Receptionist Robot

Design and Development of A Humanoid Robot

25 January 2022

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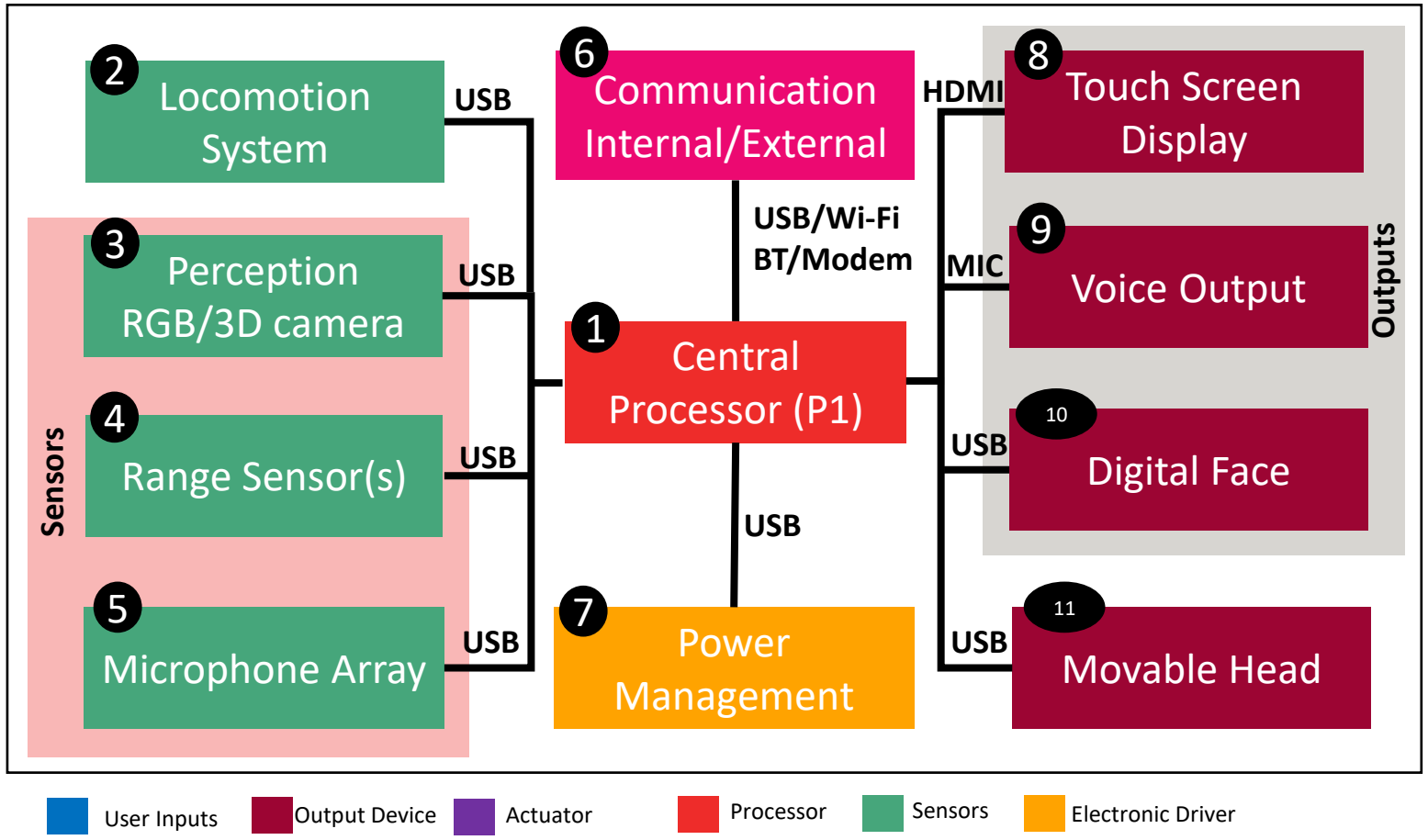
Modules (Electrical/Electronics)

- Central Processor P(1)-Running master node (node handler). All nodes are registered under this node.
- Locomotion Node runs on an independent processor (P2) connected to P1.
- All the sensors are connected to Processor 3 (P3) and connected P1.
- Output devices are connected to P1.



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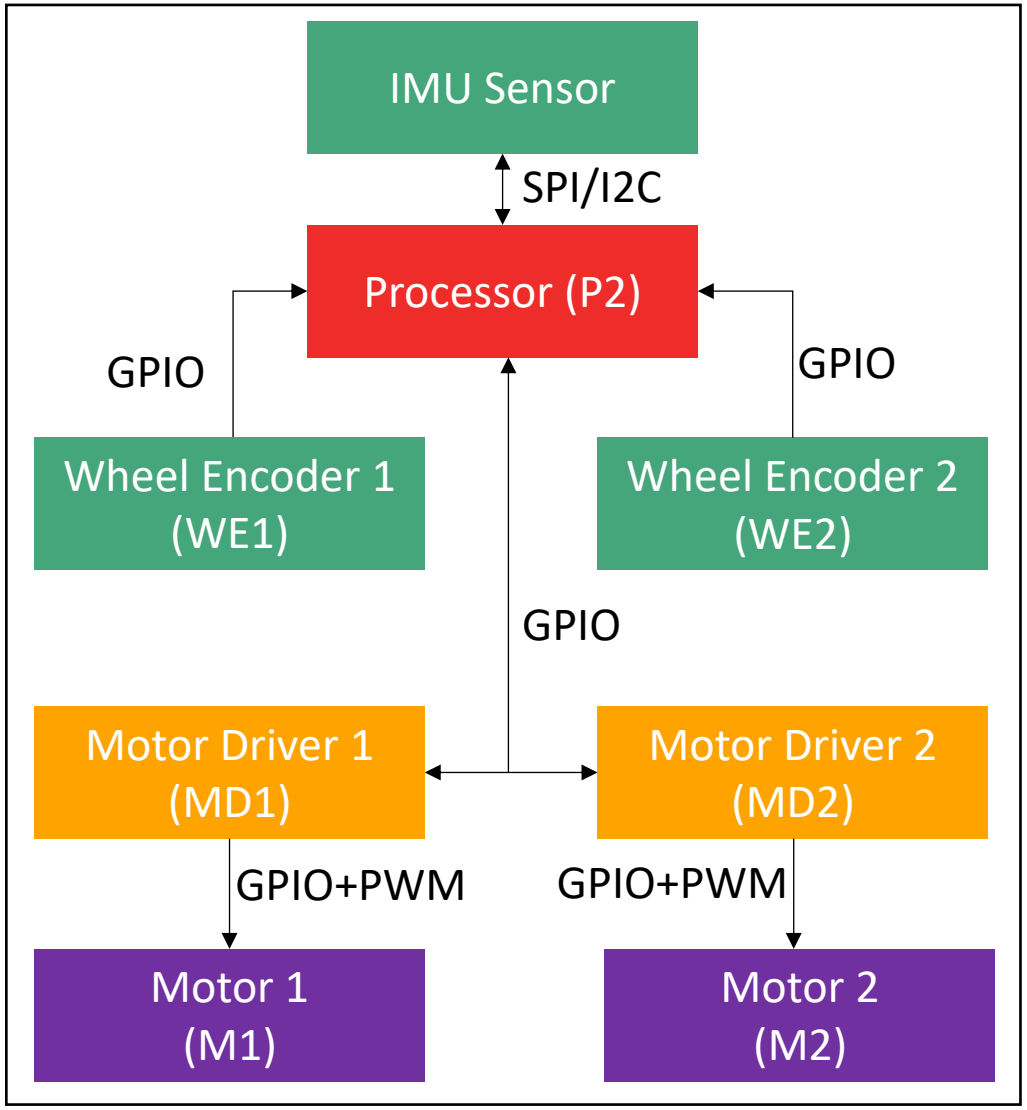
Locomotion System

- Motion control software node (stability and motion control) runs on P2 independent of the central processor.
- Receive navigation commands from P1.
- Two-wheel drive system with self balancing.
- Inputs- IMU data (SPI/I2C data Bus), Wheel Encoder data (GPIO).
- 3 Axes IMU- Orientation sensor fused with WE data.
- Motor driver- 12V direction and speed control.
- M1/M2- DC 12V motor. Attached optical quadratic wheel encoders.



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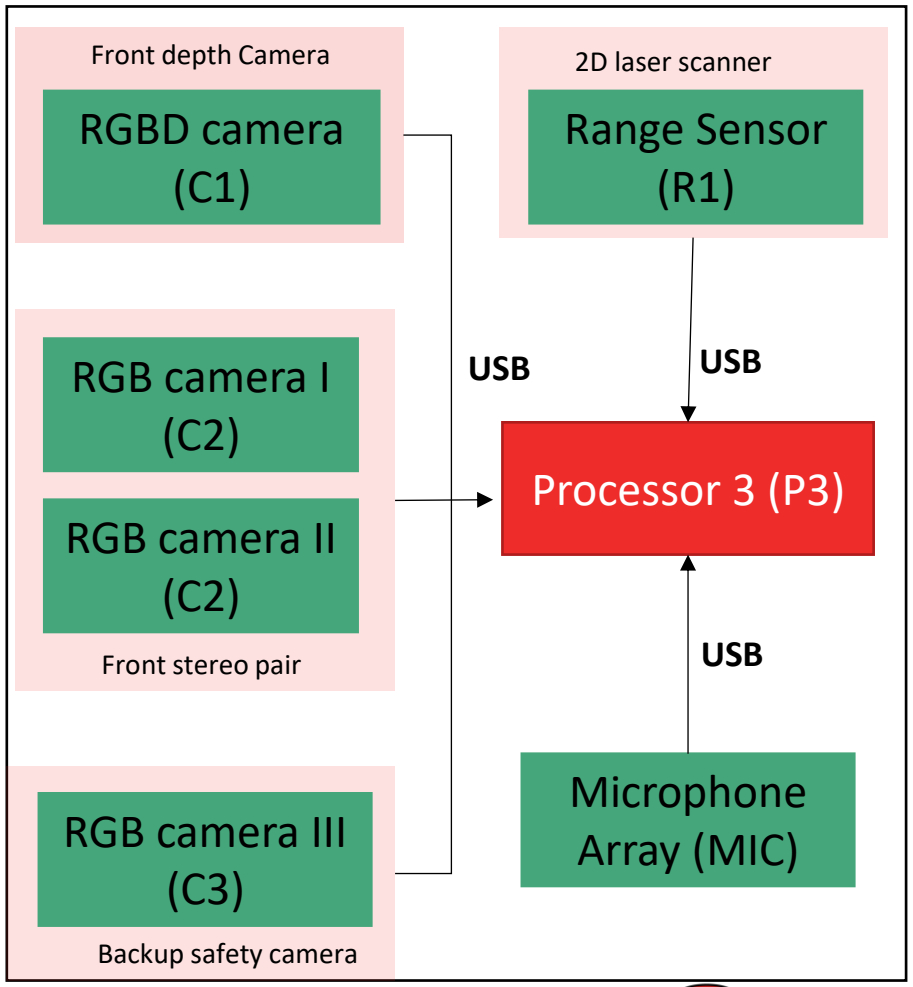
Perception/Sensors

- Front facing fixed RGB-D camera is used to capture depth data for 3D object detection and tracking up to 6m range.
- C1 and C2 RGB stereo pair is mounted on the head (eyes) to scan nearby area. The head with the stereo camera system can rotate around x and y axes.
- C3 is the fixed safety camera mounted at the back.
- R1 is used to get long-range range data up to 30m for 2D mapping that assist to path planning.
- MIC audio input for voice recognition.



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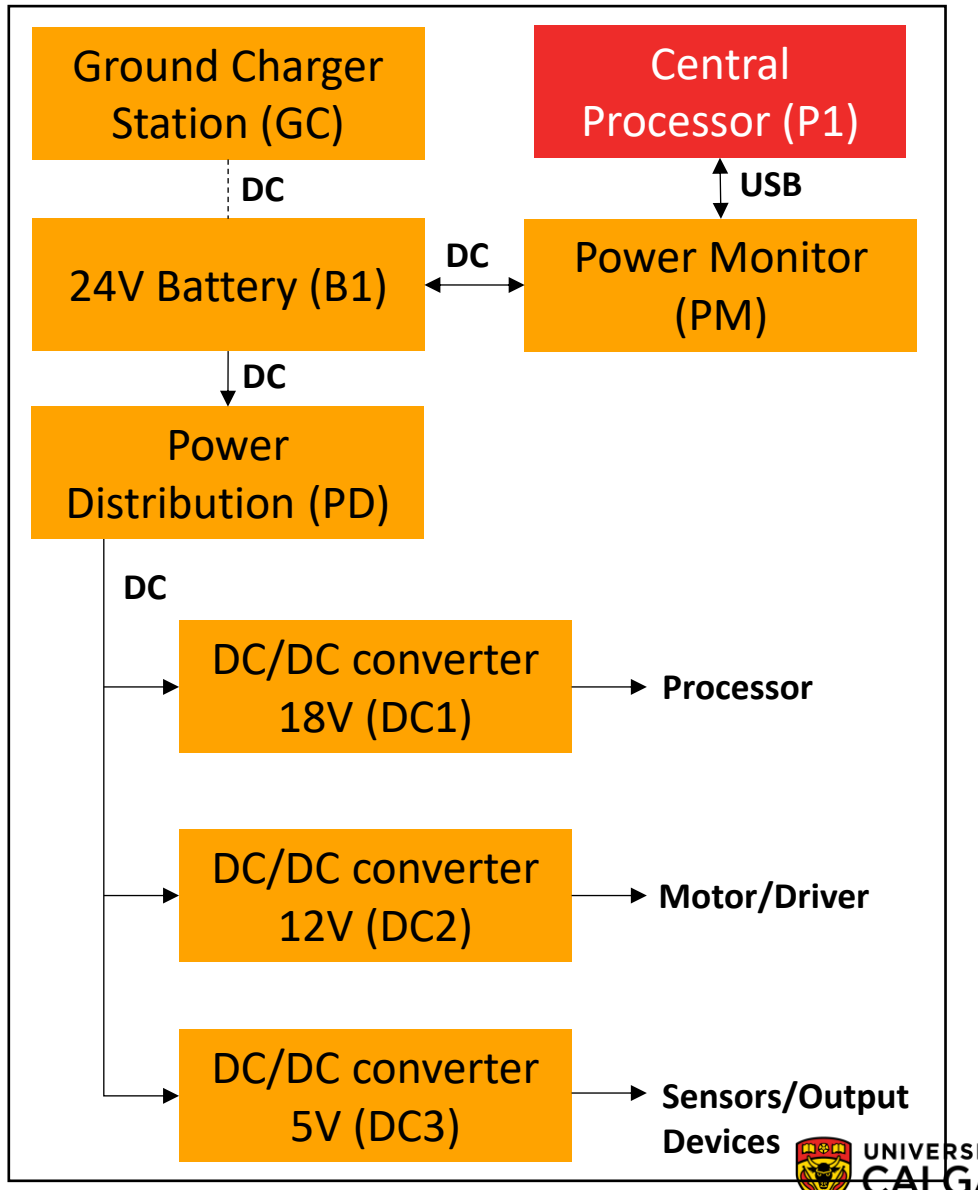
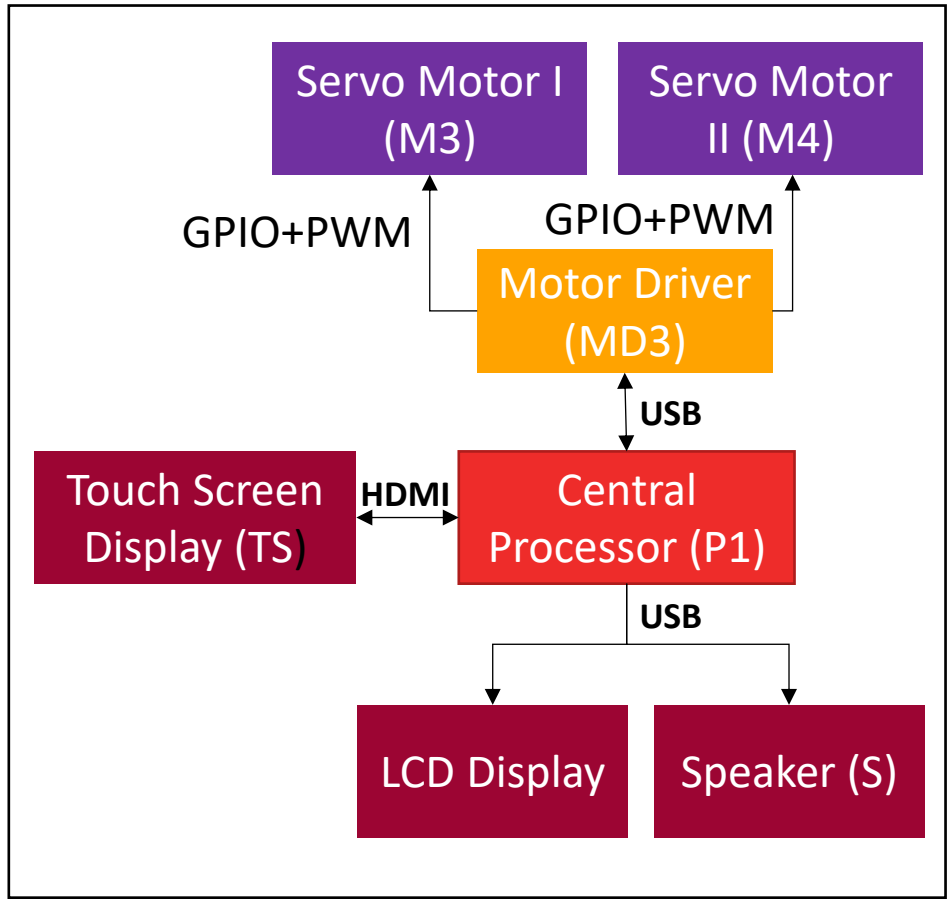
Power Management

- Robot is powered by rechargeable Li-Iron 24V battery pack.
- Robot can automatically docked to the charging station when charging command is received from P1.
- Power monitor continuously monitor the battery level and send data to P1.
- A power distribution board is used to distribute power to DC-to-DC converters.



Movable Head/Output Devices

- Head has 2-DoF motion (rotate around x and y axes) powered by servo motors.
- Front has an LCD display to express emotions.
- A touch screen display (android device) is used provide information to users and get inputs from users.
- Speakers used to deliver voice outputs.



Hardware Specifications

#	Hardware	Power	Comm	Remarks
P1	Central Processor	12-19V	USB, Ethernet, Wi-Fi, BT	
P2	Processor 2	12-19V	USB, Wi-Fi, GPIO	
P3	Processor 3	12-19V	USB, Wi-Fi, GPIO	
M1,M2	DC Motors	24V		
MD1, MD2	DC Motor Drivers	12V, 20A	USB	
IMU	IMU Sensor	5V	USB	
C1	RGBD camera	5V	USB	
C2,C3,C4	RGB camera(s)	5V	USB	
R1	Range Sensor	5V	USB	
MIC	Microphone Array	5V	USB	
B1	Battery	24V, 50C		

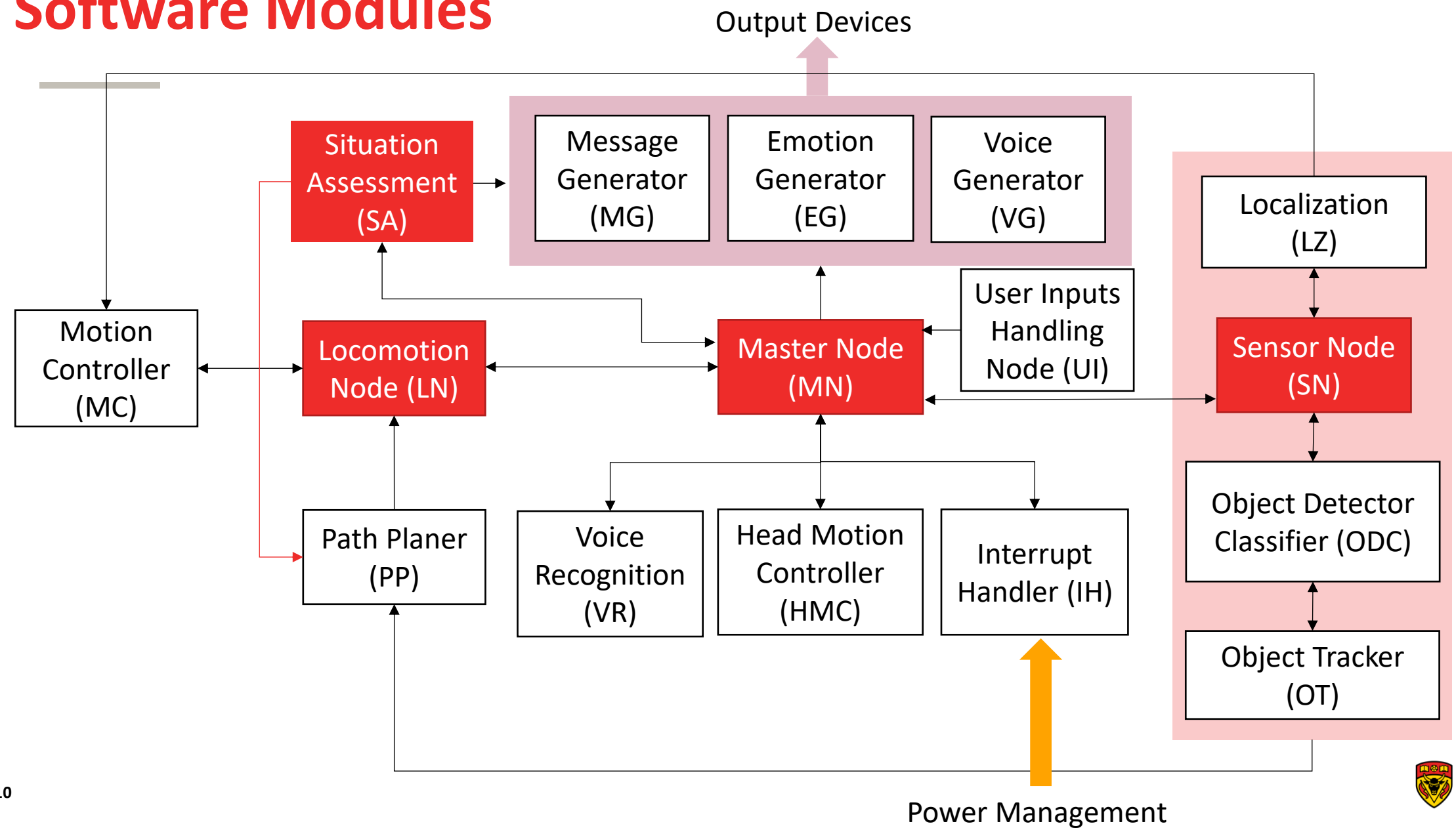
Hardware Specifications …

#	Hardware	Power	Comm	Remarks
DC1	DC/DC converter 18V	18V, 10A		
DC2	DC/DC converter 12V	12V, 100A		
DC3	DC/DC converter 5V	5V, 10A		
PM	Power Monitor	24V	USB	
M3, M4	Servo Motors	5V, 5A	PWM, GPIO	
MD3	Motor Driver	5V, 10A	USB	
TS	Touch Screen	5V	HDMI	
LCD	LCD Display	5V	USB	
S	Speaker	5V	AUX	
GC	Ground Charger	24V, 10A	DC	
PD	Power Distribution Board	24V, 18V, 12V,5V 100A		

Software Tools

- Software is developed on Robot Operating System (ROS).
- Runs on Ubuntu 18.04 LTS, C++, C-Make.
- ROS synchronous multi-threading method is used for real time operations.
- All nodes are running independently, however they are synchronized to maintain proper data flow.
- Third Party Libraries:
  - OpenCV-Computer Vision Library
  - OpenGL- Computer Graphics Library
  - Point Cloud Library
  - TensorFlow- Deep learning toolkit
  - Android Studio

Software Modules



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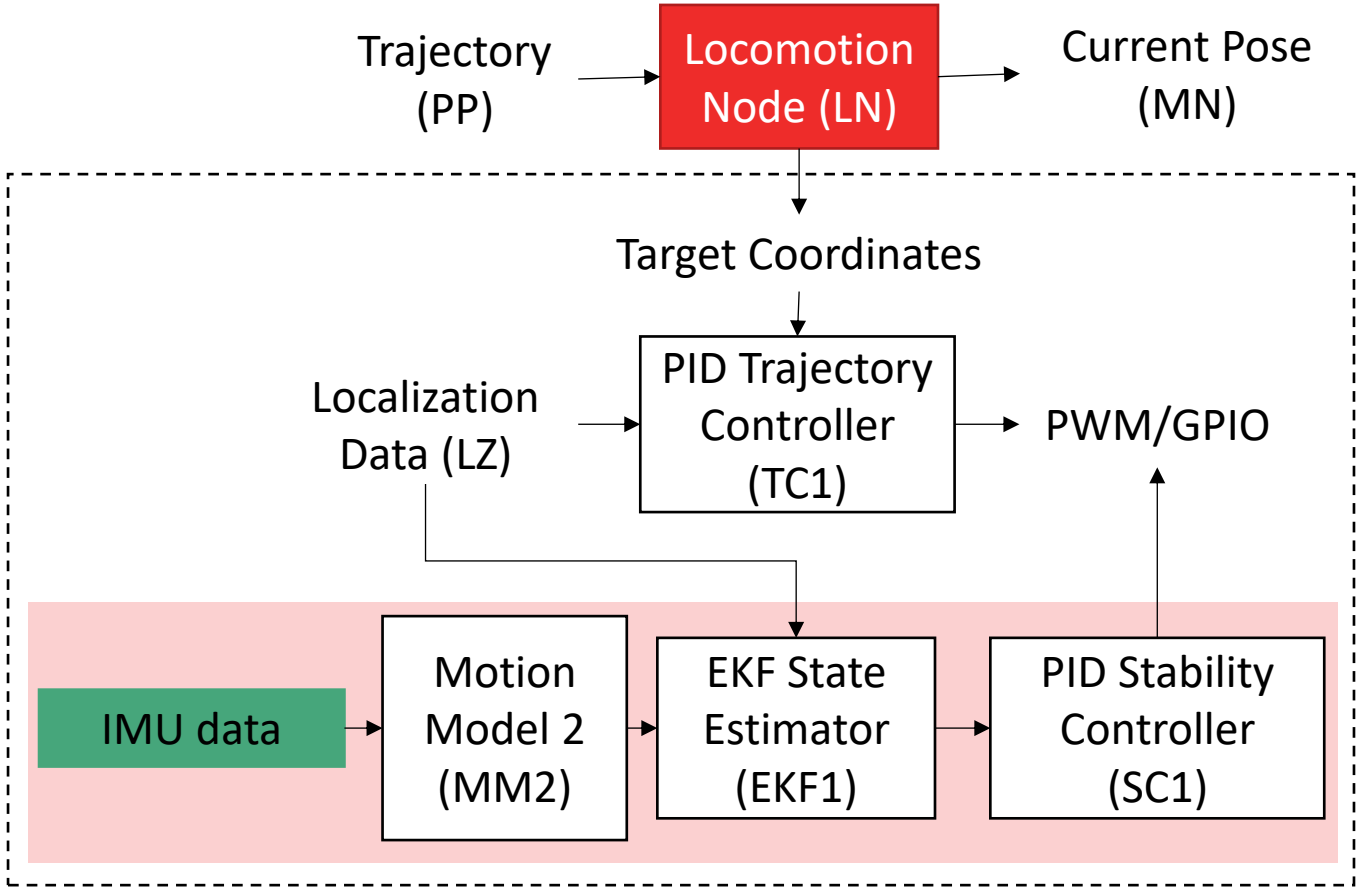
Master Node

- Master ROS node runs on the central processor (P1) at 30Hz.
- Connected to all the nodes directly or through intermediate nodes.
- Master node maintains and synchronizes dataflow from sensor input to output commands.

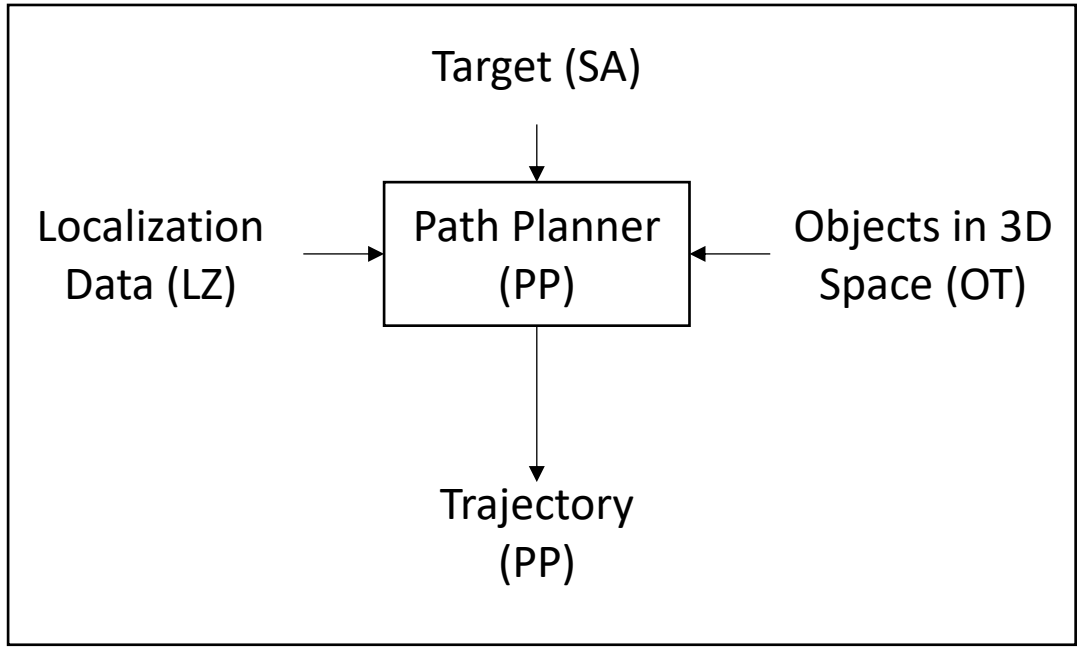
Motion Controller

- Locomotion node receives trajectory information from path planner.
- Send current pose info (position and orientation) to the MN.
- LN sends discretized target coordinates to trajectory controller.
- MM1-2D robot motion model.
- MM2-Two-wheel balancing model.
- EKF1 fuse localization and IMU data to estimate current orientation.



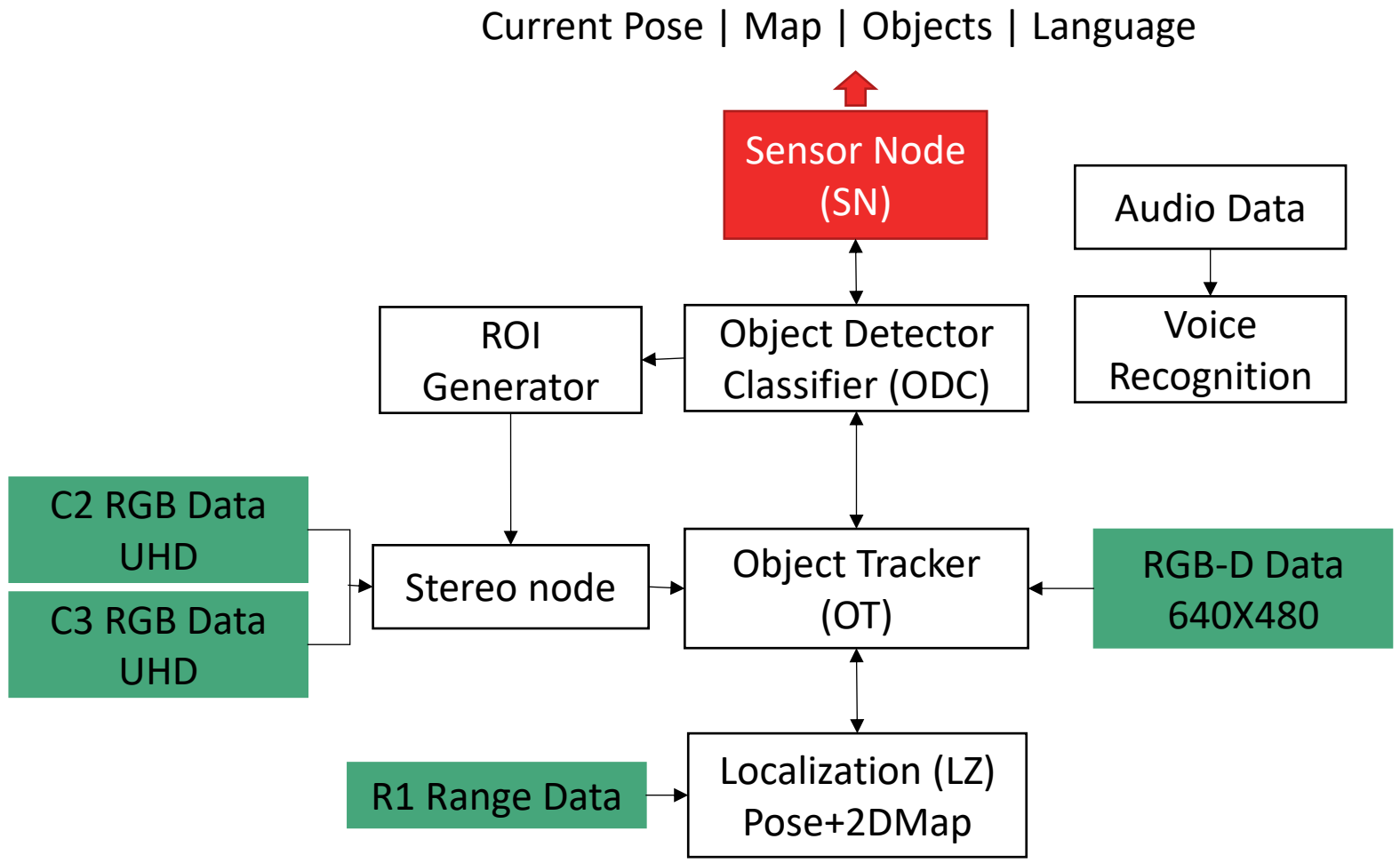
Path Planner

- Path planner compute a sequence of coordinate points from current pose the target pose.
- Obstacle's locations and their occupancy in space are taken to plan the path.
- Path must be frequently updated based on obstacles motion in the space to avoid them.
- Target point is received from the situation assessment module (SA) based on most recent and relevant input data.



Sensor Node

- Sensor node outputs:
  - Current robot pose and 2D map.
  - Detected objects with classification class ID.
  - Object's location in the map.
  - Language interpretation of processed audio data.
- Contains data reading programs (Sensor nodes).
- Data synchronized to closes time stamp.
- Stereo node generate 3D data based on region of interest (ROI) to reduce computation overhead.



Other Nodes

Node Name	Algorithm/Method
Message Generator (MG)	To be determined
Emotion Generator (EG)	
Voice Generator (VG)	
Voice Recognition (VR)	
Head Motion Controller (HMC)	
Interrupt Handler (IH)	
User Inputs Handling Node (UI)	

Node Specifications

Node #	Node Name	Parent Node	CPU	Speed (Min)	Inputs	Outputs	Remarks
1	Locomotion (LN)	Master Node (MN)	P2	10Hz			
2	Motion Controller (MC)	Locomotion (LN)	P2	10Hz			
3	Path Planer (PP)	Locomotion (LN)	P2	10Hz			
4	Sensor Node (SN)	Master Node (MN)	P3	10Hz			
5	Localization (LZ)	Sensor Node (SN)	P3	10Hz			
6	Object Detector Classifier (ODC)	Sensor Node (SN)	P3	10Hz			
7	Object Tracker (OT)	Sensor Node (SN)	P3	10Hz			
8	Voice Recognition (VR)	Master Node (MN	P1	10Hz			
9	Head Motion Controller (HMC)	Master Node (MN)	P1	10Hz			
10	Interrupt Handler (IH)	Master Node (MN)	P1	30Hz			
11	Message Generator (MG)	Master Node (MN)	P1	10Hz			
12	Emotion Generator (EG)	Master Node (MN)	P1	10Hz			
13	Voice Generator (VG)	Master Node (MN)	P1	10Hz			
14	User Inputs Handling Node (UI)	Master Node (MN)	P1	10Hz			

Base Development

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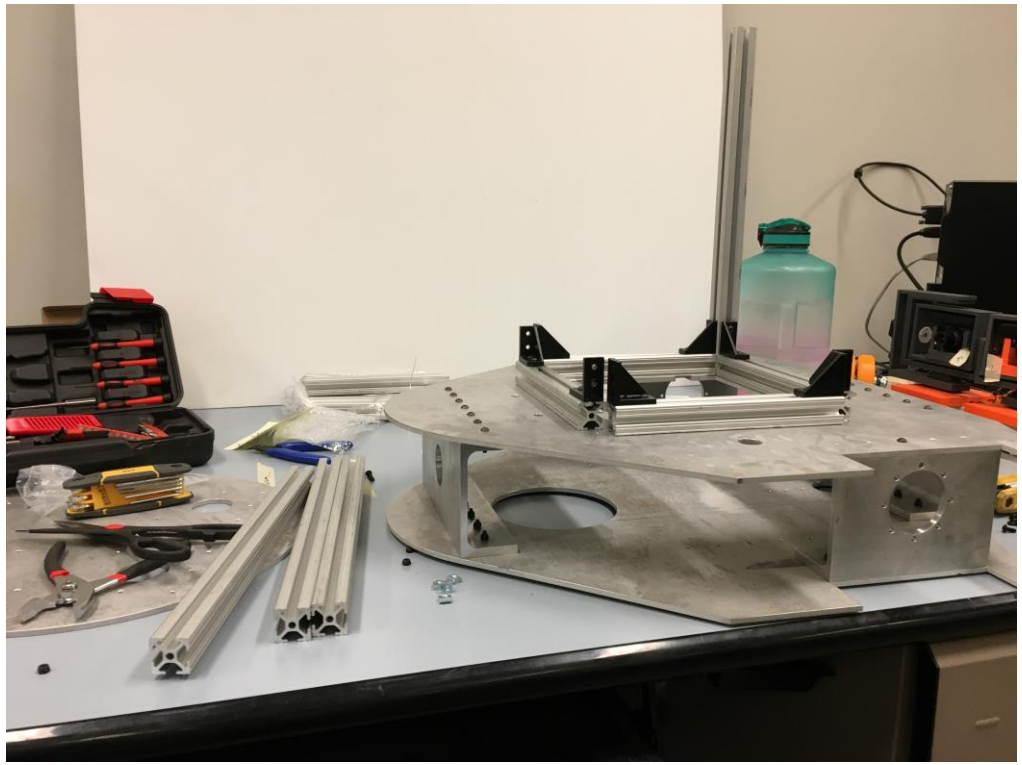
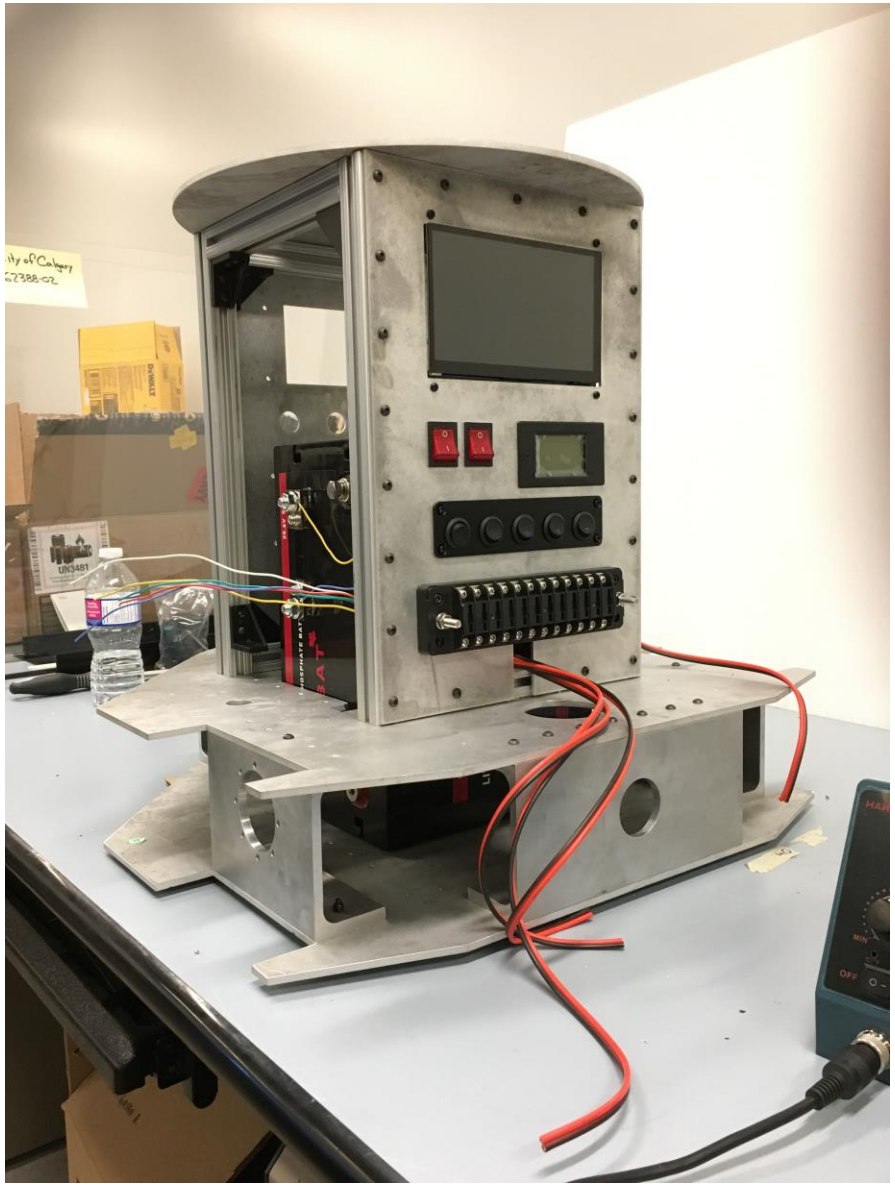
Base- Mechanical Design, Fabrication and Assembling

Assembling in the UofC Lab





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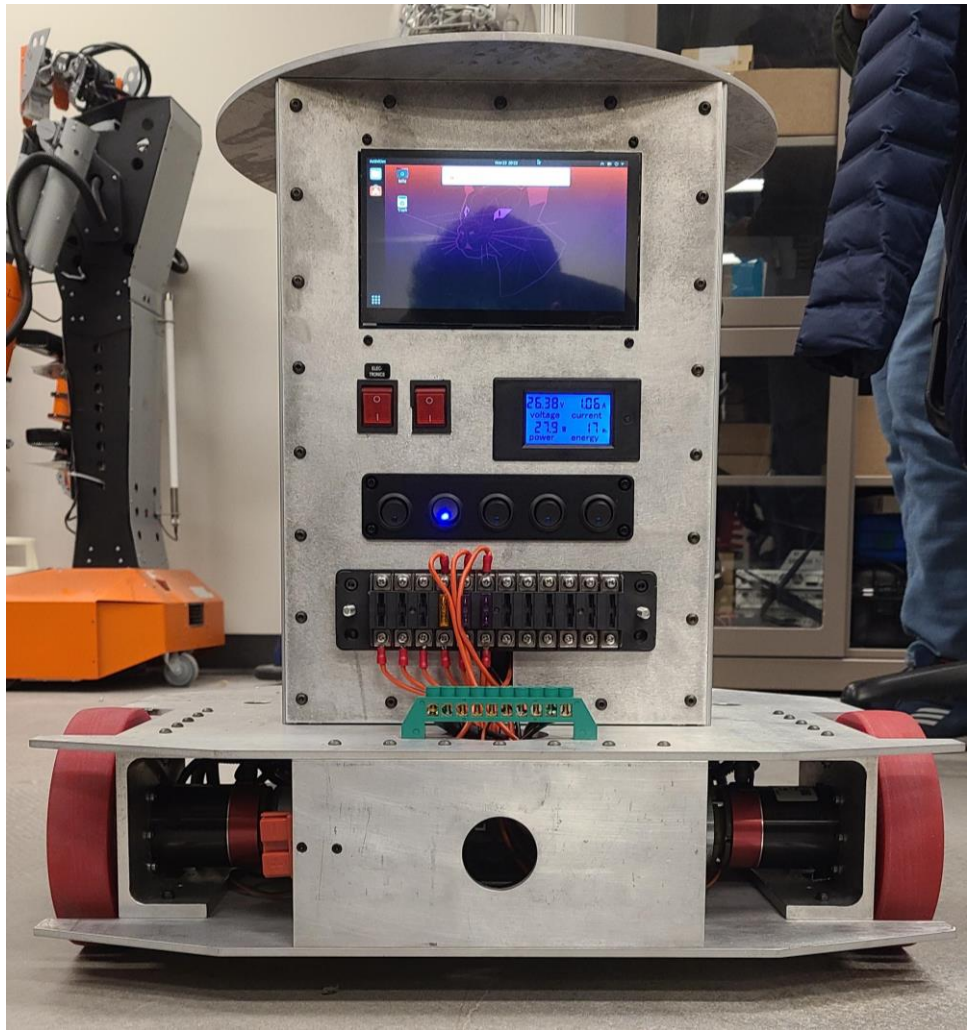
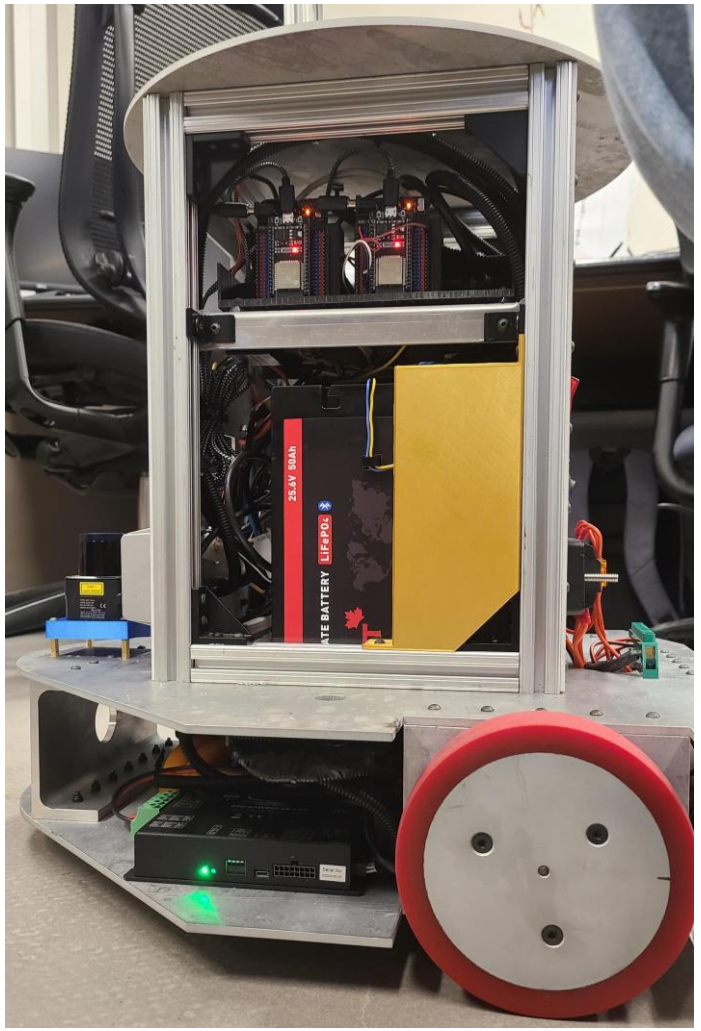
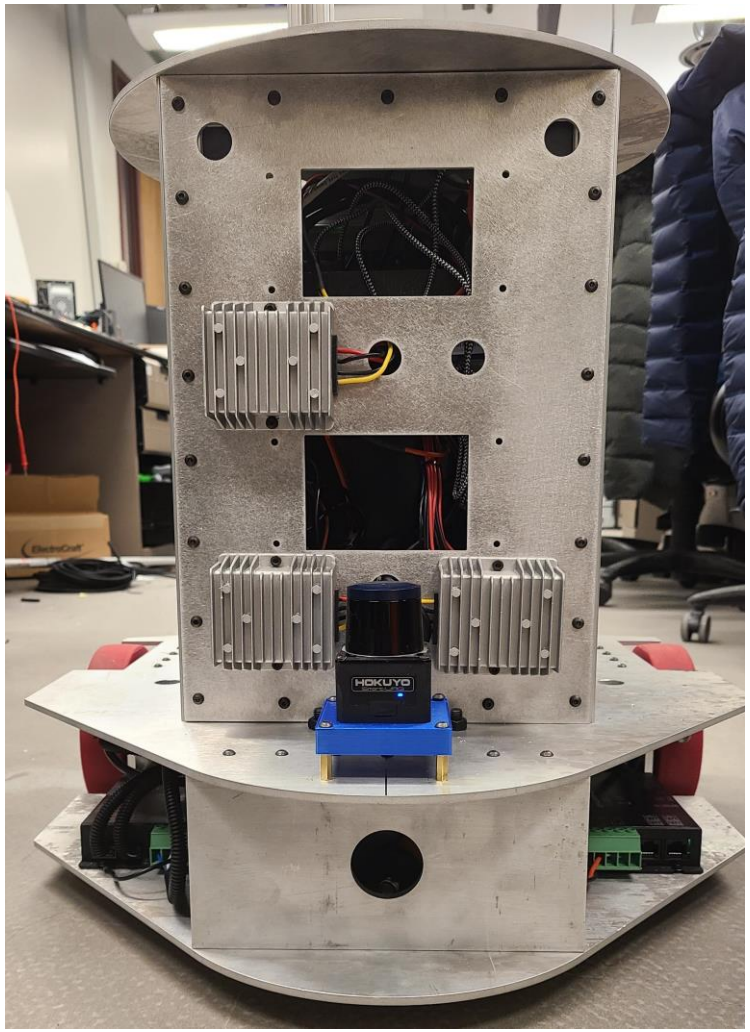
Completed Base







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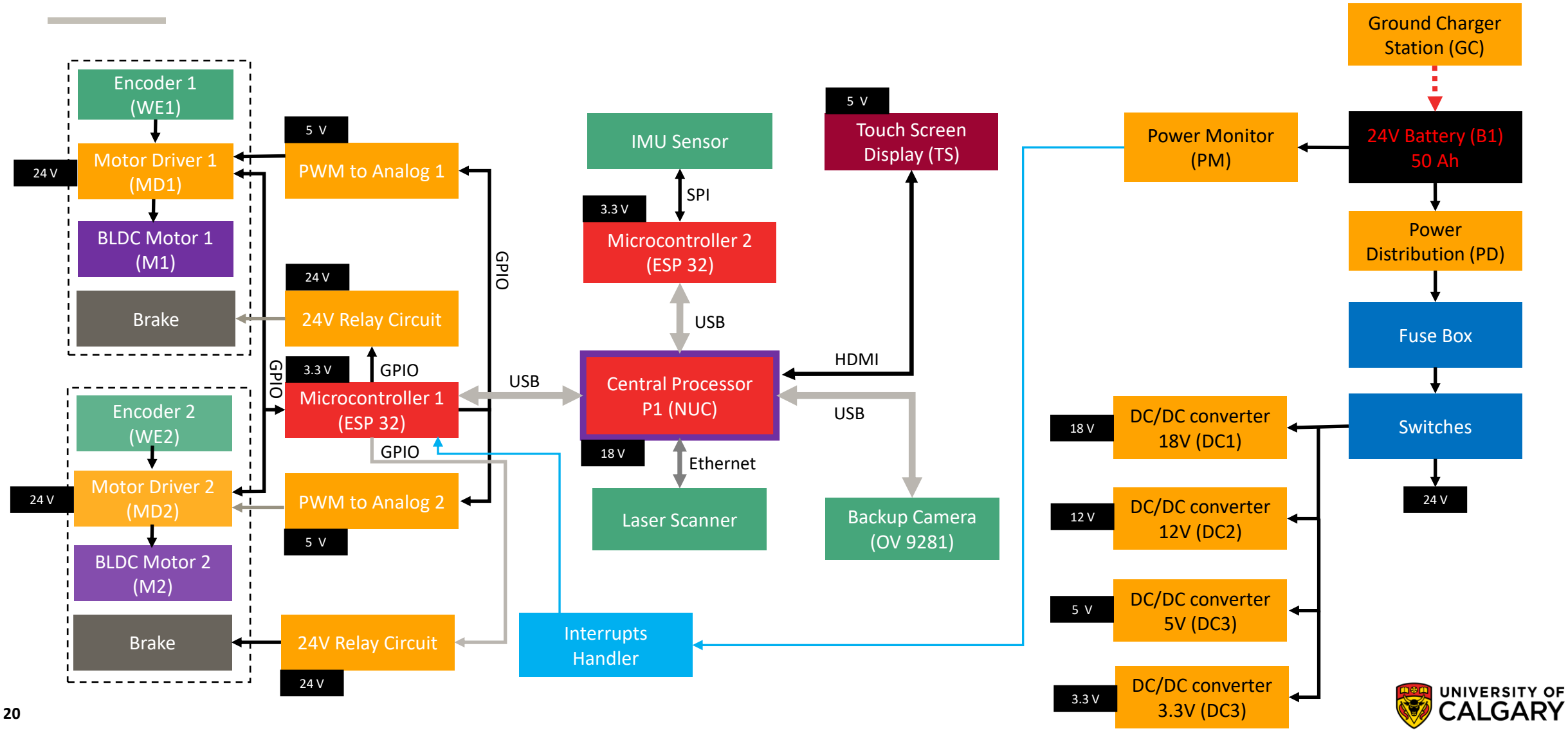
Completed Electronics



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