Autonomous drone swarm of the AVADER Student Research Group

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INTRODUCTION:
In today's world, the technology of "Unmanned Aerial Vehicles" (UAV), commonly known as "drones", is becoming increasingly important, serving not only as a tool in various commercial applications but also as a subject of advanced scientific research. Autonomous control systems, which enable drones to move and carry out tasks without human intervention, are one of the key challenges scientists are facing. Our proposed project involves building a cooperating group of drones, called a swarm, and the development and implementation of innovative algorithms for image processing and event data.

METHODOLOGY:
The methodology of the presented project includes the processes of designing, constructing, and implementing algorithms necessary to build a swarm of autonomous drones capable of cooperating in various applications. The project focuses on full autonomy of the system, i.e. control based on data from its own sensors, without dependence on external signals.
The primary step is the purchase of 3 to 5 sets to build autonomous drones according to the specification described in the UZH/ETH Zurich team's work. The construction is to include the Jetson Orin computing platform and the Intel RealSense D435 depth camera. Additionally, the purchase of two SoC FPGA systems is planned, allowing mounting on drones, considering the requirements for size and sensor connection interfaces.
In the area of algorithms, the project includes the development and implementation of techniques capable of analyzing and interpreting data in real-time, including SLAM technology, automatic obstacle avoidance, and trajectory generation using reinforcement learning. An essential element is also the development of control methods based on data from embedded sensors (e.g. cameras, IMU), ensuring independence from external signals such as GPS.
An important aspect is the development and implementation of appropriate communication protocols and mechanisms, enabling cooperation between flying units in the swarm. These drones are to be used in various applications, such as land inspection, building map generation, or the transportation of heavier loads.
The testing and validation phases assume the use of a special drone arena to test algorithms in controlled conditions, regardless of weather conditions. Cooperation with research centers and the Embedded Vision Systems Team at the Department of Automation and Robotics at the Faculty of Electrical Engineering, Automatics, Computer Science, and Biomedical Engineering is also planned, enabling precise testing and validation of the system.

RESULTS:
Currently, the project is in the crucial phase of purchasing the necessary components. All components for building autonomous drones are carefully selected to meet the high requirements set by the project team. The purchase includes 4 sets containing the Jetson Orin computing platform and the Intel RealSense D435i depth camera, in line with the specification described in the UZH/ETH Zurich team's work. Among the additional steps,, SpeedyBee F405 flight controllers, KV2500 engines, 7-inch frames, and 1550 mAH 22.2V 6S batteries were purchased. The remaining components will be manufactured using 3D printing technology.
At the same time, in the background of these activities, a second, equally important project is being developed – a motion-capture system. This system will be used to precisely track the drones' movements in real time, which is crucial for the correct operation and coordination of the entire swarm. The intention is to integrate this system into the main project, which will allow for even more precise data analysis and enable better testing and validation of algorithms.
In addition, the AVADER Student Research Group continues to work closely with the Embedded Vision Systems Team. Many of the people involved in the project are former or current members of the Circle, and their experience and knowledge are invaluable in the context of delivering such an ambitious project.

DISCUSSION:
An important aspect to highlight in the context of this project is the approach to drone construction. Choosing to design and build the drones ourselves, rather than purchasing off-the-shelf units, allows for considerable customisation for specific research and operational purposes. For example, the team has complete freedom in the choice of cameras and, in the future, they can be replaced by event cameras, which can open up new possibilities in image processing and drone control.
Additionally, building identical drones to the same specifications and standards provides inestimable value to the project. Unifying the design allows for faster and more consistent integration of the drone swarm system. Each drone will operate consistently with the others, facilitating coordination and enabling the entire system to operate more efficiently. Integration with the parallel motion-capture project under development is also an important part of the discussion. This system will not only be a research tool, but also a practical solution to support the operation of the drone swarm. Its use could affect the precision, efficiency, and reliability of the entire system.

SUMMARY:
The project, being at the stage of transitioning from the purchasing phase to the assembly phase, presents a unique approach to drone swarm design and integration. This not only gives the team flexibility and control over key components of the system, but also creates opportunities for further development and innovation. This strategy could prove to be a valuable contribution to the field of autonomous unmanned aerial vehicles, both nationally and internationally.

Figure 1. Intel realsense d435i camera.

Figure 2. Protective cage with mocap system.

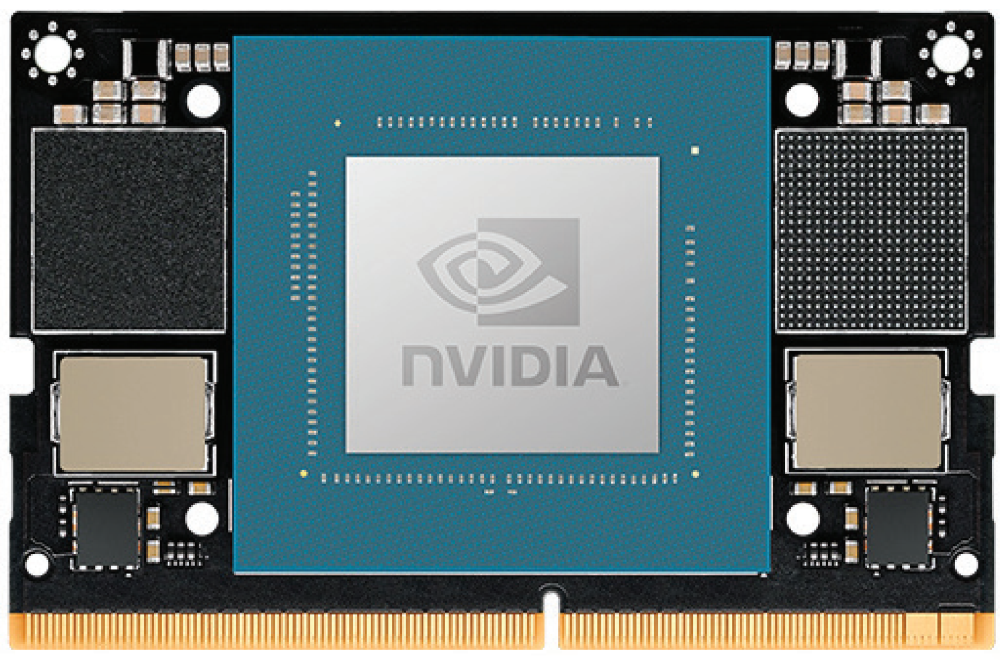

Figure 3. Protective cage with mocap system.

Figure 4. Jetson Orin computing platform.

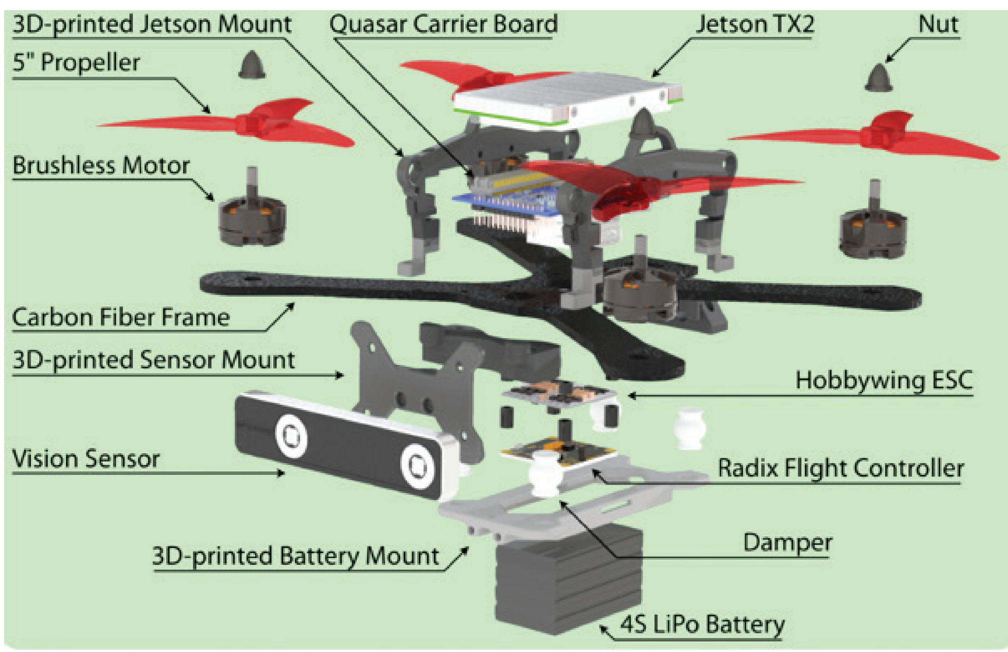

Figure 5. Schematic of the drone being built.