Non-Intrusive Human Body Temperature Acquisition and Monitoring System

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***Abstract* - Patient health monitoring is a common thing done by doctors to monitor their patients' health. The most crucial reading monitored by doctors is the patient's read time body temperature. Unfortunately, current system used by doctors required them to see patients face to face, and the doctors will have to walk door to door to check the patient's temperature. "The Non-Intrusive Human Body Temperature Acquisition and Measurement System" is a one-off health system to monitor the patient's temperature by using computer. The aim of developing this system is to provide body temperature measurement without being intrusive and uncomfortable. It also processes less threat to the doctor when testing patient's body temperature because diseases have chance to infect the doctor. This system is also convenient for patient measure body temperature. This is because it can be installed or mounted on the wall. By using this system, infrared temperature sensor plays an important role. The radiation of infrared temperature sensor determines temperature. It can be used at airports, schools and clinics to prevent disease from spreading disease. Another aim of this project is to measure body temperature accurately. When infrared temperature sensor detects the human body temperature, it will transmit the data to microcontroller. Microcontroller plays its roles to send data to the computer by using Zigbee. The user can get the results from the computer.**

Keywords: Infrared temperature sensor; Zigbee

I. INTRODUCTION

The aim of our work is to accurately measure body temperature. Temperature is one of the most often-measured environmental quantities. This is because most physical, electronic, chemical, mechanical and biological systems exhibit some form of temperature dependence [1].

Several applications that use temperature measurement devices nowadays are mercury glass thermometer, tympanic ear thermometer, and probes thermometer. Real time non-intrusive body temperature sensor for temperature monitoring is an emerging technology in both electronics and computer world, and plays the important role in society, mainly in elderly and children health care services.

Non-intrusive temperature measurement is an optical measurement based on the property of all materials to send out electromagnetic radiation (infrared radiation). The infrared measuring instrument uses this radiation to determine temperature. This is particularly important when measuring the moving or quickly heated objects. New infrared sensor on the market has response times selectable down to 1 millisecond.

Since the outbreak of EBOLA disease, more body temperature devices have shown up in the market such as thermal imagers which use the tomography principle that is non-contact temperature measurement. Infrared technology has a high development potential since it is cheap and very effective. Infrared is energy radiation with a frequency below our eyes visibility, so we cannot see it.

II. LITERATURE REVIEW

A. Temperature of a Healthy Human

Temperature is a measure of the degree of heat intensity. The temperature of a body is an expression of its molecular excitation. The temperature difference between two points indicates a potential for heat to move from the warmer to the colder point. The human body's core temperature varies from day to day, and from time to time, but these fluctuations are small, usually no more than 1.0ºC. Humans are homoeothermic and body temperature is regulated at about 37ºC ±1ºC. The thermoregulatory canter in the hypothalamus plays a very active role in keeping body temperature in the normal range. External and internal heat sources influence body temperature. The basic of normal temperature off-normal human is 36.1℃ to 37.2℃.

Temperature is taken to establish a baseline of normal body temperature for the location and measuring conditions. The main reason for examining body temperature is to hunt for any signs of systemic infection or inflammation in the presence of a fever or high significantly above the individual's normal temperature. Other causes of high temperature include hyperthermia. The low temperature includes hypothermia [2]. Temperature depression needs to be evaluated. It is also important to review the trend of the patient's temperature.

A patient with a fever of 38°C does not necessarily show a menacing sign if his previous temperature has been higher as detailed. Body temperature is maintained through a balance of the heat produced by the body and

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the heat lost from the body. When the patient is at rest, the temperature also will change [3].

Table 1 *Temperature of a Healthy Human*

Temperature	Effect
44°C	Almost death. Sometimes patient known to survive at up to46.5°C
43°C	Normally death/brain damage/cardio-respiratory collapse
41-42°C	Fainting, confusion, very fast heart rate, convulsion, Low/high blood pressure
38-40°C	Severe sweating, dehydration, weakness, vomiting, headache, dizziness, fast heart rate, slightly hungry
37°C	Normal temperature
36°C	Mild or moderate shivering. May be normal temperature
34-35°C	Intensive shivering, numbness and bluish/greyness of the skin. Heart irritability. Confusion and Loss of movement of finger
29-33°C	Moderate to severe confusion or complete, sleepiness, progressive loss of shivering or stop, slow heartbeat, shallow breathing, unresponsive to stimulus and hallucinations
24-28°C	Breathing may stop. But mostly death. Sometimes patient known to survive at 14.2°C

B. Human Body Temperature Range

Body temperature range	Hypothermia (low temperature)	Normal	Hyperthermia (high temperature)
Baby (Birth to 2 years)	36°C	36 °C to 37°C	37 to 38°C
Children (3 to 12 years)	36°C	36 °C to 36.77°C	38°C
Adult (13 to 40 years)	36.1°C	36.1 °C to37.2°C	37.5°C
Elder(above 40)	35°C	35.77°C to 36.94°C	37.44 °C to 37.94°C

Every person has his or her own body temperature and there are many factors that can affect the body temperature. When assessing body temperature, some basic aspects have to be considered, namely the influence of normal thermoregulation, gender, ageing and site of measurement [4].

C. Sleeping Affect Body Temperature

Throughout the 24-hour day, the occurrence of sleep and wakefulness is closely related to changes in body temperatures. Changes in skin temperature may causally affect the ability to initiate and maintain sleep [5]. Previous findings on the relation between skin temperature and sleep-onset latency, indicating that sleep propensity can be enhanced by warming the skin to the level that normally occurs prior to and during sleep. Distal vasodilatation plays a primary role in the circadian regulation of body heat loss and is strongly associated with sleepiness and sleep induction. The human sleep–wake cycle is usually tightly coupled to the circadian time course of core body temperature.

The circadian regulation of heat loss in the evening, via distal skin regions, is intimately associated with sleepiness and the ease to fall asleep, whereas the homeostatic increase in sleep pressure does not influences the thermoregulatory system. The rise in heat loss and reduction in heat production during lying down and relaxing behavior before sleep is hypothesized to be part of the role of sleep as a mechanism for energy conservation and may be a remnant of our evolutionary past. After sleep initiation, non–rapid eye movement (NREM) sleep to rapid eye movement (REM) sleep cycle fluctuations seem to have minor thermoregulatory functions, especially in humans [6].

D. Core Body Temperature Measurement Using Sensor

Many researchers and engineers have been working on real time and remote monitoring systems. “Non-Invasive Measurement of Core Body Temperature in Marathon Runners” was published by Kay R¨omer in 2013. The core body temperature is a well-known measure of the human body’s effectiveness in maintaining its operating temperature within a constant range. In case of prolonged exercise and extreme conditions, such as in Marathons and iron-man races, precise measurements of core body temperature can be used to optimize the athletic performance and detect health risks such as hypo- or hyperthermia. Each runner wears an unobtrusive body sensor that measures core body temperature at the tympanic membrane, skin temperature at the outer ear, ambient temperature in the proximity of the ear, and then transmits the collected measurements wirelessly. Support bikers following the Marathon runners on the track are equipped with wireless sink nodes that collect the measured data. With the help of a mobile phone collecting the current GPS position and acting as a gateway, the measurements are forwarded to a remote database, so that trainers and caregivers can monitor the physiological parameters of the athletes during the race and can immediately be alerted as soon as the risk for a circulatory collapse becomes too high. In principle, runners could carry the mobile phone themselves inside a pocket. Mobile phone is also used to record changes in the environmental conditions, such as presence of direct sunlight, wind, or shadow. Bikers have the task of signaling all these information by interacting with the mobile phone placed on the handlebar of their bikes [7].

E. *Wearable Physiological Sensors*

Another system has been designed by Mark. J. Buller, William J. Tharion, Reed W. Hoyt, and Odest C. Jenkins. The system is described in their work "Estimation of Human Internal Temperature from Wearable Physiological Sensors". The system uses Evaluated Kalman Filter (KF) approach to model the physiology of internal temperature viewed through "noisy" non-invasive observations of heart rate. Human core body temperature (Tcore) is an important measure of thermal state, e.g. hypo- or hyperthermia, but is difficult to measure using non-invasive wearable sensors. Parameters for a discrete KF model are estimated from data collected during several Military training events and from distance runners (n=38). This state estimation problem in computational physiology illustrates the potential for collaboration between the artificial intelligence and ambulatory physiological monitoring communities [8].

Wearable sensor nodes are required to be small in size, and consume low operating power. This is to ensure that the battery size is reduced, for longer durations. Due to physical structure, sensor node has limited battery power, computing, and communication capability. Wearable sensor node consists of micro-controller, analog to digital convertor, external memory, and power source [9].

III. SYSTEM DESIGN

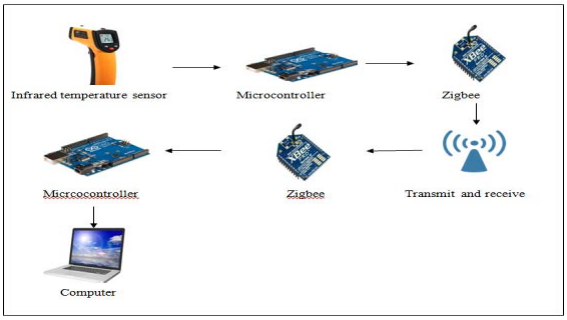

Figure 3: Block Diagram of non-intrusive human body temperature acquisition and monitoring system.

The above block diagram it shows how the project works. Firstly, infrared temperature sensor will detect the human body temperature and get the data. Then the data will be sent to microcontroller which is connected to the zigbee. The zigbee will transmit the data to another zigbee. Zigbee receiver is connected to microcontroller and then connects to the computer via usb port. The system uses the visual basic application to record and display the data. Thereafter the user can get the results from computer.

IV. METHODOLOGY

A. *Infrared Temperature Sensor*

Infrared temperature measurement technology is more and more receptive by businesses and manufacturers in recent years [10]. Infrared light works like visible light. It can be focused, reflected or absorbed. Handheld infrared thermometers typically use a lens to focus infrared light from one object onto a detector, called a thermopile. The thermopile absorbs the infrared radiation and turns it into heat. The more infrared energy, the hotter the thermopile gets. This heat is turned into electricity. The electricity is sent to a detector, which uses it to determine the temperature of whatever the thermometer is pointed at. The more electricity, the hotter the object is. The higher the temperature, the more electricity sent to the detector, hence the higher the reading [11].

Emissivity is a term used to quantify the energy-emitting characteristics of different materials and surfaces. IR sensors have adjustable emissivity settings, usually from 0.1 to 1.0, which allow accurate temperature measurements of several surface types.

The emitted energy comes from an object and reaches the IR sensor through its optical system, which focuses the energy onto one or more photosensitive detectors. The detector then converts the IR energy into an electrical signal, which is in turn converted into a temperature value based on the sensor's calibration equation and the target's emissivity. This temperature value can be displayed on the sensor or, in the case of the smart sensor, converted to a digital output and displayed on computer terminal surface types.

B. *Zigbee Technology*

Zigbee is a low-cost, low-power, wireless mesh networking proprietary standard [12]. It basically uses digital radios to allow devices to communicate with one another. A typical Zigbee network consists of several types of devices. Every Zigbee network must contain a network coordinator. Several topologies are supported by Zigbee, including star, mesh, and cluster tree. ZigBee-compliant devices are sometimes specified to support point-to-point and point-to-multipoint topologies. They can serve as network routers or as devices that interact with physical world. The final device found in these networks is the Reduced Function Device, which basically only serves to interact with physical world. Zigbee operates in two main modes namely: non-beacon mode and beacon mode. Beacon mode is a fully coordinated mode in that all the devices know when to coordinate with one another. Non-beacon mode, on the other hand, is less coordinated, as any device can communicate with the coordinator at will [13].

C. *Bluetooth Technology*

The Bluetooth is wireless, inexpensive and automatic. There are other ways to get around using wires, including infrared communication. Infrared refers to light waves of a lower frequency than human eyes that can receive and interpret data. Bluetooth networking transmits data via low-power radio waves. It communicates on a frequency

of 2.45 gigahertz. Bluetooth uses spread-spectrum to transmit data automatically. It is unlikely that two transmitters will be on the same frequency at the same time [14].

D. WiFi Technology

WLANs are the most popular means of access to the Internet. The proliferation of mobile devices equipped with WiFi interfaces, such as smart phones, laptops, and personal mobile multimedia devices, has heightened this trend. However, the performance of WiFi hotspots serving locations such as large conventions and busy airports has been extremely poor. In such a setting, more than one WiFi access points (APs) are required to provide wireless access to the Internet for many user devices (STAs) [15].

Wireless Fidelity (Wi-Fi) includes IEEE 802.11a/b/g standards for wireless local area networks (WLAN). It allows users to surf the Internet at broadband speeds when connected to an access point (AP) or in ad hoc mode. The IEEE 802.11 architecture consists of several components that interact to provide a wireless LAN that supports station mobility transparently to upper layers The basic cell of an IEEE 802.11 LAN is called a basic service set (BSS), which is a set of mobile or fixed stations. If a station moves out of its BSS, it can no longer directly communicate with other members of the BSS. Based on the BSS, IEEE 802.11 employs the independent basic service set (IBSS) and extended service set (ESS) 47network configurations [16].

E. Comparison of Wireless Standards

Wireless Parameter	**Zigbee**	**Bluetooth**	**Wifi**
Frequency band	2.4GHz	2.4GHz	2.4GHz
Range	Indoors: up to 30m Outdoors: up to 100m	9m	75 to 90m
Current consumption	25-35mA(Tx mode) 3 μA (Standby mode)	60mA (Tx mode)	400mA(Tx mode) 20mA(Standby mode)
Maximum number of nodes per network	64K	7	32 per access point
Number of channels	16	19	13
Maximum quiet bandwidth required	3MHz (static)	15MHz (dynamic)	22MHz(static)
Typical network join time	30ms typically	>3sec	Variable, 1 sec typically

Table 4: Comparison of Wireless Standards.

The demand for wireless solutions continues to grow and with it new standards have come forward and other existing standards have strengthened their position in the marketplace. This table compares three popular wireless standards being used today and lists some of the design considerations that differentiate them [17].

F. Arduino UNO

The Arduino Uno is a microcontroller board based on the ATmega328 (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. Arduino UNO can be connected to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. Micro-controller contains the processor (which all computers have) and memory, and some input/output pins that user can control [18]. The Arduino is open source, which means hardware is reasonably priced and development software is free. The Arduino programming language is a simplified version of C/C++ [19].

G. Visual Basic

Microsoft Visual Basic providesIDE that could develop Windows applications. It can create applications and also Windows operating system. Microsoft Visual Basic is a computer programming language used to create graphical application for the Microsoft Windows family of operating systems. It uses to give instructions to a computer. The instructions can be written from a text editor such as Notepad. Another way is to use a programming environment that is equipped with many tools which make it easy to work on projects, to create the necessary files, and to distribute a completed application. Microsoft updated development environments (IDE) were soon developed by Microsoft, which are light weight versions of the Microsoft Visual Studio product line. Express Editions were conceived beginning with Visual Studio 2005. The idea of Express editions is to provide streamlined, easy-to-use and easy-to-learn IDEs for users other than professional software developers, such as hobbyists and students.

H. X-CTU

X-CTU is a Windows-based application provided by Digi. This program is designed to interact with the firmware files found on Digi's RF products and to provide

a simple-to-use graphical user interface to them. X-CTU is intended to upload firmware to XBee radio modules. This is needed to change the firmware between router and co-ordinator of the Zigbee mesh network, and between the different protocol variants that the XBee radios can support.

One limitation of X-CTU is that it only works on Windows. One can download the latest X-CTU from Digi's X-CTU page. Alternatively, there is a version installed on the Citizen Sensing VM.

To use X-CTU, XBee module needs to be connected to user's computer. The easiest way to do this is using an XBee USB breakout board, which provides an XBee socket and a USB socket. Insert the radio into the board, plug in a USB cable, and plug the other end into a USB socket.

V. FUTURE IMPROVEMENT

In addition to the above, the system can be enhanced with attachment of GSM modem so that user can receive emergency messages. The user can receive the data anywhere by using mobile phone.

VI. CONCLUSION

Nowadays, many hospitals and physicians need reliable wireless monitoring system to observe real time physiological signals from patients outside the hospital with high and reliable accuracy.

There are many different types of diseases in the world, and there is also an increase in the number of patients. To avoid unexpected health problems and to obtain higher accuracy in diagnosis of the health conditions of a patient, efficient and comprehensive data collecting, monitoring and control play an important role to improve the health care system.

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