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A. Akhaladze, O. Lisovychenko, N. Bogdanova

APPLICATION OF ARTIFICIAL INTELLIGENCE MODELS TO SOLVE THE PROBLEM OF LOSS OF CONTROL OVER THE DRONE

Abstract. This article considers an approach to solving the problem of losing control over a swarm of drones when the connection with the IoT infrastructure is lost. The use of artificial intelligence models of Azure Cognitive Service was proposed to search and classify the command by the operator when creating a duplicate control system.

The designed control system has the possibility of deployment on each drone before the execution of the flight plan, maintenance of performance in conditions of lack of communication with the IoT infrastructure in the presence of only visual contact with the operator.

Key words: Drone Control, Azure, Azure IoT Hub Edge

Introduction

The drone swarm control system based on the IoT (Internet of Things) architecture works satisfactorily when executing deterministic flight plans, that is, when each subsequent target point of the trajectory is predetermined and serves as a point of synchronization of the swarm members[1].

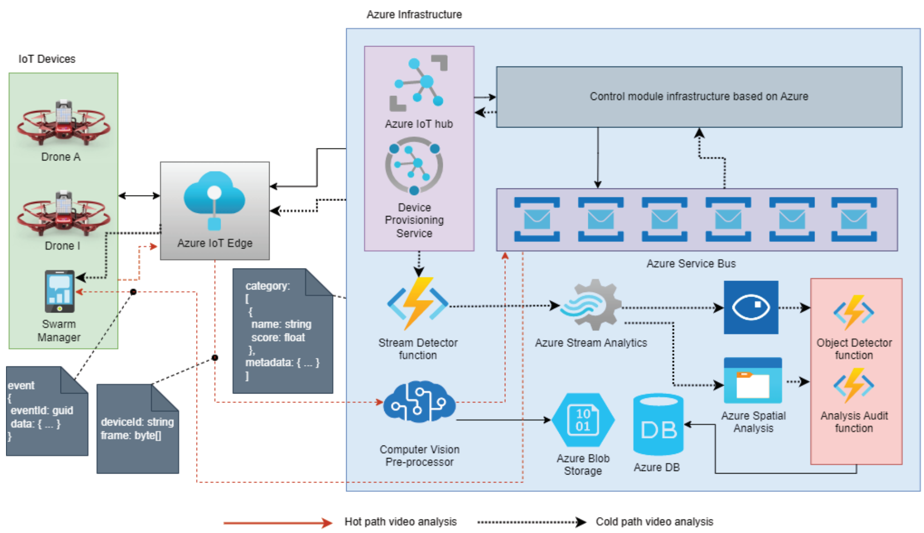

Fig. 1. Block diagram of drone swarm control using Azure IoT Hub

The swarm manager sends a command to execute the flight plan, which is sent to the Control module using Azure IoT Hub and then sent to each member of the swarm.

Structural and architectural schemes of drone control using the following technologies and tools Azure, DJI, .net are discussed in detail in previous publications [1,2,11,12].

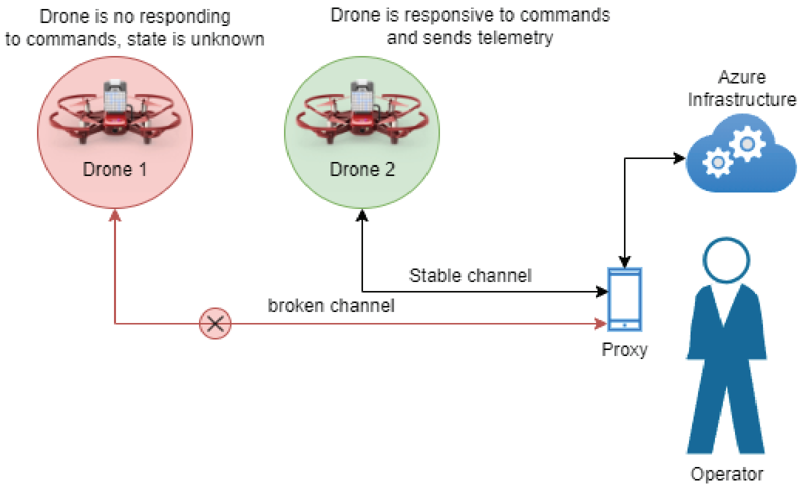

Fig. 2. Structural diagram of communication breakdown with the drone and the control hub

That is, in the case of a temporary disconnection with the IoT infrastructure, the drones will execute the last received instruction, and then wait for the next one. The longest possible waiting time is equal to the longest working time of a swarm member. This creates a risk of losing the drone in adverse conditions (gusts of wind). There is a need to build a duplicative swarm management system.

Problem statement

To solve the problem of maintaining control over the drone in the swarm control system in conditions of loss of communication with the IoT hub while maintaining the following functionality:

1. Visual operator search
2. Search for the operator's gesture when there is no connection with the IoT hub

The designed redundant control system must be deployed on each drone (isolated) before the flight plan is executed, and work in conditions of no communication with the IoT infrastructure and only visual contact with the operator.

Solving the tasks

Operator gesture recognition as a duplicative control system

The control system for two drones and a swarm based on Azure IoT hub works under conditions of a stable high-speed connection with the IoT infrastructure, but the system has a situation of disconnection or instability of the connection with the IoT infrastructure, as a result of which each member of the swarm goes into standby mode.

To solve the problem of restoring control over the swarm, we will build a duplicate control system based on visual gesture recognition technologies. Let's define the following algorithm of actions of the duplicating system.

For the structure of the redundant control system, we will use ready-made ANN training (Azure Custom Vision Service), as shown in Figure 3. The selected model is supplied as SaaS and has a closed implementation, including the model topology and training methods. It can also be deployed on each drone based on Azure IoT Edge and Azure Custom Vision Service.

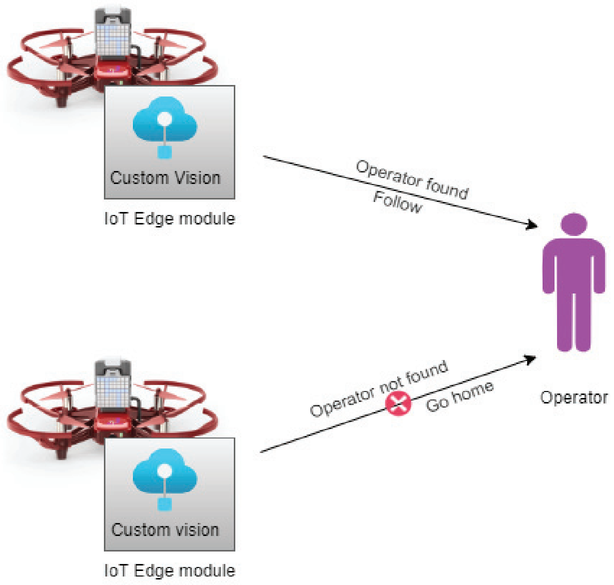

Fig. 3. Schematic diagram of swarm members with the Custom Vision module deployed

In this study, the model was used as a "black box" and allows for face identification and gesture recognition. A set of images taken from open sources were used as training images.

Having the ability to recognize the face and gestures of the operator, we will build a set of instructions that allow us to restore control over the swarm in the event of a disconnection with the IoT infrastructure [2]. The instruction set is deployed before the flight plan is executed and must be reviewed before each drone is launched (problems and solutions will be addressed and proposed in future posts).

Figure 4 shows the deployment diagram of the gesture recognition module and includes the necessary infrastructure for deployment. The model used not only offers the advantages of speed in recognition and is compatible with the DJI Mini 3 Pro drone used in development.

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Based on Azure Custom Service, we retrain the model using 3 images of the gesture corresponding to the "return home" command and a trained dataset for frame gesture recognition. The ready-to-use model is deployed as an Azure IoT Module together with a Camera Capture Module that contains the implementation of a 3-level instruction set on each drone. That is, when the connection with the Azure IoT Hub infrastructure is broken, the Camera Capture Module is launched and the execution of a 3-level set of instructions is started on each drone in isolation.

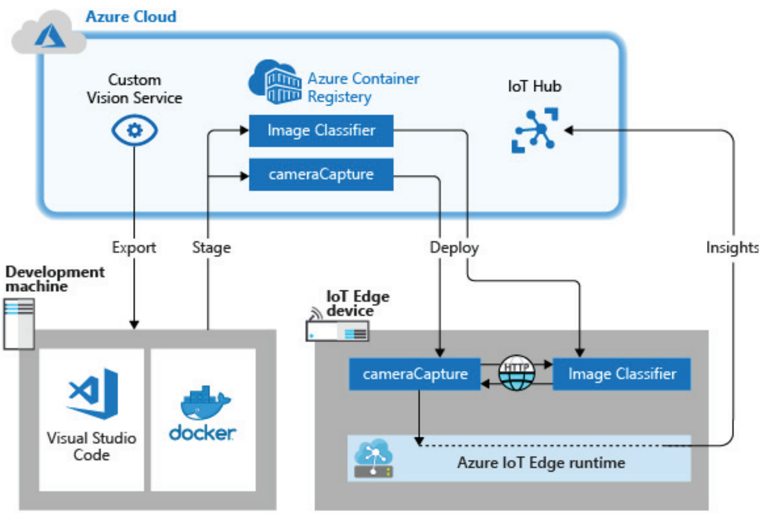

Fig. 4. Deployment scheme of the gesture recognition module

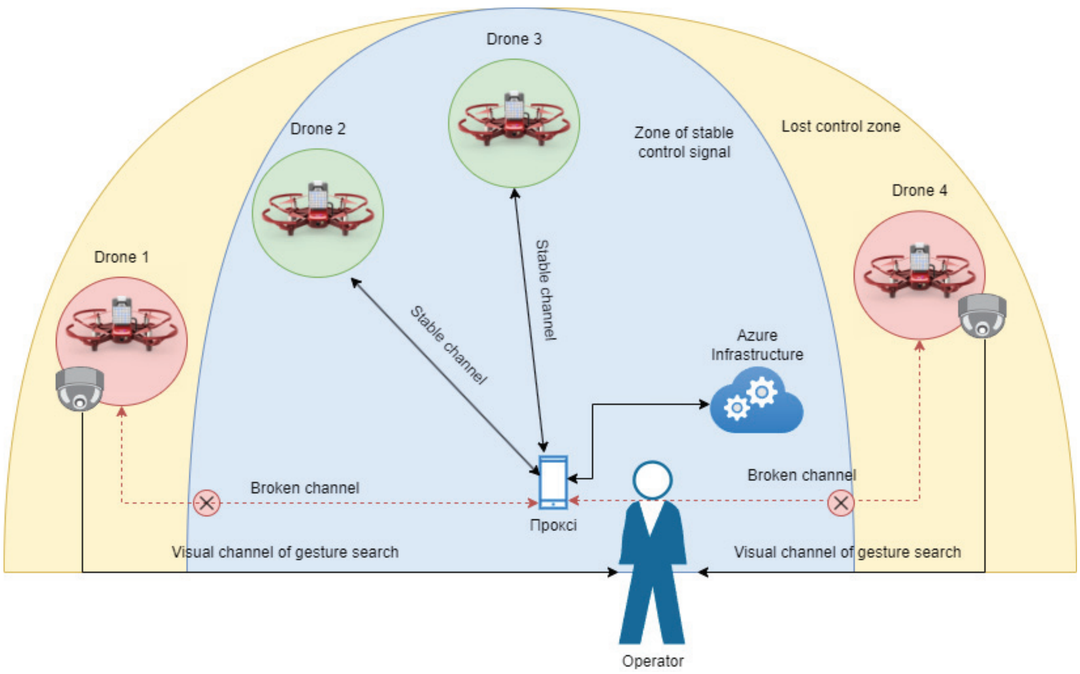

Fig. 5. Schematic representation of the visual communication channel

The Custom Vision service uses a machine learning algorithm to analyze images. You submit sets of images that do and do not have the visual characteristics you are looking for. The image is then tagged with its own tags during submission. The algorithm trains on this data and calculates its own accuracy by testing itself on the same images. After training a model, you can test it, retrain it, and eventually use it in your image recognition application for image classification or object detection. You can also export the model for offline use.

The logic of the gesture search algorithm and the reaction to a positive result are shown in Figure 6.

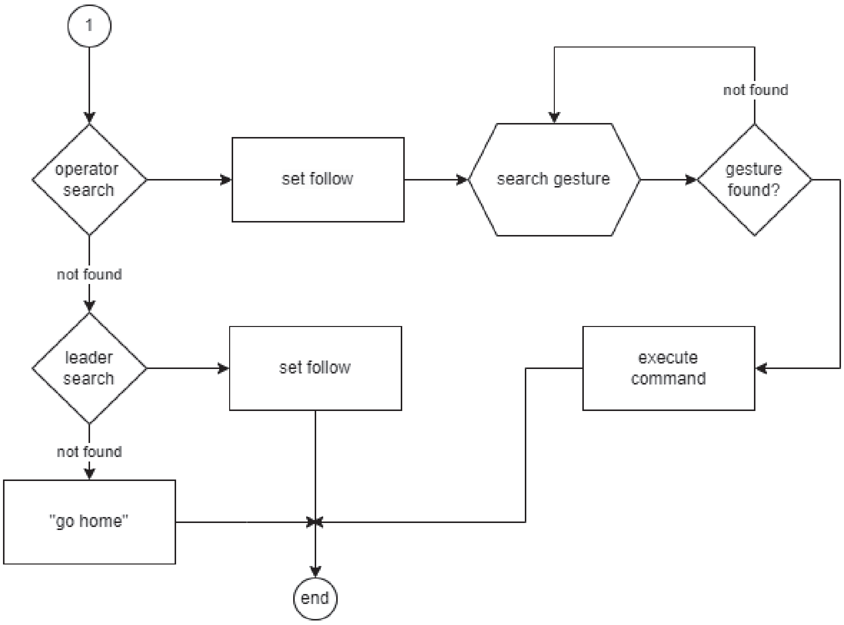

Fig. 6. Logical diagram of the recognition system algorithm

When the communication channel of the swarm member with the control system is broken, the operator search algorithm is started, as shown in Figure 6. When the result of the operator search is positive, the system starts to transmit the image from the camera to the IoT Edge Module, which is able to perform image classification very quickly. As soon as the classifier returns a positive result, that is, the gesture is found, the pre-programmed landing scenario is executed. This allows you to save the drone from hanging in an uncertain state or losing it.

Conclusions

Modern drone remote control systems use cloud technologies to exchange data between drones and the operator. However, in case of loss of communication with the cloud, the drones lose the ability to receive commands and send data. This can lead to a crash, or a swarm hang, where the swarm has no communication with the Azure IoT Hub and cannot complete the flight task.

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To solve the problem of restoring control over the swarm, a duplicate control system based on visual gesture recognition technologies was built. As shown in Figure 5, drones that enter a weak signal area maintain controllability using visual channel data and a simple classification model as a trigger to execute a landing command.

The integration of an artificial neural network as an IoT Edge module into the control system of each drone made it possible to recognize two types of objects (operator, operator gesture), which allows to restore control over the swarm for safe management and preservation of the integrity of the swarm members when the communication channel is broken. Azure IoT Hub infrastructure.

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