

A Diagnostic Device for Hyperthermia and Hypothermia Patients and Aiding a Therapy Using Wearable Jackets

Jesline.A¹, Sivasri.A², Subha Bharathi.C³, Gowrishankar.K⁴

¹²³ B.Tech, Department of BME, Rajiv Gandhi College of Engineering and Technology, Puducherry, India.

⁴ Associate Professor & Head of the Department of BME, Rajiv Gandhi College of Engineering and Technology, Puducherry, India

Submitted: 01-11-2021

Revised: 06-11-2021

Accepted: 09-11-2021

ABSTRACT:

The goal of creating this paper on the basis of disease causes using temperature such as hyperthermia, hypothermia, heat stress, heat cramps, cold stress, SIDS on earlier stages. For the later stages it can lead to CIPA, Erythromelalgia, complete heart and lung failure, and causes damage in the hypothalamus. This paper mainly concentrates on the hyperthermia and hypothermia patients. This paper is based on the early detection of those diseases at the earlier stage. This paper proposes a multi-parameter sensor method for measuring the thermoregulation of the body such body temperature, heart rate and environmental humidity for the analysis of the hyperthermia and hypothermia for the patients. And the main objective of the paper is to detect the affected people and treat the person affected by aiding a proper first aid to the patients. The proposed paper will aid a therapy for the hyperthermia and hypothermia patients at the earlier stage using Peltier effect. These diagnostic and therapy part will be processed using Arduino NANO microcontroller. This paper of analysis of hyperthermia and hypothermia and treat using a aluminium plate to process the heating and cooling effect depend upon the body temperature. And the data from the analysis part will be transmitted and received using a transceiver. Were the affected individuals after diagnosis of the condition to treat the person by wearing the peltier module placed jacket which will be more adaptive than other heating and cooling wearable. The proposed methodology is more effective and user friendly for the consumers.

Keywords: hyperthermia, hypothermia, thermoregulation, diagnostic, Therapy

I. INTRODUCTION:

In this paper, we discussed about effects of the hyperthermia and hypothermia on the environment of the present world. The statistical data conveys that in the present year nearly 500 people have been died too high temperature due to fail in thermoregulation. The hyperthermia and hypothermia are affects the individual for various reason. Hyperthermia can be defined by rise in body temperature due to failed in thermoregulation. It is mainly caused due to prolonged in high external temperature such as fire fighter, athletes, farmers, are majorly affected. Hyperthermia is diagnosed via the symptoms such as high body temperature, low heart rate, increased sweating at the earlier stages and absences of sweating in the later stage. Hyperthermia is an initial stage for diseases such as Congenital insensitivity to pain, anhidrosis, Erythromelalgia. Hypothermia is the straight converse to the hyperthermia, hypothermia is the condition caused due to fall in body temperature than the normal body temperature. Hypothermia is diagnosed by the symptoms such as low body temperature, low heart rate, shivering and absences of sweating in adults and elder peoples. Hypothermia is caused majorly to the newborns as cold stress, SIDS. Hypothermia is initial stage for many chronic diseases such as Raynaud syndrome, and even for corona virus hypothermia is an initial stage. The main intention of this paper is to diagnose the hyperthermia and hypothermia at in advance which itself can cause mortal on later stages and being an ealier stage to many dangerous

diseases which cannot be treated. So by diagnosing hyperthermia and hypothermia at the earlier and aiding a therapy using Arduino nano microcontroller, DS18B20 temperature sensor, DHT 11 humidity and MAX30102 heart rate sensor for measuring the parameters to analysis the hyperthermia and hypothermia condition. The therapy will be aided by the data collected from the sensor is transmitted into the receiver placed in the the jacket for therapy purpose. In this paper, a detailed study of hyperthermia and hypothermia is discussed and the methodology, software implemented, about sensors and other hardware component are discussed in detail on the proposed prototype.

This paper is structured as follows. segment 2 describes previous related studies. segment 3 describes the system, the hardware, and the software architectures. segment 4 describes the methodology which contains experimental setup for determine the health condition of the climber in detail. segment 5 describes the evaluation of experimental results. Finally, concluding remarks and plans for our future work are provided in segment6.

II. LITERATURE SURVEY:

In this paper, we discussed in detail about the previous exertion associated to the project. The previous work related to the project depending upon the methodology and material implemented in the project. And depending upon the outcomes and results on the preceding work the proposed method is created by analysing the previous work has been produced. In this paper varies work had been done on the basis of detection of hyperthermia and

hypothermia condition on patients. The detection of hyperthermia is alone be diagnosed using the embedded system, they had used only LM35 temperature sensor for the detection of the body temperature and diagnosed the hyperthermia and detection of hyperthermia is indicated by using buzzer [1]. By analysing the symptoms of the climbers and hypothermia is being determined and treated with cooling effect using peltier module. Hence they had designed and implemented an jacket for the climbers. The jackets has been implemented for the determination of the body temperature and the heart rate is analysed and hypothermia is detected on various difference in heart rate such as bradycardia, tachycardia, etc.,. The peltier temperature is also been measured in the self heating jackets [2]. There are various reason to causes heat balanced diseases and those diseases are treated using heat balanced jacket using peltier module where an water tubes are connected and circulated through the jacket [3]. Many self heating and cooling jacket are implemented with various methodologies but those jacket are provided with only either heating or cooling process alone[2][10]. The diagnosis condition is send to the caretaker using Bluetooth transmitter and receiver, WIFI, using internet connections and data are transmitted through call or message using GSM[2][. There are various causes for hyperthermia and hypothermia and many methodologies has been implemented for analysis and therapeutic purposes, the proposed system will overcome all the draw mentioned in the previous work.

S.NO	TITLE	BENEFITS	APPLICATION
1	“An Advanced First Aid System Based on an Unmanned Aerial Vehicles and a Wireless Body Area Sensor Network for Elderly Persons in Outdoor Environments”.[9]	It is used to detect and monitor the elderly peoples from the risk of drained out or falling	It is used to detect the fall of the patient using Health Detection System
2	“Data Analytics of a Wearable Device for Heat Stroke Detection”[8]	It is used as the early detection of stroke to an athlete patient	It is used for the health monitoring heat stroke detection
3	“Wireless Body Area Network for Heart Attack Detection”[7]	Early detection of heat stroke and heart attack and abnormal electrocardiogram data will on the alarm sound through the smart phone	It is used for the early detection of heart attack
4	“IoMT Platform for Pervasive Healthcare Data Aggregation,	This system is used to monitor the health of the patient without the care	It is used monitor the

	Processing, and Sharing Based on OneM2M and OpenEHR”[6]	taker support	general patient monitoring system using temperature, oxygen saturation, heartbeat
5	“Battery based suit and location spotter”[26]	This is used for the measure the temperature of the patient and produce the heat/cool effect through Peltier	It is used in heating and cooling suit with the powered battery and also with location spotter
6	“Time to asses and change body temperature”[15]	It is used to monitor the body temperature with some basic aspects like thermoregulation and aging	It is used in clinical practice for the change of temperature and thermoregulation
7	“Adaptable jacket using ARM microcontroller”[27]	It activates the thermoelectric coolers when the temperature exceeds its normal rate and also activates the cooling fan	It is used in climatic condition with suitable jacket
8	“Refrigerator jacket using peltier”[14]	This is used to provide effect to the patient either heat or cool through the jacket	It is used in therapy for thermoregulation failure patients using jackets
9	“Design and fabrication of heat balance jacket”[3]	This system is used to regulate or monitor the patient body temperature and provide heat through the jacket	It is used to provide the heat effect through the jacket
10	“A diagnostic device for hyperthermia and hypothermia patients and aiding a therapy using wearable jackets”	This project is used in early diagnosis of hyperthermia and hypothermia in the early stages and aid a initial therapy through self heating and cooling technique.	It is used to detect hyperthermia and hypothermia patients anf provide heat or cool effect depending upon the condition using peltier placed jacket.

Table 1: comparison of proposed system with previous works

PROPOSED SYSTEM:

In this paper, the main objective of the proposed system is to overcome the drawbacks from the previous work based on this project. The proposed system consists of two parts namely diagnostic and the therapeutic part. In the diagnostic part, it detects the hyperthermia and hypothermia by analysing the measured parameter using sensors and display the output. It also sends an alert message to the care taker depending upon

the body temperature. As aiding an therapy for the patients the passive rewarming and passive cooling technique is being implemented automatically using Arduino microcontroller by self heating and cooling jackets. Depending upon the measured parameters using sensor the data are transmitted to the therapy part which holds with an receiver into it.

SYSTEM ARCHITECTURE:

The materials and methods are separated into two parts covering the hardware part and the software part. In the hardware part is further split up into two parts and the first part is utilised for sensing, sending alert message and data transmission and the second part is used for processing the concept using peltier effect. And the software part is used for activation of sensor and merging the hardware part wirelessly as a firmware.

The methods employed for data collection, analysis of the data and processing the output.

DS18B20 TEMPERATURE SENSOR:



Fig 1: DS18B20 Temperature Sensor

TEMPERATURE SENSOR - DS18B20

Temperature sensor DS18B20 was used to determine the temperature of the person for analysis the hyperthermia and hypothermia condition. It allowed the individual see the measured temperature in the LCD display and also measured temperature data is transmitted towards the receiver in the jacket. The DS18B20 sensor is a digital temperature sensor so as to uses the one-wire communication technique. This sensor uses a voltage of 3V to 5V, and it can measure the temperature from -55°C to 125°C with an accuracy of about 0.5°C. The main advantage DS18B20 temperature sensor is time conservation and it is a waterproof sensor, since it cannot be damaged by external water substances such as sweat.

MAX30102 PULSE SENSOR:



Fig 2: MAX30102 Pulse Rate Sensor

Pulse sensor is implemented in this project were it is an necessary parameter to measure in the determination of hyperthermia and hypothermia. The measurement of pulse rate is done using

MAX30102 pulse sensor. The MAX30102 pulse sensor is digital sensor which produce the output in a digital numerical data. It works on main basis of I2C communication. The process of producing output of the sensor is done by averaging of measured heart rate and output is being produced. MAX30102 pulse sensor is works on the basis of photodetectors, LEDs and filter for noise reduction in it, where MAX30102 pulse sensor is widely used in many wearable technologies an application such as electrical wrist band, watches and mobile phones. It is well known for its practical application.

DHT11 HUMIDITY SENSOR:



Fig 3: DHT 11 Humidity Sensor

DHT11 humidity sensor was used to measure the relative humidity of the environment for the hyperthermia and hypothermia patients. One of the main causes for hypothermia and hyperthermia is relative humidity on the environment, since it is very necessary to measure the humidity on the environment. DHT11 humidity can measure both temperature and humidity, but in our project we utilized only measuring of humidity in it. DHT11 is more cost efficient and it is well known for its long term stability. It has high accuracy of $\pm 2\%RH$ and it produce the fast response than other humidity sensor.

ARDUINO NANO:

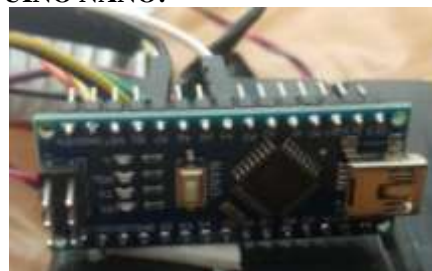


Fig 4: Arduino NANO

Arduino is a single-board microcontroller that is open source created to make the usage of electronics in a variety of industries easier. The ATmega 328 microcontroller with AVR is used in the Arduino Nano architecture. It runs on 5 volts and draws 19 milliamps.usage of energy It has a 32KB flash memory and a 2GB hard drive. SRAM

with a 16MHz clock speed. There are 22 digital pins on the Arduino. Six of the I/O pins are PWM pins. Each I/O pin has current of 40mA. Arduino Nano size is 18 x 45mm with 7g weight.

GSM MODULE:



Fig 5:GSM modem

The mode of communication using GSM modem is an efficient way to send SMS/MMS even for low network areas. The main advantage of sending alert message to the care taker or to the affected individual regarding the hyperthermia and hypothermia condition, since they can be aiding a proper therapy before any serious issue. GSM was utilized in a large application such as computer based administration in corporate and government sectors. In this project we utilized SIM800L GSM modem for sending alert message. It requires an SIM card for sending SMS to the receiver and it is worked with 2G based SIM card only. It is also a drawback of this type of modem on GSM.

RF TRANSMITTER AND RECEIVER:

The RF module is a combination of RF transmitter and RF receiver and it is operated in the frequency of 433MHz. It is an easy and simplest way of communication of data on electronic gadgets. The transmission and receiveing of data from an point to point such as transmitter to the receiver alone and it cannot process from receiver to the transmitter. RF module can transmit data from minimum of 3 meter and maximum upto 100 meters by using antenna.

PELTIER MODULE:



Fig 6: Peltier Module

When contemplating the use of these peltier modules, it's important to assess the module's performance over the heat removal rate and heat addition rate. It is important to maintain the system, according to a manufacturer data sheet of a peltier module known as TE Technology, Inc. Temperature differential in relation to the amount of heat that must be removed in order to maintain the Peltier module's COP performance. Peltier heating and cooling using copper or aluminium heat sinks will, of course, be expensive to fabricate, but given that this method of cooling could eliminate some of the shortcomings of existing compressor-based cooling, it is still worth the investment. This project will conduct a complete study on the selection of peltier module and heat sinks by taking all of these factors into account. Because the goal is to heat and cool the prototype's design.

ALUMINIUM PLATE:



Fig 7: Aluminium Foil

An aluminium plate was used in this project for the spreading of heat or cool through the surface of the aluminium metal plate. The aluminium plate produce heat/ cool depending upon peltier output. The aluminium plate can put up with both heat and cool uniformly.

BATTERY:

Battery used in our project is Lead acid battery. Lead acid battery are used for high load application projects. In our project to process the GSM and Peltier module and all other sensor activaton. We used lead acid battery.

4 CHANNEL RELAY



Fig 8: Relay

The 4 Channel Relay Module is a handy board for regulating high voltage, high current loads such as motors, solenoid valves, lamps, and AC loads. It's made to work with microcontrollers like Arduino, PIC, and others. It also has an LED that reveals the state of the relay.

LED

LED was utilized in the project for the indication process on the jacket. It provides the status of the jacket whether heating or cooling process is takes place on the jacket. LED lights are used for indication because of its low power consumption, longer life time, compact in size and for easy switching.

LCD DISPLAY



Fig 9: LCD display

LCD display was used display the measured parameter such as temperature, relative humidity and heart rate. LCD display is works on the basis of I2C communication in this project. The 16*2 LCD display is being used.

ARDUINO IDE:

Arduino has its own software, Arduino Nightly, which is available for download open source, and the following are some of the reasons for its popularity are Downloadable for free from the developer's website, and simple to use, install, simple to use, and the ability to include libraries from other sources direct download of hex code into the flash memory of microcontrollers. There is no need for an external programmer because the microcontroller has its own memory or a burner, there are numerous references for analysis purposes.

IMPLEMENTATION:

BLOCK DIAGRAM:

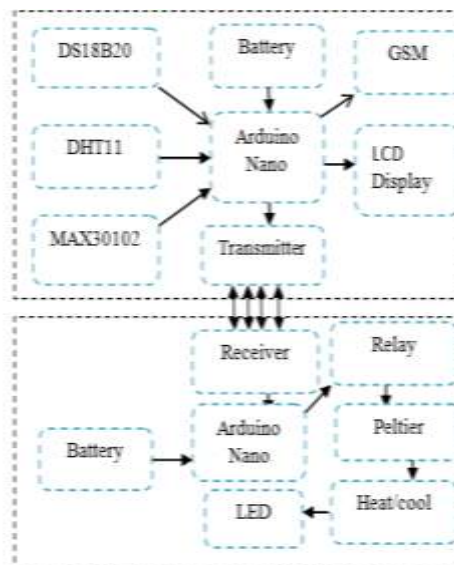


Fig 10: Block diagram

In this paper, the project is implemented the proposed system. By using the block diagram the hardware set up made. The hardware setup was of two parts namely the Diagnostic part and the therapy part. In the Diagnostic part the activation of sensor takes place. The sensor DS18B20 temperature sensor, DHT11 humidity sensor and MAX3012 pulse sensor are gets activated. The LCD display, GSM modem, RF transmitter are connected to the output port of the Arduino Nano microcontroller. The embedded system is the way of integrating hardware and software components that is employed here. The input signal is measured by an input sensor employing a DS18B20 temperature sensor, a DHT11 humidity sensor, and a MAX30102 pulse rate sensor. The determination of hyperthermia and hypothermia is implemented here. By analysing the measured parameter the hyperthermia and hypothermia is determined and the data are transmitted for aiding a therapy. The process of diagnoses is mentioned as a flow chart and the hardware setup in the following.

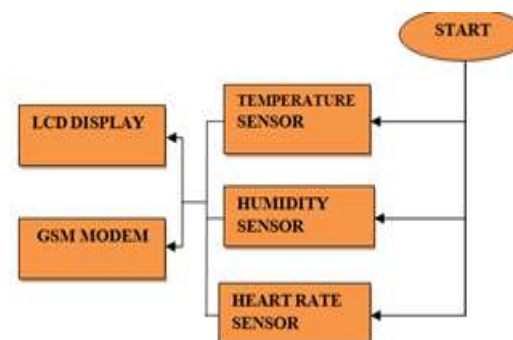


Fig 11: Flowchart of analytical device

As aiding a initial first aid therapy for affected individuals of hyperthermia and hypothermia is by

passive rewarming and cooling using peltier. The parameter analysed on the diagnostic part transmit the data to the therapy part which produces the heat or cool effect depending on the analysed condition on the determination part. The process of heating and cooling will be indicated using LED light

indication. The relay present in the therapeutically part plays an vital role in activation of peltier module. The activation of both heat and cool effect is done by interchanging the polarity it produce the inverse effect into it.

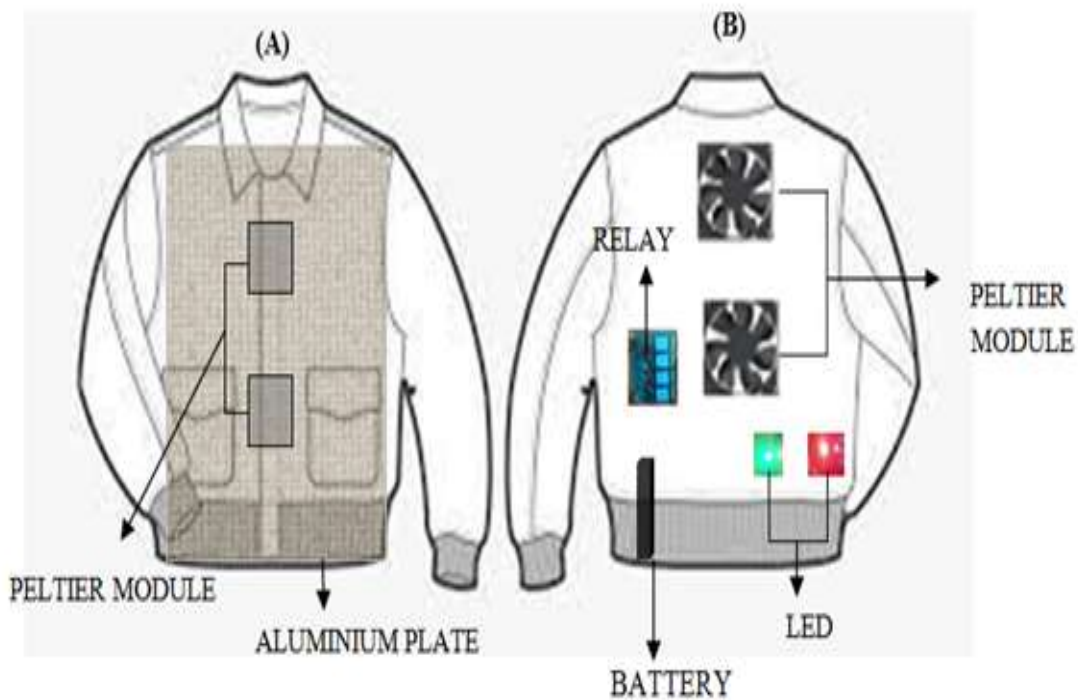


Fig 12: designed jacket for hyperthermia and hypothermia patients,a) front view of the jacket consist of aluminium plate over the peltier module which spread the heat/cool over the jacket, b)the connection setup behind the jacket of battery, peltier module, relay

OUTPUT:

A diagnostic device for hyperthermia and hypothermia patients and aiding a therapy using wearable jackets. In this paper the diagnoses of hyperthermia and hypothermia patients and aiding therapy to the affected individuals are discussed in detail. The temperature sensor DS18B20, the MAX30102 heart rate sensor, and the DHT11 humidity sensor are all linked to the Arduino NANO microcontroller's input ports. In the diagnostic component, an RF transmitter, GSM modem, and an LCD display make up the output part. The sensor that measures body temperature, heart rate, and humidity level is displayed in the LCD display as an output. An SMS is sent to the caregiver, and the signal is sent to the therapeutic Arduino NANO microcontroller.



Fig13: Hardware connection of diagnostic devices



Fig 14: LCD output of diagnostic part

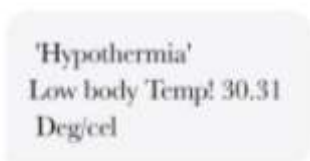


Fig 15: GSM alert message of hypothermic condition



Fig 16: GSM alert message of hyperthermic condition

From the diagnostic system the signal is passed through the receiver where the battery is on and the LED indication is done. The Peltier module fan is used to proceed heat/cool effect according to the indication given. Relay is controlled by a controller where the heat/cool effect is given to the patients. Through the signal from the transmitter to the receiver the heat or cool effect is given to the patient through the Peltier induced jacket



Fig 17: Hardware connection of therapeutic device



Fig 18: LED indication on hyperthermia condition



Fig 19: LED indication on hypothermia condition

III. RESULT AND DISUSSION:

If there are any temperature anomalies, the GSM module will send a notification. If there are any irregularities in the patient's temperature, the LED will flash, and the GSM will receive an alarm message. The message is sent to the therapeutic devices via these GSM modules. The diagnostic device's transmitter sends a code to the GSM module, which alerts the patient. The signal is received by the therapeutic device's receiver and passed to the Peltier, where it is connected to the relay, which controls the temperature change.

EXPERIMENTAL RUNS	TEMPERATURE
1	29.5
2	31.3
3	31.7
4	32.4
5	32.80
6	33.13
7	33.48
8	33.9
9	34.02
10	34.52

Table 2: Experimental result of measured parameter using DS18B20 temperature sensor

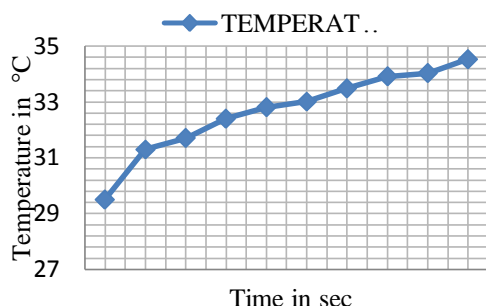


Fig 20 : Measured body temperature in graphical form

In the graphical depiction, the measured temperature is shown. When measuring temperature in a real-world situation, the individual's initial condition is determined by the ambient temperature, which is subsequently followed by the human body temperature. With the little difference in temperature, the temperature gradually climbed and remained steady. The hyperthermic and hypothermic conditions are diagnosed and output is obtained based on the temperature. The diagnosis rules are used to ensure that the condition is true, the result is displayed, and the SMS is delivered using the GSM module..

RULES FOR DIAGNOSING THE CONDITIONS

Condition	Temperature range	Heart beat
Hyperthermia	> 34° C	High
Hypothermia	<28°C	High
Normal condition	28°- 34°C	Low

Table 3: rules for diagnosing

The parameters measured in the diagnostic stage of the project, such as body temperature, humidity, and heart beats per minute, are listed below in the form of a graph in Fig 18. These parameters are measured with sensors and displayed on the LCD display before being sent to the therapeutic section of the project, which analyses the situation and generates the output. The experimental results are obtained by measuring the parameters for the individual and acquiring data. And the LED indication is dependent on the measured temperature of the experimental setup, and the LED is lighted till it reaches the normal condition of thermoregulation, depending on the condition being diagnosed.

Condition	LED indication	Operations
Hyperthermia	Green LED glow	Cooling
Hypothermia	Red LED glow	Heating
Normal	No LED glow	No operation

Table 4: Condition of LED indication

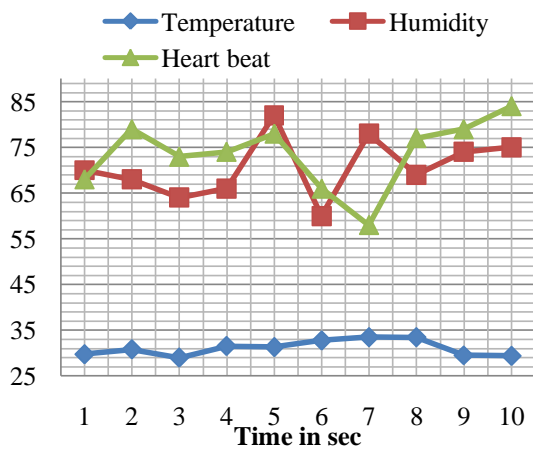


Fig 21: Graphical output of the measured parameters

IV. CONCLUSION:

This research based on the structural design and implemented of the proposed prototype to detect hypothermia and hyperthermia has been successfully completed and outputs are obtained by conducting various experimental runs. This project was very useful for many hospitalized application and for the common people who are suffering from hyperthermia and hypothermia. This project will be very much useful for the mountain climbers, swimmers, people at colder region and being in water for a long can be easily affected by hypothermia since these patients can be diagnosed the hypothermia condition and providing proper initial treatment using self heating and cooling jacket. In case of hyperthermia patients patient exposure to high temperature are affected and can be treated with self cooling jacket depending upon the body temperature. By using this proposed prototype the lateral stages of hyperthermia and hypothermia can be avoided and can reduce death rate caused by hyperthermia and hypothermia.

REFERENCES:

- [1]. Abhinaya.M, Silambarasan.A, Sowmiya A.P, "wearable hyperthermic device", International Journal of Advance Research and Development, vol 2, pp.49-53,2017.
- [2]. M. Udin Harun Al Rasyid, Sritrusta Sukaridhoto, Amang Sudarsono, and Afdolash Nur Kaffah "Design and Implementation of Hypothermia Symptoms Early Detection with Smart Jacket based on Wireless Body Area Network", IEEE Access, august 2020, vol. 7, pp. 29355 – 29364,
- [3]. Rohit.Nandan, Akhlakh. Ahmad, Shivam. Dixit, Sarvesh Kumar. Vishwakarma, "Design and fabrication of body heat balance jacket", International Journal of Advanced Research, Ideas and Innovations in Technology, vol 5, pp. 167- 169, 2019.
- [4]. V. Cojocaru, D. Vrabii, "Simulations of the effect of the cooling elements' temperature on the hypothermia efficiency," in Proc. EHB, Sinaia, Romania, 2017, pp. 13-16.
- [5]. Flora Salim, Daniel Prohasky, Aaron Belbasis, Shadi Houshyar, "Design and evaluation of smart wearable undergarment for monitoring physiological extremes in firefighting", 13 Sep 2014.
- [6]. J.N.S. Rubi, P.R.L. Gondim, "IoMT Platform for Pervasive Healthcare Data Aggregation, Processing, and Sharing Based on OneM2M and OpenEHR," Sensors, vol. 19, no. 4283, pp. 1-25, Oct.2019.
- [7]. G. Wolgast, C. Ehrenborg, A. Israelsson, J. Helander, E. Johansson, H. Manefjord, "Wireless Body Area Network for Heart Attack Detection," IEEE Antennas and Propagation Magazine, vol. 58, pp.84-92, Oct. 2016.
- [8]. S.-S. Lin, C.-W. Lan, H.-Y. Hsu, S.-T. Chen, "Data Analytics of a Wearable Device for Heat Stroke Detection," Sensors, vol. 18, no.4347, pp. 1-14, Dec. 2018.
- [9]. S.S. Fakhruddin, S.K. Gharghan, A. Al-Naji, J. Chahl, "An Advanced First Aid System Based on an Unmanned Aerial Vehicles and a Wireless Body Area Sensor Network for Elderly Persons in Outdoor Environments," Sensors, vol. 19, no. 2955, pp. 1-28, July 2019.
- [10]. Srinivasan Vijayakumar, Preethika Immaculate Britto, "Heating-Gloves and Socks for The Treatment of Surgical Hypothermia in Theatre Conditions", International Journal of Engineering Research & Technology, Vol.3, pp.:1-3,2016.
- [11]. E. Baba, A. Jilbab, A. Hammouch," A health remote monitoring application based on wireless body area networks," in Proc. ISCV, Fez, Morocco, April 2018.
- [12]. Gayathri S, Rajkumar N,Vinothkumar. V. , "Human Health Monitoring System Using Wearable Sensors", International Research Journal of Engineering and Technologies, Vol 2, pp.: 122-126,2015.
- [13]. Nivetha.S, Vinitha.J ,Praveena.M, Bhuvaneshavri.B,M.E"E-Military jocket with climate adjustable suit".Internatinal Journal of Advance Research in Science and

- Engineering, vol.No.9,Issue no.3,March 2020,pp:68-72
- [14]. Lavanya. G, Venkanteswarlu. S, Nagaraju. A, Prasanthi. G, “Cooling and Heating of Refrigerator Jacket”, *Insight of Mechanical Engineering*, vol 1, pp.26-31, 2016.
- [15]. Sund-Levander M, Grodzinsky E, “Time for a change to assess and evaluate body temperature in clinical practice”, *International Journal of Nursing Practice* vol 15, pp. 241-249, 2009.
- [16]. Mark. J.Buller, Willian J. Tario, Reed W.Hoyt, Odest C.J, “Estimation of human internal temperature from wearable physiological sensors”, Dept of computer science brown uni.
- [17]. Naveen M, Ajith D M, Manoj N, Lakshmikanth D, “Weather Sensible Smart Adaptable Jacket”, *International Research Journal of Engineering and Technologies*, vol 7, pp.517-521,2020.
- [18]. Gregory Paul and Edward Gim, David “Battery Powered heating and cooling jacket”*IEEE Long Island System,application and technology coference(LISAT),2014.*
- [19]. Goldsmith, H.J, “Timeliness in the development of thermoelectric cooling” *IEEE Xplore,N.P.18Aug.1998.Web.13 Dec.2013.*
- [20]. Carolyn I Proulx, Michel B Ducharme, Glen P kenny “Effect of water temperature on cooling efficiency during hyperthermia in humans”*Journal of Applied Physiology* 94(4), 1317-1323, 2003
- [21]. Brendon P McDermott. Douglas J Casa, Matthew S Gaino “Acute whole-body cooling for exercise-induced hyperthermia: a systematic review”*Journal of athletic training* 44(1), 84-93, 2009.
- [22]. Lawrence E Armstrong, Arthur E Crago, Richard Adams “Whole-body cooling of hyperthermic runners:comparsion of two field therapies” *The American journal of emergency medicine* 15(4), 355-358, 1996.
- [23]. JW Hand , Gail ter haar “Heating techniques in hyperthermia” *The British journal of radiology* 54(642),443-466,1981.
- [24]. Anthony S Leict, Wade H sinclair, Mark J Patterson “ Influence of postexercise cooling techniques on heart rate variability in men” *Experimental physiology* 94(6), 695-703,2009.
- [25]. Margarethus M Paul Staffer, Esra Neufed Paolo F Maccarini “Simulation techniques in hyperthermia treatment planning” *International journal of hyperthermia* 29(4),346-357,2013.
- [26]. Vinod Kumar .C, “Battery Powered Heating and Cooling Suit With location spotter”, *International Magazine of Engineering, Technology, Management and Research*, vol 2, pp.226-230, February 2015.
- [27]. Annapurna. S and Ramesh Kumar. P, “Adaptable Jacket Based on Climatic conditions Using ARM microcontroller”, *International Journal of Engineering and Technologies*, vol 2, pp.125-129, sep-oct 2016.