Heat Index Based Medical Alert System for Geriatrics

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Abstract— **Human body has a natural tendency to adjust itself to the internal temperature of the body irrespective of the changes in the external condition in order to maintain good health.But this is not the case with elder citizens. They are more prone to heat stress. Most of them have continual medical condition that changes normal body responses to heat. The intake of prescription medicines also impair the body's ability to adjust to its normal temperature. Hence Geriatrics, receiving special health care need assistive tools for knowing temperature and humidity outside the house before stepping out. These tools also help in taking precautions for healthy living. Heat index is one such parameter which gives a measure of how hot it really feels when relative humidity is factored with the actual air temperature and hence can be used to alert the geriatrics or their custodians to minimize the risk of exposure to heat stress.**

This work presents the design of heat index based medical alert system using Arduino, Temperature and humidity sensor. An android app is developed to display the temperature and humidity values sensed by the sensor periodically and alerts the needy based on the heat index measured. This android app is also helpful for visually impaired by reading out loud the sensor values and giving caution.

Keyword-Geriatrics;Heat Index; Arduino; DHT11; Android; MIT App Inventor

I. INTRODUCTION

Human beings are mammals called Homotherms [1] and they try to regulate their body temperature close to about 98.4°F. If it deviates for more than a few degrees from 98.4°F then it could create serious consequences and threat to life. The temperature of the human body generally is influenced by the temperature of fluids, solids or the surroundings which includes the atmospheric air.

In the light of the evidence of adaptation to normal temperatures it is seen that a higher number of deaths occur at unusually extreme temperatures. A long-term exposure shows higher mortality during summer or winter time temperature variability which increases with climate change.

An investigation by Zanobetti et al [2] shows that a long-term increase in summer temperature variability may increase the risk of mortality in different subgroups of susceptible older populations [3]. Various studies of short-term mortality displacement reveal that a higher number of deaths are associated with heat and heat waves. There are merely deaths advanced by a few weeks [4] [5], although heat may reduce life expectancy in a more substantial way, for example, among children in Delhi, India [4]. However, these studies indicate that the variability of summer time temperature is the major factor among cities revealing the effects of very hot days [5], [6].

The centres for disease control and prevention provide a list of warning signs and symptoms of heat illness [11].Some of these symptoms are listed below.

1. Heat Cramps with symptoms, painful muscle cramps and spasms usually in legs and abdomen and heavy sweating is the first sign of heat related illness, and may lead to heat exhaustion or stroke.

2.   Heat exhaustion with some symptoms is heavy sweating, weakness; cool, pale, clammy skin; fast, weak pulse; possible muscle cramps, dizziness, nausea, vomiting or fainting.

3.   Heat stroke symptoms are altered mental state, throbbing headache, confusion, nausea, dizziness, shallow breathing, body temperature above 103°F; hot, red, dry or moist skin; rapid and strong pulse; faints or lose consciousness.

To minimize these symptoms of heat illness and to take necessary precautions, we recommend a method of alerting the Geriatrics based on heat index calculated. This automatic alerting system is designed on Arduino platform.

Arduino is an open-source electronics platform. It is an easy-to- use hardware and software. Arduino is intended for making any interactive projects. It senses by receiving inputs from many sensors, and affects its

surroundings by controlling lights, motors etc. Arduino performs the operations specified in the form of code in a loop until its power supply is switched off.

II. DESIGN BLOCK STRUCTURE AND SCHEMATIC

The complete design process is presented in Fig.1 in the form of a block structure. The functioning starts with the Digital Humidity and Temperature sensor (DHT) giving the values of ambient temperature (℉) and relative humidity (%) once powered from Arduino. From the measured parameters heat index is calculated. These values along with the alert are transmitted using Bluetooth wirelessly and are viewed in the android application designed using MIT App Inventor. Additional feature provided in the app is that the sensed values can be read out loud so that this electronic aid will be helpful for visually impaired.

This designed device is placed outside the house and the received values refer to the conditions outside. Based on the alert received, the user takes necessary precautions. The Schematic design is displayed in Fig. 2.
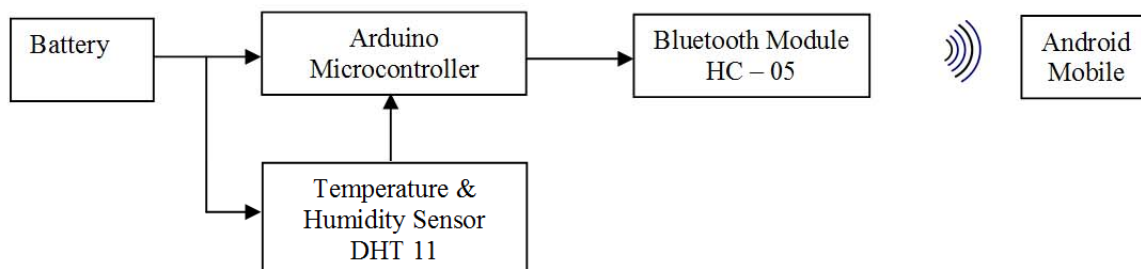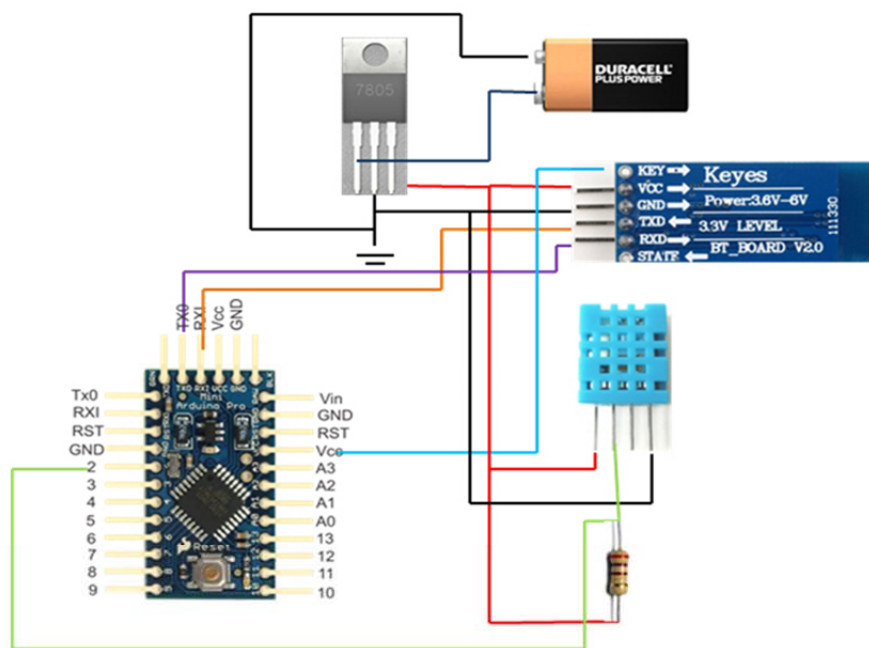

Fig.1.Block Structure Design

Fig.2. Schematic Diagram

III. LIST OF COMPONENTS USED

A. Arduino Pro Mini

The Arduino Pro Mini shown in Fig.3 is an ATmega328 based microcontroller board with a built-in Arduino boot loader. It consists of 14 digital input/output pins among which 6pins are PWM outputs, 8 analog inputs, an on-board resonator, a reset button, and holes for mounting the pin headers. The board can run on USB power when connected to PC using the USB port. Pro Mini has two versions, one runs at 3.3V, 8MHz and the other at 5V, 16MHz.

Fig. 3. Arduino Pro Mini board and its pin structure[12]

B. Bluetooth Module(HC05)

HC-05 Bluetooth Module is an easy to use Bluetooth SPP (Serial Port Protocol) module presented in Fig.4. It works on DC 5V and is designed for transparent wireless serial connection setup. Its serial communication is an easy way to interface with controller or PC. A switching between master & slave modes is provided by Bluetooth module.
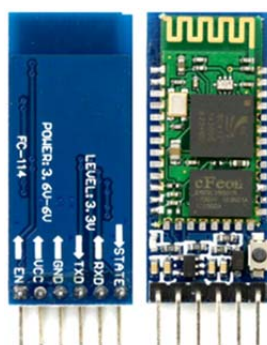

Fig. 4. HC-05 Bluetooth Module[16]

TABLE I

Pin Description – HC 05

Pin	Description	Function
VCC	+5V	Connect to +5V
GND	Ground	Connect to Ground
TXD	UART_TXD, Bluetooth serial sending PIN	Connect with the MCU's (Microcontroller and etc)
RXD	UART_RXD, Bluetooth serial sending receiving PIN	Connect with the MCU's (Microcontroller and etc) TXD PIN.
KEY	Mode switch input	If it is input low level or connect to the air, the module is at paired or communication mode. If it's input high level, the module will enter to AT mode .

C. DHT11

DHT11 is a temperature & humidity sensor which gives a calibrated digital signal output. Excellent long term stability & high reliability are achieved by using the digital signal acquisition technique & temperature-humidity sensing technology. This sensor includes a resistive-type humidity measurement component based on negative temperature coefficient (NTC). It offers excellent quality & fast response and can be connected to a high performance 8-bit microcontroller. DHT11 offers anti interference ability which is cost effective. Basic specifications of DHT11 are shown in Table II.

Accurate humidity calibration is done for DHT11. One time programmable (OTP) memory is available for storing calibration coefficients. Its pin structure is shown in Fig. 5. It is the best choice for various applications due to its small size and low power consumption. It can be used by the most demanding and challenging applications also. DHT11 is 4-pin single row pin package.
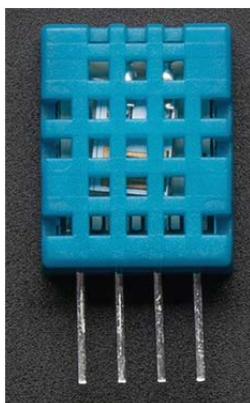
Pin 1: Vcc   Pin 2: Data   Pin 3: NC   Pin 4: GND (from left to right)

Fig. 5.DHT11 Sensor and pin nomenclature[15]

TABLE II

Basic Specifications of DHT 11

Temperature Range	0° to 50° C
Relative Humidity	20 to 90%
Temperature Accuracy	$\pm\, 2^o$C
Relative Humidity Accuracy	$\pm\, 5\%$

D. Breakout Module

FTDI (Future Technology Devices International) FT232RL is a basic breakout board for USB to serial conversion. This board with the FTDI cable can be used to work with official Arduino and any cloned 3.3V Arduino boards. It can also be used for any general serial applications. When a new sketch is downloaded using Arduino IDE, Auto reset of Arduino target is allowed by DTR pin.

USB protocol stack is implemented by FTDI chips. Using this protocol, computer can load the right driver for this hardware. Managing Data transactions with PC is also done very easily. This breakout module displayed in Fig. 6 is used to transfer the program onto the memory of Arduino board.
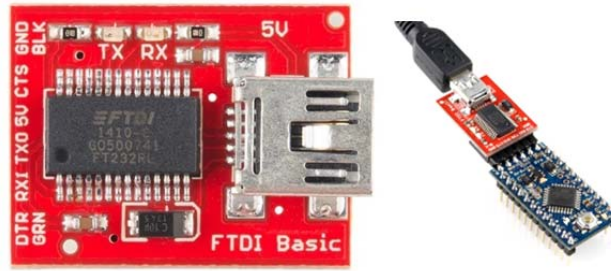
Fig. 6. Breakout Module[13] and Connection with Arduino Pro mini for code dumping[14]

IV. PARAMETERS SENSED AND CALCULATED

A. Temperature

The quantity which determines the direction of the flow of heat between the two bodies kept in contact is called temperature. It is also measured as the degree of hotness or coldness of a body or environment. It is a measure of the average kinetic energy of the particles in a sample of matter, expressed in terms of units or degrees designated on a standard scale. The degree of heat in the body of a human being is usually about 37.0°C (98.6°F).

B. Relative Humidity

Relative humidity (RH) is the ratio of the actual partial vapour pressure of water to the saturation vapour pressure at that temperature. The saturation vapour pressure of water increases rapidly with temperature, from 610 Pascal at zero degrees to 2800 Pa at 23oC. At 100oC the vapour pressure reaches 101,000 Pa, which is about atmospheric pressure.

C. Heat Index

Heat index also known as the apparent temperature, is what the temperature feels like to the human body when relative humidity is combined with the air temperature [7]. There is direct relationship between the air temperature and relative humidity and the heat index. As the air temperature and relative humidity increases/decreases, the heat index increases / decreases.

HEAT INDEX
Temperature(°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130
46	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137	
55	81	84	86	89	93	97	101	106	112	117	124	130	137		
60	82	84	88	91	95	100	105	110	116	123	129	137			
65	82	85	89	93	98	103	108	114	121	128	136				
70	83	86	90	95	100	105	112	119	126	134					
75	84	88	92	97	103	109	116	124	132						
80	84	89	94	100	106	113	121	129							
86	85	90	96	102	110	117	126	135							
90	86	91	98	105	113	122	131								
95	86	93	100	108	117	127									
100	87	95	103	112	121	132									

◻ Caution   ◻ Extreme Caution   ◻ Danger   ◻ Extreme Danger

Courtesy: NOAA's Weather Chart [8]
Fig. 7.Heat Index Chart - Likelihood of Heat disorders with prolonged exposure or strenuous activity

To determine the heat index using the chart given by National Oceanic and Atmospheric Administration (NOAA) shown in Fig. 7, we need to know the air temperature and relative humidity.

TABLE III
Heat Index [7]

Classification	Heat Index	Effect on the body
Caution	80° F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme caution	90°F -103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F -124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

Heat Index is calculated from the measured parameters Temperature (^{o}F) and Relative Humidity (%) [9].

$$Heat\ Index = -42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783 \times 10^{-3}T^2$$
$$- 5.481717 \times 10^{-2}R^2 + 1.22874 \times 10^{-3}T^2R + 8.5282 \times 10^{-4}TR^2 - 1.99 \times 10^{-6}T^2R^2$$

where R is Relative humidity (%) and T is Air Temperature(^{o}F)

If geriatrics are exposed to direct sunlight, the heat index [10] value can be increased upto 15°F. As shown in Table III. Heat indices meeting or exceeding 103°F can lead to dangerous heat disorders with prolonged exposure and/or physical activity in the heat.

V. COMMUNICATION PROCESS

Synchronization and communication between DHT11 sensor and Micro Computer Unit (MCU) is done using a single-bus data format 4ms is the time elapsed for and one communication process. Data consists of decimal and integral parts. 40-bit data is transmitted and the higher data bit is sent first by the sensor.

A. Overall Communication Process

DHT11 stays in low power consumption mode by default. When there is no signal from Arduino (MCU) sends a start signal and completes sending it. Then DHT11 sends 40-bit data as response signal which include temperature & relative humidity information to MCU. DHT11 gives the response only when the MCU sends the start signal. DHT11 again shifts into low power consumption mode until MCU sends start signal again. This process is shown in the form of a timing diagram in Fig.8.
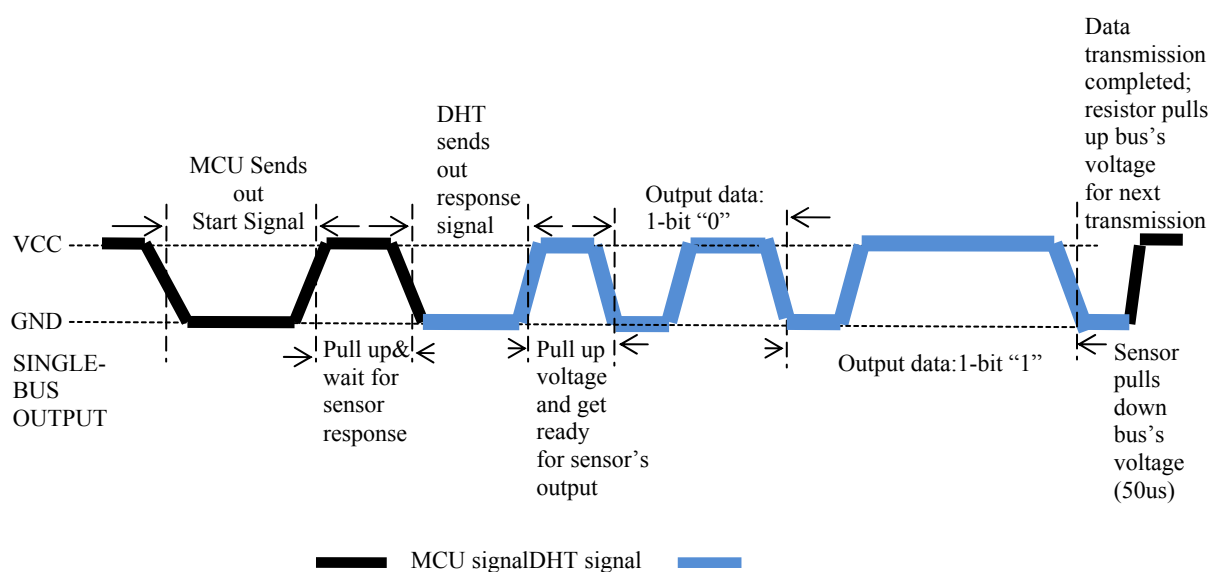
Fig. 8. Overall Communication Process

B. MCU sends out Start signal to DHT

The data single-bus free status is at high voltage level as shown in the timing diagram in Fig.9. The program of MCU will set Data Single-bus voltage level from high to low when the communication between MCU and DHT11 begins. It takes at least 18ms for DHT11 to detect MCU's signal. Then MCU will pull up voltage and wait 20-40µs for DHT's response.
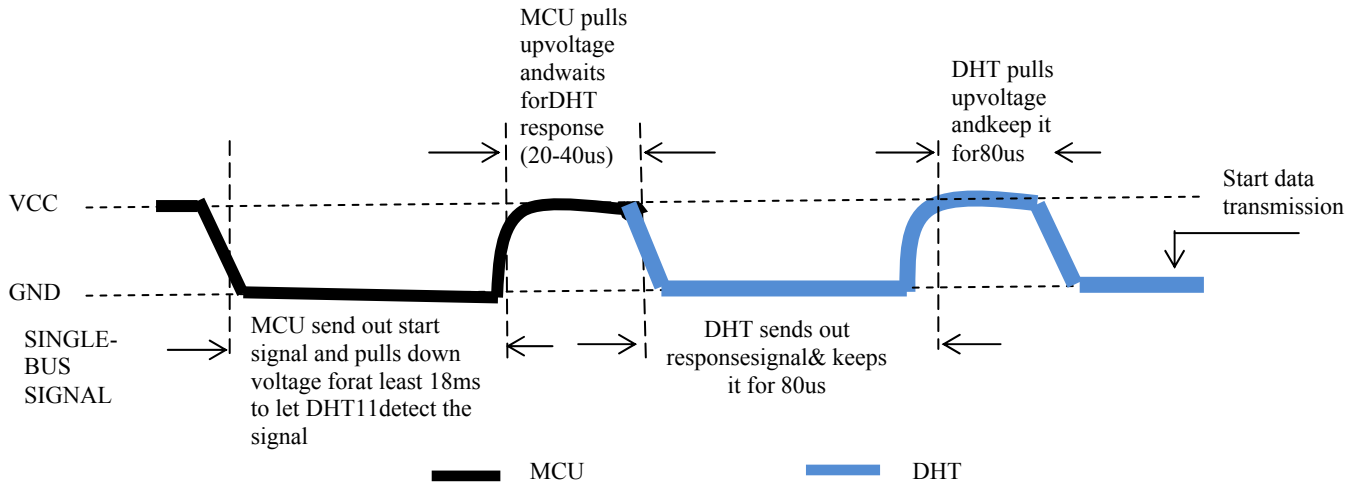
Fig. 9.MCU sends out start signal and DHT responses

C. DHT Responses to MCU

The DHT detects the start signal from MCU and sends out a low voltage level response signal which lasts for 80µs. For sending data the program of DHT sets data signal-bus from low to high voltage level which is kept for 80µs. During this time DHT prepares for sending data. Data '0' and '1' indication is shown in Fig.10 & Fig.11.
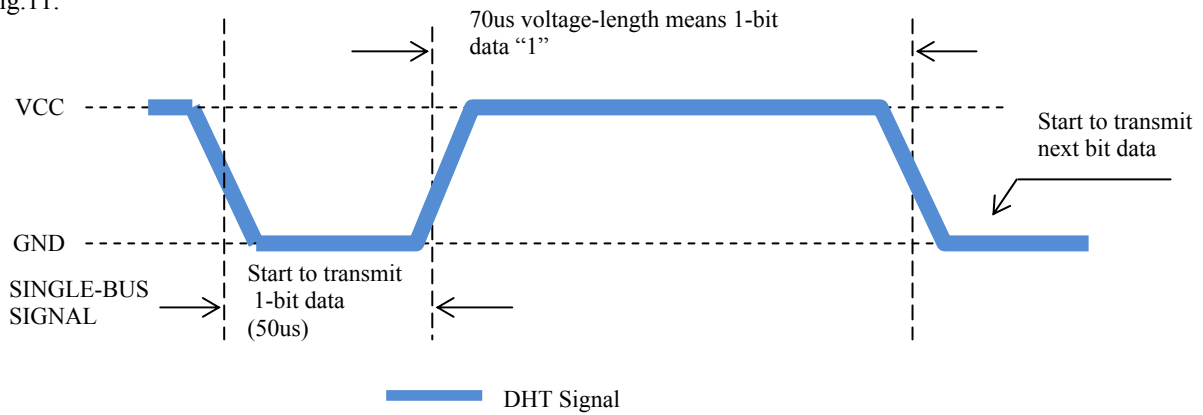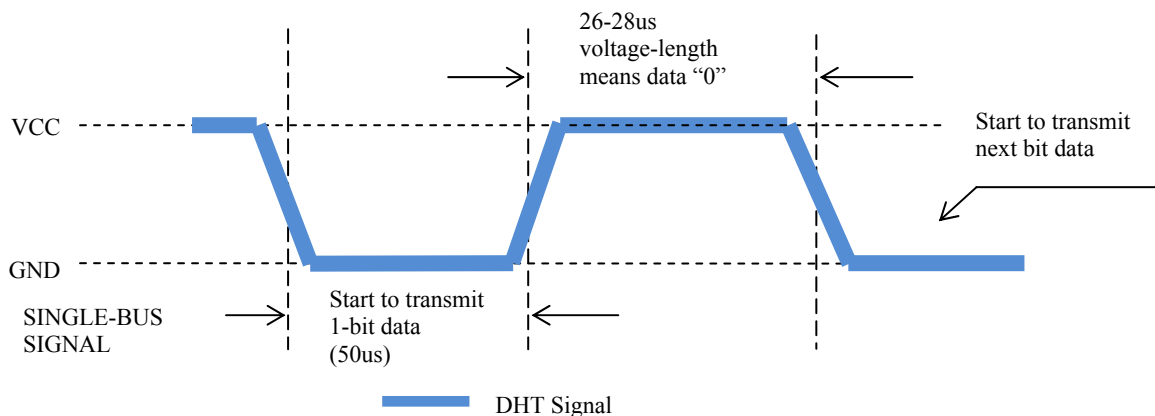

Fig. 10.Data '0'indication

Fig. 11.Data '1' indication

The temperature and humidity sensor, DHT11 values i.e., temperature and humidity, are communicated to the android mobile through Bluetooth into an Android application developed using MIT App Inventor.

VI. RESULTS

First the results are observed in Arduino IDE Serial Monitor in Fig.12. Then results are communicated serially using Bluetooth (HC-05) and observed in Bluetooth Terminal application shown in Fig.13, which is installed from Google play store before designing the android app in MIT APP INVENTOR.
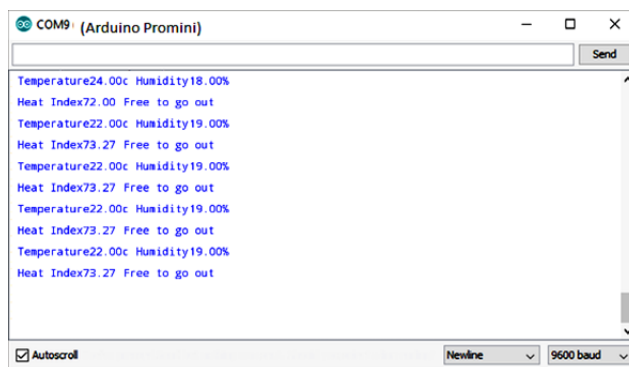

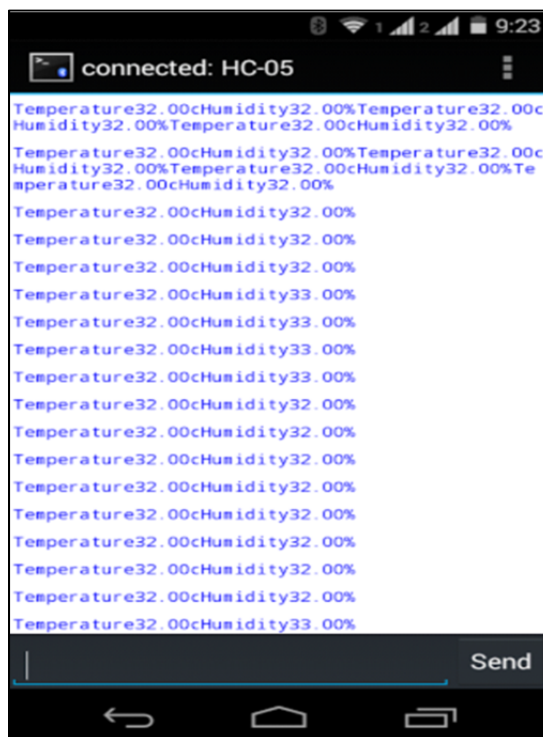Fig.12. Sensed Data display in Arduino IDE Serial Monitor

Fig.13. Sensed Data Display in Bluetooth Terminal APP in Android Mobile

VII. DESIGNING ANDROID APPLICATION – MIT APP INVENTOR

MIT App Inventor is an innovative beginner's introduction to programming and app creation that transforms the complex language of text-based coding into visual, drag-and-drop building blocks. The simple graphical interface grants even an inexperienced novice the ability to create a basic, fully functional app within an hour or less. App Inventor runs as a web service administered by staff at MIT's Center for Mobile Learning - a collaboration of MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) and the MIT Media Lab.

The Android App is designed using MIT App Inventor by linking different blocks. The design procedure is explained as under Fig.14
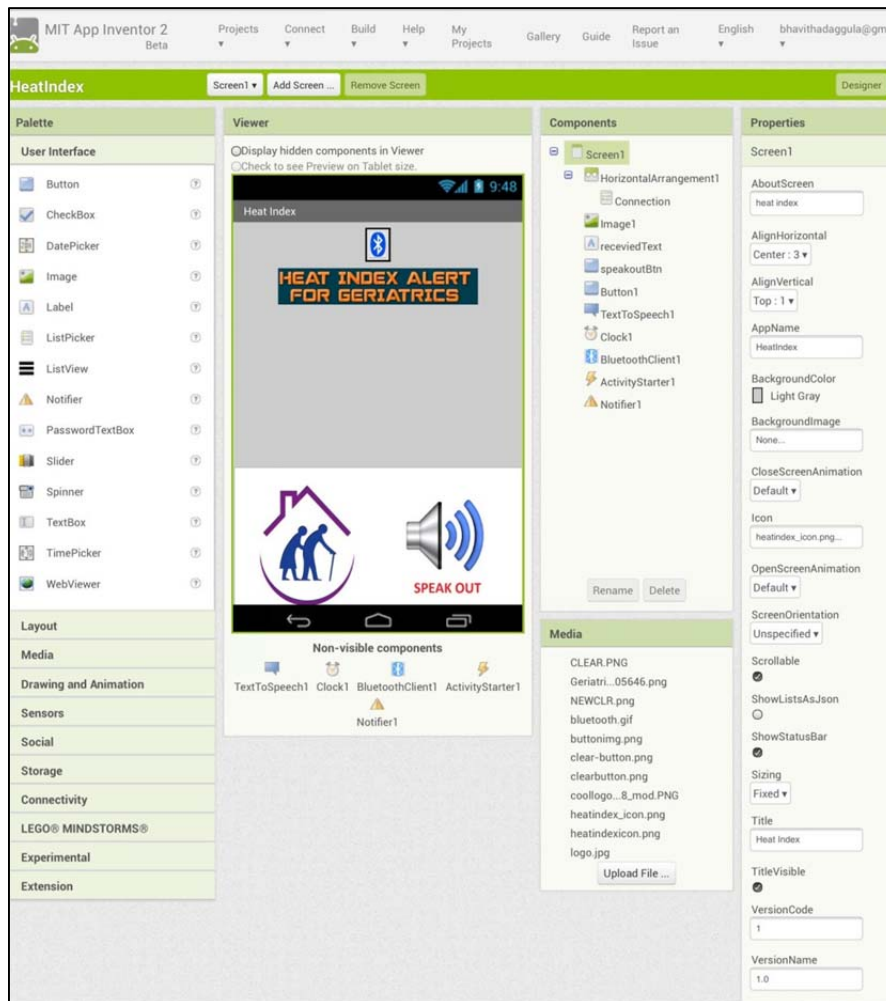

Fig.14. Screenshot of MIT APP INVENTOR

Fig.15 refers to initialization of screen1(App Screen) and connection status of BluetoothClient1.
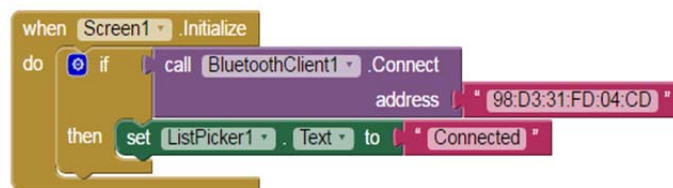

Fig.15. Bluetooth Connection

Using the block shown in Fig 16, Bluetooth client is selected based on the MAC addresses listed.
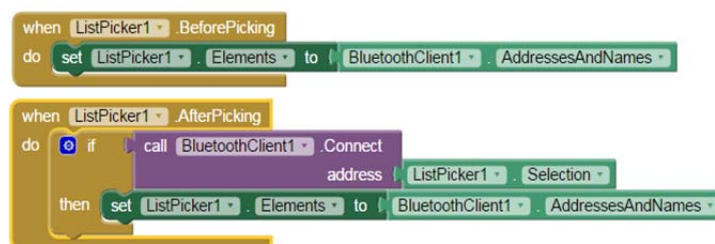

Fig.16 Elements List Picking

The block referred in Fig17, is used to create global variables. It takes any type of value as an argument. Global variables are used in all procedures or events so this block stands alone.

Fig.17 Global Initialization

Retrieving the variable values into the app for a period is referred by the block in Fig 18.

Fig.18. Clock Timer

The block referred in Fig 19, shows the button used for reading out the displayed values in the label. An option is provided to read out the values by clicking a button.

Fig.19. Speak out buttons

Button 1 is used to clear the data, So that the new data is received & displayed in the label. The block structure for this operation is shown in Fig 20.

Fig.20 Clear Button

VIII. FINAL ANDROID APPLICATION SCREEN

The screenshot of the Application in android mobile phone developed using MIT APP INVENTOR is shown in Fig.22 and Fig.21 shows the application icon.
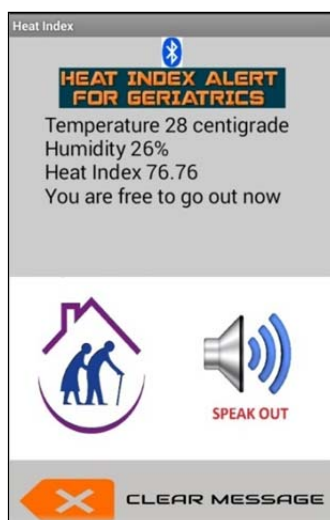

Fig.21. Application icon

Fig.22 Final Android APP output screen

The final design of the device Heat Index Medical Alert System for Geriatrics is shown in the Fig.23.

Fig.23. Heat Index Alert Device

IX. CONCLUSION

The proposed Android based medical alert system is placed outside the house and tested under different atmospheric conditions and is observed very useful not only for geriatrics but also for the patients under medication. But in colder countries during winter, geriatrics experience the problems like increase in systolic blood pressure, respiratory diseases including flu, etc.

In order to make this device suitable for colder countries there is a need for replacing DHT11 sensor. As the measurable range of DHT11 sensor is limited to 0oC to 50oC which is not suitable for colder countries, it can be replaced with DHT22 whose range of temperature measurement is -40oC to 80oC and increased range of relative humidity with 0 to 100%. DHT22 is also advantageous than DHT11 with accuracy in temperature of +0.5oC and relative humidity of +2%.

Along with DHT22 this project can be extended by including different sensors using which we can provide the access for healthy living.

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[13]   Sparkfun Electronics (US) : https://www.sparkfun.com/products/9716
[14]   Sparkfun Electronics (US) : https://learn.sparkfun.com/tutorials/using-the-arduino-pro-mini-33v
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