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SMART SURVEILLANCE USING ON CLOUD MACHINE LEARNING AND INTERNET CONTROLLED UAVS

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ABSTRACT. With an increase in 4G connectivity and the advent of 5G Internet, a wider range of applications can be ensured that can use radio frequency for piloting the UAVs and execute various real time applications as well. Real-time applications of Machine Learning can also be made possible with high data transfer rates of 5G. One such application is the real-time object detection and activity tracking using a UAV mounted system and this paper proposes architecture for such a system. The system proposes to transmit data received from UAV onto Cloud and implementation of Machine Learning application to be executed on the Cloud or on-board in real-time. Through Cellular network, the UAVs can be controlled remotely from virtually anywhere in the world, eliminating the requirement of the physical presence of a pilot on the spot.

1. INTRODUCTION

With the governments all over the world liberalizing and legalizing drone use, various new areas of research and development had opened up and have drawn widespread attention. The main focus of this paper is to propose smart surveillance system with cellular control of drones and implementing analysis of captured data from drones' cameras and sensors by using Artificial Intelligence and Machine Learning models. System is designed to implement security and reduce human efforts in data analysis. Cellular control will allow UAVs to

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Key words and phrases. Unmanned Aerial Vehicles (UAVs), 4G/5G Connectivity, Machine Learning (ML), Person Tracking, Cloud Storage, Ad-Hoc Networks, UAS – Unmanned Aerial System, Flying Ad-Hoc Networks (FANETs), Search and Rescue (SAR), Ground Control Station (GCS) .

go to remote areas during disaster or emergency situations when the terrestrial reach is limited due to debris or other factors. For example, in Search and Rescue (SAR) missions, UAVs can act as first responders and reach immediately on the spot. Since the introduction of neural networks, detection frameworks have become increasingly fast and accurate. Therefore, their application in disaster management and surveillance based applications is highly desirable since rapid response is required. However, most of the detection methods are still applicable to a small set of objects for customized solutions because the computational requirements for using these networks are very high, and the power available on the UAVs is scarce. Remote processing of data is the optimum solution which can be achieved by setting up Cloud that can perform on-demand machine and deep learning tasks on the captured data. For applications with small computational requirements, processing can be done on-board also. In [1], authors have proposed a very efficient object detection system that has the capability to detect around 9000 categories of objects.

2. Literature Survey

In [2], the authors have proposed the idea of an autonomous flight of a drone by using GPS tracking and graph algorithms. The drone follows the shortest path with the help of data generated by graph points. In [3], the authors have presented the idea of tracking-learning-detection (TLD) to track an arbitrary object selected by a user. It can be used to monitor suspicious objects, trafficked vehicles or specific applications can be availed. In [4] the authors have described a Cloud-based system for object detection that acts in real time using UAVs. The authors have proposed the idea of offloading computation to the Cloud while keeping the low-level object detection on board. In [5], authors have proposed to use FANETs (Flying Ad-Hoc Networks) but there are several challenges that need to be addressed before their widespread use. The technology will enable direct drone-to-drone communication which will surely increase survivability, transmission efficiency and enrich the applications.

3. Architecture, Implementation set-up and Use Cases

The basic diagram of the proposed UAV based smart surveillance system with major architectural components is shown in Figure 1. A UAV with the capability of connecting to the Cloud requires a microprocessor installed on it. Also an

active high-speed Internet connection (4G/5G) is required to transmit data to Cloud Servers and receive CNPC commands from the ground station.

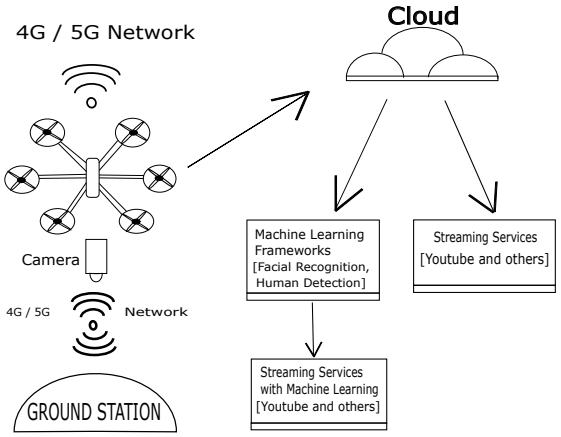

FIGURE 1. Architecture of the proposed UAVs based smart surveillance system

3.1. **Components and Software Description.** The major components and open source software necessary for smart surveillance using Internet controlled UAV flight are as follows:

- Raspberry Pi: Raspberry Pi (Companion Computer) makes the communication between the Ground Station and UAVs possible. Also, the Cloud connection to the UAVs (for uploading captured data to Cloud) can be set up easily. Raspberry Pi is used to convert the digital signals sent from ground station to the PPM signal on which flight controllers work.
- XB Station: XB station is an easy to use and implement software that provides a connection between ground station and UAVs over the Internet and video streaming facility using gStreamer, [6]. It provides video streaming to the ground station. This software needs to be installed on both the companion computers on the UAV and ground station.
- Cameras: The Raspberry Pi camera module is used for image and video capturing. It needs to be compatible with and connected to the Raspberry Pi. Other cameras with special features can also be deployed as per desired requirements.
- Cloud Services: Many of the Cloud platforms provide services like storage, machine learning and deep learning frameworks, analytical tools

and alike. Data is analyzed in real-time using these services and can be streamed to desired stakeholders and locations as per the requirements.

3.2. **System Implementation.** The system described above can be implemented with the help of a microprocessor, which is installed on the UAV. This on-board processor establishes a connection with the Cloud and sends the captured video to the Cloud using high-speed 4G/5G Internet. The video can be streamed in

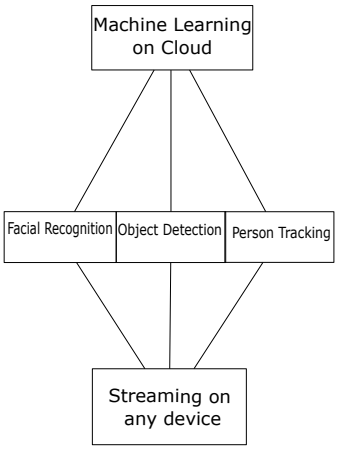

FIGURE 2. The flow of data in the proposed system

its raw form or after being processed by machine learning models on the Cloud with minimum time lag ensured by powerful computational capacity of high-end Cloud Servers. Figure 2 shows the tasks that can be accomplished via machine learning on Cloud.

- Object Detection and Tracking, [7]: The deep learning based YOLO (You Only Look Once) model can be used for object detection in real-time. The system can further be enhanced to track the objects as well.
- Facial Recognition, [8]: In case of surveillance, tracking suspects, or during SAR missions, such algorithms can be implemented.
- Person Tracking, [9]: It is useful for autonomously following a body for border surveillance or in emergency situations.
- Human Activity Recognition, [10]: Activity recognition can be implemented to cater to a number of use cases that require detection of events of different types .

Using XBStation makes it easy to control UAVs over the Internet, [11], and XBStation API, [12] can be used to develop custom applications. After the proper setup of XBStation, the ground station is able to control UAVs over the Internet.

Videos from the UAVs can be streamed to Cloud using AWS Kinesis, and passed to Amazon Rekognition that is able to produce results like detecting the face or particular type of object category.

This system proves to be highly beneficial for surveillance as it sets up a virtual window between the site and the person observing it. On disputed territories, where troops movement is difficult this system can be used for checking any suspicious activity. During complex medical operations, serious cases, or during disasters, when medical facilities are not readily available, then instant help can be provided using UAVs. UAVs can also play a vital role in enabling communication and can be used as a mediator between experts and the remote site of action.

4. Future Work

The ability to convert existing UAVs into smart surveillance system at minimal costs require integration of existing and new infrastructure, eventually leading to their efficient use. The next approach includes forming an Ad-Hoc network of UAVs independent of any radio communication and providing services through Internet so that more efficient and versatile applications can be made possible. Future system can also be thought of as employing a group of UAVs to form a Wireless network zone for providing Internet and calling facility in low coverage or disaster struck zone.

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