NutrientMatch: Simplifying Nutrition

E2: Surya Chandramouleeswaran, Grace Liu, Steven Zeng
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Electrical and Computer Engineering Department
Carnegie Mellon University

Product Pitch

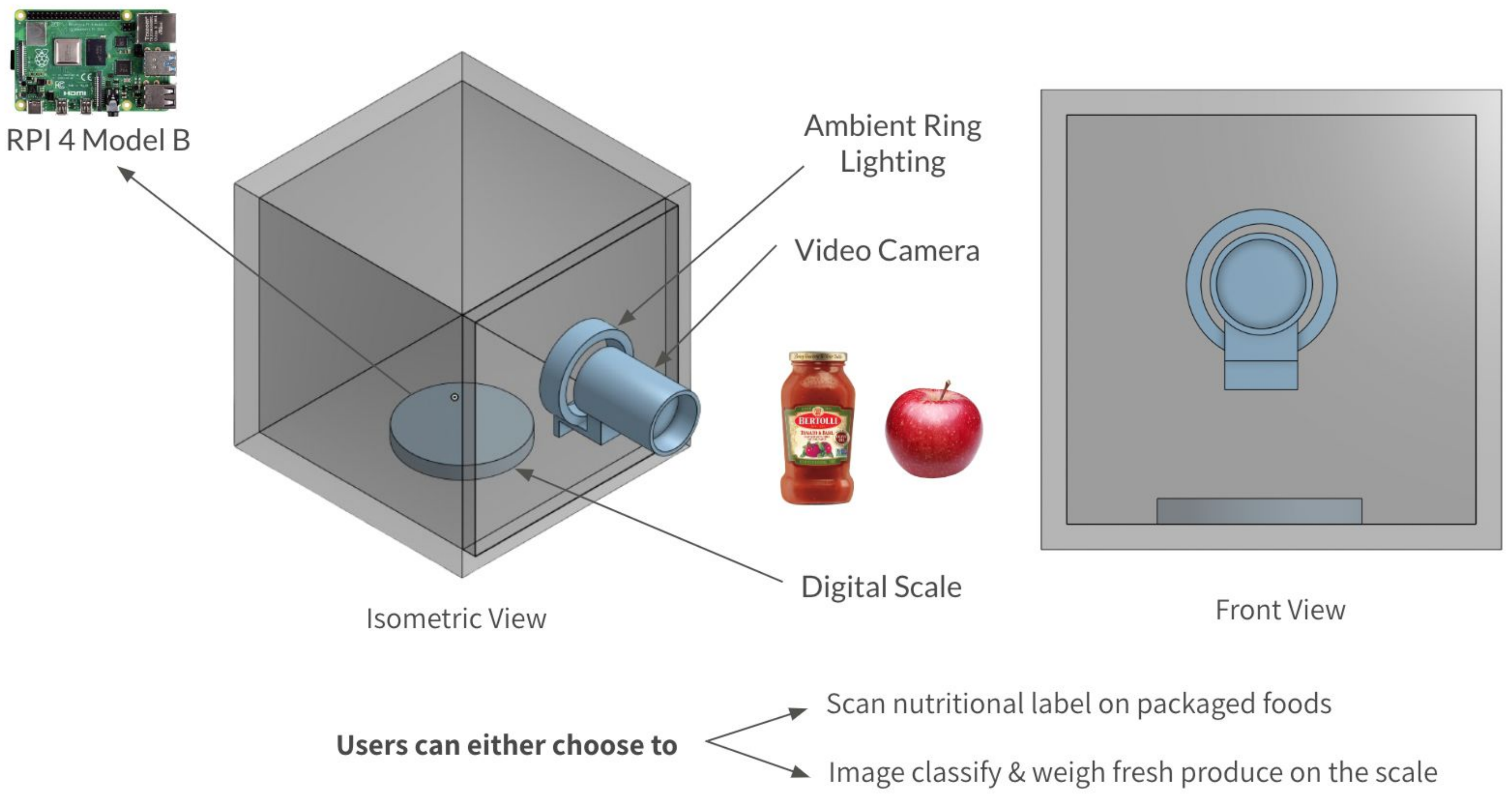
- **NutrientMatch** is a system that seeks to track inventory of foods and calorie consumption in people's daily lives. The device aims to improve the state of the art pantries and refrigerators which currently do not have inventory capabilities and/or calorie-tracking functions. The rather tedious and error-prone nature of manual food tracking is the primary motivating factor for the development of our automated inventory-tracking device.

- Our **use-case requirements** are defined both from a design and user experience perspective. The MVP is a wooden cubic structure of 2 feet edge length of that houses the product components. There are two use-cases that come it. Users may log canned foods via a 2 megapixel, 15 frames per second (fps) video camera for image capturing and label reading. Next, automated scale reading functionality is present for fresh produce quantified by mass; the weight reading will be forwarded to the web application for backend calorie calculations. Both product and scale cameras are illuminated with a diffuse light source of 55 watts, ensuring quality image capture and subsequent efficient algorithm performance.

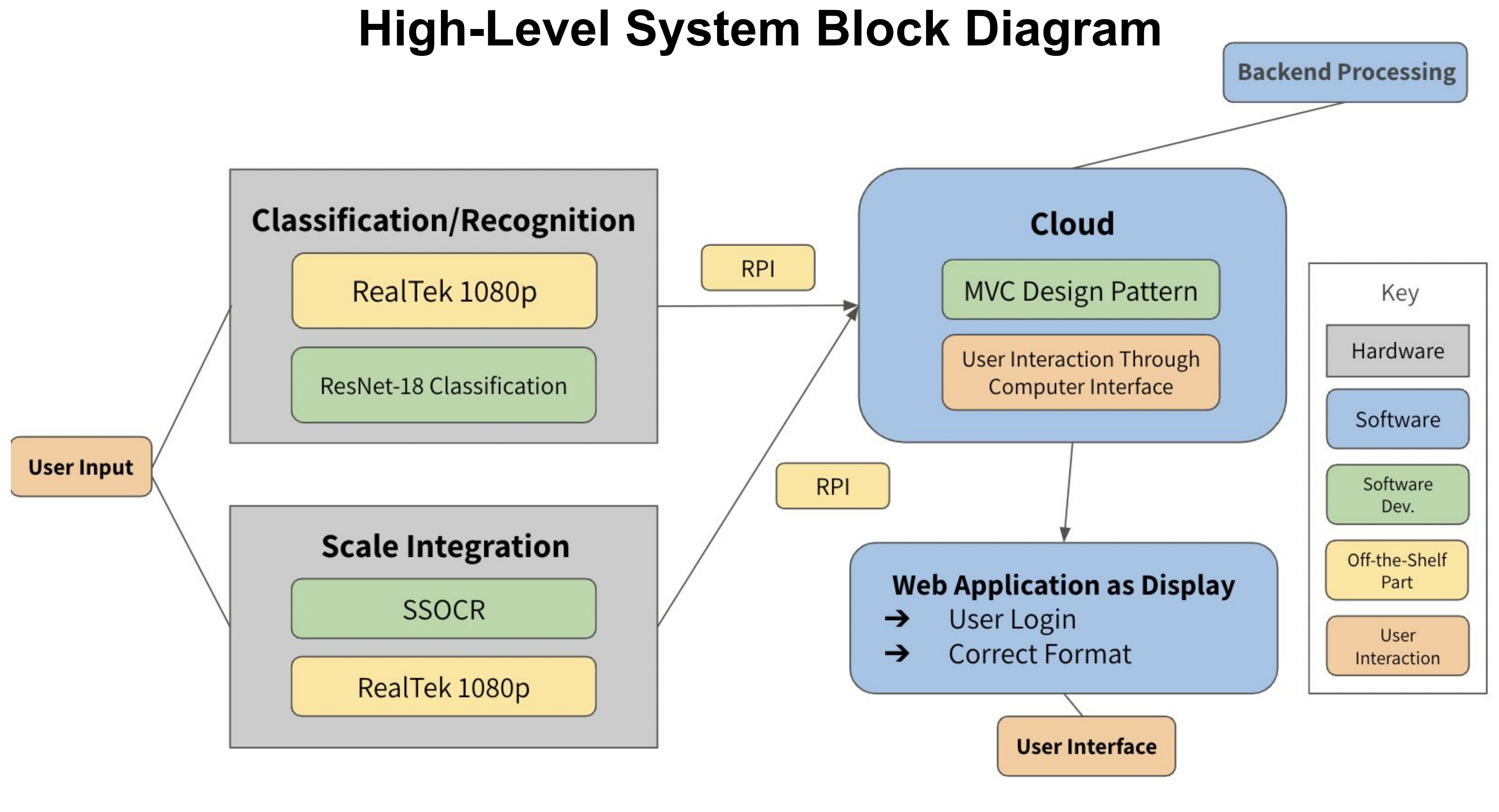
- Our product correctly classifies items **96%** of the time from camera capture. Forwarding of this capture to the web application holds an average overall process latency of around **36 seconds**. Lastly, user inventory is properly displayed on the website with an item deletion that results in a caloric consumption calculation for the user. This caloric amount was within a **10% range** of the actual amount. As a result, **users can expect a functioning inventory and calorie tracking system that fits the desired requirements provided above.**

System Architecture

System Overview


RPI 4 Model B
Ambient Ring Lighting
Video Camera
Digital Scale
Isometric View
Front View
Users can either choose to
Scan nutritional label on packaged foods
Image classify & weigh fresh produce on the scale

High-Level System Block Diagram



Conclusions & Additional Information

- Our system implementation did not directly match our original aspirations. The ease-of-use differed from what we had initially expected. However, the ML accuracy and design pipeline (hardware to website with ML computation done on the cloud) were consistent with our original plan.
- One lesson we learned was the importance of organization and proper documentation. Our project consisted of hundreds of git commits within each group member. There were many instances where we needed to rollback commits to return to a previous version. The lack of specificity in the commits resulted in misunderstandings between group members as well as difficulty in differentiating what was changed. There was a wide variety of code changes being submitted every hour (i.e. RPi code, Django code, ML), so better documentation would have resulted in less confusion.
- Another lesson we learned was the importance of slack in scheduling. There were multiple instances of hardware components breaking and compatibility issues with the integration of various software components that complicated our schedule. However, we were able to address a majority of these issues in a timely manner due to proper planning and the usage of slack during planning.
- Future possibilities for this project include full-scale integration into a smart refrigerator. Likewise, there is potential for more automation to ensure a more user-friendly experience.

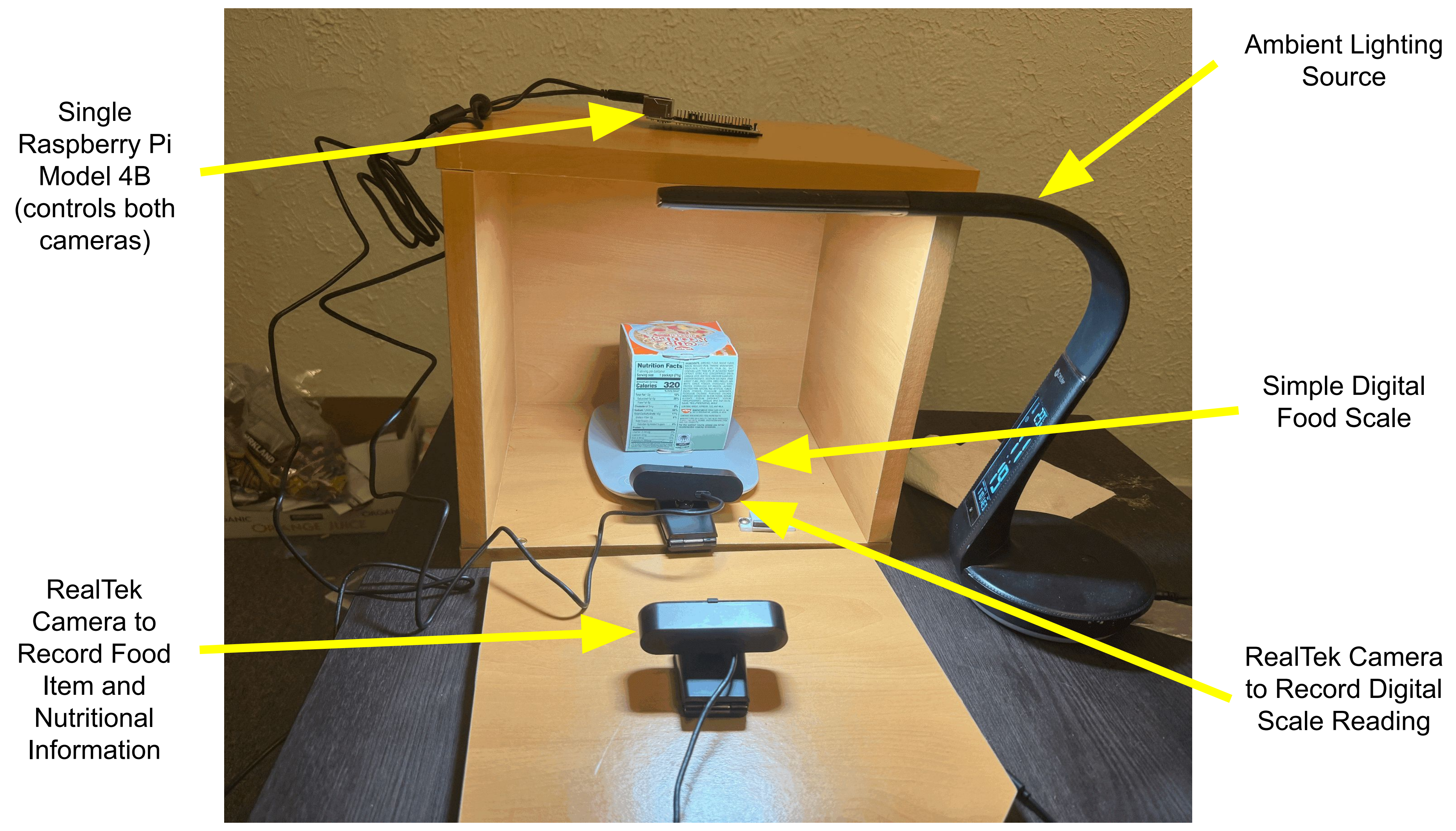
System Description

Software Components

- *ResNet-18*: 18-layer neural network used for Image classification
- *Tesseract and 7 Segment OCR*: Text extraction for nutritional label and scale reading
- *Django MVC Framework*: Web application deployed through Amazon EC2 and MySQL
- *MySQL Connector*: Driver for storing images in a MySQL database from Raspberry Pi

Hardware Components

- *Raspberry Pi Model 4B Microcontroller:* Interfaces Camera Hardware and forwards images to Database
- *RealTek 1080p Camera (x2):* AutoFocus and automatic capturing logic controlled through the Raspberry Pi (RPI)
- *Amazon Basics Digital Kitchen Scale:* Simple Digital scale; readings are recorded through camera and forwarded to database via RPI


Single Raspberry Pi Model 4B (controls both cameras)
Ambient Lighting Source
Simple Digital Food Scale
RealTek Camera to Record Food Item and Nutritional Information
RealTek Camera to Record Digital Scale Reading

Demonstrated Prototype (Door removed for viewing purposes)

System Evaluation

Testing, Verification, and Validation

01 **Image Recognition Testing**
- Canned Foods
- Fruits
- Invalid Groups

02 **Overall Performance Testing**
- Weight Detection
- Caloric Accuracy
- Overall Process Latency

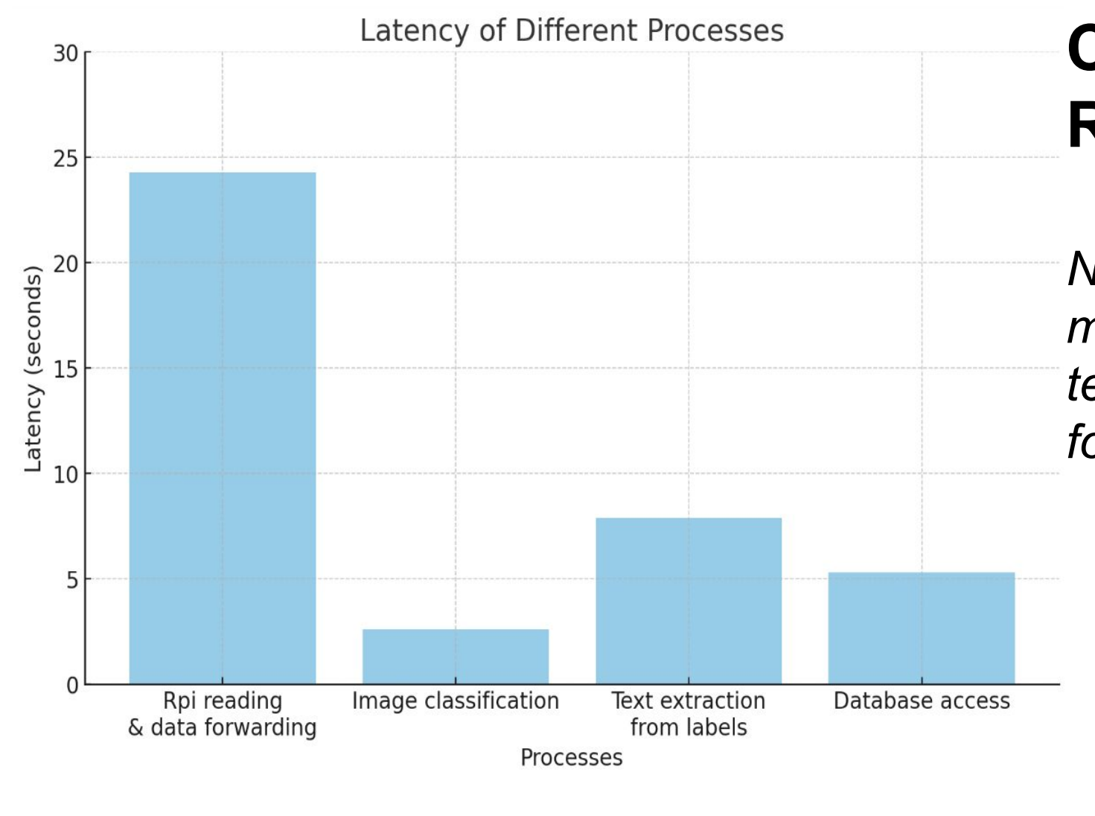
03 **Risk Mitigation: Invalid Measurement**
- Ability to edit incorrect entries/errors
- Ability to interrupt/restart measuring process in flexible manner

ML Model Design Tradeoffs

ML Models	GoogLeNet	Tesseract OCR*	Nutrition Reader	ResNet-18*
Benefits	-> Pre-trained IC Library -> Quick to Run	-> Label-reading -> Pre-trained Library with High Accuracy	-> Scanning Capabilities -> Label-reading	-> Pre-trained IC Library -> Highest Accuracy
Problems	-> Relatively Low Accuracy -> Not a Representative Dataset	-> Poorly Formatted Text Output	-> Low Calorie Extraction Accuracy (~50%)	-> A lot of Computation Power -> High Latency

System Latency Results

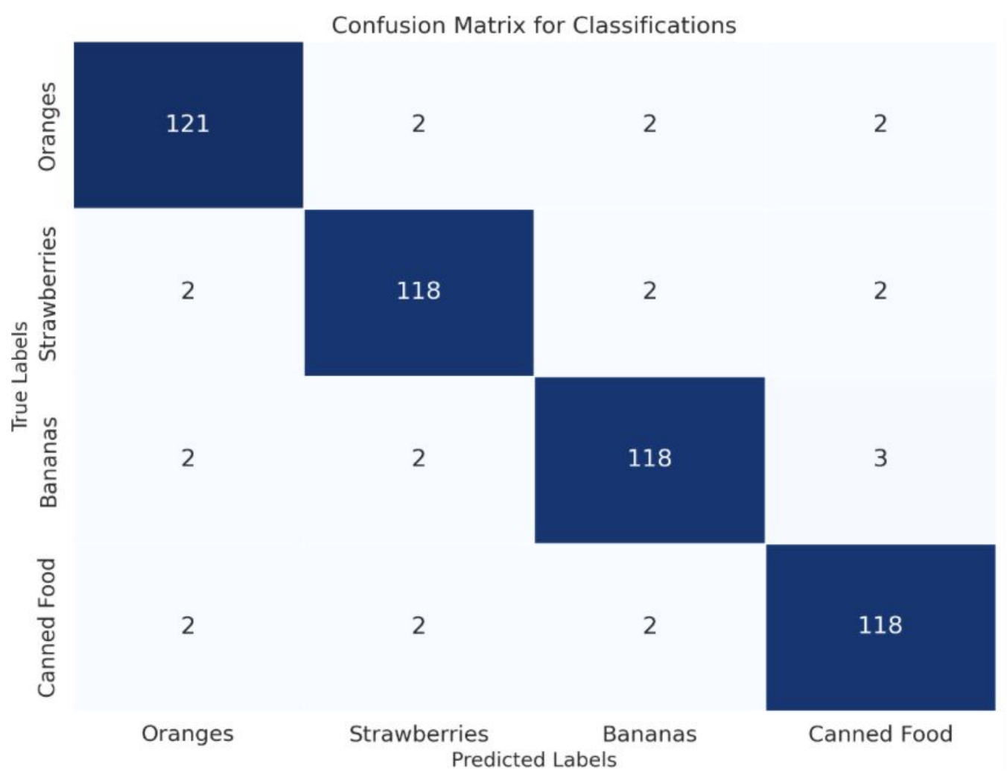
Note: Tested four processes where system latency is sum of the four components



These values were computed as an average of 50 runs for each category.

Classification Results

Note: In confusion matrix form and tested using only four categories



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http://www.ece.cmu.edu/~ece500/projects/S24-teame2