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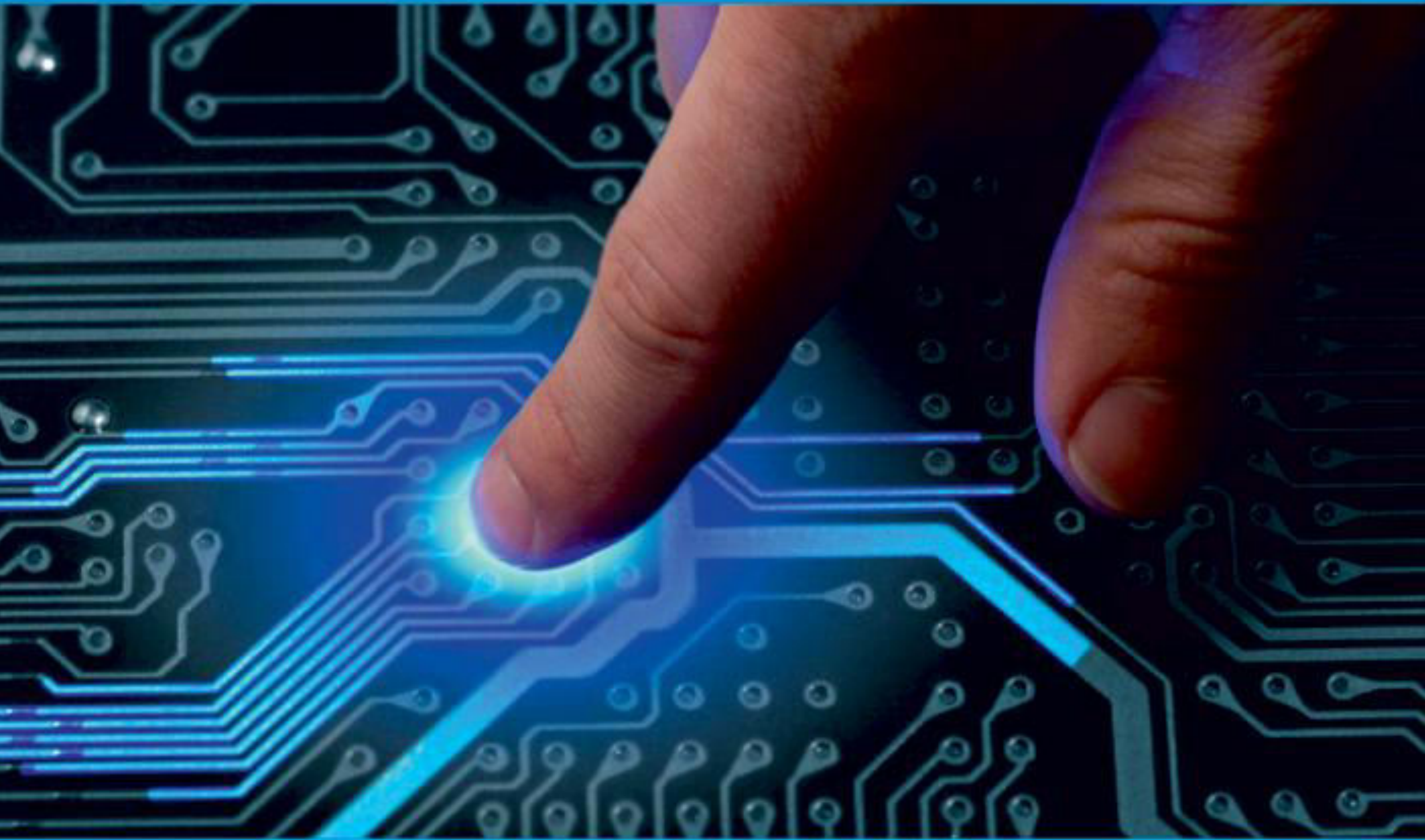

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An Implementation of Polymer Based Sensor for the Analysis of Sleep Disorder

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ABSTRACT:Sleep Disorder breathing is an increasing common condition among the general population. Conventional sleep disordered breathing diagnosis depends on in-lab polysomnography, while at home sleep test devices are becoming a more widespread. We present the design, implementation and preliminary result from a novel " IOT ready" Sleep test device named "VitalCore".

This devices utilizes electroresistive polymer sensor and acclerometer to measure respiratory,cardioc and actigraphy information. The device Bluetooth 5 to stream and transfer data and is capable of reliably acquiring high quality sleep data. In this paper,Vital core is bench tested andcompared to gold standard respiration and pulse measurments to verify its function ability and to access the quality of data captured during sleep and during lightexercise.

Here we can show that these polymer based sensors and identify respiratory peaks with a sensitive of 99.4%, precision of 96.28%, and false- negative rate of 0.557% during sleep. We also show that this T-shirt configuration allows the wearer to sleep in all positionswith a negative differenceof data quality. The device was able to capture breathing during gait with 88.9-100 % accuracy respiratory peak detection. The device significantly improves the user experianse by completly concealing the hardware into the T-shirt while providing the 5 days of battery life,fullspeedbluetooth 5 live data streeming/downloading with local storage capabl of more than a year worth to sleep data.Remote health monitoring, based on non- invasive and wearable sensors, actuators and modern communication and information technologies offers an efficient and cost-effective solution that allows the elderly to continue to live in their comfortable home environment instead of expensive healthcarefacilities.

KEYWORDS: Vital core, Sleeping Disorder, IOT Ready, T-Shirt

I. INTRODUCTION

Sleep disorders are a major public health issue. Nearly one in two people will experience sleep disturbances during their lifetime (1) with a potential harmful impact on well-being, physical and mental health (2).For example, insomnia is characterized by complaints about the duration and quality of sleep, difficulty falling asleep, nocturnal awakenings, early awakening and / or non-recuperative sleep (4). This symptomatology must be present at least three times a week, for at least one month, with negative consequences on the next day. Sleep and mental health are highly related, with many mental health problems also being associated with sleeping disorders (5). Traditionally, sleeping disorders have been viewed as a consequence of mental health disorders, and evidence also suggests that sleeping disorders can contribute to the development of new mental

On average, we spend about 30% of our lives asleep, and we have little idea why. This ignorance is probably the main reason why our society has such little regard for sleep. At best, we tolerate fact that we need to sleep; at worst, we think of sleep as an illness that needs a cure. This attitude is not only dangerous but unsustainable. Sleep is a highly complex state that arises from an interaction between multiple brain regions, neurotransmitter pathways, and hormones, none of which is exclusive to the generation of sleep. This complexity makes sleep very vulnerable to disruption. Small changes in brain function can have a big effect on sleep, and disrupted sleep leads to many healthproblems.

It is important to stress that sleep disruption is much more than an individual's frustration at failing to initiate or sustain sleep, or even the sensation of feeling sleepy at an inappropriate time. Disrupted sleep is closely linked to an increased susceptibility to a broad range of disorders, ranging from poor vigilance and memory to reduced mental and physical reaction times, reduced motivation, depression, insomnia, metabolic abnormalities, obesity, immune impairment, and even a greater risk of cancer.

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II. RELATED WORK

Normal sleep is characterized by a succession of four to six cycles lasting about ninety minutes. Each of these cycles consists of slow-wave phases and rapid eye movement (REM) sleep, which are related to slowdown and activation of the central nervous system. During REM sleep, or stage 5, rapid eye movements are observed and muscle tone is abolished. The early-night cycles are especially rich in deep, slow sleep and the latter in a REM sleep (7).The duration of normal sleep varies between six and ten hours, depending on several factors, the most important of which are age and genetics. Normal and pathological sleep can be explored either subjectively, i.e. by asking the subject, or objectively, using sensors. An epidemiological study conducted in 2013 with over 1000 participants found a subjective prevalence of insomnia of 15%, while the objective prevalence measured by polysomnography (PSG) was 32% (8).

To date, polysomnography remains the gold standard to objectively assess sleep characteristics. The polysomnograph plots a hypnogram, integrating data from several sensors: electroencephalogram (EEG), electromyogram (EMG), electrooculogram (EOG), thoracic movement (from belts on the chest and abdomen), airflow measures, oximetry, and electrocardiogram (ECG). The sleep stages are scored according to standard visual criteria based on the EEG, EOG, and EMG sensors(5).The assessment must be carried out under controlled conditions in the laboratory for eight to twelve hours. An automated hypnogram analysis is possible, but still needs manual integration of data (7). Successful recording of the polysomnography over the course of the recording and the analysis of the results must be carried out by a clinician with expertise in sleep pathologies in brain disorders.Although polysomnography is considered the "gold standard", it is an examination with limitations: it can be cumbersome for the patient, not very accessible, and not being realized in ecological conditions. It may therefore not be suitable for all populations of interest, such as individuals who are suicidal, sensitive to the environment or who may requireemergency.The polysomnogram is viewed as the clinical best quality level methods for surveying the nature of rest . It requires the patient to go through different evenings at a particular rest facility. While the nature of determination is the best accessible, it includes some significant downfalls of constrained rest center access, significant expense (~$800 – $2,000) , and the time required to produce the conclusion. Moreover, the polysomnogram is acted in a new domain and for the most partawkward because of the quantity of sensors applied. Above all, polysomnography assesses just a solitary night/scarcely any evenings depiction of conditions and isn't reasonable for long haul restchecking.

III. PROPOSED ALGORITHM

To install the gadgets inside the shirt texture, the equipment must be as little and slender as could be expected under the circumstances. Segment determination is basic subsequently. The parts which must be available in the shirt are appeared in Fig. Where potential, segments that gave different required highlights were chosen.The hardware is manufactured in a 40 mm x 41 mm four layer PCB as shown in Fig. Custom made U- shaped ERBs connect to the two sides of the circuit board such that chest expansion is divided between two bands. This allows respiration recording even while the user lies on their side. The PCB is coated with circuit board lacquer to protect from sweat and concealed under the tshirtsuch that the PCB part placed just below the sternal bone, where both male and female human body naturally have a small gap under the rib cage. The only rigid part of the device is placed to occupy this space. Even when the user sleeps in a prone position.

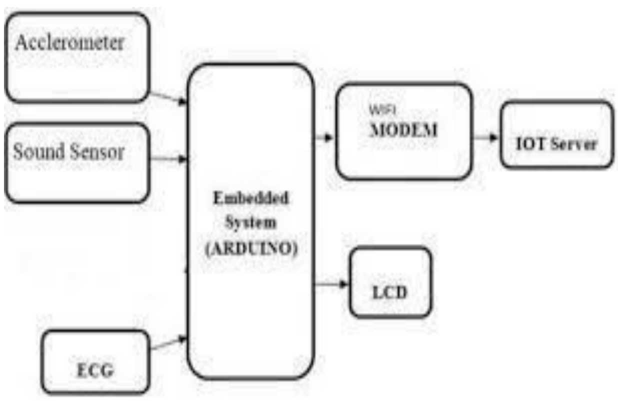

Fig: Parts inside the principle controller

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The core requirement of the device is to monitor cardiac and respiratory function. It further needs to be aware of body position and activity such that artefacts resulting from movement may be detected. Data needs to be captured, recorded and transferred to an external PC/Mobile Phone and subsequent Cloud for further analysis.A series of device test experiments were performed to assess the overall performance of the device. First we assessed technical aspects of the device, i.e. data throughput via Bluetooth, SD card throughput, power consumption. Second, we assessed functional capabilities, i.e. respiration and cardiac activity detection. For all experiments, the data is sampled at 100Hz for each channel, ERB1, ERB2, ECG and Accelerometer. Each sample consists of a 32bit integer.The ECG channels are not intended to be used in the home environment as cardiac activity will be captured using the noncontact ERB, thus negating the need for any electrodes. However, it is useful in validating the deviceand potentially will be used in future application to gain additional information about cardiac activity. The connections to the disposable ECG electrodes can be routed via either jumper wires or shielded low resistive EMIfabric.

The design of fabrics which embedded a monitoring system capable of reading an ECG signal and temperature of a patient and is then transmitted via WIFI to a display module that can be a WEB application. The captured information is sent via a IOT using local network to a database implemented on a web page. A Web application allows access to data from any WIFI-connected device. Non- contact electrode procedures for obtaining physiological signals become increasingly necessary and mark the current trend in medical. In this system we are continuously monitoring the patient's different parameters such as body temperature, ECG andpulse.

Fig: Electronic PCB and ERB

IV. RESULT

The steps of the literature review research and analysis are summarized in Figure 1. The initial search identified 255 articles. No duplicate articles were identified, and screening based on the titles removed 94 articles. 109 articles were excluded after review of the abstracts. After review of the full text, 34 additional articles were excluded because they did not meet the inclusion criteria.

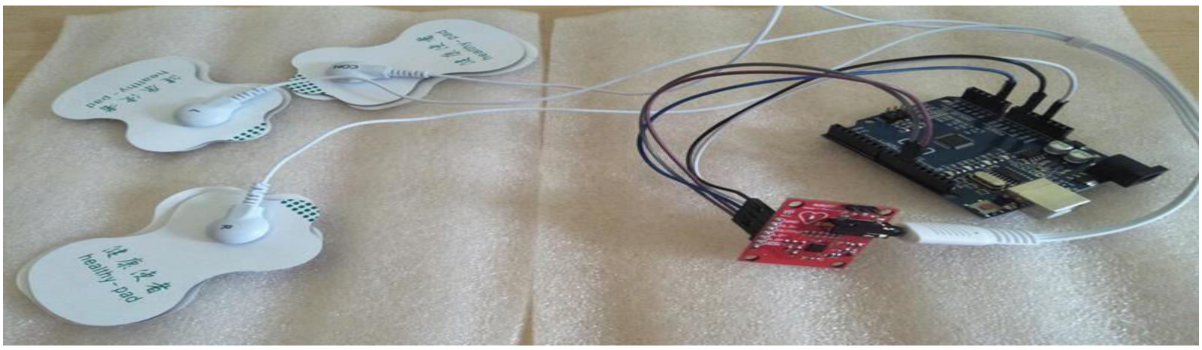

Fig: Component Setup

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The two readings from spirometer and ERBs. The corresponding peaks were marked for inspiration for ERBs and expiration for spirometer readings. The inset shows the time shift between two graphs when aligned. The peak detection and respiratory flow calculation are extremely simple for the ERB data due to clean, low noise data output it produces. A simple 0.1 Hz high pass filter is sufficient to eliminate DC offset while a 30% cut-off peak detector with a minimum 1-second distance could find almost all the inspiratory peaks available.The find peaks function available in MATLAB was used to find the peaks from both signals. Instantaneous respiratory rate was calculated using the time difference between peaks for both signals. The mean percentage error for instantaneous respiratory rate compared to spirometer reading was only -0.087% breaths/minute with a standard deviation of 3.2%. When averaged over time, the calculated respiratory rate from the spirometer was 19.7191 breaths/minute while Vital Core was 19.7179breaths/minute.

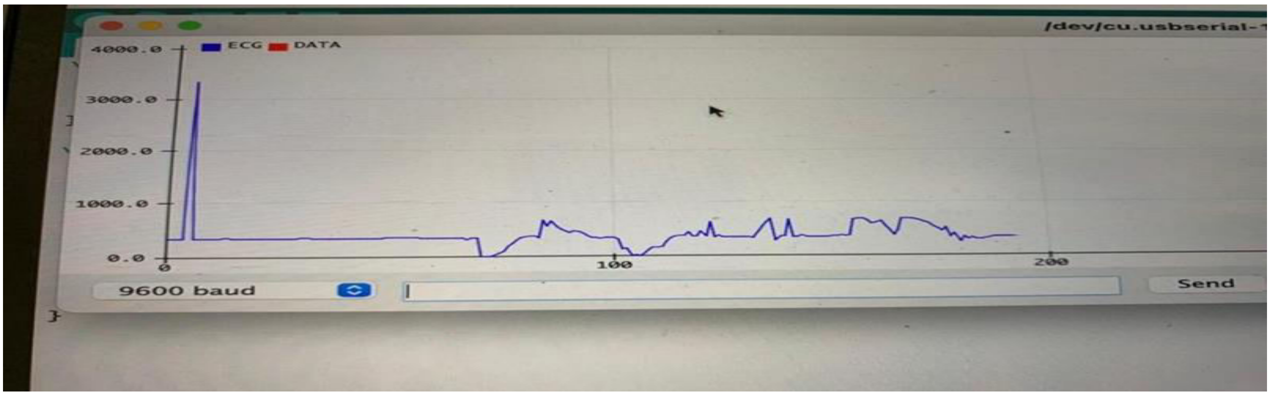

Fig: Expected result

These trials exhibit the qualities of the created Vital Core gadget and potential to fill in as a free IOT hub for ceaseless rest observing. In light of the fundamental outcomes demonstrated the gadget fills in true to form and satisfy the essential prerequisites to incorporate into completely utilitarian IOT stage. The gadget can possibly beat huge shortcomings of current rest observing gadgets. It is totally hidden in an article of clothing giving least hindrance and burden to theclient.

The equipment is littler in zone and thickness contrasted with presently accessible business choices. The gadget can be controlled with 200mAh~600mAh li-particle battery without the battery size surpassing the elements of the PCB to permit single day to entire week utilization from a solitary battery charge. The equipment bolsters the most recent Bluetooth 5 locally giving the greatest Bluetooth remote exchange rate accessible with current innovation.

Wearables are able to perform passive (or autonomous) data gathering, i.e., to extract information about the users without their intervention. Actigraphy, geolocation, and communication activity are usual features of current smartphones and may be useful indicators, if properly processed, of the individual's condition or state . Advances in sensor technologies, and novel textile electronic integration technics also draw new perspectives for behavioral ecological assessment (BEA).

V: CONCLUSION AND FUTURE WORK

Wearable sensors, particularly those equipped with non-contact IoT intelligence, offer attractive options for enabling observation and recording of data in home and work environments, over much longer durations than are currently done at office and laboratory visits.. The doctors can view the sent data by logging to the html webpage using unique IP and page refreshing option given so continuously data reception achieved. Hence continuous Heartbeat monitoring system is designed.Applications grant both patients and suppliers to have passage to reference materials, lab tests, and therapeutic records utilizing cell phones. Complex versatile wellbeing applications help in regions, for example, preparing for human services labours, the administration of perpetual sickness, and observing of basic wellbeing markers. These developments can encouraging in order to cut down costs the transport of thought, and interfacing people to their human administrationsuppliers.

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