Title

Photon Flight

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Abstract

Photon Flight is a FAA Group 1 fiber optic tethered drone developed for search-and-rescue operations. The drone uses a bidirectional SFP fiber module paired with single mode fiber optic cable to prevent signal interference and operate in damaged infrastructure without GPS availability. A mounted camera leverages pretrained AI models for autonomous tracking of targets and live feed video.

Objectives

- Design, build and integrate a high-performance tethered drone that transmits real-time video feeds and full flight telemetry via fiber optic cable.
- Replace traditional RF links with a lightweight, noise-immune system.
- Develop IP video transport, low-latency encoding, network architecture, companion-computer integration, and flight-controller interfacing.
- Implement a real-time object detection pipeline using pretrained AI vision modules that enabled autonomous tracking optimizing frame capture, inference threading, and interprocess communication.
- Engineer a robust, high-bandwidth communication pipeline, demonstrate reliable fiber-based command and control.
- Design custom parts for specific functionality.

Materials and Methods

Mechanical Design & Fabrication
- Custom mounting components modeled in SolidWorks 2024.
- Parts manufactured via FDM 3D printing on a Prusa 3D Printer.
- Toolpaths and print parameters optimized using PrusaSlicer.

Flight Control & Communication
- ArduPilot firmware used for flight control.
- Telemetry, tuning conducted, TCP connection, HUD interface in Mission Planner.
- MAVLink protocol implemented over a UDP network interface.

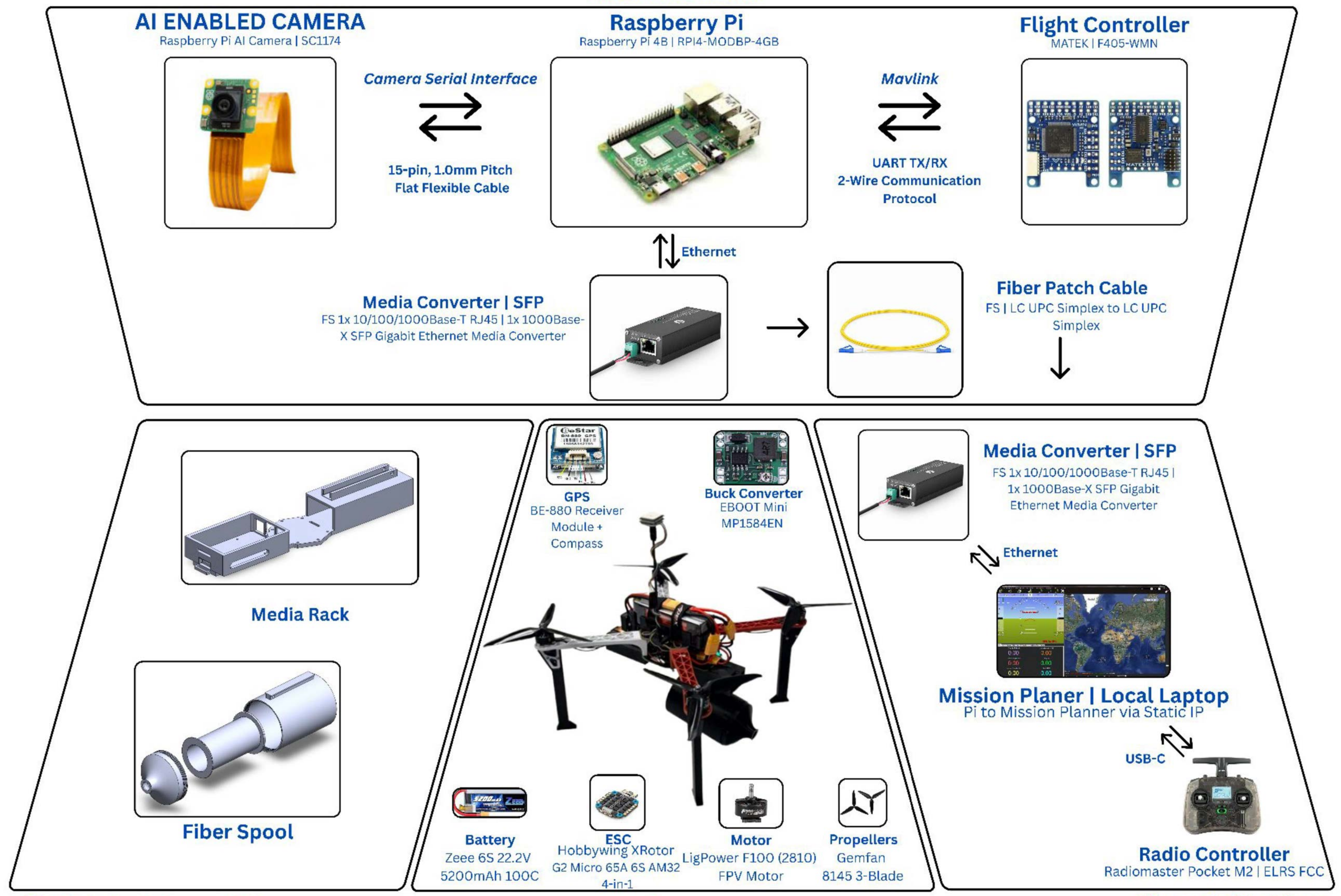
Vision & AI System
- IMX500 Raspberry Pi AI Camera connected to a Raspberry Pi 4B.
- YOLOv2 AI model running on the IMX500's integrated neural network processor.
- Real-time object detection processed onboard without external compute.

Video Streaming & Transmission
- GStreamer pipeline configured for live video streaming.
- Frame capture optimization applied to reduce latency and maximize throughput
- Long-range transmission via fiber link with SFP transceiver pairing
- Fiber link performance analysis conducted to validate signal integrity

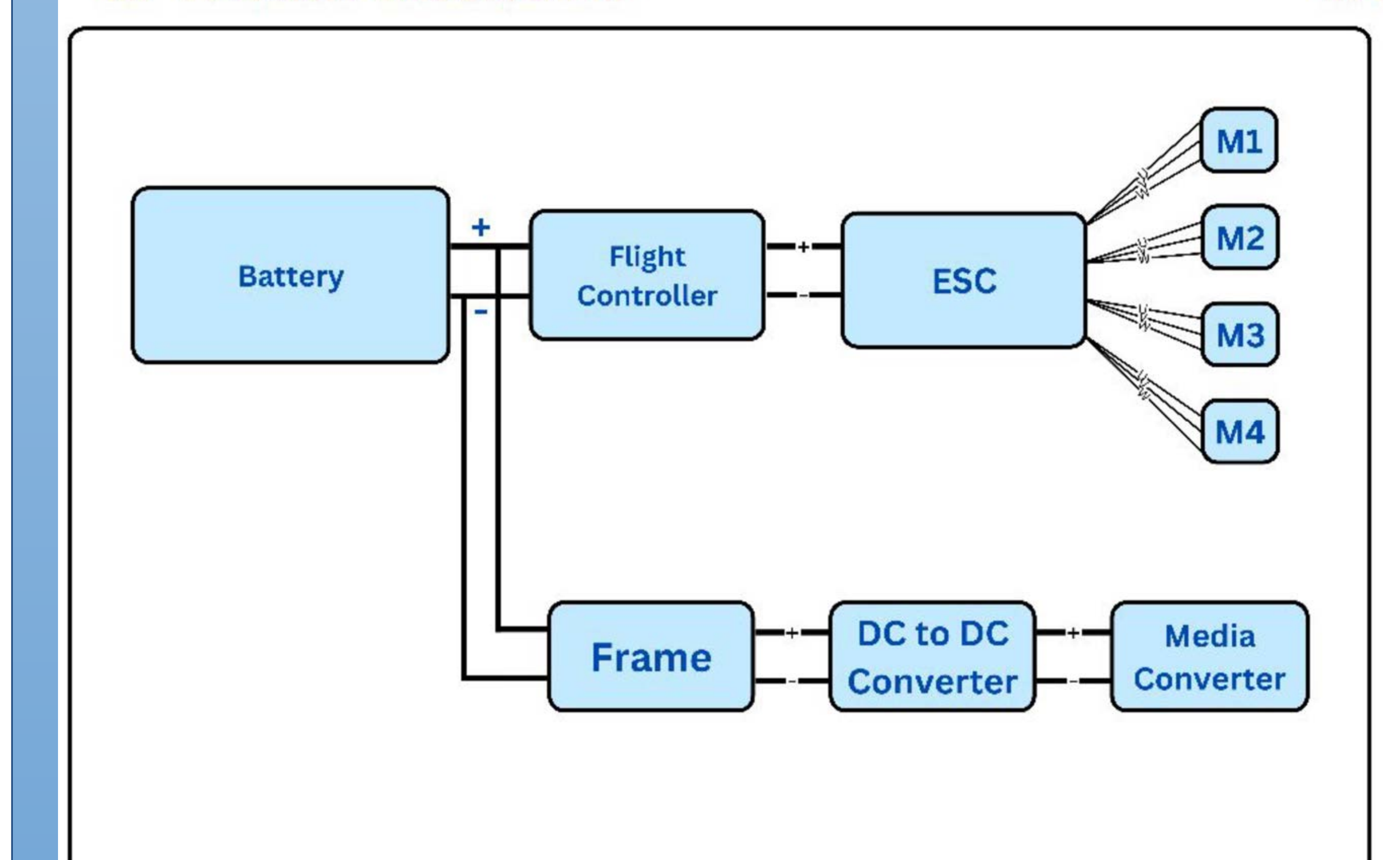
Software Development
- Used pymavlink and picamera2 Python libraries for flight-responsive object detection

Diagrams/Figures/Experiments

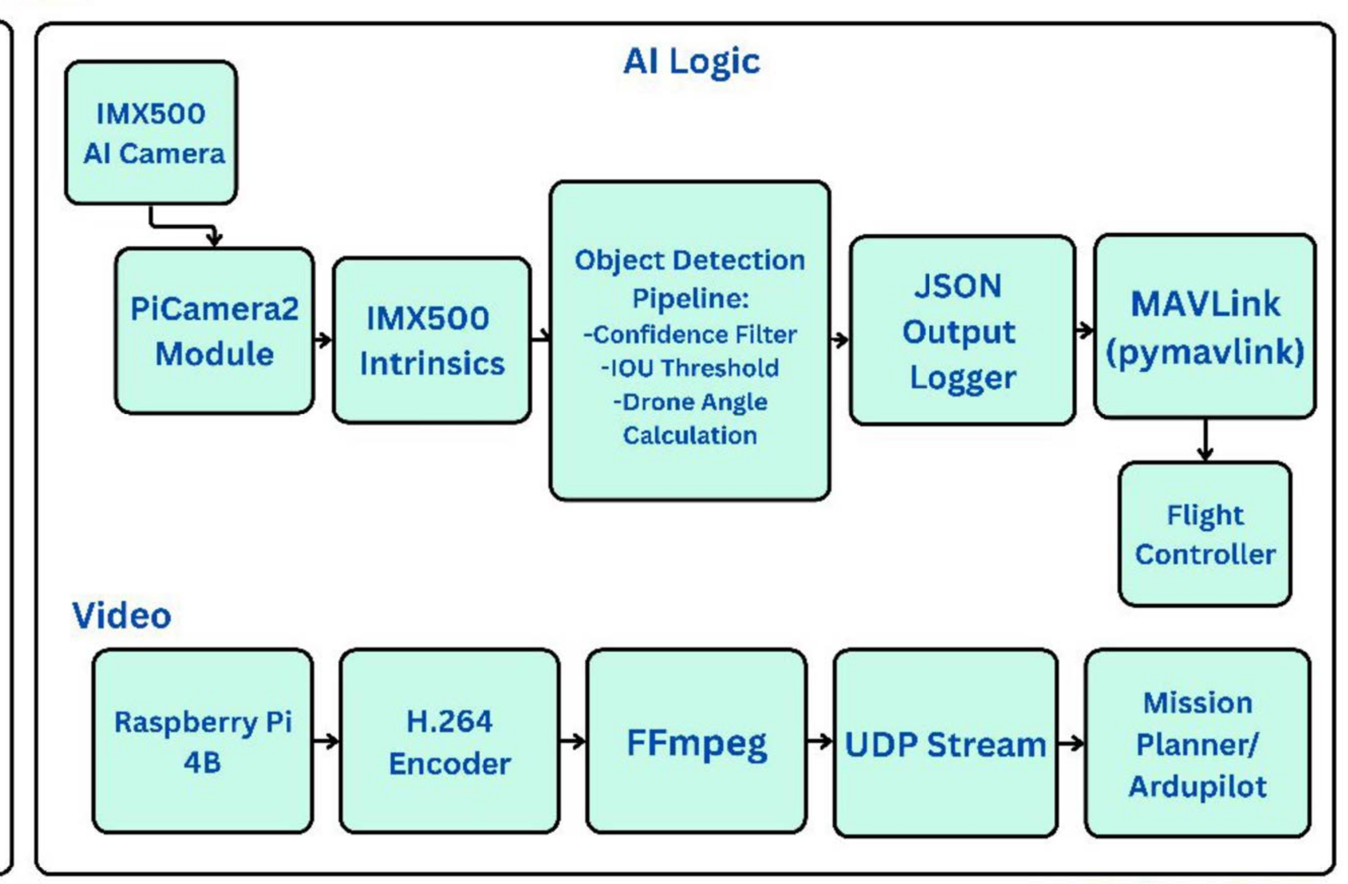
<Communcations>



<3D Printed Assemblies> <Drone> <Ground Station>



<Power Diagram>



<Logic Flow>

Results

Flight was demonstrated using the 150 foot fiber optic link. The system can maintain fiber optic communication throughout the duration of flight and the AI camera can successfully transmit live video to the ground station.

Key Drone Performance Figures
- Flight Time: ~20 minutes
- Dry Weight: 1494g | All-Up-Weight (AUW): 2274g
- Max payload capacity: 2730g
- Thrust per motor: 2,467g
- Total max thrust: 9,868g
- No-load RPM: 24,420
- Loaded RPM: ~20,757
- Thrust-to-weight ratio: 4.49:1

AI Camera Metrics
- FPS: 20-35 frames
- Resolution: 720p
- Latency: 2-4 ms
- Object Detection: 75.86% correct identification
  - Average over 6 trials

Additional Information

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