those techniques not appropriate for regular or daily use at a living environment like home or office for an early stroke alarm generation. Hence, it is highly necessary to have a technology to detect and promptly alert the wake-up stroke onset automatically.

II. BACKGROUND

Sleep plays an important role in keeping good health and well-being throughout our lives. We spend approximately one-third of our life in bed, and a synergy of psychological and physical conditions affects the quality of sleep. Parameters can be measured during sleep those are affected while the individual experience stroke: electroencephalogram (EEG), electrooculogram (EOG), electromyogram (EMG), cardiovascular measurements, respiration, blood pressure, photoplethysmograph (PPG), and skin temperature and conductance.

The cerebral blood flow is the blood supply to the brain in a given period. The cerebral blood flow turns out to be compromised, changes occur in the electrical activity of neurons in the brain. The EEG is the method to record the electrical activity of the brain. The EEG changes closely tied to cerebral blood flow. A recent study highlighted the relationship between cerebral blood flow, EEG change, and cellular response. To summarize when the cerebral blood flow declines to the range of 25-35ml/100g/min, the EEG loses its alpha frequencies, then the flow declines further to 17-18ml/100g/min, theta frequencies gradually increase. This cerebral blood flow is the crucial limit for ischemic stroke, where neurons begin to lose their transmembrane gradients, and leading to brain cell death. If the cerebral blood flow declines further to 12-18 ml/100 g/min, increased delta frequencies seen in the EEG activity. Finally, if the cerebral blood flow decreased further to 10-12ml/100g/min and below, the EEG activity becomes silent and cellular damage become irreversible. Hence, measuring the EEG activities are necessary while sleeping, which would aid to understand the cerebral blood flow.

The ECG is the process of recording the electrical activity conducted through the heart muscle, which can be measured over a period by electrodes or sensors. The ECG waveform could be used to collect information about electrical activity associated with different aspects of a heartbeat. The abnormalities in the ECG waveform frequently associated with stroke. The few ECG waveform abnormalities are ST- segment changes, inversion of T wave, pathologic Q waves, QT prolongation, and atrial fibrillation. The QTc prolongation followed by T-wave inversion followed by ST segment changes are the most frequent ECG changes observed in acute stroke patients. Another method of measuring or detecting volumetric changes in blood in peripheral circulation, i.e., the rate of blood flow is the photoplethysmography (PPG). It is an optical method and allows the measurement of time-related cardiovascular parameters, i.e., pulse transit time (PTT). Another parameter spontaneously changes in stroke patients is the blood pressure. The blood pressure pattern showed different dynamic and pattern before and after a stroke onset. The normal blood pressure changes around the baseline. However, the blood pressure change in a stroke event takes about hours to fall back to the baseline, i.e., pre-stroke level.

III. WEARABLE DEVICES FOR SLEEP MONITORING

There are many wearable devices for sleep monitoring based on physiological signals. For example, iBrain (NeuroVigil), Zeo, SleePic system, Heally recording system, M1(sleep image), air cushion, EarlySense mattress, Emfit bed sensor, Linen sensor, LifeShirt, magic vest, SenseWear Armband (BodyMedia), SmartShirt (Sensatex), WristCare (Vivago), WakeMate, and Wrist Device (AMON). Each wearable devices has own validation, sensitivity, and specificity issues. Some of them are discussed here. The iBrain (NeuroVigil) device records a single frontal EEG through headgear. The accuracy of the device was 84% when compared to the manual sleep-wake scoring of the zebra finch. However, the company does not have human validation studies. The Zeo is an elastic headband with fabric sensors can detect EEG, EMG, and EOG signals. This device has 75% agreement on epoch-by-epoch scoring with gold standard method i.e. Polysomnography (PSG). The Heally recording system consists of a shirt with a combination of embedded sensors and electrodes. This system can measure respiratory, ECG, EMG, and EOG signals from human subjects. This device has 80% accuracy with human scoring. The air cushion is a thin, air-filled cushion can record heart rate, respiration rate, body movement, and snoring. This system can detect Non-Rapid Eye Movement sleep 82.6%, Rapid Eye Movement sleep 38.3%, and wake 70.5% compared with PSG data.

There are several wearable devices for sleep monitoring based on body movement. For example, Fibit, Lark, Sleep cycle alarm, sleep tracker, wake Mate, and beddit. The Fibit is a wrist-worn device can measure metrics sleep and wake, total sleep time, sleep latency based on body movement. However, there are no validation studies available. The sleep cycle alarm clock is an iPhone application to measure body movement while sleeping. This clock uses the built-in accelerometer of the iPhone. This clock also does not have supporting validation studies. Another wrist-worn wearable device is Wake Mate. This device can measure metrics total sleep time, sleep latency, sleep quality, and a number of time of awakenings. Similar to other devices, there are no validation studies available for this device. To summarize, there are wearable devices for sleep monitoring with different methods and algorithms. However, each wearable device has its monitoring limitation and validity issue. Even the conclusions by each wearable device may only be relevant for the specific conditions of the study and specific population.

IV. RELATED STUDIES ON STROKE PREDICTION

A recent study developed stroke risk prediction model with patient demographic. The demographic data were analyzed using data mining technics such as decision tree, Naïve bays, and neural network. This study concluded that decision tree was more accurate than other two classification models. Also highlighted that neural network was better than decision tree and Naïve bays regarding the safety of life. Stroke prediction framework was proposed based on ontology and Bayesian belief networks. This system specially designed to predict risk level for transient ischemic attack (TIA) patients. The Bayesian model designed in this system was implemented using the Netica tool. Another study proposed a stroke prediction model on climate factors based on multiple regression analysis. This study used multiple linear regression backward independent variables and proposed multiple nonlinear regression equations. There were few other stroke prediction models available, which use electronic health record. The models are Cox proportional model, integrated machine learning, Bayesian list machine model, and multivariate Cox model.

V.BLOCK DIAGRAM OF STROKE PREDICTION

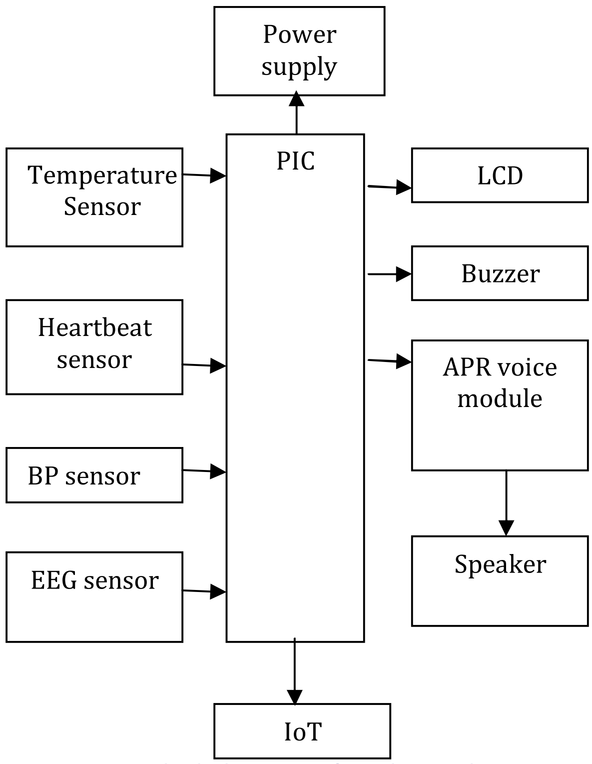

Fig.1.Block diagram of stroke prediction

VI. PRESENT STUDY OBJECTIVE ON STROKE PREDICTION

This research project objective is to successful real-time detection and generation of alarms in cases of stroke onset while sleeping through Internet of Technology (IoT) especially for the elderly, which will allow the timely delivery of medical assistance. Stroke prediction through intelligence technology controlled by hyper-connected self-machine learning engine. The idea achieved through building a knowledge base including physiological data, motion data, bio signal, risk factors and electronic health record.

The physiological, bio signal, and motion data will be measured through wearable sensors. After successfully creating a knowledge base, the hyper-connected self-machine learning engine can predict stroke through its intelligence and prediction algorithms. The system would include multi-model learning (SVM, Bayes, RF, CNN, LSTM, deep learning) and model generator. If the proposed system predicts stroke symptom above 90%, it will generate an alarm to family, the victim, people around the victim, and healthcare professionals. Then the victim will get the timely medical assistance.

VII. CONCLUSION

The objective of this study is to predict/monitor stroke onset i.e., stroke onset time. Stroke onset during night-time sleep (wake-up stroke) only identified through advanced imaging techniques. To avoid these shortcomings, this study proposes a conceptual idea to predict/monitor stroke while at sleep using IoT. The system to be developed would include intelligence technology, prediction algorithms and hyper-connected self-machine learning engine. Through this development, the elderly group will get the timely medical assistance.

ACKNOWLEDGEMENT

We are thankful to the management of Sengunthar College of Engineering, Tiruchengode, Tamil Nadu for providing all the amenities to complete this work successfully.

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