Boston University
Electrical & Computer Engineering
EC463 Capstone Senior Design Project

First Prototype Testing Report

Blitz

Team 7
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1.0 Summary

Our first prototype test focused on validating basic hardware and software functionality as well as each system's ability to interface with each other. Hardware functionality was tested through the addition and removal of four items: 1.0 gal of apple juice, two identical 16.3 oz jars of peanut butter, and a 6.25 oz bag of chips. Three unique sequences of item addition and removal were followed to test the system's adaptability. Following the addition or removal of any item, the shelf's recorded inventory in mydb.shelf in MySQL Workbench was compared with the actual inventory on the shelf. This test's measurable criterion for success was that the shelf inventory represented in the SQL database matched the actual inventory on the shelf at all points during the test. Our setup and testing procedure were identical to those laid out in the test plan.

2.0 Materials

2.1 Hardware

1. ESP32 Module
2. HX711 AD Module
3. 4 x 50kg Half Bridge Load Cells
4. 3D Printed Load Cell Mount
5. Breadboard
6. Jumper Wires
7. 3' x 1.5' Plywood Board (Shelf surface)
8. Objects of known weight (apple juice, 2 x peanut butter jar, bag of chips)
9. Laptop (for power and to host local server)
10. USB to Micro USB (for power and data transfer)
11. Linksys Router

2.2 Software

1. Arduino IDE Calibration Sketch
2. Arduino IDE Weight Testing Sketch
3. Node.js Server (server.js)
    a. This server received data from ESP32 through a UDP socket and sent inventory data to the frontend using an HTTP get request
4. HTML File (index.html)
    a. This file received inventory updates using an HTTP get request and displayed a visual of the database

3.0 Set Up

3.1 Overview

Hardware setup consisted of positioning the load cells on their plastic bases and placing the composite shelf on the array of four load cells. In addition, we connected the load cells to the HX711 and connected the HX711 to the ESP32. We connected the ESP32 and the node.js server via UDP sockets. The node.js server had access to the SQL database, which tracked the items on the shelf. The inventory could be viewed in browser at localhost:3000.

3.2 Hardware Procedure

1. Attached each load cell to its plastic mount
2. Connected the load cells to each other and to the HX711 and connected the HX711 to the ESP32 according to Figures 1 and 2 in section 3.4
3. Placed the 3’ x 1.5’ plywood board atop the 4 load cells
4. Uploaded the Calibration_Sketch.ino to the ESP32 via a USB to Micro USB cable
5. Placed 1lb. peanut butter jar onto the scale while the sketch was running; determined the correct calibration factor
6. Uploaded the First_Prototype_Testing_Sketch.ino to the ESP32
7. Adjusted the calibration factor in First_Prototype_Testing_Sketch.ino to the determined calibration factor
8. Took 1lb. peanut butter jar off of the scale

3.3 Software Procedure

1. Started Node server (node ./LabTest_1/server.js)
2. Opened localhost:3000 in browser
3. Observed weight changes using the update button

4.0 Testing

4.1 Procedure

1. Completed hardware and software set up procedures according to sections 2.2 and 2.3
2. Opened mydb.shelf in MySQL Workbench and ensured that the stored weights of each item to be placed on the shelf were correct
3. Removed all items from the shelf before running the testing sequences
4. Ran Sequence 1
    a. After each item was placed on or removed from the shelf, we clicked the update button in the browser to update the UI
    b. Marked “Yes” only if the expected inventory matched the inventory in the UI
5. Ran Sequence 2 in the same manner as Sequence 1
6. Ran Sequence 3 in the same manner as Sequence 1

a. After all items were placed on the shelf, we clicked the update button in the browser and marked whether or not the inventory in the UI was accurate
b. Removed all items from the shelf, clicked update, and noted the accuracy

4.2 Measurable Criterion

Table 1: Item Name and Weight

Item Name	Weight
Apple Juice	4.15 lbs
Peanut Butter	1 lbs
Chips	0.39 lbs

Table 2: Sequence 1

Item Name	On/Off Shelf	Expected Inventory of Apple Juice	Expected Inventory of Peanut Butter	Expected Inventory of Chips	Accurate Inventory (Yes/No)
Apple Juice	On	1	0	0	Y
Apple Juice	Off	0	0	0	Y
Peanut Butter 1	On	0	1	0	Y
Peanut Butter 2	On	0	2	0	Y
Peanut Butter 1	Off	0	1	0	Y
Peanut Butter 2	Off	0	0	0	Y
Chips	On	0	0	1	Y
Chips	Off	0	0	0	Y

Table 3: Sequence 2

Item Name	On/Off Shelf	Expected Inventory of Apple Juice	Expected Inventory of Peanut Butter	Expected Inventory of Chips	Accurate Inventory (Yes/No)
Apple Juice	On	1	0	0	Y
Peanut Butter 1	On	1	1	0	Y
Peanut Butter 2	On	1	2	0	Y
Peanut Butter 1	Off	1	1	0	Y
Peanut Butter 2	Off	1	0	0	Y
Chips	On	1	0	1	Y
Apple Juice	Off	0	0	1	Y
Chips	Off	0	0	0	Y

Table 4: Sequence 3: All On, All Off

Item Name	On/Off Shelf	Expected Inventory of Apple Juice	Expected Inventory of Peanut Butter	Expected Inventory of Chips	Accurate Inventory (Yes/No)
All items	On	1	2	1	Y
All items	Off	0	0	0	Y

4.4 Schematic Diagrams

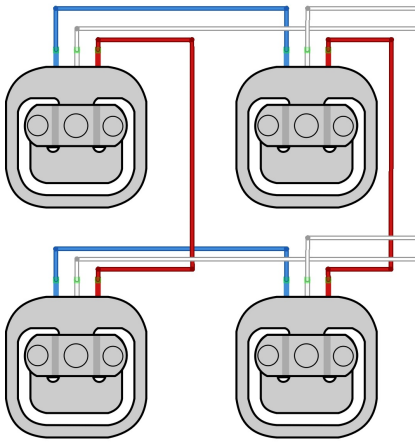

Figure 1: Load Cell Wiring Schematic

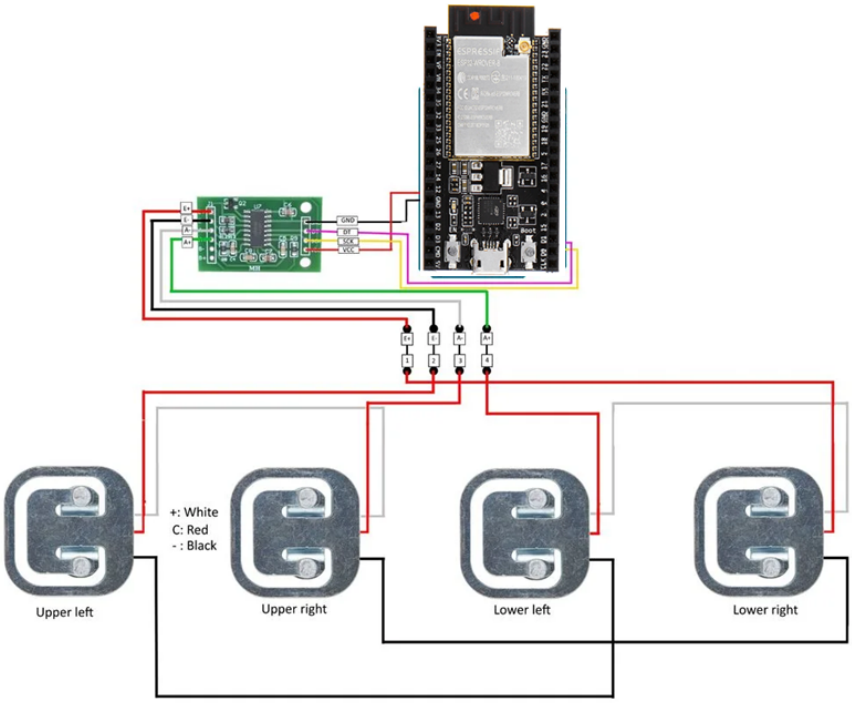

Figure 2: Load Cell, HX711, and ESP32 Wiring Schematic

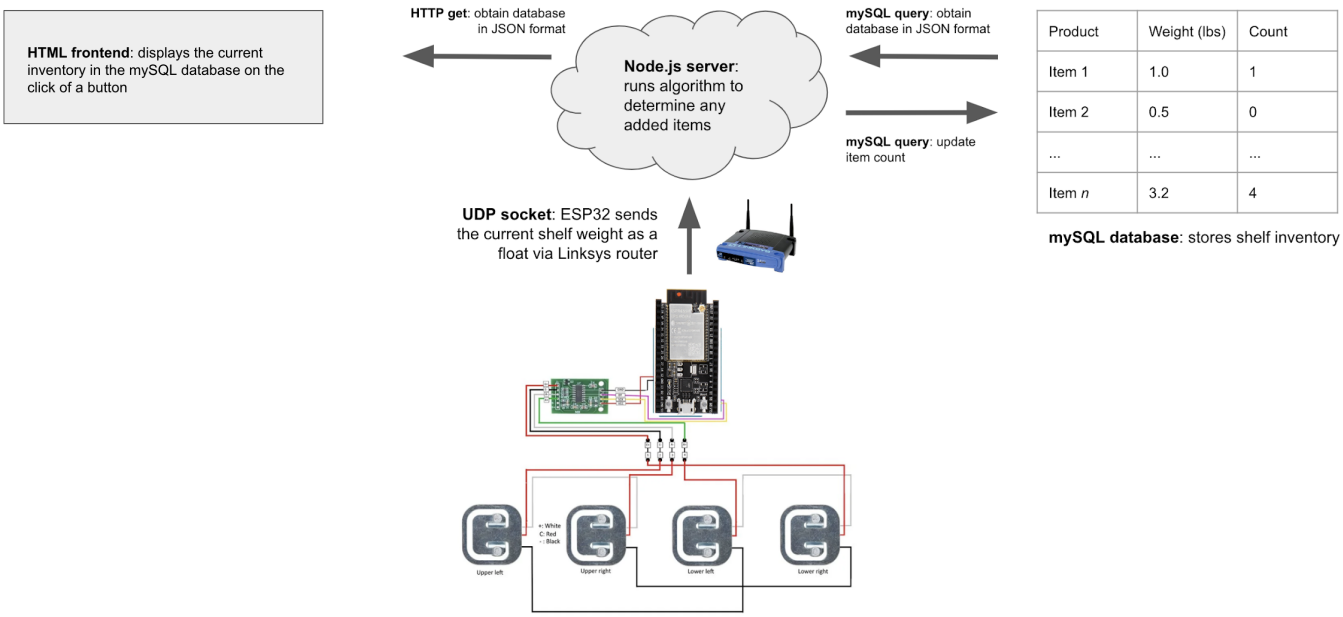

Figure 3: System Overview

4.5 Pinout

Table 1: ESP32 Pinout

Signal	Pin
VCC (from HX711)	3V
DT (from HX711)	Digital Pin 6
SCK (from HX711)	Digital Pin 5
GND (from HX711)	GND

Table 2: HX711 Pinout

Signal	Pin
Lower Right Load Cell Data	E+
Upper Left Load Cell Data	E-
Upper Right Load Cell Data	A-
Lower Left Load Cell Data	A+

5.0 Conclusion

As described in section 1.0, our testing consisted of three sequences of addition and removal of apple juice, peanut butter, and a bag of chips. After each addition and removal, the inventory represented in the SQL database was checked for accuracy. Our testing was a success, as the inventory represented in the SQL database matched the actual inventory at all points during the test. Therefore, the functionality of our shelving unit and SQL database was demonstrated. These results show that we are taking steps towards implementing a functional and reliable shopping system. We are now starting to focus on further tweaking the shelving unit and further developing the mobile and web applications that shoppers and store employees will utilize. Therefore, we hope to have complete communication between our shelving unit and mobile and web applications by our next round of testing.