Design and Implementation of Patient Activity Monitoring System using Wearable Sensors

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Abstract—Wearable sensors have become very popular in many applications such as medical, entertainment, security, and commercial fields. They can be extremely useful in providing accurate and reliable information on people’s activities and behaviours, thereby ensuring a safe and sound living environment. The human activity monitoring is a vibrant area of research and a lot of commercial development are reported. It is expected that many more light-weight, high-performance wearable devices will be available for monitoring a wide range of activities. This monitoring system uses sensors to collect the data and it is fed to the microcontroller to perform controlling operations and the details about the patient are displayed on the computer. The advancement of sensing technologies and embedded systems makes it possible to develop a system to monitor activities of human beings continuously. Wearable sensors detect abnormal and/or unforeseen situations by monitoring physiological parameters along with other symptoms. Therefore, necessary help can be provided in times of dire need. This paper is the latest system on activity monitoring of humans based on wearable sensors.

Key words: Wearable sensors, activity monitoring, light weight device, physiological parameters monitoring

I. INTRODUCTION

Wearable sensors have become very popular in many applications such as medical, entertainment, security, and the commercial fields. They can be extremely useful in providing accurate and reliable information on people’s activities and behaviours, thereby ensuring a safe and sound living environment [6]. It may be that the wearable sensors Technology will revolutionize our life, social interaction and activities very much in the same way that personal computers have done a few decades back.

The embedded system can be widely used in the medical instruments. The monitoring of any Human physiological parameters in hospital requires non-invasive sensors for the patient.

In recent times there has been a surge of usages of wearable sensors, especially in the medical sciences, where there are a lot of different applications in monitoring physiological activities. In the medical field, it is possible to monitor patients’ body temperature, heart rate, brain activity, muscle motion and other critical data [2]. It is important to have very light sensors that could be worn on the body to perform standard medical monitoring [6].

Running is a popular sport for the masses. In 2010, 625 marathons were carried out alone in the U.S. (www.runningusa.com; www.runningusa.com). Despite its popularity, running is considered to be a high injury risk sport with 65% of runners being injured per year [1]. Falls are the number one cause of injuries in older adults, including approximately 90% of hip fractures, 40% of vertebral fractures, and 60% of head injuries [12]. Wearable kinematic sensors, typically consisting of miniature accelerometers and/or gyroscopes, represent a promising technology for preventing and mitigating the effects of falls in older adults.

Embedded system used in the monitoring of human activity in hospitals. It can be also used in agriculture, medical, satellite communication etc. Embedded systems play a vital role in the patient activity monitoring in the hospitals.

An embedded system is a special-purpose computer system designed to perform one or a few dedicated functions, often with real-time computing constraints. It is usually embedded as part of a complete device including hardware and mechanical parts. In contrast, a general-purpose computer, such as a personal computer, can do many different tasks depending on programming. Embedded systems have become very important today as they control many of the common devices we use.

Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance. Some embedded systems are mass-produced, benefiting from economies of scale.

II. EXISTING METHOD

In existing method, the wireless technology is used to transmitting and receiving the data. It needs to avoid the risk of thermal injuring to tissue due to the sensing frequency and wireless frequency. Continuous supply of energy is one of the paramount importance for making the wireless wearable electronics sustainable in long-term use. Although a huge amount of effort has been made to make the electronics sympathetic to power, the Communication system is the main culprit to consume most of energy [6]. The disadvantages are high cost, high Power consumption, difficult to implement and an error in one node will affect the entire system.

Fig. 1: Wireless technology using transmitting and receiving the data
The wide impedance and axial ratio bandwidths make it suitable for low microwave power transmission to a wearable sensor system. Rechargeable battery along with some kind of energy harvester is becoming common to address the issue[6]. If the battery can be eliminated from the system it can solve a huge problem.

III. PROPOSED METHOD
In proposed method the wired communication is used for monitoring the patients. This method can overcome the thermal injury to tissues, high cost, high power consumption etc. This method can avoid the errors occurred due to wireless frequencies. The errors occurred in the wireless technology is avoided and Wearable devices that are compact, robust, and comfortable will enable widespread use in extending the care and support of emergency operators.

IV. BLOCK DIAGRAM
It consists of the temperature sensor, heartbeat sensor, force sensor, microcontroller, power supply and personal computer. The sensors are connected to the microcontroller to sense the physiological parameters of the human body. The signals from the sensor are given to the microcontroller and the microcontroller collects the data and perform the controlling operations.

![Block diagram for patient monitoring system.](image)

The microcontroller is connected to the personal computer via USB to monitoring the physiological parameters. The advantages are low cost, low Power consumption, easy to implement, an error in any part of the system does not affect the entire system.

V. BLOCK DIAGRAM DESCRIPTION
The sensor is a device that measures a physical quantity such as temperature and sends the information to a device such as a computer. The temperature sensor LM35 senses the surrounding temperature. The output of this IC is analog voltage. This voltage is given to the LM339 for compensating the present condition with the ideal one. Heart beat sensor is designed to give digital output of heat beat when a finger is placed on it. The microcontroller use here is ATMEGA328. It is responsible for controlling all the functions. The power supply is an electronics circuit. This is used to give regulated power to any electronics system. A computer is a system that has the following or more components:

- A microprocessor
- A large memory,
- I/O units such as touch screen, modem, fax cum modem etc.

The proposed methodology can overcome the demerits in the existing method and the wired technology is used. The patient activity monitoring system can be easily implemented in the hospital to serve the patients effectively.

VI. SENSORS FOR HUMAN ACTIVITY MONITORING
In this section it will review a few sensors which are commonly used for monitoring different human activities. Sensors are fundamental elements of the whole monitoring system and should measure the physiological parameters of interest accurately and reliably over a long duration. The rapid development of microelectronics, micromechanics, integrated optics and other related technologies has enabled the development of various kinds of smart sensors to sense and measure data more efficiently and faster, with lower energy consumption and less processing resources. Accelerometers proved to be the most information-rich and most accurate sensors for activity recognition. They react fast to activity changes and they reflect well the type of activity.

Body temperature is one of the common physiological parameters measured by wearable sensors for human activity monitoring. The LM35 series are precision integrated-circuit temperature sensors, whose 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. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/4°C at room temperature and ±3/4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.01°C of the surface temperature. This presumes that the ambient air temperature is almost the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature, the actual temperature of the LM35 die would be at an intermediate temperature between the surface temperature and the air temperature. The variation in temperature measured on the skin can give an indication of what is happening with the person’s body temperature and can be used to detect the symptoms of medical stress that might lead to various health conditions, including stroke, heart attacks and shock. The measurement of body temperature is extremely useful for determining the physiological condition as well as for other things such as activity classification [15], [16], or even harvesting energy from body heat.

The next most common physiological parameter is the heart rate of the person under monitoring. Heart beat sensor is designed to give digital output of heat beat when a finger is placed on it. Heart rate is a precisely regulated variable, which plays a critical role in health and disease of human. There are many methods available to measure heart rate of a person; Photoplethysmography (PPG) based technology [15], [16], sound based [17], based on changes on brightness of person’s face [18], and so on.

Force Sensing Resistors, or FSRs, are robust polymer thick film (PTF) devices that exhibit a decrease in
resistance with increase in force applied to the surface of the sensor. This force sensitivity is optimized for use in human touch control of electronic devices such as automotive electronics, medical systems, and in industrial and robotics applications. The standard 402 sensor is a round sensor 18.28 mm in diameter. Custom sensors can be manufactured in sizes ranging from 5mm to over 600mm. Female connector and short tail versions can also be ordered.

VII. MICROCONTROLLER

Microcontroller is the processing chip in an embedded system based device and it has a number of advantages over microprocessors. Microprocessor is a ‘System on Board’ and hence requires a number of peripheral devices to work as a system. Where as in a microcontroller, commonly used devices like ADC, timers, counters, I/O ports, USART etc., are all integrated in it and so, it is known as system on chip. This has resulted in the microcontroller to be used in many applications with relatively compact size of the device to be integrated.

Atmega32 can be programmed either by In-System Programming via Serial peripheral interface or by Parallel programming. Programming via JTAG interface is also possible. Programmer must ensure that SPI programming and JTAG are not be disabled using fuse bits; if the programming is supposed to be done using SPI or JTAG.

It has 32Kbytes of In-System Self-programmable Flash program memory, 1024 Bytes EEPROM, 2Kbytes Internal SRAM. Write/Erase Cycles: 10,000 Flash / 100,000 EEPROM. It can run at a frequency from 1 to 16 MHz. Frequency can be obtained from external Quartz Crystal, Ceramic crystal or an R-C network. Internal calibrated RC oscillator can also be used.

<table>
<thead>
<tr>
<th>Microcontroller</th>
<th>ATmega328</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Voltage</td>
<td>5V</td>
</tr>
<tr>
<td>Input Voltage (recommended)</td>
<td>7-12V</td>
</tr>
<tr>
<td>Input Voltage (limits)</td>
<td>6-20V</td>
</tr>
<tr>
<td>Digital I/O Pins</td>
<td>14 (of which 6 provide PWM output)</td>
</tr>
<tr>
<td>Analog Input Pins</td>
<td>6</td>
</tr>
<tr>
<td>DC Current per I/O Pin</td>
<td>40 mA</td>
</tr>
<tr>
<td>DC Current for 3.3V Pin</td>
<td>50 mA</td>
</tr>
<tr>
<td>Flash Memory</td>
<td>32 KB (ATmega328) of which 0.5 KB used by bootloader</td>
</tr>
<tr>
<td>SRAM</td>
<td>2 KB (ATmega328)</td>
</tr>
<tr>
<td>EEPROM</td>
<td>1 KB (ATmega328)</td>
</tr>
<tr>
<td>Clock Speed</td>
<td>16 MHz</td>
</tr>
<tr>
<td>Length</td>
<td>68.6 mm</td>
</tr>
<tr>
<td>Width</td>
<td>53.4 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>25 g</td>
</tr>
</tbody>
</table>

Table 1: Summary of Microcontroller

The ATmega328 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

VIII. RESULTS

The implemented project can give several benefits to the patients in the hospital.

The diagram below shows the software output of the patient monitoring system in the Arduino Uno software.

Fig. 3: Simulation output for patient monitoring system

The implementation of an embedded system based on a microcontroller for patient activity monitoring system has been investigated. The system has been tested successfully on simulation using arduino uno software for monitoring temperature, heartbeat and availability of the patient on the bed.

IX. CONCLUSION

The paper has reviewed the reported literature on wearablesensors and devices for monitoring human activities. The human activity monitoring is a vibrant area of research and a lot of commercial development are reported. It is expected that many more light-weight, high-performance wearables will be available for monitoring a wide range of activities. The challenges faced by the current design will also be addressed in future devices. The development of light-weight physiological sensors will lead to comfortable wearable devices to monitor different ranges of activities of inhabitants. Formal and Informal survey predicts an increase of interest and consequent usages of wearable devices in the near future. The cost of the devices is also expected to fall resulting in wide application in the society.

In this paper, the implementation of an embedded system based on a microcontroller for patient activity monitoring system has been investigated. The system has been tested successfully on simulation using arduino uno software for monitoring temperature, heartbeat and availability of the patient on the bed. In this method, the cost and power consumption was minimized since the wired technology is used instead of the wireless technology.

X. FUTURE SCOPE

In the future, it is plan on proceeding with the next phase of system testing, clinical validation, and, therefore, optimizing the system’s performance.
In summary, a new medical wearable device has been developed as part of a study targeted to monitoring the heart rate, temperature and force of the normal or abnormal person. Final goals of this paper are monitoring the patient’s body conditions continuously by using light weight wearable sensors. In addition, patients and families quality of life are increased. Furthermore, it is believe that elderly people as well, may benefit from this system.

REFERENCES


