A wearable diagnostic and therapeutic device for hyperthermic and hypothermic patients

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Abstract: The main objective of proposing this theme as a undertaking is the well-being of the human being in the modern world. And out of the various affecting factors. Hyperthermia is conditions were the body temperature is high when compartable to the normal temperature. Hyperthermia is usually diagnosed by the mixture of unexpectedly high body temperature and a history that supports hyperthermia instead of a fever. Hypothermia is direct opposite to the Hyperthermia. Heat stroke is also a hyperthermic condition which can affect the person at normal temperature region itself. It affects the person by dehydrating and causes more effects. If these problems are untreated it leads to severe problems even mortal. So this type of problem should be detected earlier by using Arduino NANO microcontroller by detecting the body temperature, humidity level and heart pulse rate in the body by a wrist watch by using DS18B20 temperature sensor module, DHT11 humidity sensor and MAX30102 pulse rate sensor. By aiding a treatment via providing a Peltier module placed smart jacket for the hypothermic and hyperthermic patients. The heating and cooling effect in the jacket will act as a first aid to the affected individuals. Where the smart watch works on the diagnostic purpose of these condition and smart jacket as a therapeutic purpose of these conditions. If the body temperature is lower than the normal body temperature or higher than the body temperature then the signal is transmitted to the jacket and send an alert message is to the care taker or to the affected individuals by using GSM module. While the receiver in jacket starts to produce warmness or cool according to the temperature, humidity and pulse rate low or high. The heat and cool is varied by measuring the temperature, humidity and pulse rate in the body. Where the developed system is aimed by the combination of these technologies in a module fulfils the requirements of delivering diagnostic and therapeutic device with a wearable technology. In order to detect and aid a therapy for various hyper and hypothermic conditions, it is possible to use a wearable device like smart watches, smart jackets and other accessories in the present world.

Index Terms: hypothermia, hyperthermia, heat stroke, heat stress, arduino, DS18B20 temperature sensor, humidity sensor, peltier module, pulse rate sensor, GSM module.

I. INTRODUCTION:

In worldwide the climatic condition are become very low and high now-a-days. These sudden changes in temperature can lead to some health issues to the people. When the thermoregulation is failed in our body it causes hyperthermic and hypothermic conditions such as heat stroke, heat stress, hyperthermia, pyrexia, hyperpyrexia, hypothermia, cold stress and SIDS in infants. The average human body temperature should be 97.7°F to 99.5°F. When it falls below 95.0°F, then the condition is called hypothermic condition. The direct opposite condition of hypothermia is called hyperthermia. Hyperthermia is the global burden in the warmer regions. The rise in the body temperature causes hyperthermia, heat stroke, heat cramps, etc. The sudden fall in the body temperature causes cold stress, hypothermia and SIDS in infants. There is difference between normal fever and hyperthermia. Both hyperthermia and hypothermia causes serious effect in the world where 600 people die each year in US from the avoidable exposure to extreme heat. The threat of death related to hyperthermia and hypothermia for the very young and elder peoples are high. So it is important to detect hypothermia, hyperthermia, and heat stroke at early stages and provide a proper treatment to the affected individuals.
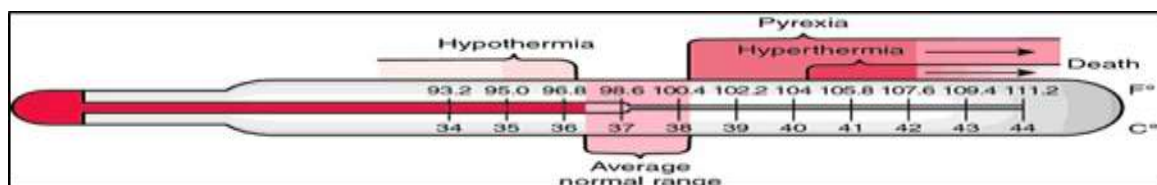
CLASSIFCATION OF BODY TEMPERATURE:

Fig. i

This paper proposes a system to perform measurement of the body temperature, humidity and pulse rate based on sensors. And the peltier based heating and cooling jackets. For the diagnostic purpose a watch is designed and for the therapeutic purpose a jacket is designed using peltier module. The proposed system is able to evaluate both hypothermia and hyperthermia temperature for the affected individuals. The system has functioned acceptably and can be used by elderly people or people suffering from variety of

medical ailments & thus to improve medical care quality not only for younger and elder people but also for adults suffering owing to some medical issues related to thermoregulation in the human body.

II. LITERATURE SURVEY :

In this paper a light wearable device that can progress patient's comfort and can be located closeness to the body, thereby enhancing the energy deposition and reducing the power requirements. This device is primarily aimed at continuously tracking the skin temperature to indicate the onset of hyperthermia. The proposed system provides a user interface which is simple and efficient for monitoring the body temperature and a sound alarm from buzzer in case of hyperthermia condition. The temperature status obtained will be transmitted to the monitor window via Arduino UNO and USB cable. This would help in identifying the hyperthermia in its initial stage. The main drawback of the project is it detects only hyperthermic conditions [3]. In this journal the emphasis is on development of a heat exchanger jacket for the application in the field of military and medical science. There are refrigerators used to cool the jackets using arrangements of pipes and with the use of cold water circulation, then by using the electric circuits for controlling operations and then use of Peltier module is inculcated to achieve desired function [5]. 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 [7]. The proposed paper of Adaptable jacket for climatic conditions using ARM microcontroller, by which the people/user can easily control the temperature of the jacket. The abuser controls the peltier plate temperature by the condition of the relay. The jacket is very supple to wear, convenient, healthy and light in weight. The user wears a climate adaptable jacket as a dress, and moreover there is an ability to switch on TEC and view the temperature status in the LCD, which is sited in this jacket. In this project only cooling effect is being produced and using of DC fans produces more noises in it [2]. 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) move towards to model the physiology of internal temperature viewed through "noisy" non-invasive observations of heart rate. Human core body temperature (Tcore) is an vital measure of thermal state, e.g. hypothermia or hyperthermia, but is not easy to measure using non-invasive wearable sensors [8].

Body temperature range	Hypothermia (low temperature)	Normal Hyperthermia (high temperature	Hyperthermia (high temperature)
Baby (Birth to 2 years)	36°C	36 °C to 37 °C	37° to 38° C
Children (3to 12 years)	36°C	36 °C to 36.77° C	38 °C
Adult (13 to 40 years)	36.1°C	36.1 °C to 37.2 °C	37.5° C
Elder(above40)	35°C	35.77° C to 36.94 °C	37.44° C to 37.94 °C

Table i

III COMPONENTS:
1. SENSOR:
A.   DS18B20 TEMPERATURE:

Fig 1.1

The DS18B20 is a 1-wire interface digital temperature sensor from Maxim IC. The internal functionality of DS18B20 is its direct-to-digital temperature sensor. It reports degrees in temperature from -55°C to +125°C and comparable Fahrenheit is -67°F to +257°F. Its accuracy is ±0.5°C from -10°C to -85°C. It converts 12-bit temperature to digital word in 750ms. The DS18B20 powers-up in a little power idle state. . In the DS18B20 cannot be over 8 in parallel connections or else, brownout will happen and the signal transmission will turn to be unbalanced. As a result, multi-point temperature measurement will not succeed.

B.DHT 22 SENSOR :

Fig. 1.2

The DHT22 is the digital temperature sensor which is economical or available at low cost. It uses the capacitive humidity sensor in addition to thermostat for measuring temperature and the surrounding air. No analog input pins are needed to measure temperature with DHT22. We can analyse relative humidity by measuring the electrical resistance between any two electrodes. The technology of a dedicated digital modules collection and the temperature and humidity sensing technology are applied to ensure that the product has high reliability and excellent long-term stability. It compared to DHT11 sensor it is more precise, more accurate and works in a bigger range.

C.PULSE RATE SENSOR (MAX30102):

Fig. 1.3

MAX30102 Oximeter Heart Rate Beat Pulse Sensor 1.8V-3.3V Replace MAX30100 A5N2 MAX30102 Oximeter Heart Rate Beat Pulse Sensor 1.8V-3.3V Replace MAX30100 A5N2 Description: Optical Heart-Rate Monitor and Pulse Oximetry Solution Tiny 12.7mm x 12.7mm (0.5in x 0.5in) Board Size Low Power Device Drivers Free Algorithm Example C Source Code For Arduino And mbed Platforms Test Data Competitive Advantages Highly-integrated, small-size sensor Non-chest based heart-rate/SpO2 detection Ultra-low power consumption Applications: Wearables Heart-rate monitor Pulse oximeter Color: Green Material: Plastic Package Included: 1 x MAX30102 Beat Pulse Sensor 1 x pin header Only the above package content, other products are not included. Light shooting and different displays may cause the color of the item in the picture a little different from the real thing. The measurement allowed error is +/- 1-3cm.

2. ARDUINO NANO:

Fig. 2

Arduino NANO is an open source electronics platform primarily based on easy-to-use hardware and software. Arduino NANO boards are capable of study inputs like light on a sensor, a finger on a button, or a message and flip its output like turning ON a motor, turning ON a light through online. Arduino NANO is a microcontroller easy to use for beginners. It is simple and accessible user experiences. Arduino NANO is been brain of thousands of projects and application. It comes with a crystal oscillator of frequency using constant voltage. There is a one limitation using Arduino NANO i.e it doesn't come with dc power jack, means you not supply external power source through a battery. It is small, complete, and breadboard- friendly board on the ATmega328.

3. PELTIER MODULE:

Fig. 3.1

Thermoelectric /peltier module is operated by the Peltier effect. The device has two sides, and while DC current is passed through it. It brings heat from one side and cooler on another side. A peltier module is a semiconductor-based electronic component and functions as a small heat pump. When the device is turned to the hot side, the device gets heat up quickly and the cold side becomes cool quickly too.

PELTIER EFFECT:

Fig. 3.2

The **Peltier effect** is a temperature difference formed by applying a potential difference between two electrodes connected to a sample of semiconductors. This effect is stronger when two different semiconductors are used in place of conductors. It is very important to transfer/remove heat from one medium to another medium to produce cooling effect. The main application of The Peltier effect is used in function of thermoelectric heat pumps and thermoelectric cooling devices.

$$Q \, \alpha \, I$$

Where,Q= Rate of cooling or heating.
I= Current passing through the junction.

4. LI-ION BATTERY:

Fig. 4

A lithium polymer or lithium-on battery is a kind of rechargeable battery. Lithium batteries are broadly utilized in transportable client digital gadgets. These batteries can easily support the concise and maintain high voltage for a long time. In this battery, lithium ion move from negative to positive electrode during discharging and reverse back when charging. Lithium batteries can provide extremely high currents and can discharge rapidly when short-circuited. Lithium ion polymer battery is a rechargeable battery of lithium ion technology using a polymer electrolyte instead of a liquid electrolyte. But LiPo batteries can be highly dangerous. Dropping, denting or crushing can shorten the life of the battery and even cause an internal short. These are a type of rechargeable battery that has taken the electric RC world by storm, especially for planes, helicopter. They are the main reason for electric flight is now a very viable option over fuel powered models. The battery is 1300 mA out of the box, it drops to 75%.

5. GSM MODULE:

Fig. 5

GSM is a Mobile Communication Modem. It stands for global system for communication (GSM). GSM/ GPRS modem is a set of wireless modem, designed for communication over the GSM & GPRS network. It requires a sim card to activate the communication network. These are mainly employed for computer based SMS and MMS services. SIM800L Module is a small cellular GSM / GPRS breakout board that allow GPRS communication, transfer and acceptance messages, and making and receiving calls. This module supports quad-band GSM/GPRS network, which is offered for GPRS and SMS data remote transmission. Having a small footprint, quad-band frequency support and low price make it perfect for any project that requires long-range connectivity. The GSM be different type of handsets such as GSM cellular, GSM mobile phones, GSM handsets, GSM mobile handsets, GSM technology, etc. The device uses a serial communication method, so it communicates with almost every controller via the UART port. After giving voltage supply module boots up, search for the cellular network, and login automatically.

6. TRANSMITTER & RECEIVER:

Fig. 6

Zigbee is a low-cost, low-power, wireless mesh network standard targeted at battery-powered devices in wireless control and monitoring applications. Zigbee delivers low-latency communication. ZigBee is a wireless networking for high-level communication protocols using small and low-cost radios. Zigbee digital transmitter in 2.4GHZ band is planned via Verilog in support of acknowledgement outline (or) architecture. Zigbee mostly operates three frequency bands. In the industrial, scientific and medical(ISM) radio bands; 868 MHz i, 915 MHz, and 2.4 GHz in generally jurisdictions on worldwide. In this operating frequency is 2.4 GHz and data transmission range is from 10 to 100 meters . It operates on 2.4 GHz with data rate of 250 Kbps . ZigBee uses very low data rate and has a long battery life, which makes it widely useful in monitoring and control applications. Therefore, markets as building automation, industrial control, lighting in smart homes, personal health care, and commercial control are perfect fits. The human interfacing devices such as keyboards, mice, joysticks etc. and high end remote control for consumer electronics are in addition for good fits.

7. LCD Display:

Fig. 7

Liquid Crystal Display (LCD) is an electronic display module. It is most commonly used in embedded system because it is very cheap price, accessibility, easy to use and provides programmer friendly. The LCD displays 32 characters, in each character there will be 32 crystals for displaying a character. In our day to day life we come up to across these kinds of displays such as PCO's or calculators. It operates in the range of 4.7V to 5.3V.

III. WORKING :
BLOCK DIAGRAM:
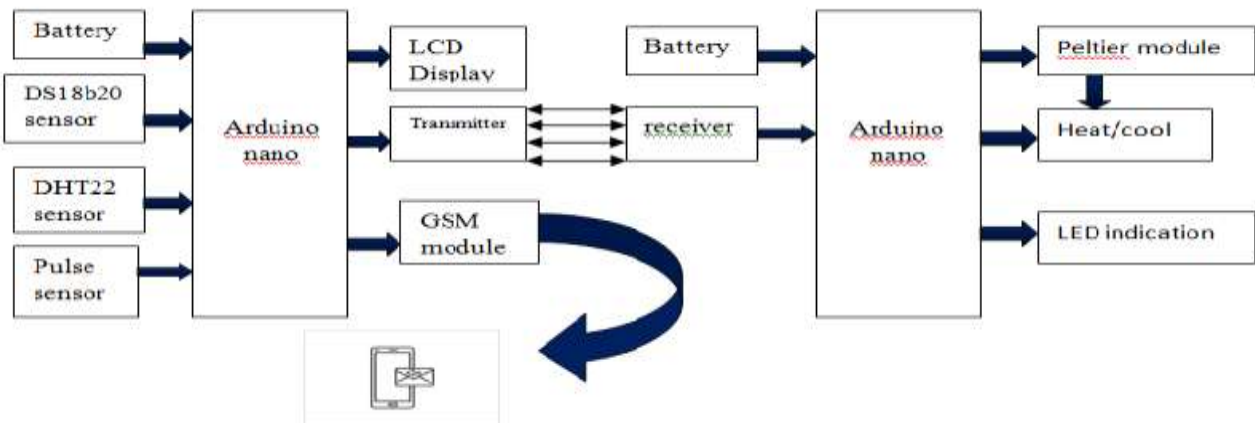
The methodology used here is by interfacing hardware and software components using embedded systems. The input signal is measured by means of input sensors from the human by using DS18B20 temperature sensor, DHT22 humidity sensor, and pulse rate sensor. There is need of current for the sensor in which USB port is used for Arduino NANO board. Arduino board is used for interfacing the circuit in addition to corresponding temperatures, humidity and pulse rate are being monitored. The hypothermic and hyperthermic conditions are being monitored and displayed in the LCD display and send an alert message using GSM modem. If any abnormalities in the temperature, humidity and pulse rate, the transmitter in the diagnostic device transmits the signal into the receiver in the jacket.

PARAMETERS	NORMAL RANGE
TEMPRATURE	36.5°-37.5°C
HUMIDITY	30-60%
PULSE RATE	60-100 beats

Table i

The main purpose of the jacket is too. If any abnormalities in the temperature, humidity and pulse rate it transmit the signal into the receiver in the jacket via transmitter in the diagnostic device. The jacket is designed using peltier module. When the temperature, pulse rate is high and humidity level is low than the normal level it produces the cooling effect and the temperature, pulse rate is low and humidity level is high than the normal level it produces the heating effect. Depending upon the heat and cool effect is LED indication is being provide if it is heat it indicates red colour and if it is cool it indicates blue colour and if normal green colour.

CONDITIONS	LED INDICATION	PELTIER EFFECT
HYPERTHERMIA	Blue LED indication	Cooling effect
HYPOTHERMIA	Red LED indication	Heating effect
NORMAL THERMO -REGULATION	Green LED indication	No heat/ cool effect

Table iii

IV. RESULT :
As per the results "A wearable diagnostic and therapeutic device for hyperthermic and hypothermic patients". It will measures ambient body temperature, pulse rate and humidity level in diagnostic device. It sends the affected condition to the care taker via GSM module & transmits the signal to the therapeutic device. The receiver in the therapeutic device produces heat/cool according to the conditions & indicated the effect produced via LED (red, blue, green).

V. CONCLUSION :
The main goal of this work is to sense, send, and display the physiological parameter such as human body temperature, pulse rate. The system is simple, low cost as it is implemented using Arduino NANO Microcontroller and portable. The reduction of the cost of hospitalization & assistance and to increase patient's quality of life via smart clothing application is the aim of this work. The system has functioned satisfactorily and can be used by elderly people or people suffering from variety of medical ailments & thus to improve medical care quality not only for younger and elder people but also for adults affliction due to some medical issues related to thermoregulation in the human body.

VI. FUTURE SCOPE :
The future scope of our project is to design a washable, less weight, with high cooling effect and heating effect jacket for the therapeutic purposes. In diagnostic purposes rain drop sensor and other biosensors should be interfaced in the smart watch. To improve the component stability and accuracy in the wearable device. To diminish the size and making a cosy diagnostic watch &

therapeutic jacket. To implement this type of jacket at low cost for the cancer patients for hyperthermic therapy for the affected individuals.

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