Rust and Corrosion on Naval Ships

- Oxidation rate dramatically increased by salt water.
- Repair costs the Navy 21 billion dollars annually.
Problem: Rust and Corrosion

- **Salt water**
  - Electrolyte increases conductivity.
  - Conductivity speeds up oxidation of iron.
  - Iron + Oxygen $\rightarrow$ Iron Oxide ($\text{Fe}_2\text{O}_3$).

- **Hull integrity**
  - United States Navy ships are constructed with steel.
  - Hull strength diminished by rust and corrosion.
  - Heavy guns, aircraft, and buoyant force of the sea cause immense stress.
Rust Inhibiting Liquid Application

• Rinse salt water; slow down oxidation.

• Cover rust; protect steel from oxygen.

• Solution: Apply using drone with rust detection capability.
Solution: Drone that Applies Rust Inhibiting Liquid

• Advantages Over Manual Application:
  • Safety:
    • A drone can reach places that are precarious for humans to get to.

  • Speed:
    • Faster application from point to point.

  • Versatility:
    • A drone is able to move from the bottom of the ship to the top without requiring any extra equipment.
Flight Controller

• HEX Cube Orange.
• Ardupilot Firmware.
Drone Construction

1.5 gallon payload; 25lb all-up weight.
Drone Construction
Test Flights

• https://youtu.be/W1a7B4UNp6I
Companion Computer

- NVIDIA Jetson Nano Developer Kit
  - Image processing.
  - MAVLink connection using Dronekit Python.

- Intel AC8265 Wireless NIC Module
  - WiFi Access Point capable.
NVIDIA Jetson Nano

UART (/dev/ttyTHS1)

Dronekit Python

Connect and Run Python Script

commands.txt •Intel AC8265 NIC

Samsung Tab E

SeaShield App

Video

Commands
• Buttons will write to the Jetson nano via SSH
  • Respective button sets command string.
  • SSH connection is established, and the string is written to the command file.
• Currently, each button press creates its own connection instance to prevent locking.
• Could be re-written in the future if we choose not to run.
Image Processing/Rust Detection

- Annotated Image.
Image Augmentation

• Manufacture new training images from base set.
Validation Accuracy

- Higher mAP is equivalent to a higher accuracy in rust detection.
Detection of Rust in Image

- Rust detected is annotated with blue box.
YOLOv3 Object Detection Algorithm

• One pass on each image.

• Regression based algorithm.

• Trades small amount of accuracy for large gain in speed.
Quarter Progress

• Drone construction completed.

• Successful manual test flight with full weight.

• Dronekit Python implemented for control.

• Companion computer added and successfully interfaced with drone.

• Rust detection currently being integrated.
Spring Quarter Plan

• Establish video feed to application.

• Full control from application.

• Implement real time image processing and object detection using Nano.

• Flight control algorithm using object detection information.
Team

• Eric Kim:
  • Android application and Wifi communication.

• Andrew Berry:
  • Android application and video feed.

• Derek Cheng:
  • Image processing and rust detection.

• Andrew Cizas:
  • Image augmentation for training set and real time image processing.

• Chris Scott:
  • Drone construction and control using Nano/Dronekit.
Acknowledgements

• **UCSB Electrical and Computer Engineering**
  • Professor Yogananda Isukapalli
  • Teaching Assistants Boning Dong and Trenton Rochelle

• **Naval Sea Systems Command**
  • Ramon Flores
  • Alan Jaeger
  • Armen Kvryan
Questions?