Role of the Accurate Detection of Core Body Temperature in the Early Detection of Coronavirus

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Abstract  Recently, the COVID-19 virus appeared and threatened people’s lives over the entire world. The danger of this virus is its rapid spread and there are no specific vaccines or treatments for COVID-19 at this time. One of the most important symptoms of the COVID-19 virus is the high temperature. Therefore, we must quickly discover people whose temperature has risen. So, the local manufacturing of medical non-contact thermometer is challenging requirement in this time. In this paper we outlined several core body temperature estimation techniques which is used in the manufacturing of the non-contact medical thermometers.

Keywords  Coronavirus · Non-contact thermometer · Core body temperature · Forehead · Internet of things (IoT) · Fifth generation (5G) · Local manufacturing

1 Introduction

The sudden appearance of the Coronavirus caused global panic and occupied the minds of all researchers around the world. Egypt is at the forefront of the world’s countries that took all precautions and measures to face the Coronavirus crisis, and the Egyptian health system provided a model in dealing with the Coronavirus crisis professionally in accordance with the instructions of the World Health Organization (WHO). It also encourages researchers in all fields to confront the Coronavirus, many teams trying to produce respirators and others in the production of smart masks, or in the production of a non-contact thermometer.
Actually, there is a great need for the non-contact thermometer \[1, 2\] to early detect coronavirus by rapidly discovering the person who suffers from high temperature. It is used to remotely measure the core body temperature, it can measure the core body temperature within few seconds, few centimeters away from the body \[3\], records approximately 30 readings, and gives an alarm at 38 °C. The prices of this kind of thermometers are ranging from 100 to 200 dollars. IR thermometers have two types namely medical and industrial thermometer. Industrial thermometers \[4\] can be used as a medical thermometer \[5\], but it gives inaccurate readings \[6\]. Many companies in Egypt imported large quantities of thermometers with large amounts of money, and still, there is a need for more and more. So, we designed and manufactured non-contact IoT thermometer to help in the early detection of the coronavirus with reasonable cost.

Generally, the health care services are suffering from enormous challenges such as, high cost of the devices, the increase number of patients, a wide spread of chronic diseases, and a lack of healthcare management resources. The utilization of IoT & 5G in medical services \[7, 8\] will solve a lot of these problems by introducing the coming benefits:

Easy access to health care service by both of patients and doctors, smooth incorporation with several technologies, ensure the analysis and processing of massive data.

Effective utilization of healthcare resources, provide real time and remote monitoring established by the joint healthcare services, ensure real-time interaction between doctors and patients, and authorize health care services.

All of these benefits of the IoT & 5G services will improve the performance of healthcare applications by presenting different services to hospital, clinics and non-clinical patient environments.

1.1 Types of Thermometers

The non-contact thermometers are categorized into two types based on their purpose medical thermometers and industrial thermometers. Recently, medical thermometers manufacturing gained an enormous attention due to current events of appearance covid-19 virus.

Local manufacturing of Non-contact medical thermometer save money for the government and has a great role in tracking infected person with coronavirus as it gives an alarm when the person temperature is 38 °C or more. There are two kinds of medical IR thermometer: skin and ear. IR thermometry such as tympanic thermometry as shown in Fig. 1 can be used to measure the temperature rectally by placing the thermometer in the child’s bottom, orally by placing the thermometer in the mouth under the tongue, axillary by placing the thermometer in the armpit. IR skin thermometry as shown in Fig. 2 is used to estimate the temperature of a certain place on the skin (e.g., axilla, forehead).
Any IR thermometer should satisfy these specifications [11].

- **The Range of Displayed Temperature:** In any display mode, an ear canal IR thermometer should show a volunteer’s temperature over a minimum range of 34.4–42.2 °C (94.0–108.0 °F). On the other hand, a skin IR thermometer should show a volunteer’s temperature over a minimum range of 22–40.0 °C (71.6–104.0 °F).
- **Maximum Permissible Laboratory Error:** for an Ear Canal IR Thermometer, for a blackbody temperature range from 36 to 39 °C (96.8 to 102.2 °F), the error should not be greater than 0.2 °C (0.4 °F), whereas for a Skin IR Thermometer, the laboratory error should be no greater than 0.3 °C (0.5 °F).
• Clinical Accuracy: The clinical accuracy is differentiated for different conditions such as device model, display mode, and for every age group of febrile and afebrile subjects on which the IR thermometer is intended to be used. Under no circumstances may the upper limit of the operating temperature range should be less than 35 °C (95 °F).

• Operating Humidity Range: The relative humidity range for the operating temperature range is up to 95%. The design of the IR thermometer to be used for medical purposes to detect a person who suffers from fever has great importance at this time.

1.2 Difference Between Industrial Thermometer and Medical Thermometer

Both of the industrial and medical infrared thermometers [12] are working by converting the analog signal to digital one. They consist of a thermopile sensor and microcontroller, power circuit, battery, memory, LCD monitor, alarm source and some buttons for measurement and operation. Generally, industrial thermometers are primary tools in observing experiments, assessing test materials, calibrating instruments, and other scientific procedures. Some researchers use them to ensure freezing and boiling points. Since they may be used for different kinds of solvents, the range is −10 °C to more than 300 °C as shown in Fig. 3. The material used in some thermometers is metal which is enriched via annealing or thermal tempering. While clinical thermometers (medical thermometers) as shown in Fig. 4 are used to measure the temperature of the human body. The range that they can assess is from 3510 to 4210 °C. Industrial thermometer can’t be used as a clinical thermometer because the second one used for a fever to measure the internal core body temperature (hence the ear, mouth, or …). While the industrial IR thermometer is used in experiments, evaluating test materials, calibrating instruments, and other scientific procedure. If it used to measure core body temperature, it is only able to measure skin temperature which will vary more. As skin temperature is usually around 30–31 °C, but it mainly depends on the weared clothes and environment. While the core is generating energy, and because of thermal resistance, there will generally be a temperature decrease to your skin temperature. The core temperature is always kept at 37 °C (98.6 °F) as it is appropriate for normal body functions. It could be pointed to the ear but it would be pretty hard to get a reading from inside the ear, even if you centered it you wouldn’t be sure of how accurate it would be. Table 1 summarizes the difference between clinical and industrial thermometers.
2 Related Research

Measuring the core degree of core body temperature $T_C$ without surgery (non-invasively) is one of the most important research topics. Conventional techniques of estimating $T_C$ are usually not proper for the continual applications for the time of physical activity because it is invasive and it is not accurate enough. The rectal measurement of $T_C$ or measuring at the bottom border of the esophagus (close to the heart) is annoying particularly in case of using sensors connected via wired connection. Axillary, orally, and ear (tympanic membrane) temperatures are not accurate especially through the practice of actions. The alternative method for measuring $T_C$ is the use of ingestible telemetric thermometers but they are very expensive for daily use by a large number of persons. Although its great importance, the easy, cheap, and accurate measurement of $T_C$ still a great challenge. Therefore, a lot of techniques have been investigated for the non-invasive $T_C$ measurement. The invasively measurement of core body temperature is conducted using several experiments with varying assumption. The experiment is done in each method with a varying number of volunteers. The volunteers are varying in characteristics such as age, weight, height, and body fat. They wear different clothes with different thermal and vapor resistance. The volunteers were put under different test scenarios such as standing rest, walking on the treadmill for different times. The volunteers engaged in a different number of test sessions. The volunteers enter the test room with different room conditions.
**Table 1** Difference between clinical and industrial thermometers

| Clinical thermometer                                      | Industrial thermometer                                      |
|-----------------------------------------------------------|-----------------------------------------------------------|
| Short range as it used for human body                     | Broad range as it used for different substance            |
| Used for human body                                       | Used for solid, liquid and gas substances                 |
| Used in hospitals, homes and airports                     | Used in laboratories and companies                        |
| The range from 35 degrees Celsius to 42 degrees Celsius   | The range is $-10$ degrees Celsius to more than 300 °C    |
| Give alarm at 38 °C.                                      | No alarm                                                  |
| Measure core body temperature within 3 s, 10 cm away from the body | Measure the skin temperature which is differed approximately 3 °C from the core body temperature |
| Price is approximately 2000 L.E                           | 300 L.E                                                   |

**Fig. 4** Non-contact medical thermometer [14]
such as snug [50% Relative Humidity (RH), 25 °C], hot-dry (20% RH, 40 °C), and hot-humid (70% RH, 35 °C)… etc. $T_C$ was measured within different places such as pectoralis, sternum forehead, left scapula, left thigh, and left rib cage. The method that estimate $T_C$ non-invasively are varying in the factors which $T_C$ depends on such as skin temperature, ambient temperature, heat flux, heart rate…etc. The estimated $T_C$ was compared to the observed $T_C$. The observed $T_C$ is a rectal temperature or taken through a thermometer pill.

In [15] the protocol estimates the core body temperature $T_C$ based on three factors which are skin temperature $T_s$, ambient temperature $T_a$ and Heat Flux (HF) or Heat loss which is known as the heat transferred per unit time per unit area or from or to an object. Several linear regression techniques were presented to predict $T_C$ which is dependent variables from two dependent variables HF and $T_s$. The system composed of $T_C$, $T_s$, and HF is regularly considered a dynamic system (the variables changes with time) as it affected by physical factors and physiological factors. The physical factors include the thickness of the tissue such as the thickness of the skin, fat, bone…etc. and the features of heat transfer of the tissue (e.g., thermal conductivity, heat capacity). The physiological factors including blood flow and sweat evaporation of the tissues. Metabolic heat is generated in the core of the body and is transported from the core to the skin by conduction over the tissue, after that it depletes from the skin to ambient ($T_a$) at a rate of heat flux (HF) by evaporation, convection, and radiation. The heat transfer resulted from the core to the skin through tissues is defined as follows:

$$\rho c \frac{\partial T}{\partial t} = \lambda \frac{\partial}{\partial x} \left( \frac{\partial T}{\partial x} \right)$$  \hspace{1cm} (1)

where $T$ is the temperature (°C), $t$ is time in second (s), $x$ is the distance from the core to the tissue in meter (m), $q$ is the density in kg m$^{-3}$, $c$ is the specific heat capacity in J kg$^{-1}$ °C$^{-1}$, and $k$ is the thermal conductivity in W m$^{-1}$ °C$^{-1}$.

The heat exchange between the core surface and the skin surface is influenced by dynamic factors such as ambient temperature that change from time to time so the system is a varying system consists of steady state and dynamic state. The equation of heat transfer Eq. (1) is solved in the steady state as follows:

$$T_c = T_s + HF \frac{d}{\lambda}$$  \hspace{1cm} (2)

where $d$ is the shell thickness in m. This means that the derivation of $T_c$ from $T_s$ and HF in case of knowing $d$ and $k$ of the tissue is possible. The steady state is seldom in the human therefore, the process of heat transfer is usually varying. So, it is an important task to solve the steady state equation (Eq. 2) in varying conditions. Solving the steady state equation of the tissues (Eq. 1) means the varying temperature distributions over the tissue which indicates that the relation between $T_C$, $T_s$, and HF, is dynamic relation. The varying conditions were declared as follows:
The uniform temperature of the tissue is 33 °C, therefore, the initial condition at time \( t = 0 \) is \( T(x, 0) = 33 \) °C.

The dynamic process is begun when \( T_C \) (i.e., the core temperature at \( x = 0 \)) is increased by 1–34 °C. So, the boundary condition at the core, (i.e., at \( x = 0 \) is \( T(0, t) = 34 \) °C at \( t > 0 \).

The boundary condition at the skin surface (i.e., at \( x = d \)) is heat loss via convection. The coefficient of heat transfer due to convective \( \alpha \) is set at 10 Wm\(^{-2}\) °C, and the initial ambient temperature \( T_a \) is 33 °C.

The mathematic description of these initial and boundary conditions are:

\[
t = 0, \quad T(x, 0) = 33 \degree C; \quad (3)
\]

\[
t > 0, \quad x = 0, \quad T(0, t) = 34 \degree C; \quad (4)
\]

\[
t > 0, \quad x = d, \quad -\lambda \frac{\partial T}{\partial t} = \alpha(T(x, t) - T_a) \quad (5)
\]

The temperature distribution \( T(x, t) \) changes little by little till it reaches another steady state [i.e., \( T(x, \text{end}) \)]. Within this transient time, the value of \( T_C \) in the steady state condition which is estimated by Eq. (2) will progressively converge to the perfect \( T_C \). The results of the noticed \( T_C, T_s \), and HF were taken from two places, the sternum and forehead and, at varying conditions (40 °C and 20% RH), the noticed \( T_C \) was taken by the telemetry pill or rectally and also it taken at different assumed condition and different assumed places (pectoralis, forehead, sternum, left rib cage, left scapula, and left thigh) it was confirmed that the mechanisms for measuring \( T_C \) are based on the location of the sensor and their efficiency is varying based on the location of the sensor. For the placement studied, the best places are the sternum, or a collection of the sternum, scapula and rib sites.

Whereas in [16] estimate \( T_C \) exactly as [15] based on \( T_s \), HF but the main difference that it take into consideration the Heart Rate (HR).

In [17] the core temperature is estimated using Kalman Filtering (KF) which consists of training and validation datasets. These data sets are consisting of the data from different persons. The parameters of KF model were predicted from the practice dataset using linear regression of \( T_C \) against \( T_s, HF \), and \( HR \). KF method used to estimate \( T_C \) consists of three states: state-transition state (A), noise correlated with each state and observation state (C).

First, the state-transition state shows the diversity in the state of the hidden variable \( T_c(x) \) from one time point to another as stated by:

\[
x_t = A x_{t-1} + W_t
\]

where \( w \) is the transition state noise is assumed to be a zero means normal Gaussian distribution with covariance \( Q \) which depicted by:
\[ W_t \sim N(0, Qt) \] (7)

Second, the observation state \((C)\) compares full or a group of the observed variables \(T_s, HF,\) and \(HR (z)\) to the hidden variable of \(T_c\) from one time point to another as stated by:

\[ Z_t = C x_t + v_t \] (8)

where \(v\) is the observation state noise and supposed to be a zero mean normal Gaussian distribution with covariance \(R\) which depicted by:

\[ v_t \sim N(0, Rt) \] (9)

\(T_c\) was the only hidden value, the matrix \(A\) composed of one value practiced using linear regression of time appeared in (minute to minute) to \(T_c\) values it means \((T_{c,t-1}, T_{c,t})\) from the practice dataset. Likewise, the matrix \(C\) composed of the weights practiced by linear regression of \(T_s, HF,\) and \(HR\) versus \(T_c\). Variety of observation states were produced for each location of the HF sensor by using all sets of the \(T_s, HF,\) and \(HR\) as filter inputs for a total number of different states. The Q matrix consists of the variance of the differences of time showed in minutes in \(T_c\) whereas the values of the matrix \(R\) were practiced by utilizing the covariance of the minute differences of the various collection of \(T_s, HF,\) and \(HR\). KF approach achieves perfect assessment of core body temperature in case of the availability of two of those three inputs \((T_s, HF\) and \(HR)\).

In [18] a Kalman filter was used to suits the parameters of its model to each person and gives real-time \(T_c\) estimates. The model composed of, a mathematical model and a Kalman filter. This group was utilized wholly predict \(T_C\) through three steps as shown in Fig. 5.

This model uses the Activity \((A_c)\) of the person, \(HR,\) and \(T_s,\) also uses two environmental variables, \(T_a\) and Relative Humidity (RH), to estimate the person’s \(T_C\) in real time. The model consists of, a mathematical model and a Kalman filter. This combination was used altogether to give real-time individualized estimates of \(T_C\) via the following three procedures: First, in procedure 1, the calculated \(A_c\) and the environmental variables \(T_a\) and RH were utilized by the mathematical model for the estimation of the state variables, the actual estimated Heart Rate (HR) and the actual estimated core temperature \((\hat{T}_s)\). After that, in procedure 2, the difference (errors) between the measured values of \(T_s, HR\) and the actual estimated \(\hat{T}_s, \hat{HR}\) were calculated. Lastly, in procedure 3, the Kalman filter utilizes these errors to justify the state variables and uses this repairing to update the mathematical model parameters. The mathematical model is formed of the following two sub models: a phenomenological element that connects \(A_c\) to HR and a first-principles macroscopic energy-balance element that relates HR to \(T_s\) and \(T_C\). First, the framework of the phenomenological model was obtained by the observation of positive relationship between \(A_c\) and HR.
which means that the rise in $A_c$ leads to a fast rise in HR, thereafter decreases exponentially when $A_c$ decreases. This relationship was mathematically obtained by the next equation:

$$\frac{d\Delta HR}{dt} = -\alpha_1 \Delta HR + \beta A_c^4$$  \hspace{1cm} (10)

where $\Delta HR$ denotes the change in HR from a resting state HR0 (i.e., $\Delta HR = HR - HR0$), $\alpha_1$ denotes the rate constant for HR, and $\beta$ represents the gain in HR resulting from physical activity. Second, the first-principles component of the model consists of the core and skin-temperature compartments:

$$\frac{d\Delta T_c}{dt} = -\alpha \Delta T_c + \gamma_1 S(\Delta HR) \Delta HR - \gamma_2(T_c - T_s)$$ \hspace{1cm} (11)

where $\Delta T_c = T_c - T_{c0}$ and $\Delta T_s = T_s - T_{s0}$

$T_{c0}$ is the initial core temperature, $T_{c0}$ is the initial skin temperature, $P_a$ denotes the vapor pressure of water for $T_s$, $P_a$ represents the vapor pressure of water at a given $T_a$ and RH, $T_{c0}$ was set to 37 °C and $T_{s0}$ is the mean of the measured T during the initial 10 min of data collection. The data is used from four studies to estimate the parameters $\alpha_1$ and $\beta$, which relate Ac to HR. Assessment of the performance of the model was evaluated by calculating the capability of the model to learn a person’s heat-stress response under various experimental and environmental conditions by simulating the estimates of each $T_C$ (i.e., $\hat{T}_C$) in continuous time and making a comparison between
them. The accuracy of $\hat{T}_C$, was assessed by computing the square root of the mean squared differences between $\hat{T}_C$ and the $T_C$.

There are several methods of estimating core body temperature that has already experimentally applied as a patent [19, 20]. In [21], the patented introduce the procedure of estimating the core body temperature including: determining heat flux from an aimed surface area of the body that way giving the surface temperature; estimating the core temperature of the body based on two factors (ambient temperature and surface temperature), the function including the skin heat loss to the environment; for example the external ear canal or axilla, can be computed as follows:

$$q = hA(T_s - T_a)$$  \hspace{1cm} (12)

where $q$ is heat flow, $A$ is surface area, $T_s$ is the skin temperature and $T_a$ is the ambient temperature, and $h$ is an experientially calculated coefficient which comprises a radiation view factor between the ambient temperature and skin tissue. The heat flow process from the core arterial source to the skin is through the circulation of the blood, this model is very successful with comparison to the model of tissue conduction. Thermal transport through the circulation can be calculated as follows:

$$q = wc(T_c - T_s)$$  \hspace{1cm} (13)

where $q$ is heat flow, $w$ is blood mass flow rate, $c$ is blood specific heat, and $T_c$ is the core body temperature and $T_s$, is the skin temperature. Therefore, the skin has a thermal view such as tissue being heated by its blood supply as shown in Eq. 13, keep balance by radiating heat to ambient as shown in Eq. 12. By solving Eq. 12. and Eq. 13. Generate the following equation:

$$hA(T_s - T_a) = wc(T_c - T_s)$$  \hspace{1cm} (14)

Dividing by $A$ (surface area):

$$h(T_s - T_a) = \rho c(T_c - T_s)$$  \hspace{1cm} (15)

where $\rho$ is blood flow per unit area, it can be named as termed perfusion rate as well.

Finally, our target is to estimate the core body temperature $T_c$ is fulfilled by Eq. 15. in case of knowing the values of skin temperature $T_s$ and ambient temperature $T_a$ and also know their coefficients.

Determining $T_c$:

$$T_c = \frac{h}{\rho c}(T_s - T_a) + T_s$$  \hspace{1cm} (16)

Where $h/\rho c$, the weighting coefficient which weights the difference of ambient temperature and, the surface temperature is experimentally detected on a statistical basis over a set of patients and clinical states.
In [22], this invention is the thermometer that aimed to measure the body cavity temperature utilizing infrared sensing methods. Infrared radiation released by tissue surfaces gathered by an infrared lens and directed to an infrared sensor. This infrared sensor produces a signal voltage based on the difference of temperature between the body tissues being spotted and the infrared sensor. To detect the correct tissue temperature, a supplementary sensor is utilized to determine the ambient temperature of the infrared sensor and this ambient temperature is combined to the signal voltage. The relationship between the signals to produce exact tissue temperature is showed

\[ T_s = G(E_s - E_a) + T_a \]  

(17)

where \( E \) is the radiant energy from the body tissue, \( E_a \) is the radiant energy from the infrared sensor at ambient temperature.

In [23], this invention introduces a technique for the non-contact accurate and efficient measurement of the temperature of an object. By providing an infrared (IR) sensing assembly which determines the temperature of an object. This assembly consists of at least one IR sensing sensor which senses IR radiation and ambient temperature. Also, it consists of a processing circuit connected electrically to an IR sensing sensor. The processing circuit gains signals from the IR Sensing sensor and prophesies the temperature of the object.

In [24], this invention presents an IR thermometer which introduces a method for measuring core body temperature based on contact temperature, ambient temperature, and humidity degree.

In [25], this invention presents a forehead the non-contact thermometer that measures the core body temperature using the thermal radiation of the forehead. The core body temperature is calculated as a function of ambient temperature and skin temperature. The core body temperature is calculated as follows:

\[ T_c = (1 + (h/\rho c))(T_s - T_a) + T_a \]  

(18)

\( T_s \) is the skin temperature, \( T_a \) is the ambient temperature, the function contains a weighted difference of the skin temperature and the ambient temperature with a weighting coefficient \( h/\rho c \).

3 Wireless Body Area Network

Wireless Body Area Network (WBAN) is used for medical systems. The main idea of WBAN is to monitor various biological functions by a variety of medical sensors that are placed inside or on the body as shown in Fig. 6. The medical sensors detect some signs that are important to follow up the status of the patient, such as temperature, heartbeats, blood pressure …etc. The medical sensors send the biological data using wireless connection to a gateway (e.g. IoT device) which in turn transmits it to a hospital server. The continual monitoring and diagnosing of patients can protect the
lives of large number of patients particularly in the recent time because of the speed spread of coronavirus among people. Therefore, the fast detection of the peoples suffering from fever can help in preventing the fast spread of coronavirus. Thus, it demonstrates the significance of continuous communication between patients and medical servers. To ensure speedy delivery of the medical data to the medical servers, 5G technology can be used for this mission. Because of the features of 5G technology, it is considered the best technology used in WBAN systems to transfer the medical data to the medical server.

3.1 5G Technology

The fifth generation 5G wireless network is the upcoming fulfillment in the mobile communications. The main goal of this generation is to host variety devices with different types and large number, with the major increase of the number of different devices, 5G networks will connect whole world. This connectivity is accomplishment of thanks to the extreme data rate, minimum latency, and a large number of hosted devices that 5G can possess. Basically, 5G can be used for a variety of applications that get the lives of people better, for example, homes automation, remote medical care, wireless robots and driverless vehicles.
3.1.1 Role of 5G in the defense of coronavirus

Recently, because of the appearance of covid-19 the health care afford unbearable load as the existence of large number of hospitals is considered a terrible dangerous for both patients and health care workers. Using WBAN network along with 5G network can produce efficient and real time remote health care systems that gives the patients the possibility to get care from their homes [26]. Recommendations can be offered to patients by health care providers using brief video call, and give recipe demand. Doctors can give accurate diagnoses to the patient by requesting from the patients to send the report or image of tests result. The transmission process of medical images such as CT scans or X-rays requires high-speed transmission which can fulfilled using 5G network [27]. Also, the remote monitoring of large number of persons is the main reason of increased stress on the networks, this cause overcrowding and decrease network speeds, especially for healthcare providers that might be offering help to hundreds of patients per day. Additionally, the late and low level of the quality of patient care, could damage results in the long time. 5G Network can reduce whole medical costs and it permits the doctors to give nursing to anybody at any place without the need to the existence of patients at hospitals which can decrease the danger of the infection of covid-19 [28]. The features of 5G technologies as, low latency reliability…etc., fulfill high development in remote health monitoring because it awards different features in remote health care systems such as, imaging, diagnostics, treatment and data analytics. 5G will be used in several health applications that demand wide bandwidth and reliable connectivity. Utilizing the high-speed of 5G technology the transmission of tremendous files of medical images is done in a quick and reliable way, as well as, it facilitate to the doctors gaining the real time data that is required to improve the health care quality.

3.1.2 Features of 5G Network

• Very low latency
• Very fast response time
• It can host large number of devices
• It can host several types of devices
• It used for different application
• Wide capacity
• Permanent connectivity.

3.2 Using IR Thermometer in a WBAN Network

We can use the non-contact thermometer [33] as a wireless temperature sensor in a WBAN system [29] that gives an alarm when the person temperature is 38 °C or
more. This IoT non-contact thermometer will be connected to the mobile gateway which is connected to a database in the medical server, the persons whose temperature is 37 °C will be colored with green mark while the assumed infected persons whose temperature exceed 38 °C will be colored with red as shown in Fig. 7. This medical server will be located in the ministry of health to continually follow up on the temperature of a large number of people. In order to meet the 5G and the IoT requirements [30, 31], The AESAS algorithm [32] will be used to increase the capacity and density of the network to serve a large number of devices effectively without any degradation in the quality of services, and to ensure that the priority is satisfied among all types of mobile gateways, increased the overall throughput of the network due to decreasing of the data drop rate, and decreased the delay or latency for sensitive-delay applications and services. The first part of the system will be achieved by designing the non-contact thermometer [33]; the second part will be the connection of all of these devices by a WBAN system [29] to ensure reliable and fast delivery of the medical data to the medical server [34–36].

4 Conclusions

In this paper we illustrate the role of non-contact thermometers in the early detection of coronavirus as well as the types of noncontact thermometers is explained. Several
method of estimating core body temperatures is surveyed. The role of 5G along with WBAN systems to face the danger of covid-19 was discussed. The IoT non-contact thermometer could be used as a part of WBAN system for early, real time detection and tracking of people suffers from a fever which might infected with corona virus. In the future work we will design a local manufactured IoT Non- contact thermometer and link it to our WBAN system that will be connected to a database in the medical server, and track the infected persons with corona virus whose have a fever with red color.

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