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DRONE DETECTION USING IMAGE PROCESSING BASED ON DEEP LEARNING

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ABSTRACT

The objective of this experimental research is to identify solutions to detect drones using computer vision algorithm. Nowadays danger of drones operating near airports and other important sites is of utmost importance. The proposed techniques resolution pictures with a good rate of detection. The technique is using information concerning movement patterns of drones.

KEYWORDS: CFD, modelling, simulation, car brake, cooling

1. Introduction

The use of drones is becoming wide on different domains such as civil, commercial and military. With a huge number of applications, Unmanned Air Vehicles (UAVs) - also known as drones) pose a real safety issue concerning security that may lead to people live property but also cand produce catastrophes. Firstly, the danger source might be attackers who deliberately want to use drones, but also pilot lack of exercise might lead to severe consequences. Serious drones' incidents are very often. From drones having struck van in Scotland [1] to crashing drone to Pisa tower [2] the incidents produced by careless or inexperienced pilots are reported every week worldwide. The terrorist also used drones as the latest technology. The Iraq prime minister was attacked by a drone filled with explosive [3]. At the moment one of the most important threats is concerning disturbing traffic due to drone activity near airports. In 2018 hundreds of flights were cancelled at Gatwick Airport near London, England, because drones were reported close to the runway. On 14 September 2019, drones were used to attack oil processing facility in eastern Saudi Arabia.

Though authorities worldwide are imposing serious law by regulating drone operation careless drone operators' actions are causing serious problems for airports. Laws are discouraging using drones near airports but not address the criminal or terrorist activities [3]. The solution for avoiding tragic consequences is the use of technologies to detect and counter the drone operation in certain areas.

There are several solutions for detection of drones. One of the most used solution is detecting the Radio frequency (RF) [4]. Except autonomous ones most of the drones are navigating by communication between drone and the ground operator. This technique has very good results in case of civil drones that are operating at certain known frequency.

However, the main issue with this technology is that the drone may use peculiars frequency. With advanced RF scanner even, this issue can be solved but in the case the drone is autonomous or the drone has a pre-programmed flight path, it cannot be used at all [5].

Another solution is using acoustics analysis to detect drones [6,7]. Special software is using digital signal processing to identify specific sound of rotors. However, this solution cannot achieve good results for a greater than 200-400 m operational range.

Another technique used is the use of radar, but the small size and specific geometry means that are reflecting back to radar very limited electromagnetic signals. The use of the radar solution also provides high rate of false detection due to bird's activity [8].

Due to the latest development in computer vision and artificial intelligence algorithms a solution that provide good results might be used along other technical solution for drone detection. There are several computer visions approaches in order to detect drones. The "You Only Look Once" (YOLO) algorithm has enabled researchers to detect with high accuracy the drones [9, 10].

Deep learning is a latest algorithm developed that has shown very good results in computer vision. Convolutional neural networks (CNNs) can predict classes of objects by processing image features from a specific object. The training phase means providing several images sets with classes of objects to be detected. The deep learning is based on the idea that

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there is layer-based selection of features. For instance, first layer is collecting information concerning edges, the second level of layer extract colour information and the top lever layers define the object. CNNs are useful for performing identification of various objects such as humans, animals, types of plants and so on. The application varies from machine vision in industry for identification of defects, to security, and even detection of pedestrians used on ADAS (Advanced Drivers Assistance systems) onboard of the cars.

The frequency of incidents is also on the on airports worldwide which meant problems in operating air flights and serious disruptions because of drone presence and many scholars presented different approached and solutions. [11-13].

2. Experimental procedure

The detection system comprises of cameras arrays oriented to different positions towards the sky in order to identify drones. Video stream is processed by a computer running the proposed technique. In the first stage we prepare the image data sets for training. We have used 200 different images taken in different sky weather. Our object detection model uses deep learning to detect drones. A great challenge occurs in case of extreme foreground/background imbalance, such in cases when drones are black and the sky is also black.

To avoid false positive in case of presence of birds we used the information concerning relative speed of the object and also trajectory path. Birds are not usually performed close trajectory and also do not stop at a position as in fixed flight and then change the speed in an important amount. This basic path and speed analysis means that our technique significantly lowers the false positive cases. The confidence in predicting a drone class is of most important in order to develop such a detection to operate in real live conditions.

Using training only on images will not provide good results and thus the generated paths trajectory of real flights drones allows avoiding detection of birds. During detection process if the drone makes a small drift as well as stationary position, the algorithm increases chances of positive detection.

Accumulated drift analysis results in following the suspect object and its detection. To enhance algorithm feasibility, we also use speed evolution, as in case of birds there is no abrupt variation of speed. We analyse speed relative to camera position and thus we are using pixels per seconds as measurement unit. We measure different trajectories of drones and due to their technical specifications, are able to control to a complex flight’s trajectories. As seen in Figure 1, we can identify and make selection between bird and drone path in case the drones are showing specific trajectory. However due to 3d spatial trajectory there are situations when trajectory is perpendicular to camera when the algorithm is not useful. This can be improved in case we will use matrix cameras from different angles of the same airspace.

Also, distinction between birds and drones can be easily done in some circumstances when analysing speed evolution. As seen in Figure 2, we analyse speed variation and we can also use the heuristic approach concerning the operating speed variation to avoid false positive identification of birds as drones. We stress that we consider bird species living in Romania climate able to fly at a maximum of 300 m altitude. The two conditions concerning speed variation and trajectories are introducing to the predictive model more information in case the drone is performing specific movement. The proposed algorithm is using deep learning algorithm for classification. The predictive model is also using movement pattern and speed pattern. The proposed technique is using deep learning Convolutional Neural Networks (CNNs). We used 200 pictures of own pictures of drones taken in different environment conditions and consequently sky colours. As stressed above, information concerning movement patter and speed pattern are used in predictive model to make distinction and eliminate in such a manner some false positive identification.

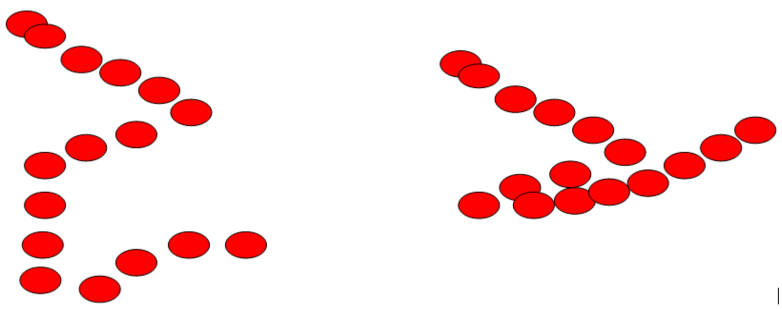

***Fig. 1.** Drone path trajectory seen by a camera*

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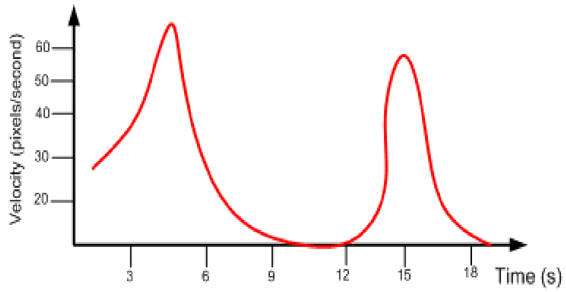
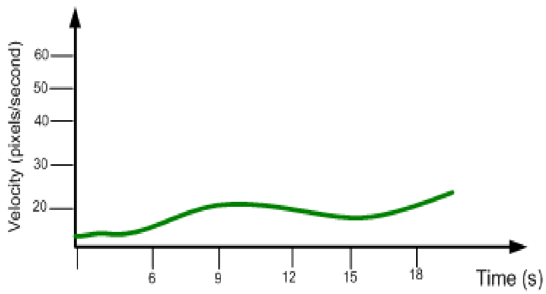


a)



b)

Fig. 2. *Speed variation in case of a) drones b) birds*

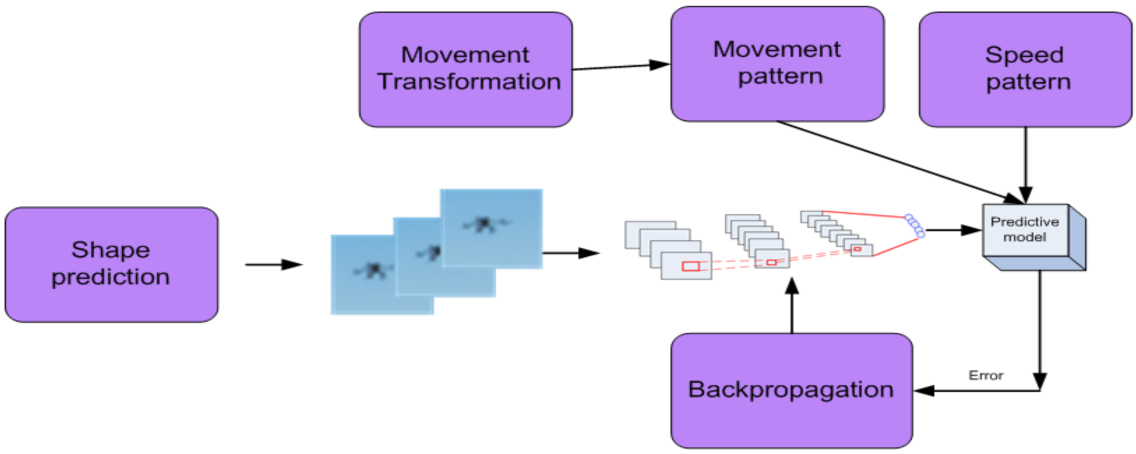


Fig. 3. *The proposed technique for drone detection*

3. Results and discussions

We used a web camera with good resolution but due to the distance to the drone, the drones need to be identified in low resolution pictures as the pixels representing the drones are in quite small amount. The dataset we use for experiment is not public data bases data set, because we need low resolution representation of our objects to be identified. Our data set contains different categories of objects: birds, airplanes. We converted the video sequences to images for CNN training and testing. We used a pc with AMD Ryzen™ 9 5900X. The application developed used 10 threads to process information in order to use processor multi-core capability better. Our case of multiple cameras processing such a platform can easily process 10 cameras in the same time without affecting speed of processing. We tested the application with 4 hours. The drone approaches the camera site every 3 minutes at different altitudes and movement patterns. The system is able to detect drone to a distance of maximum 200 meters. The detection rate in videos is 89% percent of the frames where a human can identify drone. However, each approach of the drone has been detected. False positive consisted of 2 cases of birds identify as drone, but we need to stress that no consisted bird activity presence was in the area we tested. technique need low computational resources in respect to computational platform. The application is processing 16-23 frames per seconds to identify drones. That means real time processing for video streams. We consider that in good assessment concerning false positive reliability.

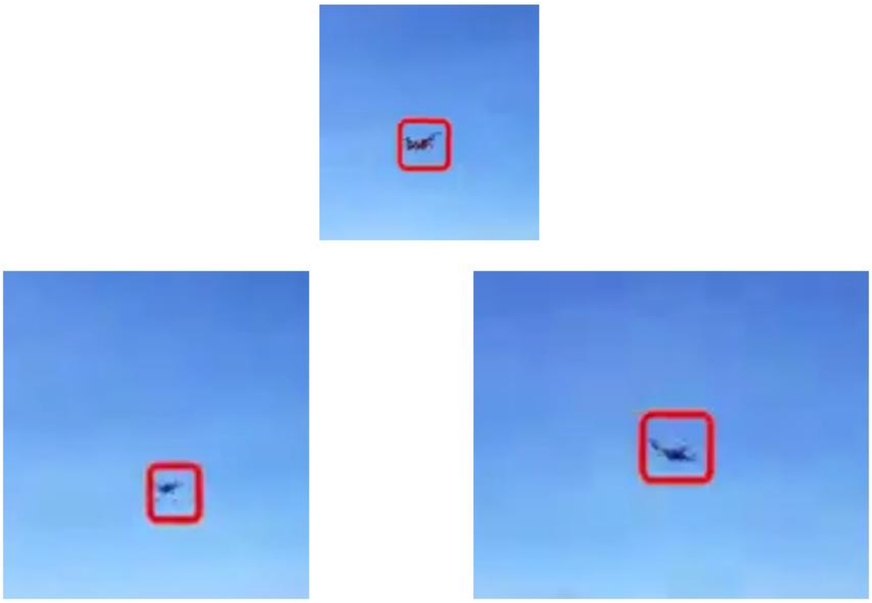


Fig. 4. *Drones' detection in low resolution pictures*

4. Conclusions

The main conclusions are the following:

- The proposed algorithm proved a good performance and can be used to a low-resolution picture.

- Low computational resources allows to implement on embedded devices as well and can be used to a matrix of cameras in order to detect drones.

- This algorithm can be used along radar detection technique.

- Further research should take into account using radar information, which are more accurate about 3d trajectory and speed in order to improve results.

- Further development need to consider better cameras or cameras with controlled zoom.

- The technique must be tested in areas with important bird presence.

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