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Embedded Health Care Monitoring Unit Using Arduino Kit

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Abstract— A lot of research has been carried out in the field of healthcare monitoring. In recent years, development of wireless healthcare monitoring has been emerged as an area of research. The embedded system based monitor and control systems have started to offer a major role in human health especially in the life of sick people. The data that is currently recorded depicting the health condition in the healthcare monitoring system rendering its service in continuously monitoring the patient and transmitting their physiological data in the way of immediately reporting it to the healthcare center. The Arduino is designed to include the low cost sensor LM35 and low power consuming sensor Heart beat which measures the heart beats (pulse sensor) and temperature of the patient respectively. The other components used in our system are LCD display and the transmitter and transceiver. The system is designed to measure and monitor the important physiological data of a patient in order to accurately describe the status of fitness and create the awareness about the patient's health condition to his relatives.

Keywords—Arduino, sensors, health monitoring, Zig-Bee

1. INTRODUCTION

In the healthcare domain, a major challenge is how to provide better healthcare services to an increasing number of people using limited financial and human resources. Wireless patient monitoring has the potential in supporting multiple activity requirements. It is based on wireless sensor networks. Wireless Sensor Networks (WSN) is an emerging technology. Wireless sensor networks have been deployed in various monitoring applications such as industrial, health, environmental, and security related. The wireless sensor nodes can be embedded to monitor the patients health related conditions. The sensor nodes are capable of collecting, processing, storing and transferring information from one node to another node.

In recent years, there has been an increasing interest in the adoption of emerging sensing technologies for instrumentation within a variety of structural systems. Wireless sensors and sensor networks are emerging as sensing paradigms that the structural engineering field has begun to consider as substitutes for traditional adapted monitoring systems. A benefit of wireless structural monitoring systems is that they are inexpensive to install because extensive wiring is no longer required between sensors and the data acquisition system. Researchers are discovering that wireless sensors are providing an exciting technology that should not be viewed as simply a substitute for traditional adapted monitoring systems. Rather, wireless sensors can play greater roles in the processing of structural response data; this feature can be utilized to screen data for signs of structural damage. This paper is intended to serve as a summary review of the collective experience the structural engineering community has gained from the use of wireless sensors and sensor networks for monitoring health condition.

For achieving ubiquitous connectivity, a seamless hand-off controller is developed which intelligently controls multiple on-chip radios during data transmission. The seamless hand-off controller drastically reduces the energy consumption by efficiently using multiple on-chip radios which have different energy consumptions. In addition to the energy saving achieved by the seamless hand-off controller, a generic adaptive rule engine based smart transmission mechanism which classifies the data and transmits only when needed is also included. The adaptive rule engine reduces the data traffic transmitted significantly without any loss of data thereby guaranteeing reliability.

The proposed architecture consists of a central gateway which gathers the data from all the users and transfers it to the central server periodically, where clinicians can classify the user's health status. One of the major issues in these remote health monitoring systems is the continuous data transmission, which leads to the hyper connectivity scenario.

The objective of the presented work is developing a system for healthcare monitoring based on wireless networking. The following are the capabilities of the components and functioning of patient monitoring system:

1. Low power consumption
2. Low manufacturing cost
3. Long distance communication
4. Compact size
5. Secure information (transfer)

1.1. ARDUINO OVERVIEW

The Arduino Diecimila is a microcontroller board based on the ATmega168 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply to connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The features are Operating voltage 5v, Input voltage (recommended) 7-12V, Input voltage (limits) 6-20V, Digital I/O pins 14, Analog Input pins 6, Flash memory 16KB, SRAM 512bytes, Clock speed 16MHz.

1.2. BUZZER:

This is a small 12mm round buzzer that operates around the audible 2 kHz range. This drove it directly from a 5V PIC to generate the tones for this Simon demonstration game. Use buzzers to create simple music or user interfaces. There is also a small piezoelectric buzzer. It can be used to modulate the buzzer to oscillate around different frequencies. It’s not the pulse width feature that is used to change the frequency. The volume of the sound created by the buzzer will be changed by modifying the pulse width. Instead, it’s possible to change the frequency of the PWM signal, and this will also change the frequency of buzzer oscillation.

1.3. LED:

Light Emitting Diodes-LED. They do dozens of different jobs and are found in all kinds of devices. Among other things, they form numbers on digital clocks, transmit information from remote control, lights up watches and tell you when your appliances are turned on.

1.4. GENERAL CHARACTERISTICS OF ZIGBEE

The objectives of the standard are to provide easy installation, reliable data transfer, good battery life, short range operation and extremely low cost [31, 32].

1. Data rates of 250 kbps (at 2.4 GHz), 40 kbps (at 915 MHz), and 20 kbps (at 868 MHz).
2. Optimized for low duty-cycle applications (<0.1%).
3. Multiple topologies: star, peer-to-peer, mesh.
4. Carrier sense multiple access with collision avoidance (CSMA-CA) channel access.
5. Allocation of guaranteed time slots (GTSs).
6. Fully acknowledged protocol for transfer reliability.
7. Low power consumption.
8. 1 channel in the 868 MHz band, 10 channels in the 915 MHz band and16 channels in the 2450 MHz band

2. LITERATURE REVIEW

A methodology to transform behavior rules for state machine is proposed in the paper. Do there, a device is being monitored for its behavior can easily be checked against the transformed state machine for deviation from its behavior specification. It is very important for safety-critical MCPS, have an activity to detect attackers while limiting the false alarm probability to protect the welfare of patients. For each device is developed is violated “attack state” as a result of a behavior rule. This attack state is their transformed into a conjunctive normal form predicate and he involved state components in the underlying state machine is developed. The union of all predicate is their transformed variables into the state components of a state machine and their corresponding ranges are established. The number of states by state collapsing and identifying combinations of values that are not legitimate are manages finally. Unsafe states in their state machine are not those “hazardous” states generated due to design faults. Such “hazardous” states, once identified, would be removed as a result of design faults being identified and removed during the testing and debugging phase. A CPS device will enter an unsafe state only when it is seen to deviate from the normal behavior specified by the behavior rule.

For it PCA device there are four attack states as a result of violating the four PCA behavior rules are listed below: (i)First PCA attack state is that a patient requesting analgesic has a pulse below some threshold. One way an attacker could exploit this is to cause an overdose of analgesic delivered by a PCA system. A patient will lose consciousness after receiving a sufficient amount of analgesic. For this attack state, the PCA module is the trustee and the VSM is the monitor.(ii) Second PCA attack state is that a patient requesting analgesic has a respiration rate below some threshold. One way an attacker could exploit this is to cause an overdose of analgesic delivered by a PCA system. A patient will lose consciousness after receiving a sufficient amount of analgesic; if the PCA receives additional requests for analgesic, then an intruder is involved. A compromised PCA device performing this attack will drive the MCPS into this state. For this attack state, the PCA module is the trustee and the VSM is the monitor. (iii)Third PCA attack state is that an analgesic request rate exceeds some threshold. One way an attacker could exploit this is to cause an overdose of analgesic delivered by a PCA system. While a patient in pain may press the button more frequently than is safe due to pain, the PCA module should only fulfill requests within the safe threshold. If the PCA module fulfills requests too frequently, then an intruder is involved. It is important to distinguish physical button presses from requests actually generated. (iv)Fourth PCA attack state is that the PCA infusion rate,x, is in (0, 100 percent] and the cardiac device mode, y, is defibrillation, yielding a state with two components. One way an attacker could exploit this is to cause an overdose of analgesic delivered by a PCA system. If the CD frequency when acting as a pacemaker is substantially different from the patient's heart rate, then an intruder is involved [1]. An episode Is modeled including a series of events, which includes spatial and temporal information about the subject being monitored. A similarity scoring function is defined that compares two episodes taking into consideration temporal aspects. A Way to determine a threshold to divide episodes into two groups that reduces wrong classification is proposed. Weights on individual functions that consist of the similarity functions are determined experimentally so that they can produce the good results in terms of area under curve in receiver operating characteristic (ROC) curve.

The authors used their data model including location, time, duration variables to extract human activity patterns and also used apriori algorithm. They used tracking cameras, door sensors, and passive infrared sensors to detect human behavior and used 30-day actual data set to extract the person's daily pattern [2]. The arduino technology is used to track the drug taking behavior of the patient based on the assumption that when the pills are taken from the medical kit, it is assumed that the patient has taken the drug. If a pill is taken and placed back in less than 10 seconds ignore the event, if a pill is taken and placed back in less than 10 seconds ignore the event. Technology enables us to achieve that with high accuracy by measuring the weight of the bottle before and after replacement. The enhancement can be done by putting a load/force sensor at the bottom of the medical kit. There are led lights to indicate the patients and alarm also provided to indicate the same.

The automated medical reminder system is useful to remind the people to take their medicine on time. The server holds all the data about pills and duration of intake which is prescribed by the doctor. As it is automated there will not be any confusion among the patients to take their medicine [3]. A bio-signal sensor and a smart phone are the main components of the system. The data collected by the bio-signal sensor are transmitted to an intelligent server via GPRS/UMTS network. The system is able to monitor the mobility, location, and vital signs of the elderly patient from a remote location. A body sensor network is used to measure and collect physiological data. Bluetooth has been used to transmit data from the sensor network to a mobile device. Wearable devices consume low power and they are small enough to fit into a shirt. To reduce the noise associated with the ECG signal an adaptive filtering method has also been proposed in this work. The system has been designed for the community based health care providers so that they can collect symptoms and perform clinical measurements at the patient's home. An Oximeter is connected to a smart phone to measure oxygen saturation level of the patient in order to predict her risk level. The system consists of three modules namely **(i)**A hardware module, **(ii)**Bluetooth module, and **(iii)**Display module [4]. A data-mining framework utilizes the concept of clinical pathways to facilitate automatic and systematic construction of an adaptable and extensible detection model. The empirical experiments show that their detection model is efficient and capable of identifying some fraudulent and abusive cases that are not detected by a manually constructed detection model. Currently, detecting such fraud and abuse relies heavily on medical knowledge**.** Approaches used in this paper reduces the work load of human experts but it requires the enormous knowledge engineering task of identifying either discriminating rules or discriminating features [5]. The gateway provides reliable IPv6 communication transmit a patient's biomedical signals to a doctor or server via the internet. Utilizing IPv6 with the IEEE 802.15.4 standard is a special match of the two technologies.

The monitoring program stores its value in a database and plots all the measured biomedical signals dynamically. The query processes handle the communication between the server and Android mobile device to display the biomedical signals graphically on a mobile screen in real time. PPG waveform display and heart rate, the IPv6 address of the node, the IPv6 address of the wireless gateway, the server IP, and buttons for the initiation and termination of a monitoring activity. The server PC can

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share the measured signals with any internet-connected client, such as a desktop, a laptop, a tablet PC, or a mobile device, provided that the client has a fixed IPv4 address. The Android software development kit (SDK) provides emulators that can mimic a variety of Android versions, screen dimensions and phone behaviors [6]

3. EXPERIMENTAL PROCEDURE

To monitor the health condition of patients a minimum power embedded wearable sensor network is used to measure the health parameters effectively. Wireless healthcare monitoring system provides real time information about the health condition of a patient. The patient's body temperature, BP, Pulse Rate and ECG are detected in the working environment using respective sensors (LM35, Pulse rate sensor, and ECG sensor). LM35's Output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. Heart beat sensor monitors the flow of blood by fitting it at the finger. Since the heart forces blood through the blood vessels in the finger, the amount of blood in the finger changes with time which corresponds to heart beat counts per minutes. The sensor shines a light (small incandescent lamp) through the finger and measures the light that is transmitted to the computer.

Fig. 1. System Architecture

Zigbee wireless technology has been optimally designed to provide some advantages namely low cost, low power, easy implementation, reliable, and high security. And it is used to transmit the patient's information. Sensor networks are able to send parameters deciding the health of the patient in real time. It enables the doctors to monitor patients health related parameters (temperature, heartbeat) in real time. It is able to send alarming messages to the healthcare professional about the patient's critical condition.

3.1. ARDUINO IDE

The first step is to install the Arduino IDE (Integrated Development Environment) on my PC. The other potential installation requirement is drivers for the microcontroller programming hardware, which is usually some kind of USB to serial translation IC or emulation, commonly known as a VCP, or "Virtual COM Port". Typically, official Arduino boards and a lot of compatible designs have used the common FTDI USB-serial driver IC (as do some Cal-Eng boards). There are other custom devices used on the Arduino UNO, Leonardo, Mega256 and others. The drivers for all the official Arduino boards are located in the "\arduino-1.0\drivers\" install directory. If and when you are prompted for a driver installation after plugging in an Arduino-compatible board the driver installer to this directory is highlighted. Typically, Mac and Linux do not need a driver installation, but if they do, the process is similar.

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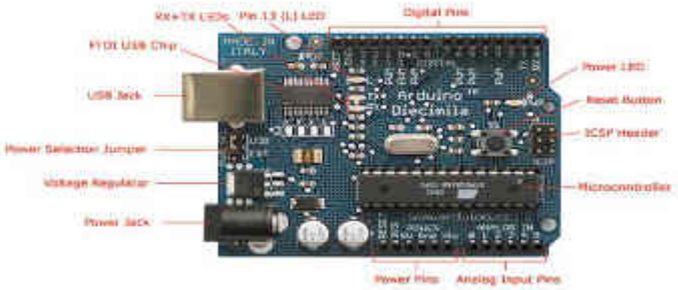

Fig.2. Arduino kit

3.2. HEART BEAT SENSOR:

The sensor used in this project is TCRT1000, which is a reflective optical sensor with both the infrared light emitter and phototransistor placed side by side and are enclosed inside a leaded package so that there is minimum effect of surrounding visible light. The circuit diagram below shows the external biasing circuit for the TCRT1000 sensor. Pulling the Enable pin high will turn the IR emitter LED on and activate the sensor. A fingertip placed over the sensor will act as a reflector of the incident light. The amount of light reflected back from the fingertip is monitored by the phototransistor. The output (VSENSOR) from the sensor is a periodic physiological waveform attributed to small variations in the reflected IR light which is caused by the pulsatile tissue blood volume inside the finger. The waveform is, therefore, synchronous with the heart beat. The following circuit diagram describes the first stage of the signal conditioning which will suppress the large DC component and boost the weak pulsatile AC component, which carries the required information.

Fig. 3. Heart-beat Sensor

3.3. LM35:

LM 35 is an Integrated Circuit sensor that can be used for measuring temperature. It generates a higher output voltage than thermocouples and may not require the output voltage to be amplified. It does not require any external calibration. Temperature range is -55 oC to 150 oC. Output voltage varies by 10mv. Scaling Factor of the temperature sensor is 0.01v/ oC. It is measured more accurately compared with thermistor**.**

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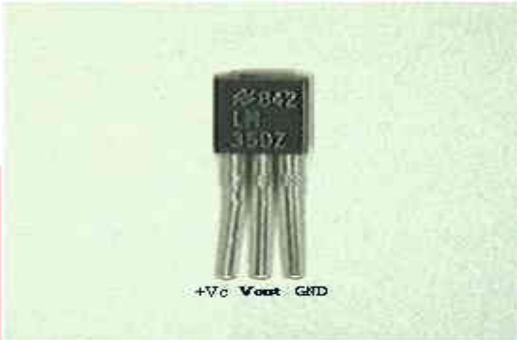

Fig. 4. LM35

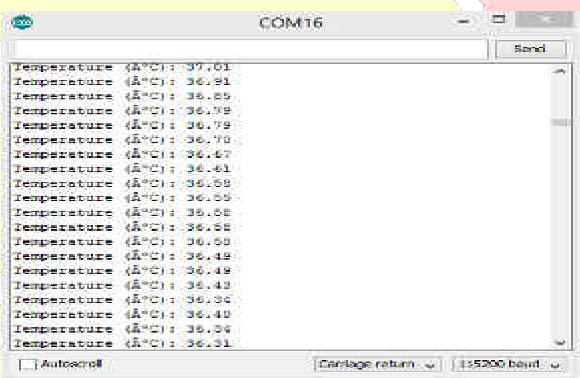

Fig.5. Experimental Result

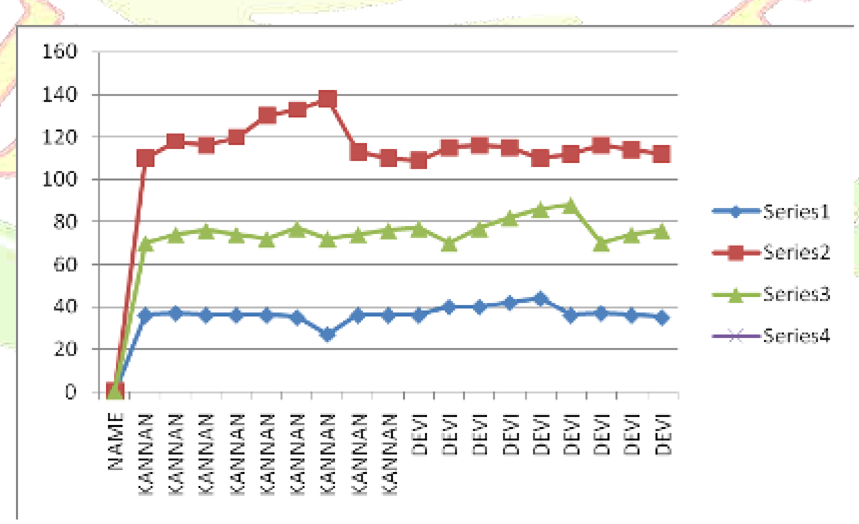

Fig.6. Line chart

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4. CONCLUSION

The developed system in the presented work is low cost, and light weight. It consists of sensing nodes. These nodes can be strategically placed on the human body and capable of creating a wireless sensor network (WSN) to monitor various physiological parameters. These parameters can be monitored for a long period of time and provide real-time feedback to the user and medical staff. The system is also capable of providing reliable and secure communication. A successful interaction among the Arduino UNO microcontroller and the different sensors fitted on the kit is achieved. The system further promises to revolutionize the health care monitoring approach. In this work temperature sensors are used to collect physiological data from patients. This healthcare monitoring sends an emergency notification message to the friends or relatives if any patient's health condition is critical.

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