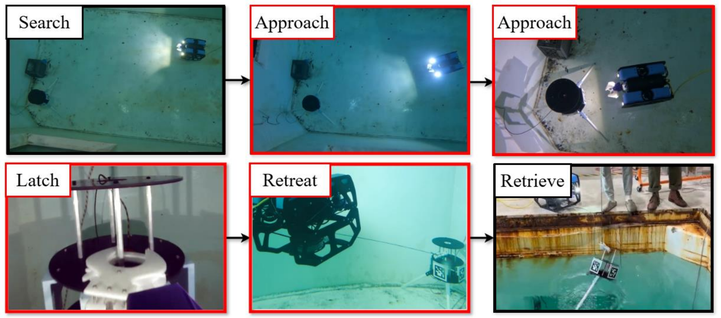
AUTONOMOUS UNDERWATER INSTRUMENT RETRIEVAL

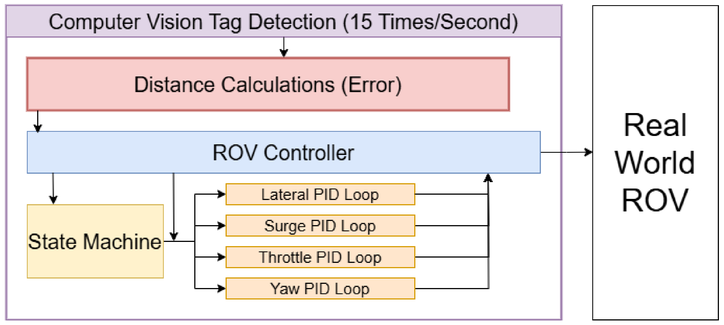
Motivation

- Underwater research often involves devices that must be retrieved later, typically involving a pre-deployment mechanism* or some form of piloted sub
- Piloted ROV missions present fewer safety risks than diver-led missions, reducing environmental impact and protecting human divers during deep-water operations
- The copilot system was developed to autonomously target and attach a recovery line to a submerged object, minimizing the skill and planning traditionally required for retrieval missions

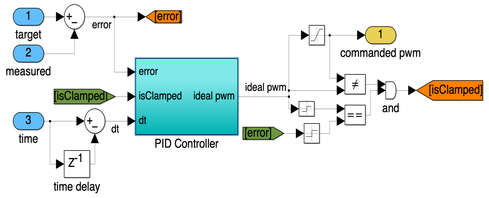
High-Level Breakdown



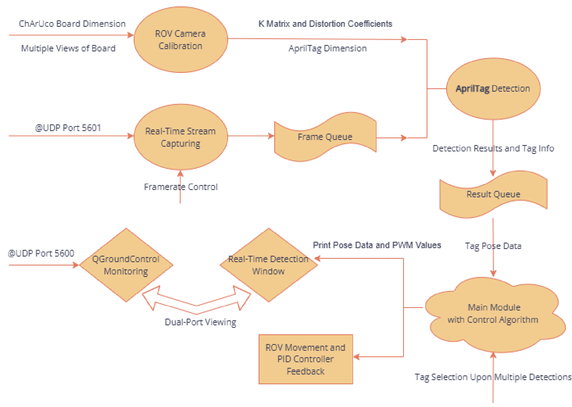
Control Algorithm

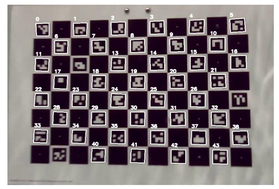


Custom PID:
- Inner ~ Calculate ideal PWM
- Outer ~ Saturate and clamp
- Implemented in Python
- Visualized in Simulink

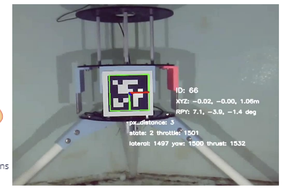


Computer Vision





ChArUco Board in Calibration



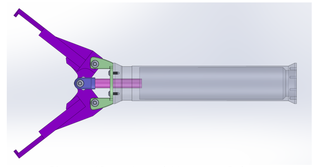
AprilTag Detection

- AprilTag pose data estimated in the ROV's camera view includes both translational values X, Y, and Z in meters and rotational angles roll, pitch, and yaw in degrees
- Multiprocessing queues were used to receive incoming frames and store tag detection results in parallel for minimized latency

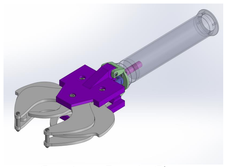
Latch and Mount

1. **Latch System:** Establish secure connection to object

Capstone Frog
(Left: Closed Position, Right: Open Position)

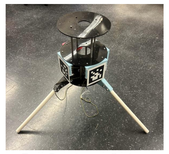


Clamp (Open) and Newton Gripper

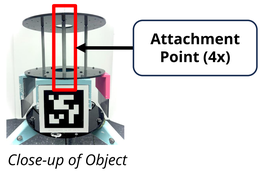


Capstone Frog in Clamp

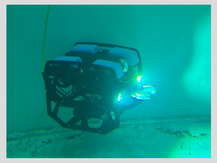
2. **Mount System:** Provide attachment point for latch and AprilTags



Full Retrieval Object



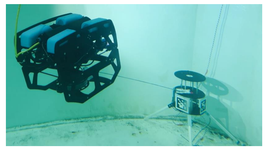
Close-up of Object



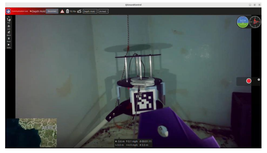
Final ROV Configuration

3. **Tether System:** Ensure secured retrieval

Payload Skid with Tether Spool and Guide

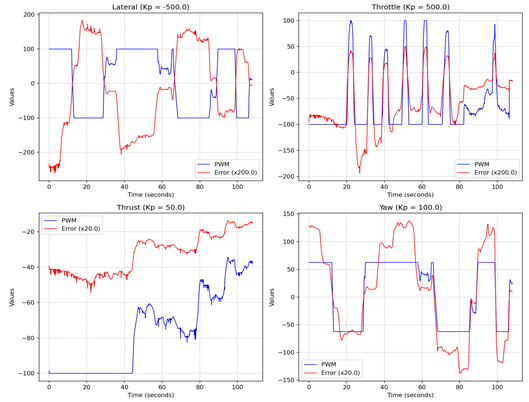


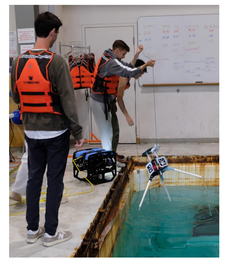
Side POV



ROV POV

Results



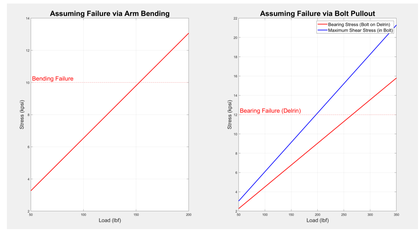


Mixed Operation Video

Average Stream Delay	Average Tag Processing Delay	Total Delay
7.003 ms	5.458 ms	12.461 ms

Capstone Frog Load Capacity Estimation

Failure is likely to happen via bending of the rotating arms. The final estimated load capacity is roughly **150 lbf**



Future Work

- QGroundControl introduces uncontrolled variables and failsafes when switching between manual and autonomous controls, it can be replaced with a dedicated joystick implementation
- Operating in different underwater zones and scenarios to prove and maximize the tag detection success rate
- Engineer a lighter, more adaptable mount for broader use-cases
- Implement extended capabilities for autonomous search, impaired approach, retreat, and retrieval
- Machine Learning implementations for underwater object detection paired with adaptable grippers
- Accurate light detection system paired with flashing/coded light signal and low powered LED implementation into mount design to increase detection range in low-visibility environments

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

ADVISERS: AARON MARBURG, DANA MANALANG, IAN GOOD

SPONSOR: UNIVERSITY OF WASHINGTON APPLIED PHYSICS LABORATORY

MECHANICAL ENGINEERING
UNIVERSITY of WASHINGTON