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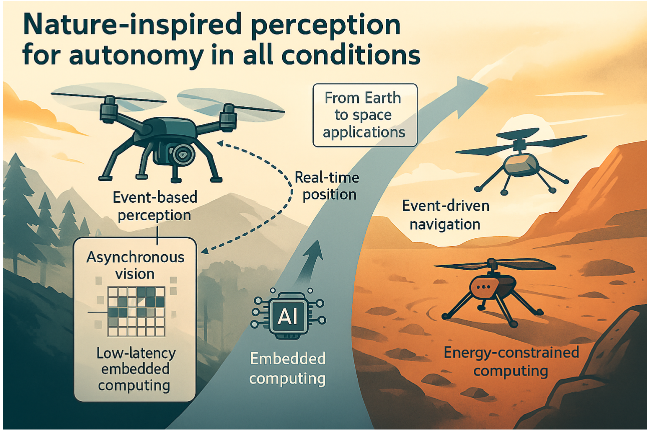
EEVONN: Embedded Event-Based Visual Odometry Using Neural Networks



Navigation and exploration of unknown environments are fields that have gained significant importance in recent years, both in scientific research and industrial applications. One of the most promising technologies in this area is unmanned aerial vehicles (UAVs), commonly known as drones. Thanks to their mobility and ability to operate in hard-to-reach places – such as building interiors, forested areas, tunnels, hazardous zones, and even hostile terrain in outer space – drones are becoming indispensable tools in many fields: from infrastructure inspection and rescue operations to environmental monitoring and planetary exploration.

For a drone to operate autonomously and safely, it must be equipped with systems that allow it to determine its position and surroundings – in real time and with high precision. Traditional solutions typically rely on cameras that capture images in the form of video frames. Although this technology is well known and widely used, it has significant limitations: in high-motion scenes, it leads to motion blur, and in challenging lighting conditions, it results in the loss of important details. Additionally, processing such data streams requires considerable computational power and energy, which is a major constraint for onboard systems, where both weight and battery capacity are strictly limited.

To address these challenges, the aim of the proposed project is to develop innovative perception and navigation methods using modern event-based cameras and energy-efficient SoC FPGA (System-on-Chip Field-Programmable Gate Array) computing platforms, which combine conventional processors (CPU) with reconfigurable logic. Event cameras are vision sensors inspired by the human visual system – instead of capturing the entire scene at regular time intervals, they send information only when an actual change occurs in the image, such as an edge shift or the appearance of a new object. This allows for the delivery of highly precise, dynamic data at significantly reduced energy consumption.

The project will involve designing algorithms that convert data from event cameras into information about the drone's position and trajectory – enabling it to determine its movement and location based on dynamic changes in the observed scene. The research will include both the development of data analysis methods (using deep neural networks) and their implementation on embedded platforms. A key focus will be to adapt the developed solutions to the capabilities of the hardware, ensuring that they operate quickly, accurately, and with low power consumption.

As a final outcome, the project will deliver a demonstrator – a drone equipped with an event camera and a SoC FPGA module – capable of navigating unknown environments autonomously, without relying on external localization systems (such as GPS). In the future, such solutions could be applied in rescue, inspection, military, and exploratory missions, as well as in space exploration – for example, in autonomous navigation of flying or walking vehicles in low-gravity conditions on the Moon or Mars, where satellite signal access is impossible. Particularly crucial here is the ability to process data locally with low energy consumption – one of the key requirements for deploying such technology in space. This work will also provide a better understanding of the strengths and weaknesses of various model simplification methods for event data processing, which will prove valuable in designing future, more efficient perception and navigation systems for autonomous drones – including those operating beyond Earth.