Laundry Manager and Optimizer (LMaO)
Marking Period 1 Design Review & Deliverables

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Contents

MADE IN THE USA

MCA for SMET

Senior Project Innovation

Invention title: Laundry Manager and Optimizer (LMaO) **Team No.** 6

Instructor Name: Mr. E. Paterno

Instructor Approval: E.P. **Date:** 10/10/18

Student Name: Spencer Ng

Student Signature: _____ **Date:** 10/10/18

Student Name: Kevin Tang

Student Signature: _____ **Date:** 10/10/18

Problem to be addressed:

Laundry tags convey important washing instructions for clothes in the form of standardized, universal laundry symbols. However, this system fails to accommodate users who may not have the time or knowledge to decode the symbols. Consequently, many individuals use the wrong cleaning products or machine settings, leading to unnecessary washing, energy waste, and wear-and-tear.

Innovation description:

The Laundry Manager and Optimizer (LMaO) is an Internet of Things (IoT) smart laundry system that scans the laundry symbols on tags using computer vision and machine learning technology. This information is uploaded to the Cloud, where it communicates with other LMaOs in the same household or living facility, allowing groups to Manage and Organize loads quickly and determine the correct settings for each of their loads.

Innovation features:

The LMaO can:

- Scan ISO laundry care symbols on standard laundry tags using computer vision and machine learning technology

- Connect multiple LMaOs for any user group to the cloud via Wi-Fi
- Automatically alert users when the attached hamper is full
- Provide user-friendly laundering instructions via a touchscreen
- Reduce energy consumption while optimizing laundry loads

Innovation operation:

To place an article of clothing into the LMaO, the user locates the tag and places it in the scanning area of the LMaO. The LMaO then identifies the symbols and prompts the user via the touchscreen to drop the article into one of several hamper areas. When the LMaO(s) have reached capacity, or if the user indicates they wish to do their laundry (via the touchscreen of any linked LMaO), the user is provided with the recommended washer and dryer settings for each load and a list of articles of clothing to wash.

Required technologies:

Hardware	Software
Raspberry Pi (Single Board Computer)	*OpenCV with Python*
Raspberry Pi Camera	*TensorFlow*
Raspberry Pi Touchscreen	*Google Cloud Platform (Firebase Server)*
AC Power Circuitry	*Wi-Fi*

Proposed customers:

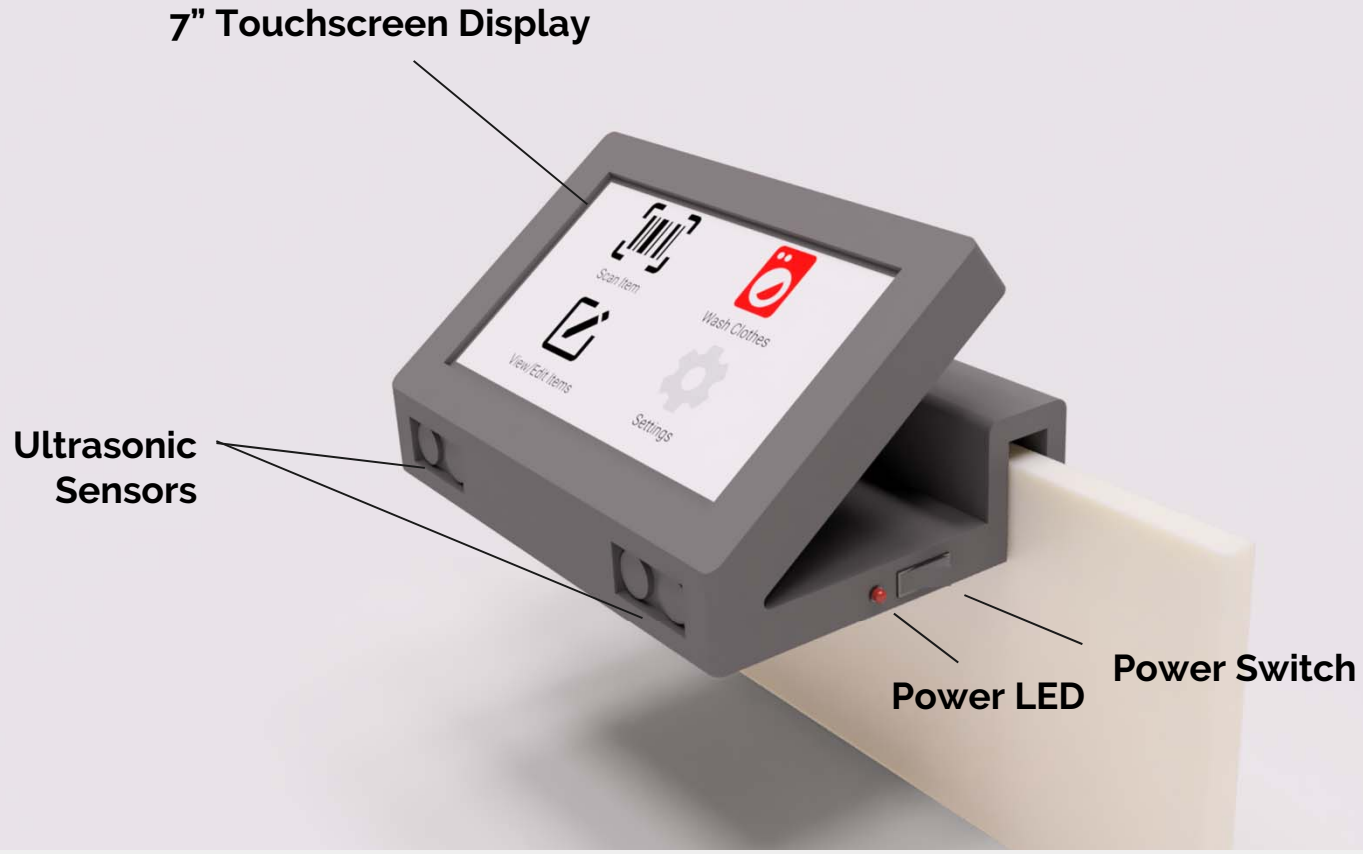
- Washing or drying machine companies who wish to promote energy efficiency and assist users in determining the correct settings to use for their machines

Invention title: Laundry Manager and Optimizer (LMaO) **Team No.** 6

Instructor Initials: E.J **Date:** 10/10/18

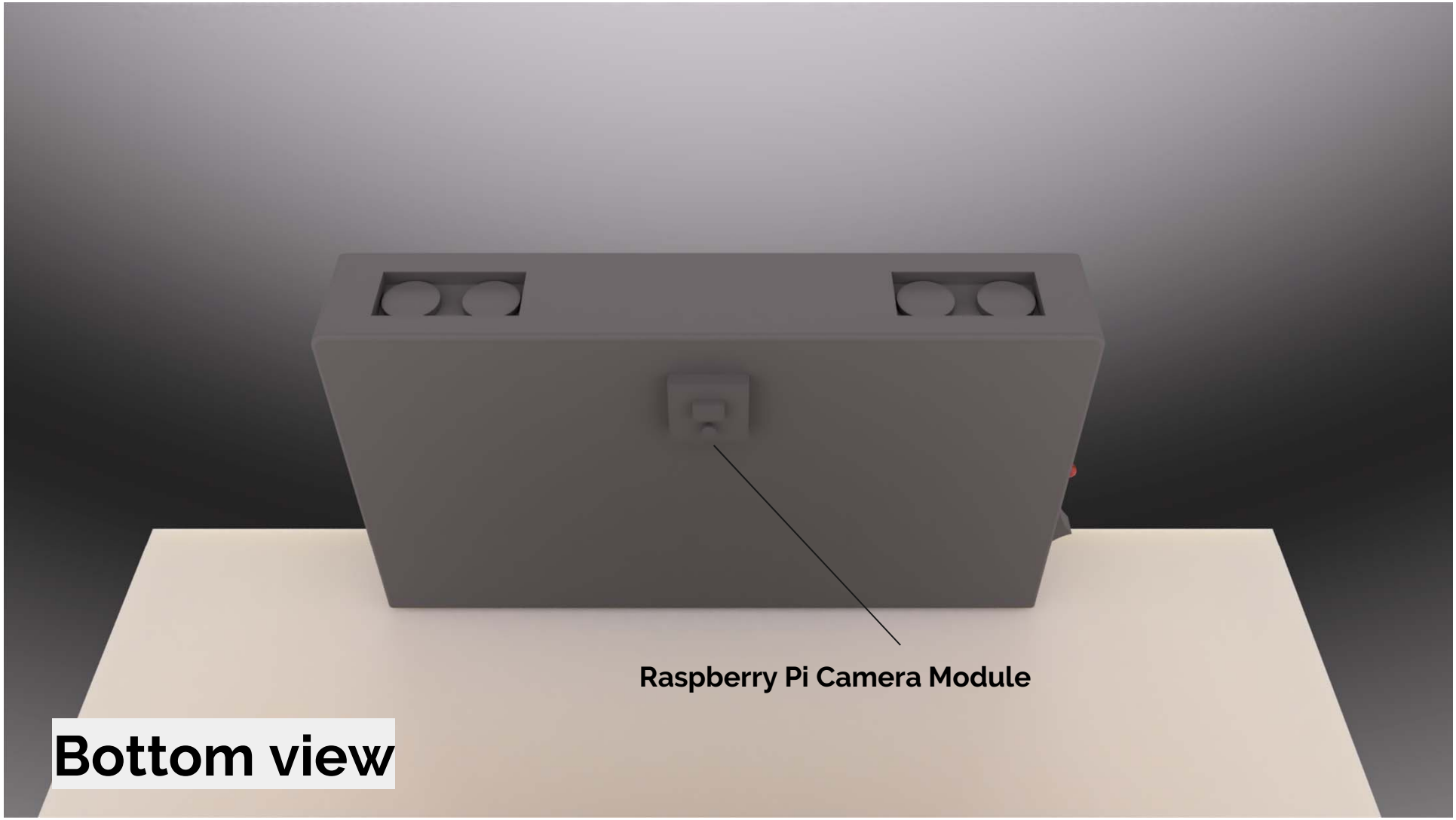
Student Initials: S.N. **Date:** 10/10/18

Student Initials: K.T **Date:** 10/10/18



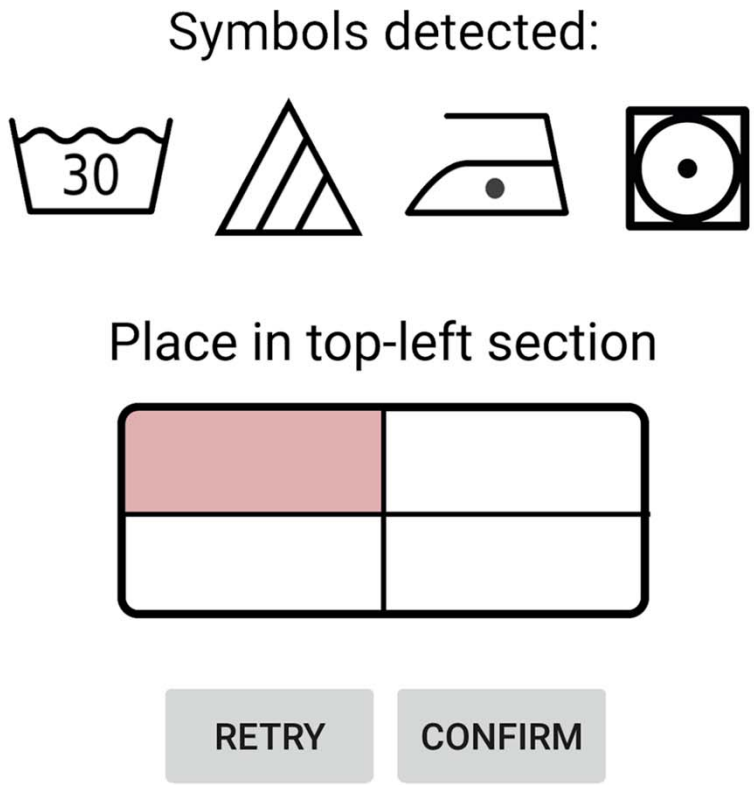
Hardware conceptual diagram (front view)

Main graphical user interface (GUI)

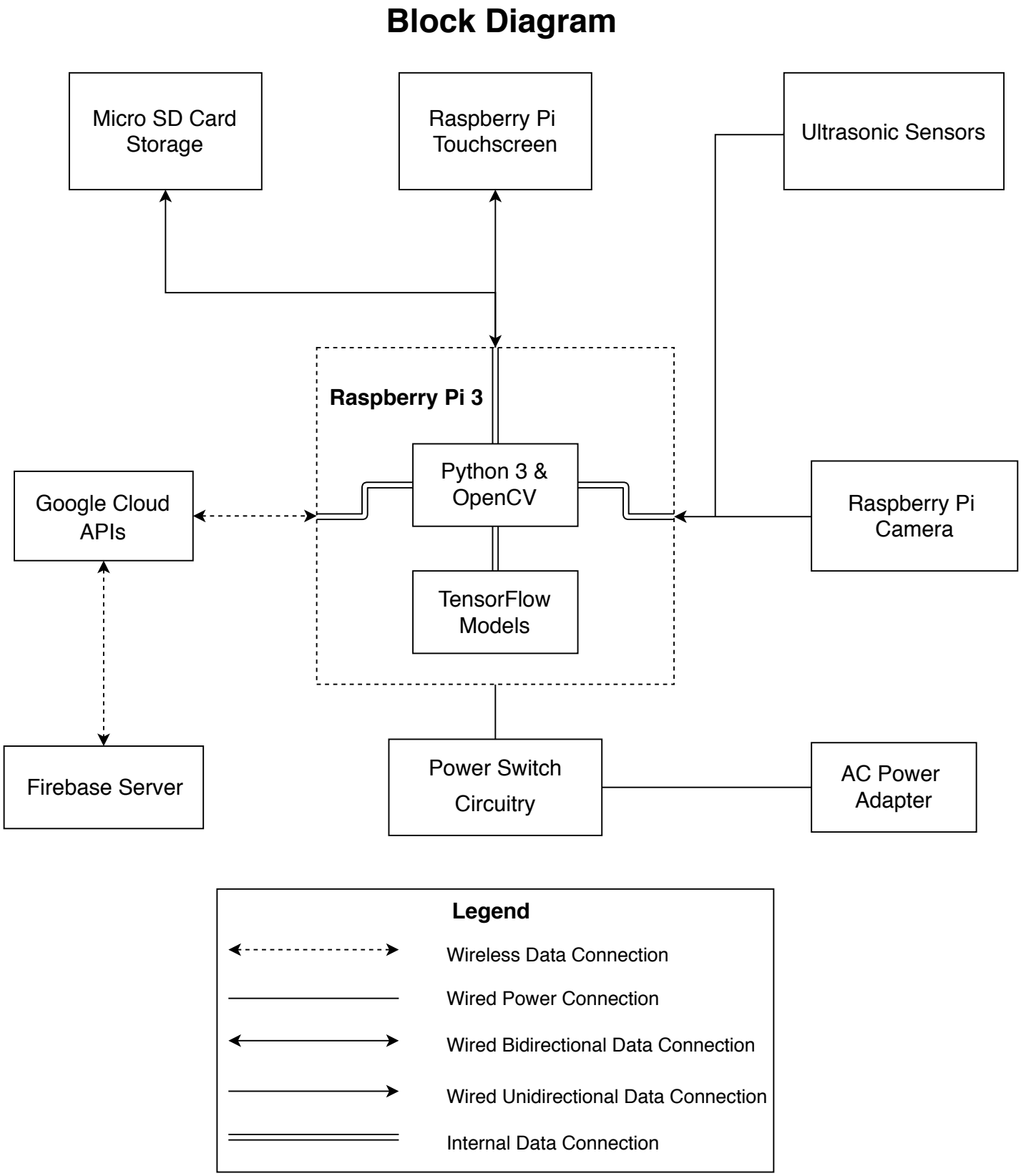

Raspberry Pi Camera Module
Bottom view


AC Power Cord
Back view


Hold the tag into focus
Other Item: Light
Other Item: Dark
Scanning interface



Confirmation screen


Block Diagram
Micro SD Card Storage
Raspberry Pi Touchscreen
Ultrasonic Sensors
Raspberry Pi 3
Python 3 & OpenCV
Google Cloud APIs
Raspberry Pi Camera
TensorFlow Models
Firebase Server
Power Switch Circuitry
AC Power Adapter
Legend
Wireless Data Connection
Wired Power Connection
Wired Bidirectional Data Connection
Wired Unidirectional Data Connection
Internal Data Connection

4 Design specifications

4.1 Hardware requirements

Raspberry Pi 3

- Single-board computer that drives the camera, touchscreen, ultrasonic sensors, and power circuitry
- Reads from and writes to external micro SD card storage
- Connects to cloud services via Wi-Fi

Ultrasonic sensors

- Send distance data to Raspberry Pi via GPIO pins
- Consistently and accurately detect when any section of the hamper is full
- Has 3 mm accuracy and 300 cm range

Raspberry Pi touchscreen

- Displays graphical user interface
- Allows users to interact with menu items
- Connects to Raspberry Pi via DSI port
- Has 7" screen size and 800 x 480 px resolution for large, easy-to-use interface

Raspberry Pi camera

- Connects to Raspberry Pi via CSI port
- Clearly scans and focuses on laundry symbols when are held 1-3" underneath
- Has 8 MP resolution

Micro SD card

- Contains 32 GB of storage for operating system, Python scripts, and TensorFlow models

Power circuitry

- Wakes and shuts down the Raspberry Pi via a slide switch
- Contains RBG LED indicator that turns green when powered on, red when off
- Located on a 2-layer printed circuit board, approximately 1" x 2"

AC power adapter

- Converts 120V AC power to 5V DC to power the Raspberry Pi via micro USB

4.2 Software requirements

Python 3 & OpenCV

- Boots into an easy-to-navigate material design GUI created with the Tkinter library
  - Contains submenus for tag scanning, washing loads, settings, and viewing/editing items
- Scanning submenu opens camera feed with a button to scan items
  - Displays recognized symbols for the user to confirm
  - Directs users to drop clothing article in the correct section, based on color and machine wash settings
  - Contains manual override for socks and underwear; prompts user for color
- Settings submenu contains user account management (create account/change password), LMaO nickname, and washer/dryer information (database with information on all models from major brands)
- View/edit submenu allows users to modify the number of items in the hamper
- Prompts users to do their laundry when any section of the hamper is detected as full
  - Ultrasonic sensors detect objects within 14" (length of hamper) for a period of at least one (1) minute
- Wash submenu instructs users to remove and wash articles from each section separately, making note of special instructions (ironing a shirt in a load of T-shirts, hand wash, dry clean, etc.)
  - Groups clothing with similar or identical washing requirements into a single wash load
  - Combines clothes from linked LMaOs for optimization, as necessary
  - Satisfies the washing requirements of at least 90% of the items in a load
  - Provides instructions pertinent to the user's washer and dryer model
- OpenCV library interfaces with stored TensorFlow models and detects presence of laundry symbols via contours and image filtering

TensorFlow models

- Trained with a set of over 200 close-up, labeled laundry symbol images
- Recognize machine wash, bleach, tumble dry, and ironing symbols with at least 90% accuracy when given a series of close-up, focused images of standard laundry tags

Firebase server

- Syncs with all LMaOs connected via Wi-Fi every five (5) minutes or when LMaOs are powered on
- Stores user account information: username and hashed/salted passwords
- Provides a list of all LMaOs linked a particular user accounts, identified by user-provided nickname
- Stores a list of clothing located in each section of an LMaO and the laundry symbols on their tags
- Updates when an item is scanned and placed into the hamper of the LMaO
- Deletes items from the database after they are washed

4.3 Mechanical requirements

LMaO packaging

- Contains Raspberry Pi, touchscreen, camera, ultrasonic sensors, AC adapter cord, and power switch circuitry in a 3D-printed box
  - Touchscreen and ultrasonic sensors face outward, toward opposite edge of hamper
  - Power switch printed circuit board soldered to the side of Raspberry Pi and is accessible by users
  - AC adapter cord extends outward from the back
  - Camera faces downward, into laundry hamper
- Held together by interlocking parts, Velcro, and screws and can withstand mild shaking
- Clamps onto the back edge of the laundry hamper without additional support
- Provides sufficient ventilation so the Raspberry Pi does not overheat

Laundry hamper

- Contains four (4) compartments of equal size for ease-of-use when removing clothes for different loads
- Supports the weight of the LMaO packaging on at least one (1) top edge
- Requires no additional support to stand up
- Approximately 14” x 14” x 23” in size with an open top; easily transportable

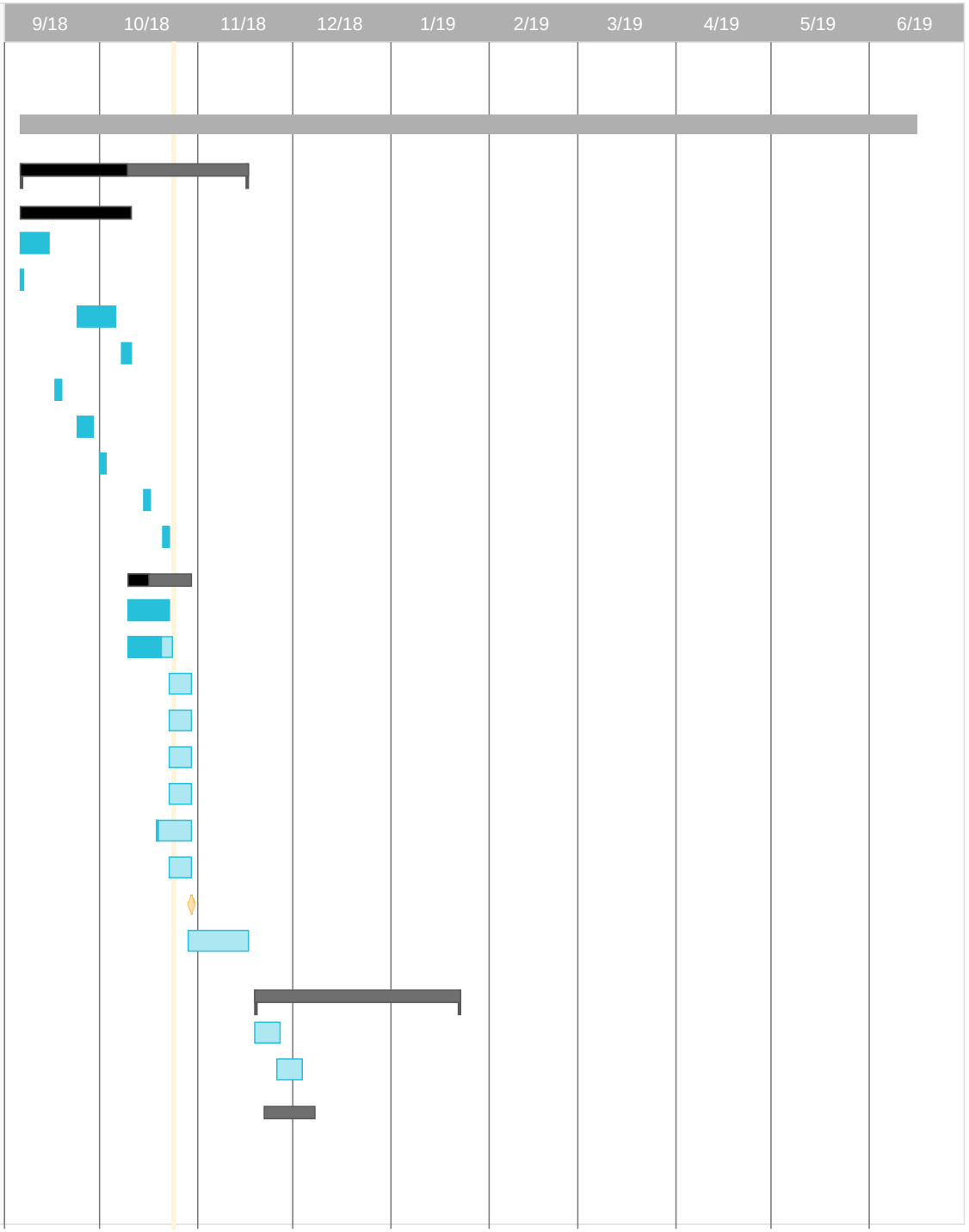
Laundry Manager and Optimizer Gantt Chart

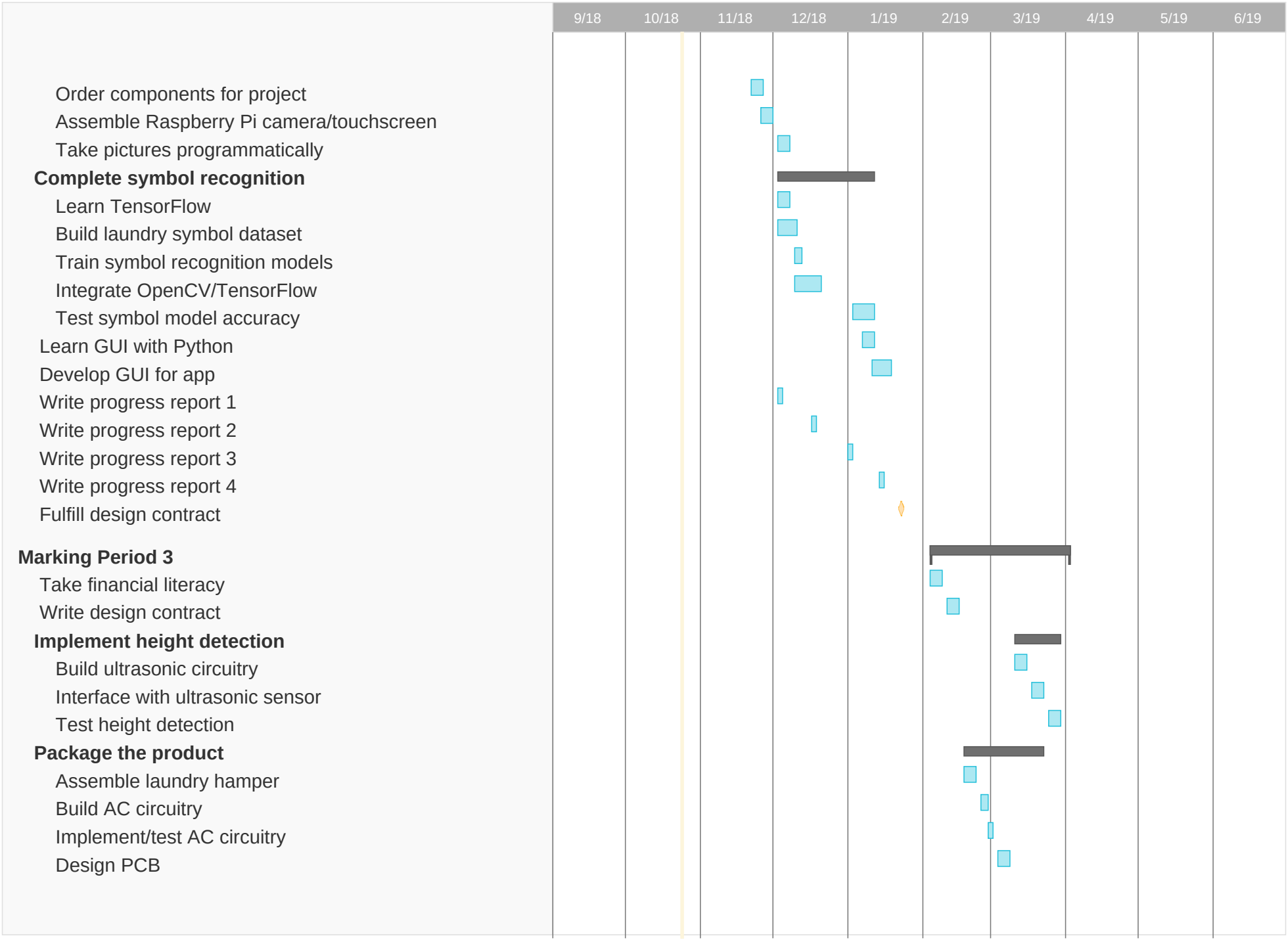
Marking Period 1

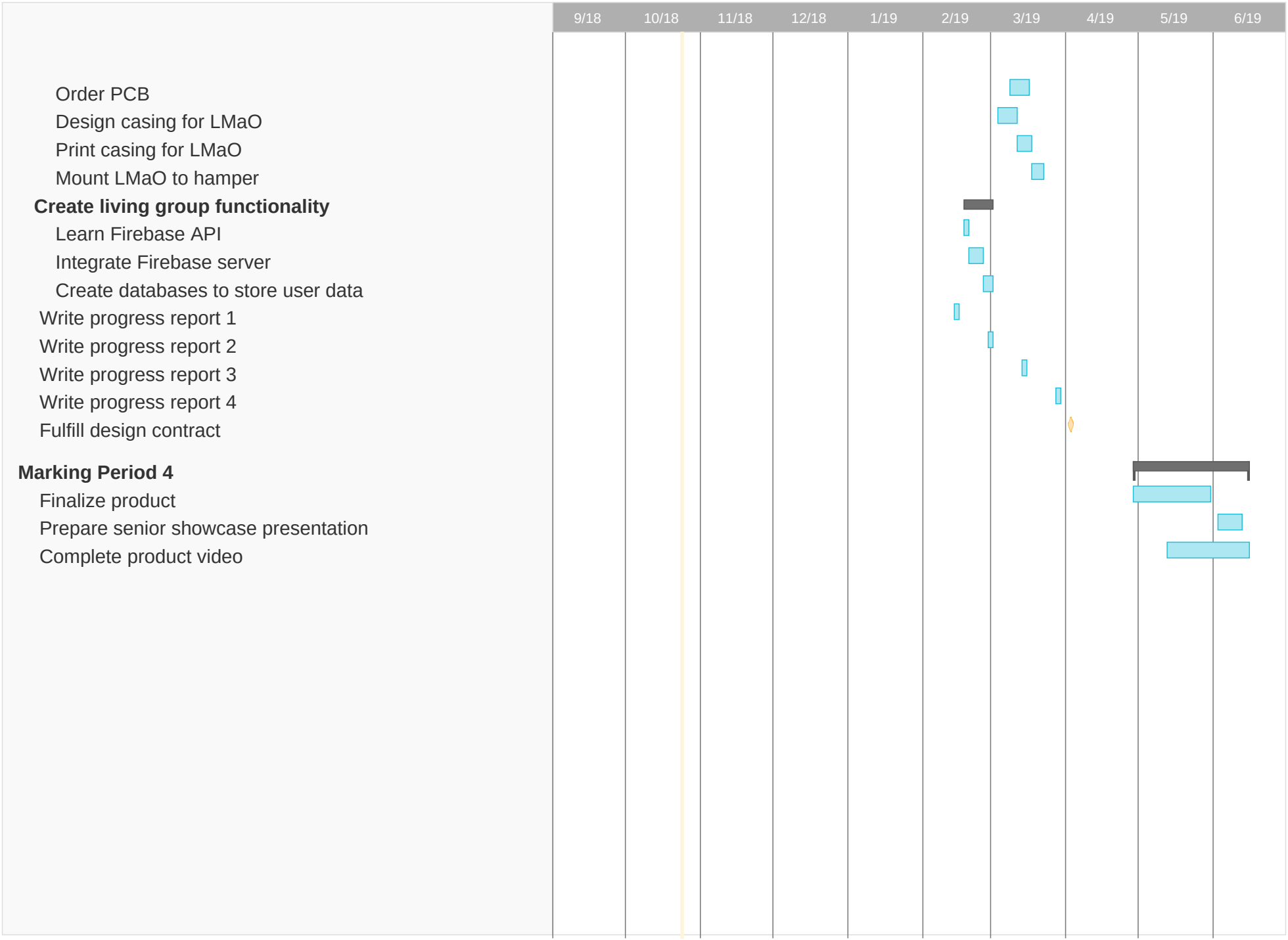
- **Finalize senior project idea**
  - Complete patent search
  - Finalize Summer Proposal Draft
  - Write final project proposal
  - Sign project proposal with Mr. Paterno
- Write progress report 1
- Create block diagram draft
- Write progress report 2
- Write progress report 3
- Write progress report 4
- **Complete design review**
  - Finish block diagram
  - Create Gantt chart
  - Complete conceptual diagram
  - Complete design requirements
  - Complete test plan
  - Describe risks and contingency plans
  - Complete Bill of Materials
  - Complete cost analysis
  - Complete MP1 Design Review
- Present design review

Marking Period 2

- Write design contract
- Get design contract approved
- **Assemble and integrate hardware**




9/18
10/18
11/18
12/18
1/19
2/19
3/19
4/19
5/19
6/19
Order components for project
Assemble Raspberry Pi camera/touchscreen
Take pictures programmatically
Complete symbol recognition
Learn TensorFlow
Build laundry symbol dataset
Train symbol recognition models
Integrate OpenCV/TensorFlow
Test symbol model accuracy
Learn GUI with Python
Develop GUI for app
Write progress report 1
Write progress report 2
Write progress report 3
Write progress report 4
Fulfill design contract
Marking Period 3
Take financial literacy
Write design contract
Implement height detection
Build ultrasonic circuitry
Interface with ultrasonic sensor
Test height detection
Package the product
Assemble laundry hamper
Build AC circuitry
Implement/test AC circuitry
Design PCB


9/18
10/18
11/18
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1/19
2/19
3/19
4/19
5/19
6/19
Order PCB
Design casing for LMaO
Print casing for LMaO
Mount LMaO to hamper
Create living group functionality
Learn Firebase API
Integrate Firebase server
Create databases to store user data
Write progress report 1
Write progress report 2
Write progress report 3
Write progress report 4
Fulfill design contract
Marking Period 4
Finalize product
Prepare senior showcase presentation
Complete product video

6 Roles and responsibilities

Team responsibilities

- Write project proposal and design requirements
- Create Gantt chart, block diagram, and bill of materials
- Write design contracts for each marking period
- Perform integration and system testing
- Write progress reports and document progress in engineering notebook
- Produce final video detailing product design

Spencer - software development

- Interface camera with Python
- Integrate OpenCV with TensorFlow models
- Create the GUI with Python
- Interface ultrasonic sensors with Python
- Create Firebase server to store user data and sync with Python
- Edit product video

Kevin - hardware design and machine learning

- Design, 3D-print, and assemble product casing and mounting solution
- Design and build power circuitry
- Manage component acquisition
- Build laundry symbol image dataset
- Train TensorFlow models
- Design and order printed circuit board

Bill of Materials

Item Number	Part Number	Part Description	Reference Designation	Primary Source	Secondary Source	Lead Time	Cost	Unit	Total Cost
RASPBERRYPI 3-MODB	51AC3219	Raspberry Pi 3 B+ Motherboard	RPI	https://goo.gl/N6efV7	https://www.adafruit.com/product/3775	1 week	$42.50	1	$42.50
N/A	N/A	Raspberry Pi 7" Touchscreen Display	TCH	https://goo.gl/1e8jwp	https://www.adafruit.com/product/2718	1 week	$78.63	1	$78.63
RPI-CAM-V2	N/A	Raspberry Pi Camera Module	CAM	https://goo.gl/ePeF2F	https://www.adafruit.com/product/3099	1 week	$26.51	1	$26.51
SDSQUNC-032G-GN6MA	N/A	32 GB microSD Card	MSD	https://goo.gl/gcbZgT	https://goo.gl/WUdMCq	1 week	$9.81	1	$9.81
N/A	N/A	Printed Circuit Board	PCB	https://jlcpcb.com	https://www.pcbway.com/	2-4 weeks	$20.00	1	$20.00
N/A	N/A	Raspberry Pi AC Adapter	AC	https://goo.gl/PSC9YC	https://goo.gl/dQE9xz	1 week	$10.61	1	$10.61
HC-SR04	EL-SM-001	Ultrasonic Sensor (x5)	US	https://goo.gl/KaqhEV	https://www.sparkfun.com/products/13959	1 week	$10.39	1	$10.39
AQ-NON005	N/A	Foldable Laundry Hamper	LH	https://goo.gl/SdDxgj	https://goo.gl/bhfSYd	1 week	$18.64	1	$18.64
								Grand Total	$217.09

8 Risk factors and contingency plans

Risk factors	Contingency plan
Image recognition with TensorFlow may not be sufficiently accurate	Use alternate machine learning platforms (Google AutoML, Microsoft Azure CV); train models with a larger dataset
Mounting the LMaO on the hamper may be difficult	Create support for LMaO casing within the hamper or improve hamper backing to endure a greater load
Space and load constraints when designing case for hardware	Reposition components to distribute load (place touchscreen to the side of the hamper, place clamps toward the middle of the casing, etc.)
Ultrasonic sensors may experience bounceback	Programatically debounce the ultrasonic sensors; use depth sensing with an additional camera and OpenCV

9 Testing plans

9.1 Unit testing

- Raspberry Pi: connect with PC and run Python 3 scripts independently
- Camera: capture images programmatically
- TensorFlow: correctly identify symbols in pre-existing images with trained models on a PC
- Ultrasonic sensors: accurately detect range when connected to a PC
- Power circuitry: lights up when 5V is applied and switch is turned
- Firebase: send and receive data through a PC using REST APIs
- Touchscreen: connect with the Raspberry Pi and ensure touch inputs are registered correctly

9.2 Integration testing

- Programmatically process images taken with the RPi camera on the Raspberry Pi using OpenCV and TensorFlow, ensuring at least 90% accuracy for 20 images
- Navigate Python GUI through the Raspberry Pi touchscreen
- Communicate with Google Cloud and sync data with Firebase from RPi, then verify by going to Firebase's web interface to modify and view data
- Accurately determine distance with ultrasonic sensors with Raspberry Pi housed in casing
- Reliably turn on and safely turn off Raspberry Pi at least five (5) times with power switch

9.3 System testing

- Power all components
- Identify pertinent laundry information accurately
- Ensure clothing items and LMaOs associated with a particular user sync to Firebase
- Instruct user to separate into proper loads, incorporating data from other LMaOs
- Detect when the hamper is full with clothes, repeating with each of the four (4) sections

10 Patent search findings

US 571555

- *"Laundry system... for reading laundering instructions contained in an electronic tag while the item is in a laundry machine"*
- LMaO operates outside of a laundry machine and does not require any electronic tags to operate - just the standard laundry tag

US 5388299

- *"Reading washing information on mediums attached to clothes, checking possibility of mixed washing with the stored info"*
- LMaO offers cloud syncing for entire living group and is not limited to the settings on a single washing machine or dryer

11 Acknowledgements and resources

- Mr. Enzo Paterno, Electrical and Computer Engineering Technologies instructor
- US 5715555: `https://patents.google.com/patent/US5715555`
- US 5388299: `https://patents.google.com/patent/US5388299`
- Laundry symbol guide: `http://www.textileaffairs.com/lguide.htm`
- Block diagram created with Draw.io
- Conceptual diagrams created with Autodesk Fusion 360 and Adobe Photoshop
- Gantt chart created with TeamGantt
- Bill of materials created with Microsoft Excel