Weightb0ard

Team - Thomas Driscoll, August Gress, Kyle Patel
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TA: Dhruv Mathur

1 Introduction

1.1 Objective

In any environment that involves cooking or food preparation, knowing the amount of ingredients on hand is of the utmost importance. This can range from large-scale restaurants that have massive quantities of any given food to athletes engaging in meal prep, often down to the gram. In between these two extremes also exist the average consumer, who rely on unreliable memory and insatiable hunger when shopping instead of their objective needs.

Our solution is an internet connected, weight-sensitive kitchen cabinet/tray that pings a grocery list app. For items such as rice, sugar, flour, protein powder, creatine, etc., a scale could measure the amount at home. If it falls below an ingredient-appropriate threshold, a microcontroller will send an update to a user's phone. Simply checking the app once in the store, or while placing a large order, allows the user to purchase the correct amount of food. It will have 7 separately sized sensors that accurately measure ingredient amounts placed on top of it, which will be a proof-of-concept to show our idea's scalability.

1.2 Background

Kitchen preparation is a part of everyday life for many people. From creating meals for themselves or their families to working in a high pressure industrial kitchen that cranks out pounds and pounds of food an hour, there is a constant need to know which ingredients are on hand.

In the pursuit of not running out of ingredients; however, there comes a tendency to overbuy ingredients, generating food waste. Food waste is a global concern, and is the subject of many different studies and research articles on its effects on the environment and society [10]. In addition to overbuying, a business or individual can also forget a particular ingredient that they needed to make a recipe simply because they didn’t know they had ran out of it.

We saw a need to create a way to simplify the lives of everyone who relies on what ingredients they have on hand and prevent overbuying on ingredients that they didn’t need. By creating this board, we aim to simplify the lives of those who depend on having the correct ingredients.

1.3 High Level Requirements

- Able to measure the weight of ingredients placed on pressure sensitive pads within ±10% of true weight.
- Board will send information about the ingredients on it at any time to a database and work over the Internet (not just a local network).
- Weight (in grams) is reported to a mobile application from an internet-connected database.

2 Design

2.1 Block Diagram

2.1.1

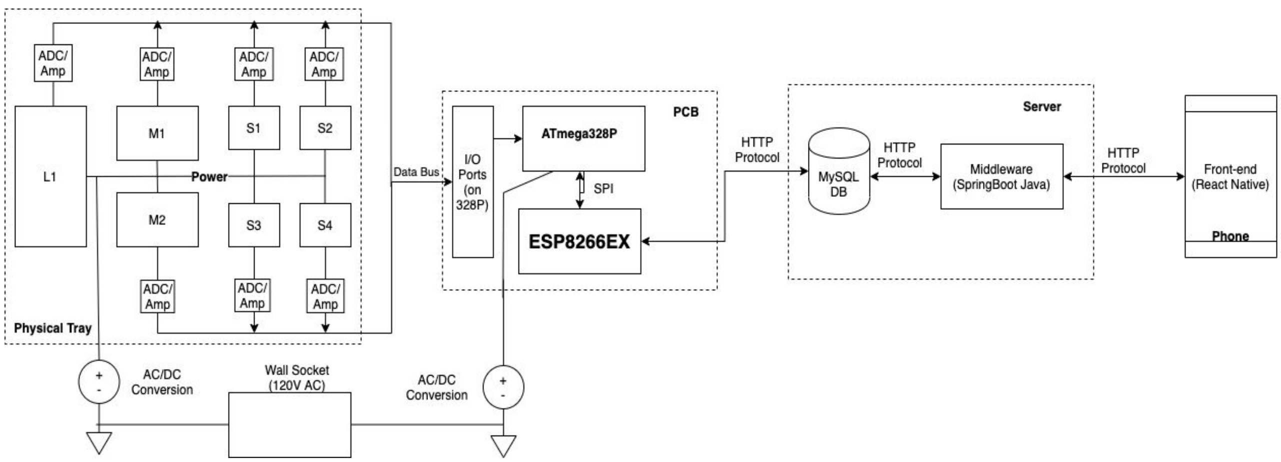

Fig. 1: Block Diagram ranging from electronics to server and application

2.1.2 Description of Block Diagram

- Physical tray = the tray container for the various sensors and handles power
- L1 = large-sized sensor
- M1-M2 = medium-sized sensors
- S1-S4 = small-sized sensors
- Data bus = wiring to indicate the output from sensors being transmitted to the microcontroller
- ADC/Amp = HX711 breakout board which amplifies analog sensor outputs and converts amplified voltages to 2's complement, 24-bit values.
- PCB = block indicating the PCB unit, tying together various sub-components
- SPI = Serial Peripheral Interface for transfer of data from ATMega328P microcontroller to ESP8266EX Wi-Fi chip
- I/O ports = input output ports
- ATmega238 = microcontroller handling I/O and Wi-Fi chip
- ESP8266EX = Wi-Fi chip
- HTTP Protocol = denotes the transmission protocol across the Internet for data packets
- Server = Linux server operating on a cloud host

- MySQL DB = a database stored on server
- Middleware = API handling requests from and to phone
- Front-end = the user-facing mobile application on a phone

2.2 Functional Overview

In the above diagram, our design consists of four major environments. What follows is a break-down of each of those environments and the modules that work inside them.

2.2.1 Physical Tray

The physical tray is the combination of sensors that will be processing the real-world input of each ingredient. The labels L, M and S correspond to large, medium, small sensors, respectively. Each sensor has a data path that it sends the current detected weight along, connecting to the I/O ports of the PCB. The sensors are all powered by a wall outlet, represented by the above voltage source diagram (which will convert from AC to DC via a consumer rectifier device).

2.2.2 PCB

Our PCB will consist of 3 main entities: I/O ports, the microcontroller(Atmega328), and the Wi-Fi adapter (ESP8266EX). The seven I/O ports, one for each sensor, will connect the data path of the sensors to the microcontroller. The microcontroller will handle processing the weights in real time and any other circuit controls necessary. If the microcontroller detects a significant weight change, it will send a HTTP message via the Wi-Fi adapter to our remote database. This ensures that the board and the user can communicate via any common Internet connection.

2.2.3 Linux Server

The server will be a remote Linux environment that handles the database and incoming/outgoing requests for information. As the weight changes on the board, the database will be updated to reflect the new associated weight for each sensor. When the user makes a request for the current weight, the database will interact with the middleware (written in SpringBoot Java) to send the weights and other pertinent information to the user. The middleware will operate by sending and receiving GET/POST operations following standard HTTP methods.

2.2.4 User Phone

In order to interact with the board, each user will load an app onto their phone. This app will be the user-interface that allows the user to see what items they need while mobile. Upon opening the app, the user’s phone will automatically make a request to the Linux server, where our middleware will direct the appropriate operations to perform. Our plan is to write this front-end in React Native to allow cross-platform support and fast development time.

2.3 Physical Design

Fig. 2 is what our physical design is going to look like for this project from the top down view. Our choices are such that each progressively larger sized sensor has a larger footprint on the board for measuring ingredients. This choice was made so that our board had space to accommodate the larger, heavier ingredients on the large pressure sensors, and the smaller, less massive ones weren't given an unnecessarily large space on the board. All of the S1, S2, S3, S4 sensors will be the same size, as will the M1 and M2 sensors. Each load cell (weight sensor) will be mounted from the edge of the pad, with a platform centered at the other end of the pad, such that the rubber center of the cell can bend to produce sensor outputs.

Fig. 3 is what our physical design is going to look like for this project from the side view perspective. We also wanted to design the board such that there was a moderately sized cavity underneath to house the PCB and wires that came off of the pressure sensors.

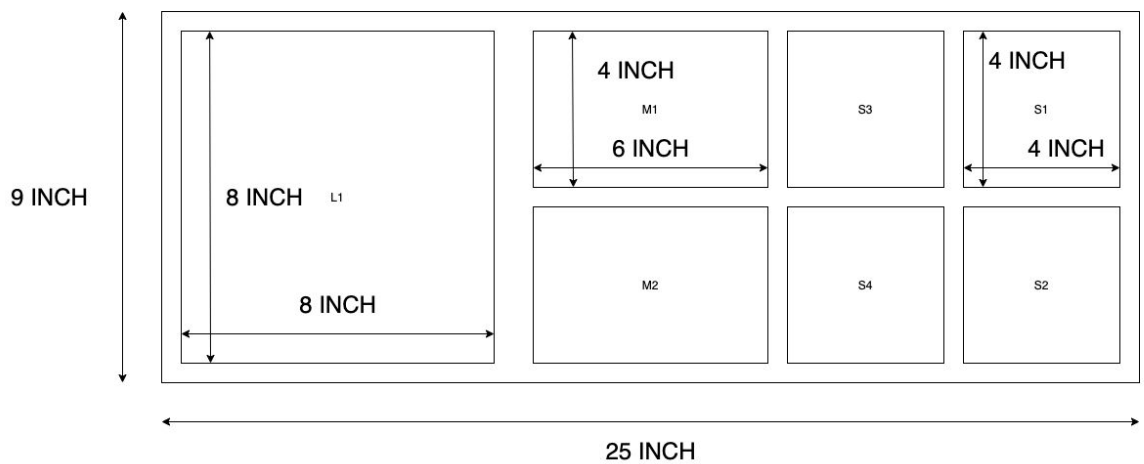

Fig 2. Physical Diagram (Top Down View)

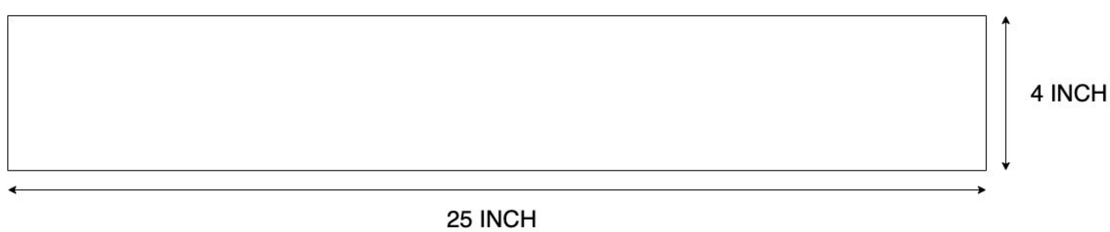

Fig 3. Physical Diagram (Side View)

2.4 Block Requirements

Module	Requirements
Physical Tray: 7x HX711 Breakout Boards for Load Sensors	1. Each breakout board must receive 5 ± 0.3V by way of linear voltage regulator [1] 2 Each breakout board must receive current of 20 ± 5mA [1]
Physical Tray: 4x TAL221 100g	1. Each sensor must be mounted in a structurally stable manner such

Load Sensors, 2x TAL221 500g Load Sensors, 1x TAL220B 5kg Load Sensor	that they can hold plastic containers, a mounted platform, and 100g/500g/5kg of an ingredient 2. Each sensor must be provided with 5 ± 0.3V supply [2][3] 3. Sensors must provide readings within 10% accuracy
PCB: Microprocessor (ATMega328P)	1. Must be able to facilitate sequential collection of quantized sensor data at 80SPS (takes ~4-6 samples at 80SPS to generate stable reading). [1] 2. Must be able to send digital sensor readings to Wi-Fi Microchip via SPI (serial port)
PCB: Wi-Fi Microchip (ESP-8266)	1. Latency of transmission of sensor data array to MySQL DB must be no greater than 30 seconds 2. Must store ~200B worth of sensor measurement values via SPI in flash memory(4-6 readings * 7 sensors * 4B / float value)
Server: MySQL DB	1. Database is reachable from a remote address 2. Database supports a table for each sensor 3. Database only accepts input from a recognized user 4. Database inserts data correctly from .json file with timestamp
Server: SpringBoot Java Middleware	1. Accepts GET request for latest weight measurement and returns an HTTP 200 header with JSON data to user-facing application 2. Accepts POST request for latest weight measurement and returns an HTTP 200 ACK to Wi-Fi chip on tray 3. Checks that request is from an accepted origin 4. >80% unit test coverage for every HTTP method
Phone: React Native Front-End	1. Users should be able to view weight information from all sensors in readable format 2. Application should successfully notify user if any readings are below user-defined thresholds for each ingredient 3. Application allows customizable labels for each sensor 4. >80% unit test coverage for every React component

2.5 Risk Analysis

One of the biggest risks that this project poses is getting high enough accuracy such that when ingredients are placed on top of it the board reports the correct weights ±10% (by our high level requirements). We think that this is further compounded by the fact that we are designing the board to use three different sizes of sensors, meaning we have to find three separate sensors that are all accurate enough that they contribute as little as possible to that error margin. We also have to take into account temperature when designing our board, as temperature can affect our accuracy greatly [11].

There are also practical considerations that can cause error in measurement such as having a load that isn't squarely placed on the load sensor (twisting load), poor bracing of a board to a weight sensor causing bending, and general noise in sensor outputs. In sensitive electric equipment subject to the outside world such as these load sensors, noise is often something that has to be accounted for to produce consistent results [12].

3 Ethics & Safety

The ethical or safety issues with our project pertain to the physical tray itself, and the microcontroller and Wi-Fi chips.

Citing the IEEE Code of Ethics #9 - to avoid injuring others, their property, reputation, or employment by false or malicious action, we will work to ensure that the construction of our tray is structurally sound such that a user will not be concerned with electrical hazards such as exposed wires or static shock, or any harm from burning ICs or plastic. We will also make considerations to prevent damage to the tray's main circuitry by contact with user ingredients. (These considerations would take the form of a protective layer on the top of the board that prevents any spillage into the sensitive electronics underneath)

Citing the ACM Code of Ethics 2.9 [7], the greatest source of ethical and security concerns is the database itself. We will be allowing multiple users the ability to request data which will include information, specifically an email address. This could lead to bad actors stealing this data and targeting users [8]. To avoid these concerns, we will be hosting our server on DigitalOceans, which comes with its own security measures to prevent bad actors. Further, we will have our own authentication measures to do our best to prevent hacking.

An additional source of safety concern is the user-facing application, specifically in regards to the ACM Code of Ethics 2.9 [7]. While we expect the user of our prototype to load the application from source code provided by the designers, bad actors could potentially hijack API calls in the app itself to download malware onto a user's phone [9]. These concerns, while valid, are an extremely low risk as our application will not be downloaded outside of the authors knowledge for the duration of the project. Further, we will adopt a one-origin policy to authenticate the requests, since our HTTP protocols will only be handled by our one server.

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