RailVision: Overgrowth Detection Drone

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Abstract

Every year, billions of dollars are spent towards railroad maintenance, with vegetation overgrowth maintenance being a prominent issue. Vegetation overgrowth creates fire hazards, infrastructure damage, and lead to many negative economic and environmental impacts. To address this problem, we built an autonomous VTOL drone using an energy efficient 4+1 quadplane configuration. Utilizing our image classifying CNN (RailNet), our quadplane autonomously flies alongside rail lines, detecting vegetation overgrowth in real time. Through RailVision, we aim to contribute to the safety of maintenance workers, address the inefficiencies of current overgrowth inspections, increase the lifespan of railroad infrastructure, and make leaps toward preventing wildfires to better conserve our environment.

Problem Formulation & Challenges

To ensure RailVision effectively addresses each problem, we must meticulously consider several factors in our design:

- Create an energy-efficient drone, capable of long-term autonomous flight
- Accurately detect occurrences of overgrowth on rail lines, including both minuscule and significant cases
- Upon detecting overgrowth, determine and store the GPS coordinates to notify rail maintenance

Proposed Solution

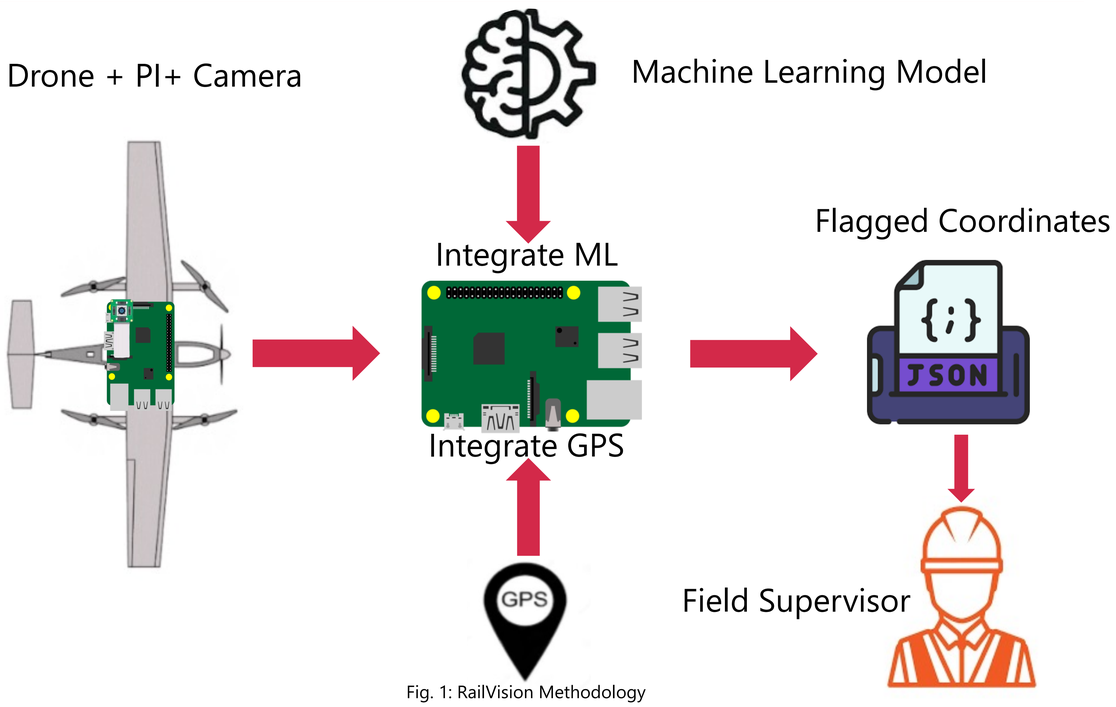

Fig. 1: RailVision Methodology

Main Results

Machine Learning Model

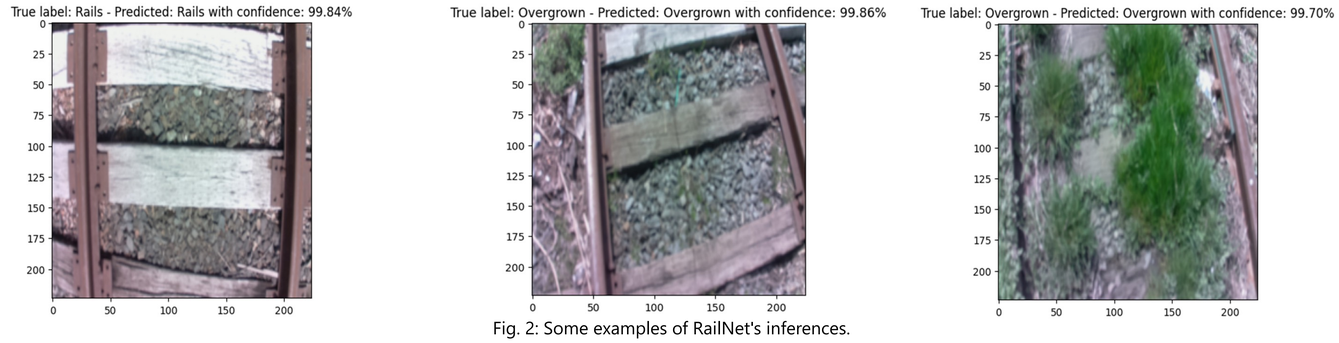

Fig. 2: Some examples of RailNet's inferences.

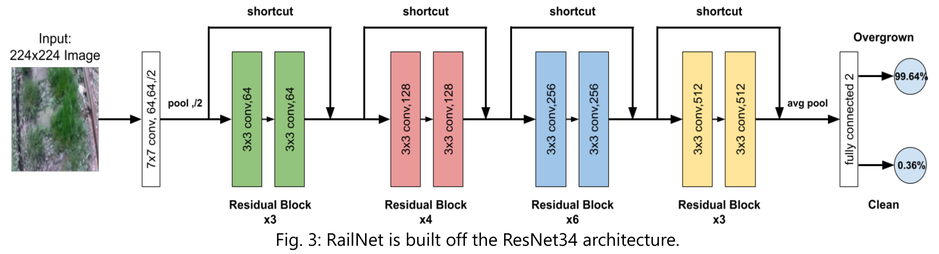

Fig. 3: RailNet is built off the ResNet34 architecture.

- RailNet was fine-tuned on our dataset of around 400 different rail images
- 97.5% Accuracy
- 97% F-Score

Specifications

Hardware

- Pixhawk PX4 2.4.8
- 4S Lipo Battery 10000mAh 14.8V
- SG90 9g Micro Servos
- FrSky 2.4GHz Access Pro Receiver
- 915MHz Radio Telemetry
- FrSky Taranis Q X7 Transmitter

Frame

- Lightweight PLA
- 16MM*14MM*245MM 3K Carbon Fiber Tube
- Total weight ~2268g

VTOL Quadplane Drone

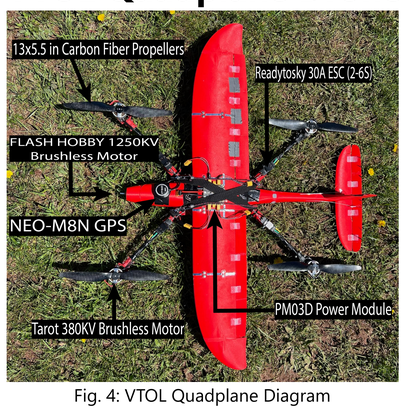

Fig. 4: VTOL Quadplane Diagram

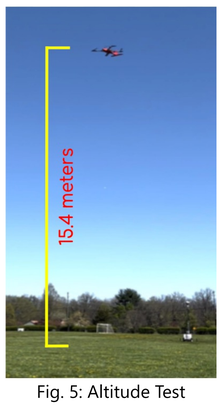

Fig. 5: Altitude Test

Ground Control Station: Mission Planner

- Monitor, Setup, and Calibrate Vehicle
- Plan and Set Missions

Future Work

- Expand the rail dataset to allow RailNet to respond even more effectively to extreme edge cases
- Develop a "homebase" software to directly communicate with RailVision
- Introduce drone swarming techniques to improve efficiency of overgrowth detection

References

[1] Lovett, A. et al. (2013). An integrated model for the evaluation and planning of railroad track maintenance. *Urbana*, *51*, 61801.
[2] Granström, R. (2005). *Maintenance for improved punctuality: a study of condition monitoring technology for the Swedish railway sector* (Doctoral dissertation, Luleå tekniska universitet).
[3] Nyberg, R. G. (2015). *Automating condition monitoring of vegetation on railway trackbeds and embankments* (Doctoral dissertation).