
Aerial Aid Delivery
to Disaster Regions
without GPS

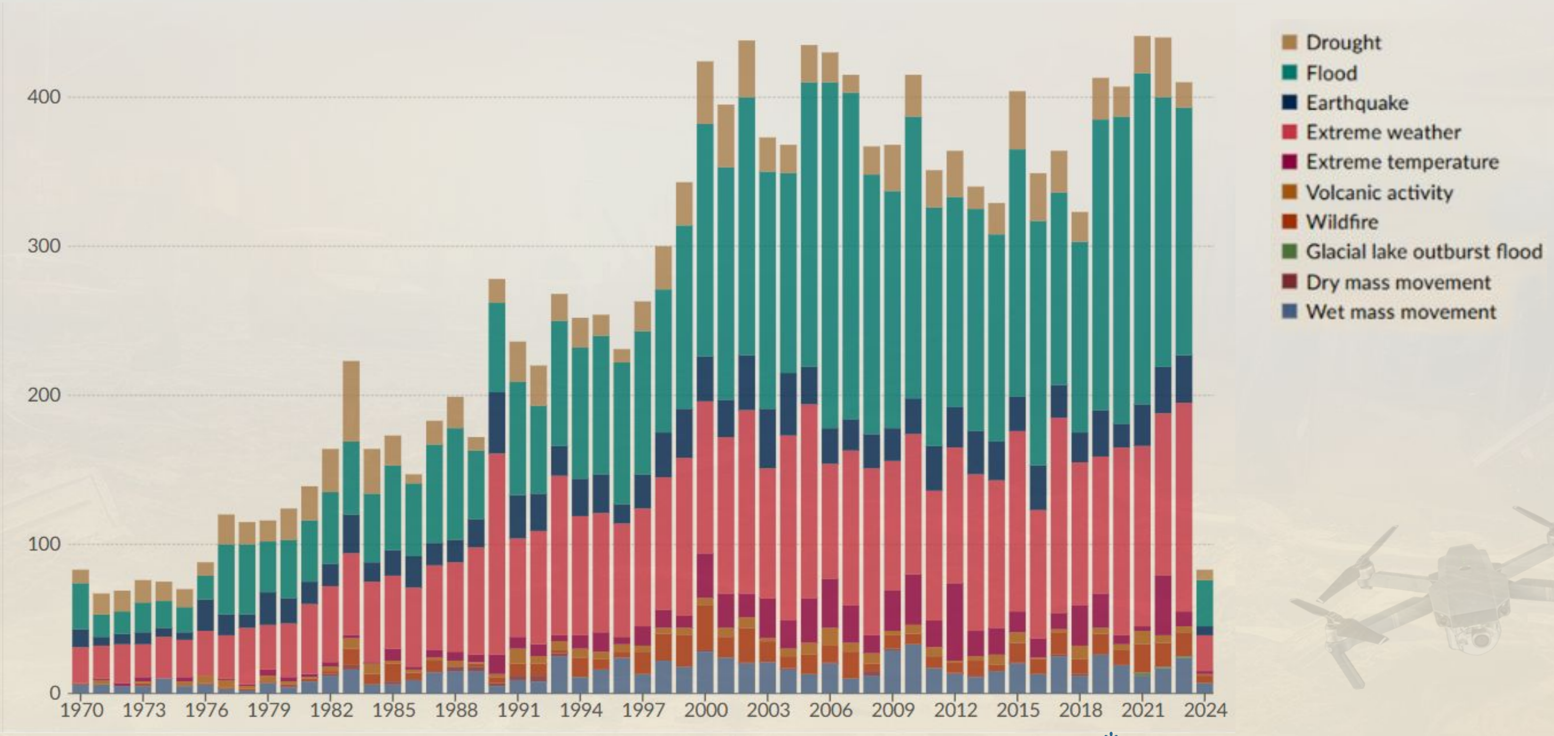
UAV Navigation Using Computer Vision

In times of natural disasters or humanitarian crises, quick and reliable access to remote or hazardous areas is essential. However, GPS navigation can be unreliable or entirely unavailable in these situations, posing significant challenges to aid delivery.

QuData is developing an innovative aerial aid delivery system to provide critical support to disaster-stricken regions with limited or no GPS access. Our technology guarantees precise navigation and positioning, enabling the delivery of essential aid to previously unreachable locations.

We strive to save lives, alleviate suffering, and assist in the rebuilding of affected regions.

Global Reported Natural Disasters by Type from 1970 to April 2024



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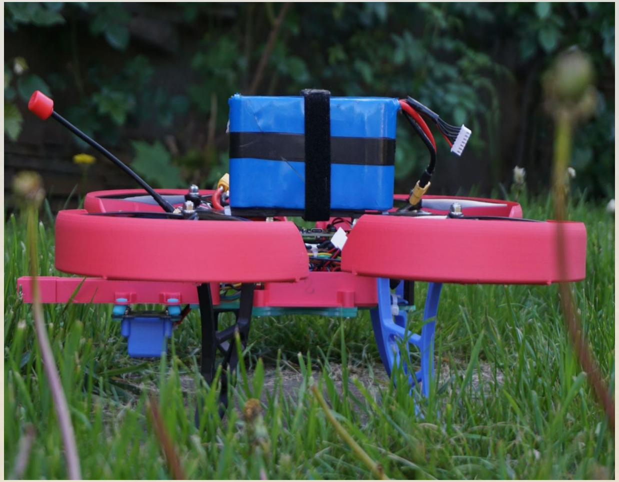
Project Description

An advanced hardware and software system for UAV navigation that utilizes camera to operate in GNSS-denied environments. This innovative solution is adaptable to both multi-copter and fixed-wing drones, ensuring versatile application across various industries.

Applications:

- **Stable Hovering**: enables relay drones to maintain a fixed position with precision.
- **Failsafe Return**: ensures UAVs automatically return to their starting point if communication with the operator is lost.
- **Targeted Navigation**: allows UAVs to accurately navigate to the specified coordinates, enhancing mission efficiency and reliability.



Applied Technology

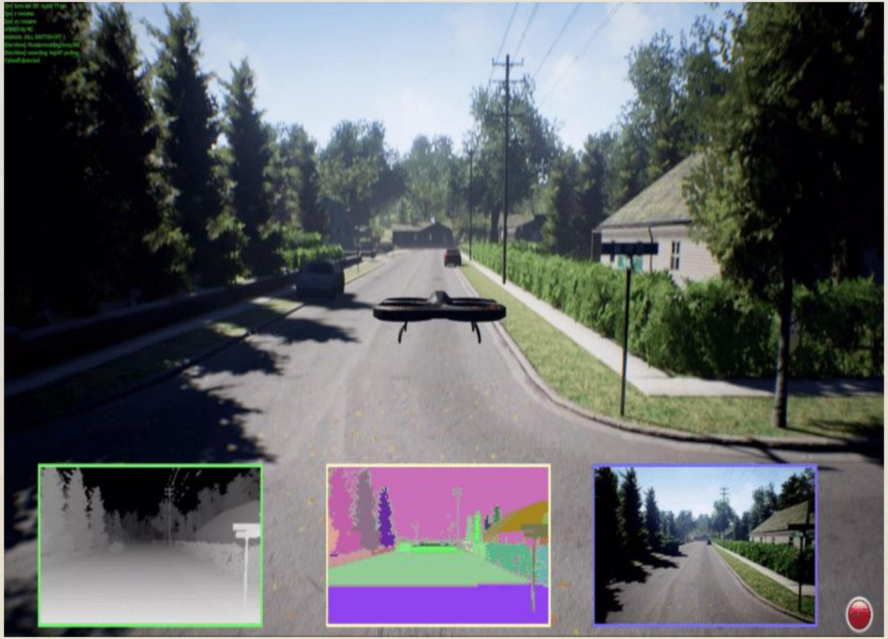
Computer Vision Algorithms: advanced computer vision algorithms analyze real-time video streams captured by onboard cameras, extracting crucial environmental features like landmarks, obstacles, and terrain texture essential for accurate navigation (Visual Odometry).

Sensor Fusion: our system integrates visual stream with data from various onboard sensors, including inertial measurement units (IMUs), barometers, magnetometers, and gyroscopes, enhancing navigation accuracy even in challenging conditions. Our navigation methods achieve a typical error of around 100m over a track of 10km.

Machine Learning: leveraging ML techniques, our system is also designed to extend the range of operations for long-distance flights, provided that real-world map data is available. To provide corrections to inertial navigation, the onboard map data is matched against the video stream received by the UAV camera.

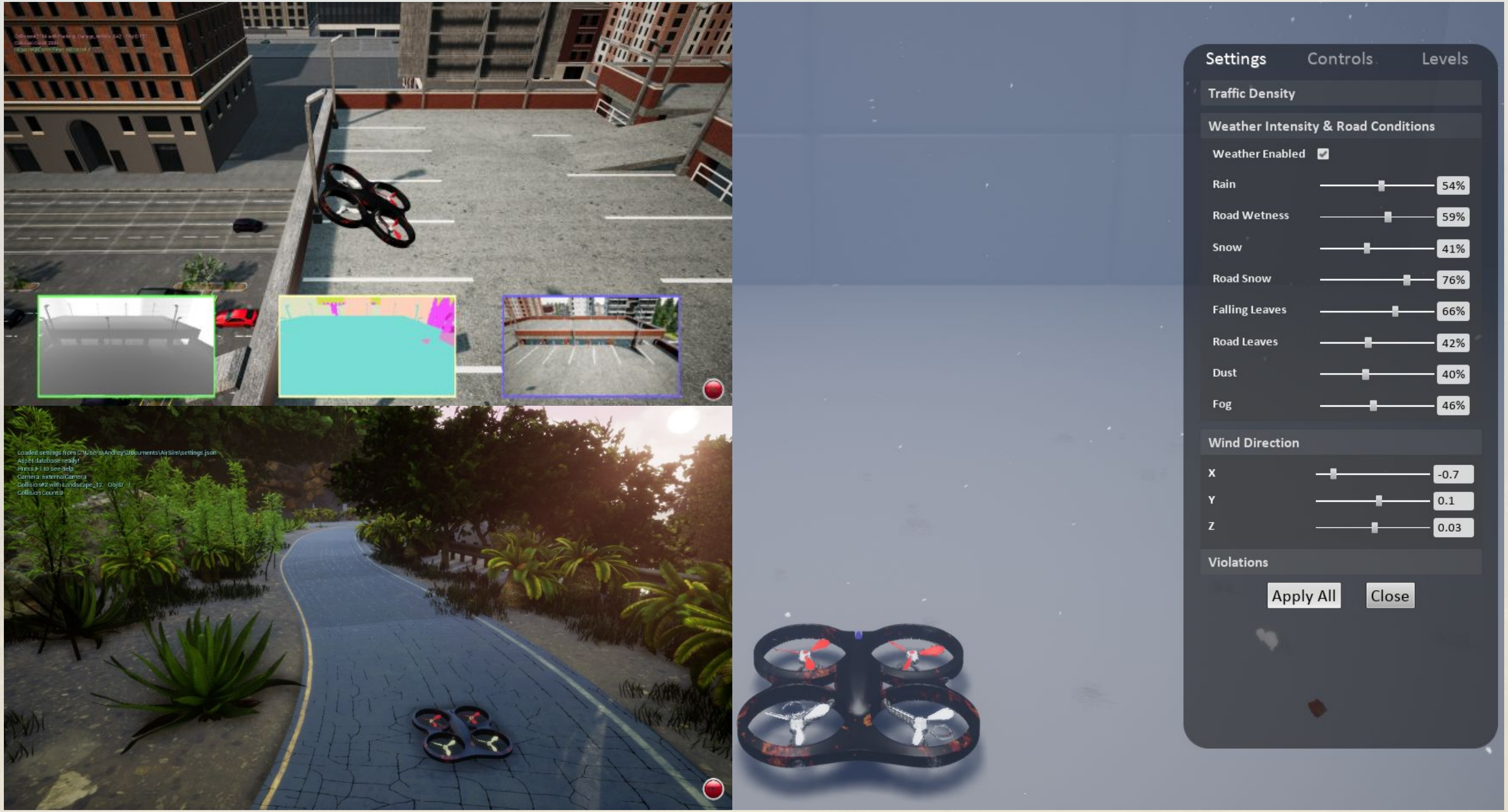
I. AirSim Simulator

We have developed a 3D location for the AirSim simulator and Unreal Engine. This environment is used for creating datasets and testing algorithms, providing a reliable platform for development and validation.



- Microsoft for DL, CV and RF
- Realistic physics
- Affordable sensor models:
  - IMU: MPU-6000
  - Barometer: MS5611
  - Magnetometer,
  - GPS, Lidar…
- Weather simulation
- Multiple camera support
- Compatibility with PX4 and Ardupilot

Changing Weather Conditions

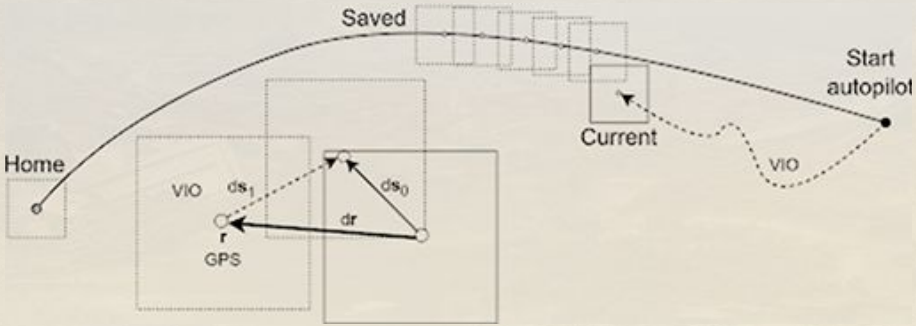


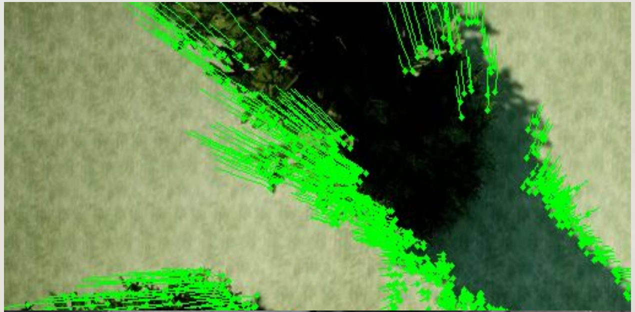
II. Visual Assessment Methods

1. State evaluation (speed, orientation, position)
   a. Optical flow analysis
   b. Visual-inertial odometry (VIO)

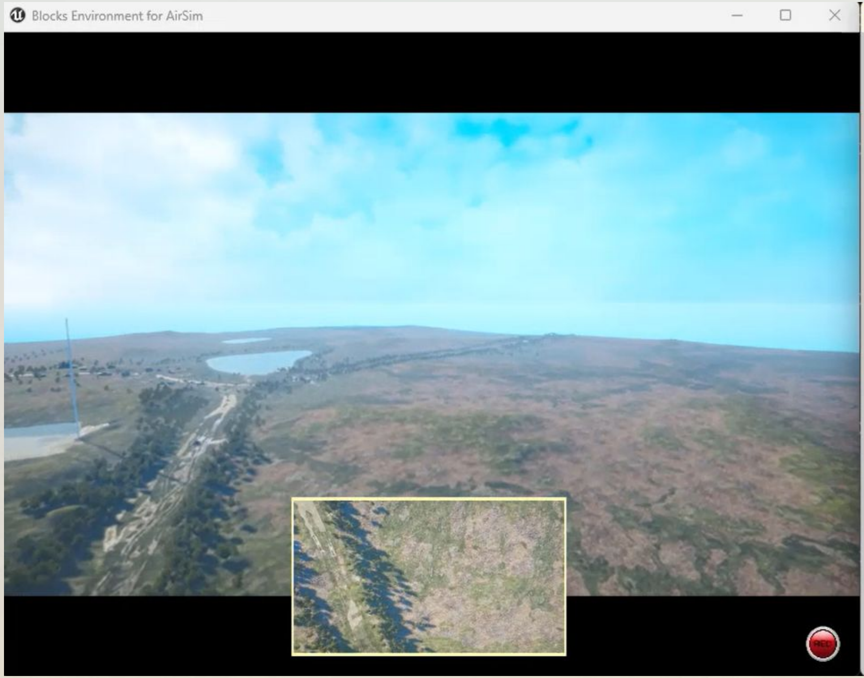
2. Flight video memory search: enables the UAV to retrace its flight path and return to its starting point.

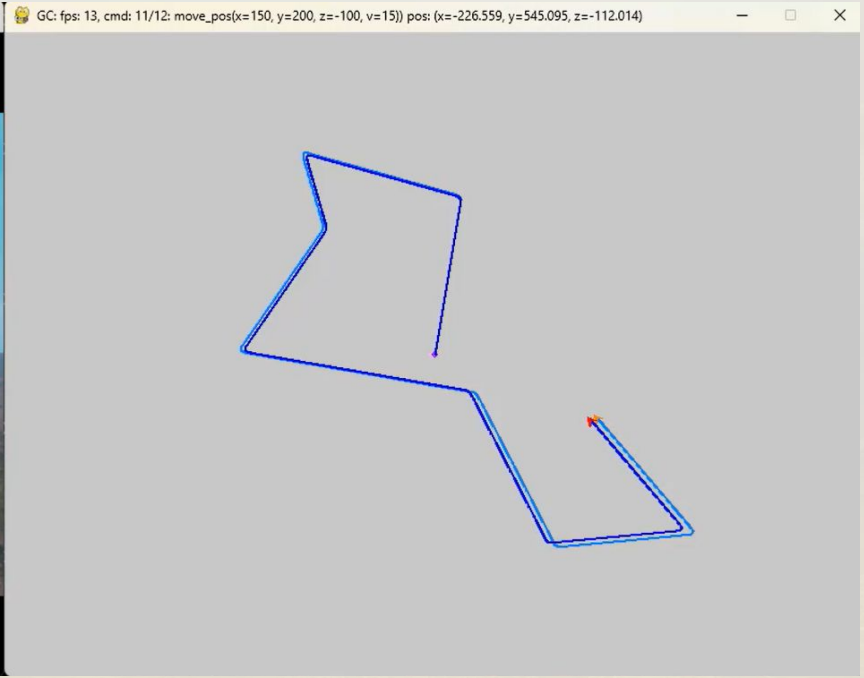
3. Target search and aerial surveying: facilitates efficient navigation and identification of specific targets using aerial imagery.





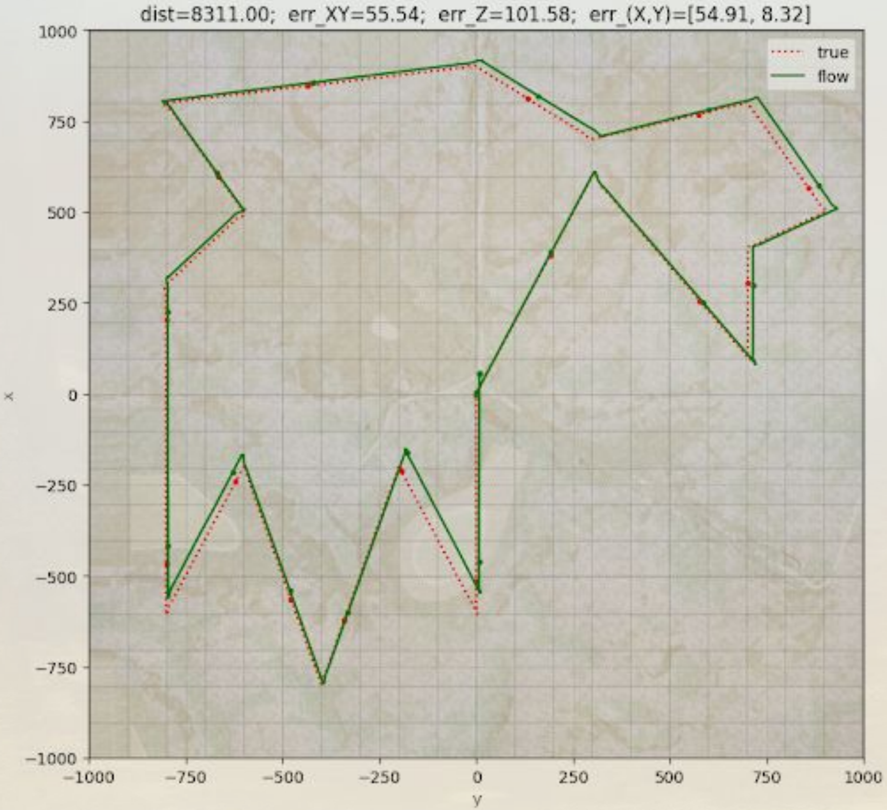
GNSS-denied UAV Position Tracking by Visual Odometry





Flight height:	Total trajectory length:	Position error:
100 m	**5 km**	**~1%**

Trajectory Reconstruction



Challenges:

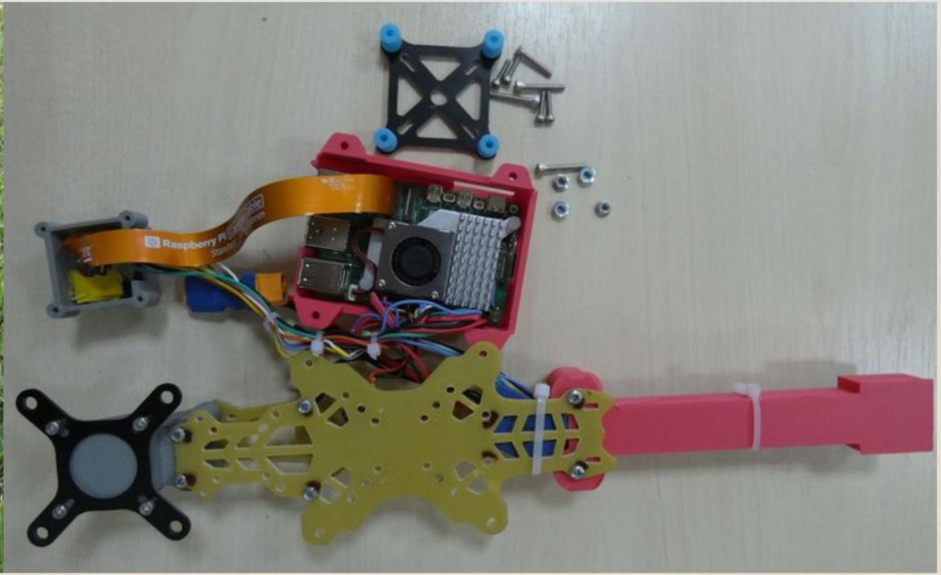
- Video quality: issues with night time, fog.
- Lakes and texture-less areas: lack of distinguishing features.
- High objects: trees, buildings.
- Altitude variability: distance to ground (dv/v=dh/h).
- Unsteady flight: difficult for the evaluator to assess.

Approaches:

- Rangefinder – for accurate distance measurement.
- Stereo camera – for enhanced depth perception and trajectory mapping.

III. Hardware System

A prototype module built with a Raspberry Pi mini-computer, equipped with a camera and various sensors.

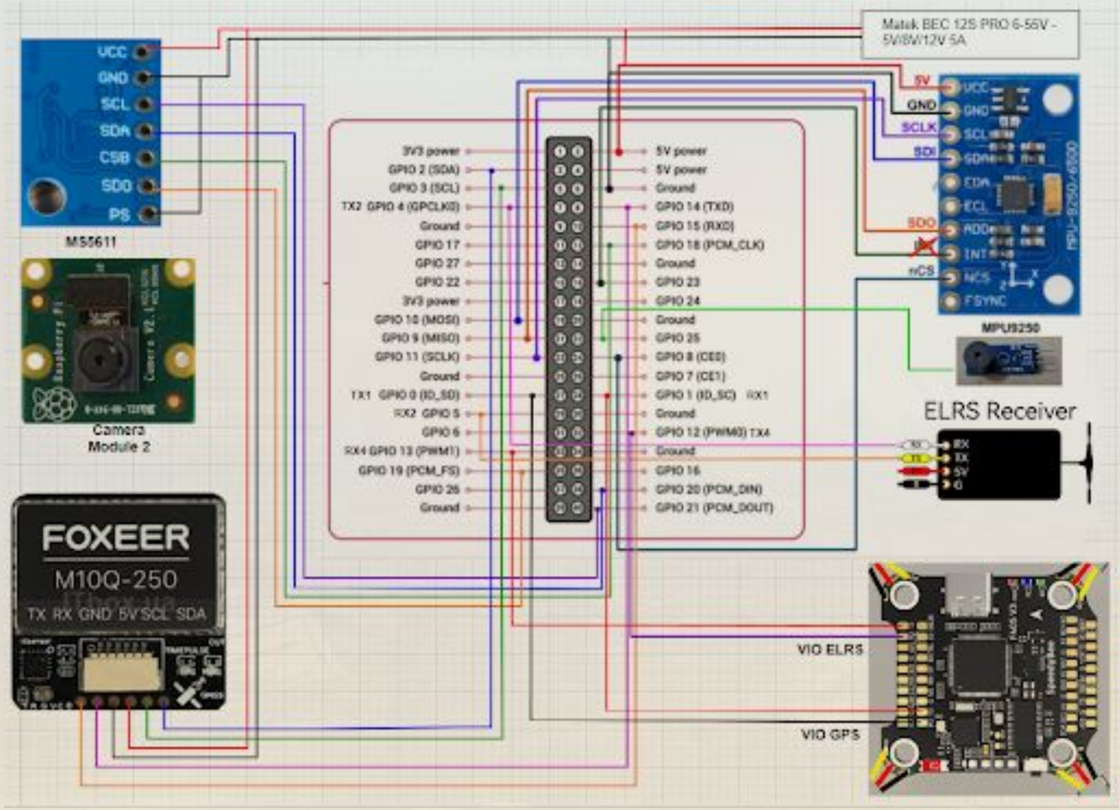


The module is mounted on the underside of the drone, with the camera facing downward.

- Communication with the flight controller occurs via the MAVLink protocol, transmitting simulated GNSS readings generated by the module.
- An alternative method is full flight control using RC commands via UART from the onboard computer to the controller.

VIO Module Components:

- Raspberry PI5
- Raspberry Pi Camera Module 2
- Gyroscope MPU9250
- Barometer MS5611
- GPS M10Q-250 (for testing purposes)
- Power Module Matek BEC 12S PRO



The module's purpose is to simulate GNSS data for flight controllers across various firmware platforms such as BetaFlight, Ardupilot, and PX4, or directly transmit control commands to emulate an RC transmitter.

Current Results

- ✓ Developed a 3D landscape model in AirSim and Unreal Engine for dataset generation and algorithm testing.
- ✓ Created an orientation estimator for drones using a gyroscope, magnetometer, and barometer, along with a flight control system that transmits RC commands to drones with any firmware or via the MavLink protocol.
- ✓ Developed and tested VIO algorithms in the simulator, which use sensor data and video streams to determine the drone's position without GNSS. The typical error of these methods is 100 meters over 10 kilometers.
- ✓ Enhanced the BetaFlight web interface for real-time display of camera feeds, sensor statuses, predictive tracking, and a console for interacting with the onboard computer.
- ✓ Conducted pilot tests at a testing range, with preliminary results confirming the successful operation of the employed methods.

Long-distance Map Navigation

We are working on a model for a long-distance orientation – up to 100 kilometers and more. To achieve this, the onboard computer stores aerial imagery of the terrain, obtained from a reconnaissance drone or satellite. The drone flies using its inertial system, refining its speed through optical odometry.

When the drone's camera image reliably matches a section of the aerial imagery, the drone's position is corrected.

QuData Team

QuData is a startup that specializes in developing advanced AI and machine learning solutions, providing services like conversational AI, autonomous systems, speech synthesis and recognition, image and text analysis, predictive analytics, and big data analysis. Company's expertise spans technologies such as PyTorch, OpenCV, TensorFlow, reinforcement learning, LLM, transformers, with application to a range of industries.

Our team consists of 12 specialists who have successfully executed numerous projects in medical diagnostics, large language models, and multidimensional sensor data processing. Two team members hold PhDs in theoretical physics. The team leader is the author of multiple internationally published articles and monographs.

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