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Design and Development of an automatic unlocking system to help during medical emergency using mechatronics

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Abstract
In this study, an advanced unlocking mechanism was developed and automated using the concepts of mechatronics for the betterment in medical sciences by providing emergency lifesaving services. The goal of minimizing the time required to provide medical help was achieved after various observations. Equipping the arduino board with a constant 12V power supply, a trial and error analysis was conducted to make the system more efficient, reliable with minimum time delay. Finally, the observed changes with respect to expected changes were noted and discussed.

Keywords: Automation, cardiac arrest, covid-19, unlocking system

1. INTRODUCTION

Nowadays, due to automation, every field is undergoing considerable changes leading them to operate at their peak efficiency. Furthermore, huge transformations have taken place in the medical field, increasing the life expectancy of mankind and better health [1-2]. Advancements in every aspect of life and its services have led to countless health related problems, yet due to the immense growth in technology, these problems have been overcome. But still some problems persist, due to the lack of immediate medical assistance, or due to poor knowledge regarding it.

Cardiac arrest is a sudden loss of blood flow caused by the heart's inability to pump effectively. Signs include loss of consciousness, chest pain and abnormal or absent breathing. If not treated within minutes, it usually results in death [2-5]. Coronary artery disease is the current leading cause of cardiac arrest. The absence of a pulse confirms the diagnosis. Non-traumatic cardiac arrests (CA) occur at home in the vast majority of cases, mostly toilets. The toilet is a confined and private space where CA is common. However, because of the sentiments of privacy connected with this space, the circumstances and causes of CA in the toilet have been rarely examined. Since they are private, confined spaces, detecting collapsed patients early is frequently challenging. According to the study made in 2012, 101 (11%) of the 907 CA patients that were treated over a span of 4 years, sustained CA in the toilet. While only 10% of these patients experienced a collapse, 41% experienced a return of spontaneous circulation (ROSC) [6].

The coronavirus disease 2019 (COVID-19), which is caused by the coronavirus 2 that causes severe acute respiratory syndrome, has spread rapidly over the world. By the end of June 2020, there had been over five million confirmed cases and over 500,000 deaths. The infection is thought to harm the lungs first in coronavirus sufferers, rendering sections of them unable to function properly and those tissues run out of oxygen and stop operating, no longer supplying oxygen to the bloodstream, resulting in silent hypoxia. Normally, the lungs perform the life-sustaining function of gas exchange, supplying oxygen to every cell in the body as we breathe in and expelling carbon dioxide. Healthy lungs keep the blood oxygenated at a level between 95 and 100 percent -- if it dips below 92 percent, it's a cause for concern and a doctor might decide to intervene with supplemental oxygen [7-8]. When hypoxia remains for an extended period of time, it can result in coma, seizures, and even brain death. When the patients are admitted to the wards for external supplemental oxygen, patients are not allowed to shower or defecate in the ward's restroom. Instead they are requested to use urinals and bedpans for defecation. Because of privacy reasons, patients prefer to use the restroom by removing the external oxygen supply which sometimes results in patients collapsing in the toilets due to hypoxia or death depending upon the patient's condition [9-10].

In this study, since time is the most crucial factor here, minimization of it is done by automating the unlocking mechanism by using accurate sensors like PIR and load cell with the help of arduino uno R3 in such a crisis and also by alarming the nearby people.

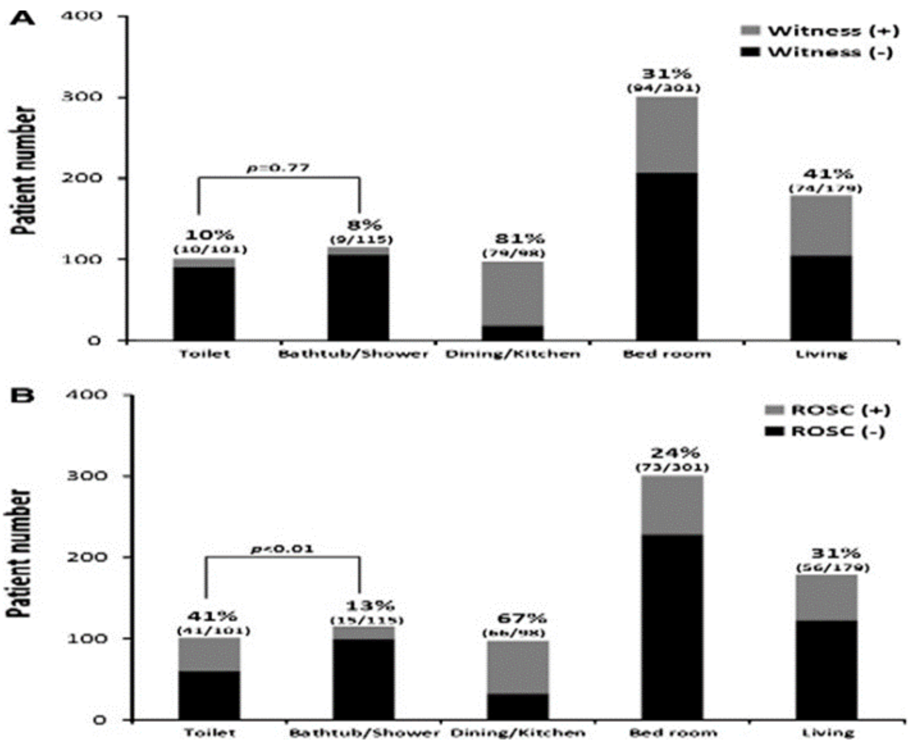


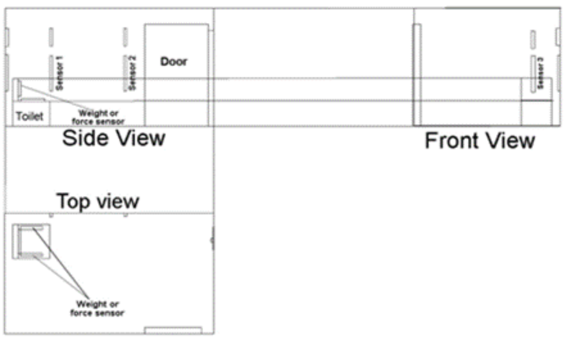
Fig 1. Percentage of cardiac arrest cases in toilets

2. EXPERIMENTAL SETUP AND PROCEDURE

This experiment was conducted on Arduino Uno R3 based on microchip ATmega328P [11]. In this experiment the load cell is placed on the toilet seat which immediatelyFig.2 shows deflection as soon as the person sits on it. A constant 12V supply is provided to it. PIR sensor is attached perpendicular to it approx. 4.5 feet above the ground considering the average height of a person 4 feet in a seated position. The PIR has a range of 3-4 m and higher accuracy than the IR sensor.

The door knob additionally includes a solenoid actuator with an integrated shaft. This shaft moves in a straight line using the push pull technique. Solenoid is powered with 12V power supply and 650 mA. The Piezoelectric buzzer with a frequency range of 800-1400 hz receives signal from PIR and is placed outside the washroom. As soon as the door is locked, the circuit gets completed and starts working. Load Cells on the toilet seat record the initial data of a person sitting on it. The sensors detect weight when a human sits on the seat cover. As soon as the person gets up, the force lowers substantially on the load cell and the person is in range of the PIR sensor, so the door remains closed. If the force lowers substantially on the load cell with no interference in the PIR sensor within a span of 15 seconds which is the delay, a signal is sent to the solenoid which automatically unlocks the door and also sets off the piezoelectric buzzer.

Fig 2. Layout of Automatic Unlocking Mechanism



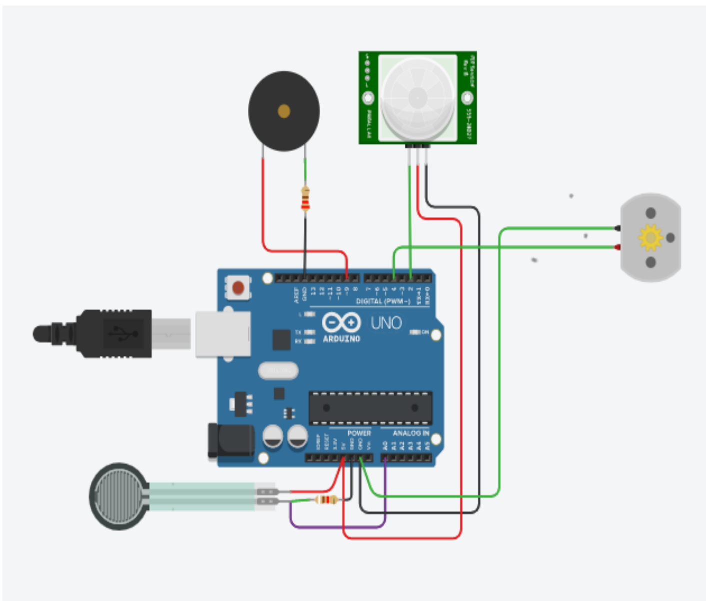


Fig 3. Connections on Simulator

3. RESULTS AND DISCUSSION

It was observed that during particular test cases on Tinker Cad, the outputs obtained were satisfactory and the goal of minimization of time was achieved. In case scenario 1, the load cell registers the weight of the person in a seated position on the toilet seat and because there is no interference in the PIR sensor's range therefore the buzzer is not activated and solenoid is still in locked position as shown in Figure 4.

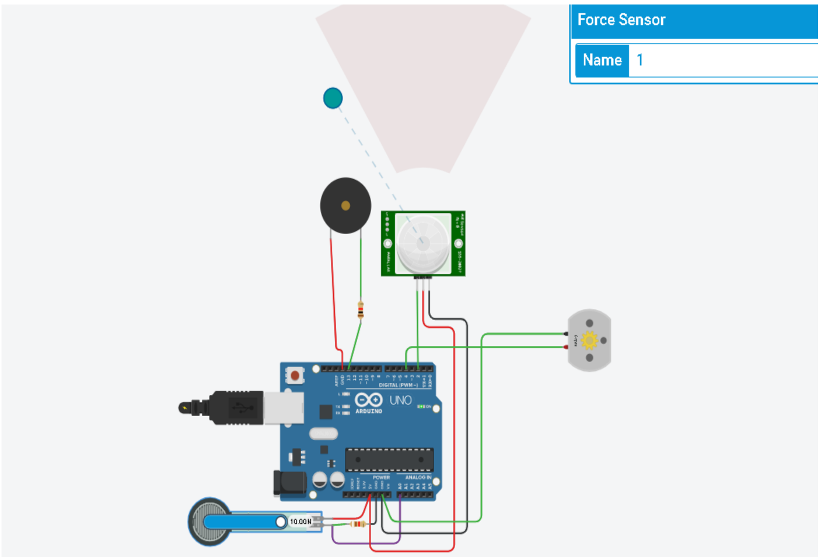


Fig 4. Case scenario 1

While in case scenario 2, the load cell detects the substantial decrease in weight because the person gets up and now there is interference in the PIR sensor's range but the buzzer is still not activated and solenoid is still in manual locking position as shown in Figure 4.

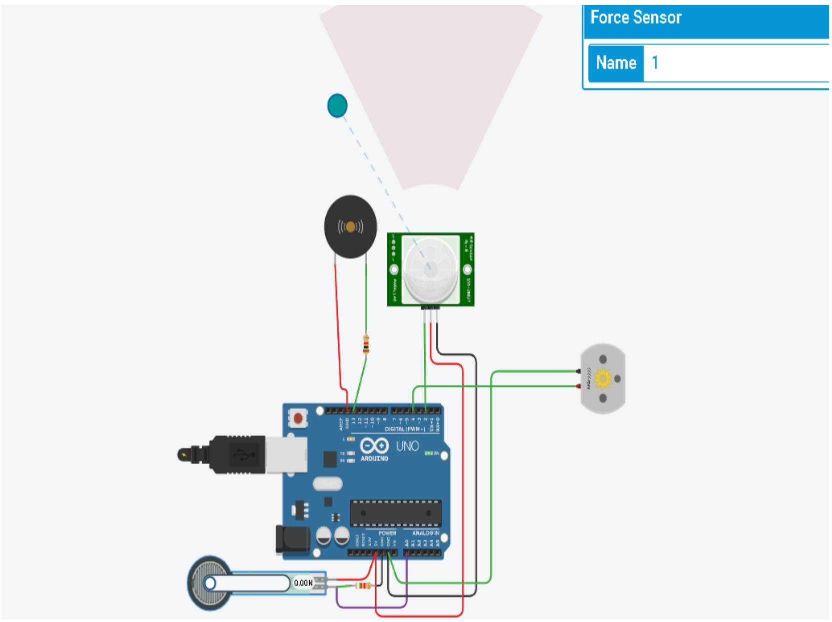


Fig 5. Case Scenario 2

In case scenario 3, if there is drastic change in weight then the load cell will detect the changes but if there is no interference in PIR sensor's range in the span of 15 seconds then the Buzzer is activated and solenoid unlocks the door using automation as shown in Figure 6.

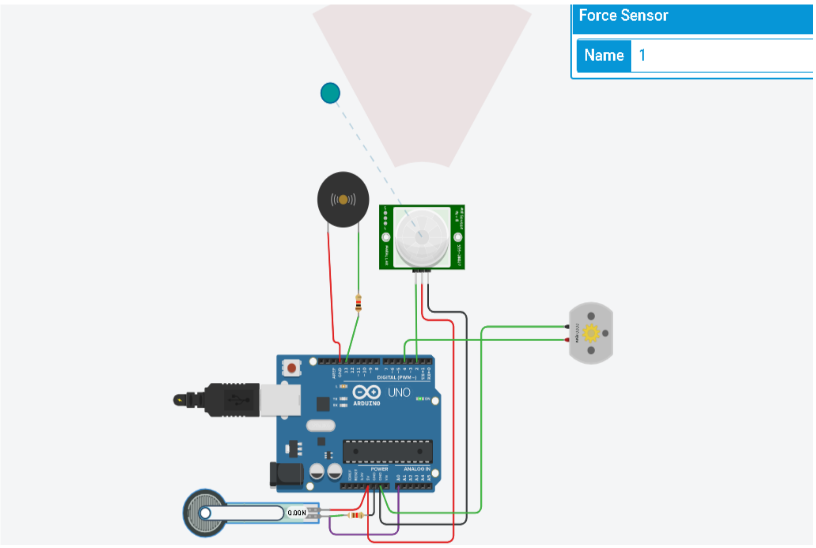


Fig 6. Case Scenario 3

The buzzer met the required alarming sound frequency requirements of 800-1400 Hz as expected. The solenoid worked flawlessly with a 12V supply, and the automation provided by arduino coding worked as well. When significant weight changes were detected, the load cell was successful and only reacted if necessary. PIR sensors have also been proven to be reliable at lower sensitivity levels of up to 4m and higher sensitivity levels of up to 7m. The location of the PIR sensor was determined to be critical because it affected the precise functioning. It was discovered to be ideal perpendicular to the floor after several tests with errors 4.5 feet higher. As a result, a simple impact.

4. CONCLUSION

The unlocking system was automated, and the results were satisfactory within reasonable parameters. All of the components operate smoothly when the system is powered by a 12V power supply. To achieve functionality, minimal components such as the buzzer limited to 3.3V and the PIR sensor limited to 5V were linked using a resistor. The Arduino R3 is programmed in such a way that it satisfies all of the prerequisites. The Tongue Solenoid performs its function flawlessly. This mechatronics system revolutionises dealing with medical emergencies in remote locations such as restrooms, etc. It has enormous future advancement potential, making it a game changer.

5. ACKNOWLEDGEMENT

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REFERENCES

1. Folke F, Gislason GH, Lippert FK, Nielsen SL, Weeke P, Hansen ML, et al. Differences between out-of-hospital cardiac arrest in residential and public locations and implications for public-access defibrillation. Circulation. 2010;122:623–630. doi: 10.1161/CIRCULATIONAHA.109.924423.
2. Hayashi S, Toyoshima H, Tanabe N, Satoh T, Miyanishi K, Seki N, et al. Activity immediately before the onset of non-fatal myocardial infarction and sudden cardiac death. Jpn Circ J. 1996; 60: 947–953. doi: 10.1253/jcj.60.947.
3. Matoba R, Shikata I, Iwai K, Onishi S, Fujitani N, Yoshida K, et al. An epidemiologic and histopathological study of sudden cardiac death in Osaka Medical Examiner's Office. Jpn Circ J. 1989;53:1581–1588. doi: 10.1253/jcj.53.1581.
4. Shigeomi S, Sato W, Enzan K, Yoshioka N. Sudden death during bathing in the elderly. J Jpn Assoc Acute Med. 2001;12:109–120
5. International Liaison Committee on Resuscitation International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Part 4: advanced life support. Resuscitation. 2005;67:213–247. doi: 10.1016/j.resuscitation.2005.09.018.
6. Tossaphon Jaysrichai Load Cells Application for Developing Weight-Bearing Detection Wireless Connection The Open Biomedical Engineering Journal 12(1):101-107
7. Mohd Heikal Husin, Goh Yao Chang, Lim Yang Kwang and Wan Yik Mun. Effectiveness of Sensors for an Arduino Microcontroller: Initial Comparisons. International Journal of Computer Applications 171(2):7-13, August 2017
8. Yordan Hasan, Abdurrahman, Yudi Wijanarko Selamat Muslimin The Automatic Door Lock to Enhance Security in RFID System Journal of Physics Conference Series 1500:012132 DOI:10.1088/1742-6596/1500/1/012132
9. Matsuda M, Watanabe K, Saito A, Matsumura K, Ichikawa M. Circumstances, activities, and events precipitating aneurysmal subarachnoid hemorrhage. J Stroke Cerebrovasc Dis. 2007;16:25–29. doi: 10.1016/j.jstrokecerebrovasdis.2006.09.001.
10. Lionel Lamhaut Christelle Dagron Roxana Apriotesei Caroline Télion Benoît Vivien Pierre Carli Comparison of intravenous and intraosseous access by pre-hospital medical emergency personnel with and without CBRN protective equipment https://doi.org/10.1016/j.resuscitation.2009.09.011
11. Leo Louis, Working Principle of Arduino and Using it as a Tool for Study and Research, International Journal of Control, Automation, Communication and Systems (IJCACS) Vol.1, No.2, April 2016 https://airccse.com/ijcacs/papers/1216ijcacs03.pdf