Drone with Artificial Intelligence

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Documentation

GitHub

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Introduction

Traditional road inspection is slow and labor-intensive. This project uses an FPV drone with on-board AI to detect road damage in real time, reducing manual effort and enabling faster, safer, and more consistent infrastructure monitoring.

Methodology

- Participants/Sample: Road segments with varying visible damage.
- Materials/Instrument: FPV drone, Raspberry Pi Zero 2 WH, Google Coral TPU, camera module, GPS, and YOLO/TensorFlow Lite models.
- Procedure: Drone followed pre-planned GPS routes, recorded video, and performed real-time damage detection during flight.
- Data Analysis: Logged footage and inference outputs were reviewed to assess detection accuracy, inference speed, and system stability.

AI Model

- YOLOv8 nano model trained on 4,510 road surface images
- Real-time pothole detection with hardware acceleration (Google Coral TPU)
- Optimized for edge computing: INT8 quantization + TensorFlow Lite

Figure 1: Detected Pothole

Drop Mechanism

- A 9g micro servo is interfaced via Raspberry Pi GPIO using hardware PWM (pigpio library) with precise 1-2ms pulse width control for 0-180° actuation.
- The release mechanism implements dual trigger modes: MSP-based RC control through the flight controller's AUX8 channel

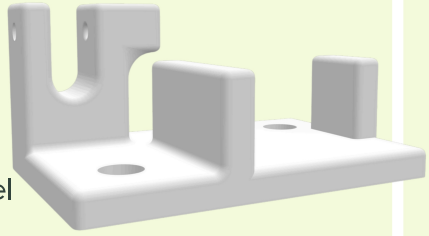

Figure 2: Drop Mechanism 3D Model

Architecture

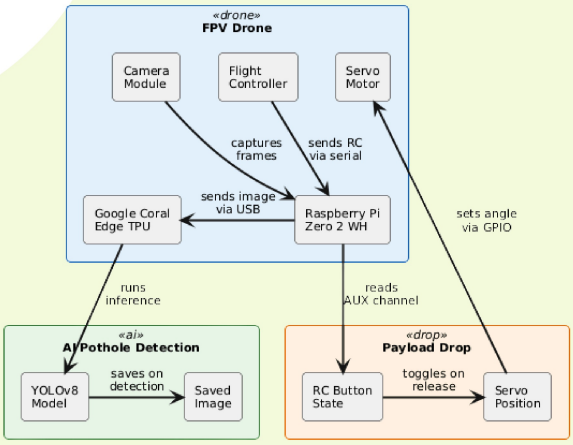

Figure 3: Architecture Diagram

Pi Output

This log shows the Raspberry Pi initializing the camera pipeline and running our onboard AI model. Once started, the system detects potholes in real time and saves each detection as an image with timestamps for later analysis.

```
python3 camera_control.py
Opened serial port: /dev/ttyS0
Model Input: 320x320, Dtype: <class 'numpy.float32'>
[0:01:18.702985049] [1130]  INFO Camera camera_manager.cpp:297 libcamera
[0:01:18.784994140] [1140]  WARN RPI vc4.cpp:383 Mismatch between Unicam
[0:01:18.786636981] [1140]  INFO RPI vc4.cpp:437 Registered camera /base/
[0:01:18.786764659] [1140]  INFO RPI pipeline_base.cpp:1101 Using configu
[0:01:18.812119034] [1130]  INFO Camera camera.cpp:1033 configuring strea
[0:01:18.813175962] [1140]  INFO RPI vc4.cpp:565 Sensor: /base/soc/i2c0mu
Camera started.
Ready. Waiting for RC switch...
[REC] Starting: /home/tpu/Videos/flight_1769342698_1f323078.h264
[AI] Pothole detected! Saved: /home/tpu/Videos/detect_1769342699_0.54.jpg
[AI] Pothole detected! Saved: /home/tpu/Videos/detect_1769342700_0.55.jpg
[AI] Pothole detected! Saved: /home/tpu/Videos/detect_1769342709_0.61.jpg
```

Figure 4: Logged Results

Conclusion

This project evaluated real-time road damage detection on an autonomous drone using on-board AI. Findings showed that the Raspberry Pi Zero 2 WH is underpowered for enhanced inference, forcing heavy model compression to run at minimal performance. While technically feasible, meaningful real-time deployment will require stronger edge hardware or further model optimization.

References

https://www.christianbaun.de/Master_Projekt_WS2526/index.html