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Smart Pre-Examination Health Care System for Doctors Developed on ARDUINO Microcontroller †

Bintu Jasson [1], Suad Ahmed Hasan Alshamsi [2] and Jasson Johny [3]

[1] Lecturer, Chemical Engineering Dept., University of Bahrain; bjasson@uob.edu.bh
[2] Engineering Student, Chemical Engineering Dept., University of Bahrain; 20182777@stu.uob.edu.bh
[3] Faculty, University of Bahrain; jjohny@uob.edu.bh
* Correspondence:
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Abstract: Nowadays, the people and the hospital management are wasting their time and wealth due to the lack of a smart system in the pre-examination process for patients. This paper has discussed an approach to designing a healthcare system that collects the necessary body conditions by using a microcontroller-based smart system and the information referred to an authorized device. The smart Health Care System is one of the economical healthcare devices for the hospital, it provides the measurement of vital signs like Temperature using DS18B20 Digital Temperature Sensor, Heartbeat and SpO2 level using Pulse Oximetry and Health Rate Sensor, and height of the patient using an ultrasonic sensor, etc. The system contains a microcontroller Arduino UNO, and all the collected information from sensors will be sent to Arduino. The LCD screen coupled with Arduino, displays all measurements from the sensors. This project has an alert system that works according to the patient's condition, if there is an emergency, the RED LED will light up and the system will generate an alert through a buzzer and send the information to the doctor using Bluetooth system. This system can be placed before entering the triage, in the intensive care unit, or as a personal device to monitor the health of the patient.

Keywords: Arduino UNO; Pulse Oximetry and Health Rate Sensor; DS18B20 Digital Temperature Sensor; LCD; buzzer; Bluetooth

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1. Introduction

These days, technological development has invaded all sectors and made them better and more at ease than before. Through novel tools, computer-based convenient embedded devices have occupied our healthcare field to another level, by utilizing these technologies people may do their regular checkups by themselves at the hospital. In addition, this is important to make available people continuous nursing in non-clinical situations, especially in the COVID-19 pandemic situation, such self-health examination systems offer more roles that can be attained only through computer-centered monitoring devices with smart sensor technologies. With the initiation of technology today, there is a massive diversity of biosensors that are used to study signals such as a blood pressure monitor a glucometer, a heart rate regulator including electrocardiograms which allow patients to take essentials daily. Day-to-day readings are directed to doctors and they will recommend medication and exercise actions that allow the patients to improve their quality of life and overcome such diseases. The Internet of Things and wireless systems used in the care of patients are becoming increasingly common in the field of health, which improves the quality of life in the healthcare sector.

The combination of biosensors and Arduino is the finest way to do smart things in real-time. These embedded systems can save the data, and convey an alert if there is any

unexpected change in the patient's health. Arduino is one of the best hardware environments that can be programmed easily and it is a good open-source microcontroller platform that allows electronics enthusiasts to build rapidly, effortlessly, and at a short cost with minimal use. The Arduino Uno Board collects data from biosensors like temperature, height, heartbeat, and pulse and displays the measured data on the LCD monitor [1,5]. The system with Arduino conjointly provides patient notifications on the screen and also advises the patient about the next step to follow in the event of an Associate in a nursing emergency. Also, the alert system works to notify the abrupt situation of the patient. The project is certainly being established for parameters like pulse rate, vital sign pressure level, etc. This measurement does it to save time and money so it can measure heart rate and height without the need for the operator for the examination room in the hospital and then send the data to the doctor by Bluetooth. This system can also be made IoT, but to avoid the complexity, reduce cost, and for proper management, the proposed system did with Bluetooth communication. Now the system can be used as a portable device and can be carried to any place where it is needed, no matter whether the patient/medical person has a personal internet connection.

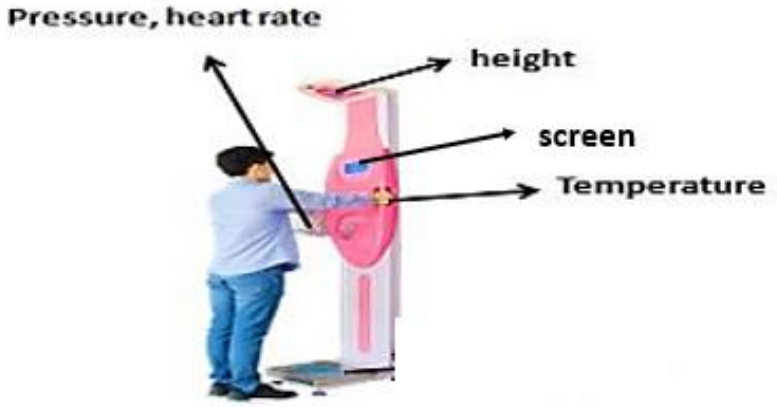


Figure 1. Patient health care unit.

2. Literature Review

The earliest patient-physician encounter is the triage nurse who brings to an end the preliminary evaluation before transferring care to another area of the emergency department or a different department in the hospital. It points toward that the staff is capable of differentiating the critically ill from the sick, and, consequently, of segregating patients who may need admission from those who will not. Thus health professionals need to be well-versed in the concepts of triaging. Functions performed by triage staff include initial assessment, physical examination, initial diagnostic studies, documentation, and disposition [6]. The expansion of the tasks required by triage staff extends the time required to assess each patient and slows the patient flow, therefore, any smart system that is adapted must be designed to balance triage activity with the patient flow. In addition, a portable physiological checking framework or self-examination system will be introduced which will reduce the time and cost of the staff. In this paper, there is a complete solution for those things by implementing a smart healthcare system with biosensors.

The supposed self-examination system is used for non-severe COVID-19 patients who wish to see a doctor. The most common symptoms of COVID-19 are an increase in body temperature, a high or irregular heart rate, low oxygen level, dry cough, etc. [8]. The innovation permits patients to screen their key signs from the smart system within a safe distance by themselves. And in times of pandemic, the importance of the healthcare monitoring system has elevated even more than ever before.

Most of the literature studies presented the smart healthcare system with IoT which receives the collected biosensor information from patients using the Wi-Fi Module. In this

system authorized personnel only can access the data stored using Bluetooth and based on these values received, the diseases are diagnosed by the doctors from a distance [7]. However, when designing for the concept of triage, the position which has to place the system, and the distance from the Health experts in these cases the IoT complexity is greater, so this system focused on the mobile application Bluetooth into considered.

3. Materials and Methods

The proposed smart health monitoring system is developed using an Arduino UNO microcontroller and sensors to measure the vital signs of the patient body. In the Arduino-based smart health care system, there are sensors used as input devices which are a temperature sensor, an oxygen level sensor, an ultrasonic sensor, a heart rate sensor, and a button as shown in Figure 2.

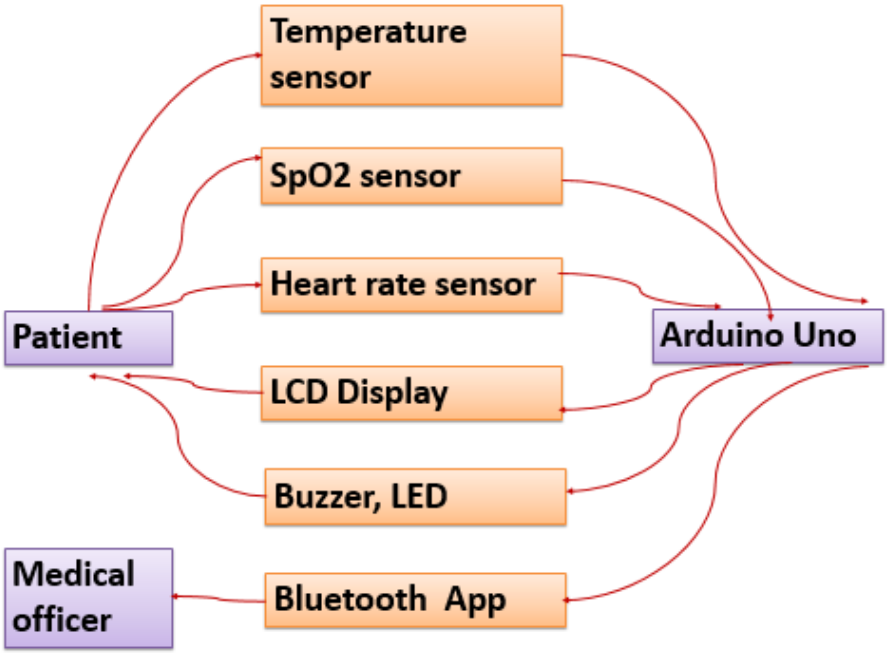


Figure 2. The basic structure of the Bluetooth-based health care monitoring system.

At the output, there are LEDs, a buzzer, a Bluetooth device, and an LCD. When the code is uploaded to the Arduino and the commands are given, the green LED will turn on, and the temperature and pulse will be measured. If they are at the normal level, the LED will remain on. If the temperature and pulse measured are abnormal then the system will produce an emergency indication the green LED will be turned off and the red LED will glow. When the red LED lights up, the buzzer will ring, and if the problem is resolved, it will return to normal and only the green LED will be on. While the red light glows the wireless Bluetooth module refers the measured information to the smart devices of doctors which are already paired by the system. If the button is pressed, the yellow LED will be on, which means the patient needs some help from a concerned person. When the button is off, it will return to normal and only the green LED will be on. Also, the real-time data from the sensors are displayed on the LCD screen. This is also useful for healthcare professionals who are actively monitoring the patient on-site or in intensive care units (ICU) and thus the patient's condition can be protected and monitored with this project.

3.1. ARDUINO-UNO

Arduino is one of the most well-known microcontroller development boards that can be used in many embedded applications. Arduino Uno has 6 analog input pins and these

pins consist of 10-bit ADC as well as 14 I/O pins that can be connected to digital actuators such as LED or motors using PMW pins such as DC motors. Of the 14 pins, there are 6 pins (PIN 3, 5, 6, 9, 10, and 11) that can be used as PMW, or they can be used as normal I/O digital pins. The microcontroller used in this board is ATmega328P from ATMEL company. This microcontroller works on an 8-bit principle with 16MHz CPU frequency, 32 KB Flash, 1KB EEPROM, and 2KB SRAM. Moreover, Arduino Uno has included two pins for voltage that can be supplied to sensors or actuators which are 5 volts and 3.3 volts as well as the (GND) to complete the electric circuit. For Bluetooth or Wi-Fi usage, there are 2 pins (pin 0 and 1) that are used to connect a separate extension to add this feature. Pin 0 called RX is used to receive the data from the Wi-Fi or Bluetooth transmitter and pin 1 called TX transmits the signal to the transmitter. For Arduino programming Arduino IDE v 2. for this project.

3.2. Pulse Oximetry and Heart Rate Sensor—MAX30100

This sensor is used to measure the amount of pulse level and heart rate of the human body and it will interface with the ARDUINO microcontroller to display the measured quantities. The sensor has a pair of high-intensity RED and IR LEDs and a photodetector. It works by transferring both lights onto the finger or earlobe or where the skin is soft, so both lights can easily enter into the tissue, and measure the amount of reflected light using a photodetector.

The working MAX30100 can do two different tasks which are Heart Rate Measurement and Pulse Oximetry to measure the oxygen level in the blood. The oxygenated hemoglobin (HbO2) in the arterial blood has the property of absorbing IR light which is utilized in the sensor action. The redder the blood means the higher the hemoglobin so more IR light is absorbed [2,3]. As the blood passes through the finger with each heartbeat, the amount of returned light will change and it creates a varying waveform at the output of the photodetector. As it continues to glow the light and take photodetector senses as the heart-beat (HR) pulse reading.

Calculating the ratio of IR and RED light received by the photodetector can calculate the amount of oxygen level (SpO2) present in the blood. To connect with the ARDUINO board there is a supporting library needed in the program for MAX30100. This supporting library installed in the program gives most of the features of the sensor and provides defined functions to access and analyze the pulse rate and oxygen level. By using the serial monitor choice in the ARDUINO program can observe what are the measured values from the sensors and the program will check with the threshold values set in the program. If the real-time data are above or below the threshold the system will consider it as an emergency. In the emergency that arises the Arduino insists on transferring the information from the sensor to the wireless system for doctors' reference and the alarm works at the same time.

3.3. Temperature Sensor—DS18B20 Temperature Sensor

The DS18B20 sensor is used in the smart health care system to collect the amount of body temperature from the patient. It is analyzed by ARDUINO and provides information on whether the patient has a fever or not. Temperature sensor works on the principle of direct conversion of temperature into a digital value by using ADC. Its default bits value is 12 but it changes values according to Temperature Change. The system reads the temperature as there is a fever for the patient the alarm works and the value at that moment for the patient which displayed on the LCD screen. The wireless system is also attached to the Arduino and the measured data during fever which referred to the doctor's smart device through Bluetooth mode. Calculation of Temperature sensor [1]:

$$\text{Temp (°c)} = (\text{analog Val}/1024)*5 \text{ Volts} * 100 \text{ degrees/Volt}$$

3.4. HC-SR04 Ultrasonic

The HC-SR04 ultrasonic sensor uses SONAR to decide the distance between the obstacles and the sensor. It offers excellent non-contact range discovery with high accuracy. In the health care system, it is used to measure the height of the patient and it will display on an LCD screen attached with Arduino. To get the actual height of the patient, the sensor is placed on the top of the system as shown in Figure No. 1, and the measured value subtracts from the actual height of the system which has already been measured before. The sensor produces an ultrasound wave at 40,000 Hz frequency which is transmitted by the transmitter module. Then it passes through the air and if there is any obstacle in its path it will travel back to the sensor and it will be received by the receiver module. Considering the travel time and the speed of the sound you can calculate the distance.

3.5. Bluetooth Module: HM-10 Module with BLE

Bluetooth is a universally used wireless communication module and is easy to practice. Over the years, there have been many versions of Bluetooth standards to keep achieving the demand of customers and technology according to the needs of time and situation. The Bluetooth versions started with version 1.0 and currently, Bluetooth version 5.0 exists in the market. Over the past few years, there have been many things improved including data transmission rate, power consumption with wearable and IoT Devices, and Security systems. The HM-10 is a popular Bluetooth 4.0 BLE module fairly used with Arduino. The system used a standard UART serial connection that makes the communication with an Arduino.

3.6. LED, Buzzer, Button, LCD Screen

In a smart healthcare system, there are three LEDs placed, the green LED is on all the time when the situation is normal. If there is any problem in the situation the green LED will be off and the red LED will become switched on. If the patient presses in an emergency can press the button, at that moment the third LED will be switched on.

To connect the buzzer with Arduino use the digital pin. Can use various electrical pulse frequencies with the Arduino, and may use a buzzer to create noises. The Arduino must inform the Arduino which pin the buzzer is connected to, what frequency (in Hertz, Hz) of the electric pulse needs to be applied to the buzzer through the program, and for how long it is to continue producing the tone.

The system used a push button to notify the emergency of the patient, which connected to an Arduino digital pin. The code instructs the Arduino to keep the LED off when the button is not being pressed to turn the LED on as long as it is being pressed to complete the circuit and to keep the LED off when the button is not being pressed.

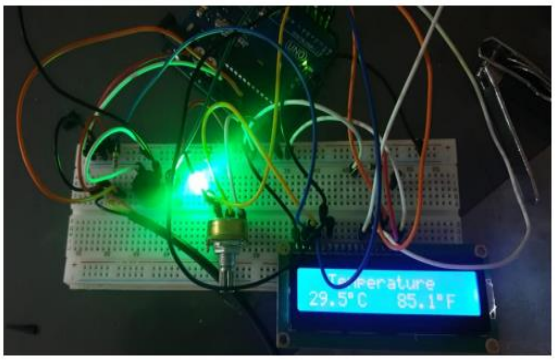
This display has a total of 16 pins. If use 12 pins only except the pins D0, D1, D2, and D3 that means interface the LCD in 4-bit mode. To connect the LCD with Arduino, the supporting library in the program, and the measured data from all the sensors will be sent to the serial monitor in Arduino and the LCD screen attached to the microcontroller.

3. Results and Discussion

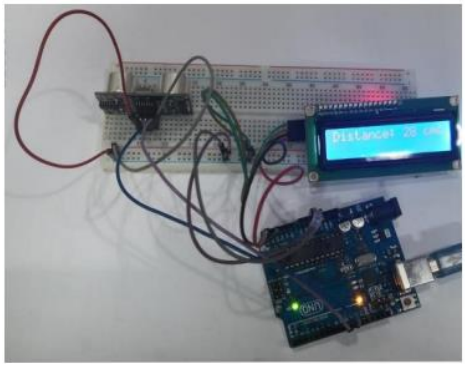
It is hard for people to notice the smallest change in their body, so using the Health Care System could be the finest solution to protect people and decrease the possibility of danger. This system will help to protect the patient from heart attacks or abnormal rises in body temperature. Also, it will help doctors to notice the smallest change in the patient's body and take the fastest action.

The smart healthcare system can place a triage unit in the hospital to collect vital body information from the patients without any time lag. To know the basic condition of the patient, one must examine the heartbeat, temperature, fever height, etc. at the beginning before the doctor's consultation. To do these responsibilities, in this project, three sensors were used, and more sensors in the future. The temperature sensor is provided to

measure the patient body temperature whether he has a fever or not and the second sensor is used to measure the heartbeat the third is an ultrasonic sensor which is used for measuring the height of the patient. Three LEDs were placed, the green LED which indicates that the temperature and pulse are stable (Figure 3), and the red LED, which indicates that there is a problem then the buzzer will ring. Also, the temperature and heart rate will be viewed on the LCD screen and sent the data to the wireless Bluetooth system. This system is essential for patient comfort and even more imperative for protection in medical services and other critical environments like the COVID-19 pandemic.



(**a**)



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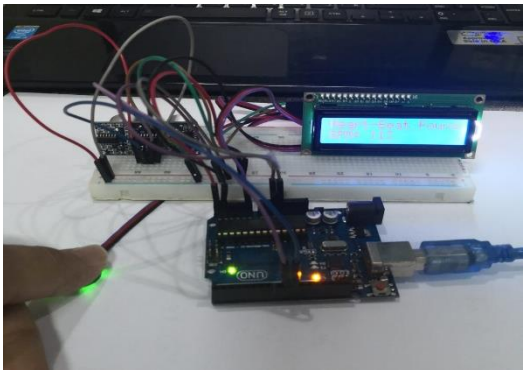
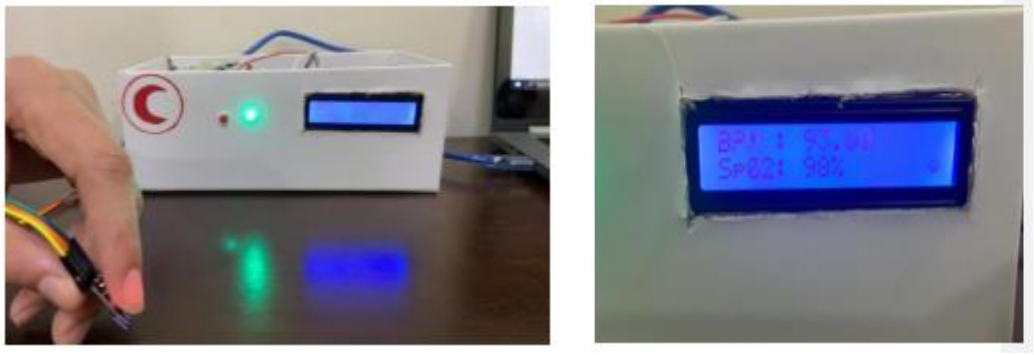


(**c**)

Figure 2. Figure (**a**–**c**) shows the circuit's connection to the health care system.

The Patient Health care System is implemented and it is tested in various persons with normal to abnormal health conditions. The observed data and normal range are given in Table 1.



(**a**) (**b**)

Figure 3. The green LED light will glow when the sensor reads normal body condition data from the patient.

(**a**) (**b**) (**c**)

Figure 4. The red LED light will glow when the sensor reads abnormal body condition data from the fever patient and the buzzer makes an alert. Figure (**c**) shows the collected information displayed in the doctor's smart device through Bluetooth.

Table 1. Collected data from different patients.

Data from Sensor	Observed Data in the System	Normal Range
The oxygen level in the blood	98—normal 99%—normal 90%—low	96% or more
Heart rate	95.77—normal 90.12—normal 135.35-high	40–100 bpm
Height	178.3—normal 162.12—normal 156.4—normal	150–180cm adult
Temperature	37.21 (normal temperature) 36.9 (normal temperature) 39.53 (fever patient)	36.6–37.5 °C

4. Conclusions

Overall conclusion, the Health Care System is a smart system that helps and ensures that the patient is on the safe side all the time and helps all patients to take care of themselves without any delay in a low-cost method. The system measures the body conditions in real-time and does the necessary action according to the data and the device can operate in any place. It also can add more sensors that examine more detail the condition of the

patent. Future work in the unit can be used and developed by adding more sensors that help in better monitoring the health and condition of patients and integrate with robots. The system is now specially designed for pre-examination rooms before the doctor's consultation as triage but further, the system can be used as a monitoring unit for patients in the intensive care unit or an alert system for bedridden patients and in ambulances. Also, there is a possibility of integrating a machine learning-based decision model via Advanced ZigBee [4] or IoT connectivity [2,7] into the monitoring of the physiological parameters.

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References

1. Khan, T.; Chattopadhyay, M.K. Smart health monitoring system. In Proceedings of the 2017 International Conference on Information, Communication, Instrumentation, and Control (ICICIC), Indore, India, 17–19 August 2017.
2. Valsalan, P.; Baomar, T.A.B.; Baabood, A.H.O. IOT-based health monitoring system. *J. Crit. Rev.* **2020**, *7*, 739–743. Abdullah, A., Ismael, A., Rashid, A., Abou-ElNour, A. and Tarique, M. Real-time wireless health monitoring application using mobile devices. *Int. J. Comput. Netw. Commun. (IJCNC)* **2015**, *7*, 13–30.
3. Tartan, E.O.; Ciflikli, C. An Android Application for Geolocation Based Health Monitoring, Consultancy and Alarm System. In Proceedings of the 2018 IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC), Tokyo, Japan, 23–27 July 2018.
4. Omar, S.; Alwan, K.; Rao, P. Dedicated Real–time monitoring system for health care using ZigBee. *Healthc. Technol. Lett.* **2017**, *4*, 142–144.
5. Pardeshi, V.; Sagar, S.; Murmurwar, S.; Hage, P. Health Monitoring Systems using IoT and Raspberry Pi—A Review. In Proceedings of the 2017 International Conference on Innovative Mechanisms for Industry Applications (ICIMIA), Bengaluru, India, 21–23 February 2017.
6. Ajani, K. Triage: A literature review of key concepts. *J. Pak. Med. Assoc.* **2012**, *62*, 487.
7. Lohar, S.; Rangari, D.; Shah, D.; Morande, R. IOT Based Health Monitoring System Using Arduino UNO. *IJRASET J. Res. Appl. Sci. Eng. Technol.* **2022**.
8. Richa, A.D.; Kushwaha, A.K.; Sreejeth, M. An IoT-based Health Monitoring System using Arduino Uno. *Int. J. Eng. Res. Technol. (IJERT)* **2021**, *10*.

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