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The University of Texas at Arlington

Architectural Design Specification
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Runtime Terror
Turing Board

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1 Introduction

The Turing Board is a concept autonomous longboard which is capable of exhibiting self-driving capabilities using computer vision. Users of the Turing Board will be able to take advantage of various features such as having the board follow you autonomously and having the board summon itself to you from a parked location, in addition to functioning as a standard electric longboard capable of recording and analyzing all trip data. Users will also be able to use the Turing Board to function as a load carrier, relieving them from the burden of carrying everyday items like backpacks, boxes, etc. if desired. The main components of the Turing Board include a remote control via an app on the user's phone, the Jetson TX2 controlling the software signals and output to other components of the board, the motorized wheels and turning mechanism, computer vision, human-machine interface, and the board's power supply.

2 System Overview

2.1 Computer Vision Layer

This layer is the heart of the core autonomous functionalities of the Turing Board. We use computer vision and depth imagery to determine the board's surroundings and calculate the best path to move forward. The user will have, strapped around their ankle, an elastic band affixed with a pattern of ArUco markers for the *Follow Along* feature. This layer tracks the movement of the user vis-a-vis the anklet to determine how to instruct the combination of motors to move so as to follow the user at an appropriate pace. It is also responsible for detecting possible obstacles when operating on its own to find the user as part of the *Summon* feature. Data taken in from the cameras will flow from this layer into the Main Control Layer to be processed and then sent out the appropriate signals primarily to the Wheels & Turning Layer. This layer also takes in data from the anklet component in the HMI layer specifically for the Follow feature.

2.2 Remote Control Layer

This layer is controlled directly by the user. It takes the form of an app that sends data to the Main Control layer for the appropriate signals to be sent to the other layers. The app requires an authentication process to log into it. It will also provide the user with ride data analysis after a trip on the board is completed. This app is available on iOS and Android.

2.3 Power Layer

This layer is responsible for controlling the power distributed to the electrical components on the Turing Board. It directly powers portions of both the HMI layer and the Wheels & Turning layer. This layer ensures power is not over-distributed by way of a Buck converter. It also provides data on how much charge is left in the battery at any given time. This data is sent to the Main Controls layer for the appropriate signals to be sent out to the other layers as needed.

2.4 Main Controls Layer

This layer is in charge of processing and sending out the majority of the signals on the Turning Board. It receives data from the Computer Vision layer, the Remote Control Layer, and the Power Layer. With these inputs, it sends data to the HMI Layer as well as the Wheels & Turning Layer. The Jetson TX2 provides the computing power in this layer and will process all of these needs. It will also fetch data from a real-time database and directly interact with a separate micro-controller that is in charge of the minor systems on the Turing Board.

2.5 HMI Layer

This layer contains all of the hardware parts of the Turing Board that interacts directly with the user. This layer includes LEDs, a pressure sensor, a buzzer/speaker, and an anklet. The LEDs let the user know what mode the board is in (Summon, Follow, or Electric) based off the color they are emitting at the time. The pressure sensor determines how much weight is currently on the board and transmits this information to the Main Controls layer to control what mode the board is in. The buzzer or speaker will make a sound if the user steps onto the board when it is not in Electric mode to notify them of improper usage. Finally, the anklet is to be worn by the user to give data to the Computer Vision Layer when the board is in *Follow Along* mode.

2.6 Wheels & Turning Layer

This layer contains the components needed to cause the board to move and turn. It contains the ESC, brushless motors, stepper motors, optical sensors for the stepper motors, solenoids, optical sensors for the solenoids, the micro-controller, and the turning mechanism. The ESC will control the speed at which the brushless motors inside of the wheels turn as determined by signals sent from the Main Controls layer. The stepper motor will turn the turning mechanism a certain amount of degrees not exceeding 30-45 in either direction as determined by the Main Controls layer. The optical sensor for the stepper motor will track how many degrees the turning mechanism has been turned and send this data to the Main Controls layer. The solenoids will be responsible for locking the turning mechanism in place when it is in Electric mode. The optical sensors for the solenoids will determine if the solenoids are properly locked in place or not and transmit this data to the Main Controls layer. The micro-controller will receive data from the Main Controls layer and use that to output the necessary signals to the motors.

3 Subsystem Definitions & Data Flow

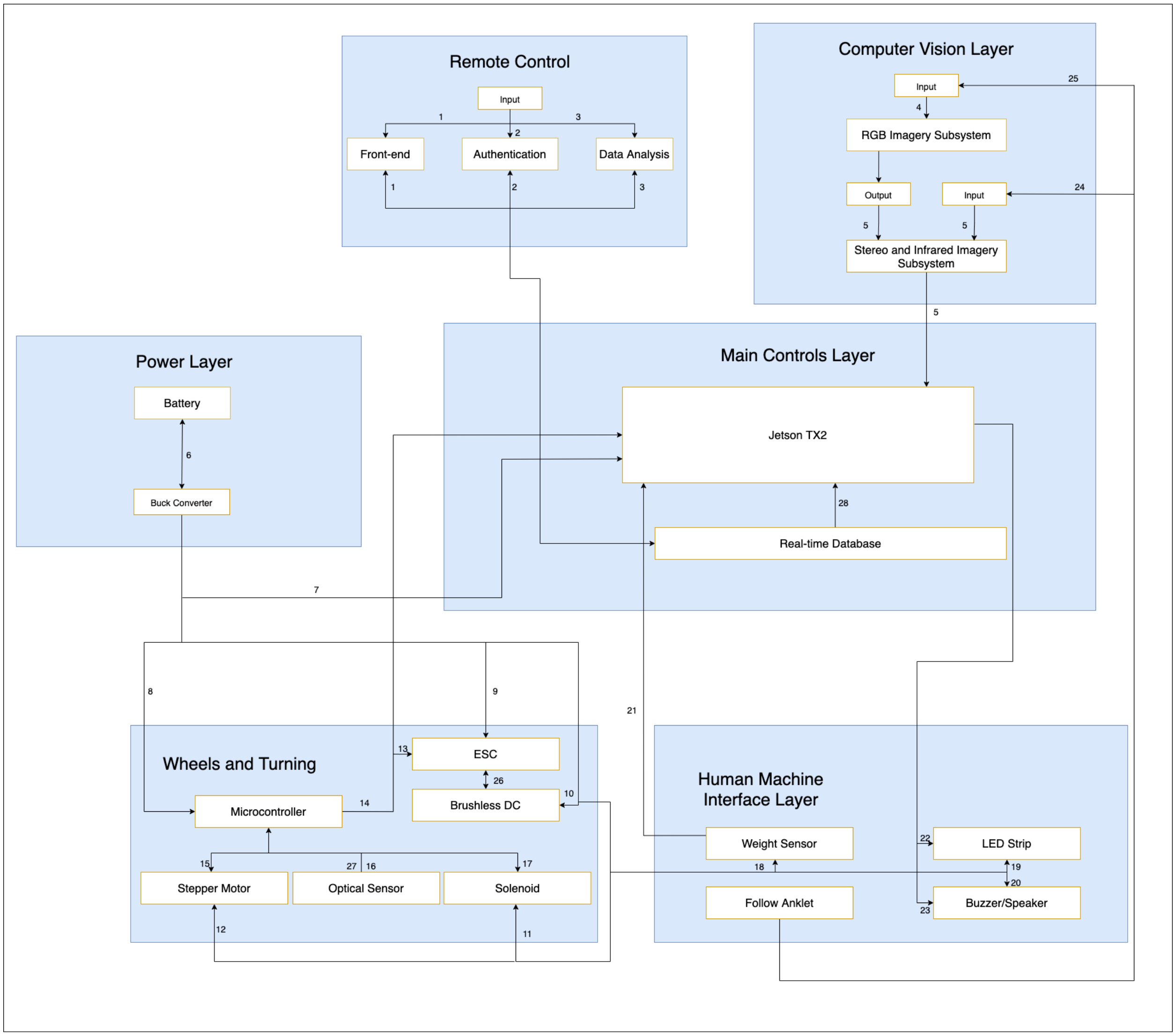

Figure 1: The Turing Board Data Flow

4 Remote Control Layer Subsystems

The purpose of this layer is to control the Turning Board. This layer is directly accessible to the user and takes the form of an Android and iOS apps. This layer communicates with the Main Control layer adequately to propagate user commands.

4.1 Front-end UI and Main Control Communication

The Front-end UI and the Main Control Layer, currently, communicate via internet. With a Firebase back-end set up, the UI interfaces with the back-end, which in turn propagates data to the Main Control. The back-end system uses a real-time NoSQL database. The Main Control, in turn, retrieves the appropriate data and passes it on to the corresponding subsystem.

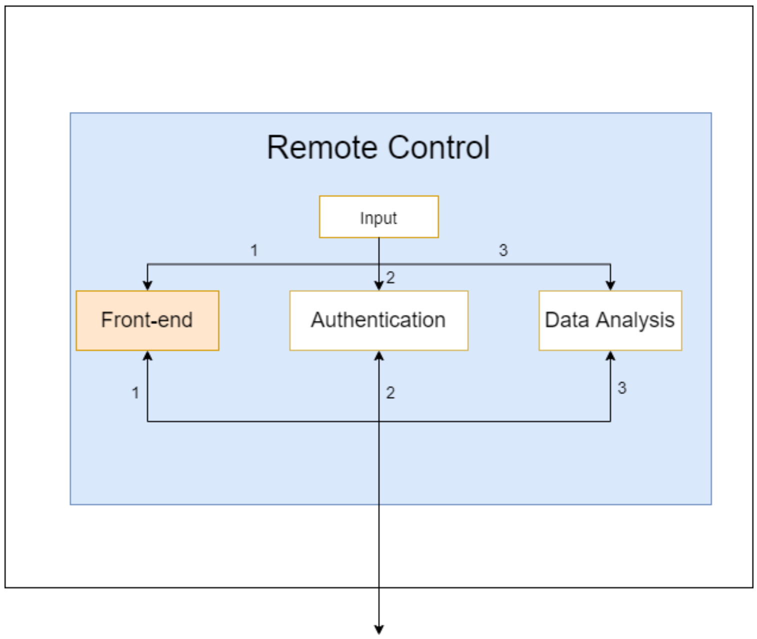

Figure 2: Front-end subsystem in Remote Control Layer

4.1.1 Assumptions

It is assumed that the latency between data posting by the front-end and data retrieval by the Main Control is almost negligible. It is also assumed the user is always connected to the internet while the Turing Board is active.

4.1.2 Responsibilities

The UI must present the user with an easy to user interface. The UI must post the component's data to the real-time database as soon as the state of a component changes.

4.1.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 2: Front-end interfaces

ID	Description	Inputs	Outputs
#1	Giving the UI a command	User command	raw data to a database

4.2 Authentication

When the user attempts to log into the app or sign up, the UI parses the login or sign up information (i.e.name, email, password, etc.). The parsed data is then sent to a Firebase Authentication API. The API in turn forwards a token to the app confirming status of the attempt - either a successful or unsuccessful login or sign up. The app then uses the data to render the UI accordingly.

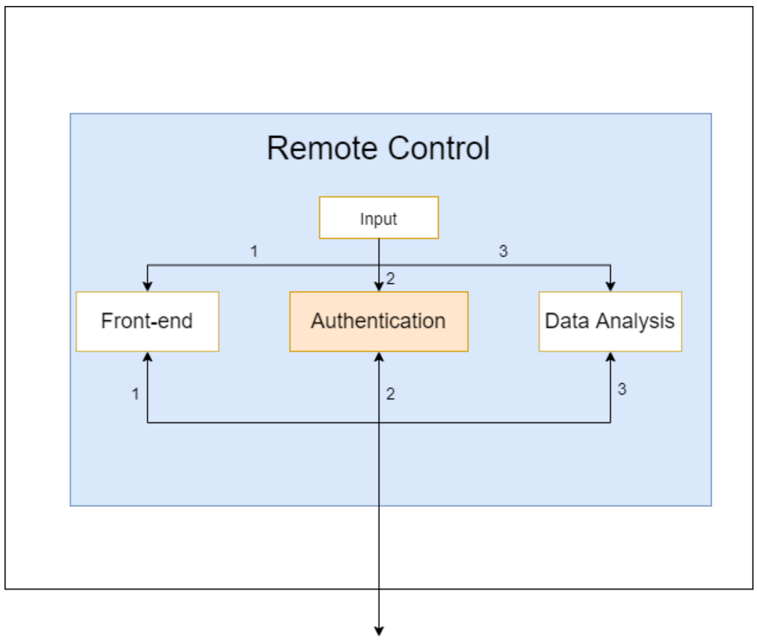

Figure 3: Authentication subsystem in Remote Control Layer

4.2.1 Responsibilities

This feature determines if a user has access to the UI controller or not. It makes sure the right data will be sent to the right Turing Board.

4.2.2 Authentication Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 3: Authentication interfaces

ID	Description	Inputs	Outputs
#2	Authentication	User information	Token

4.3 Ride Data Analysis

This will be information provided to the user after a ride. This information may include average speed of the ride, the duration of the ride, and the distance traveled.

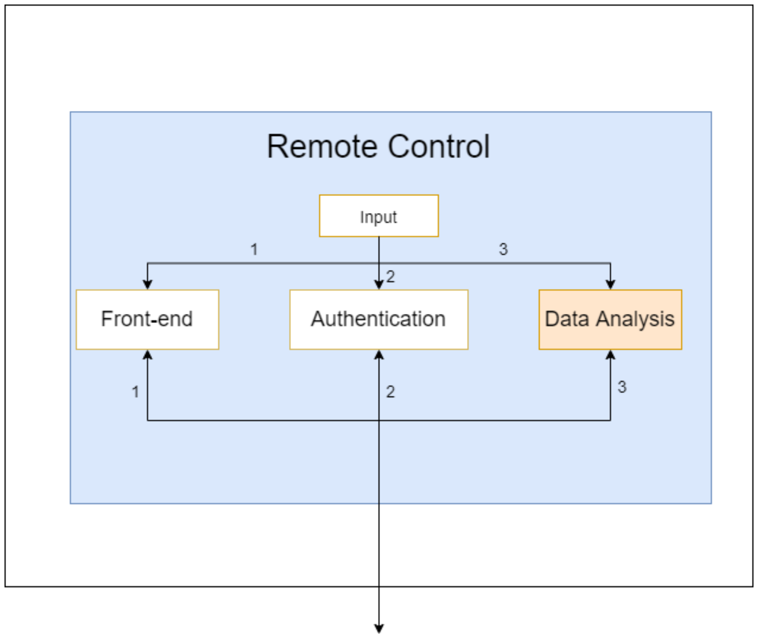

Figure 4: Ride Data Analysis subsystem in Remote Control Layer

4.3.1 Responsibilities

Provide users with their ride analysis in an understandable format.

4.3.2 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 4: Ride data analysis interfaces

ID	Description	Inputs	Outputs
#3	Ride analysis	refined database data	legible ride analysis data

5 Main Controls Layer Subsystems

This layer is responsible for binding all modules of the Turing Board into one cohesive system. All data coming in is intercepted by this layer and forwarded to the respective modules, which are responsible for processing the forwarded data.

5.1 NVIDIA Jetson TX2

The NVIDIA Jetson TX2 will be powering the main computing module for the Turing Board. It will be responsible for processing all input from the remote control and computer vision. From there, it will be responsible for sending the appropriate signals to the peripherals.

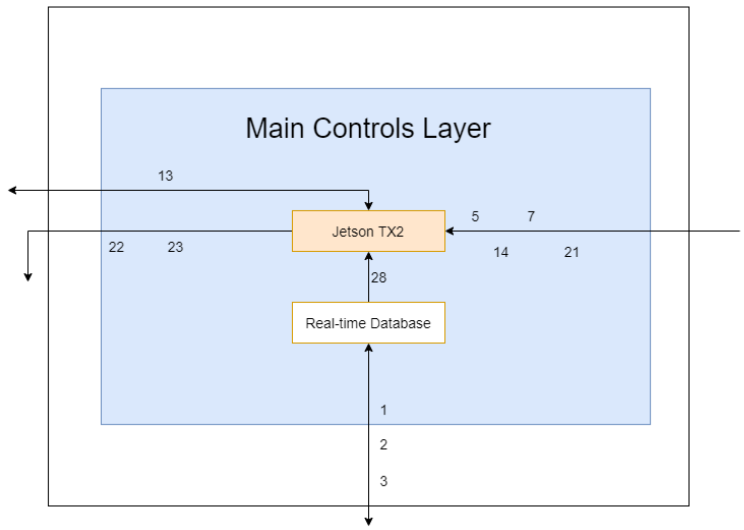

Figure 5: NVIDIA Jetson TX2 in the Main Controls Layer

5.1.1 Assumptions

It is assumed that the Jetson TX2 will be connected to WiFi the entire time it is active.

5.1.2 Responsibilities

The Jestson TX2 will take in all inputs from the remote control, computer vision and other peripherals. With this data, it will be responsible for sending the appropriate signals to the corresponding peripherals.

5.1.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 5: Controls Software Interfaces

ID	Description	Inputs	Outputs
#5	Computer Vision Data	Optimized distance of target object(s) from camera True position of target object(s) in 2D space	N/A
#7	Power	Power	N/A
#13	CAN Bus to Jetson	Motor RPM	Desired Speed
#14	Connection to the Microcontroller	Turing mechanism angle Solenoid state	Degrees to rotate turning mechanism Toggle turning mechanism (on/off) Toggle solenoid
#21	Connection to Weight Sensor	Current weight value on board	N/A
#22	Connection to LEDs	N/A	Mode Indicator Signal
#23	Connection to Buzzer/Speaker	N/A	Alert Signal
#28	Data Fetching	User entered values	

5.2 Real-Time Database

The Turing Board's real-time database is will be hosted by Google Firebase. It will hold our data values per user and allow for a quick transfer of information over internet between the Turning Board's computing components.

5.2.1 Assumptions

It is assumed that the Jetson TX2 and the user's phone (the remote control) will be connected to the internet the entire time it is active. This will allow for communication via the real-time database.

5.2.2 Responsibilities

The real-time database will be responsible for storing user entered values from the remote control so the Jetson can compare those values with the current peripheral in order to make adjustment accordingly.

5.2.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

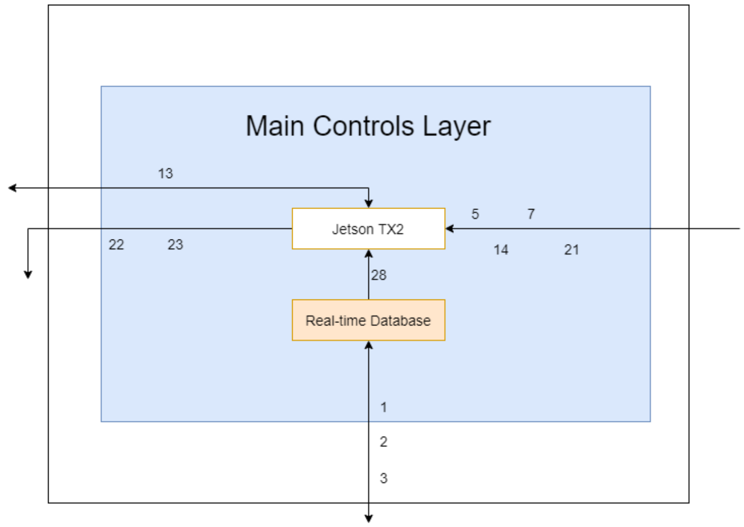

Figure 6: The Real-Time Database in the Main Controls Layer

Table 6: Controls Software Interfaces

ID	Description	Inputs	Outputs
#1	Front-end	Data from database to dispaly per screen on app	User command
#2	Authentication	Token	User information
#3	Ride analysis	legible ride analysis data	refined database data
#28	Data Fetching	N/A	User entered values

6 Wheels & Turning Layer Subsystems

This layer is responsible for the overall propulsion of the Turing Board. An Electronic Speed Controller (ESC) will be used to regulate the speed of the motors, reverse direction of the motors, and provide regenerative braking. While in autonomous mode the longboard is not capable of using weight to compress the bushing that turn the board. A mechanism is needed that will sit between the trucks and the board that will allow the front truck to rotate independently. This mechanism will be held in place by two solenoids acting as locking pins. A stepper motor using an optical sensor for positioning will interact with gears on the mechanism to rotate it to the desired angle.

6.1 Electronic Speed Controller

The Electronic Speed Controller (ESC) is an electronic circuit that controls and regulates the speed of the motors. The ESC receives desired speed commands from the Jetson TX2 using the CAN bus. Two brushless DC motors, which are embedded into the wheels of the longboard, provide feedback concerning the wheels' direction back to the ESC using hall effect sensors. Using information from both of these systems, the ESC is able to provide current to the motors in order to drive a load at a set speed.

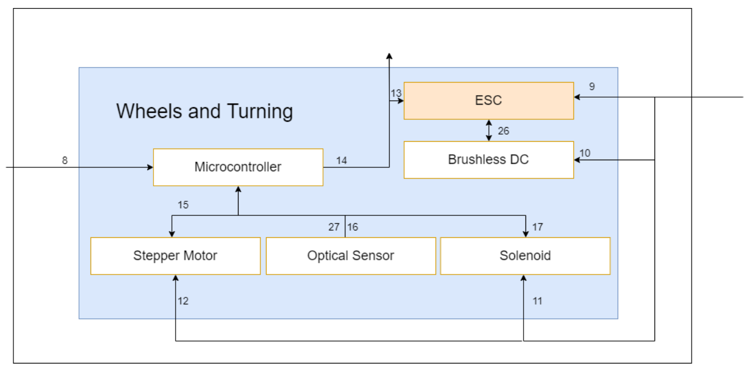

Figure 7: Electronic Speed Controller

6.1.1 Assumptions

It is assumed that this layer is only called when the board is in use. A speed command must be sent by either the user or the autonomous software.

6.1.2 Responsibilities

The ESC is responsible for driving the motors at a constant speed determined by the user. It is also responsible for reversing the direction of the motors to move the longboard backwards if desired. When the brake is applied, the ESC uses its circuitry to redirect the rotational energy of the wheel and recharge the battery powering the longboard.

6.1.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 7: ESC interfaces

ID	Description	Inputs	Outputs
#9	Power	Power	N/A
#13	CAN Bus to Jetson	Desired Speed	Motor RPM
#26	Direct Connection to Motor	Hall Effect Sensor	Current to Motor

6.2 Brushless DC Motor

There are two brushless DC motors embedded into the wheels of the longboard. Each motor has three hall effect sensors that allow the speed controller to know how fast the wheels are moving.

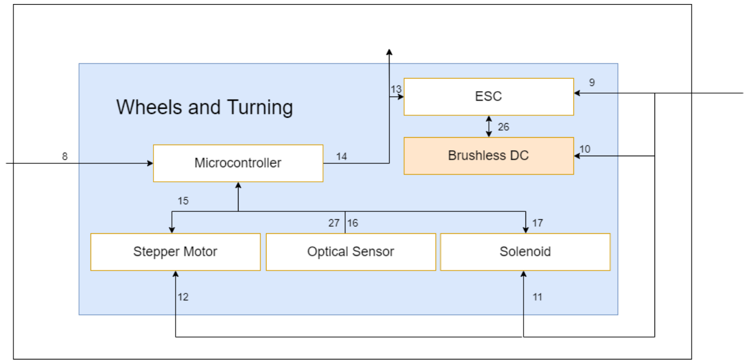

Figure 8: Brushless DC Motor

6.2.1 Assumptions

It is assumed that the battery will have sufficient charge in order to power the motor and allow it to rotate.

6.2.2 Responsibilities

Rotate when current is applied to the three phases.

6.2.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 8: Brushless Dc Motor interfaces

ID	Description	Inputs	Outputs
#10	Power	Power	N/A
#26	Connection to Motor	Electrical Current	Motor Position

6.3 Microcontroller

The micro-controller will handle the majority of the lower hardware functions such as sensors, solenoids, stepper motor, and PWM control. It will interface with the Jetson TX2.

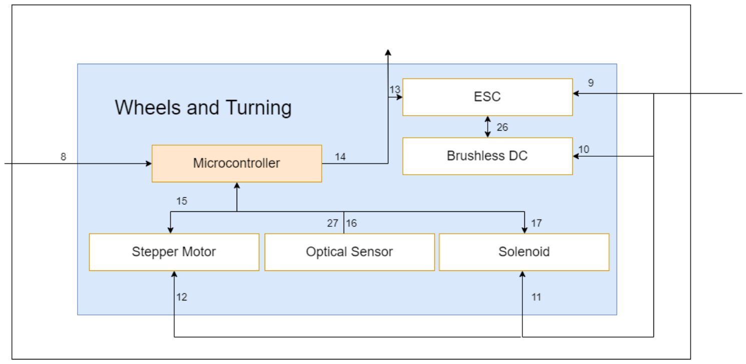

Figure 9: Microcontroller

6.3.1 Assumptions

It is assumed that the micro-controller will be receiving constant instructions from the Jetson TX2.

6.3.2 Responsibilities

The micro-controller is responsible for direct control of the stepper motor, solenoids, and optical sensors, as well as the corresponding data from each. It is primarily needed to ensure that the turning mechanism is working as intended and will alert the Jetson of any faults that occur.

6.3.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 9: Microcontroller interfaces

ID	Description	Inputs	Outputs
#8	Power	Power	N/A
#14	Connection to Jetson	Instructions	Status Update
#16	Optical Sensor	Solenoid Position	N/A
#27	Optical Sensor	Motor Position	N/A

6.4 Optical Sensors

Several optical sensors will be operating in the project. Stepper motors have no method for determining position, but by attaching a piece of metal to the motor we can determine the gear position when the rotating metal breaks the beam of light inside the optical sensor. They will also be used to detect when the plunger of the solenoid has been engaged, blocking the light of the sensor

6.4.1 Assumptions

It is assumed that the sensor will be free of all dirt, debris or any other obstruction that could give false readings to the micro-controller.

6.4.2 Responsibilities

Providing the micro-controller information on the stepper motor position or if the solenoids have been engaged.

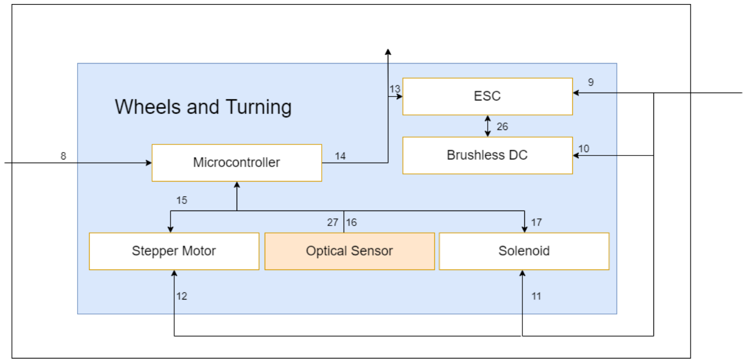

Figure 10: Optical Sensors

6.4.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 10: Optical sensor interfaces

ID	Description	Inputs	Outputs
#16	Connection to Motor	Solenoid Plunger	Solenoid Engaged
#27	Connection to Motor	Motor Shaft	Motor Position

6.5 Stepper Motor

One stepper motor will be utilized to drive a bevel gear that interacts with the turning mechanism. This stepper motor will interface with the micro-controller and will know its position based on an optical sensor mounted on it.

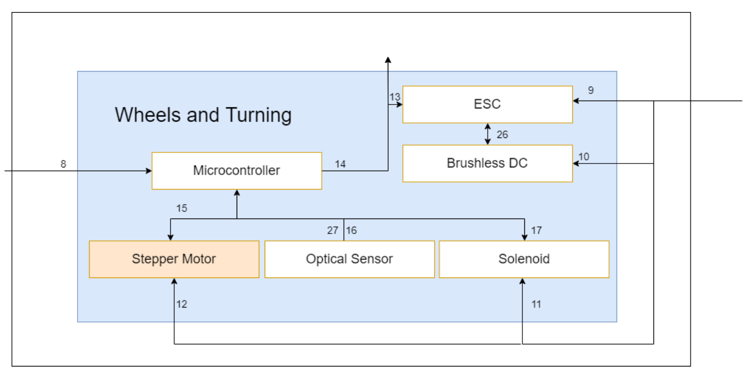

Figure 11: Stepper Motor

6.5.1 Assumptions

It is assumed that the optical sensor is operating correctly and relaying the appropriate positional information to the micro-controller.

6.5.2 Responsibilities

Drive the bevel gear connected to the turning mechanism which allows the trucks to turn.

6.5.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 11: Stepper motor interfaces

ID	Description	Inputs	Outputs
#15	Connection to Micro-Controller	Electrical Current	N/A
#27	Connection to Optical Sensor	N/A	Motor Position

6.6 Solenoid

A minimum of two solenoids will be utilized as locking pins on the turning mechanism. When needing to turn while the board is in autonomous mode, the code will engage the solenoids to pull them out of the turning mechanism housing. The solenoids will remain engaged while the stepper motor is operational. When turning is complete, the solenoids will be discharged to allow them to return to their position inside the turning mechanism.

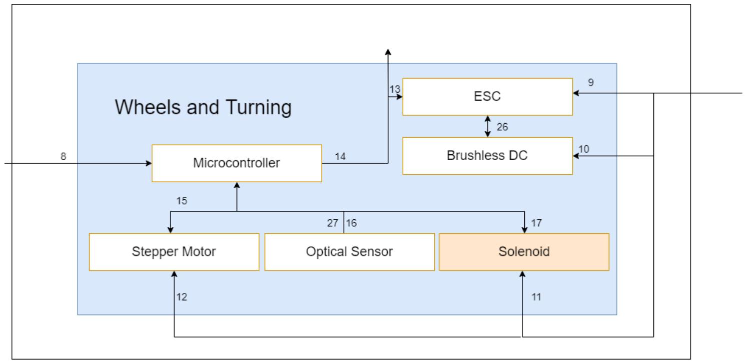

Figure 12: Solenoid

6.6.1 Assumptions

Solenoids will only engage when in autonomous mode and the truck needs to be able to rotate freely. Optical sensors will be used in conjunction and it is assumed that the micro-controller will always know if the solenoid is engaged or not.

6.6.2 Responsibilities

Insert plunger into the turning mechanism when it is at 0 degrees. Prevent the front truck from rotating while in rider mode.

6.6.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 12: Solenoid interfaces

ID	Description	Inputs	Outputs
#16	Connection to Optical Sensor	N/A	Solenoid Engaged
#17	Connection to Micro-Controller	Current	N/A

7 Computer Vision Layer Subsystems

This layer is the heart of the core autonomous functionalities of the Turing Board. We use computer vision and depth imagery to determine the board's surroundings and calculate the best path to move forward. The user will have, strapped around their ankle, an anklet-like contraption consisting of a pattern of ArUco markers for the *Follow Along* feature. This layer tracks the movement of the user through the anklet to determine how to instruct the combination of motors to move so as to follow the user at an appropriate pace. It is also responsible for detecting possible obstacles when operating on its own to find the user as part of the *Summon* feature.

7.1 RGB Imagery Subsystem

RGB Imagery of the front of the board is used as input in making various position specific calculations pertaining to navigation.

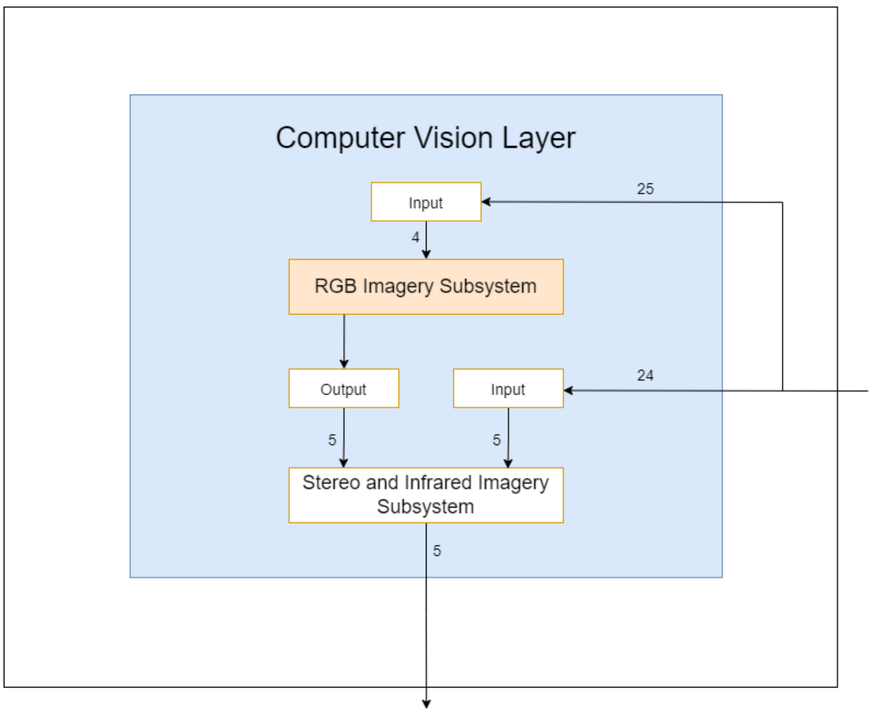

Figure 13: RGB Imagery subsystem description diagram

7.1.1 Assumptions

This layer is triggered by the user via the native iOS/Android application. It is assumed that the layer is being called upon in terrain with sufficient lighting conditions so that the RGB camera is able to produces images of good quality. For the *Follow Me* feature, it is assumed that the user has their anklet put on and proceeds to start with the anklet within the frame of the camera.

7.1.2 Responsibilities

RGB imagery is responsible for powering the *Follow Along* and the *Summon* features. For the *Follow Along* feature, this subsystem calculates the position of the user in 1D space along the horizontal axis to determine whether to turn left, right, or straight. For the *Summon* feature, this subsystem is responsible for helping identify patterns for possible obstacles ahead.

7.1.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 13: RGB Imagery Interfaces

ID	Description	Inputs	Outputs
#4,25	RGB Imagery	RGB Frame	Position of target object(s)

7.2 Stereo and Infrared Imagery Subsystem

Stereo and Infrared Imagery of the front of the board is used as input in making various depth specific calculations pertaining to navigation.

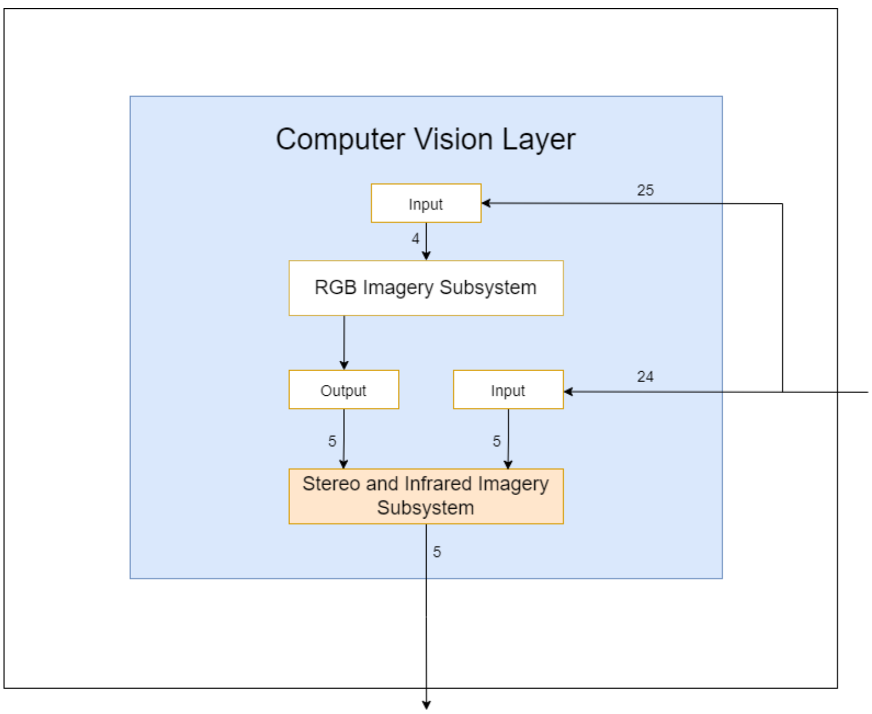

Figure 14: Stereo Imagery subsystem description diagram

7.2.1 Assumptions

This layer is triggered by the user via the native iOS/Android application. It is assumed that the layer is being called upon in terrain with sufficient lighting conditions so that the RGB Stereo cameras are able to produces images of good quality. For the *Follow Me* feature, it is assumed that the user has their anklet put on and proceeds to start with the anklet within the frame of the camera.

7.2.2 Responsibilities

Stereo and Infrared imagery is responsible for powering the *Follow Along* and the *Summon* features. For the *Follow Along* feature, this subsystem calculates the position of the user in 1D space along the longitudinal axis to determine whether to move forward or to stay put. For the *Summon* feature, this subsystem is responsible for helping identify how far objects detected by the RGB module are.

7.2.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 14: Stereo and Infrared Imagery Interfaces

ID	Description	Inputs	Outputs
#5,24	Depth Imagery	Depth Frame Position of target object(s)	Optimized distance of target object(s) from camera True position of target object(s) in 2D space

8 HMI Layer Subsystems

This layer involves the various sensors and indicators that interact between the Turing Board and the user directly. This includes the weight sensor which is used to detect if the rider falls off the board, triggering an emergency stop. It also detects if the user attempts to step on the board during autonomous mode. This, in turn, would trigger a speaker/buzzer to beep until the board finishes rotating the front turning mechanism back to the neutral position and locks it in place. An anklet will be used to help the Turing Board find the rider and track them when in follow-along mode. These are all interconnected with the central control unit and the various modes being implemented in the final product. As a result, we are implementing an LED strip to help indicate to the user what mode the Turing Board is currently in, specified by different color lights.

8.1 Weight Sensor

The weight sensor will be implemented as a safety feature primarily, with future uses in load carrying. When a user is riding on the board, it will detect if they fall off to initiate an emergency stop. When a user attempts to get on the board while in autonomous mode it will trigger an alert noise to notify the user it is not safe to ride.

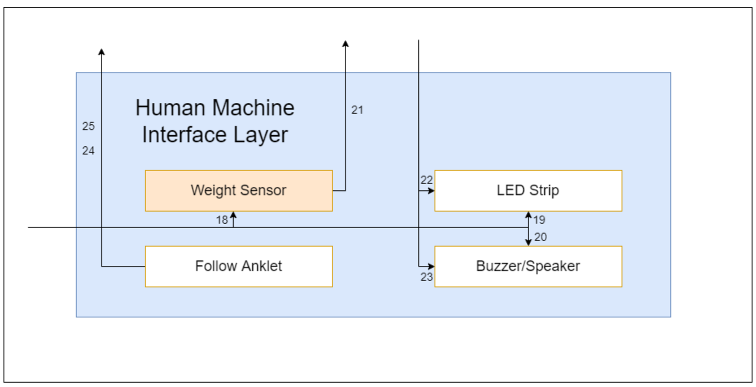

Figure 15: Weight Sensor

8.1.1 Assumptions

This subsystem is assumed to interact with the Jetson TX2 to send a signal to the motorized wheels and turning mechanism and the buzzer/speaker. It will be activated nearly all the time to detect when a rider has fallen off or attempts to get on, both in autonomous or riding mode. It is also assumed to be regulated for the weight of the rider.

8.1.2 Responsibilities

The weight sensor is responsible for alerting the Jetson TX2 when a rider has either stood on or fallen off the Turing Board. In the event the rider falls off, the weight sensor will signal for an emergency stop. In the event the rider stands on the board when in autonomous mode, it will signal for an emergency buzzer to alert the rider it is not safe to stand on the board yet.

8.1.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 15: Weight sensor interfaces

ID	Description	Inputs	Outputs
#18	Connection to Power Subsystem	Power	N/A
#21	Connection to Jetson TX2	N/A	Weight Value

8.2 Buzzer/Speaker

The buzzer/speaker will be used to alert the user if they attempt to step on the board when it is in an autonomous mode. When the weight sensor detects a person attempting to stand on the board when in autonomous mode, the buzzer will begin to sound an alert to notify the user it is unsafe to stand on it.

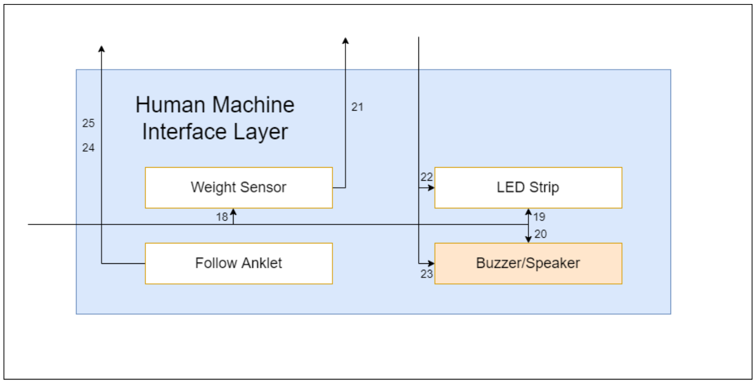

Figure 16: Buzzer/Speaker

8.2.1 Assumptions

The weight sensor is assumed to be capable of measuring the weight of the rider meaning that it does not become overburdened and unable to provide accurate readings. It is also assumed that the weight sensor is already communicating with the Jeston TX2 and a signal can be transmitted back to the speaker/buzzer.

8.2.2 Responsibilities

The buzzer/speaker is responsible for alerting the user when it is unsafe to stand on the Turing Board. In the event the rider attempts to stand on the board when in autonomous or follow-along mode, the buzzer will emit a loud noise.

8.2.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 16: Buzzer/Speaker interfaces

ID	Description	Inputs	Outputs
#20	Connection to Power Subsystem	Power	N/A
#23	Connection to Jetson TX2	Alert Signal	N/A

8.3 LED Strip

The LED strip will be used to indicate to the user what mode the Turing Board is currently in. These modes will be differentiated by implementing a different color for each mode.

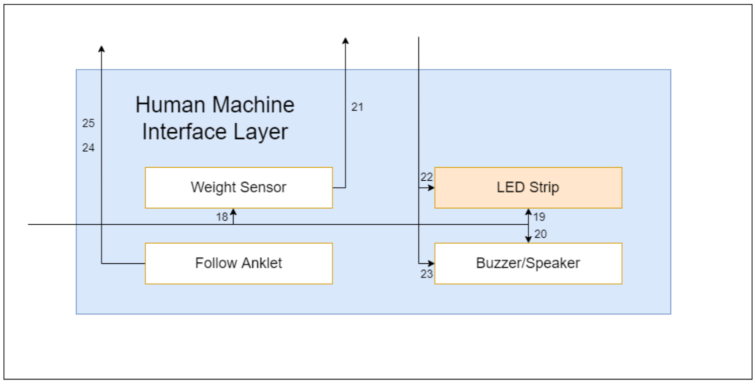

Figure 17: LED Strip

8.3.1 Assumptions

This subsystem will be active most, if not all of the time. It will be able to display different colors to indicate different modes.

8.3.2 Responsibilities

The LED strip will be in charge of indicating to the user what mode the Turing Board is currently in. This is done by displaying a different color depending on the mode it is in. It will also be partially responsible for illuminating the area at night.

8.3.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 17: LED interfaces

ID	Description	Inputs	Outputs
#19	Connection to Power Subsystem	Power	N/A
#22	Connection to Jetson TX2	Mode Indicator Signal	N/A

8.4 Follow Anklet

The Anklet will be a worn feature used for the CV to track and follow the rider in follow-along mode.

8.4.1 Assumptions

It is assumed that the user will wear this in a position viewable by the Turing Board's camera(s) during follow-along mode.

8.4.2 Responsibilities

The anklet will be responsible for allowing the Turing Board to track the user as they walk around. It will use sensors to track its position, adjusting the turning mechanism accordingly to center on it. It

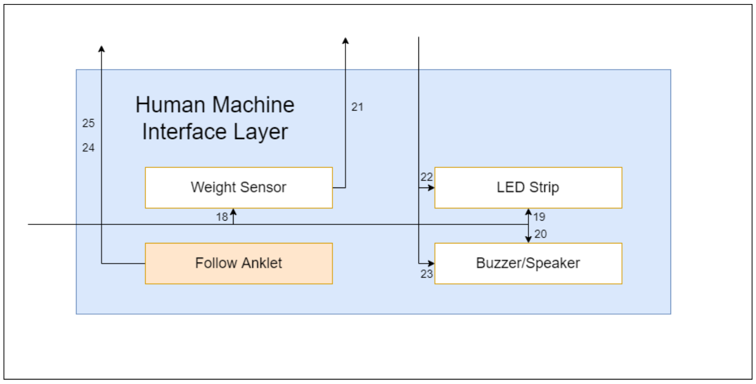

Figure 18: Follow Anklet

will also signal the board to speed up or slow down depending on the distance to the anklet calculated by depth sensing.

8.4.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 18: Anklet interfaces

ID	Description	Inputs	Outputs
#24,25	Connection to CV Subsystem	N/A	Tracking Symbol

9 Power Layer Subsystems

Each electrical component has a specific power requirement and this layer is responsible for providing that power.

9.1 Battery

This module consists of a Li-Po battery which provides power to a Buck Converter.

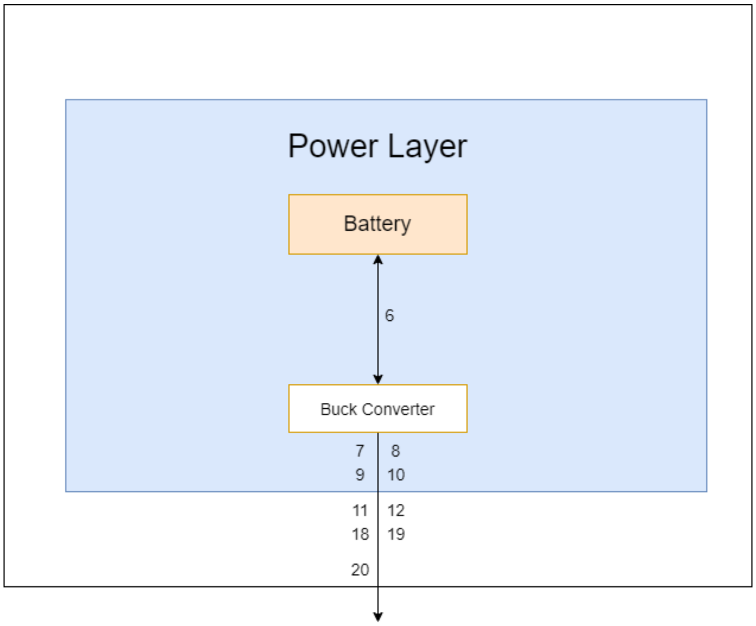

Figure 19: Battery Subsystem in Power Layer

9.1.1 Assumptions

The batteries are expected to allow the user to ride the longboard for at least 30 minutes without requiring recharging.

9.1.2 Responsibilities

The Batteries would ideally provide around 24V.

9.1.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 19: Battery interfaces

ID	Description	Inputs	Outputs
#6	Raw Power	Excess power	24V

9.2 Buck Converter

The entire module consists of a Li-Po battery which provides power to a Buck Converter which then powers the rest of the system.

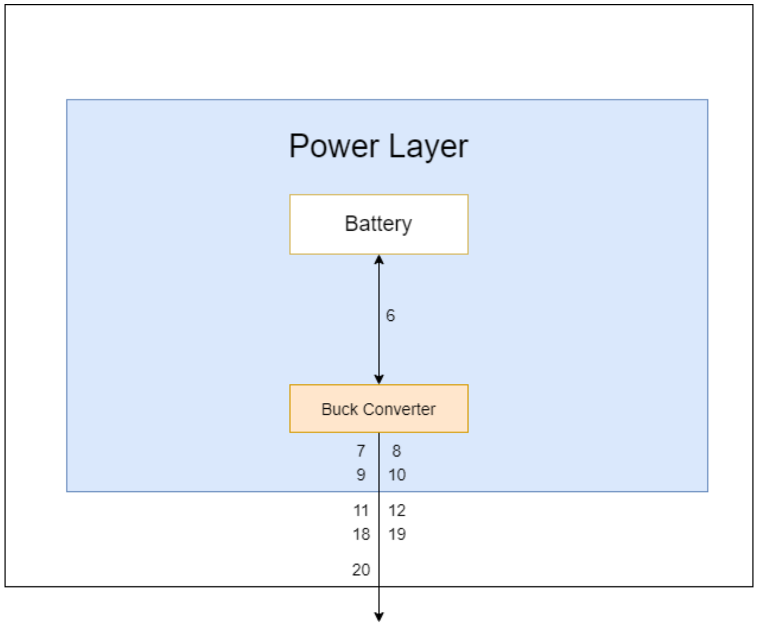

Figure 20: Buck Converter Subsystem in Power Layer

9.2.1 Assumptions

The batteries are expected to allow the user to ride the longboard for at least 30 minutes without requiring recharging.

9.2.2 Responsibilities

The Buck converter will take the 24V from the battery and step it down to 19V for the Jetson TX-2 and 5V if an auxiliary micro-controller is connected.

9.2.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 20: Buck converter interfaces

ID	Description	Inputs	Outputs
#7	Power Delivery to Jetson	N/A	19V/5V
#8	Power Delivery to Microcontroller	N/A	19V/5V
#9	Power Delivery to ESC	N/A	19V/5V
#10	Power Delivery to Brushless DC	N/A	19V/5V
#11	Power Delivery to Solenoids	N/A	19V/5V
#12	Power Delivery to Stepper Motor	N/A	19V/5V
#18	Power Delivery to Weight Sensor	N/A	19V/5V
#19	Power Delivery to LED Strip	N/A	19V/5V
#20	Power Delivery to Buzzer/Speaker	N/A	19V/5V

REFERENCES