

Monitoring and analysis of coma patients using wearable sensor system and WSN

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Abstract:

Coma patients undergo changes that may be either abnormal behaviour or unusual changes in the absence of doctor. It is necessary to monitor the unconscious/coma patients continuously to understand their health condition. The main objective is to accomplish two tasks. 1) Monitoring the coma patient using motion detection system and displaying the results. 2) Continuous recording and analysis of vital signals of the patient such as heartbeat 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 (using eye blink sensor), hand movement (using flex sensor) and body movement (using Micro-electro-mechanical systems (MEMS) sensor) to detect the conscious state of an individual. In addition, a heartbeat sensor and temperature sensor are used to detect vital signals. ARM (Advanced RISC Machine) microcontroller is used to manage the functioning of the sensor system. The project will be helpful in assisting the doctor about the health condition of the unconscious patients 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, if there is any movement in the patient or if 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). In addition, alert messages are sent to the concerned doctor.

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I. Introduction

Wearable sensor system is used to monitor the body movements and vital signals such as hand movement, eye blink movement and heartbeat rate, body temperature respectively to monitor the health condition of an individual. This system can be used to monitor and analyze coma patients, paralysis patients and individuals with complex medical conditions or disabilities. The doctor can be assisted about the health status of the patient, and can be alerted whenever

care is required. Wireless Sensor Network is a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment, here patient, and organizing the collected data at a central location. Wireless technologies such as Zigbee, Bluetooth, WLAN or GSM can be used for sensors data transmission to concerned doctor and family members. These results can displayed on the computer through Wi-Fi and on the Liquid Crystal

Display (LCD) and transmitted through GSM Modem in the form of SMS.

II. EXISTING SYSTEM

Coma patients undergo changes that may be either abnormal behaviour or unusual changes in the absence of doctor. 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 the coma patient 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 24 hours since the proportion of staff to patient is very low. 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.

III. PROPOSED SYSTEM

An embedded system is a combination of software and hardware to perform a dedicated task. Some of the main devices used in embedded products are microprocessors and microcontrollers. In this paper, coma patient health monitoring system using ARM microcontroller is implemented. Microcontroller forms the controlling module and it is the heart of the device. The health status of a coma patient using sensors like heartbeat sensor,

temperature sensor, MEMS accelerometer sensor, eye blink sensor and flex sensor can be monitored according to the instructions given by the microcontroller. Alert messages are sent to concerned doctor and family members, using GSM, if any abnormal condition of the patient is detected. Readings and messages are displayed on PC using Wi-Fi and LCD, so that the medical assistant will not miss any changes in vital signals or body movements. Block diagram of monitoring and analysis system for coma patients using wearable sensor system and wireless sensor network is shown as following.

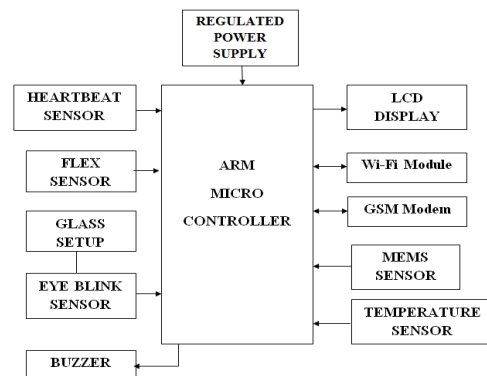


Figure 1: Block diagram

1. Initialization

Firstly, a SIM card is inserted in the GSM module and then the power supply is turned ON. In the initialization phase, Wi-Fi and GSM initialization take place, once the power supply is turned ON and the corresponding messages are displayed on LCD. After the initialization is done, 'Please insert finger' is displayed on LCD, after which the coma patient's finger is inserted in the heart beat sensor and temperature sensor is inserted in the armpit. The heart beat rate (in BPM) and body temperature (in degree Fahrenheit) are displayed on LCD.

2. Connecting Wi-Fi module to PC

After initialization of Wi-Fi module, a hotspot is switched ON on a mobile phone. The Wi-Fi module and a PC with TCP test tools are connected to the hotspot. After both

the devices are connected to the hotspot, TCP Client on TCP test tools is opened. The IP address of Wi-Fi module and remote port no. are entered and proceeded to connect the PC and Wi-Fi module. Once connected, the corresponding sensor readings and messages are displayed on the receive window.

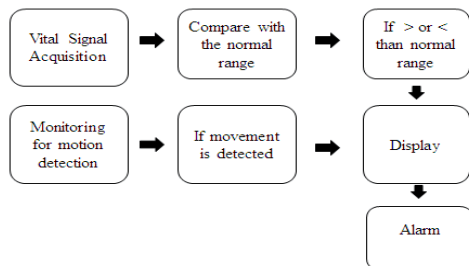


Figure 2: Working of health monitoring and alerting system

3. Monitoring and Analysis

ARM LPC 2148 is set up along with all the sensors including heartbeat sensor, temperature sensor, flex sensor, MEMS sensor and eye blink sensor, which are connected to the coma patient's body to detect vital signals and body movements. When any movement is detected in the patient, the buzzer rings and the message is displayed on the PC using Wi-Fi and LCD. In addition, an alert is sent to the concerned doctor in the form of SMS using GSM. When the heartbeat rate (in bpm) falls below the normal range (60 to 100 bpm), a message 'Low heart rate' is displayed on LCD and PC and an alert is sent to registered mobile phone via GSM module. Similarly, when the heartbeat sensor reading falls above normal range, a message 'high heart rate' is displayed. When body temperature falls above the normal range (97⁰F to 99⁰F), then a message 'High temperature' is displayed and an alert message is sent. Flex sensor is used to detect movement in fingers of the patient. The sensor bends when there is a finger movement, leading to change in resistance value. A message 'Finger movement detected' is displayed and an alert is sent.

When the body (eg. legs) of the coma patient move, MEMS sensor detects it and a message 'body movement detected' is displayed and alert is sent. Similarly, 'eye blink detected' is displayed when the patient blinks his eye, which is detected by eye blink sensor.

IV. IMPLEMENTATION

1. ARM LPC2148 Microcontroller

ARM is an advanced reduced instruction set computer (RISC) machine, and it is a 32-bit processor architecture expanded by ARM holdings. The applications of an ARM processor include several microcontrollers as well as processors. The architecture of an ARM processor was licensed by many corporations for designing ARM processor-based SoC products and CPUs. This allows the corporations to manufacture their products using ARM architecture.



Figure 3: ARM LPC2148

2. Heartbeat Sensor

Heartbeat sensor works on the principle of light modulation by blood flow through finger at each pulse. The sensor consists of a super bright red LED and light detector. When the heart pumps a pulse of blood through the blood vessels, the finger becomes slightly more opaque and so less light reached the detector. With each heart pulse the detector signal varies. This variation is converted to electrical pulse. This signal is amplified and triggered through an amplifier which outputs +5V logic level signal.



Figure 4: Heartbeat sensor

3. Eye blink sensor

Eye blink detector is a pair of IR LED and IR photo detector form. These detectors are placed on spectacles. The photo diode of this detector gives the output low when the eye is blinked. One common technique which is used in this system for eyelid movement detection utilizes the measurement of infrared light which reflected from surface of the eye.



Figure 5: Eyeblink sensor

4. Flex sensor

Flex Sensor is based on resistive carbon elements. As a variable printed resistor, the flex sensor achieves great form-factor on a thin flexible substrate. When the substrate is bent, the sensor produces a resistance output correlated to the bend radius—the smaller the radius, the higher the resistance value.



Figure 6: Flex sensor

5. MEMS sensor

The sensor consists of a micro-machined structure on a silicon wafer. The structure is suspended by poly silicon springs which allow it to deflect smoothly in any direction when subject to acceleration in the X, Y

and/or Z axis. Deflection causes a change in capacitance between fixed plates and plates attached to the suspended structure. This change in capacitance on each axis is converted to an output voltage proportional to the acceleration on that axis.

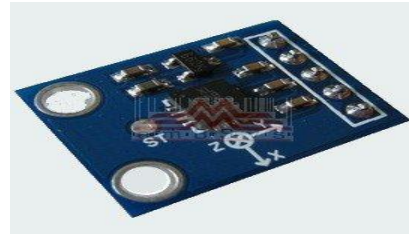


Figure 7: MEMS Sensor

6. Temperature sensor (LM35)

The LM35 sensor series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. To detect the heat produced during fire occurrence we use temperature sensor.

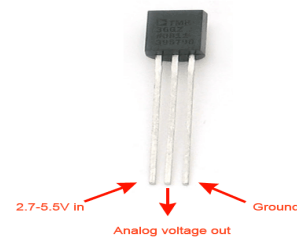


Figure 8: Temperature sensor

7. ESP8266 Wi-Fi module

The ESP8266 Wi-Fi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community.

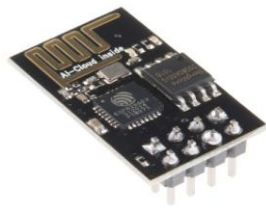


Figure 9: ESP8266 Wi-Fi module

8. Global System for Mobile Communication (GSM)

GSM, which stands for Global System for Mobile communications, reigns (important) as the world's most widely used cell phone technology. Cell phones use a cell phone service carrier's GSM network by searching for cell phone towers in the nearby area. Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz.



Figure 10: GSM modem

A) Control Section

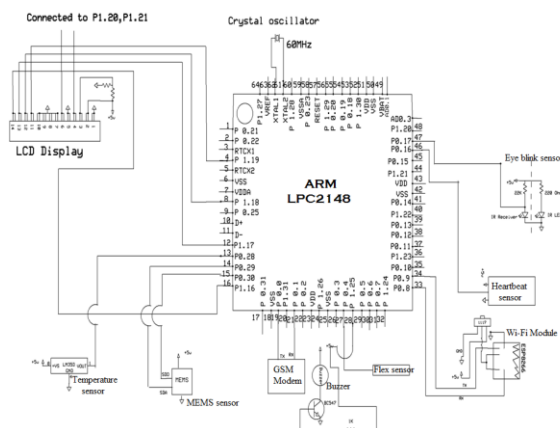


Figure 11: Circuit diagram

V. RESULTS AND DISCUSSIONS

The project health monitoring and alerting system for coma patients was designed such that the patient health monitoring system using ARM LPC2148 microcontroller it can monitor the health status of coma patients using sensors like heartbeat sensor, temperature sensor, MEMS accelerometer sensor, eye blink sensor, flex sensor according to the instructions given by the above said microcontroller. Alert messages are sent to concerned doctor and family members using GSM, whenever attention is needed.



Figure 12: Monitoring and analysis system for coma patient

The heartbeat rate and body temperature readings are displayed on LCD as shown below.

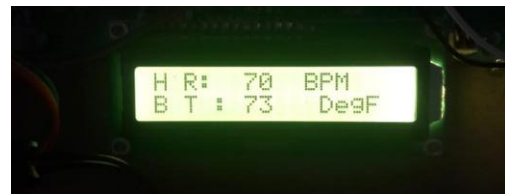


Figure 13: Heartbeat rate and temperature reading

When the heart rate (HR) of coma patient falls below the normal range, a message 'Low HR' is displayed on LCD as shown below.



Figure 14: Low heart rate

When the heart rate (HR) of coma patient falls above the normal range, a message 'High HR' is displayed on LCD as shown below.



Figure 15: High heart rate

'Finger movement detected' is displayed on LCD as shown below, when the coma patient's finger moves.



Figure 16: Finger movement detected

'Body movement detected' is displayed on LCD as shown in figure, when the coma patient's body moves.



Figure 17: Body movement detected

'Eye blink detected' is displayed on LCD as shown in figure, when the coma patient blinks his eyes.



Figure 18: Eye blink detected

Alert messages are received by concerned doctor or family members, as shown in

figure below, when the coma patient moves or his vital signals go out of range.

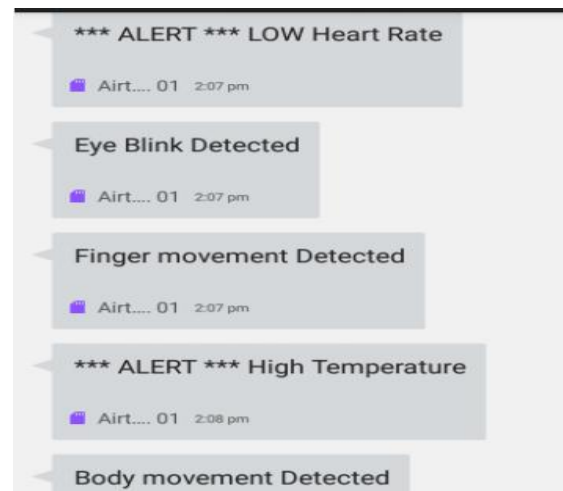


Figure 19: Alert messages through GSM Heart rate readings and coma patient movements are recorded on PC through Wi-Fi module as shown in figure below.

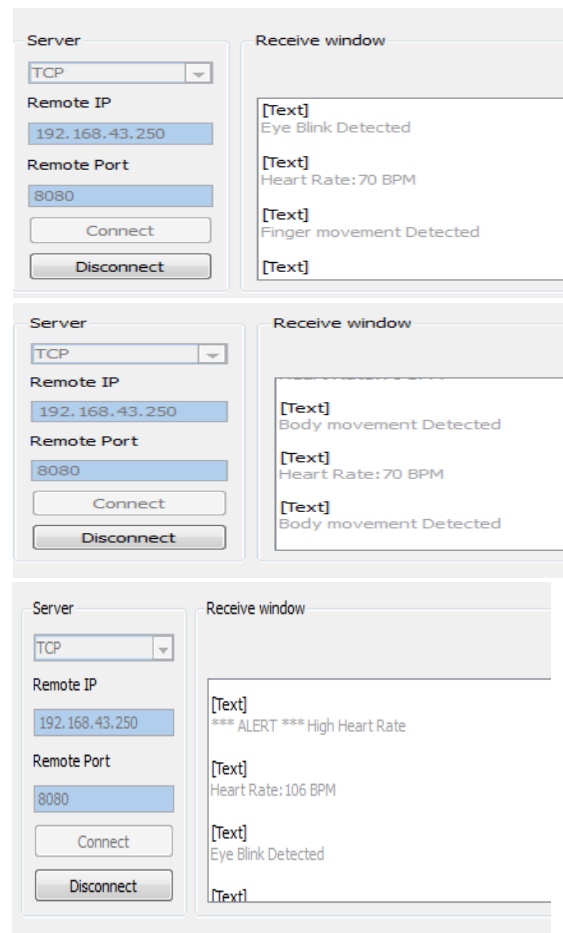


Figure 20: Readings displayed on PC through Wi-Fi

CONCLUSION

Health monitoring and alerting systems are used for monitoring the health related parameters of coma patient such as heartbeat, temperature and body movement. These parameters are sent to the concerned person through different wireless techniques. This system is developed to send the alert message about the moved part of the body which is helpful to the doctor. The system has simple structure and reliable operation with high accuracy and low power consumption. This system is designed and developed for getting different movement of the coma patient using smart sensors i.e. flex sensor for detecting the finger movement, eye blink sensor for detecting the eyelid movement and MEMS sensor for detecting where the body is tilt. This information is sent to concerned doctor through GSM for further treatment and also displayed on PC through Wi-Fi.

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