

## Secure and smart system for monitoring patients with critical cases

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### ABSTRACT

Recently, heat-related diseases like COVID19, Chickenpox, Typhoid, and others are increasing significantly; therefore, the need for portable devices to measure the heat of the human body accurately, quickly, easily with low cost has become very necessary to preserve the life of patients. For this reason, a smart system has been developed to monitor the patient's heat, in addition to temperature and humidity of the critical environment such as surgical operating rooms, patients' isolation rooms and pharmacies, because it can help propagate infectious agents like viruses and bacteria. The proposed system divided into four parts: transmitted part (arduino, heat sensor, and hygrometer sensor), alarm part consists of lights and alarm bell, emergency part (doctors and nurses), and the medical application has been used as the last part. The application can be used only by authorized persons and through the accounts which are granted to them, in order to protect the data from sabotage and maintain the privacy and confidentiality of it.

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## 1. INTRODUCTION

Health is considered one of the big challenges for humanity [1]. The process of patient health monitoring requires, For example, a medical expert (doctor) and health workforce (nurses) to visit the patients through a certain time interval, two or three times every day depending on the patient's conditions. At each visit, particular health parameters know as vital signs are taken. It includes heart rate, human body temperature, blood pressure, and respiratory rate. All these signs are prepared and maintain in the manual records and this process may result in mistakes or lateness response by doctors in the period of illness determination. Throughout the analysis of this kind of monitoring can see has huge limitations, also this kind requires a large workforce moreover the patients who are suffering from contagious diseases, an in-charge person for monitoring those patients faces challenging to contact them [2]. For these reasons, there is a need to built a system for helping healthcare experts and monitor the patients who are in a hospital or performing actions of normal daily life. One of the most important types of systems is the patient's heat monitoring system [3]. Heat is a measure of the degree of temperature intensity. Normally, all humans are homoeothermic and the body's temperature is structured at nearly  $37^{\circ}\text{C} \pm 1^{\circ}\text{C}$ . The heat of human body different every day and can be affected by the heat of external sources [4].

Moreover, high temperature and humidity may provide a suitable environment for the transmission of viruses, bacteria and may negatively affect the patient's health causing other health problems. The organization of this study is as follows: Section 2 reviewed the previous works in this domain while Section 3 presented detailed discussions on arduino microcontroller, heat sensor, and hygrometer sensor and web

application. The proposed system is presented in Section 4 while the implementation of the proposed system is offered in Section 5. Section 6 presented the results and discussed of the experiments while the conclusion drawn from the study was presented in the last section.

## 2. RELATED WORK

In recent years many contributions have been achieved in the field of health Monitoring Systems; some of them are present briefly: Md. Asaduzzaman Miah et al. [5] a monitoring system for continuously heart rate and body heat is proposed. The system involves of Arduino UNO microcontroller, transmission part, and android application. It offers information about heart rate and body heat simultaneously obtained on the portable device in real-time and appearances it through the associated android application directly. The proposed system showed its efficiency with the low cost compared to other devices. Nidhi Mutha et al. [6] suggested a system to help the medical expert (doctor) in diagnosing the ill properly. The system composed of a wearable device to monitor the health of patient, and android-based application. It involves heat sensors and pulse sensors. The mechanism of system starts from sending the data to the server over the application, wherein totally the processing will take place. After that, the medical expert can access the data through his application. The system showed its flexibility in access to the data, besides reduce the overhead. Vikramsingh R. Parihar et al. [7] introduced a wireless heartbeat and heat monitoring system depending on the microcontroller ATmega328. The system composed of heartbeat sensors, and heat sensors. Constantly, the system works on transfer the patient's data from the remote position to the microcontroller. Finally, the data are presented at the LCD monitor. The system appears it's effective in diagnosing with the low cost. Ch Sai Manasa [8] proposed a device that can be digitally sensing the patient's health. The device includes: Arduino which is used to receiving the input from different sensors, LM35 to sense the body heat, heartbeat sensor, and Android device to display the data. In this study, two parameters of health (heart rate and heat rate) have been used to diagnose and monitor human health accurately. Also, the device can be utilized to measure their mean arterial pressure over one minute. The proposed device showed its accuracy at work. F M Yassin et al. [9] developed a system to decrease the monitor frequency of patients. The system consists of a microcontroller (Arduino), sensor of Heart Rate Grove, LM35 heat sensor and laptop to communicate with Arduino via Bluetooth which is used to transfer, processed and show the data each minute. Also, the system used various colors of LED to alert the health workforce about the patient's condition. For the adult with a fever respondent, the system displays the result of 37.63oC of body heat and 81 bpm of heart rate together with 3.83% and 0.65% of the mean absolute percent fault respectively. The proposed system demonstrated its ability to facilitate independent monitoring jobs successfully.

## 3. PROPOSED SYSTEM REQUIREMENTS

The requirements of system that needed to accomplish their objective are explained in Table 1.

Table 1. System requirements

H.W Requirements		S.W Requirements	
1.	Microcontroller Arduino UNO	1.	Arduino C language
2.	Heat Sensor	2.	Microsoft visual studio 2012
3.	Humidity Sensor	3.	Microsoft SQL server 2010
4.	LCD	4.	Asp.Net
5.	Power Supply		
6.	Pc		

### 3.1. Arduino microcontroller

A micro-controller is a small computer on a single completed circuit having a processor core, memory (M), and programmable I/O peripherals. Arduino Uno is a micro-controller board. It has many I/O pins utilized to receive the input data from different sensors, and controls a wide range of outputs like lights, recorders, motors, and sound. The software (S.W.) of arduino is integrated development environment (IDE). The board is programmed with Arduino IDE and provided with 14 (I/O) pins. Also, a USB cable or external dc used to provide the board in voltage through supply with a range of 720 volts Figure 1 [10-15].

### 3.2. Heat sensor

The sensor (mlx90614) will be used to measure the heat and send the values to Arduino. Constantly, the sensor checks the heat's value and if the result is above of a specific value, Figure 2 arduino will generate an alert and sends a warning to the competent authority [16-18].

### 3.3. Hygrometer sensor

The sensor (DHT11) as shown in Figure 3 is utilized to collect the data of temperature and humidity of the outside environment and sends it to the micro-controller. It contains a resistive-kind humidity measurement component and communicates to a high-execution 8-bit micro-controller, therefore, it provides high reliability, rapid response, anti-interference capability, and cost-effectiveness. The temperature range of sensor is 00-55<sup>o</sup>C while the Humidity is 20-90% [19-23].



Figure 1. Arduino uno



Figure 2. Heat sensor



Figure 3. Hygrometer sensor

### 3.4. Web application

Web application (WA) can be defined as one of the famous prevalent platforms for sending and receiving information via the internet using a web browser. The standard architecture of WA includes three-layers: presentation layer (PL), domain logic layer (DLL), and data source layer (DSL) [24-26].

## 4. PROPOSED SYSTEM

In this work, a smart and secure system has been designed which consists of several parts as shown in Figure 4. This system aims to monitor the heat of patients especially those with COVID19 by using heat (mlx90614) sensor, provide a suitable health environment using hygrometer (DHT11) sensor which works on calculating the humidity and temperature inside the rooms of patients, finally, the medical application has been used to protect the personal data from delete, update by unauthorized persons and maintain the privacy and confidentiality of it. ASP.NET is utilized to building dynamic application with SQL server as database management system of application.

The mechanism of system starts from the first part (transmitted part). When the sensors sense the rise in the patient's heat, room's humidity or temperature, alarm part will send a warning to the emergency part. The warning includes lights and alarm bell which work together. The task of emergency part is to receive the warning and treat the patients, deals with the data in the medical application, finally, ensure that an appropriate healthy environment is available. The two parts (transmitted part and alarm part) are controlled using the Arduino UNO microcontroller. Figure 5 illustrates the main page of medical application.

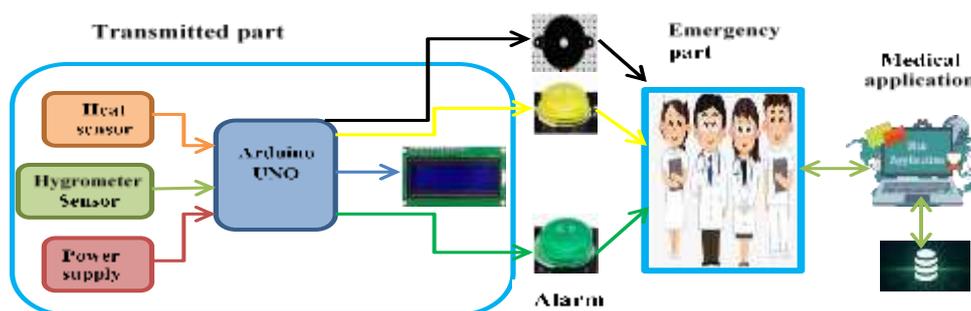


Figure 4. Overflow of proposed system



Figure 5. Main page of medical application

**5. PROPOSED SYSTEM IMPLEMENTATION**

A proposed system has been developed to explain how deals with normal and abnormal cases. Figure 6 shows the implementation of system in a hospital. Normally, when the patient's hand contact with the heat sensor (mlx90614), it will sense and measure the heat and send the collected data to the Arduino. If the body heat equal to the normal value  $37^{\circ}\text{C} - 1^{\circ}\text{C}$ , the data will be displayed on the LCD monitor without any warning. As well as, the hygrometer sensor (DHT11) which is installed inside the patients rooms, it constantly works to measure the room temperature with humidity and send the data also to Arduino, as illustrates in Figure 7.

The previous figure shows the heat of patient is  $36.6^{\circ}\text{C}$ , while the room temperature with humidity is  $25.00^{\circ}\text{C}$  and  $52.0$  respectively. In abnormal cases, patients with COVID19 suffer from high fever, thus if the medical intervention is not done in proper time, the heat will lead to other health problems such as shortness of breath. Therefore, it is necessary to monitor and measure the heat constantly. For example, when the heat of patient rise into  $40.4^{\circ}\text{C}$  as shown in Figure 8, the system works on display the collected data on the LCD monitor at the same time sends an alert to the health workforce. The alert represents blue light with alarm bell to treat the patient as quickly as possible.



Figure 6. The implementation of sytem



Figure 7. The implementation of system with normal case



Figure 8. Implementation of system with abnormal case (1)

Sometimes, increasing the temperature of surrounding environment (patient's room) may lead to an increase in the severity of respiratory diseases such as COVID19, asthma, and respiratory allergy. Therefore, maintaining the normal degree of heat in patients' rooms is necessary. Figure 9 shows the room's temperature height into 43.00°C which is not equal to the normal value 39.00°C. Therefore, the sensor sensed, measured and sent the data to display it. After that, the system announced the state of alarm represented by yellow light and alarm bell. The alarm continues until the case is resolved by the competent authorities.

Also monitoring, controlling, and maintaining humidity is important because it can help to propagate viruses and bacteria. Therefore, if the humidity degree  $> 69.0$  (threshold value) then the sensor will provide a signal to Arduino and an alarm will appear, otherwise, if the humidity degree  $\leq 69.0$  then nothing happens. Figure 10 shows increase humidity to 70.0.



Figure 9. Implementation of system with abnormal case (2)



Figure 10. Implementation of system with abnormal case (3)

Finally, the medical application will be used to store the data of patient and retrieve it as needed. The persons who are authorized as a medical expert (doctor) and health workforce (nurses) can only enter and display the data through accounts. This procedure will protect the privacy and confidentiality of data. Figure 11 shows the process of log-in to the application by a doctor.



Figure 11. Login page of medical application

The application contains personal data as shown in Figure 12, besides health data which used by the medical expert to monitor the improvement of health condition, also, to build medical conclusions and find out how the treatment effective. For the conclusions to be correct, the database must be reliable: the data must be maintained through a secure application to prevent the penetration, modification, deletion or addition by unauthorized persons. This work will preserve the quality and delivery of health services in hospitals.

id	username	age	Telephone number	Title	number of family members	Does any member of the family have the same disease?
1	حسان وليد	30	0771786****	بعداد/حبي الفاهرة	6	كلا
2	احمد محمد	21	0771254****	بعداد/شارع فلسطين	5	كلا
3	وسام رائق	19	0771321****	*****	6	كلا
4	جعفر عبد الأمير	43	0781123****	*****	7	نعم
5	علاء عبد وليد	38	07901676****	*****	9	كلا
6	لمياء محمود	55	0770225****	*****	2	كلا
7	امنة اباد	26	0750218****	*****	4	نعم
8	زينة مروان	56	0772661****	*****	5	كلا
9	حسين ماجد	30	0771258****	*****	4	كلا
10	خالد ابراهيم	17	0790185****	*****	3	نعم
11	حنين مؤيد	22	0772325****	*****	5	كلا
12	وداد جواد	57	0770105****	*****	4	نعم
13	وضي عبد الله	69	0770590****	*****	7	كلا
14	سميرة ناجي	71	0771337****	*****	8	كلا
15	هالة هارون	65	0770271****	*****	4	نعم
16	همسة علاء	11	0772644****	*****	3	كلا
17	امل هاشم	34	0771095****	*****	2	كلا
18	أكرم كريم	59	0772554****	*****	5	كلا
19	أمالي منير	63	0770122****	*****	1	نعم
20	هديل حميد	37	0790169****	*****	3	نعم
21	حازم محمود	58	0772883****	*****	3	نعم

Figure 12. Personal information of patients

**6. RESULTS AND DISCUSSION**

In this work, the system succeeded in solving the problem of continuous monitoring of patients and maintaining their health through rapid response. Also, it reduces direct mixing with patients who are suffering from contagious diseases like COVID19. Figure 13 shows the results obtained via the proposed system based on heat sensor, the values of patient’s heat over the week was recorded and kept safely in the application’s database to prevent unauthorized access.

Table 2 illustrates increasing the degree of temperature with humidity inside the patients' rooms and how the competent authorities reduced it to normal values. This objective has been achieved depending on the hygrometer sensor.

id	username	age	Date of entry	The type of disease	Temperature (Saturday)	Temperature (Sunday)	Temperature (Monday)	Temperature (Tuesday)	Temperature (Wednesday)
1	حنان وليد	30	2/4/2020	Chickenpox	38.0	39.3	38.5	37.1	37.0
2	احمد محمد	21	2/4/2020	Chickenpox	39.5	40.1	40.2	40.5	40.4
3	ويعام يزيق	19	2/4/2020	Coronavirus	40.0	40.2	39.5	39.1	38.0
4	جعفر عبد الأمير	43	3/4/2020	Coronavirus	38.5	39.1	39.5	40.2	39.1
5	غلاك عبد الوليد	38	3/4/2020	Coronavirus	38.2	38.5	40.0	40.1	38.2
6	لمياء محمود	35	4/4/2020	Coronavirus	40.0	40.0	38.2	39.4	38.5
7	انغية ايزاد	26	5/4/2020	Coronavirus	38.4	39.5	40.1	40.2	39.5
8	رندة حيوان	56	5/4/2020	Typhoid	38.0	39.5	40.1	39.0	38.0
9	حسين ماجد	30	7/4/2020	Typhoid	73.5	38.2	38.5	40.2	38.0
10	خالد ابراهيم	17	8/4/2020	Chickenpox	39.5	40.1	39.4	39.1	38.0
11	حنين مؤيد	22	8/4/2020	Coronavirus	39.2	40.0	40.0	40.5	39.1
12	ورداد حويلا	57	8/4/2020	Chickenpox	38.5	38.0	39.4	40.0	40.2
13	وصي عبد الله	69	9/4/2020	Coronavirus	38.3	38.5	39.5	40.0	40.5
14	سميرة ناجي	71	9/4/2020	Coronavirus	39.5	38.5	39.2	39.5	38.0
15	هالة هارون	65	10/4/2020	Chickenpox	38.0	39.5	40.0	40.2	39.1
16	همسة علك	11	10/4/2020	Typhoid	38.3	40.0	40.3	38.5	37.3
17	اسل هاتيم	34	10/4/2020	Coronavirus	40.1	39.2	40.0	40.3	39.5
18	اكرم كريم	39	11/4/2020	Typhoid	37.5	37.0	39.3	38.5	38.0
19	امال منير	63	11/4/2020	Coronavirus	39.2	39.5	40.1	40.5	39.4
20	هديل حميد	37	12/4/2020	Coronavirus	40.0	40.1	39.5	40.2	40.5
21	حازم محمود	58	12/4/2020	Coronavirus	38.4	38.5	39.2	40.0	38.5

Figure 13. Results of heat sensor

Table 2. Results of hygrometer sensor

Abnormal Value of Temperature	Abnormal Value of Humidity	Normal Value of Temperature	Normal Value of Humidity
43.00°C	-	25.00°C	-
45.00°C	-	32.00°C	-
-	70.0	-	36.0
-	75.0	-	40.0

## 7. CONCLUSION

The proposed system is used to monitor the heat of patients depending on the heat sensor, in addition to providing a suitable environment for patients using the hygrometer sensor. Also, Microcontroller has been utilized to develop a smart monitoring system that alerts the health workforce remotely. It sends lights and alarm bell to the emergency part that monitors and treats the patients. Finally, the medical application has been used to maintain the privacy and confidentiality of data and prevent the process of sabotage. The system can be easily implemented with high accuracy, high security, and low cost.

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