Autonomous Surveillance of Restricted Areas Using Drones

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Pennsylvania State University and Chalmers University; Instructor Dr. Vlajic

Team Composition

The team consists of a 5-person team of students from Penn State and 6 students from Chalmers University in Göteborg, Sweden. The project is sponsored by the Swedish company AstaZero AB, which tests autonomous vehicle technology.

Equipment for Project

The automation and image recognition was tested and developed for DJI Mavic 2 Enterprise and the programming library DSS was used to help accomplish automated flight.

Figure 1: DJI Mavic 2
"Mavic 2 - DJI." *DJI Official*, https://www.dji.com/mavic-2.

Problem Statement

This project has two main objectives: automate drone flight and identify possible breaches in the fence. By accomplishing these two tasks, AstaZero employees can spend more time working on autonomous vehicles and less time hiking an 8–10-kilometer fence perimeter.

To automate flight, the drone must take off successfully, reach a set altitude, align the drone axis with the fence, fly towards numerous waypoints, and land safely. To recognize breaches in the fence, the software must locate the fence from a top-down perspective, identify gaps in the fence, and store the modified footage for review.

Project Background

The AstaZero test facility, shown in Figure 2, is surrounded by fence which needs to be monitored using a surveillance drone for any breaches. AstaZero is a facility used for testing autonomous features in Volvo vehicles and their biggest issues is animals entering the facility due to a breach in the fence. To solve this issue, the sponsor would like Penn State and Chalmers university students to automate the path of a drone along the fence and utilize image recognition to flag any breaches in the fence.

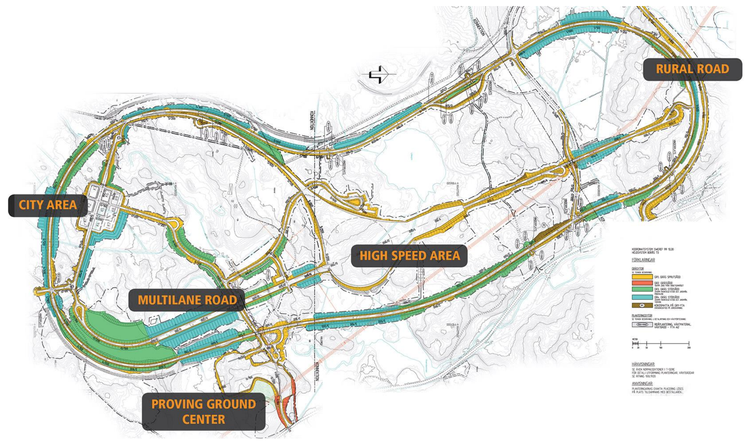

Figure 2: Track that the drone will surveil
Group, Volvo. "Volvo Group Develops Safety System at the World's Most Advanced Test Track." *Home*, 4 Feb. 2021, https://www.volvogroup.com/en/news-and-media/news/2014/aug/volvo-group-develops-safety-system-at-the-worlds-most-advanced-test-track.html.

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Image Recognition

As the drone flies over the fence, a top-down view of the fence is recorded. This video is then analyzed by the image recognition software to detect where there might be breaches in the fence. This is done using a line detection algorithm on the fence, and each step of the process is visualized below. Once this process is finished, an AstaZero employee can manually review the footage to confirm any positive readings on the saved video. The software is designed to detect as many breaches as possible, since false positives are preferable to missing a possible security breach in the facility.

Results and Future Improvements

The line detection software detects the top of the fence very well, but further improvements in accuracy can be made. Since we do not have footage of the fence broken, we could not tune the parameters very specifically. Once a fence break is detected, the parameters will be able to be tuned much more tightly to decrease the number of false positives.

Step 1: Video is captured from the drone and converted to the Lab color space

Step 2: Color thresholding is applied to isolate the fence from its surroundings

Step 3: An edge detection algorithm is applied to turn the white blob representing the fence into two lines

Step 4: A line detection algorithm is applied to record the positions of the lines and display them on the original image

Step 5: The distance between lines is calculated, and frames with large gaps are saved for manual review

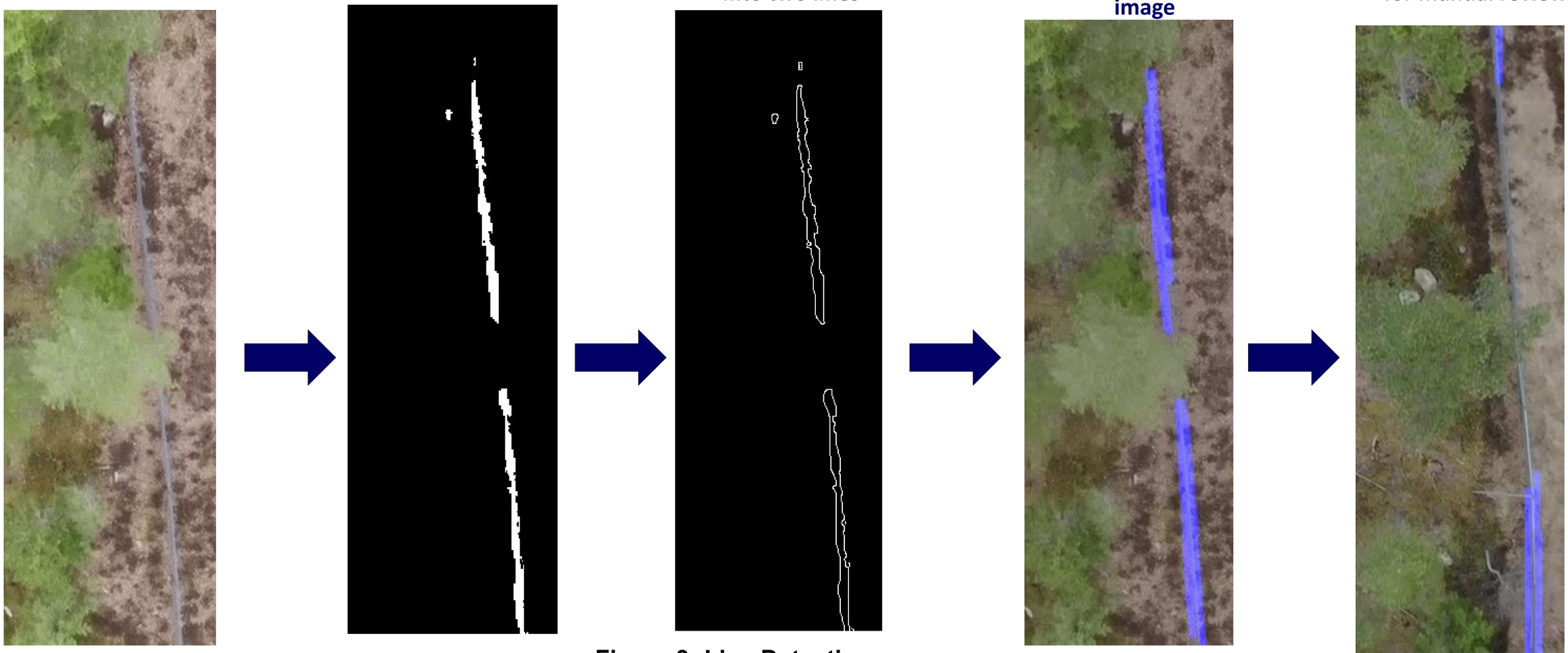

Figure 3: Line Detection process

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Drone Control

To achieve drone control, the team developed an automation program in Python that utilize the Drone Security System (DSS) library that ensures the DJI Mavic Pro flies upward towards a set altitude. Once the altitude is reached, the drone will head towards the first registered GPS waypoint. After this, the drone will align its axis of symmetry with the fence and fly towards the second GPS waypoint. The program then repeats these instructions until the last waypoint, in which the drone will fly toward the GPS coordinates of a nearby landing area.

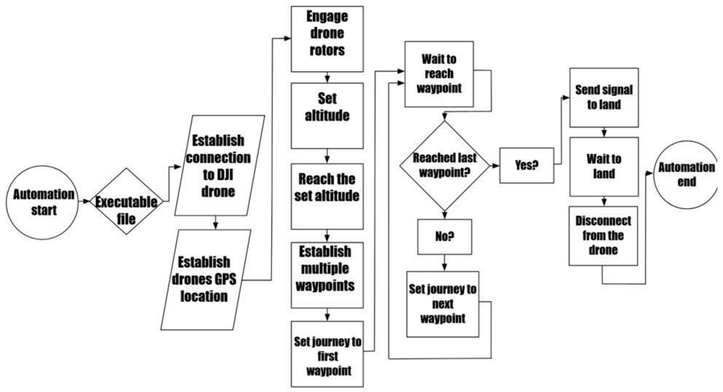

Figure 4. Drone Automation Block diagram.

Future Work

Future work for this project would be to replace the line detection with a neural network. This takes thousands of pictures and trains the program to detect what a normal fence looks like and what a fence breach looks like.

Figure 6. Neural Network Results

Results of Drone Control

Figure 5 shows the drone executing the Python automation script, reaching a set altitude, and fly towards the first waypoint. After executing these actions, the drone aligns itself to the fence and flies towards the next waypoint.

Figure 5. Video showing drone aligning with fence then following the fence

Acknowledgements

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