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USING IOT TO SYNCHRONIZE DRONE FLIGHT PATHS

Abstract: An analysis of the experience of reasoned use of drones in various fields of human activity and demonstrates the need to study the use of IoT architectures to build a control system for several drones. The paper considers the problems of increased requirements for computing power required for the analysis of photo / video sensor data. The use of "cloud sensor" technology is also proposed.

Keywords: Drone, domain domain object tracking, automated flight scenarios, video stream analysis, HOG, YOLO, IoT, sensor cloud.

Introduction

Sports events and entertainment are one of the most common cases of commercial drones today, as they offer a wide range of aerial photography and video. The term "drone" (hereinafter referred to as a drone) is considered a quadcopter, with the ability to fly on three axes, the ability to conduct photography, video and data transmission channel (control signals, sensor data and camera). Note that the FAA [2] has strict rules for the use of private drones near sporting events for health and safety.

According to Statista [1], the global budget for drone research and development has reached more than $ 4 billion by mid-2021.

Using the current revolution of Internet of Things (IoT) technology, drones have undergone an accelerated transformation in their use - from amateur toys to sophisticated IoT devices. The growing popularity of the use of drones expands the range of tasks they can solve, and thus places increased demands on their performance (data processing and transmission), reliability and functionality. Meeting these requirements makes them an invaluable addition to different sectors.In addition, the deployment of 5G technology is expected to increase the ability of drones to respond to commands in real time, providing instant feedback. The decomposition of the areas of activity by the percentage of drone use shows that the leader is the video audio recording of sports and mass cultural events, where the popularity is growing, as shown in Fig. 1.

One of the sectors for the use of drones, which is currently gaining popularity, is their personal use in travel, at various entertainment and sporting events. The ability to take pictures during the trekking routes of tourists to save memories or coverage on social networks is now becoming a necessity. However, drone piloting and surveillance control require:

1. certain user training: maintenance, assembly, transportation takes 4 times more time than the time of effective use of the drone);

2. control skills: the end user is required to know not only the basic techniques of control, but also an understanding of the ultimate capabilities of the device (maximum speed, remote control, flight time, etc.);

3. analysis of weather conditions: the user must also analyze and take into account wind speed, visibility, probability of precipitation, etc., which directly affects the service life of the device and threatens its integrity;

4. Selection of exposure during shooting and post-processing of materials: practice shows that knowledge of the basic principles of video-audio shooting directly affects the quality of materials, not the lack of this knowledge leads to the need to make several duplicates of each frame, which increases post-processing time .

In addition, there are time limits on the flight life of the device itself (from 5 to 35 minutes of flight time without recharging, depending on weather conditions, which must be taken into account by the user).

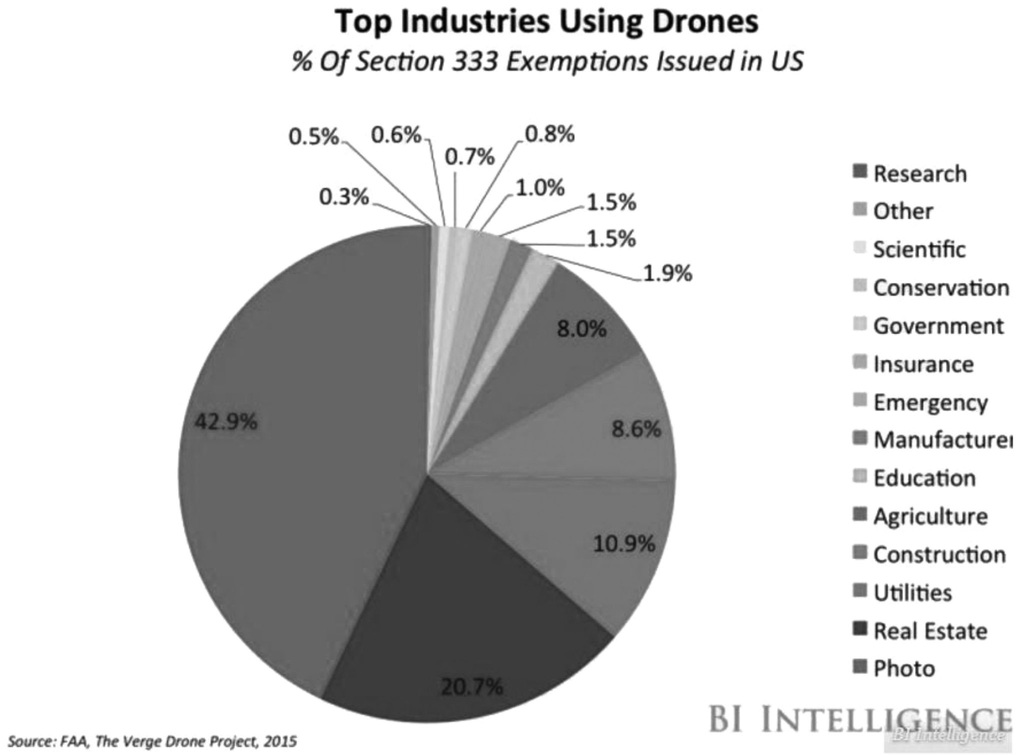

Figure 1. Scope

Problem statement

It is necessary to offer approaches to reducing the time spent by users for video logging of active actions, through the use of IoT architecture by synchronizing flight paths, recharging cycles and automated execution of programmed scenarios.

Analyze the disadvantages and advantages of using the IoT architecture to synchronize the decision node, the flight paths of the end devices of the selected architecture.

Solving the tasks

The physical implementation of the architecture will allow sending independent signals to end devices and this allows centralized synchronization of drone flight trajectories and synchronization of recharging cycles of swarm members, which will increase the efficiency of drone use (in terms of maintenance / maintenance time to effective drone operation). use a separate transport channel.

Consider in this system the possibility of using IoT technology to solve problems and analyze the effectiveness of its use. The drone in this system acts as a limit device of the system, the task of which is to receive control commands from the decision center and transmit the video stream to the repository. A separate service will analyze the incoming video stream from each device, synchronize it in time, taking into account the presence of several sources of the stream and their angles. The tasks of the decision-making center will be the synchronization of flight trajectories, monitoring of the state of end devices (drones) and preliminary analysis of incoming video streams.

Implementation of the proposed approach

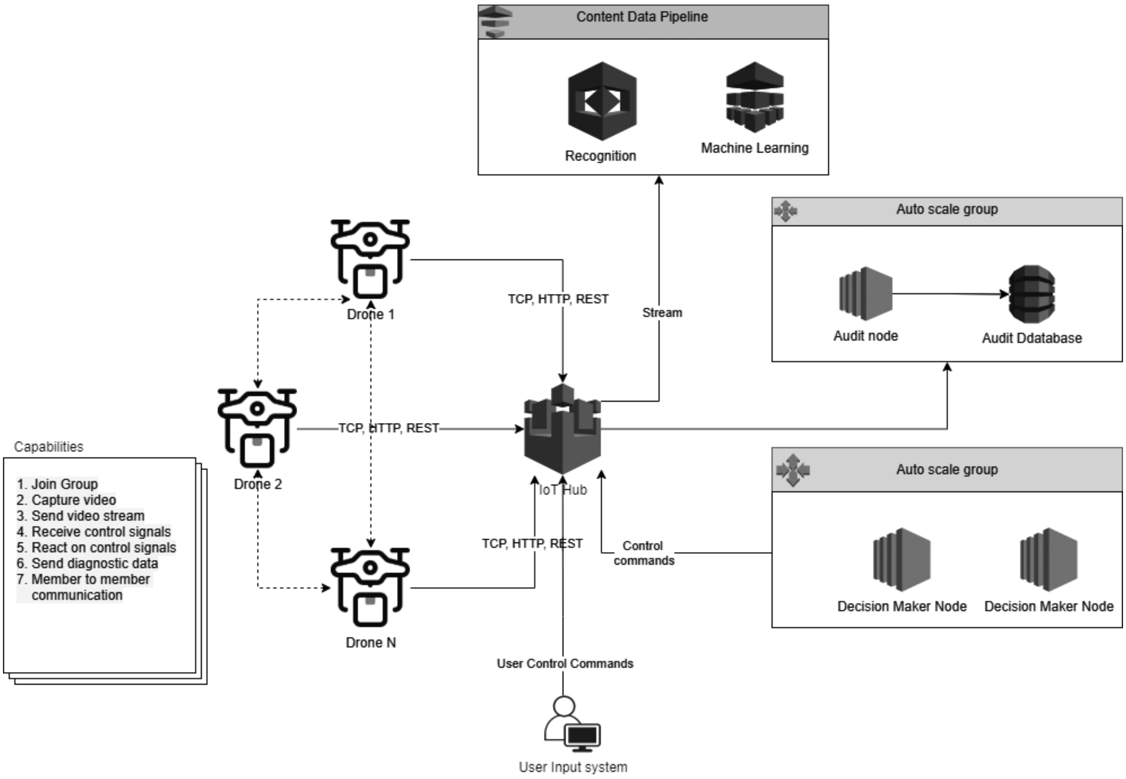

Figure 2. General scheme of the system

It is necessary to implement a system that would reduce the disadvantages of manual control of the device and the required level of user training for piloting, as well as increase the time of continuous shooting. Additional advantages of the proposed approach are the development of pre-programmed trajectories and the use of template turns, which can create a sense of presence of the camera crew. Also, the ability to control the system from multiple devices using gestures, as well as automatic composition and editing of video streams from different devices.

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Manual drone control requires the user to take constant action during the flight, which increases the time spent on controlling one drone up to 100% of the flight time of the drone, and parallel control of multiple devices manually not only reduces the efficiency of drones for video logging, but also creates the risk of sending erroneous commands. . Organizing multiple drones into a controlled group that performs pre-programmed turns using action scenarios reduces the time required to control the drone, in fact, only until the time of selecting the scenario. In addition, team members send diagnostic information to the decision center using the IoT transport channel, where, depending on a number of factors, the schedule and logistics of drone rotation for recharging are built. The chosen approach reduces the time requirements for the pilot, expands the functionality through automated use of multiple drones, and increases the efficiency of using drones for video logging, by reducing downtime while waiting for control commands from the pilot, and organizing automated charging cycles.

The use of IoT architecture to solve this problem allows to granulate the responsibility for different modules of the system, which simplifies the implementation of competitive use of communication channels and data storage, and the use of fast data protocols (5G for example) improves system feedback and sensitivity to control signals .

The most resource-intensive (in terms of energy and computation time) group of tasks, which directly affects the system architecture and creates increased performance requirements, is the task of tracking the object in real time. Decomposition of the representation in Fig. 3.

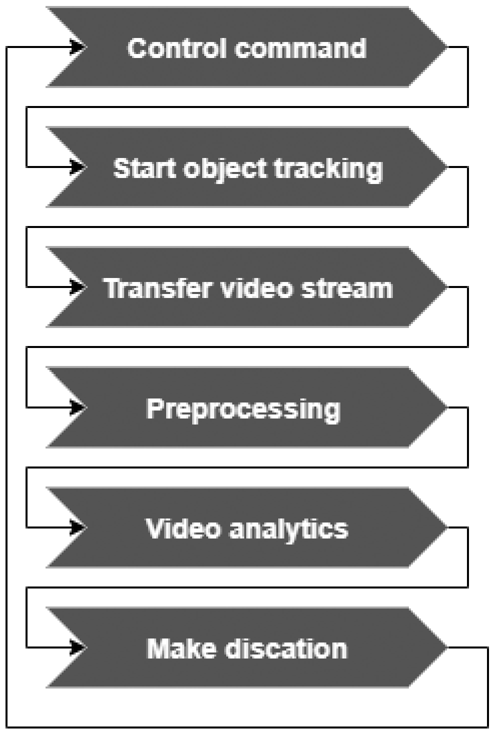

Figure 3. Decomposition of the object tracking task

Object tracking by end devices, object tracking functionality, and pre-domain domain analysis require a large amount of energy (up to 75%), which significantly reduces flight time without recharging. Cognitive programs are often very demanding on computing power, which complicates their work on embedded computers, which have low-power, light, small design requirements. For example, state-of-the-art machine learning models for image classification, such as ResNet [5], require gigaflops to process a single image.

To calculate these models in real time requires a lot of ALU (Arithmetic Logic Unit) in the processor, which increases the size of the chip, and thus increases the heatsinks and larger, heavier devices, which increases the takeoff weight of drones and reduces their flight time. Analysis of the functionality and requirements of the proposed solution shows that the operational load can be reduced by controlling the number of analyzed frames of the video stream, for tasks where the dynamics of changes in the state of the system is slow.

A comparative scheme of the use of energy resources on end devices when using different algorithms for visual tracking of objects on end devices, which negatively affects the efficiency of the drone is shown in Fig. 4. It shows that the most efficient in terms of energy costs, works out the HOG algorithm, in addition, this algorithm demonstrates the best adaptation of energy costs in relation to the number of frames of the video stream. In turn, the YOLO and F-RCNN algorithms not only require much more energy for analysis, but also demonstrate a negative cost response by reducing the percentage of analyzed flow frames.Based on the analysis of energy costs, we exclude the use of the two slowest algorithms, and for the algorithms HOG and HaaR, it is necessary to conduct a performance analysis on the indicator of the time of analysis.

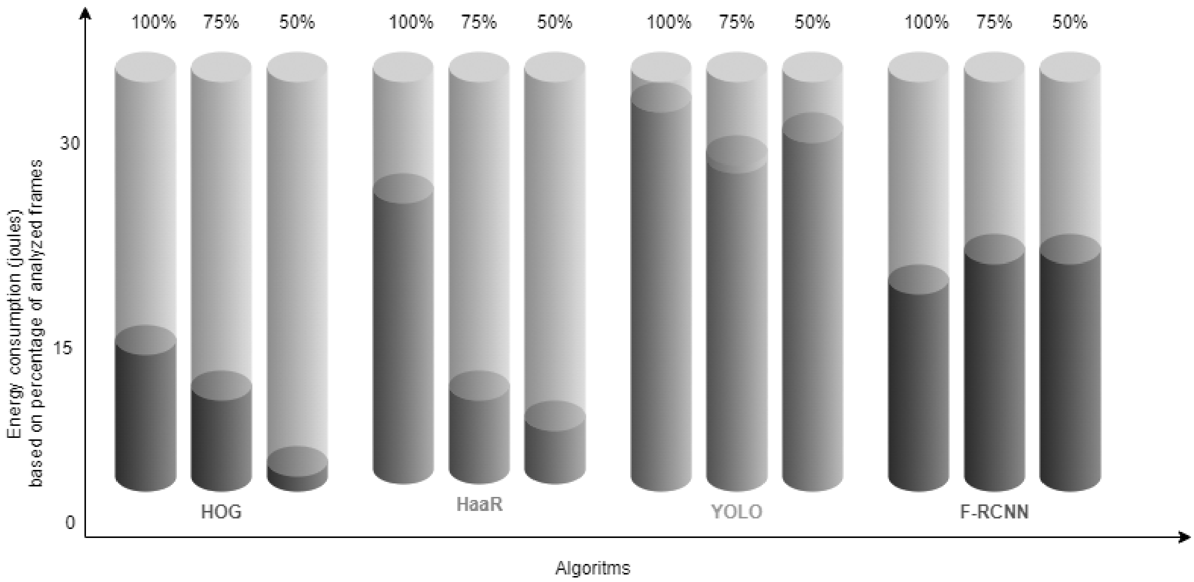

Figure 4. Distribute performance while you follow
Follow the Leader on a high-performance computer

Development of an alternative architecture for end devices

The task of increasing the effective time of use of the drone and reducing energy consumption for the analysis of sensor data, adds the need to improve the architecture.

The solution is to unload most of the "hard" work - data collection, analysis and response - on end devices in the cloud.

One alternative approach is to use a “cloud of sensor” architecture to provide parallelization (delimitation / unbalance). In the sensor-cloud system, computational-volume tasks are loaded into the cloud, while data collection tasks are performed at the boundary of the IP architecture.

With greater energy efficiency, the drone will be extremely fast, can focus on the monitored object and perform the received control signals. The “Follow the Leader” approach is proposed, where the end device detects and tracks a moving human target in real time. The drone used in this system must be able to follow human targets, whether it is recording a fast-moving athlete's video or simply tracking a moving domain object. To detect targets, the proposed algorithm runs the functionality of detecting objects in images taken from drone cameras.

The drone then flies along a horizontal plane, centering its target in the middle of the drone's field of view. The decision-making node has strict requirements in real time, because it must receive, analyze and respond to sensory data quickly enough to avoid leaving its moving targets out of sight. The analysis of two approaches proves the expediency of using the “sensor cloud” approach based on the IoT architecture, which demonstrates fig. 3 guided by energy requirements.

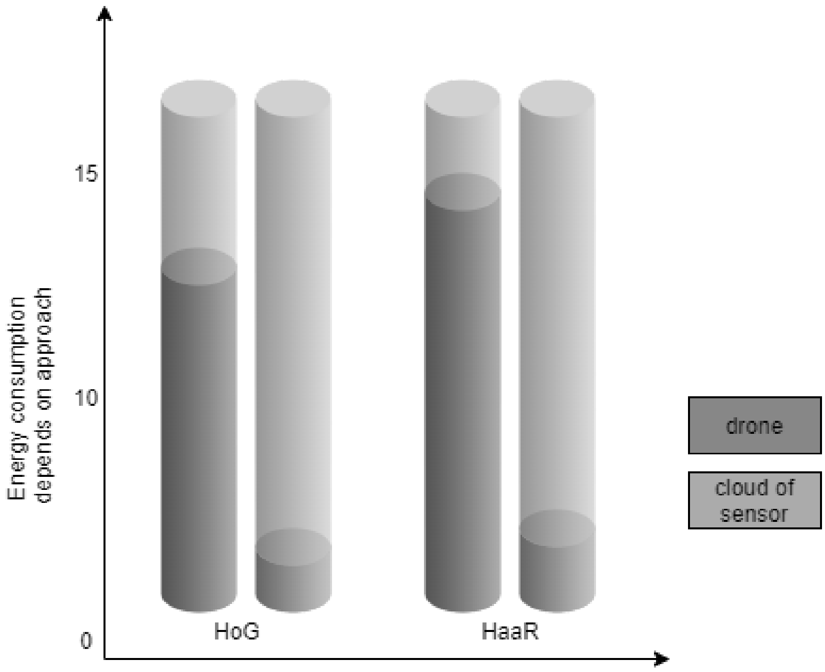

Figure 5. Energy consumption for data processing when performing calculations by drone and IoT architecture

Conclusions

The proposed approach to reducing the time spent by users for video logging of active actions, through the use of IoT architecture by synchronizing flight paths, recharging cycles and automated execution of programmed scenarios, demonstrates the feasibility of using the approach. As a result, the time spent by the end user of the system is reduced to the response time to non-standard scenarios and information monitoring.

The analysis of the feasibility of using the IoT architecture shows the advantages of using the proposed approach, and the analysis of energy consumption requirements for solving data analysis problems is solved using the "sensor cloud" approach, which demonstrates reduced energy consumption on end devices and increases continuous video logging time. In addition, the analysis allowed us to exclude the most expensive algorithms for video stream analysis.

The next step of the study will be to analyze the performance of the system with the selected architectural approach, as well as security requirements, which will be considered in the next work.

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