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Full Length Research Article

Simple and Low-Cost Optical Technique Photoplethysmography (PPG) for using Heart Rate Sensor Application

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A B S T R A C T

There is an increasing number in world population of elderly citizen. Many elderly people live independently or alone which can be difficult and dangerous. There is an immediate need to develop a monitoring device, although technology has a huge role in achieving this aspiration, any solution must be designed, implemented and validated using appropriate domain knowledge. In this project, we present a monitoring device based on IOT to monitor the elderly people in real-time monitoring system. The remote real-time monitoring of a person's health can be done to identify relapses in conditions, therefore, enabling early intervention. This device focuses on the ability to track a person's physiological data to detect specific disorder which can aid in early intervention practices. These functions are carried out through certain sensors such as temperature sensor, respiratory strain sensor, heart rate sensor and GPS modem which are integrated to a microprocessor to measure vital sign. The output readings are then transmitted to central system to detect any abnormalities and are stored in cloud storage for future reference. This information is sent to close family member and care takers. These devices are cost effective in terms of data acquisition and manipulation. These devices has many potentials and would allow elderly to live healthily and safe despite being alone and independent. It can also track the person's were about.

***Key words*:** Healthcare, Real-time monitoring, Sensor network, Internet of things

The population of elderly is increasing rapidly in most countries around the world. The proportion of the population aged_≥ 65 years is expected to be peak at 25%of the total population around 2050. Statistically during survey in Malaysia, the total population of senior citizens increases from 8.2% in 2012 to 8.6% in 2013 which is equivalent to 2.57 million of Malaysians. By 2030, Malaysia is expected to be in the category of ageing nation with approximately 4.66 million of Malaysians. In United States, millions of senior citizens (65 and older) are involved in fall accidents. Almost 2.8 million elders are treated in emergency department for fall injuries. Majority of senior citizen live independently. However, aging involves decreased mobility, decreased strength and stamina, and reduced acuity. Frailty develops as a consequence of age-related decline in many physiological parameters leading to increased risk of falling, progressive disability, need for long term care, and increased mortality. Frailty is mostly diagnosed based on grip strength, walking speed, clinical frailty scales, self-reported exhaustion, low physical activities. Healthcare costs are continuously rising and the quality of services does not meet the needs of modern society. Remote real-time health monitoring provides one possible solution and relief. Constantly monitoring the health of elderly via wearable device and fitness trackers. Recent research indicates the potential applications of IOT, along with advances in sensor technology.

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Heart rate sensor

One can measure the heart rate in real time or help to record the heart rate for future reference using heart rate sensor. An optical heart rate sensor measures pulse waves, which are the changes in the volume of a blood vessel that occur when the heart pumps blood. Pulse waves are detected by measuring the changes in volume using an optical sensor. It is a non-invasive technique. The principle behind the heart rate sensor is Photoplethysmography. It helps to measure the change in volume of blood passing through any organ of the body. The optical heart rate sensor consists of an electronic circuit that monitors heartbeat of the placed area. It does it by shining light into (or through) the skin and measuring how much light is reflected (or absorbed). This goes up and down as blood is pumped through. Usually, it is a combination of an infrared light sender and a light receiver used for this operation.

Respiratory strain sensor

Within a clinical setting, continuous monitors can be used to track a patient's respiration data for diagnosis. These types of strain sensor are composed of a piezo-resistive metal a

thin film set in a silicone elastomer substrate. The sensing mechanism of this sensor is based on controlled fracturing of a metal thin film to increase resistance with respect to strain. The thin film has integrated hierarchal (nano- and micro- sized) wrinkle structure that acts as strain relieving features and also help control the crack propagation. The strain sensor is placed on the ribcage and abdomen to measure the expansion and contraction of the respective locations during respiration. The continuous respiration volume was measured for each subject while the expansion and contraction of the ribcage and abdomen were concurrently recorded using the strain sensors. The exhalation volume and associated change in resistance (ΔR) of the strain sensors were then calculated. To ensure a comprehensive model, a wide range of respiration volumes were measured; each subject was instructed to breath at three different depths (shallow, medium, and deep) at their discretion since lung capacity varies between individuals.

Temperature sensor

Wearable temperature sensors are used to measure the body temperature of a person. These sensors are mostly of digital thermometers which provide clinical grade accuracy combined with ultra-low power operation to support this medical application. These sensors are also used in watches, medical patches, and smart cloths. Temperature sensors help us to keep a track of the body temperature. It can be used to track any abnormal rise or drop in temperature. Body temperature plays a vital role in diagnosis of various abnormalities in body. These sensors track the body temperature in real time and also records it for future references. The difference in body temperature can indicate various results.

Global positioning system modem

Global Positioning System is a satellite navigation system used to determine the position of an object in the world. It was first used by United States military during 1960s, it expanded into civilian use over the decades, now GPS are included in many products including smart phones, smart watches, automobiles, etc. The GPS has 24 satellites deployed in space about 19,300 km above the earth surface. These satellites orbit the earth every 12 hours at a pace of roughly 11,200 km per hour. They are evenly spread in such a way that four satellites are accessible in direct line of sight from anywhere on the earth. Ever GPS satellite broadcasts a a message along with it's current position and time. A GPS receiver combines these broadcasts from other satellites to calculate the exact position through a method called triangulation. We would require three satellites to determine the receiver's location, by connecting to four satellite the accuracy gets higher. For proper working of a GPS device, it establishes a connection to a required number of satellites. This process takes from few seconds to a few minutes, it depends on the receiver's strength. The basic format of data sent by a GPS is by the longitudinal and latitudinal coordinates of the specific location.

Arduino

Arduino is an open-source electronics platform which has a easy-to-use hardware and software. Arduino board are able to read input – light on a sensor, a finger on a button or a twitter message and turn it into an output – activating a motor, turning on an LED. You can tell the board what to do by sending a set of instructions to the microcontroller on the board. Over the years arduino has been the brain of thousands of projects, from everyday object to complex scientific instruments.

Internet of things (IOT)

Internet of things has become one of the most important technologies of the 21st century. Now that we can connect everyday objects to the internet through embedded device, seamless communication is possible between people, processes, and things. The recent advancement in a number of different technologies has made it practical for use. IOTs are used in wearable to monitor human health and environmental conditions. IOT wearable enables people to better understand their own health and allow physician to remotely monitor patients. This technology enables companies to track the health and safety of their employees, which is especially useful for workers in hazardous conditions. IOT are used in healthcare, doctor, nurse, and other hospital staff members can monitor the patient using wireless devices connected to a IOT. The data that is stored can also be viewed in future for reference and follow up to monitor the improvement of the treatment. It can also be used to monitor real time, and can avoid any complication beforehand.

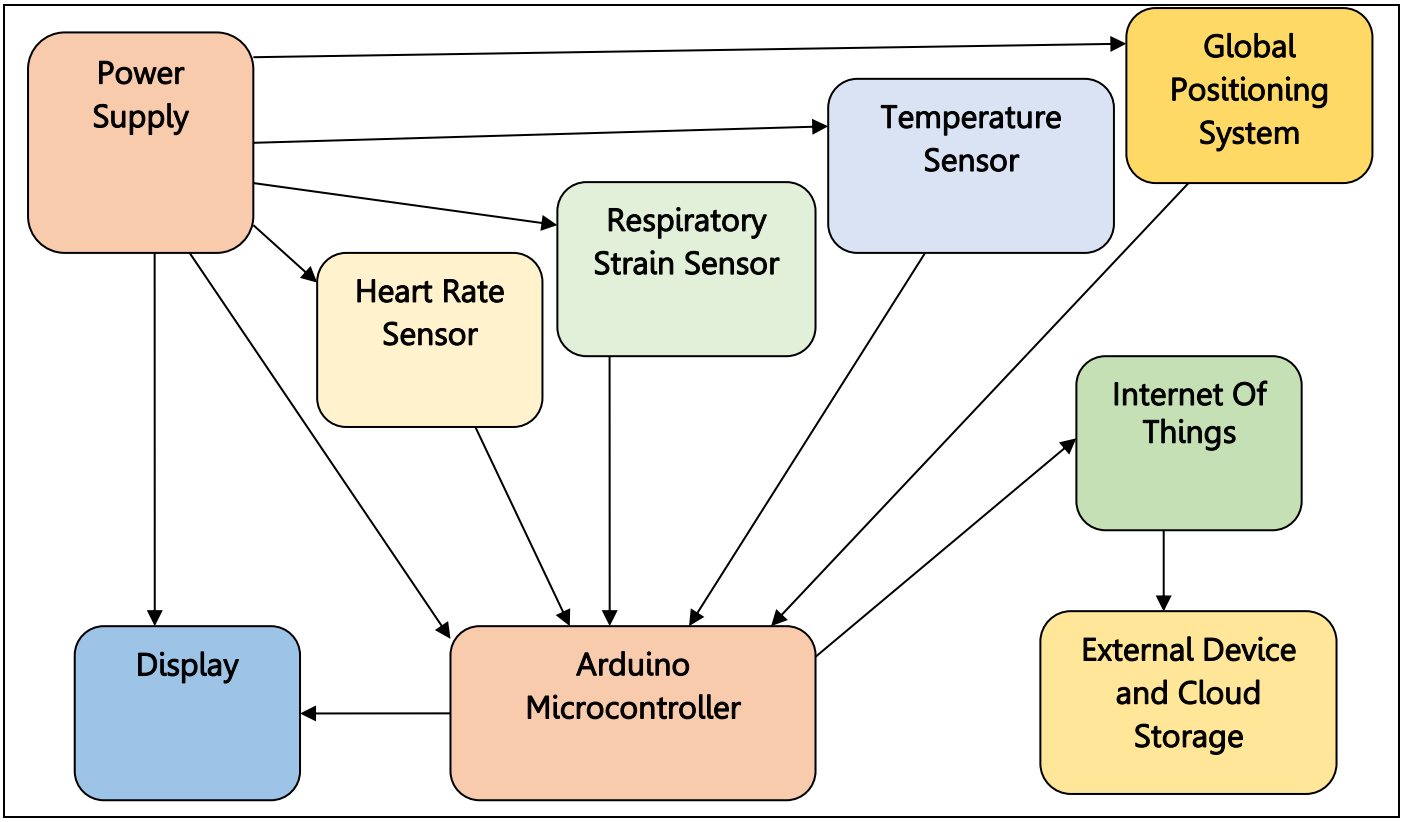
Power supply

Lithium Battery have metallic lithium as an anode; hence they are also referred as lithium-metal batteries. They have high charge density (long life), depending on the design and chemical compounds these cells can produce voltage from 1.5 V to about 3.7V. Primary lithium battery (disposable) are distinguished from secondary lithium battery (rechargeable). The ions in the battery can be arranged to move between the anode and cathode, by an intercalated lithium compound as the cathode without using lithium metal as anode. Lithium in its pure state reacts with water, or moisture in air but the lithium in the battery is less reactive compound. Lithium batteries are mainly used in portable devices and radio-controlled toys. Lithium batteries might have different lithium metal chemistries having different cathode and electrodes but with lithium metal as anode. The common use battery mostly made of metallic lithium as anode and manganese dioxide as cathode along with salt of lithium dissolved in an organic solvent.

MATERIALS AND METHODS

The kit is powered by a 9V lithium battery, which has high charge density and so they are long lasting. The heart rate sensor receives the heartbeat of the person and sends the information as output to the Arduino. The normal heart beat for adults is 60 – 100 beats per minute, if it decreases below 60 or increases above 100 may lead to complications. The Respiratory Strain Sensor obtains the amount of strain applied to it at expansion of chest during breathing and measures the volume of lungs. Temperature Sensors monitors the body temperature the obtained readings are sent to Arduino for processing and comparison. GPS is connected to a power supply and the GPS tracks the location of the user and the information received is sent to Arduino for processing. Arduino is connected to the power supply and to all the sensors the out of these sensors is the input for Arduino. The information obtained is processed here. The information obtained from the heart rate sensor is compared with the reference data which is fed in the microcontroller as programs if the value does not match with the reference, it sends a alert to the clinician or a caretaker or to family members. The information obtained from the Respiratory Strain sensor and Temperature Sensor undergo same process. After this process the information is sent as output. The output from the Arduino is sent to display and IOT as input. The display shows the result on the LCD screen for

easy to obtain information. The information sent to IOT includes GPS which can be monitored by caretakers or family members to track the person in times of emergency. The health is also sent to external device for regular monitoring.



RESULTS AND DISCUSSION

This device is used for monitoring the health and to watch over the wellbeing of the senior citizens. With the help of these sensors we can regularly check the wellbeing of all people. It consists of lithium battery which are light weight and are comfortable to the users. By using Arduino, the processing and display of the information about the users body is accurate and reliably fast. Taking advantages of IOT the care takers and family members can monitor the person from a distant. We can also track the location of the person using GPS in case of emergency. In this device the heart rate is detected through Heart Rate Sensor, body temperature through Temperature Sensor, lung capacity through Respiratory Strain Sensor. This information are received form the respective sensor and are processed by Arduino. It also includes IOT and GPS modem for monitoring the health and tracking their whereabouts at the time of emergency. It makes the live of elderly a less risky one.

It is easy to handle the device. People can use it in day-to-day activities. It increases the safety and health care of people**.** It keeps a day to day record of the person's health for future reference. This device can reduce the rate of death of elderly and greatly improve the heath. With constant monitoring the health of the elderly member can support rest of the family members. Through this device the elderly who prefer living independently can actually do it without worrying other family members. This device can alert the family member and caretaker in case of emergency to avoid any complication in health.

CONCLUSION

Through this project we made a prototype of a device by which we can monitor and help senior citizen to have a better and healthy life. Because, it is easily accessible and regular monitoring of the care takers and by family members the elderly need not depend on anyone. It has a GPS system which make it easier to track them in case of emergency. In future the AI technology can be used for better results. More sensors and other components can be added for acquiring more healthcare data. It can be designed into a microchip using nano technology for more convenience, and can also be placed inside the body. The size of the device can be reduced and performance can be enhanced.

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