Design of Smart-Gate System for Monitoring Body Temperature Detection During the COVID-19 Pandemic

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Abstract

The current worldwide COVID-19 pandemic created a vital need for innovative solutions to aid in early detection and control of the virus. High body temperature is one of the early symptoms of covid-19. Thus, this project proposed to design and develop a smart-gate system that will be placed at an entrance of a public places such as markets, shops to detect the body temperature of a person entering and also calculate the level of social distance of the same place. The level of social distance is determined by the number of people in relation to the area. The system operates as follows; it calculates the level of social distancing of a public place showing the maximum number of people the place can hold at a time. When a person enters, the temperature is detected and if it is within the acceptable range, the system will send a signal to the gate to open only if the maximum number of people has not been exceeded. The system also displays the number of people on a screen. Additionally, if the temperature exceeds 37^0C, the system will not send a signal to the gate to open while a buzzer is activated indicating the detection of covid symptom. This system developed for this study can be used in numerous applications such as stores, meeting rooms, classrooms, government buildings, courts, and hospitals.

Keywords

Arduino, Smart-Gate System, Temperature Sensor, Buzzer.

1. Introduction and Literature Review

The world is in the middle of coronavirus dabbed Covid – 19 virus which is a pneumonic outbreak that was first identified in Wuhan, China (Al Mamlook et al,2021). According to health practitioners and World Health Organization (WHO), the virus is extremely contagious (Al Mamlook et al,2020). Hence, safe early detection modes that do not expose others to the virus are urgently required (Khayyat 2020). Commonly, COVID – 19 affects the central nervous and respiratory systems of the human body. Thus, evaluation of people exposed to the virus required to possess at least a respiratory sign as well as elevated body temperature (fever) (Azmi et al. 2021) This paper, therefore, presents a smart way of detecting the temperature of an individual without contacting the potentially exposed person Coronavirus causes fever among other respiratory and body discomforts. Thus, primary detection involves temperature measurement using thermometers.

The temperature measurement is mostly carried out by medical practitioners and may expose them to the virus. Therefore, Khayyat (2020) recommends a smart Gate, an automatic temperature-measuring tool that eliminates the manual use of a thermometer to detect body temperature. The Smart Gate has the ability to sense the possible availability of the virus through high temperatures without human intervention. Additionally, the Smart gate design process is based on the Triz theory principles. Still on measuring temperature as an early detector of COVID- 19, Azmi et al (2021) proposed a Healthy Smart Door design that is based on human body temperature. The Healthy Smart Door is based on Arduino Uno with Fuzzy Logic and utilizes a DC motor and operates on the basis of readings

obtained from the MLX90614 temperature sensor as well as an ultrasonic sensor.

Similar to the above two researches, Cirrincione (2020) also proposes automated temperature measurement at an entrance to public space and the gate only opens when the temperature detected is within the normal range. The researchers recommended a system that monitors the human body temperature through the PIR sensor. The buzzer of the system is activated when high body temperature is detected, signaling a symptom of COVID-19. COVID-19 has ameliorated the application of smart technologies to contain the spread of the virus. In a paper authored by Petrović (2021), the focus is on the adoption of smart technologies to ensure compliance with COVID-19 containment rules as well as maintain and monitor indoor safety to curb the spread. The research leverages the Internet of Things devices like single board computers, microcontrollers, and smartphones in combination with augmented reality and robotics. Additionally, it covers important COVID-19 indoor safety including detection of the mask, social distancing, contact tracing, automated touch-free hand sanitizer, and person count among others.

Management of risk and preparing for emergencies during a global pandemic is paramount. As such, blockchain has been employed as one of the strategic tools to enhance health operations as well as create efficient and effective decision-making processes based on tangible evidence. Thus, Fusco (2020), adopted blockchain in combination with artificial intelligence systems as a predictive system to contain pandemic risk. Also, a SWOT analysis of the adoption of a blockchain-based prediction model in COVID-19 infection is conducted to determine opportunities and limitations to its adoption. Similarly, Bollu (2021) provides a protocol that can be applied in the prevention of the spread of COVID-19 infection. The protocol was arrived at via analyses of targeted evidence-based guidelines by countries ravaged by the pandemic. Also considered were proposals for the prevention of other diseases caused by other pathogens in the same family as coronavirus.

COVID-19 has been an abrupt pandemic and since it was first reported in 2020 according to Al-Mamlook et al (2021), extensive research is being conducted around the world to fathom the virus and how to handle it to prevent the impact it has on the human body. Like other numerous infectious ailments, the movement of human beings must be managed and curtailed to specific areas while temperature of the body is monitored. This is so because the body temperature is the critical and simplest way to determine any person infected by COVID-19. To avoid further spread of the virus or put others at risk of infection, temperature measurement using while being in close contact with a potentially infected individual has to be avoided. This paper proposes a Smart Gate system that automatically measures body temperature without human intervention hence prevents close contact with a person manually measuring body temperature. This in turn prevents further spread of COVID-19 virus. Also, the Smart Gate has the capacity to link information to government databases. Moreover, development of the proposed Smart Gate design means the system can be placed at entrances to various public places such as schools, airports, shopping malls, hospitals, bus and train stations among others to detect temperatures of those entering and indicate if they can be allowed inside or not. In addition, this Smart Gate design opens up the need for development of automation processes as well as efficient performance of tasks especially now with the possibility of having pandemics in future.

This research begins by introducing the coronavirus strand and ends with the proposed Smart Gate to detect the potential of the virus in patients without human intervention. This is to reduce the manual use of thermometers to measure temperature and to shift the detection to automation. This project is about a smart gate system, which can identify people's temperature before they enter into a public place and calculate their number which can assure social distance in this specific place. This project can be installed in all kinds of stores, offices, meeting rooms... etc. The source of the power of our project can be provided by rechargeable electric batteries (which can be installed in remote areas) or directly from a single line of electricity which we can find in any room or store. The application of this Smart Gate will have the benefit of reducing human exposure in detecting Coronavirus disease (COVID-19) and provide a tracking database of suspected cases for statistical and monitoring purposes. Regulations, policies, and procedures have been taken into consideration in the proposed design.

Furthermore, the main objective of this research is to help in early detection and control of reducing the possibility of infection of COVID-19 and provide a safe environment for visitors as much as possible. The objective of the system also is to build and develop a smart system that will be placed at the entrances to markets, shops, and other public places such that the system detects the body temperature of a person entering and the level of social distance of the place under consideration. This system will reduce cost and time. The security guard’s salary is approximately 4000 SAR. In this paper, several available technologies are integrated to build an innovative solution that will help the world to live safer and provide a better future for the coming generations. The contributions of this study are to Create

a system that helps the Ministry of Health to implement precautionary measures to combat COVID-19 that this system can be applied in all places that work 24/7 with low consumption. The recent worldwide COVID-19 pandemic created the urgent need for innovative solutions to aid in the early detection and control of this disease. This research begins by introducing the coronavirus strand and ends with the proposed SmartGate to detect the potential of the virus in patients without human intervention. This is to reduce the manual use of thermometers to measure temperature and to shift the detection to automation. several available technologies are integrated to build an innovative solution that will help the world to live safer and provide a better future for the coming generations. Our project focuses on the idea of a smart gate system, which can gauge people's temperature before they get to any place and calculate their number which can assure social distance in that specific place. This project also proposed a smart-gate system that will be placed in public places entrance such as markets, shops such that the system detects the body temperature of a person entering and the level of social distance of the place under consideration. The rest of the paper is organized as following: Section 2 describes the methodology of this study according to the Smart-Gate system. Section 3. demonstrates the design of Smart Gate system components, followed by section 4. for discussion and result, and Section 5. for the conclusion

2. Methodology of Research

The flowchart for the proposed system is shown in Figure 1. The proposed system starts with initialization of temperature sensors for collection of real time temperature data compared to environmental temperature values. This system is designed without a push button scheme to attain the wireless monitoring of temperature. The normal body temperature ranges between 36.50C to 37.50C [8]. The hyperthermia, also referred to as the tumor conditional stage is the only condition where temperature exceeds 38.5 0C [9-10]. The individual body temperature measurement is dependent of different aspects i.e. age, exertion, infection and place of body at which measurement made (Sohail et al 2017). The system detects the temperature of a person entering and the level of social distance of the place under consideration. The level of social distance is determined by the number of people in relation to the area of the place. The system will operate as follows; the system will calculate the level of social distancing of a public place showing the maximum number of people the place can hold at a time. When a person enters, the temperature is detected and if it falls within the normal (acceptable) range, the system will send a signal to the gate to open only if the maximum number of people has not been exceeded.

The system will also project the number of people on a screen next to gate. Additionally, if the temperature is above the acceptable range, the system will not send a signal to the gate to open. The proposed monitoring system works in a closed loop strategy. This strategy is followed up after initial setup of sensors to measure the ambient and body temperature. The activation of sensors acknowledges the configured ESP-Wi-Fi shield to transfer and display the obtained data to the selected online portal with delay of about 1 minute. In result, the closed loop will run until all the satisfactory result displayed at online portal.

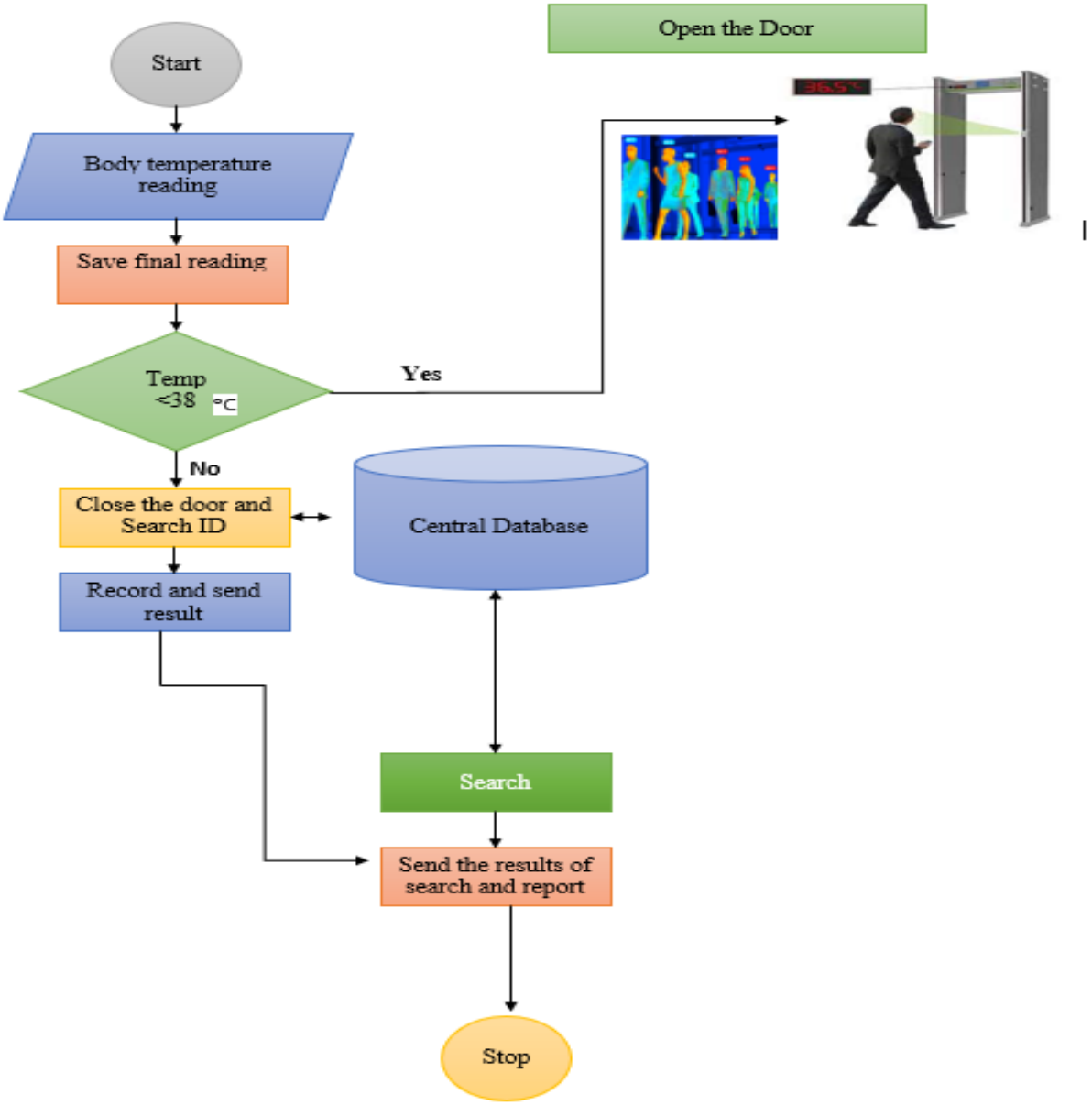

Figure 1. Proposed sensors platform for remote ambient and body Temperature monitoring

3. Design of Smart-Gate System for Monitoring Body Temperature

3.1 Devices and used components

When discussing the components used in the project, the starting is the whole project brain, which is the Arduino Nano. Nano Arduino is a member of the Arduino family. It is more like a small computer that contains a microcontroller and memory and has the ability to deal with electrical engineering projects.

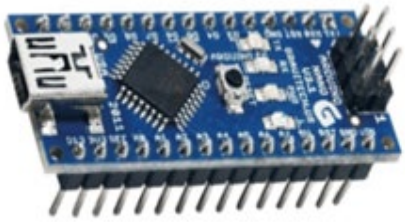

Figure 2. Nano Aduino

Figure 3. Breadboard

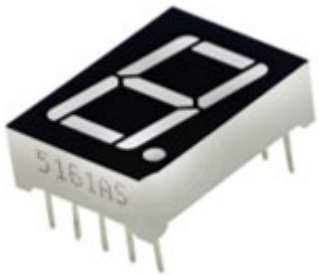

Figure 4. 7-Segment display

For this project, it was possible to apply it to any type of Arduino, but the Nano shown in Figure 2 was chosen because it is cheaper compared to others; which is one of the objectives of the project. Breadboard is a tool for connecting the wires to each other as shown in Figure 3. The breadboard can be dispensed with in case we want to solder the wires by welding, but it is better to use it because it provides an easy wire exchange without the need for cutting. Segment display shown in Figure 4 is a small screen to display numbers, and contains seven LEDs. It is used project to display the number of people inside the shop. It works such that when you want to show a specific number, with the code used, you can run a, b, or c... etc. in different ways, to form a number to be projected on the screen.

Figure 5. Servo Motor

The servo motor is a DC 5V motor that is responsible for opening and closing the shop gate as shown. Breadboard on the other hand is a tool for connecting the wires to each other as shown in Figure 5.

Figure 6. A buzzer

Figure 7. A temperature sensor

Figure 8. Object sensor

A small engine is used in the project to show the idea, and if the project is applied to the major gates, this engine will be replaced with a larger one. It is easy to control the servo motor, as it consists of three terminals, one of which is the communication wire between it and the Arduino Nano. A buzzer is shown in Figure 6 generates a sound and is used as a signal to the incoming people to indicate that the public place is full (even if a person's temperature is within the acceptable range). A temperature sensor shown in Figure 7 is one of the most sensitive equipment in this project and detects the temperature of the coming person without any touch with an accuracy of ± 0. 5°C.The object sensor in Figure 8 is used in conjunction with the temperature sensor, otherwise the temperature sensor would give temperature readings to anything that passes in near it. Thus, the object sensor detects the hand of the incoming person and then allow the temperature sensor to take its temperature. The way the object sensor works is, it generates Infrared lights

that cannot be detected with naked eyes, when an object gets near it. The object then reflects the signal to the receiver, implying there is someone there.

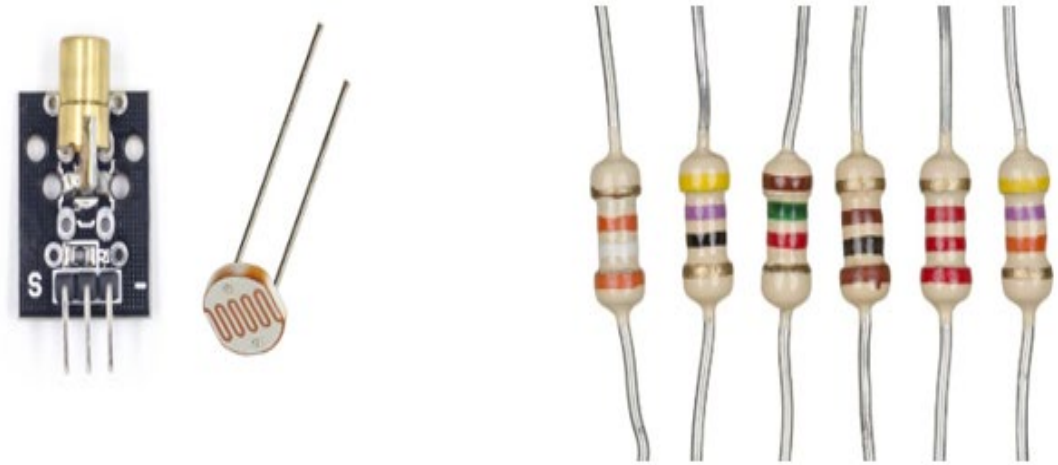

Figure 9. Laser & Receiver with photo resistors

Laser & Receiver are demonstrated in Figure 9. The laser and photo resistor or light dependent resistor are used in this project as a sender and receiver. The working principle is that when a laser (sender) is pointed to photo resistor (receiver), the resistance of photo resistor decreases. When a person passes across and shields the light, the resistance increases, giving a signal to the Nano Arduino that a person has passed across. The laser can work correctly within distance of 2m away from receiver. For resistors, they are used to prevent any large current to flow in the components used because each component has rated value of current that it can handle safely and connected to a resistor (Almazroa et al. 2019). If the resistors are not used, the large current drawn will damage equipment. This makes resistors an important part of this project.

3.2 Circuit Diagram

The circuit diagram of this project represents the overall connection between the used components as shown in Figure 10. As a start, each electrical circuit must have its source of power. For this circuit, power is supplied by a DC source of 5V, and this can be provided by rechargeable electric batteries (which can be installed in remote areas) or directly from single line of electricity after converting it from AC/DC through a USB power adapter which easily available.

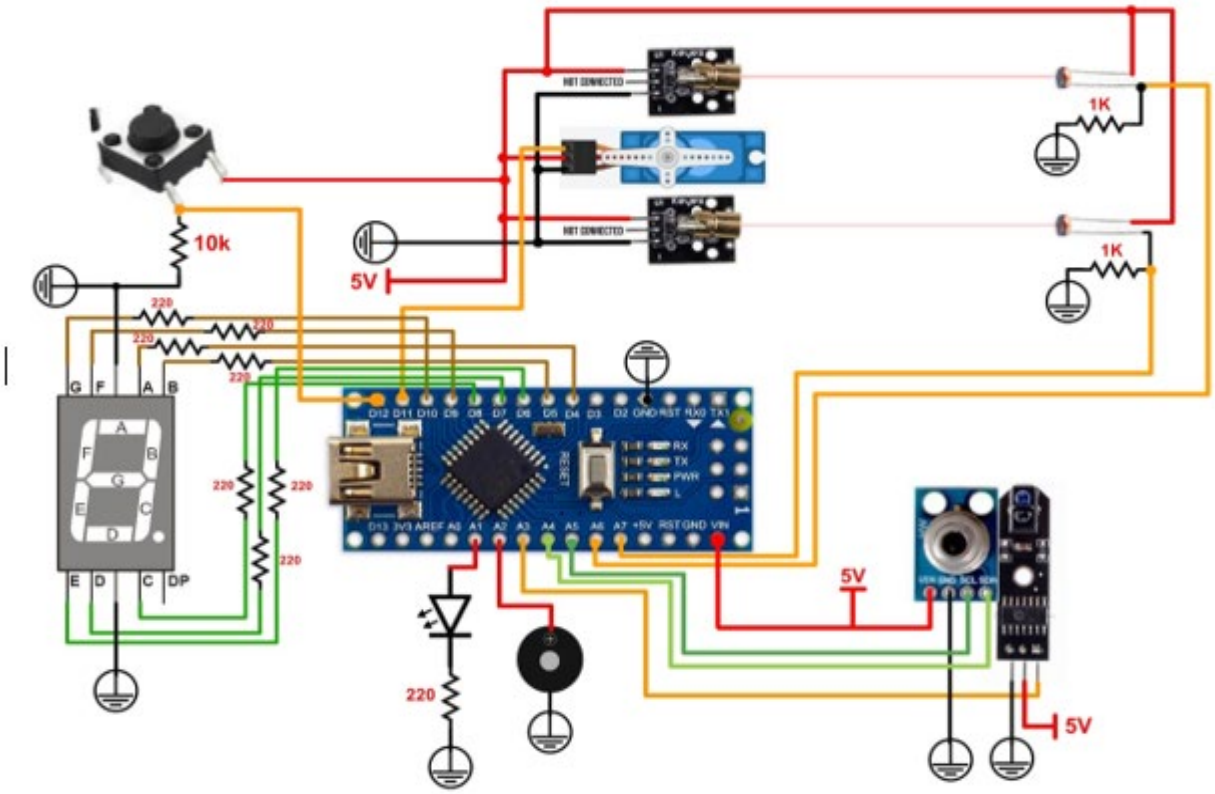

Figure 10. Project's Circuit Diagram

As can be seen in the circuit diagram in Figure 10 above, the Arduino Nano in the center is the brain of the project and a complete code has been built that enables it to control the components. Its operation mode is such that when a person comes, the temperature sensor detects the temperature and sends it to the Arduino, the Arduino analyzes the sent data from the temperature sensor and takes an action.

If the temperature is within the normal range (between 36 and 38 °C) and the room contains not more than 4 people (can be changed in software according to the specific number of people a space can hold), the green led will flash (meaning everything is ok) and the gate will open. On the other hand, if the temperature of the coming person is not in the normal range, the gate will not open in any case. This loop continuous until the specific room reaches its maximum allowed number of people (which we chose for a small room to be five people.), after that, if the sixth person wants to get in the room (although his temperature is normal temperature range.) the gate will not open until someone inside the room goes out. As can be seen, each component is connected with Nano Arduino inputs, some of the components are connected with resistor, which protect the other components from any large currents. Each component has rated current in mA that allows for the selection of a suitable value of resistance in Ω (van Rhoon et al 2015). Also, the screen of showing numbers of people inside the store has letters a, b, c... etc. The Nano Arduino can form any number from zero to nine using the code. If the system is to be installed at a large place which it may contain number of people more than nine, another screen play must be included. There is also a button that allows the person in charge of any store to stop the system for whatever reason. This simple design is used to show the idea and a small motor (micro servo) is chosen that can handle gates that weigh not more than 1.5kg. But, for large gates, another motor must be installing with a mechanical design to work correctly.

4. Result and Discussion

4.1 System Testing and Analysis

The project was tested using both power supply and Arduino & tools as following:

Power Supply

The project was tested using two sets of power supply. First by a 5V DC battery, which is rechargeable, if it is full, it can produce power for 6 hours. Its merit is that it can also connected to solar cell or wind turbines to increase its power.

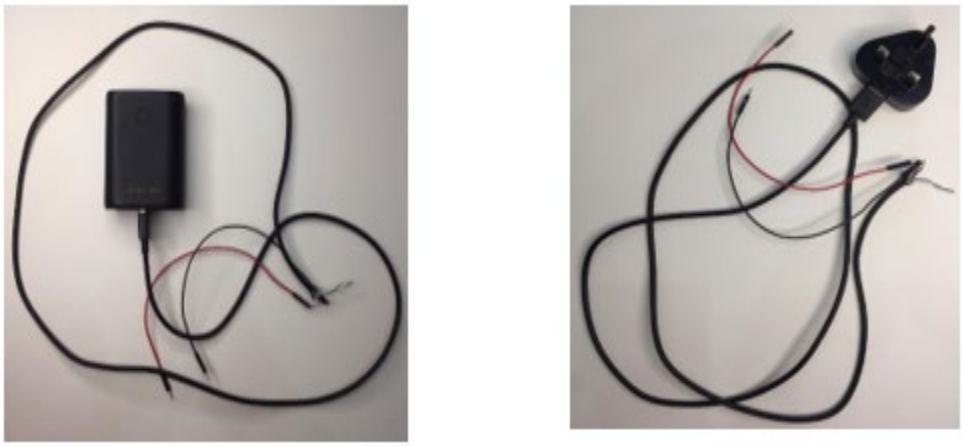

Figure 11. 5V DC Power Bank and Supply

This power bank can be found easily in mobile phone markets and it is not costly. Figure 11. Illustrates a 5V DC Power Bank and Supply. The second power supply to test is a simple USB power adapter connected to our wires. During the testing, we found this power supply ensures that the power supply is available all the time, which matches our project purpose.

Arduino & Tools

The Arduino is the brain of the project, we built the code and tested it with the other components and the result was excellent. Some components, such as the temperature sensor, may not have high accuracy at times due to its quality, but it is possible to develop the project and replace it with a more accurate sensor. We observed the motor and found that after a long period of use it may vibrate a little, which causes minor inconvenience, but this is also due to its low quality and it can be replaced with a motor with better efficiency and quality. The result of the project was satisfying as it was anticipated. We are looking forward into a bigger design in the future. One of the ideas was to put a sanitizer in case if the person's temperature was tested and it appeared less than the normal temperature, then the device would spread the sterilizer in the air in front of the gate, but this was not implemented due to the increase in the overall cost. Figure.12. shows System tools final connections.

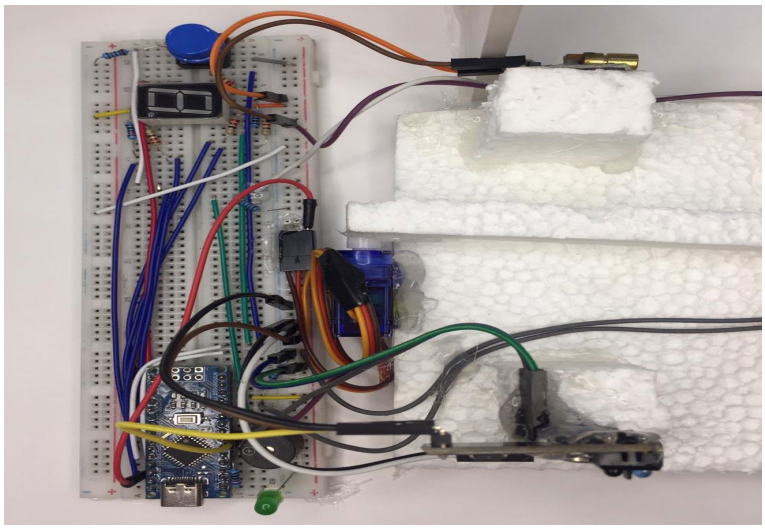

Figure 12. System tools final connections

4.2 Application in Jouf University

The testing and analysis of the proposed system were performed at Jouf University of including an indoor and outdoor environment with a recorded ambient temperature of 35.6 0C Figure.9.

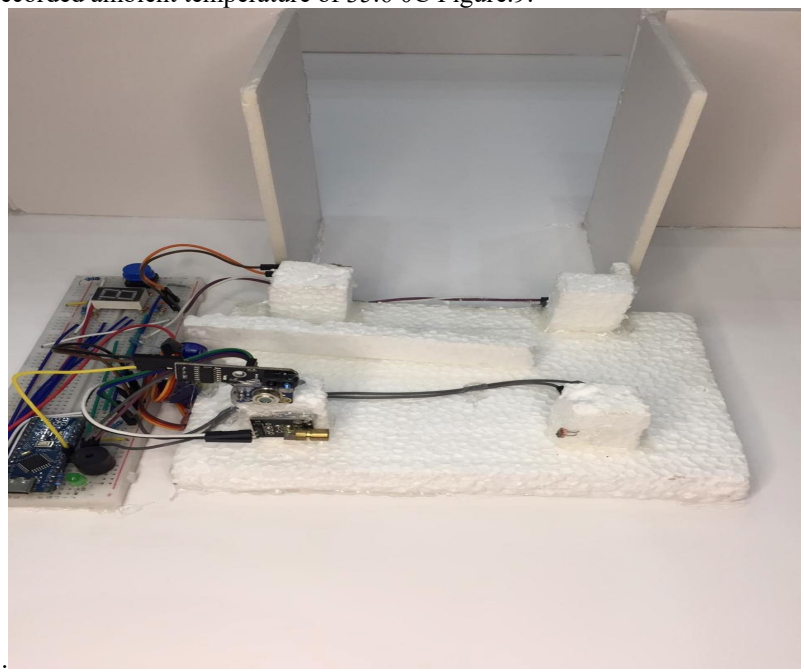

Figure 13. Application in Jouf University

At initial, the collection of data is directly monitored with the Arduino platform and later was transferred to the online portal using wifi. COVID 19 has made a huge impact on society, the new restriction has been imposed as in the number of users allowed in a particular room in the university. In this project, we stimulate a room where such necessary precautions are taken, we make use of a laser diode and receiver to detect the entrance of a person, when the device detects a person at the entrance it measures the temperature of the person if the temperature is less than the set temperature the person is allowed entry otherwise the entry is denied. Only a pre-determined number of people are allowed in the room. The allowed temperature, the number of people allowed in the room as well as the number of people actively present in the room can be set/viewed using a Bluetooth App.

5. Conclusions and Future work

An assumption can be made that the development and building of smart gate based on temperature detection could help reduce the risk of spreading the virus and provide a safe environment for visitors as much as possible. It also helps in identifying the individuals with the symptoms. The education system in world has suffered during COVID-19 pandemic, and by using our electric and electronics tools, we build a project that may save lives from this pandemic. The project is built to be used in every public space, even remote areas. Our project supports the Saudi Ministry of Health in its fight against this pandemic. By providing a system that can test person's temperature and apply social distance. The result shows that the system is working as planned. For future work, we need to increase the size of motor so it can handle with large gates. Also, Iron gates can be replaced by aluminum ones, to reduce its weight for easy handling by the motor. Multi renewable power sources such as wind turbine, solar... etc. can be used in case of remote areas to make sure the system works almost all the time. The proposed design system can be attached to gates in airports, hospitals, subways, schools, train and bus stations, shopping malls, companies, universities, and other crowded places. Finally, with the current global population expansion and the possibility of future pandemics, the world needs to develop automation processes for effective and efficient task performance.

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References

Khayyat, M., and Raafat M., SmartGate system: Automating the detection and control of COVID-19. The 4th International Conference on Future Networks and Distributed Systems (ICFNDS), 2020.
Azmi, F., Gopas P., and Rizki, I., Healthy smart door based on body temperature using arduino uno and fuzzy logic. Infokum 9.2, pp. 236-241, 2021.
Cirrincione, L., et al. COVID-19 pandemic: Prevention and protection measures to be adopted at the workplace. Sustainability, pp.3603. 2020.
Petrović, N., and Đ. Kocić. Smart technologies for Covid-19 indoor monitoring. 2021.
Fusco, A., et al. Blockchain in healthcare: Insights on COVID-19. International Journal of Environmental Research and Public Health 17.19 7167. 2020.
Bollu, G., Auto Temperature Detection System at the Entrance. Available at SSRN 3915495 ,2021.
Al Mamlook, R., Al-Mawee, W., Alden, A. Y. Q., Alsheakh, H., & Bzizi, H. (2021, February). Evaluation of Machine Learning Models to Forecast COVID-19 Relying on Laboratory Outcomes Characteristics in Children. In IOP Conference Series: Materials Science and Engineering (Vol. 1094, No. 1, p. 012072). IOP Publishing.
Almazroa, A., et al., Easy Clinic: Smart Sensing Application in Healthcare, in 2019 2nd International Conference on Computer Applications & Information Security (ICCAIS), pp. 1-5, 2019.
Van Rhoon, G. C., Hyperthermia and the need to monitor temperature, International Conference on Electromagnetics in Advanced Applications (ICEAA), pp. 1181-1185, 2015.
Sohail, A., et al., A review on hyperthermia via nanoparticle- mediated therapy, Bulletin du Cancer, vol. 104, no. 5, pp. 452-461, 2017.
Al Mamlook, R. E., Hashi, Z., Abdulhameed, T. Z., & Bzizi, H. F. Investigating the Male and Older People Susceptibility to Death from (COVID-19) Using Statistical Models. J Biom Biostat, 11, 2020.

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