ROAD PATROL AUTONOMOUS DRONE "Flying Eye"

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Abstract

Unmanned Aerial Vehicles (UAV) are widely used in our daily life for various purposes such as traffic monitoring, fire tracking, agricultural planting and disinfection, logistics and military intelligence. In addition to functional facilities, UAVs also provide easy access to difficult or dangerous points by air. It is predicted that these systems will become widespread especially in civil defense applications and their usage areas will increase in the future. UAVs are widely controlled by remote control within a certain aerial range. Another method of flying UAVs is self-flying autonomous flight. By using the feature of the flight control card in the UAV, it is possible to fly UAVs autonomously.

In this study, our UAV named "Flying Eye" was designed based on the autonomous method. It is aimed to monitor the traffic flow by flying above the village and district roads which is difficult to reach by land.

Remote district and village roads may be closed as a result of natural disasters. Especially when the GSM network coverage doesn't exist and there is no communication, the roads that are blocked are an important problem. It may take a long time to recognize and intervene in this situation, which poses significant risks. At the same time, it is undesirable for drivers who do not know that the road is closed to lose time and waste fuel by entering these roads

In this study, a UAV that monitors the road with its camera by flying on such roads controls the traffic flow with an image processing algorithm, when it detects a problem, it helps to solve the problem by transferring information to the road rescue center and traffic boards.

Keywords: UAV, image processing, openCV, raspberry pi 4

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Objective

Our study is the production of an autonomous UAV that informs the relevant traffic centers when the traffic flow stops on the road by continuously monitoring the traffic flow on the remote district and village roads by using a special image processing algorithm and demonstrating its applicability in practice with flight control tests.

Introduction

Unmanned aerial vehicles are seen as the systems of the future in the military and civilian fields. The systems in question have been used in sensitive tasks and risky environments that pose a life-threatening threat to humans since the beginning of the 20th century

In near future, it is predicted that a significant amount of the systems used by the armed forces of developed countries will consist of unmanned systems. For this reason, many developed countries allocate large amounts of resources for R&D studies on unmanned aerial vehicles. Today, more than forty countries are working on the development and production of UAV systems. In Turkey, studies in this direction are carried out with the private sector and government support. (Turkey UAV Systems Road Map 2011-2030)

The UAV named "Flying Eye" used in this study was handcrafted from scratch using basic materials, image processing algorithm and opensource software. The similar and different aspects of this study with the existing studies are mentioned under the title of technical details.

Method

Materials Used:

- Hexacopter UAV frame F550
- 6 of Sunnysky X2212 kv980 brushless motor
- 6 of Simonk 30A esc module
- Fpv radio telemetry receiver
- RD9S RC Receiver module
- Pixhawk cube flight controller
- Pixhawk here 2 GPS
- Pixflow optical flow sensor
- Raspberry pi 4
- Pi Camera V2

Technical Details

Unmanned aerial vehicles with open source flight control cards can be managed from outside with computer software. Autonomous flight is provided by placing the auxiliary computers called "companion computers" connected to the flight control module on the UAV frame.

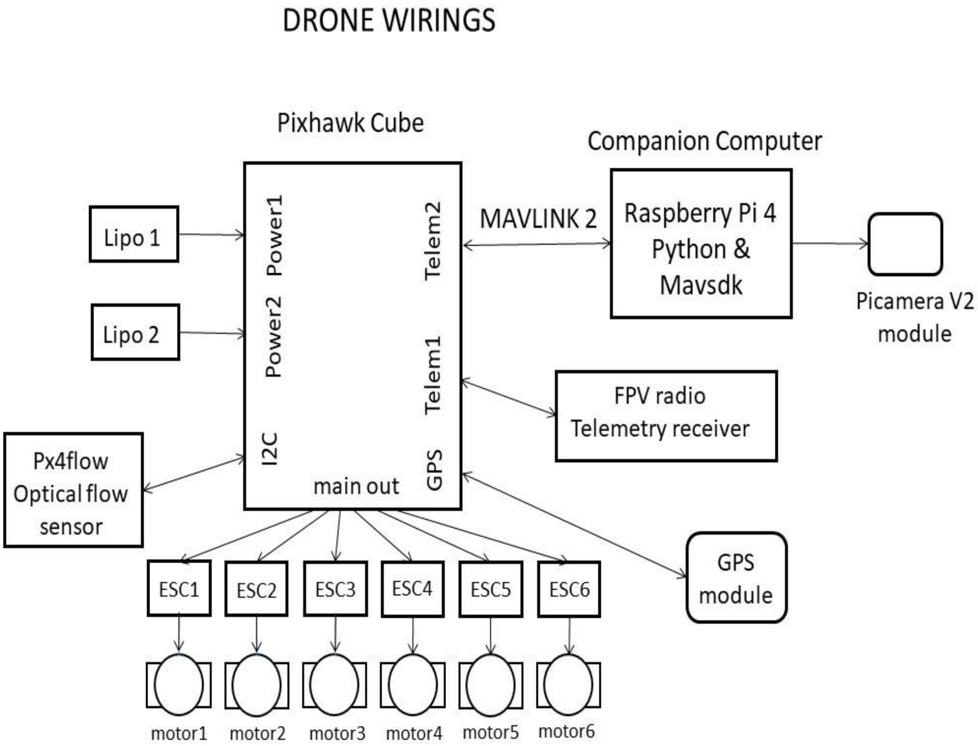
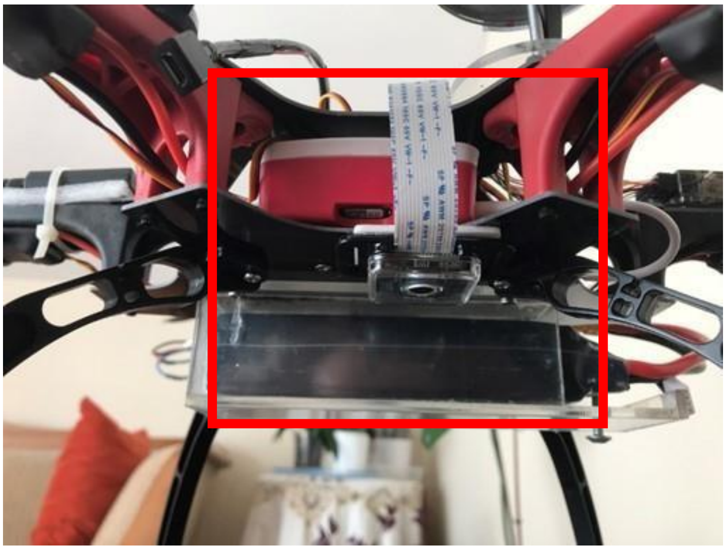


Figure 1: “Flying Eye” UAV wirings

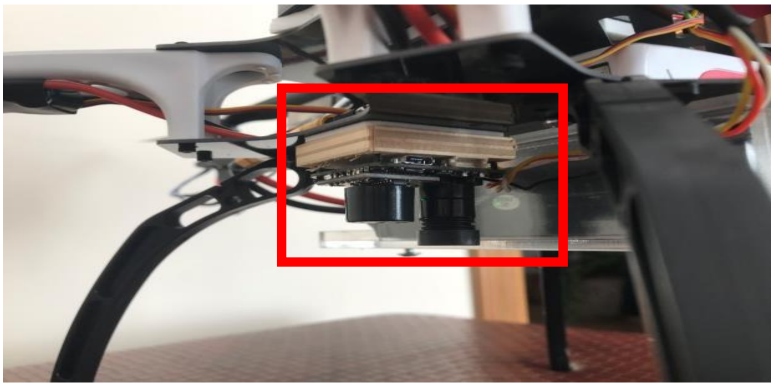
In this study, "pixhawk cube" is used as opensource flight control module and raspberry pi 4 is used as companion computer. PX4 firmware is used as opensource code on “Pixhawk cube”. Raspberry pi 4 and Pixhawk Cube" flight control module communicates with the "mavlink 2" protocol. It is the "Mavsdk" interface used with the "python" language that provides this communication.

Picture 1: Pixhawk Cube Flight Controller

Today, although the processing of the photos taken by the camera with deep learning gives better results, openCV image processing methods are used in this study. The reason for this is that the raspberry pi 4 used in the study is too slow for the deep learning platform. In order for processing the image of each and every passing vehicle on the road, raspberry pi must be able to take and process a photo every second otherwise, passing vehicle may escape from the view. This is only possible with image processing Picamera V2 is used as a camera on Raspberry pi 4. As parameters like shutter speed, ISO and exposure time can be adjusted through the software, the use of the picamera V2 has been found ideal in the study.



Picture 2: Raspberry pi 4 and picamera V2



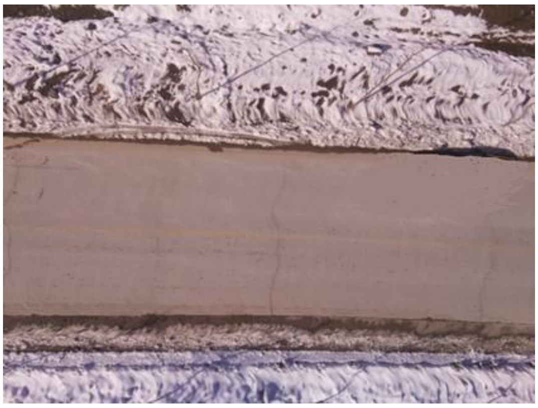
Picture 3: Px4flow Optical flow sensor

By using the method developed, the autonomous UAV "Flying Eye" which is flown above district and village roads, checks whether there is traffic flow on the road with image processing techniques. If there is no passing vehicle for 10 minutes on a road with quite frequent vehicle traffic in normal times, for example everyone minute, this indicates a problem. When this happens, the UAV "Flying Eye" leaves its stationary point on the road and returns to the station by taking photos above the road. Necessary actions can be taken by examining the road photographs taken by the UAV "Flying Eye" that returns to the station upon a potential problem.

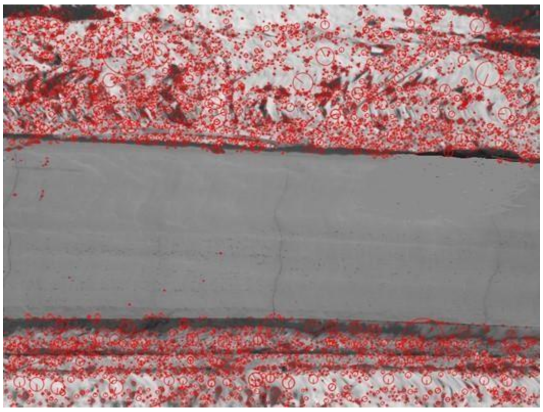
During the road control, the UAV “Flying Eye” hovers at a certain height on the road and takes photos. The software in Raspberry pi 4 compares the photo it takes every second with the next photo. This comparison is made by the "OpenCV keypoints" function. "Opencv keypoints" function quickly finds edge and corner points in a picture. If the numbers of "keypoints" in two consecutive photos are close to each other, it is understood that there is no traffic on the road. When the number of keypoints differs to a certain extent, it is understood that there is a passing vehicle on the road. Another problematic situation is the case of accumulation of immobile vehicles on the road. In this case, as we will get a keypoint number much higher than the number of keypoints we know as a reference when the road is empty, the “UAV” Flying Eye can still identify the problem and take the necessary actions.

Raspberry pi 4 and Pixhawk Cube flight control modules were used for this study, but beforehand, the UAV “Flying Eye” was simulated with Mavsdk software interface and Jmavsim UAV flight simulator against problems that may occur in the physical environments. All technical details and potential problems were obtained using the simulator and necessary adjustments were made.

The images taken from the UAV "Flying Eye" flown on a countryside village road in the open area and the photographs obtained as a result of the processing of these images are shown in Figures 4, 5, 6 and 7.

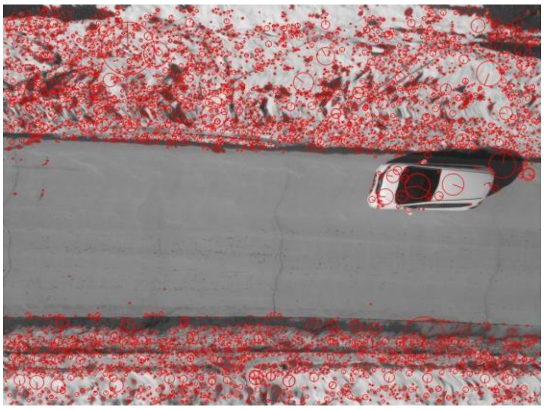


Picture 4: 1024x768 pixel empty road photograph taken from a height of 16 meters



Picture 5: 1024x768 pixel empty road photograph taken from a height of 16 meters (Number of Keypoints 6840)

Picture 6: 1024x768 pixel vehicle road photograph taken from a height of 16 meters



Picture 7: 1024x768 pixel vehicle road photograph taken from a height of 16 meters (Number of key points: 6976)

The differences of the number of "opencv keypoints" were investigated in the tests performed with the UAV “Flying Eye”, which was kept constant at an altitude of 16-20 meters, while the vehicle was passing and not passing. When there is a vehicle on the road the number of keypoints increases by 120-150 compared to the empty road. (In order not to create confusion, not all keypoints are displayed.)

Table 1: Project Timeline

	MONTHS									
Job Description	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**
Literature Review	X	X	X							
Design and Planning		X	X	X						
Material Supply				X						
Assembly and Experiments				X	X	X				
Field Work						X	X	X		
Data Collections and Analysis						X	X	X		
Project Report Writing								X	X	X

Findings

It is very important for the correct calculation of the number of "opencv keypoints" that the Flying Eye UAV remains stationary without moving even one meter in the east-west or north-south direction. Therefore, the Here 2 GPS antenna used in the UAV “Flying Eye” has been selected with the capacity to connect 4 GNSS systems (GPS, Glonass, Galileo, Beidou) at the same time. With this antenna that can perform RTK (real time kinematics) in a clean sky, it is possible to keep the Flying Eye UAV stable within centimeters. In addition to that, px4flow optical flow sensor (optical flow sensor) has also been installed in the UAV “Flying Eye” in case this system is not sufficient for the required stability. In the tests that we made, it has been observed that "Here 2 GPS" can connect up to 17 satellites and is sufficient for stability in the air.

Conclusion and Discussion

Various classifications are made by considering the characteristics of UAVs, which have different features from each other. For example, the weight measure or the maximum take-off weight criterion is used for classification purposes. In addition, fuel or energy source, wing structure, automatic or remote control of the vehicle are considered as criteria.

The “Flying Eye”, which was produced and tested in this study, can be classified as an autonomously flying UAV using image processing technology.

Balanced construction is very important for the UAV “Flying Eye” to be operated autonomously. In the tests during the assembly, the balance problems occurring during the take-offs from the ground were eliminated.

It was observed that the vibrations in the UAV “Flying Eye” were reflected to a certain extent in photographs in windy sky. Although the anti-shake feature of the camera prevents this problem to some extent, it has been observed that it is more appropriate to use a gimbal-connected camera

Since the Pixhawk Cube flight control module has 2 power inputs, it has been observed that the range and the airtime can be extended when two separate batteries are installed.

Optical flow sensor is very suitable for stability, but when there are very similar images (image patterns) on the ground, it has been observed that there may be problems in the detection of these images by the flow sensor.

The biggest drawback for using UAVs more functionally is the energy problem. Even though high capacity batteries are used, they can last for a maximum of 1-2 hours. In this study, it is thought that there will be more than one UAV that will work at the stationary point as a solution to the battery problem. The UAV whose battery is depleted will be recharged by returning to the central station, and the other UAV will take over the task.

Suggestions

Lighter and longer-lasting battery technology should be used in order to achieve high efficiency in the future studies. In addition, it is recommended that the UAV frame be constructed of materials as light as possible and to use a high-precision camera.

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Annex

Annex1: Flying eye code

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