Alex Eagles Megaproject

Task 4

Team 3

Manipal Institute of Technology

The project carried out at Manipal Institute of Technology used a Raspberry Pi 4B as the main onboard computer to handle image transfer to the ground control station (GCS). The GCS operator was responsible for monitoring flight system parameters, guiding the safety pilot with corrective actions, and coordinating with the ODLC (Object Detection and Localization Challenge) operator to ensure smooth mission execution. A Sony a6000 camera was integrated into the system, with the Raspberry Pi controlling its operation and geotagging captured images using GPS coordinates received via the MAVLink protocol from the flight controller. These images, along with flight data such as latitude, longitude, altitude, and orientation, were then sent to the GCS for further analysis.

A convolutional neural network (CNN) was used to detect, localize, and classify objects on the field. A mathematical Earth model was then applied to determine the exact GPS coordinates of the detected objects. Once the drone reached these target locations, a comparison-based neural network was activated, using a reference image of the O'Neill Seas to track the drone's position during the livestream and accurately center it over the target before triggering payload release.

For communication, the system utilized a dual-link setup. The first link was an RF900 radio modem operating at 900 MHz and using the MAVLink protocol to transfer messages at a rate of 128 kilobytes per second, providing a communication range of up to 2 miles for autonomous navigation. The second link was an ExpressLRS-based long-range transceiver, operating at 2.4 GHz with the CRSF protocol, allowing the safety pilot to maintain control at distances of up to 18 miles.

The image classification pipeline was built using a YOLO-based detection model trained on a custom synthetic dataset to identify ODLC objects. It incorporated a ResNet-based classification architecture and a false positive removal algorithm, achieving a detection accuracy of 85.6% and a classification accuracy of 89.5%. The Raspberry Pi 4B's built-in Wi-Fi enabled wireless connection to the GCS, allowing for smooth telemetry transmission, live video streaming, and mission uploads without requiring physical connections.

Arab Academy for Science, Technology and Maritime transport

The Fox Tech EH340 mini camera was chosen because it features a 4K Ultra HD sensor that delivers high-quality images. It is equipped with a 3-axis gimbal for stabilization and includes a CANVAS port, which allows the flight controller to manage gimbal movements. The camera feed is processed using Python's OpenCV library, where each second of live video is split into 25 frames. Each frame, along with the aircraft's coordinates, is transmitted to the ground station. A fine-tuned OpenAI CLIP model then classifies the feed, detecting key frames that contain an object with 94% accuracy. These key frames, along with ATR frames, are organized into separate folders.

For the key frames, a sliding window technique is applied on a 4x4 grid to locate key subframes containing objects. This process is repeated recursively until the smallest relevant subframe is identified. These subframes are then analyzed by the YOLOv8 CNN model, which distinguishes between standard and emergent objects based on their shapes, achieving an average accuracy of 89%. To identify colors, a trained CNN model is used to classify each pixel by its value with 97% accuracy. The results are separated into two categories: the most dominant color, representing the object color, and the second dominant color, representing the alphanumeric color.

The communication system relies on three transmission links. The first is the Spektrum RC transmitter, which operates at 2.4 GHz and provides secure, fast, and reliable communication, as well as a manual control backup for the pilot. The second is the RFD900+ telemetry link at 900 MHz, which serves as the primary telemetry connection between the aircraft and the ground station. The third is the Ubiquity AC Bullet, operating at 5 GHz, which functions as a backup telemetry link and the main data transfer link for the ODLC system.

A proxy server acts as the central controller of the communication system, connecting directly to the aircraft. It distributes signals to both the ground control station and the AI/image recognition station, ensuring smooth data flow and dependable system performance.

Institute of Technology, Nirma University

The imaging system consisted of a three-axis gimbal equipped with a 14-megapixel camera, autofocus capabilities, and a 10x optical zoom. To improve object detection and identification, it offered a resolution of 0.062 centimeters per pixel in both horizontal and vertical directions. The algorithm used for object detection was YOLO v5, optimized to run efficiently on Jetson and its companion computer. The camera's video feed was sent to Jetson, where an algorithm divided the images into smaller segments, which were then passed to YOLO for object detection within the frames.

Once an object was successfully detected, the companion computer assumed control of the autopilot, enabling the UAV to navigate toward the target for payload delivery. The video feed operated at 20 fps, a rate determined through software and hardware simulations. This frame rate was chosen to allow the UAV to detect objects effectively while in motion, while also preventing image overload on the companion computer. Custom weights and CNN algorithms were applied to fine-tune the model for identifying very small objects and for distinguishing humans on the ground from other objects. The video feed was split into smaller image segments to enhance the algorithm's accuracy and detection performance.

Herelink served as the main communication link between the UAV and the ground control station. It was used for RC control, telemetry, and internet connectivity, all functioning at a 2.4 gigahertz frequency. The Herelink air module connected to Jetson NX via Ethernet. The RC link transmitted signals for manual control of the UAV, the telemetry link connected to Mission Planner for UAV monitoring, and the Wi-Fi link managed Jetson NX and facilitated image transfer.

The 2.4 gigahertz communication frequency provided a tested range of more than 5 kilometers. The throughput, limited to 4.5 Mbps, ensured smooth and noiseless HD video streaming without interruptions. The system also offered minimal latency, particularly on the Wi-Fi link, where HD video was delivered with precise timing, free from lag, and without affecting the other two links. Additionally, all three links supported automatic reconnection in the event of communication loss, underscoring the system's reliable and versatile operational efficiency.