

CS321 – Group 11:

Automated Item Dispenser Report



Motivation for Project:

The allocation mechanism of hardware lab is a problem whose shortcomings are clearly visible to us in college:

- It was necessary for students to issue equipment during the time instructor was available. There were several instances where students had to make multiple rounds to obtain lab equipment.

- Currently, student equipment allocated records are maintained on multiple registers. This makes it hard to track down equipment allocation and hampers equipment retrieval.
- The record maintenance and allocation of equipment sometimes creates confusion. As an example, during the sensor allocation of this project, some sensors were allocated to a certain group but given to another.

As such, we felt there could be considerable improvement in this regard through the introduction of an automated item dispenser. We had limited experience working on a hardware-based project before and felt this project would allow us to explore different sensors and understand their working.

Brief Description of the Project

The Automated Item Dispenser aims to provide ease of usage for both the stakeholders – professor and students. It allows for efficient weekly lab item dispensing and authentication of the student. For instructors, easy restocking of machine and well as alerts on malfunctions and low supply provide easy usage. The project thus streamlines the process of issuing weekly lab equipment for all involved.

Features of the Project

There are two types of stakeholders for the project – the professor and students. The features of the system for each are explained below:

Professor:

1. He/She is required to log into the system by entering the correct password through the matrix keypad. An incorrect password redirects him/her back to the main menu.
2. On entering the correct password, the professor has three options. The first option allows him/her to set weekly issues for students, i.e., the count of each type of item that is to be issued for the weekly assignment.

3. The second responsibility is to refill/ add items to the automated item dispenser. We have three different types of items to dispense: up-down counters, multiplexers and wires. Each item has been assigned a colour (red, green, blue respectively) to be detected on the colour sensor. The professor is required to scan the item on the color sensor and place it in the correct slot.
4. The third job of the professor is to, at end of each week, update which group has returned how many items in our software. This enables him/her to keep account of currently issued items for each group.

Student Groups:

1. Each group has a group leader whose RFID is registered in our database. The student needs to scan his/her RFID on the RFID scanner. In case of an invalid RFID, we redirect him/her back to the main menu.
2. On correct RFID scan, the dispenser looks at the item count for each type of item to be issued and dispenses them one item at a time from the dispenser using Archimedes' screw principle explained in the working section
3. The student is required to pick up each dispensed item from the collection area within 10 seconds of being dispensed, or else a mail is sent to the professor informing the student has left without picking up the item.

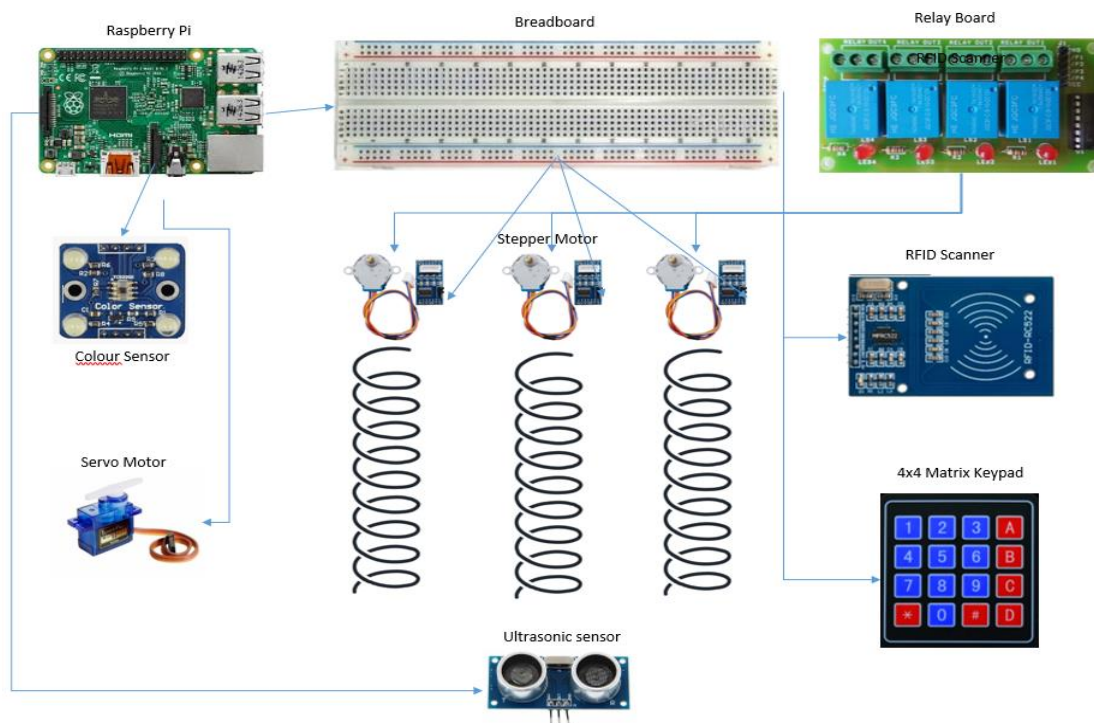
Recovery Mechanisms and MQTT:

1. We have set up MQTT from Pi to a main server which then sends a mail to the professor using MQTT protocol in case of a system or user failure.
2. If one the stepper motors stops working or there is some error in the spring and the item fails to dispense, a mail is sent to the professor indicating which row of items are facing the issue.
3. If the quantity of a particular of item is less than what needs to be issued to a student, a similar mail is sent highlighting which type of items need refilling.
4. If an item is dispensed by the machine but the student fails to pick it up within 10 seconds, we assume the student has left and inform the instructor through a mail to clear off the collecting tray.

Working of the Project:

Our project utilizes the following sensors:

- Stepper Motor - x3: Drive the coils for item dispensing; 1 rotation of the motor (360 degrees) corresponds to 1 item being dispensed
- Ultrasonic Sensor: Verification of item dispensed
 - If item is not dispensed, alert sent to prof
 - If item dispensed but not picked up, alert sent to prof
- Servo Motor: Opening and closing the door for access to item dispenser restocking --> Only accessible by professor
- Colour Sensor: Distinguish between different items (to be replaced by QR code for scaled up version) while the professor is restocking the item dispenser to allow the database to be updated correctly
- RFID Scanner: Student/group authentication (with ID card) prior to authenticate weekly item dispensing
- Matrix Keypad: User input to drive the menu-based program (1-9 to select different options, B for Backspace, * for Enter)



Circuit Layout

To communicate user and system error, we use MQTT and SMTP protocol. The Raspberry Pi is a publisher to a MQTT subscribed central server (that ideally handles all error related reporting from multiple vending machines). Upon receiving an error report from the vending machine, the central server sends an automated mail to the professor using SMTP protocol. The emails are tailored according to the specific error that has occurred.

The dispensing mechanism is based on helical spring connected to a stepper motor in the back. 1 item is placed in each gap between the windings of the coil. As the stepper motor rotates, it incrementally pushes all the items forward. This is achieved by the Archimedes screw-based mechanism, where the part of the coil that is rotating downwards is a little ahead of the part that is touching the ground. As the helix rotates, this part pushes the items forward steadily. Crucially, 1 complete rotation of the stepper motor results in only 1 item being dispensed; helping ensure that the quantity of items dispensed can be reliably fixed.

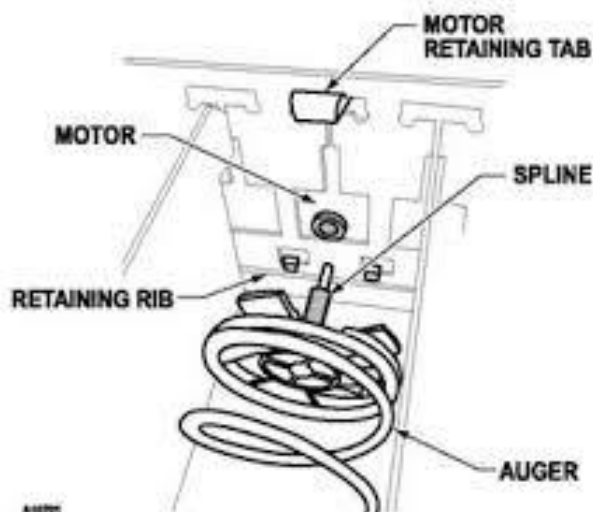


Figure 8. Auger Timing

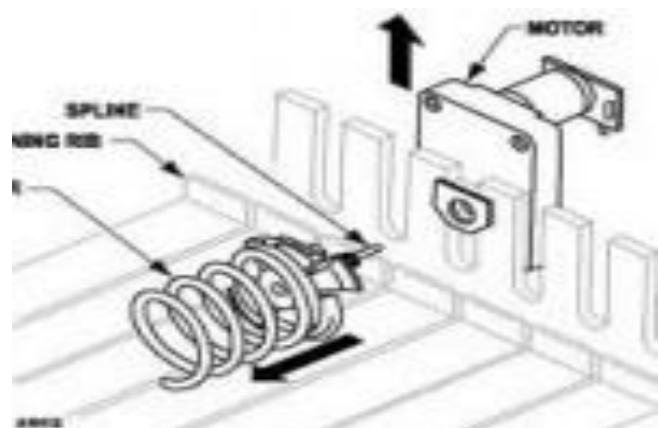


Figure 5. Auger Timing

Drawbacks:

- 1) We expect the student to not keep moving his hand in front of the proximity sensor while the dispensing is proceeding. Ultrasonic sensor is not 100% reliable and might give wrong distance readings at times.
- 2) The instructor is expected to place one item in the right slot after each scan. Failure to do so will result in inconsistent counts being maintained by the software and the item dispensed machine.
- 3) Scalability: For each slot we require a separate stepper motor, which becomes cost inefficient in the long run. The idea is to have a motor which moves across the slots then latches onto the respective slot. Due to time constraints, such a mechanism could not be implemented.
- 4) The servo door is an open loop system, i.e. if the servo door fails, there is no fail safe. This can lead to potential security problems as the door may not lock properly and can be left ajar by the professor.

Future Scope:

- 1) Returning feature: Right now, our dispensing machine dispenses item, but the returning must be done to the instructor who then refills the machine. Further we can have a feature where when a student scans his RFID card, he has an option to return the item by inserting it in the right slot through an opening created by movement of another motor.
- 2) Automatic insertion: Currently, the professor, after placing the item on color sensor, needs to place the item in the right slot by themselves. In future, we can have a system, where the professor, after scanning the item, can simply place it in the slot and based on the type of item scanned, a motor moves it to the right row.
- 3) The dispensing verification could be replaced with plate connected to a force transducer as opposed to an ultrasonic sensor. This would allow easier and reliable verification of item dispensing as currently some items dispensed are not registered due to the unreliability of the ultrasonic sensor.

Conclusion:

The automated item dispenser was developed to ease the lives of both students and professors for weekly lab equipment dispensing. It enables students to obtain their weekly lab assignments as per their convenience and prevents professors from having to maintain lengthy paper trails to track hardware lab inventory. As such, the item dispenser helps digitize the lab inventory and truly brings the Hardware lab into the 21st century.