

Six-Thruster AUV for Chesapeake Bay Data Collection

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PROBLEM DEFINITION

In the 2025 UMCES Report Card, the Chesapeake Bay received a "C" grade, water clarity at 18%, aquatic grasses at 38%, and 11 of 15 regions declining. Current infrastructure relies on fixed sensors, expensive dives, and satellite imaging, leaving critical subsurface gaps.

"Monitoring for CBP outcomes is insufficient and needs to be improved. Improvement is urgently needed."

"Having the latest data is a critical tool for clean water advocates."

-Kristin Reilly, Choose Clean Water Coalition

We aim to create an Autonomous Underwater Vehicle (AUV) that is able to search for, navigate towards, and collect data on a set target.

FUTURE IMPLEMENTATION

- Depth Control** - Add a ballast tank for quieter, more energy-efficient, and less disruptive depth management.
- Improved Navigation** - Shift to acoustic sonar and a wide-angle camera for better environmental awareness in open waters.
- Improved Monitoring** - Add water quality, turbidity, temperature, and conductivity sensors to address failing 2025 Report Card indicators.
- Targeted Artificial Vision** - Train model on new classes to detect and geolocate invasive species or organisms of interest.

DESIGN CALCULATIONS AND ANALYSIS

SENSOR CHARACTERIZATION

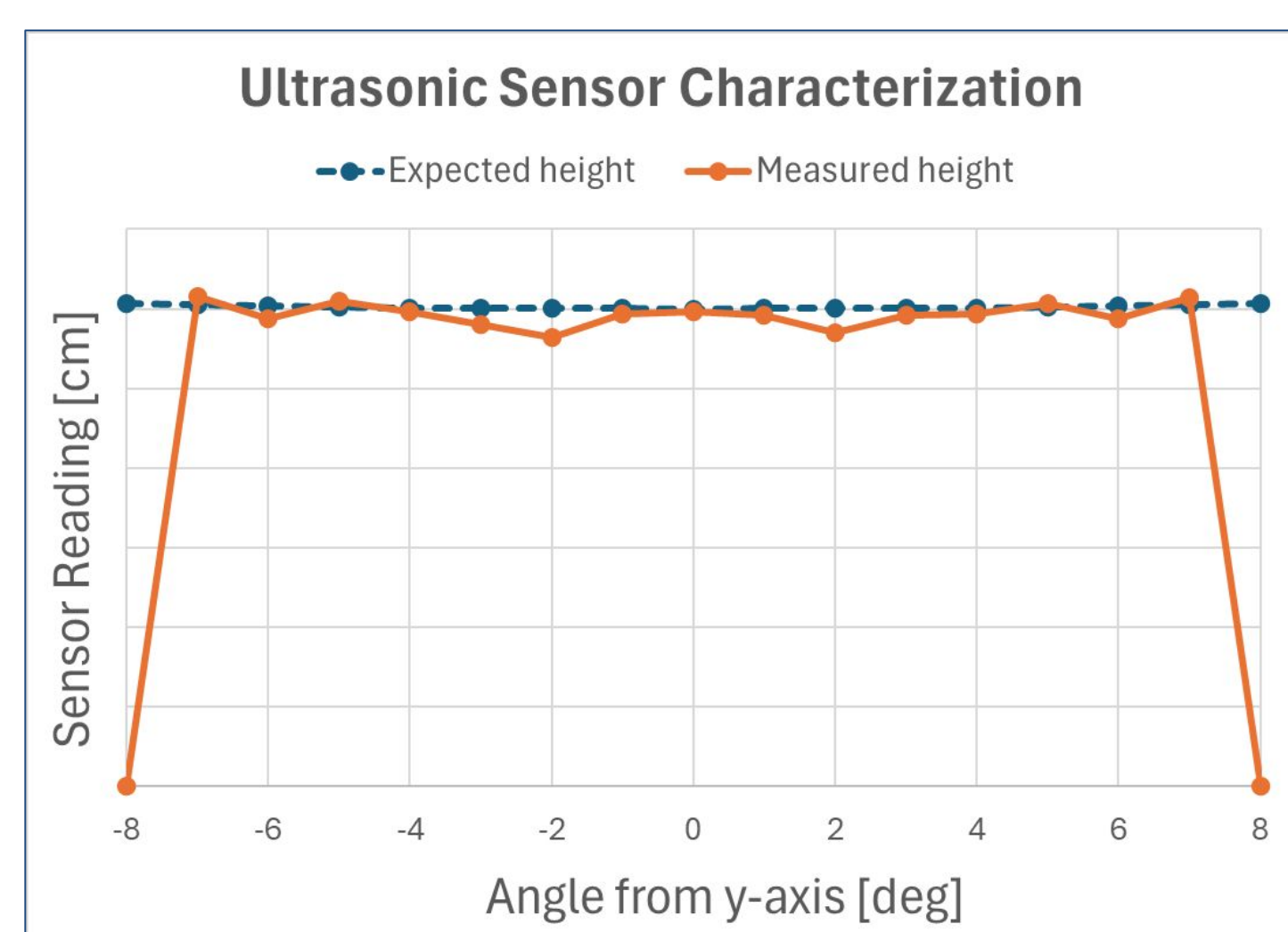


Fig. 1. Sensor characterization based on angle of measurement.

Shows a slight dropoff in accuracy past 1°, and a complete loss of measurement at 8°

MOTOR CHARACTERIZATION

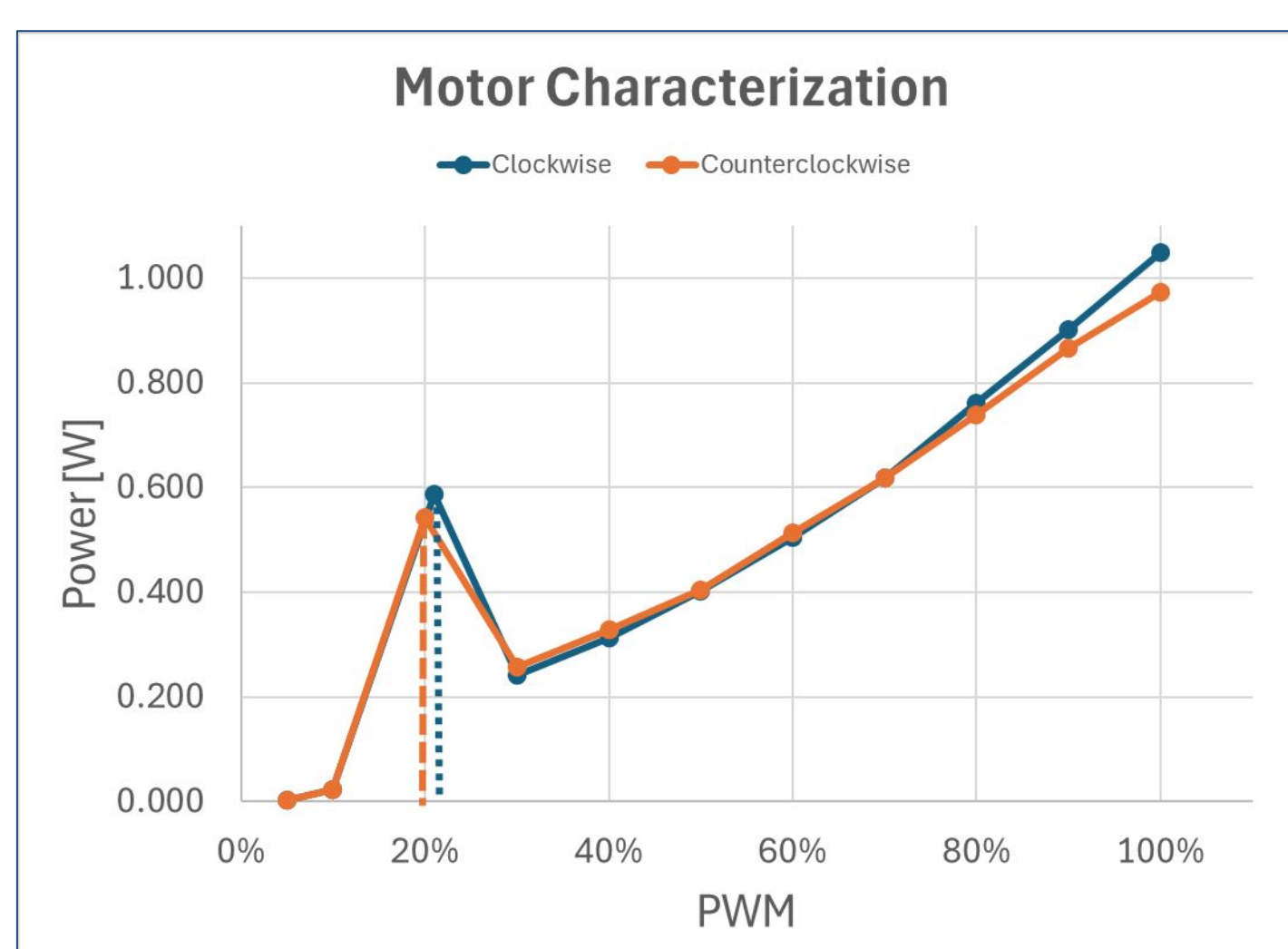


Fig 2. Motor characterization showing the mechanical output at increasing PWM.

Shows a steep increase in current consumption near 20%

FINAL DESIGN

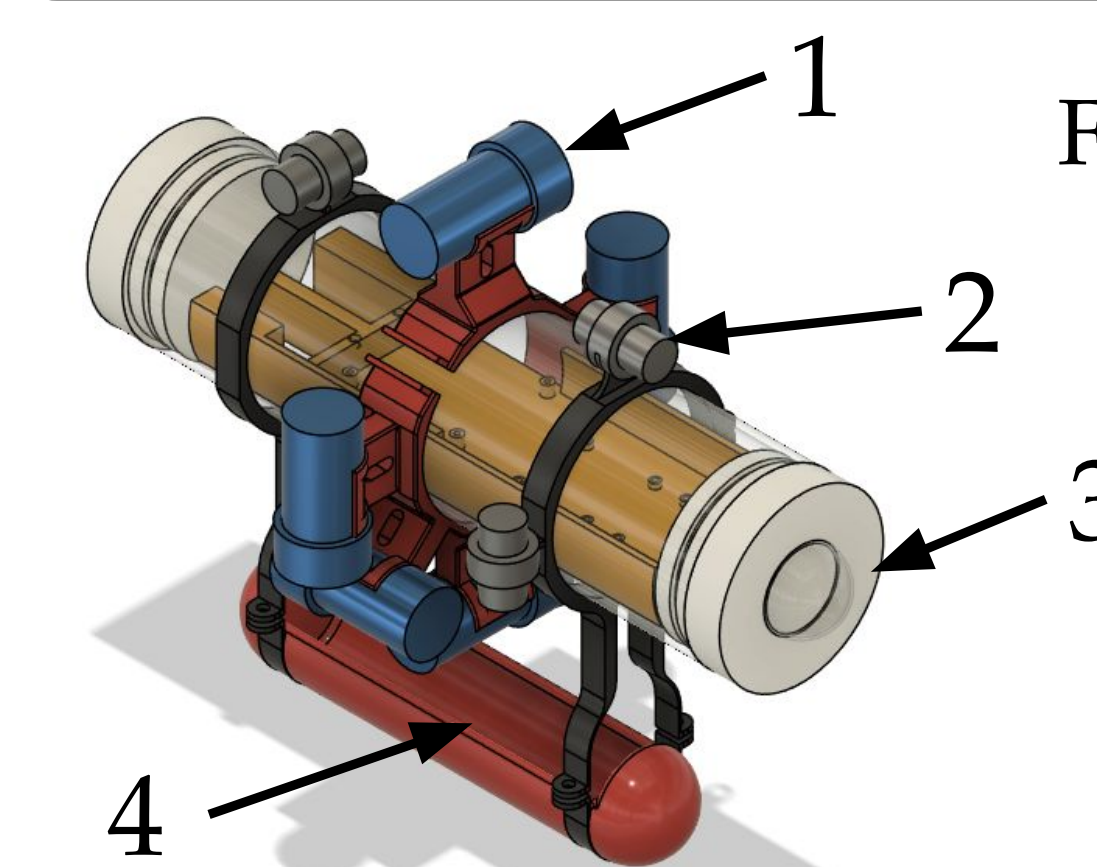
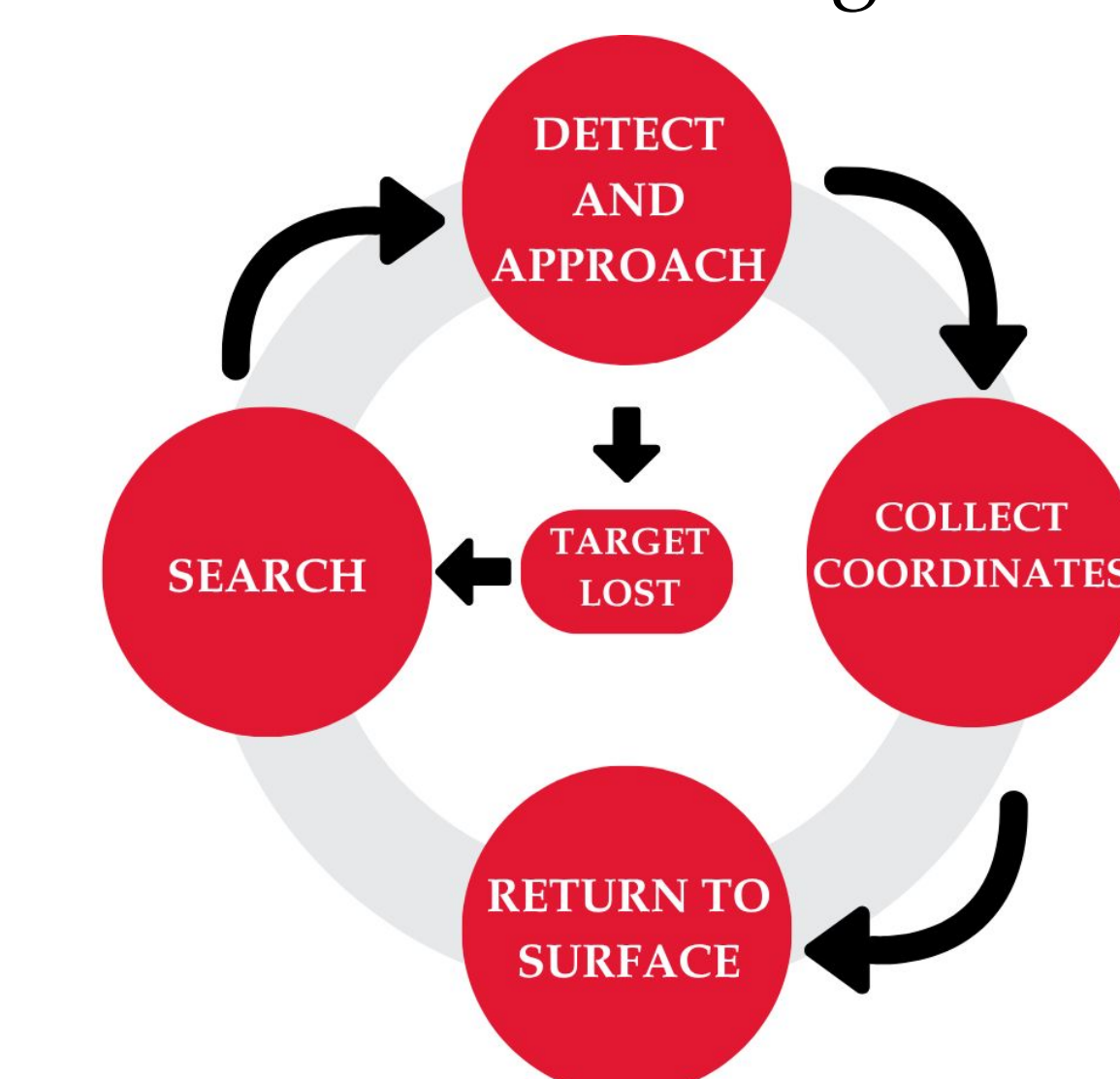


Fig. 6. CAD model of the final UAV design.

Legend:
1: Motors 2: Sensors
3: Camera 4: Weights

Fig. 7. UAV state diagram.

Simplified version of the algorithm run by the UAV.



TESTING AND VALIDATION

DEPTH CONTROL

Originally, depth control was based on our underwater ultrasonic distance sensor with the measurements serving as the input to our PID controller.

The K_p , K_d , and K_i were 0.5, 0.1, and 0.01 respectively.

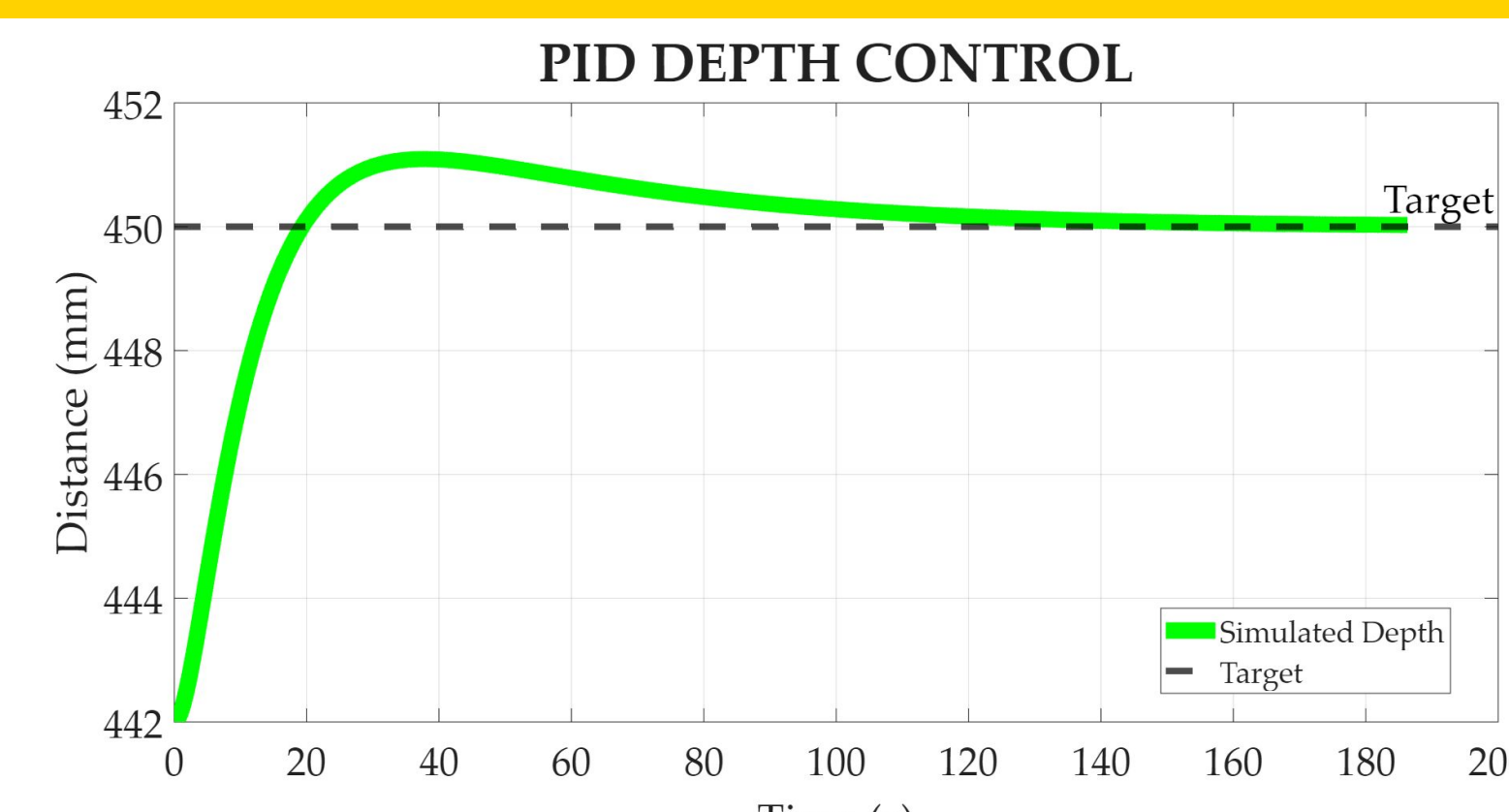


Fig. 3. PID simulation results

OBJECT BASED NAVIGATION



Fig 4. IBVS testing

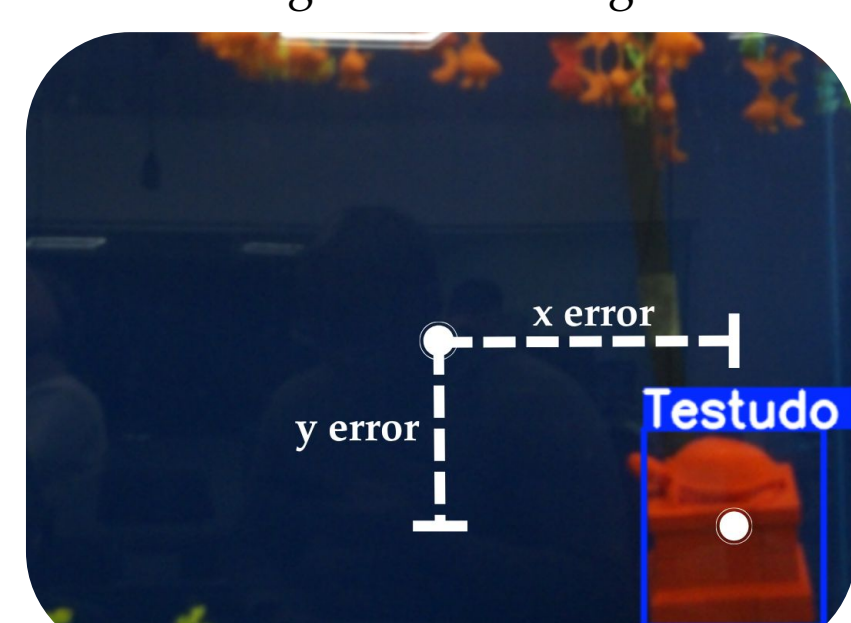


Fig 5. Pixel error calculation example

Used our trained YOLO11 model to calculate a normalized error based on pixels from center in both the X and Y directions. Achieving a precision of 98.6% in the validation dataset.

For forward thrust, area error was calculated by getting the area of the frame and subtracting the area of the detected object. The error was then normalized and used as input for our forward motion PID controller.

$$\text{norm. error} = \text{pixel offset} / (\text{resolution}/2)$$

$$\text{norm. area error} = \text{area error} / \text{frame area}$$

We used these normalized errors for X, Y, and proximity as PID controller inputs.

Vision PID	X	Y	Area
K_p	12	25	40
K_d	20	8	0
K_i	0	1	0

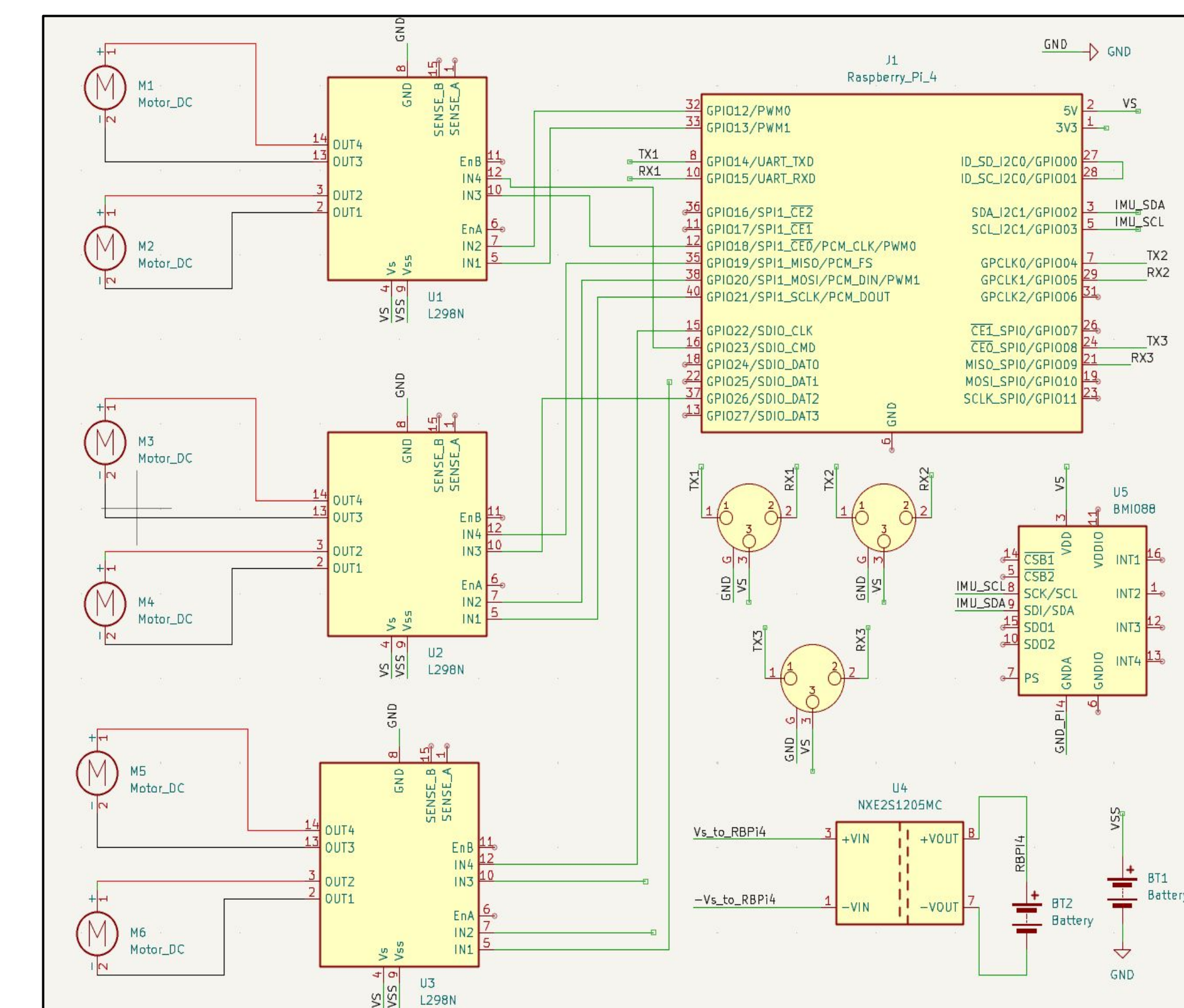


Fig. 8. Electrical schematic.

Shows all components and their connections

SOURCES

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