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AN IOT (INTERNET OF THINGS) BASED SURGICAL BOX STORAGE MONITORING SYSTEM

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Abstract

Generally, the nature of operating rooms is hectic and the staff has a high workload as claimed. Due to this distraction, multitasking, and time pressure, staff who is handling the surgical kit can wrongly arrange or count the surgical items such as swabs or sponges. This could lead to serious problems such as unintended retention of foreign objects (URFOs) in a patient's body during surgery. To overcome these unwanted issues, we have developed an IOT-based surgical box storage monitoring system. This device consists of an ultrasonic sensor, Arduino, Wifi-NRF24L01, and the Blynk application. When the items are arranged in the surgical box they will be counted using an ultrasonic sensor and recorded to the system. After the surgery, the items that are rearranged in the surgical box and disposed into the bin will be counted by referring to the initial data and any error in the data will alert the healthcare personnel via an LCD and the application for immediate action. This is a cost-effective solution that could potentially mitigate any risks of unintended retention of foreign objects which could also improve the concentration among surgeons and staff members when surgery is taking place.

Keywords: Unintended retention of foreign object (URFO), ultrasonic sensor, Arduino, Blynk application.

1. Introduction

In 2018, the most reported avoidable incident with 272 voluntary disclosures by health care providers was the unexpected retention of a foreign object (URFO) incident (Grant et al., 2020). In addition, about 132 incidents were reported to have involved the removal of unintended retention of a foreign object (URFO) leftover from previous surgery, according to summary data of sentinel events reviewed by The Joint Commission (The Joint Commission, 2012). Surgical swabs were the most frequently retained foreign objects.

Despite their rarity, unintentional retained surgical swabs are dangerous to surgery patients because if the swabs are left in the body for too long and if the patient is not infected with any disease, the surgical swab will be classified as clinical waste, or they will be classified as infectious waste if there is a risk of contamination on the patient. It is also costly to hospitals because it requires an x-ray to detect the surgical swabs left inside the patient's body, as well as the inconvenience of opening the wound to potentially remove the swab (Lampe et al., 2004). This issue is currently being addressed by incorporating a thin thread into swabs, which can be seen in a post-surgery x-ray.

Unintended retained surgical items (URFO), most typically swabs or sponges, are errors that occur in surgically invasive environments and are harmful to patient safety. An URFO after surgery is the occurrence of unwanted object retention at any stage following surgery. Examples include retention of a swab, sponge, cannula tip, or guidewire. This knowledge is needed to design safer processes of care and improve patient safety ("Commonwealth of Massachusetts Board of Registration in Medicine Quality and Patient Safety Division Quality and Patient Safety Division, MA Board of Registration in Medicine Performance Data Guidelines," 2010).

Therefore, surgical box storage concept is a suitable solution for reducing the possibility of leaving a swab inside the body in the first place, as well as removing the annoyance of keeping track of the swabs used and also for reducing the probability of these unfavorable outcomes (Steelman et al., 2019). The proposed system employs an ultrasonic sensor as an input, while the number of waste is displayed on an LCD as an output, allowing the user to know the number of waste in the bin without checking it again.

2. Methodology

This chapter will explain the methodology used in developing this project which consists primarily of hardware components, the project's construction, flowchart contents, drawing block diagram of the operating system. The data collection also has been done to analyze the usability of the wrist joint rehabilitation. These methods are used to achieve the objective of the project that accomplish a perfect result.

2.1 Project Design

The project is designed to fit on an operating room trolley and not be too high or too heavy to use. Figure 1 shows an overview of where the project will be used, i.e. placed on an operating room trolley. Figure 2 shows the top view of the trolley. Figure 3 is an overview of the kit part of this project that serves as a place to store swabs before use in surgery. Finally, Figure 4 shows an overview of the Bin section of this project. This Bin section serves as a place to dispose of clinical waste after a surgical session. Both parts are equipped with ultrasound sensors, NodeMCU V3 ESP8266, LCDs, and NRF24L01.

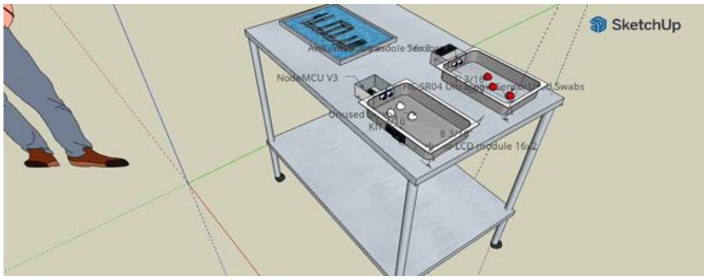

Figure 1: An overview of the project

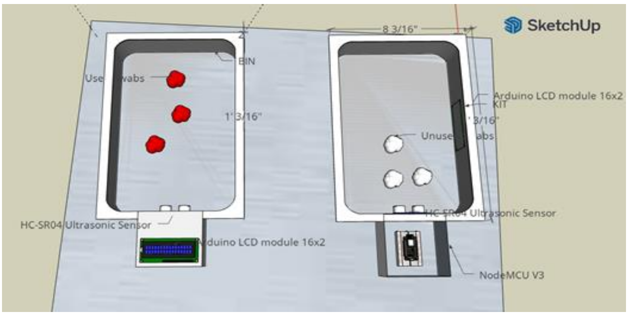

Figure 2: Top view of the project

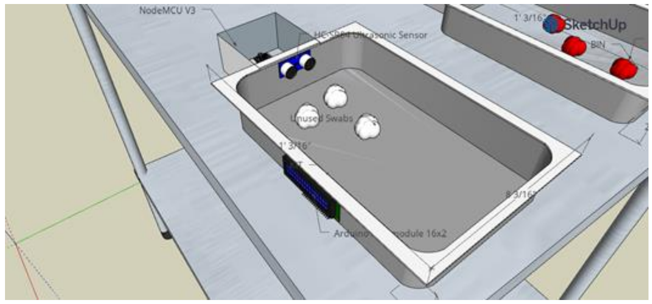

Figure 3: One of the part of the project design (Kit)

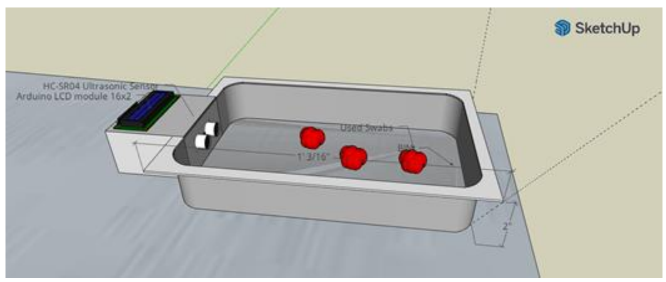

Figure 4: One of the part of the project design (Bin)

Figure 5 shows the circuit of the an IoT (Internet Of Things) Based Surgical Box Storage Monitoring System for both KIT and BIN. One ultrasonic was used to get the range of object detection. The Arduino is links with the NodeMCU as the microcontroller between the hardware and the smartphone. The input voltage fed into microcontroller which is Arduino Uno and NodeMCU then the board will supply the voltage to other components. All of the VCC component will connected to positive terminal, while all of the GND components will directly to negative terminal.

This circuit need one ultrasonic sensors as the input of the device. Then the pin of echo and trig ultrasonic will connect to Digital pin D4 until D5 of NODE MCU ESP8266. Then, the LCD pin of SCL and SDA will connect to Digital pin D2 and D1.

The NodeMCU will link with Blynk App, so for the circuit, we only need two components for NodeMCU which is ultrasonic sensor, and NRF24L01 module. The connection pretty simple, connect all the pin of the component to Digital pin NodeMCU we ready to go to the program then compile to microcontroller based on Figure 6.

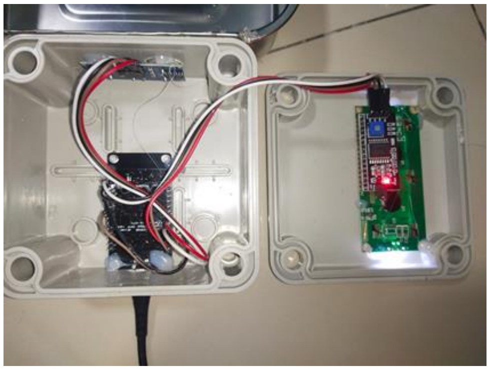

Figure 5 shows the circuit of the an IoT (Internet Of Things) Based Surgical Box Storage Monitoring System for both KIT and BIN

Figure 6 when the system is on

2.2 Block Diagram

The block diagram of the project design, shown in Figure 7, consists of two inputs and outputs, and one microcontroller. The main processor is nodeMCU. The ultrasonic sensor detects an obstacle in the storage container as the input. During the process, make sure the Wi-Fi connection is on and in stable condition for the NRF24L01 ready to start in real-time through a mobile application processing and transmitting the data. As for the output, the LCD, to give a little information. Also, for the part of the IoT application, the Blynk apps will display the data and send a notification to users.

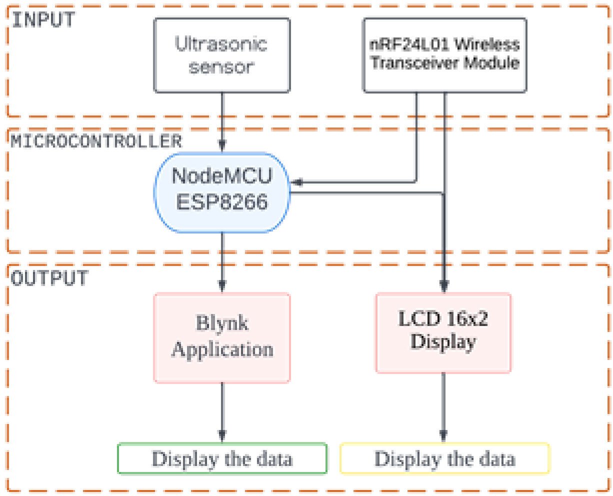

Figure 7: Electronic Components in the an IoT (Internet Of Things) Based Surgical Box Storage Monitoring System

2.3 Flowchart

Figure 8 shows the process that will be implemented in the kit and bin of the an IoT (Internet Of Things) Based Surgical Box Storage Monitoring System. Both kit and the bin will start by turning on the power supply connect with Wi-Fi NRF24L01. If the connection is successful, it will initialize on NodeMCU. If the connection is not successful, you need to start again with the power supply. Next, the process data will begin and the LCD will display the data as the output. the Blynk application will be function as a notification to notify the user if the data on the bin is the same as the data on the kit. If it is successful, it will end the process.

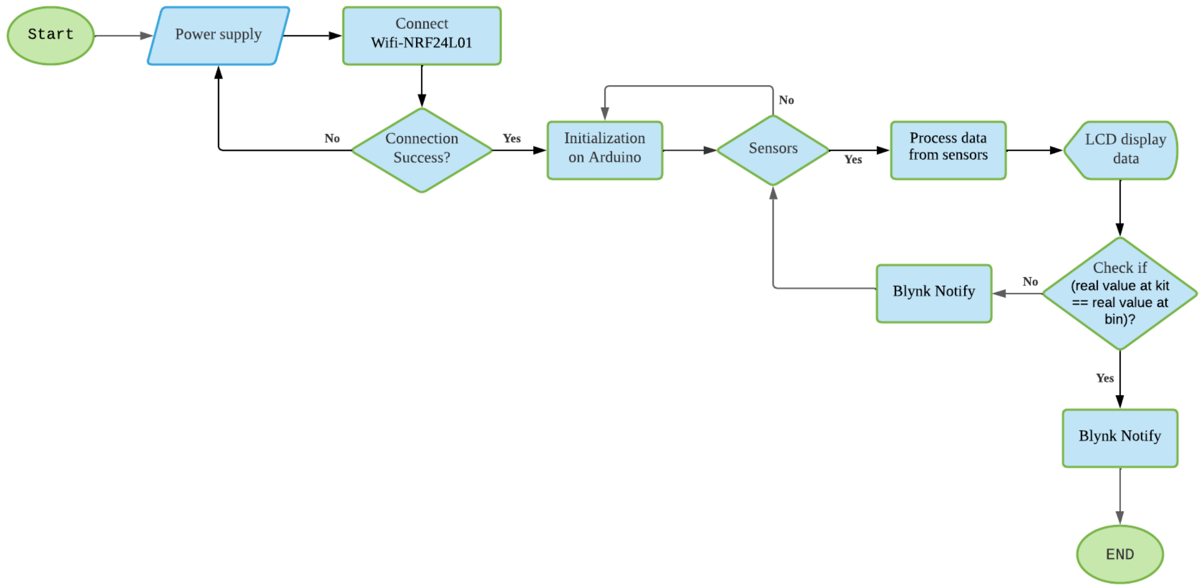

Figure 8: Flowchart Function Project

2.4 Data collection method

Data collection is the process of gathering, measuring, and evaluating correct insights for study following defined, accepted techniques.Three methods are used to acquire data. We have created a series of questionnaires, a project experiment, and procedures for conducting the experiment on the subject. The data collecting flowchart is shown in Figure 9.

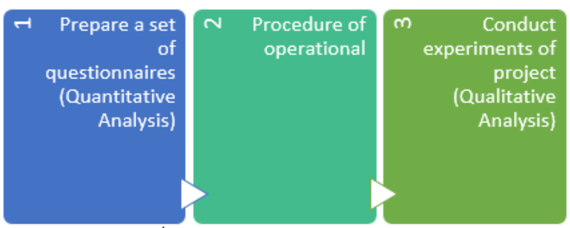

Figure 9 Flowchart of data collection

2.4.1 Questionnaire

We created a questionnaire to collect data and responses from Google Forms. Because of the COVID-19 pandemic and the lockdown, we only have a few options for obtaining this result. As a result, we created a Google Form questionnaire as one of the ways to interact with the public. We successfully received 25 responses to this survey. It is divided into two sections: pre-survey and post-survey.

Figure 10 Overview of questionnaire

2.4.2 Experimental of Ultrasonic Sensor

In this step, the ultrasonic sensor was tested to make sure it works as planned and to find out how much different the measured value is from the actual value. The sketch is simple, and it uses the Serial Monitor to show the distance measured in centimetres. The performance of the sensor was measured by slowly changing the distance between the transducer and the object being looked at from 1 cm to 21 cm. Figure 11 shows how the NodeMCU and ultrasonic sensor are hooked up and ready to test for each distance thought about.

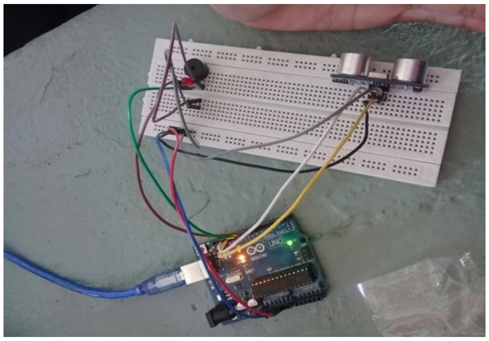

Figure 11 Testing the Ultrasonic sensor

3. Result and Discussion

3.1 Experiments of Project

This research looks into how an ultrasonic sensor works. The information gathered is summarised in Table 1. The result of the ultrasonic sensor, the real distance value between the measured distance value, is shown in table 1.

Table 1: Analysis of Ultrasonic Sensor: Measured Distance(cm) VS Actual Distance(cm).

	Average Measured value (cm), x	
Actual Distance (cm), y	**Ultrasonic Sensor 1 [Kit (Cm)]**	**Ultrasonic Sensor 2 [Bin (Cm)]**
2	1.9	2.0
4	3.8	4.0
6	6.0	6.1
8	8.1	8.0
10	10.1	9.9
12	12.2	12.1
14	13.9	13.9
16	16.0	16.0
18	18.0	17.9
20	20.1	20.2

Table 1 displays the ultrasonic sensor analysis, which is the difference between the actual and measurement values. The following conclusion can be drawn from the analysis of the experimental results: to develop an accurate obstacle detection system capable of integrating sensors. In the case of Table 1, the closer the sensor is to the object, the more accurate the measured value. In this regard, the relative error of the ultrasonic sensor did not exceed 5.8 percent, which is the value appropriate for use in this project. As expected, the output of the ultrasonic sensor is highly dependent on the accuracy of the calculated distance. In a nutshell, the ultrasonic sensor is the best sensor to use for this project.

4. Conclusions

The outcome for this project is the users e.g. surgeons and staff members can focus on doing surgery operations without any problems. It is also cost-effective and a highly reliable system as it has additional services such as the Surgical Box Storage Monitoring System Based on IoT are interfaced with an android application to keep track of the history of the medical swabs used in every operation and a notification will be sent to the surgeons or staff members when the LCDs display does not show the same number on both part (the surgical kit and the bin). This product also acts as a one-stop unique solution to reduce the risk of URFOs (Unintended Retained Foreign Objects) and can improve patient safety in the facility's perioperative department (Operating Room). By defining this project well on the background, problem statement, objectives, scope, and significance of the project in proper structure without letting out any highlighted issue. Also, electronic devices are known as complex things to human beings. We as a user can make it better and positive to their life by following the requirements and purposes.

5. Acknowledgment

We would like to express my sincere thanks and gratitude to my supervisor, Madam Pushpa, for letting me work on this project. We are very grateful to her and all the lecturers from the Electrical Department for their support and guidance in completing this project. We are also thankful to my parents as well, because we were able to successfully complete this project with the help of their guidance and support. Finally, I want to thank all my dear friends as well. It helps me a lot in finishing the project.

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