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CSE 321: Project 3

Fall 2020

Touchless Hand Sanitizer Dispenser

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Introduction

Amidst the global pandemic, it is advised to wear masks, maintain social distancing, and minimalize any type of physical contact. On top of that, it is advised to wash our hands frequently and use hand sanitizers to keep ourselves and our surroundings sanitary. This project involves building of a prototype that dispenses hand sanitizer without any physical contact. This project falls under the “Safety” category since it promotes minimalizing physical contact as well as healthy sanitizing habits. This prototype uses a pumping sanitizer bottle attached to a servo motor which is triggered by waving in front of the ultrasonic distance sensor. The servo motor is then used to pull down on the pump to dispense the sanitizer.

Project Requirements

Features

The Touchless Hand Sanitizer includes the following:

- Ultrasonic Distance Sensor
- Pumping Hand Sanitizer Bottle
- Servo Motor
- Two LEDs
- Reset Button

This prototype of a touchless hand sanitizer dispenser uses two key components: the ultrasonic distance sensor and a servo motor. The servo motor is connected to the top of the pump of the hand sanitizer bottle. The RED led is turned ON to indicate that the system is off and not dispensing. The ultrasonic distance sensor constantly checks to see if there is an object in front of it. Whenever there is an object in front of it within a certain distance (3 inches), it triggers the servo motor and the GREEN led is turned ON. The GREEN led ON is to indicate that the system is on and the sanitizer is being dispensed. The servo motor then pulls on the pump to dispense the sanitizer. Once that is done, the GREEN led turns OFF and RED led turns ON. This means that the dispenser is ready to be used again. The sensor constantly checks for objects in its path and the dispenser keeps dispensing until the object is removed from the path.

Specifications

- Inputs:
    - Waving of an object in the front, within a certain set distance (3 inches), of the ultrasonic distance sensor
- Outputs:
    - Triggering the ultrasonic distance sensor that will signal the servo motor to turn on which will ultimately result into dispensing of the hand sanitizer
    - Green LED light is to indicate when the prototype is dispensing the sanitizer and Red LED light is to indicate when the prototype is not dispensing the sanitizer. In other words, whenever the system is in idle state it will have the Red LED turned ON. Whenever the system turns on, the red LED will turn OFF and the green LED will turn ON. After the dispensing, the system will go back to the idle state unless triggered again.
- Constraints:
    - The dispenser cannot dispense sanitizer if the object, in front of the sensor, is farther than 3 inches.
    - It is not as fast as traditional automatic sanitizer dispensers.
    - Based on the design, only one specific hand sanitizer bottle would work.
    - The current design does not exert enough pressure for a full pump of the sanitizer so multiple dispenses might be needed to get enough sanitizer for one use.

- Functions:
    - This prototype will dispense hand sanitizer every time an object is waved within the set range of the ultrasonic distance sensor.
    - It is totally touchless and will function without any physical contact
    - It will even function in the dark.
    - It will reduce any wastage of sanitizer as well as promote safe and sanitary practice.

Design Process Review

Block Diagram

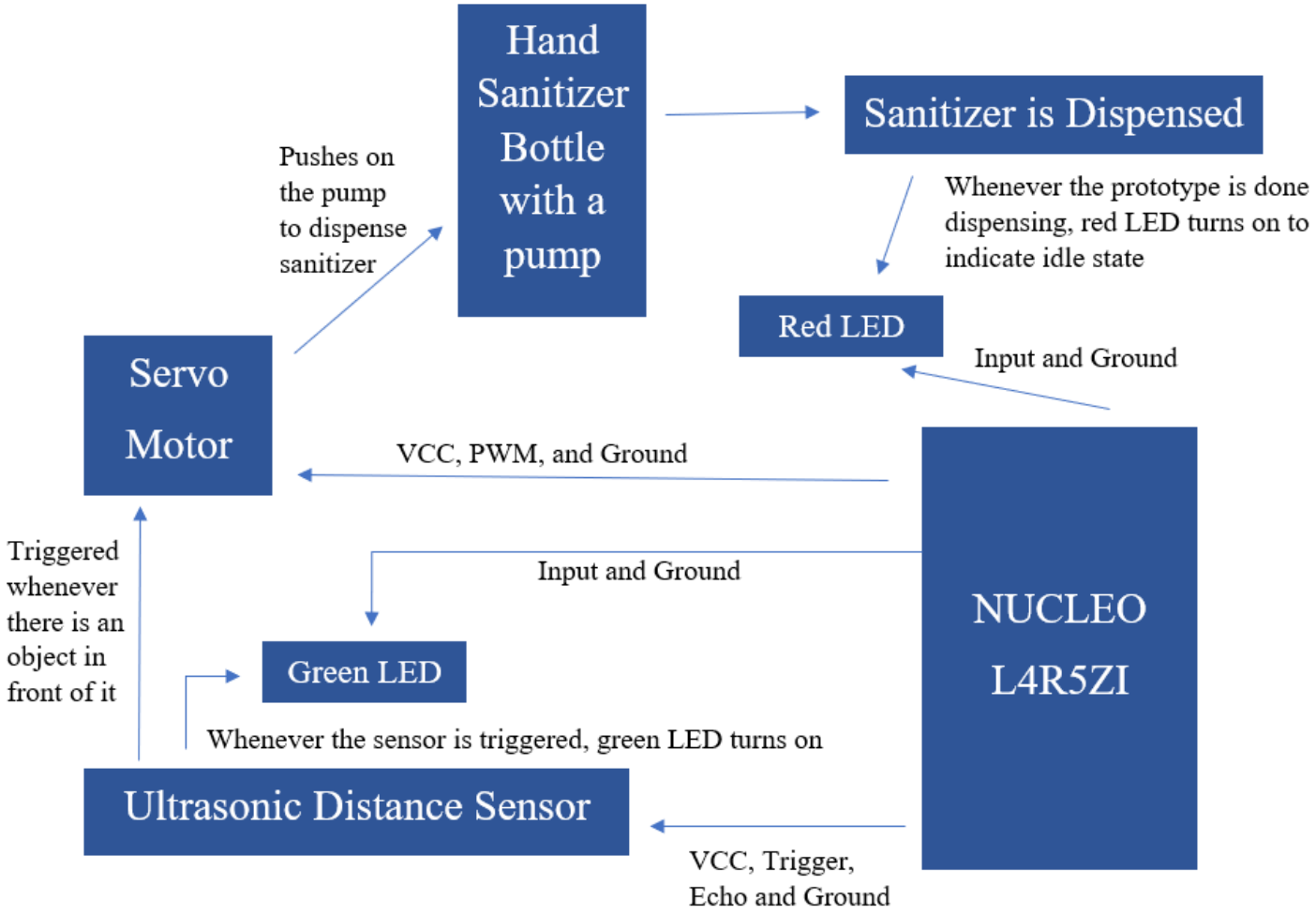

Figure 1: Shows the block diagram of the prototype of the touchless hand sanitizer dispenser

System Diagram

Flowchart

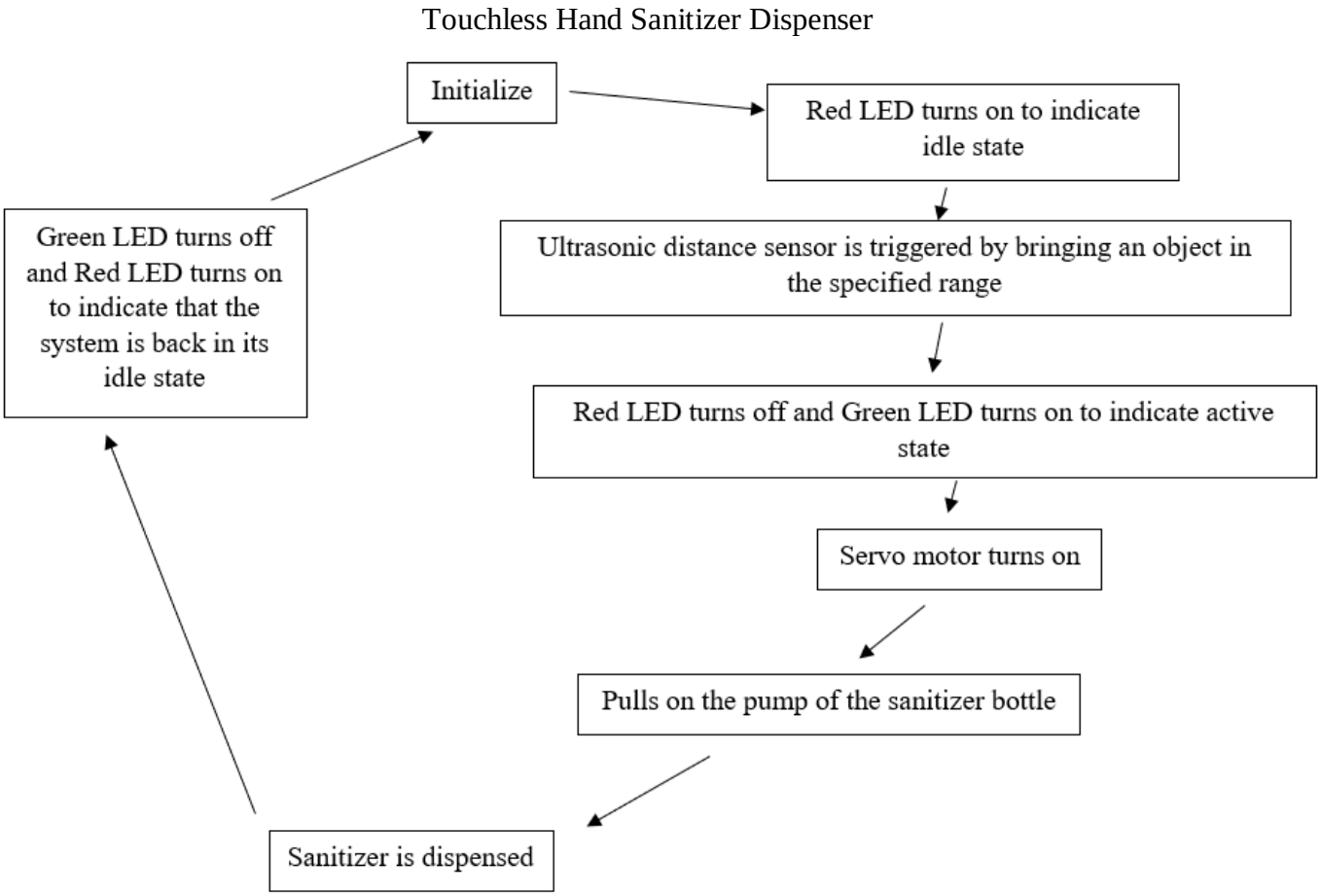

Figure 2: Shows the System Diagram (Flowchart) of the prototype of the touchless hand sanitizer dispenser

User Instructions

Bill of Materials

- CSE 321 Mechanical Components
    - Nucleo-L4R5ZI
    - Micro-USB Cable
    - Breadboard
    - Ultrasonic Distance Sensor (HC-SR04)
    - Servo Motor (SG90)
    - Jumpers/ Wires
        - Standard Male to Male Wires
    - One Green LED
    - One Red LED
    - Four 1 kOhm Resistors

- Components to Build the Prototype
    - Pumping Hand Sanitizer Bottle
    - Duct Tape
    - Scissors
    - Fishing Line/ Thin strong thread (~Length of 50 cm)
    - Cap of a lip balm (Chapstick brand or something similar)
    - 1/16-inch Drill
    - Plastic Container
    - One Screw Eye Hook

Schematic

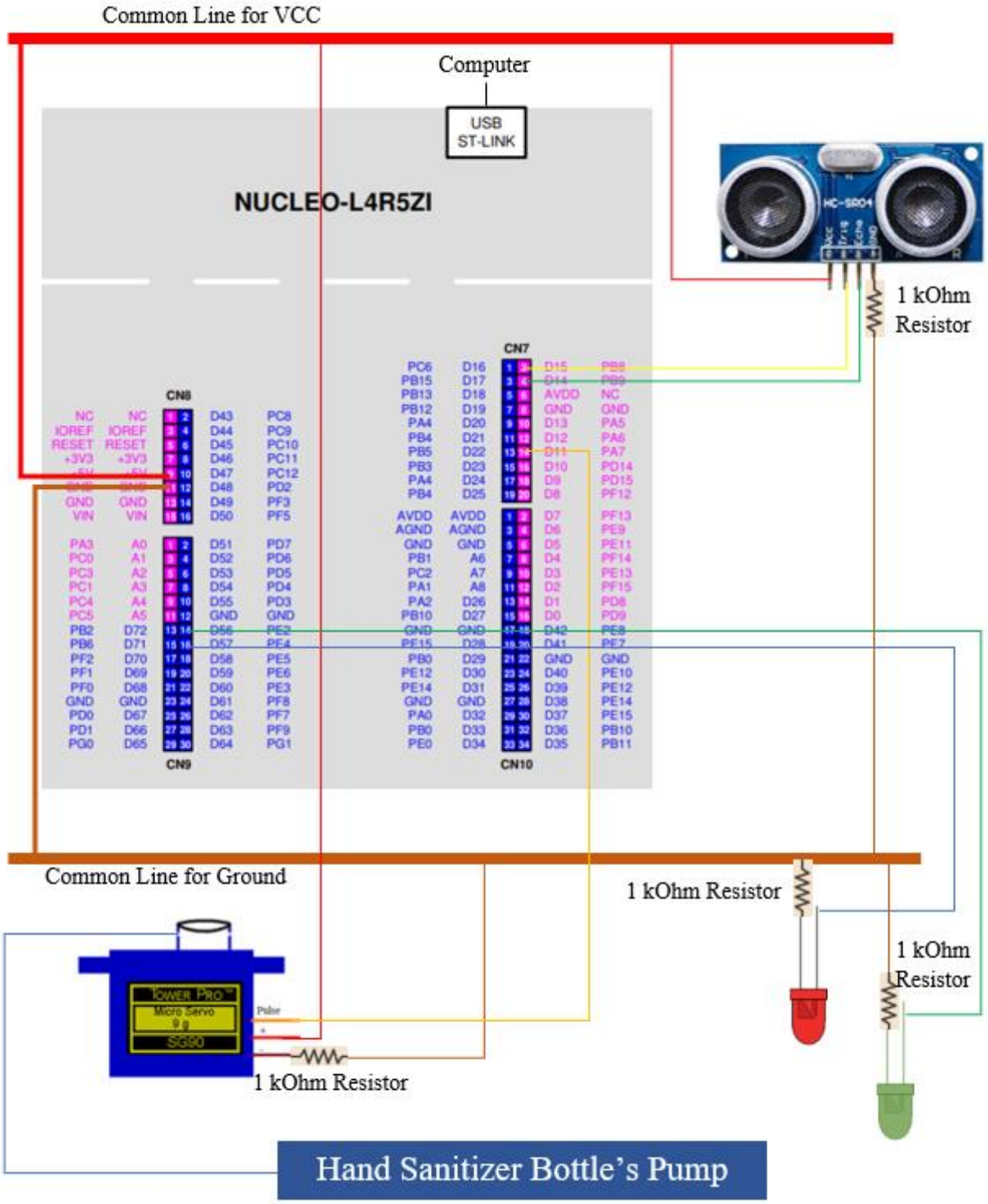

Figure 3: Shows the schematic of the project

Setup Instructions

Figure 4: Shows the finished prototype

Before beginning the construction, please refer to Figure 4. It shows the built prototype and that is how the built system is supposed to look like.

Steps to build the prototype:

1. The plastic lip balm cap was attached to the top of the pump of the hand sanitizer bottle using duct tape.
2. A hole was made straight through the cap (from left to right of the sanitizer bottle) that is attached on the bottle using the 1/16-inch drill as shown in Figure 5.
3. A hole was made using the same drill on the right side of the plastic container, big enough to contain the sanitizer bottle, to insert a screw eye hook through.

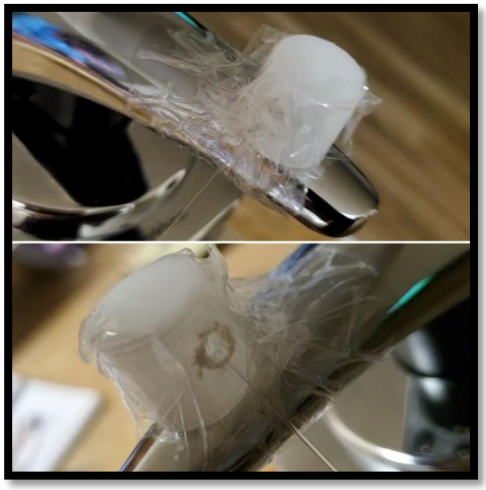

Figure 5: Shows the finished product from step two.

4. Servo Motor was then taped to the left side of the container so that it stays in place.
5. Hand sanitizer bottle was then placed in the plastic container and taped so that it stays in place.
6. A fishing line/thread was then connected from the screw eye hook to the servo motor after it was passed through the hole made in step two as shown in Figure 5. The fishing line was then tied on both ends (the screw eye hook and the servo motor) as shown in Figure 6.

Figure 6: Shows the finished product from step six.

7. The servo motor was then connected to the Nucleo board and the rest of the schematic was implemented as shown in Figure 3.

Guide to Use the System

Once the system is built and the prototype is completed along with the whole schematic from figure 3, the user can build the code on Mbed Studio. Make sure that the JSON file is present before the building process. Once the code is built, red LED will turn ON which indicates that it is ready to use. The user can then wave in front of the ultrasonic distance sensor. If the distance is less than 3 inches, red LED will turn OFF and green LED will turn ON. It will then trigger the servo motor which will then pull on the pump of the sanitizer bottle. This will result in dispensing of the sanitizer. After one pump, the green LED will turn OFF and the red LED will turn ON which means that the system is ready to use again assuming that the object is

removed from the sensor's path. If not, the green LED light will stay ON and the system will continue dispensing until the object is removed from the path.

Test Plan

Analysis Plan

1. Test the functionality of the Ultra Sonic Sensor
    - What? : We are testing the functionality of the Ultrasonic distance sensor.
    - Why? : We need to ensure that it is triggered when an object crosses its path at a certain length because it is vital for the functionality of a touchless dispenser.
    - How? : Once it is implemented, an LED will be used to test the output. If the LED lights up, it can be concluded that the Ultrasonic distance sensor works as intended.
2. Test the functionality of the Servo Motor
    - What? : We are testing the functionality of the Servo Motor.
    - Why? : Servo motors are primarily responsible for the pulling of the string. These strings are crucial in the dispensing process of the sanitizer.
    - How? : This will be tested by checking to see if the servo motor moves according to the way it is programmed.
3. Test to find the optimal angle of rotation for the servo motors
    - What? : We are testing to find the optimal angle of rotation needed for the servo motor to push on the pump and get maximum output.

- Why? : The optimal angle of rotation is needed so that it is able to push on the pump. If it is not optimal, the pressure would be low and not enough to push on the pump which will result into little to no dispensing of sanitizer.
- How? : Once the design is implemented, the code will be modified and tested with various angles to determine the optimal angle to maximize the pressure on the pump.

4. Test to see if the distance measured by the Ultrasonic distance sensor is accurate
    - What? : We are testing to make sure the distance measured by the ultrasonic sensor is accurate.
    - Why? : The most important part of this prototype is for it to function without any physical contact. If there is inaccuracy in distance measurement, it can result in a lot of inefficiency in terms of its functionality.
    - How? : This will be tested using a printf statement. Every time the sensor is trigged, it will print the value of the distance in inches. This will help us ensure that there are no major discrepancies in distance measurement.
5. Test to see if the watchdog timer is implemented correctly
    - What? : We are testing to see if the watchdog timer is implemented correctly.
    - Why? : We are using this to ensure that the system resets after every 30 seconds just in case there are any issues with the system.
    - How? : This can be tested using printf statement. Every time the Watchdog timer resets, it prints out “Reset.” The red LED also blinks once whenever there is a reset. This will ensure that the watchdog timer works as intended.

Test Plan

The analysis plan was determined in Stage 5 of the project. The components from the analysis plan were tested using these following test procedures.

1. Red LED ON indicates that the system is in idle state and not dispensing sanitizer. Green LED ON indicates that the system is in active state and is currently dispensing sanitizer. When an object is waved within 3 inches of the ultrasonic distance sensor, the red LED will turn OFF and green LED will turn ON.
2. When the sanitizer is done dispensing, the green LED will turn OFF and the red LED will turn ON.
3. When an object is waved within 3 inches of the ultrasonic distance sensor, it will print the distance, in inches, on the screen.
4. When an object is waved within 3 inches of the ultrasonic distance sensor, it will trigger the servo and the servo will start rotating 180 degrees and back.
5. Pressing the RESET button will print “Reset” because it is resetting the whole system and it will cause the red LED to blink once.
6. When the Watchdog timer resets, the red LED blinks once.
7. When the servo is triggered, it will pull on the pump of the bottle causing the sanitizer to dispense.

Revision History

Date	Revision	Changes
31-October-2020	Initial Definition of Problem/System	– Initial Start
2-November-2020	Stage 2 Close Out	– Repository was created – Project was determined based on the initially given constraints and requirements – Initial constraints and specifications were determined for the design
9-November-2020	Stage 3 Close Out	– The ASKS for the project were determined (purpose, inputs, outputs, and constraints) – Bill of Materials was created – Initial Plan for the project was created – A rough draft of the design was devised
16-November-2020	Stage 4 Close Out	– The required parts were ordered
23-November-2020	Stage 5 Close Out	– The required parts were received – Watchdog timer was implemented – Analysis and Testing Plans for the design were determined
10-December-2020	Final Submission Deadline	– The ultrasonic distance sensor was implemented and tested – The servo motor was implemented and tested – Watchdog timer was tested along with the ultrasonic sensor and the servo motor implemented – The prototype of Touchless Hand Sanitizer Dispenser was built – The prototype was tested – The documentation for the project was completed

Future Design Considerations

Shortfalls for System Design

No system is ever ideal from the beginning. There are many changes that could be made to improve the design of this prototype. But most importantly, in this design, the pressure exerted on the pump is not enough which results into little amount of sanitizer dispensed. This is due to the torque/ power of the SG90 servo used. A few modifications, such as using a stronger servo or multiple SG90 servos, can be used to resolve the issue of the pressure. It still supports the goal and falls under the "Safety" category. However, it is not as efficient as expected. A design that not only promotes healthy sanitary habits but is also efficient at the same time would be an optimal design.

Communication Feature

This project can be improved if Serial Peripheral Input (SPI) is used as a part of the interface implementation. SPI can be used for communication with SPI slave devices such as FLASH memory, LCD screens, and many other modules and components. It is also very fast compared to UART and I2C. The current prototype of this sanitizer looks very unaesthetic and complicated. An individual, without any knowledge of the peripherals, would not know what exactly it is and does or how it functions. In the future, SPI communication method can be used to program a TFT LCD screen with information regarding how the prototype works and or what each peripheral is with their respective functionality explained briefly.

Memory Management

This project is straightforward and simple. Therefore, there is not much memory management involved in this project. To promote good memory management in this design, 0 was returned at the end of the main function to reduce any memory leaks. It may not play a big role in this project but there could be potential leaks if the project involves complex memory management. This would even make the debugging process, related to memory, easier. If this project had memory management involved, the usage of the malloc method to allocate memory would definitely be avoided. Any typical prototype of a touchless hand sanitizer dispenser with similar peripherals would usually require allocations of small chunks of memory, if applicable, for the most part. Therefore, malloc is not very space efficient. It would be better to allocate them in arrays. This would make the system efficient since a lot less memory will be used.

Direct Memory Access

Direct Memory Access (DMA) is a very useful tool that helps us increase the speed, efficiency of our system by directly connecting our peripheral address to a location in memory. As mentioned above, there is not much memory management involved. However, if there was then directly connecting the servo motor to a location in memory would make the program much faster and more efficient. The CPU would be eliminated in the connection which would make the whole system much faster and efficient overall.

Improvement Recommendations

As previously mentioned in “Shortfalls for System Design” section on Pg. 16, the pressure exerted on the pump is not enough. In order to fix that, a stronger servo or multiple SG90 servos can be used. But apart from that, there is a better way to implement the ultrasonic distance sensor. The implementation method used for this project only uses a timer and is slow. However, there is a method that uses a timer along with interrupts which is much faster. This method might not make a significant impact for this project but it will definitely improve the performance.

References

- CSE 321 Lecture Slides and example .cpp files
- UM2179 User Manual
- RM0432 Reference Manual
- Mbed Website/ Documentation
- Image for the HC-SR04 Schematic:
    - https://i5.walmartimages.com/asr/7f2bf884-b4f7-46b2-911e-24eca31dd7fe.ae147668bf8322fd595658a876923065.jpeg?odnWidth=undefined&odnHeight=undefined&odnBg=ffffff
- Image for the Servo Motor and the Resistor Schematic:
    - https://www.electronicshub.org/wp-content/uploads/2018/09/How-to-make-a-Simple-Servo-Motor-Tester-Circuit-Circuit-Diagram.jpg
- Image for the LED Schematic:
    - https://cdn.sciencebuddies.org/Files/2864/5/Elec_img082.jpg