

Wearable Sensors for Monitoring Vital Signs of Patients

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Abstract

Vital signs of a person are the indicator of basic bodily functions and provide critical information for accessing a patient's state of health. The four Vital signs are: Blood Pressure, Pulse Rate, Body temperature and Respiration Rate. In some cases, blood oxygen saturation is also measured. Vital signs help in identifying an already existing medical condition, diagnosing new disease and can also be very helpful in providing critical care to patients in time of emergency. Traditional ways of Vital sign monitoring are being replaced by more technical methods employing the use of wearable sensors. Not only are wearable sensors an aid for getting vital signs accurately but a multitude of parameters can be obtained by using an assembly of wearable sensors. With the help of wearable sensors, telemonitoring of patients has become a reality. This paper discusses the Vital parameters, their normal ranges and different wearable sensors to measure these parameters.

Keywords: Blood Oxygen saturation; Health Monitoring; Vital Signs; Wearable Sensors.

1. Introduction

Health Care has taken a center stage in today's time. With the number of diseases on rise and an increase in longevity has resulted in more focus being laid on providing better health care facilities. Wireless Technologies are playing a significant role in healthcare monitoring for the elderly, post surgery patients or in emergency rooms of hospitals. Vital Signs of patients hold much significance considering that they help in accessing the health of an individual at any time, they are important for patients on recovery path and also in monitoring rehabilitation of patients. Efficient recording of patient's vital signs may also play an important role in saving lives in an emergency. In case of an emergency, the first task is to record vital signs. Traditional methods maybe time consuming and may need expertise of the nursing staff to attend to the emergency quickly. Wearable sensors have come to the rescue in such cases where a patient may be provided wearable sensor or an integrated set of sensors, thus displaying readings on the emergency monitor almost instantly [1]. Noting the vital parameters and identifying patients whose parameters are beyond the normal range can play an important role in the emergency staff's decision to attend to patients out of order, based on their criticality. Patients reporting in an emergency room may be subjected to a measurement of Blood pressure, Pulse rate, Body temperature, Respiration Rate and Blood Oxygen Saturation [2]. Different wearable sensors are used to note these parameters.

2. Literature Review

R.T. Hameed, O.A. Mohamad, Nicolae Tapus [1] have proposed a system wherein the data collected through sensors is stored on cloud platform to facilitate tele monitoring of patients.

Sensors have been used to continuously monitor patients for health conditions like sleep apnea and diabetes. Zigbee protocol is used to implement the WSN that results in low power consumption, low cost and support a mesh topology that aids in better data transmission.

S.K. Islam, A.Fathy, Y.Wang, M.Kuhn and Mohd. Mahfouz [2] have discussed the role of wireless technologies in shifting the concept of clinic-centric approach to patient-centric approach in healthcare. With the use of Biosensors, continuous monitoring of patients has become possible even at remote locations. The use of wireless technologies, sensors and networks has enabled an immediate access to healthcare facilities as the patient data, lab and insurance records are easily available in the system.

With easily available internet access on anytime anywhere basis, T.R.Toral, R.A. Palomares and M.C.Y.T-Itturiaga [3] proposed a model to keep a patient under continuous supervision virtually. Having data stored in the computer, makes it easier for analysis, remote monitoring through internet and the versatility of virtual instrumentation that enables the system to adapt new algorithms in real time operation.

S.Dudakiya, A.Shaikh. R.A.Late, H.Galani, D. Thanki and Prof. S.E. Pawar [4] introduced a low cost, light weight sensor and an Arduino board which monitors patients continuously so that medical attention is provided immediately. There are sensors implanted on patient's body which are used to collect the data. In case of a medical emergency, the message is transmitted to the server via Internet and medical intervention is provided on the spot.

A Bluetooth based Wireless wearable sensor has been developed by B.Massot, T.Risset, G.Michelet and Eric McAdams [5] for continuous monitoring of patient's cardiac activity The sensor communicates with a smart phone application. AEC algorithms have been used to ensure data security over the Bluetooth Channel.

This WBAN system can be used to collect data from patients both inside the hospital and those at remote locations.

R.K.Megalingam, G.Pocklassery, V.Jayakrishnan, G.Mourya, A.A. Thulasi [6] have proposed a smart phone based system for continuous monitoring of elderly patients at home. The parameters being recorded include ECG, BP, respiration rate, fall and tilt, heart rate and body temperature. The proposed system has a Central Controller module that consists of an Arduino board and a Bluetooth unit to communicate with the sensors. In case the elderly patient faces any emergency situation, a message can be sent to the care taker or the hospital for arranging immediate medical care

3. Vital Parameters

Being able to continuously monitor the vital parameters of the patients or elderly with the help of wireless technology and wireless sensors for providing care within the hospital or for telemonitoring purposes has proved to be a boon [2]. As soon as the vital parameters go beyond their normal range, the healthcare providers can be alerted immediately. The four vital parameters, their role in accessing health and their normal ranges are discussed below:

3.1 Blood Pressure: Cardiovascular Disease (CVD) is a major cause of deaths worldwide. Hypertension is a precursor to cardiovascular disease [7]. So the Blood pressure monitoring becomes essential be it in routine, for patients in emergency or for patients post surgery. Blood Pressure is the force of blood against the arteries. It is recorded as Systolic pressure/Diastolic pressure. Systolic pressure indicates the pressure when heart beats whereas the Diastolic pressure indicates blood pressure when the heart relaxes in between beats. Blood Pressure is measured in millimeters of Mercury (mm Hg). Normal adult Blood pressure should be 120/80 mm Hg and any reading more than 140/90 mm Hg is termed as Hypertension. The range between 120-139/80-89 mm Hg has been termed as pre-hypertension [4]. Factors that affect Blood Pressure include Stress, Anxiety, caffeine consumption, salt intake, exercise and some medications.

3.2 Pulse Rate: Pulse rate indicates heart beat rate and measures the number of times heart beats per minute. The range for a normal adult is between 60 to 80 beats per minute [4]. Pulse rate may vary from person to person. Pulse rate may vary if a person is suffering from some disease, injury or also in case of shock and disturbed emotions or had physical exercise. An increased pulse rate is a clear indicator of how hard the heart has to pump blood and may point to health problems such as infection, dehydration, stress, anxiety, a thyroid disorder, shock, anemia, or certain heart conditions. A slow pulse may indicate a blood clot (which may lead to a stroke even), disease of the blood vessels, heart or even heart failure.

3.3 Body Temperature: The normal body temperature may vary from person to person depending on the fitness level, the type of physical activity engaged in and the kind of environment exposed to. However, the normal body temperature ranges from 97.8 Fahrenheit to 99 Fahrenheit. Body temperature may vary due to fever i.e. temperature above 99 °F or hypothermia caused by prolonged exposure to low temperatures i.e. body temperature below 95 °F. Stress, dehydration, exercise, shock may result in a variation of body temperature.

3.4 Respiration Rate: Respiration rate is the number of breaths taken per minute. For a healthy adult, the number varies from 12 to 20 breaths per minute. Respiration rate monitoring also involves checking for difficulty in breathing. A respiration rate under 12 or above 25 are considered abnormal. Factors influencing respiratory rate may include Asthma, Anxiety, lung disorder, drug overdose or congestive heart failure [5].

3.5 Blood Oxygen Saturation: Blood Oxygen saturation refers to the fraction of oxygenated hemoglobin to the total hemoglobin. Normal oxygen saturation levels are from 95-100%. A level below 95% refers to hypoxemia. Blood oxygen saturation levels less than 80% may compromise organ functionality including the heart and brain. A lower than normal blood oxygen saturation is termed as hypoxemia. Decreased levels of Blood oxygen can lead to cardiac arrhythmias. Patients with previous heart disease history have less tolerance to hypoxemia as compared to healthy people [6]. Causes of Hypoxemia may range from anemia, asthma, heart disease, pulmonary edema and side effect of some medications or drugs. Smoke inhalation and even shock can be the main cause of hypoxemia.

4. Wearable Sensors

In the last decade, the number of wearable sensors available in the market has increased considerably. The main reason for such a growth is the increase in average age of persons and the need for continuous health monitoring due to lifestyle and age related health disorders. With the help of wearable sensors, patients can be provided medical aid on time as the doctor or the medical staff can get a real time feedback about the health of the patient wearing these devices. As the Vital signs that are essential for health monitoring have been discussed in section III, this section will focus on the various wearable sensors used for monitoring those vital signs.

4.1 Measuring Blood Pressure: Traditional Arm-cuff based Blood Pressure measurement systems are fast being replaced by cuff less systems. Cuff-less systems are based on Pulse Transit Time (PTT) and are convenient, fast and cheap [6]. Blood Pressure is related to PTT, an increase in blood pressure will lower the PTT, thus signaling faster pulse transit. PTT is the time taken by the arterial pulse pressure wave to travel from the aortic valve to the periphery. The delay between the R wave as noted in ECG and subsequent detection of R wave at the finger by Pulse Oximetry gives a fair estimation of PTT [14].

4.2 Pulse Rate Measurement: Pulse Sensor is a plug and play device compatible with Arduino used for pulse rate measurement.

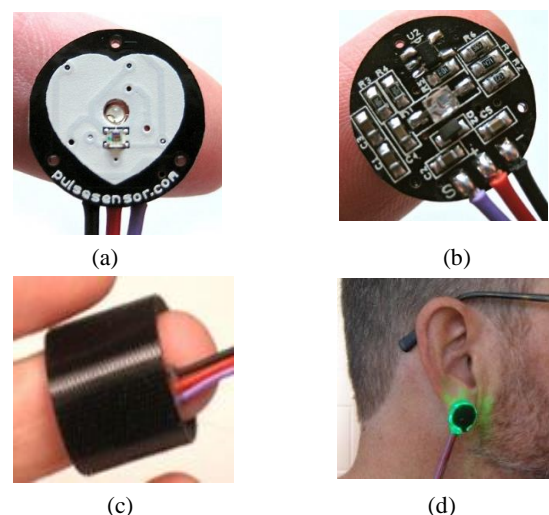


Fig. 1: Pulse Sensor (a) Front View (b) Rear View (c) Sensor on fingertip, (d) on Ear Lobe. (Source: www.pulsesensor.com)

The heart shaped white portion as shown in Fig. 1 is the front side with LED in the centre, this side is the one that touches the skin. Just below the LED is the light detector. This Pulse sensor can be wrapped around the finger or worn on the ear lobe as shown in Fig 1 (c) and (d). After the Sensor is worn, code is run on the

can be then made available to either a medical database, a medical center, ambulance or to the caregiver or family of the patient [9]. For data transmission between the sensors and the home network, Zigbee or Bluetooth [5] can be employed [10]. Both Zigbee and Bluetooth offer low cost, low power connectivity. Maximum transmission range offered by Zigbee is 75m whereas that offered by Bluetooth is 100m.

5. Conclusion & Future Scope

In this paper, the concept of wearable sensors has been limited to the measurement of vital parameters only. Vital signs are necessary for immediate assessment of patients in emergency or for tele monitoring of elderly patients or those recovering post surgery. In future, this study can be extended to incorporate parameters like blood glucose and ECG measurements. An effort can be made to have a wearable system with multiple sensors integrated as a single portable unit. The availability of Tele-ECG, a credit card sized 12-channel ECG monitoring system by BARC, India will give impetus to further research and development of miniaturized sensors that will help in achieving the aim of a single unit Wearable Health Monitoring System. Factors such as patient data security, speed of data transmission can also be evaluated.

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