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Analysis and Monitoring of Coma Patients using Wearable Motion Sensor System

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Abstract: ***It is very essential to continuously monitor the unconscious/coma patients to understand their health condition. The main objective of the proposed is to accomplish two tasks. 1) Monitoring and alerting the medical person, when the comatose gains consciousness using motion detection system. 2) Continuous recording and analysis of vital signals of the patient such as Pulse rate and temperature and alert the doctor whenever attention is needed. Wearable Motion sensor system is used to monitor the body movements such as eye blink movement and hand movement to detect the conscious state of an individual. This system will be helpful in assisting the doctor about the health condition of the unconscious patient and alerting the doctor whenever care is required. The proposed system will assist the doctor by giving an alarm about the health condition of the patient, when the set of vital signals recorded are out of the normal range. These results are displayed on the computer and on the Liquid crystal display(LCD).***

Keywords: Attention, Alerting, Coma patient, Monitoring, Motion detection, Physical movement, Vital signal

1. Introduction

Coma or unconsciousness is a state of a person where an individual cannot respond to the internal and external stimulus [1]. Coma is a deep state of unconsciousness. Coma is not a brain-death. A person in the coma state is alive but could not move or respond to the environment. Coma can occur as a result of injuries such as head injuries or as an aggravation of an underlying illness. Individuals in coma state will lose their thinking abilities and awareness of their surroundings, but will retain normal sleep patterns and non-cognitive function. For an individual in a persistent vegetative state the important functions like circulation and breathing remains unharmed even though the individual loses his top level brain functions. Sometimes the person in a coma state can respond to the external environment by voluntary movements such as he may open his eyes in response to external impulse. Even though an individual in a coma state appears normal but they could not respond to the external commands. Since the physical motion of persistent vegetative state individual are rare, there is a need for regular attention and care.

In present system used in hospitals a healthcare professional is needed to continuously monitor and record all the vital information of a particular subject by maintaining all the records of that comatose manually. Such methods of continuous supervision by a paramedical assistant are error prone and may lead to difficulties due to human error. In case of critically ill patients it requires to measure the vital parameters at least for every 15 seconds until the patient's condition stabilizes. Therefore monitoring of coma patients is different from monitoring the normal patients. It is very tough job for the paramedical staff to continuously monitor each patient's 24 hours since the proportion of staff to patient is very low. So it is not an easy task to monitor each and every patient regularly. This system is proposed to eliminate the burden of continuous supervision and will alert the doctor or paramedical staff only when attention is needed. This system will be helpful in assisting the doctor about the patient condition whether he is stable or unstable and will monitor the comatose regularly to see if there are any changes in the physical movement of the vegetative state patient.

2. Related works Review

Kansal et. al, has developed advanced coma patient monitoring system using image processing techniques such as pattern recognition and pattern rejection algorithms.

Malika et. al [2] has proposed a wireless Zigee based patient monitoring system. This system has a PIR sensor, Temperature sensor, Humidity sensor, smoke sensor connected are connected to the patient's body wirelessly and the doctor is alerted whenever there is medical emergency.

Navya et. al [3] has developed a Zigbee based wireless sensor based network for patient health monitoring. This system has a heartbeat sensor, MEMS sensor, body temperature sensor, saline level sensor and the results are transmitted via Zigbee which is used the monitor the elderly people.

Chopade et. al [4] has proposed a remote patient health monitoring system using Zigbee protocol to monitor certain patients who needs continuous monitoring such as heart failure. This system has a Temperature sensor and heartbeat sensor and these values are transmitted using ATMEGA and the Zigbee unit.

Chen [5] has developed a wearable inertial sensor for human motion analysis to continuous track motions and positions of aging people. This system is comprised inertial measuring unit such as MEMS sensor for motion tracking.

AlSharqi et. al [6] has developed a system for monitoring the health condition of elderly people. Reports are transmitted by Zigbee to the doctor. This system consists of heart rate sensor, pulse sensor, ECG sensor and Muscle sensor and a local monitoring pc and Zigbee transmitter and receiver.

3. Proposed System

This proposed system is based on motion detection sensor system. The system is used for monitoring physical health and physical changes in a vegetative state individual. The various hardware requirements and their working principles are discussed below(Figure 1).

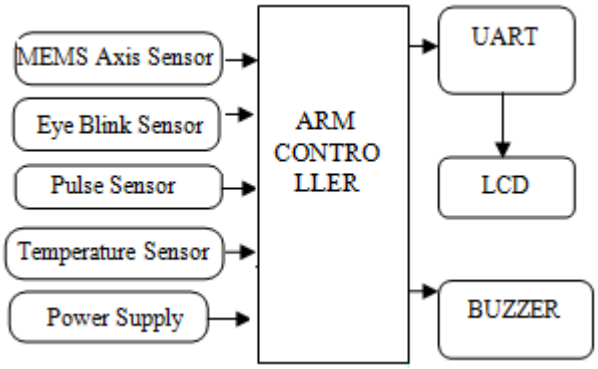


Figure 1: Block Diagram of the system

3.1 MEMS Axis Sensor

This sensor is used to sense the acceleration changes in the person this sensor is placed on the fingers of the patient (figure 2). Whenever there are an acceleration changes in the patient i.e whenever there is any movement it will be recorded and a phase demodulation principle is used to determine the value and direction. This sensor is made up of a polysilicon surface micro machined structure which is built on the top of a silicon wafer. The resistance against the acceleration forces is provided by suspending the spring over the surface of the wafer. It works on a principle of measuring the deflection using a differential capacitor which has independent fixed plates that are attached to the moving mass. These plates are at 180 degree out of phase. When there is an acceleration there will be a deflection in the moving mass which unbalances the differential capacitor which results in a output amplitude is proportional to acceleration, than a Phase sensitive demodulation process is used to estimate the value and direction of acceleration. This sensor can be used as single structure for a complete 3-axis sensing.

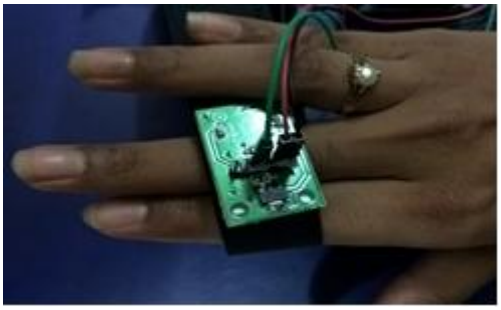


Figure 2: Hand Movement sensor placement

3.2 Eye Blink Sensor

This sensor is used to detect any blinks in a comatose. This sensor works on IR principle. This sensor works by illuminating an eye area using an infrared light. It has a transmitter and a receiver. The transmitter is used to transmit an infrared light that is used for illuminating the eye area. The reflected light is obtained at the receiver. When there is an eye blink there will be no infrared light received at the receiver end.(Figure 3).

Figure 3: Eye Blink Sensor placement

3.3 Pulse Rate Sensor

This sensor is used to monitor the pulse rate of the person. This sensor works on a principle of light modulation by blood flow through finger at each pulse. The pulse rate sensor compromise of a super bright red light emitting diode(LED) for illumination and LDR(Light Dependent Resistor) is used as a detector. The finger when placed inside the sensor is illuminated with a super bright red LED. This LED needs to be super bright so that the light must be able to pass through the finger and could be detected at the detector side. When heart pumps blood through the blood vessels the finger gets more opaque which results in absorbing of certain amount of light and less amount of light will be received by a detector. The finger is placed between LED and LDR. The amount of light absorbed by the blood depends on the blood volume in that area. The signal obtained at the detector end will be in the form of electrical signal which is proportional to pulse rate. LDR works on a principle of its change in resistivity when light is incident on it. The light intensity is inversely proportional to resistance change which results in voltage drop. The detector signal varies with each pulse.(Figure 4).

Figure 4: Pulse sensor

3.4 Temperature Sensor

The body temperature is measured using LM 35 sensor. Temperature regulation is a main part that keeps the body at correct operating temperature due to its impact on the rate of chemical processes. In normal individual the temperature is about 30 ℃ to 38 ℃. In LM 35 sensor the output voltage is in direct proportion with the body of the patient. The operating range of LM 35 sensor is from -55 to +150°C. The advantage of this sensor is that it does not require any external calibration. The sensor is sealed to avoid oxidation effects. This sensor generates greater output voltages compared to that of thermocouples(Figure 5).

Figure 5: Temperature sensor

3.5 Arm controller

In this system LPC 2148 controller has been used which is based on 16 bit ARM7TDMI CPU with embedded real time emulation. It has a high speed flash memory about 32 KB to 512 KB. These controllers are ideal for use because of their tiny size and low power consumption. It also has a serial communication interface. The vital signals measured from the above sensor are interfaced with the arm controller and in this controller these signal are processed and are compared with the normal values.

3.6 UART

In this proposed system serial communication interfacing is done using a MAX232 and RS232 where MAX232 is an integrated circuit that converts signals from RS232 to signals suitable for use in digital logic. These measured values are displayed on the doctor's computer using this serial communication interface.

3.7 LCD

These values along with the movements are also displayed on the LCD. The LCD used is a 16*2, 8 bit mode. (Figure 6).

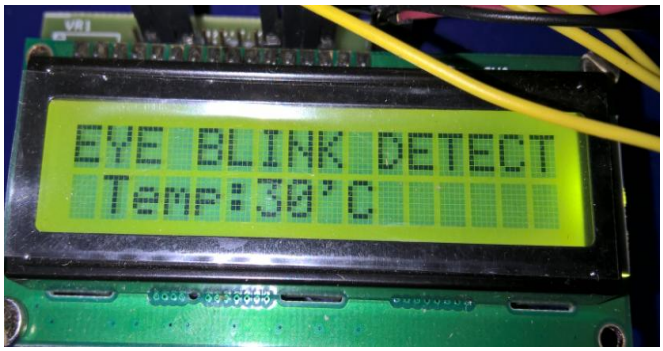


Figure 6: LCD display

3.8 Buzzer

The buzzers are designed using piezoelectric materials for high performance and for ease of incorporation into the systems. They are low power consumption elements. These are used for alerting a doctor whenever the sensed signals are outside the normal values and whenever physical movements are recorded.

4. Methodology

The proposed system consists of four sensor in which two sensors are used for monitoring vitals of the comatose. Temperature and pulse rate are the two vitals recorded and monitored to understand health status of a comatose. The other two sensors are MEMS accelerometer sensor and Eye blink sensor which are used recording any physical changes that occur in a comatose. These signals which provides information are recorded and monitored continuously to understand the body functioning. These sets of sensed signals which are outside normal ranges typically imply the need for some care or possible evacuation to a higher level of treatment during which we alert the doctor.

5. Program Flow

The first step in work flow is to set up the controller and the sensor. When the eye blink is detected that is when the output is high then the result will be displayed as eye blink detected. If the output is low than it will be displayed as no eye blink detected the need for care or attention. (Figure 7).

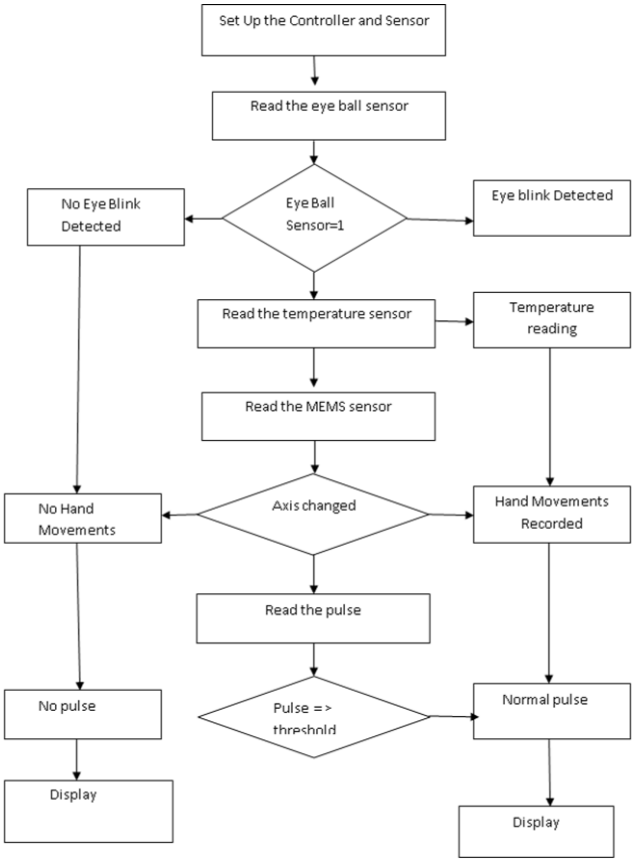
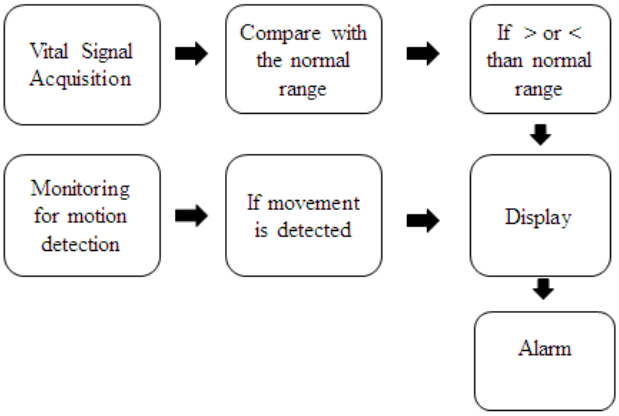
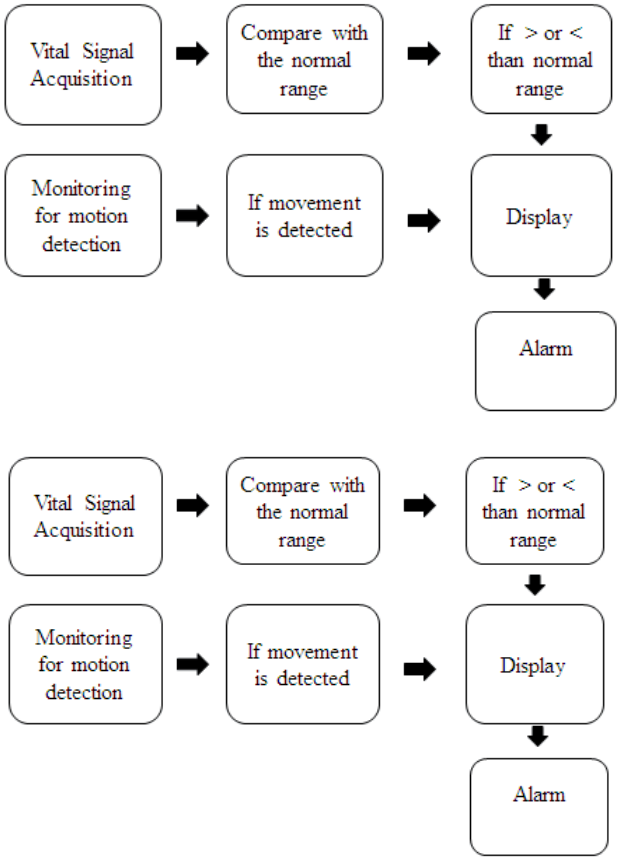


Figure 7: Program flow

6. Results and Discussions

This system will be helpful in assisting the doctors about patient's health condition. The results obtained in the proposed system will have the information about Eye blinks and hand movements, pulse rate and body temperature(Figure: 8). This system eliminates the burden of continuous recording of vital signal information on the paramedical person. It is low cost and low power system. With slight modifications this system can be used to diagnose motion related disorders such as epilepsy and Parkinson's disease. A system studying movement disorders featuring tremor can also be developed.





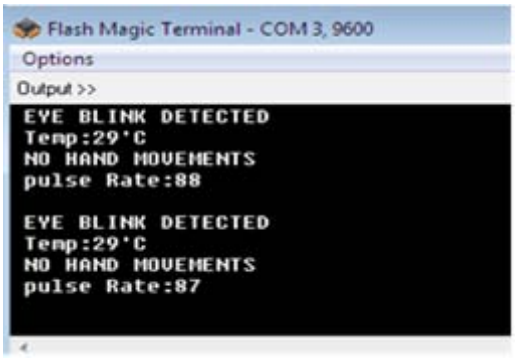


Figure 8: Results obtained

7. Conclusion

In this proposed system, the vital parameters such as temperature and pulse rate are monitored. The MEMS sensors sensitivity was a problem during the process later it was improved by using potentiometer. The system is designed for unconscious patients who need continuous care. Sometimes due to the critical condition of the patient there will be a difficult in measuring the pulse at the finger, therefore the pulse sensor can be developed which can be placed on the neck for the pulse measurement.

8. Acknowledgement

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