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DRONE AND UAV DETECTION FOR SECURITY APPLICATIONS USING DL

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ABSTRACT

This paper presents a systematic approach to drone detection and classification using deep learning with different modalities. The YOLOv3 object detector is used to detect the moving or still objects. It uses a computer vision-based approach as a reliable solution. The convolutional neural network helps to extract features from images and to detect the object with maximum accuracy. The model is trained with a proper dataset and trained for 150 epoch only to detect various types of drones. A convolutional neural network with modern object detection methods shows an excellent approach for realtime detection of drones.

INTRODUCTION

The size of the drone industry expands exponentially to make this gadget reachable to common citizens with cheaper prices. By loading explosives, with them, the drone can easily be converted into killer weapons. Even by pertaining drones, some terror attacks attempts have been reported [1, 17]. As drones are small in size and having small electromagnetic signature makes difficulties for conventional RADAR for detection. A counter mechanis m is appraised by industry and the academic world. An object is having a specific structure, texture as well as some specific pattern. In natural environments, it is difficult to differentiate between the same types of objects because of high variation. The performance of an object detector reduces due to the lighting condition, change of appearance, and at what angle the object is facing towards the camera. Most object detector fails when some deformation happens to the object or changes in scale happens to the object [3, 4]. Stopple and background noises add more difficulties to the object detector. In the modern-day object detection, a convolutional neural network (CNN) [14] has performed so well that traditional methods have almost vanished from the picture. The best part of the convolutional neural network is its ability for extracting features. Based on the convolutional neural network, many object detectors come in to picture such as R-CNN [15], Fast R-CNN [7], Faster R-CNN [9], YOLO [6], SSD [12], etc. Apart from that, the highperformance GPUs and its easy availability through the use of high-performance cloud computing advanced computational ability. In the success of

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Vol 15 Issue 1 Feb 2024

the neural network, it played a crucial role. Deep learning architectures allow the ability to extract features easy to understand and reliable than conventional machine learning approaches [4-5]. In this study, experiments with the latest object detectors are carried out based on the deep learning approach to detect drones. While detecting it is going to classify the type such as tricopter, quadcopter, or hexacopter. The model is trained with a proper dataset so that in the case due to some orientation or scaling issue it is not able to find out the type but it is going to detect the drone. In figure 1, some images from the dataset are shown with ground truth annotation [6- 8]

LITERATURE SURVEY

Convolutional Neural Network-Based Real-Time Object Detection and Tracking for Parrot AR Drone 2,ALI ROHAN,MOHAMMED RABAH, AND SUNG-HO KIM1 School of Electronics and Information Engineer-ing, Kunsan National University,South Korea, Department of Control and Robotics Engineering, Kunsan National University, Gunsan

Recent advancements in the field of Artificial Intelligence (AI) have provided an opportunity to create autonomous devices, robots, and machines characterized particularly with the ability to make decisions and perform tasks without human mediation. One of these devices, Unmanned Aerial Vehicles (UAVs) or drones are widely used to perform tasks like surveillance, search and rescue, object detection and target tracking, parcel delivery (recently started by Amazon), and many more. The sensitivity in performing said tasks demands that drones must be efficient and reliable. For this, in this paper, an approach to detect and track the target object, moving or still, for a drone is presented. The Parrot AR Drone 2 is used for this application. Convolutional Neural Network (CNN) is used for object detection and target tracking. The object detection results show that CNN detects and classifies object with a high level of accuracy (98%). For real-time tracking, the tracking algorithm responds faster than conventionally used approaches, efficiently tracking the detected object without losing it from sight. The calculations based on several iterations exhibit that the efficiency achieved for target tracking is 96.5%.Deep learning (DL) in Artificial Intelligence (AI) has recently gained a significant interest. It is used in a wide range of applications such as autonomous systems, facial recognition, self-driving cars, image and speech recognition,

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www.ijsem.org
Vol 15 Issuse 1 Feb 2024

classification, and object detection. Among the most promising systems that can utilize Deep Learning are Unmanned Aerial Vehicles (UAVs), which are becoming an attractive solution for a wide range of applications. Recently, Convolutional Neural Networks (CNNs) have achieved great results in different fields of recognition, detection, and classification, especially in computer vision. CNN is a class of deep neural networks, and is mostly applied to analyze visual imagery. For the application of object detection and classification, CNN is considered as a very powerful tool. CNNs are biologically inspired hierarchical models that can be trained to perform a variety of detection, recognition, and segmentation tasks [1]. The structure of a CNN typically comprises a feature extractor stage followed by a classifier. In past years, a lot of progress has been made on CNN-based object detection. Several object detectors have been proposed by the deep learning community, including Faster R-CNN [2], R-FCN [3], YOLO [4] and SSD [5]. The main emphasis of these designs is placed on improving (1) detection accuracy and (2) computational complexity of their methods in order to achieve real-time performance for mobile and embedded platforms [6]. CNN-based object detectors are divided into two categories with respect to their high-level structure: (1) region-based detectors and (2) single-shot detectors. Region-based detectors usually consist of a region-proposal stage followed by a classifier. Faster R-CNN is an example of region-based detectors. The problem with region-based detectors is that they are computationally heavy and it is difficult to achieve high performance in embedded platforms. Single-shot detectors, on the other hand, employs a single CNN to perform end-to-end object detection. YOLO and SSD are examples of single-shot detectors. YOLO is designedfor real-time execution and, by design, provides a trade-off favoring high performance over accuracy [7]. Generally, traditional techniques utilize background subtraction [8] or Haar Cascade classifiers to detect object [9]. In [10], authors proposed an automatic disease detection and classification method in radish fields using a camera attached to a UAV. In [11], authors used CNN to detect drones from other flying objects using deep convolutional neural networks. In [12], authors used convolutional neural network for real-time analysis of information and performance in detecting cattle using drone. In [13], authors presented target detection and safe landing algorithm for UAV. In [14], an approach for drone wireless charging was implemented

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www.ijsem.org
Vol 15 Issue 1 Feb 2024

using Hill-climbing algorithm. Many UAV studies have tried to detect and track certain types of objects such as vehicles [15, 16], people including moving pedestrians [17], [18], and landmarks for autonomous navigation and landing [19], [20] in real-time.

Real-Time, Cloud-based Object Detection for Unmanned Aerial Vehicles Jangwon Lee, Jingya Wang, David Crandall, Selma Sabanovi c, and Geoffrey Fox School of Informatics and Comput ing Indiana University

Real-time object detection is crucial for many applications of Unmanned Aerial Vehicles (UAVs) such as reconnaissance and surveillance, search-and-rescue, and infrastructure inspection. In the last few years, Convolutional Neural Networks (CNNs) have emerged as a powerful class of models for recognizing image content, and are widely considered in the computer vision community to be the de facto standard approach for most problems. However, object detection based on CNNs is extremely computationally demanding, typically requiring highend Graphics Processing Units (GPUs) that require too much power and weight, especially for a lightweight and low-cost drone. In this paper, we propose moving the computation to an off-board computing cloud, while keeping low-level object detection and short-term navigation onboard. We apply Faster Regions with CNNs (R-CNNs), a state-of-the-art algorithm, to detect not one or two but hundreds of object types in near real-time. Recent years have brought increasing interest in autonomous UAVs and their applications, including reconnaissance and surveillance, search-and-rescue, and infrastructure inspection [1]–[5]. Visual object detection is an important component of such UAV applications, and is critical to develop fully autonomous systems. However, the task of object detection is very challenging, and is made even more difficult by the imaging conditions aboard low-cost consumer UAVs: images are often noisy and blurred due to UAV motion, onboard cameras often have relatively low resolution, and targets are usually quite small. The task is even more difficult because of the need for near real-time performance in many UAV applications. Many UAV studies have tried to detect and track certain types of objects such as vehicles [6], [7], people including moving pedestrians [8], [9], and landmarks for autonomous navigation and landing [10], [11] in real-time. However, there are only a few that consider detecting multiple objects [12], despite the fact that detecting multiple

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www.ijsem.org
Vol 15 Issuse 1 Feb 2024

target objects is obviously important for many applications of UAVs. In our view, this gap between application needs and technical capabilities are due to three practical but critical limitations: (1) object recognition algorithms often need to be hand-tuned to particular object and context types; (2) it is difficult to build and store a variety of target object models, especially when the objects are diverse in appearance, and (3) real-time object detection demands high computing power even to detect a single object, much lesswhen many target objects are involved. However, object recognition performance is rapidly improving, thanks to breakthrough techniques in computer vision that work well on a wide variety of objects. Most of these techniques are based on “deep learning” with Convolutional Neural Networks, and have delivered striking performance increases on a range of recognition problems [13]–[15]. The key idea is to learn the object models from raw pixel data, instead of using hand-tuned features as in tradition recognition approaches. Training these deep models typically requires large training datasets, but this problem has also been overcome by new large-scale labeled datasets like ImageNet [16]. Unfortunately, these new techniques also require unprecedented amounts of computation; the number of parameters in an object model is typically in the millions or billions, requiring gigabytes of memory, and training and recognition using the object models requires high-end Graphics Processing Units (GPUs). Using these new techniques on low-cost, light-weight drones is thus infeasible because of the size, weight, and power requirements of these devices.

Using Shape Descriptors for UAV Detection , Eren Unlu, Emmanuel Zenou, Nicolas Riviere` ,Eren Unlu, Emmanuel Zenou, Nicolas Riviere`. Using Shape Descriptors for UAV Detection. Electronic Imaging 2017, Jan 2018, Burlingam, United States.pp. 1-5.

The rapid development of Unmanned Aerial Vehicle (UAV) technology, -also known as drones- has raised concerns on the safety of critical locations such as governmental buildings, nuclear stations, crowded places etc. Computer vision based approach for detecting these threats seems as a viable solution due to various advantages. We envision an autonomous drone detection and tracking system for the protection of strategic locations. It has been reported numerous times that, one of the main challenges for aerial object recognition with computer vision is discriminating birds from the targets. In this work, we have used 2-

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www.ijsem.org
Vol 15 Issue 1 Feb 2024

dimensional scale, rotation and translation invariant Generic Fourier Descriptor (GFD) features and classified targets as a drone or bird by a neural network. For the training of this system, a large dataset composed of birds and drones is gathered from open sources. We have achieved up to 85.3% overall correct classification rate. The volume of the Unmanned Aerial Vehicle (UAV) -also known as drone- industry expands constantly, making these gadgets accessible to more and more ordinary citizens, with cheaper prices. This situation enforces authorities to change the security paradigm for strategic locations such as nuclear power stations, touristic hot spots, governmental buildings etc.. Drones can easily be converted to dangerous weapons by loading them with explosives. A couple of terrorist attack attempts involving drones have been reported [1]. In addition to this, more and more incidents on drones threating civil aviation have being reported [2]. Also, espionage and privacy issues are other problems [3]. They cannot be detected efficiently with conventional methods, such as RADARs etc. due to their size and small electromagnetic signatures [4]. These developments have raised concerns as drones are immune the conventional defence systems, mainly developed for military purposes. They cannot be detected efficiently with conventional methods, such as RADARs etc. due to their size and small electromagnetic signatures [4]. Therefore, new kind of counter measures are being evaluated by industry and academia. Among these methods, RF signal detection aims to detect the RF signals between the operator and the drone. Another set of method rely on the X-band and micro-doppler RADAR technology. There exists also acoustics systems where the specific noise emitted from the drone rotors is detected. Finally, computer vision is a versatile choice in addition to these approaches [5][6][7]. All of these methods have their advantages and drawbacks, however computer vision approach distincts itself with its effectiveness due to its rich features and robustness [4]. In this work, we have used Generic Fourier Descriptor (GFD) to characterize the binary shapes, (e.g. silhouettes) of drones and birds, which is an effective algorithm proposed by [9]. These are two dimensional scale, translate and rotation invariant features, which are defining shapes with high detail [9]. One of the main challenges in computer vision approach is the difficulty of distinguishing birds from the drones [8]. Therefore, we have developed a system which compare the GFDs of binary silhouettes of birds and drones to classify.

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Vol 15 Issue 1 Feb 2024

Drone Detection and Identification System using Artificial Intelligence,**Dongkyu 'Roy' Lee,Woong Gyu La and Hwangnam Kim,School of Electrical Engineering, Korea University, Seoul, Rep.**

As drone attracts much interest, the drone industry has opened their market to ordinary people, making drones to be used in daily lives. However, as it got easier for drone to be used by more people, safety and security issues have raised as accidents are much more likely to happen: colliding into people by losing control or invading secured properties. For safety purposes, it is essential for observers and drone to be aware of an approaching drone. In this paper, we introduce a comprehensive drone detection system based on machine learning. This system is designed to be operable on drones with camera. Based on the camera images, the system deduces location on image and vendor model of drone based on machine classification. The system is actually built with OpenCV library. We collected drone imagery and information for learning process. The system's output shows about 89 percent accuracy. Recently, the interest and demand in drone are higher than ever. With this popular demand, new types of drone merchandise has been designed and manufactured, so that civilians can afford to buy them for various purposes (i.e., research, leisure, etc.). As for this shift, the commercial drone industry keep on growing. Although commercial drones have been massively produced to satisfy the civilians needs, there has been some downsides to this. As it became easier to spot drones outdoors, more safety issues has been brought up as concerns. These are not merely about accidents regrading to drones harming individuals, but include drones invading government restricted areas. Additionally, considering that a coordinated fleet of drones is capable of more various tasks [1], drones can be a bigger threat than people could imagine. As there are more drones out in public, it became harder to regulate them legally and safely. For regulation, it is essential to detect and identify drones up in the sky. When it comes to detection, the first thing that comes to mind is a radar. Among various radars, there are radars specially designed to detect small aircrafts that humans cannot be on board. However, these radars have limits. For one thing, it cannot distinguish between birds and drones. This calls for an alternative solutions to detect drones accurately. In this paper, we propose a comprehensive drone detection system based on machine learning as an alternative solution for the aforementioned matter. This

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www.ijsem.org
Vol 15 Issuse 1 Feb 2024

system applies object detection to capture the unknown drones as objects in the image, then identify the unknown drones model type by matching the captured image of the drone to vendor catalog using machine learning. Our system can be applied in an environment with surveillance drones with following scenario. During its mission, the surveillance drone records its surrounding on camera. If there were an unknown drone, it will be found on the video frame by applying object detection, and the system will mark it on the frame. The marked frame is then used further. The system, which has learned various drone model through machine learning, identifies the unknown drone by model. Such system can be applied on other surveillance system such as [2], and complement its ability to find unknown flying objects. For image processing, the system uses GPU with CUDA programming [3] on the video frames. On each frames, objection detection algorithm is applied to spot the drone in the video frames. Specifically, cascade classification is adapted for object detection. With machine learning based on various drone images, which are given and processed beforehand, the system learns how to detect drones accurately from frames. Then, frames with drone detected are processed once more to identify the drones model type.

EXISTING SYSTEM

The existing system for drone and Unmanned Aerial Vehicle (UAV) detection in security applications using Deep Learning (DL) represents a pivotal advancement in safeguarding critical infrastructures and public spaces. This system harnesses the capabilities of DL algorithms to autonomously identify and classify drones in real-time. Deep Learning, a subset of artificial intelligence, enables the system to analyze vast amounts of visual data and distinguish between authorized and unauthorized aerial vehicles with high accuracy. The integration of DL in this context allows for the continuous learning and improvement of detection models, adapting to emerging drone technologies and tactics employed by potential threats. The system often relies on a network of sensors, including cameras and radars, to capture data and feed it into the DL algorithms for analysis. This technology is crucial in enhancing security protocols, as it enables early detection of potential threats posed by drones, ranging from unauthorized surveillance to more malicious activities. The application of DL in drone detection for security not only augments response times but also provides a proactive and intelligent

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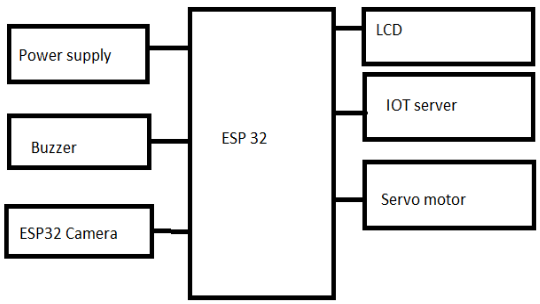
Vol 15 Issuse 1 Feb 2024

layer of defense against evolving security challenges in the airspace.

IMPLEMENTATION

BLOCK DIAGRAM



The proposed system presents an advanced solution for security applications by leveraging Deep Learning (DL) techniques to detect and mitigate the threats posed by drones and Unmanned Aerial Vehicles (UAVs). The system employs sophisticated DL algorithms that are trained on extensive datasets to accurately identify and classify aerial objects in real-time. By analyzing visual and sensor data, the model can distinguish between authorized UAVs and potential security risks such as unauthorized drones or those exhibiting erratic behavior.

The core of the system lies in its ability to continuously learn and adapt to evolving drone technologies and tactics. The deep neural network is trained to recognize patterns in the flight behavior, size, and appearance of different drones, enabling it to make rapid and precise decisions regarding potential security threats. Additionally, the system is equipped with advanced sensor technologies, including radar and infrared sensors, to enhance detection accuracy, especially in challenging environmental conditions.

To further enhance its capabilities, the system integrates with existing security infrastructure, such as surveillance cameras and other sensors, creating a comprehensive and interconnected security network. When a potential threat is identified, the system can trigger real-time alerts to security personnel, allowing for prompt and targeted responses to neutralize or mitigate the risks posed by unauthorized drones. Moreover, the system can be configured to autonomously deploy countermeasures, such as signal jamming or interception, to ensure a proactive and effective security response.

In summary, the proposed Drone and UAV Detection System using Deep Learning represents a cutting-edge approach to bolstering security measures. By combining the power of DL algorithms with advanced sensor technologies, the system provides a robust defense against emerging threats from unauthorized aerial vehicles, offering a

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www.ijsem.org
Vol 15 Issuse 1 Feb 2024

crucial layer of protection for critical infrastructure, public events, and sensitive areas where security is of paramount importance.

CONCLUSION

Due to the big architecture of the YOLOv3 model and less class, the model is trained for 150 epoch only. In some cases, the model is unable to detect the correct drone type. For improvement of accuracy, a new kind of counter mechanis m can be integrated, such as RF signal detection. In which the RF signal between the operator and the drone. X band RADAR and micro-doppler RADAR are the new methods. A new acoustic system is a modern method to detect drone from drone blade sound also able to detect the type of drone.

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