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USE OF MULTIPLE LOW COST AUTONOMOUS DRONES FOR HIGH VOLTAGE LINE INSPECTION

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Abstract

Many high-voltage line monitoring companies have been using drones to carry out preventive inspection. The inspection procedure usually makes use of pilots that control drones which films the transmission lines. Afterwards, the images need to be analyzed in order to detect problems. This work proposes the usage of drones that make autonomous flights to perform the inspection. The proposed approach exploits three drones to inspect each important part of a transmission line, with the first inspecting the wires, the second inspecting the towers and the third checking the safety area under the line. All three drones are controlled by an embedded system with artificial intelligence which is able to identify a potential problem and issue an alert to locations that might present issues.

Keywords: Drone; Artificial Intelligence; High Line Tension; Multiple Drones; Real-time Detection

1. Introduction

Brazil has more than 161,000 kilometers of high voltage transmission lines that supply energy to millions of Brazilians located in 26 states and the federal district. [1]. Electricity is vital to the functioning of modern life. The lack of electrical energy, even if temporary, can result in great damages and even cause deaths in hospitals, if it is not restored quickly.

In order to avoid problems in power transmission lines due to poor maintenance, the responsible dealers need to perform preventive inspections of these lines. These inspections are carried out to verify the integrity of the towers, the condition of the line cables, the integrity of the insulators, issues associated to vegetation nearby the lines, and to verify a possible invasion of the protected area near the towers. Inspections are carried out every twelve months and if the need for an intervention is observed, a ground team is sent to carry out a more detailed inspection with specialized workers to solve the problem.[2]

In recent years, there has been an increase in the use of drones to perform various tasks. For instance, Dantas et al.[3] propose the use of drones to deliver medicine to Covid-19 patients living in remote locations. Drones can also be useful in inspecting transmission lines, avoiding the use of more expensive resources such as helicopters. Another advantage of using drones to inspect high-power transmission lines is to prevent people from exposing themselves to risks when approaching these lines. Even so, the use of a drone controlled by a pilot requires him to approach the line to perform the filming.

This work aims to demonstrate that, with the artificial intelligence techniques used today, the inspection can be done in a much more autonomous way and using the autonomous flight mode of drones. There are several high-value drones that can be used for this type of task, but integration with proprietary software that runs in real time on the drone itself is complex. Given this limitation, we choose to use low-cost drones commonly found on the market. This approach has already been used in other works, but with a focus on navigation over transmission lines.

Our inspecting approach includes threee drones. The first is used to inspect the wires and insulators, the second is responsible for checking the conditions of the tower, and the third is used to observe the protected area near the tower and its lines (easement area). Checking the easement area is important to verify if there is any unauthorized construction and also to observe if the vegetation may cause any trouble to the tower or to the transmission lines.

As far as the use of artificial intelligence is concerned, research was done to understand the state of the art in this subject. As a result, it was observed that Yolov5 has been used in some works for real-time detection.[5]

In the next sections we discuss the operation of Yolov5. We also present how the experiments were carried out and discuss the results obtained so far.

2. Theoretical Reference

In recent years the techniques for detecting objects in images have had a significant evolution. Due to the Covid-19 pandemic that has spread around the world, research in image processing has emerged with the aim of preventing the spread of the virus, such as verifying the use of mask in image analysis [6] and checking social distance [5]. Another research area that exploits image processing in real time is the one related to autonomous vehicles. Autonoums cars need to detect street signs so that they know how to react intelligently and without the need for driver interference [7]. We also have some work developed to make crossing windows [**?**] and even to track the car using drones[8].

In many current works we see that Yolov5 has been increasingly used due to the fact that it has a very acceptable accuracy and present a very good performance in real time.

2.1 Yolov5

Yolov5 (You Only Look Once, Version 5) was registered by a private company called Ultralytics. For this reason, there are no publications detailing its operation. However, it is known that its operation is similar to its previous version Yolof4, which was created at almost the same time. The difference is that Yolof5 uses the TensorFlow library, while Yolof4 uses the Darknet-53 library.

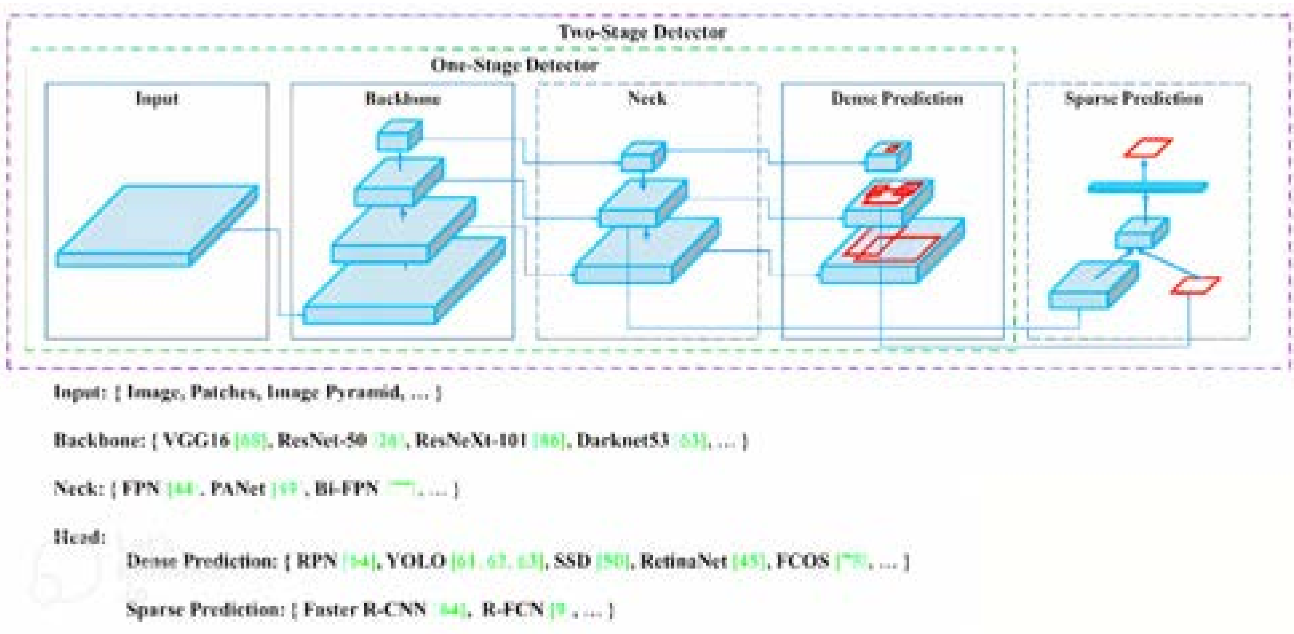

Figure 1 – Object detector[9].

Figure 1 demonstrates how the Yolov4 network training works. As can be seen the training of neural networks can be done in one stage like Yolo or in two stages. In the case of Yolo, the network goes through a convolution network, then the convoluted images are passed to perform a feature

collection of the images and then a dense prediction is performed that will inform the trained objects of the image. In networks that have two stages, it's still the sparse prediction layer where it goes through one more layer to try to get a bigger prediction.
The biggest advantage of this training is that you can learn to detect objects at near, medium or far distances, making it ideal for applications that have to keep moving, varying distance from the object. The differences we see between Yolov5 and Yolov4 is that they use a different framework and the configuration files are different.[10]

3. Experiment

This work was divided into two parts. We initially performed tests with controller boards to find out the most suitable for the drone. Afterwards, we focused on the acquisition of the dataset, training and programming of the algorithm to detect objects in the image.

3.1 Drone assembly

The aim was to assemble a low-cost drone so that you can carry out inspection safely. Initially, it was defined the use of a drone in the F450 quadcopter model, with 4 1000KV a2212/13T engines, 4 30A readytosky ESC and fs-r9b flysky radio receiver. We tested 3 models of controller boards: apm 2.6, naza and pixhawk 2.4.8. We chose pixhawk 2.4.8 due to the internal sensors it has such as barometer, gyroscope and accelerometer. Moreover, it presents a greater precision and the main reason for choosing it was the fact that its main processor is the FMU STM32F427, which accepts programming parameters in 32 bits. Figure 2 presents the drone used in this work.
QGroundControl was used as ground station for flights because it is compatible with PX4 firmware, used in pixhawk. For communication between the computer and the drone, a 433 mHz telemetry was used. To obtain the images, a 1280 x 720 FPV image capture camera with a frame rate of 30 frames/s and a 5.8GHz video transmitter was installed.

Figure 2 – Drone mounted in laboratory.

Several autonomous flight tests were carried out to check how pre-programmed flights by the ground station would behave. We also tested the MAVSDK library, which accepts several programming languages and communicates through MAVLink with drones, cameras and ground station[**?**].

As companies that have high voltage towers keep the latitude and longitude record of each tower, it is easy to draw waypoints. So, using a python code, it is possible to read a file with the locations and run the waypoints so that it doesn't have trouble repeating the same tower in the process.
As all drones fly together for inspection, as a security measure we configured the drones to keep 5 meters distance from each other, so that there is no collision problem between them. We also pogrammed a takeoff delay of 3 minutes so that one drone does not interfere with the observation of the other.
The test of the main code was done on only one real drone to see if it was possible to run for inspection purposes, but it was not possible to test with more than one drone due to the fact that the period studied had problems such as escs burns and because covid-19 got in the way. But other tests were done in the Airsim simulator.
This simulator was developed on the Unreal Engine platform by Microsoft. Its intention was to be used to carry out an experiment with artificial intelligence of all segments, making a simulation as close to the real thing as possible[11]. Figure 3 refers to airsim with a drone in a landscape.

Figure 3 – Airsim Simulator images with a drone[12].

3.2 Artificial intelligence

The biggest challenge was finding a dataset to train the network. However, with a lot of research, an aerial image dataset was found for the detection and segment of transmission towers and power lines [13].
The dataset found was impressive. We collected images of towers in flights performed with a DJI Mavic Pro, where we gathered 500 images between transmission lines and towers with some nearby objects to see if it was possible to detect any object that invades the easement area. Figure 4 presents some of the obtained images.
It was classified as image classes: trees, cars, pole, transmission line, towers, houses and buildings. The biggest challenge was to find a dataset where there were problems in the transmission line as companies end up not disclosing this type of image so that it can be used in research.
With the dataset already assembled, the roboflow site was used. This tool helps to prepare for training the neural network, making it possible to classify the images obtained and adjust for training.[14]
After training, the network was tested on videos taken by Mavic Pro initially to see if it had good accuracy. The results are as follows: 65% average in line detection, 90% average detection in transmission tower and 78 % detection in other classes that could enter the line's easement range. Figure 5 shows the images that were used in training with the label markings.
With that, the test went to the airsim simulator, where it had a code that executed the drone commands and another one where it obtained the classification in the image. In the simulator we had an accuracy of 65%, which was very good for a real-time technique.

4. Conclusion

The purpose of this work was to verify if it is possible to carry out inspection in high transmission lines using low cost and autonomous drones. With the assembly of the drone we were able to see that it is possible to carry out flights with low-cost drones, however, in order to have a more plausible result,

Figure 4 – Images taken from a Dji Mavic Pro.

Figure 5 – Test images used for training where it is set to detect cable and line.

the camera needs to have a higher quality than the one used in the research, which was an Eachine TX06.

In the real test using the FPV camera, there was a lot of noise in the images, thus generating some problems in image reception.

In the simulator, the navigation code, with the Yolov5 network running, was very good, but running on a computer that has an i7 4500U, 8gb of ram and a GT 750M 2gb video card, it was a bit bottlenecked.

The bottleneck was bigger when using the 3 drones in the simulation at the same time.
However, it was proven that there is the possibility of autonomous flights to inspect the transmission line with an embedded system running Yolov5 to detect the lines or possible problems that may appear and run the code that manages which tower should follow.

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