Arduino UNO Bottle Opener/Unscrewer

Overview

This project is a basic bottle unscrewer involving two Arduinos that communicate via the I2C/Master-Slave technique, which are able to simultaneously and automatically reset each time the task is complete. The aim of this project comes from the idea of helping disabled people to open things that they may not physically be able to, or the elderly who could perhaps have lost the strength to open ordinary containers. The project involves a servo and motor which combine to open the bottle, as well as a light sensor under the bottle stand, and an ultrasonic sensor to check that something has truly been placed upon the stand. We also incorporated 2 LEDs to show the user when the light sensor and ultrasonic sensor have been triggered respectively, and a piezo speaker which aids the user in knowing when the task is complete and will reset, and they can remove the bottle from the stand or swap it for a different bottle.

The Two Arduinos (Slave-Master)

For this project, we decided that the “Master” Arduino would be the one connected to all the input components, and therefore taking readings (note: this Arduino also has LEDs as outputs for ease of use). The “Slave” Arduino is therefore the one with all the output devices that can actually open the bottle, and this Arduino is purely controlled by the “Master” based on the input readings it finds.

Serial Monitor

To begin with in this project, we used the serial monitor in the code for both the master and slave Arduinos. This was important early on to test the critical values of light and distance that we would use to call future functions. While we could have removed this code when we had finalised these values, we decided to leave this in for two reasons: a) We may want to alter the critical values based on different environments (e.g. a dim room) and so we would need further testing and b) The serial monitor can be a really good educational tool for the user who may not have much knowledge of both the software and hardware and they can understand a bit about how the project works through this.

Light Sensor

In the design we have a circular stand that the bottle rests upon, and underneath this stand is a light sensor. When the value given by the light sensor is dim enough, a red LED lights up and a function called checkDistance is called that checks the distance received by the ultrasonic sensor. We were able to tweak our critical values for the calling of this function through checking the light reading on the serial monitor and picking a value that would minimise calling this function accidentally in a standard lit-room, but would accurately and with certainty be called if a bottle was indeed placed on the stand.

The light sensor worked really well for this prototype, however the only problem that could arise is in low-lit/dim conditions where the Arduino would always be triggered and call the next function. To solve this, in the final project we could instead use another ultrasonic sensor, or perhaps a motion sensor. These would both be able to recognise a bottle being placed regardless of lighting conditions.

Ultrasonic Sensor

Facing close towards the bottle stand we set up an ultrasonic sensor. When the checkDistance function is called, the ultrasonic sensor sends out a sound wave that, upon hitting a barrier, will bounce back and be picked back up by the sensor. It can then use the time it takes for this sound wave to bounce back to calculate a distance. With the help of code from a site called howtomechatronics.com, we were able to experiment and implement this checkDistance function so that we could calculate the distance in cm that the bottle is away from the ultrasonic sensor. We decided that given a distance less than 10cm, we could be sure that something was actually on the bottle stand and ready to be opened.

We therefore set the code up so that the distance is found and then a function called bottleAvailable is called. This function will only do something if the distance variable is less than 10. When this occurs, a green LED will light up along with the red LED and a transmission will begin between the 2 Arduinos. The “Master” Arduino taking in these distance and light readings will send the distance to the second “Slave” Arduino which will then know that a bottle is there and can initiate the opening procedure.

LEDs

As mentioned previously, there are two LEDS, one red and one green. The red LED lights up when the light sensor becomes dim enough, and the green LED lights up whenever the red LED has been triggered AND the distance read by the ultrasonic sensor is small enough. This allows for ease of use for the user, as they can see exactly when each sensor is triggered, and they can not only realise when the opening procedure will be underway (i.e. both LEDs are lit), but they could also see what went wrong should the procedure fail to start.

Servo

The servo is wired to the “Slave” Arduino and is triggered when this Arduino receives a positive distance value from the “Master” Arduino. A motor is attached to this servo which needs to move up against the lid of the bottle. Through trial and error, we found that a range of motion of 70 degrees was perfect for this project. Therefore, when the “Slave” Arduino receives a positive distance value from the “Master”, the servo (and therefore the motor) will turn clockwise 70 degrees towards the bottleneck.

Motor

The motor is upside down and has a gear attached. When the servo has completed its swing, the motor will start spinning anticlockwise (i.e. clockwise when looking down upon it) for 3 seconds seconds which will open the bottle.

Piezo Speaker

This speaker was a useful addition to the project in allowing the user to know when it is safe to remove the bottle and that the servo and motor have reset. It plays a two-tone melody 3 seconds after the servo has moved back into its original position of 0 degrees.

Breadboard

On the “Master” breadboard, we had the light sensor attached to pin A0, the ultrasonic sensor trig pin attached to pin 9, and the ultrasonic sensor echo pin attached to pin 10. We also had the red and green LEDs attached to pins 12 and 13 respectively. We used 560 Ohm resistors for the LEDs, a 2.2k Ohm resistor for the light sensor, and the ultrasonic sensor does not require a resistor.

On the “Slave” breadboard, we had the servo attached to pin 3, the motor attached to pin 9, and the piezo speaker attached to pin A2. The motor also required both a transistor and a diode, and we used a 2.2k Ohm resistor for the motor which was attached through the middle leg of the transistor. Both the servo and the piezo speaker did not require resistors.

In both cases, we colour-coded our wires where possible, using red for 5V connections, and black for ground connections. We managed also to colour code some, but not all, of the components as we were unable to access the lovelace lab during the strike to get more materials (such as coloured wires).

The Build

For the build, we started with a short cut-off of a tin can as a stand to rest the bottle on. In the centre of this stand we had the light sensor. We then used a weighted shoe box to which we glued the servo and motor at cap-height of a standard 1L bottle upon the stand. We also used another shoebox perpendicular to the stand/servo/motor which we glued the ultrasonic sensor to. We used female-male wires on all our components to allow them to reach their specified areas.

The build worked really well for this prototype however in the final version we would prefer to make an incorporated wooden bottle stand that has all the components together in one portable object. We could also then drill holes to feed all the wires through, and have compartments to store the two Arduinos, as the extra-long wires looked fairly messy in this model and could be tidied further this way.

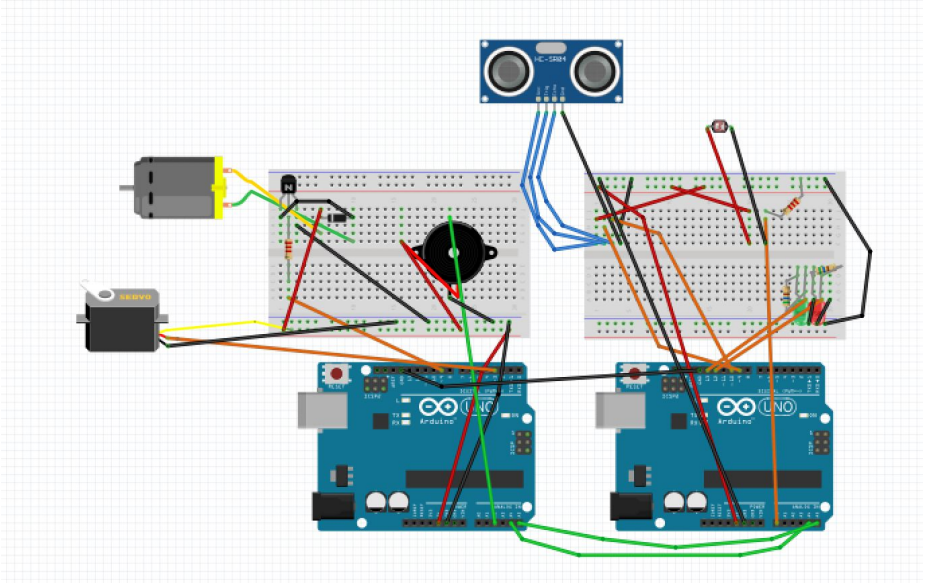
Improvements for the Final Build

I believe this project provided a solid proof of concept, and with some alternate components and materials, this could quite easily become a useful project in the real world outside of the computer science lab. There are 2 main ways we could improve this project. The first is allowing the freedom of compatibility with all plastic bottle sizes and shapes. The second is allowing more tightly screwed on bottles to be opened through this project.

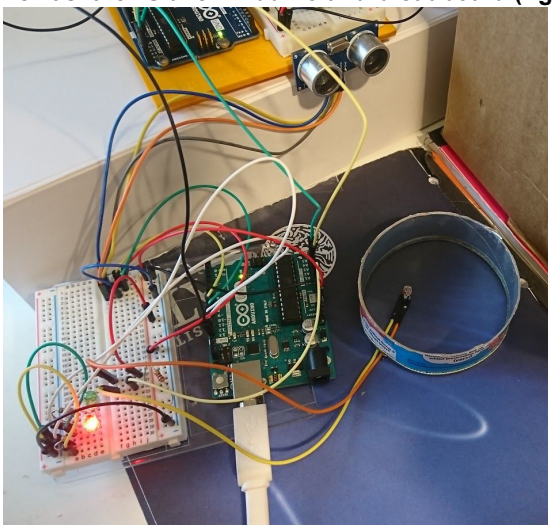
In the first case, we could for example have the ultrasonic sensor aiming at the bottleneck of the bottle and use this information to alter the swing of the servo arm depending on how close or far away the neck is (i.e. how wide the cap is in this case). We did originally think of this idea when designing and testing our project but in the end decided it was out of the scope for the materials we had. We could also then add a second ultrasonic sensor that looks straight down on the bottle stand to measure the height of the bottle. We could then adjust the motor height to account for these shorter or taller bottles. This would probably involve a robot arm rather than attempting a three-dimensional double servo solution.

In the second case, for trying to unscrew more tightly capped bottles, we would likely need a way to hold the bottle in place while the cap is unscrewed. For this, we believe the solution would be a robot arm at the base of the bottle stand which would contract to hold the bottle, while a second robot arm at the neck of the bottle can unscrew the cap with a much higher torque than a geared motor ever could.

Schematic of our bottle-opening project (created using fritzing.org)



Photos showing the "Master" Arduino and breadboard (left), with bottle stand and all components, as well as the "Slave" Arduino and breadboard (right) along with the piezo speaker



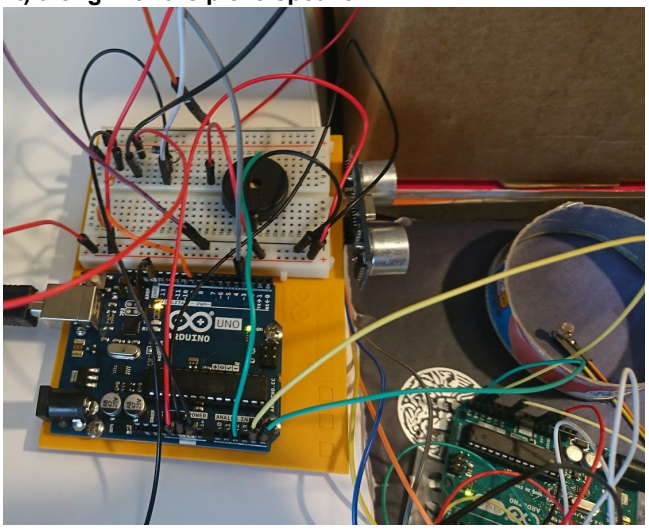


Photo showing the entire project including the servo and motor of the "Slave" Arduino