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Design of a contactless body temperature measurement system using arduino

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ABSTRACT

The recent advances in electronics and microelectronics devices allow the development of newly low-cost monitoring tools used by peoples for health preventive purposes. Sensors used in medical equipments convert various forms of human body vital signs into electrical signals. Therefore, the healthcare monitoring systems considering non-invasive and wearable sensors with integrated communication mediums allow an efficient solution to live a comfortable home life. This paper presents the remote monitoring of human body temperature (HBT) wirelessly by means of Arduino controller with different sensors and open source internet connection. The proposed monitoring system uses an internet network via wireless fieldity (wifi) connection to be linked with online portal on smart phone or computer. The proposed system is comprised of an Arduino controller, LM-35 (S1), MLX-90614 (S2) temperature sensors and ESP-wifi shield module. The obtained result has shown that real time temperature monitoring data can be transferred to authentic observer by utilizing internet of things (IoT) applications. The findings from this research indicates that the difference of average temperature in between Sensor S1 and S2 is about 15 ^{0}C.

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1. INTRODUCTION

Nowaday's, health monitoring is a global challenge in peoples life time. The comfort of life lies in a healthy condition which effected by environmental and surgical facts. The measurement of human body vital signs is an important to acknowledge the health status. The perfrormance of any work or exercise in hot conditions disturbs the balanced thermal homeostasis state of human body (HB). This balance acknowledges the HB about physiological and cognitive performance of body [1-3].

The normal body temperature ranges by 36.5^{0}C to 37.5^{0}C [4]. The status of health below this limit is stated as hypothermia and the status above is refered as fever and hyperthermia conditions. The hyperthermia also refered as tumour conditional stage that ranges more than 38.5 ^{0}C [5-7]. The individual body temperature measurement is dependent of different aspects i.e. age, exertion, infection and place of body at which measurment made. There are several methods to measure the HBT i.e. oral, retal and axillary through mercurial and contactless thermometers [8, 9].

The measurment of HBT with mercurial thermometer is crucial than contactless like as broken of thermometer if bitten during oral measurementm, injury of rectum during rectal measurement. Although, researcher are focusing to present digital and contacless thermometer for HBT measurement linealy. Therefore, this paper presents the contactless Infrared based HBT measurement prototype. The paper is organised as follows: in Section 2 a detailed description on the system importance is provided. In Section 3, implementation and demonstrate the hardware and software used for system design is discussed while Section 4 present the output results of experimental setup.

2. NEED OF TEMPERATURE MONITORING SYSTEM

The variation in human body temperature (HBT) can lead to different disease. It is essential to quantify the the range of temperature as shown in Figure 1. As stated by researchers that, while evaluating and measuring the health status specially HBT, some vital points are necessary [7, 10-12]. Few measurement methods are shown in Figure 2, while some aspects are justified in sub-sections 2.1 and 2.2 respectively and linked are listed in Table 1.

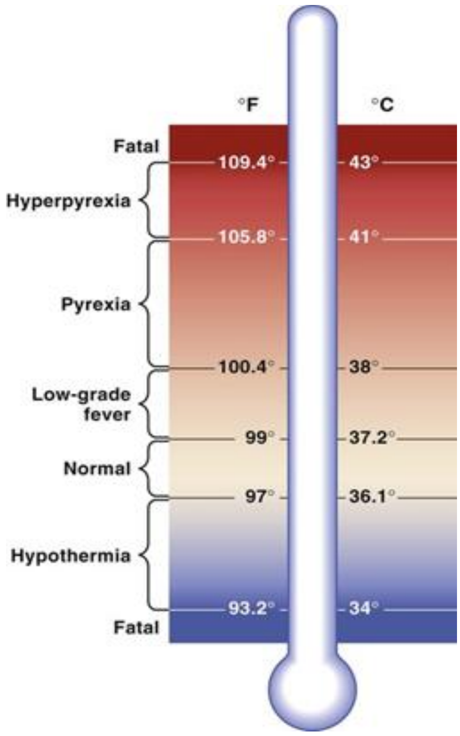

Figure 1. Body temperataure measurement range

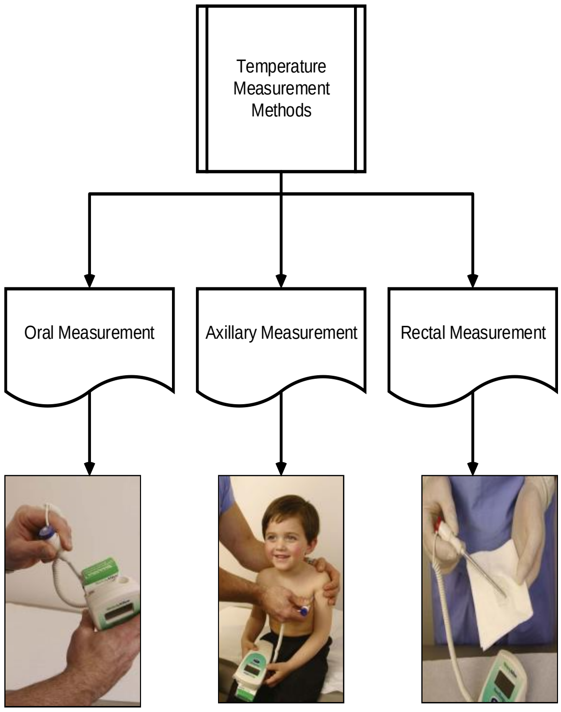

Figure 2. Temperature measurement methods

2.1. Diurnal variations

This variation is dependent of human body metabolism. During the sleep the metbolism is slower as decrement in contractions of muscles.

2.2. Emotional states

These variations frequently observed with young childrens during extreme anger and crying state which increase the body temperature.

Table 1. Variations in body temperature by age

Age Level	Method	Average temperature °C
Newborn	Axillary	36.1° C- 37.8° C
1 year	Oral	37.6° C
5 year	Oral	37° C
	Oral	37° C
Adult	rectal	37.5° C
	Axillary	36.4° C
Over 70 years	Oral	36° C

To attain the perfect health status, balance relationship among core body temperature (CBT) and skin temperature (ST) by non-invasive methods had been attempted [9, 12-14]. The prediction of CBT through chest measurement requires professional equipments for longer-term and continuous monitoring in natural habitats or daily environment. While, the prediction ST with and without external parameters i.e (humadity) was performed with a patch-type device (PTD) attached over the clavicle point of skin [15]. Although the relationship between perspiration rate and ST was also focused to monitor and measure the temperature but the applied PTD was not feasible for long-term use as the monitoring error was 15% larger than the commercial device.

The monitoring and measurement of ST can be performed with contact and contacless methods i.e utiliziation of arduino controller [16-24], a wireless sensor technology incorporating radio frequency technology (RFT) [25] and android application [26]. These developed measuring prototypes were not suitable to use on large scale applications due to the designing limitation. Furthermore the development in electronic circuitry moves the focused the researcher for smart measuremnt using smart watches and thermoregulator tools. Therefore to measure the human body vital sign the need of measurement tool is essential. This research only limited with temperature measurement using Arduino. The concerned tools to design the proposed health monitoring system are discussed in section 3.

3. SYSTEM OVERVIEW

The functional block diagram of proposed system is shown in Figure 3. The proposed system starts with initialization of temperature sensors for collection of real time temperature data in compare to environmental temperature values.

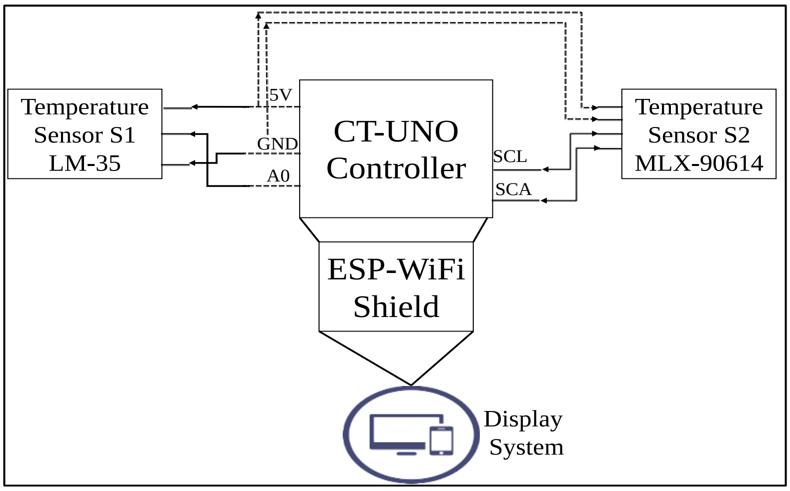

Figure 3. Block diagram of proposed monitoring system

The sensitivity of temperature sensors LM35 (S1) and MLX-90614 (S2) is programmed in C++ language and access through Arduino CT-UNO controller. The ports of configured wifi shield is powered from 5V internal supply of CT-UNO controller to transfer the collected data ay online portal. This system is designed without push button scheme to attain the wireless monitoring of temperature. The connective parts of the proposed prototype are expressed in sub-sections 3.1, 3.2 and 3.3 respectively.

3.1. Arduino CT-UNO controller

The applied CT-uno is one type of Arduino Mega controller. This microcontroller is based on ATMega328 data sheet consisting of 14 digital input-output pins, 6 pins for pulse width modulation (PWM) outputs and 6 pins for analog inputs. This controller have some auxiliary ports i.e. 16 Mhz oscillator, USB connection and Power jack with reset button. The pins allotted for (S1) and (S2) on Arduino are either A4/A5 in this proposed monitoring system the pin allocations are A0, SDA and SCL respectively for both sensors as shown in Figure 4. The utilization of simple Arduino controller was used for monitoring of the temperature, heart beats, electrocardiography and humadity parameters [13, 20, 27-28]. The CT-UNO controller has reduce the complexity of Arduino mega controller with inclusion of new and simple attached electronic circuitry and utilized in this research work.

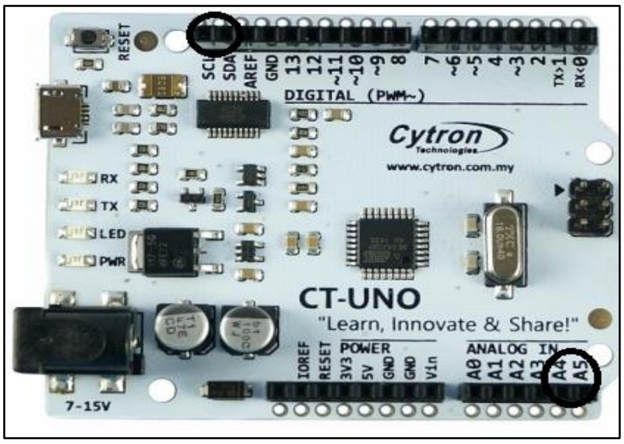

Figure 4. Arduino controller kit

3.2. Temperature sensor

The two temperature sensors LM35 (S1) a contact type and MLX-90614 (S2) contactless are used in this proposed monitoring system as shown in Figure 5. The LM35 sensor is a precise sensor which directly converts the output voltage into temperature in Celsius. This conversion is programmed into Arduino panel using the (1). This sensor is better than thermistor due to linear output and low impedance advantages. The range of this sensor is between -55 ^{0}C to 150 ^{0}C [18].

$$Output\ Temp\ in^{o}C := Temp \times 0.48828125 \qquad (1)$$

This equation normally used for S1 sensor while assembling with Arduino controller and stated numerical value represent the ratio of input voltage and analog value [23]. The linearity of this S1 sensor is 10mV/^{o}C.While, the Infrared sensor (S2) manufactured by melexis is also used for measurement of body temperature through PWM output pins. This sensor uses low-noise amplifier, 17bit analog-digital coverter for accurate temperature measurement.

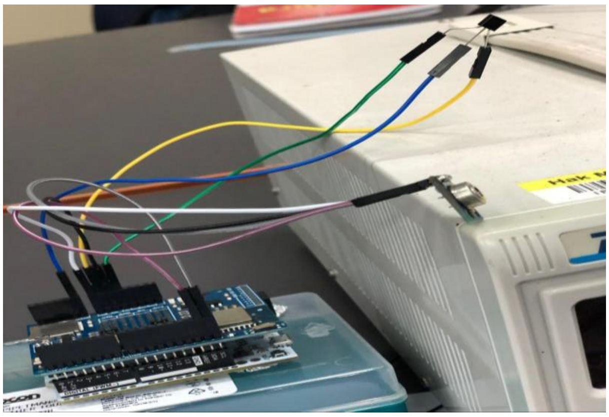

Figure 5. Connectivity of temperature sensors

3.3. Arduino wifi-sheild

The Esp-wifi shield is a wireless programable microcontroller that is capable to perform as host or offload wifi network functions. This shield in this research act like as central server hub for transfer and monitoring of collected temperature data. Although researcher also used the Arduino, raspberry pi controller for data monitoring and transferring purpose [28-30]. The comparative analysis of these controller is shown in Table 2. The monitoring can be performed with wire or wireless communication devices to make the designed system reliable considering system protocols [31].

Table 2. Comparison of Microcontrollers [29]

parameters	Arduino	Raspeberry Pi	ESP-Wifi sheild
Processor	ATMega	ARM Cortex-53	-
Operating voltage	5 V	5 V	3.3 V
Clock speed	16 Mhz	1.2Ghz	26Mhz-52Mhz
Development Environment	Arduino IDE		Arduino IDE, Lua Loader
Supported Communication	IEEE 802.11 b/g/n IEEE-802.15.4	IEEE 802.11 b/g/n IEEE-802.15.4	IEEE 802.11 b/g/n

The flowchart for the proposed system is shown in Figure 6. The proposed system is powered through CT-UNO to initiate the process of embedded sensors S1 and S2 respectively. The sensitivity of applied sensors is dependant of two factors. i.e placement of sensor and delay time to monitor and measure the obtained data. The proposed monitoring system works in a closed loop strategy. This strategy is followed up after initial setup of sensors to measure the ambient and body temperature. The activation of sensors acknowledge the configured ESP-wifi shield to transfer and display the obtained data to the selected online portal with delay of about 1 minute. This delay is used to verify the system effectiveness in case any interruption or external effects occurs during operating state of applied circuitry. In result, the closed loop will run until all the satisfactory result displayed at online portal.

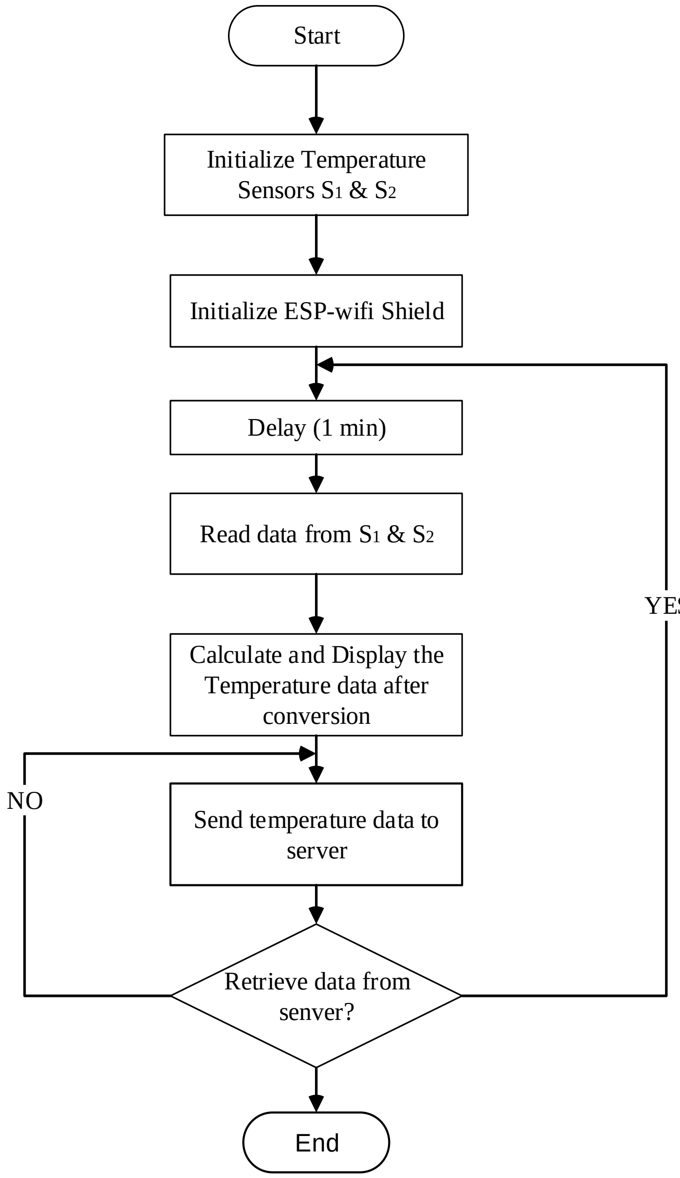

Figure 6. General flow chart of proposed system

4. RESULT AND DISCUSSION

The testing and analyzing of proposed system was performed in UTHM premises on 21st January including an indoor and outdoor environment with recorded ambient temperature of 35.6 ^{0}C. The F2 block with ground to 2nd level longue was selected for experimental setup to monitor the variations in temperature as stated in Figure 7(a-c). At initial, the collection of data is directly monitored with Arduino platform and later was transferred to the online portal using ESP-wifi shield.

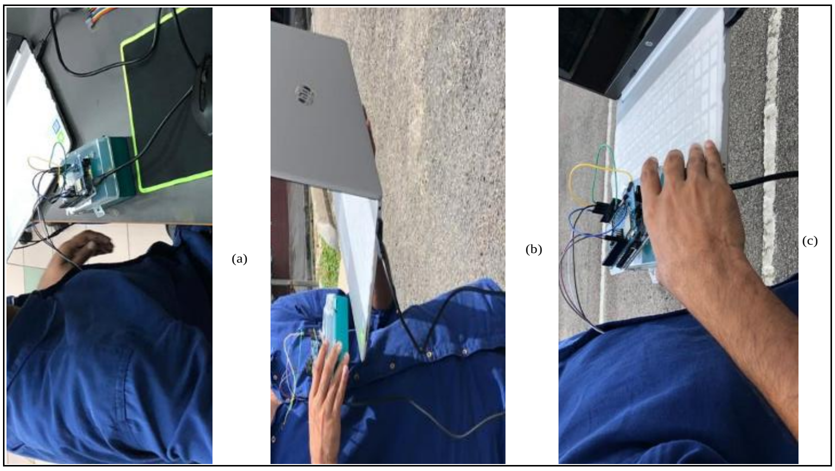

Figure 7(a-c). Measurement with indoor and outdoor environment

The monitored data of temperature sensors LM-35 as sensor 1 (S1) and MLX-90614 (S2) through CT-UNO monitor is slightly differnt due to operating functionality as shwn in Figure 8. Moreover, S1 sense the data in thermal contact otherwise it just observes the surrounding temperature. Similarly, IR based S2 sensor used to measure the body temperature at indoor and outdoor environment.

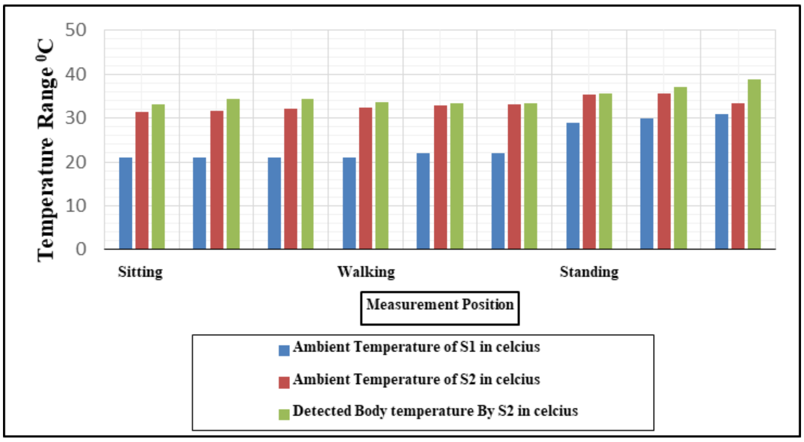

Figure 8. Monitoring result of proposed system

5. CONCLUSION

Healthcare organizations i.e. insurance companies need a real-time, reliable and accurate dignositc monitoring system provided by low-cost sensor system application, whether the patient is in hospital or at home. A real time monitoring of body temperature using embedded platform has been presented in this paper. The collection of real time data is controlled by CT-UNO controller. The transferring of sensed data from implemented LM-35 and MLX-90614 temperature sensors at the online portal is performed through ESP-wifi shield. This platform is wirelessly connected to monitor and display the real time data of deployed S1 and S2 sensors respecticvely at indoor and outdoor environment. This deployment clearify the effects of elevation in temperature readings which varies due to other environmental aspects i.e humadity, barometer, blood pressure and heart rate that are not considered in this research. The findings from this research indicates the difference in average temperature from S2 is about 15^0C. Although, the daily monitoring of body temperature can prevent the people from threaten of fever, hypothermia and hyperthermia illness.

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