DESIGN AND DEVELOPMENT OF UNMANNED AERIAL SYSTEM (UAS) SIMULATOR FOR LABORATORY STUDIES

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Unmanned Aerial System (UAS), Mission Planner, Flight Gear, SITL, Telemetry, Image Stitching, Human Detection.

Introduction:

Unmanned Aerial System (UAS) are widely used in areas such as surveillance, mapping, agriculture, and scientific research. Real world testing for drones can be risk of hardware damage, and sometimes unsafe, so using simulation-based testing a practical alternative for UAS development. This project introduces the design and implementation of an FPV (First Person View) simulation setup to analyze drone behavior and control strategies. The system combines Mission Planner with FlightGear to create an interactive virtual flight environment. In this setup, Mission Planner acts as the Ground Control Station (GCS), handling mission planner, monitoring telemetry, and adjusting the parameters, while FlightGear provides live 3D visualization of UAS motion. Communication of two platforms is achieved through a joystick-based interface, providing an FPV experience similar to flying a real drone. This simulation framework can also be expanded to physical UAS by connecting Mission Planner with onboard hardware using an RC transmitter or telemetry system. Along with flight simulation, the project features an image-based application that stitches aerial image together to produce panoramic views, showcasing the importance of UAS in mapping and surveillance tasks. Overall, the proposed platform combines UAS simulation, control mechanisms, and image processing techniques to offer a safe, scalable, and cost-effective environment for research, training, and mission validation.

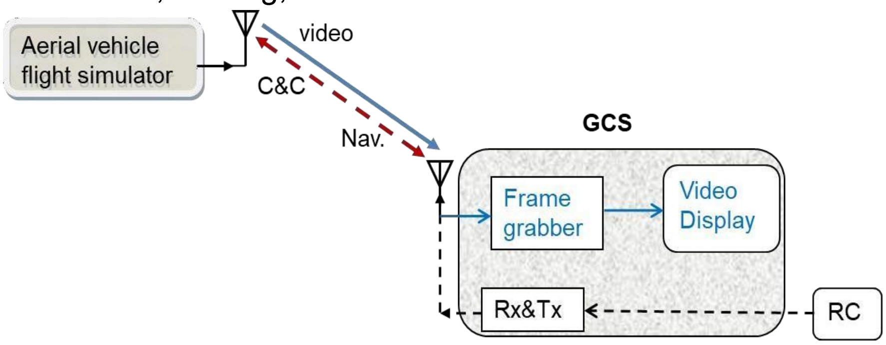

Figure 1: Block Diagram

Objectives:

1. Designing a SITL-based simulation environment
2. Enabling live monitoring and mission planning
3. Capturing aerial images from the drone's onboard camera
4. Performing image stitching to generate panoramic outputs
5. Detecting human presence within the stitched imagery for situational awareness

Methodology:

The project involves integrating simulation, hardware deployment, and image-based processing to evaluate the performance of an Unmanned Aerial System (UAS). Initially, a Software-In-The-Loop (SITL) simulation environment is established by connecting Mission Planner with FlightGear. This setup enables real-time 3D visualization, telemetry monitoring, mission planning, and joystick-based control of the virtual drone. Once the system behavior is validated in the simulation environment, a physical drone is assembled using essential components such as Pixhawk flight controller, GPS module, telemetry system, and an onboard camera. The drone is then deployed to capture a sequence of aerial images over the target area. The captured images are processed to generate a panoramic view through image stitching techniques. This process involves detecting and extracting key features from overlapping images, matching these features across frames, applying geometric transformations, and blending them to form a seamless wide-area image. Further, human detection is performed on the stitched panoramic output using the DEtection TRansformer (DETR) algorithm. DETR utilizes transformer-based attention mechanisms along with bounding box regression to perform end-to-end object detection.

This approach enables accurate identification and localization of humans within the aerial scene, improving situational awareness. Overall system performance is evaluated based on simulation accuracy, stitching quality, detection performance, and reliability in both virtual and real-world environments.

Result and Conclusion:

In conclusion, the project shows that a reliable UAS simulation and control system can be developed by combining FlightGear and Mission Planner. This combination results in a realistic FPV environment for flight testing and ground control operations. The system helps users understand how the drone behaves during flight, practice controlling it, and try out different mission plans without the need for actual hardware. It also allows users to get familiar with the interface and workflow of ground control systems, which is useful before working on real drones. Along with this, the hardware setup shows stable drone operation, supports real-time monitoring, and performs basic image processing, giving a better idea of how it works in real situations. The process of calibration, parameter tuning, and testing further adds to the overall learning experience. Overall, the project serves as a simple and cost-effective platform for learning, testing, and exploring further improvements in UAS applications.

Figure2: Stitched image with human detection

References:

1. R. W. Beard and T. W. McLain, *Small Unmanned Aircraft: Theory and Practice*. Princeton, NJ, USA: Princeton University Press, 2012.
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Future Scope:

The future scope of this project includes:

1. Improving simulation realism by integrating advanced environments and photorealistic 3D terrains.
2. Extending autonomous capabilities with features like automated mission planning and waypoint navigation.
3. Enhancing system performance through better communication and more reliable real-time control.
4. Integrating advanced AI models beyond DEtection TRansformer (DETR) for multi-object detection and tracking.
5. Implementing swarm drone coordination for large-scale surveillance and mapping applications.
6. Incorporating obstacle avoidance and collision detection using sensors such as LiDAR and ultrasonic modules.