UDC 004.042

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REAL-TIME VIDEO STREAM ANALYSIS BASED ON AZURE SERVERLESS SERVICES

Abstract: An analysis of existing architectural solutions was carried out, taking into account the principle of cold/hot analysis of video streams based on various services. The obtained results made it possible to choose an architectural approach based on services[1], which allows for obtaining additional information about the state of the environment where the swarm executes the flight plan. The principle of modularity, optionality and the possibility of stopping the video flow analysis module without affecting the control module was implemented, which made it possible to increase the flexibility of the system's economic efficiency.

The implemented mechanism of selective filtering of frames of video streams allows to reduce the load on the communication channel by 4 times, and the two-circuit approach to the analysis of the video stream allows for obtaining analysis data faster when using surface analysis and carrying out resource-intensive (in terms of time) analysis operations on the second circuit.

Key words: IoT, video, frame, stream, analysis, hot/cold analysis

Introduction

The tasks of recognition, search, and identification in the modern world are increasingly becoming more relevant. Especially when it comes to object recognition based on a video stream in real time. For example, the task of recognizing a person's face on various modern devices, recognizing license plates, and automatically detecting offenders already works in real life.

A drone swarm control system without video stream analysis is static and can only execute pre-programmed flight scenarios, which makes it vulnerable to changes, such as the position of objects in the outside world where the swarm is executing the scenario. The analysis of video stream data from each drone will allow it not only to adjust its position more and avoid collisions but also to implement flexible flight scenarios, for example, object tracking functions, gesture control functions, or the "shadow" function, in which agents repeat the behavior " leader".

The video stream analysis operation is resource-intensive and not sufficiently formalized, that is, the information resulting from the analysis is not unambiguous and can only be used as an auxiliary instrument for influencing the behavior of the swarm (command system). For the swarm control system, the control signals have the highest priority, therefore, the video analytics module should not affect the speed of the system.

Problem statement

Consider and propose architectural approaches and software methods that will allow obtaining additional data from the video stream of a drone performing a flight plan[1] in a swarm by analyzing the video stream in real-time and under variable load conditions on the video analytics system. The video analysis module should not adversely affect the swarm management system. The applied task of video analytics: find a face in a frame and notify if the face is classified (we will use a prepared trained classifier or Azure FaceId Service)[3].

Solving the tasks

Let's outline the architectural scheme of system services, for which it is necessary to develop algorithms for the analysis of video data:

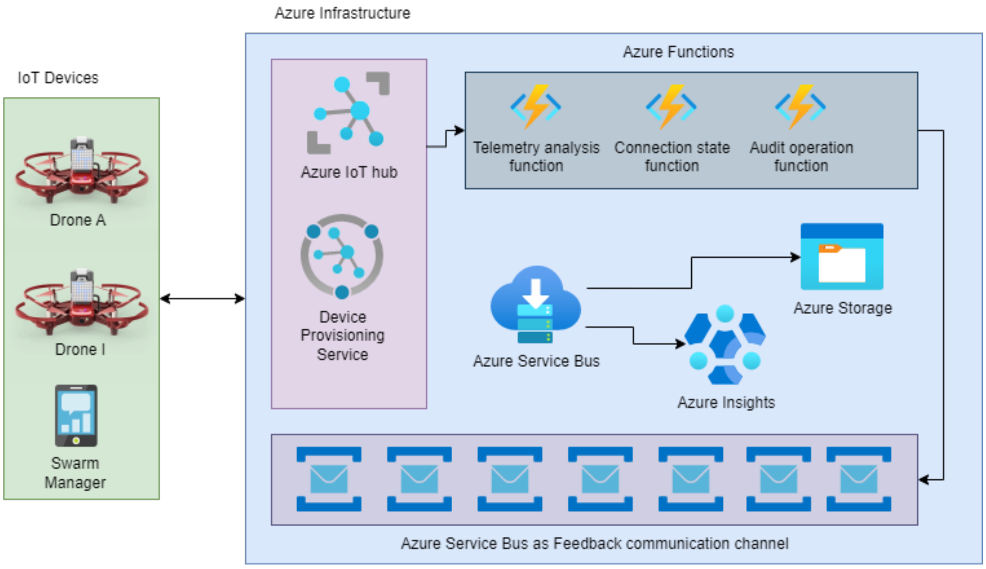

Figure 1. Agent management system architecture

The set of IoT devices is created by two drones (Fig. 1) and the software implementation of the swarm operator. The software interface of drones is described by 3 functionalities:

1. Responding to commands from Swarm Manager
2. Transmission of telemetry data with a given discreteness to IoT
3. Transmission of the video stream to IoT for analysis and influence on the behavior of the system through the feedback channel

Telemetry data, including notification of a change in connection status, is sent by each drone and analyzed by serverless functions, implementing a mechanism for synchronizing agents in the swarm. In addition, the data is written to the storage by a separate serverless function, for the purpose of auditing the statistics of command execution.

ISSN 1560-8956

The Azure Service Bus[5] service is used as a transport channel for auditing data passing through the system[1]. Also, this service is used to implement swarm control feedback, the signal of which is displayed by the software implementation of the swarm operator (Swarm Manager).

Taking into account the requirements to reduce data traffic in the system, we will propose the separation of video data transmission according to the scenario of hot and cold analysis (Fig. 2).

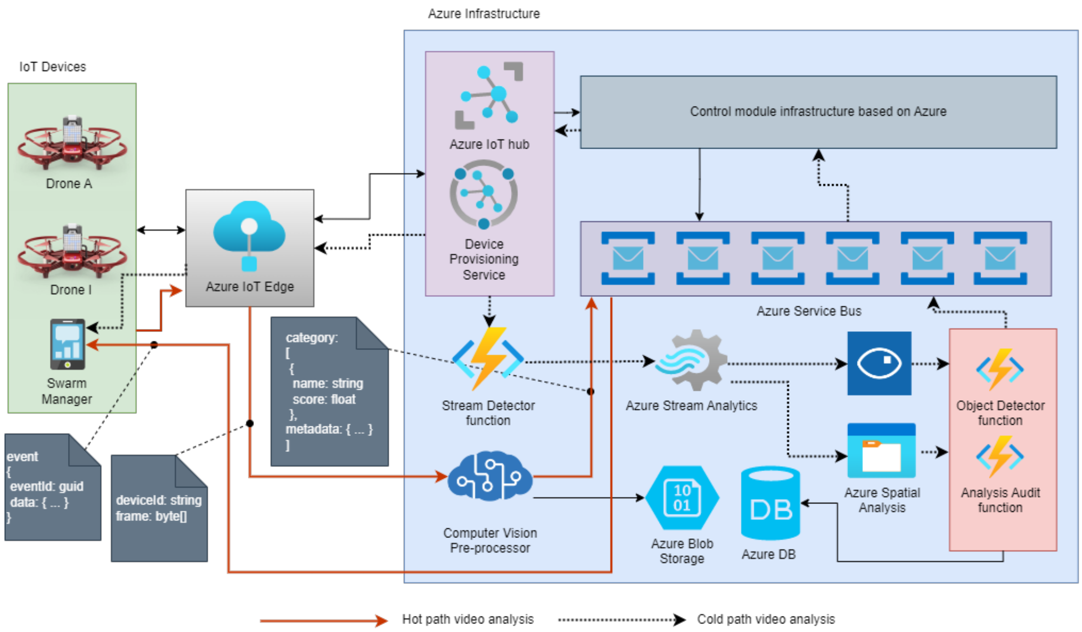

Figure 2. Architectural diagram of video analysis system integration

The constructed architecture shown in fig. 2, is completely placed in the cloud, and the integration of the services of the video analysis module does not affect the speed of the control module shown in fig. 1, as it is completely isolated and uses only the message broker bus (Azure Service Bus)[7] for communication. For the flexibility of managing the economic cost of the architecture, all services of the video analysis module are created in a separate project branch, that is, the module can be completely disabled without a negative effect on the control system.

The system is implemented using a hot/cold analysis approach to meet the requirement of reducing traffic in the system. For this, the intermediate analytical engine Azure IoT Edge was used between the end devices and the IoT hub. Physical is a custom application that acts as a proxy for traffic coming from end devices to the hub. Its purpose is to detect incoming video streams from end devices, process them and transfer filtered data to the IoT hub. Our implementation of the service (IoT Edge service)[5] reacts to the registration of the flow from the drone by sending a signal to the hub, and receiving a set of frames (24/s), sending every 12 frames through the tagging service API, and every 6 frames to the hub. Every 12th frame is analyzed by a tagging service trained in advance and sends detected tags through a message broker, which is received and displayed by the swarm operator client. So, we reduced the traffic passing through the hub by 4 times and got a very fast video content tagging system.

The path of cold analysis of streaming video data begins with a signal about the registration of a new incoming stream. The serverless function[1] subscribes to the signal to the hub, and in case of receiving the signal, starts the analytics unit (Stream Analytic Job). The task of this unit is to create a channel and ensure data transmission (every 6 frames from each drone) from the hub to two services: the object recognition service (Computer Vision) and the user analysis module (Azure Spatial Analytics)[3]. The results of these services are responded to by corresponding server functions, which publish the results of the analysis through a message broker. Now, the control module can subscribe to the analysis results and use them in its logic.

Conclusions

The control system of a swarm of drones without the use of video sensor data is limited and can only perform pre-described flight scenarios and without taking into account the dynamic change in the state of objects in the outside world where the swarm executes the flight plan. Expanding the analytical capabilities of the system by analyzing the video stream data of each agent will allow implementing of flexible swarm flight scenarios, for example, the scenario of tracking the operator and following the swarm or clarifying the mutual positions of the agents in space to avoid collisions based on the results of the video stream analysis.

The implemented architecture is built taking into account the principle of cold/hot analysis based on Azure services[6]. The video stream analysis module is designed with the principles of modularity and optionality in mind and can be stopped without affecting the control module, which increases the flexibility of the economic efficiency of the system.

Using the IoT Edge service reduced the volume of traffic passing through the hub by selectively filtering frames of video streams by 4 times. The next step of the research will be the investigation of existing ready-made solutions for a wider analysis of video streams, which can provide an opportunity to predict and correct the trajectory based on video data from each drone.

REFERENCES

1. I. Akhaladze. Improving the efficiency of streaming video processing through the use of serverless technologies. 2021. № 39. C.32-40 URL: http://asac.kpi.ua/article/view/247393

https://doi.org/10.20535/1560-8956.39.2021.247393

2. I. Akhaladze. Use of serverless functions in the algorithm for calculating the target point of the trajectory under dynamic loading. 2022. № 40. C.34-38 URL: http://asac.kpi.ua/article/view/261531 https://doi.org/10.20535/1560-8956.40.2022.261531

ISSN 1560-8956

3. Clint B. (2019)Will serverless computing be the future of cloud computing. Computer world, 2019-03-25(005).

4. Brandon B. (2017)Serverless Computing: Next Generation Cloud Infrastructure. Computer world, 2017-05-15(003).

5. Carter G. (2018) Serverless Architecture. Mechanical Industry Press. Beijing.

6. Su J., Tian J.B. (2019) Microservice Architecture of Web Application in Cloud Environment. Electronic Technology and Software Engineering, (15):131-132.

7. Lingming Xia. (2018)Deep understanding of serverless architecture. https://blog.csdn.net/xialingming/article/details/81369624.