



UAV Computer Vision at the Edge

Development, Security, and Hardware Acceleration

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Problem statement



Testing risky algorithms on real drones is expensive



Captured devices leak technology

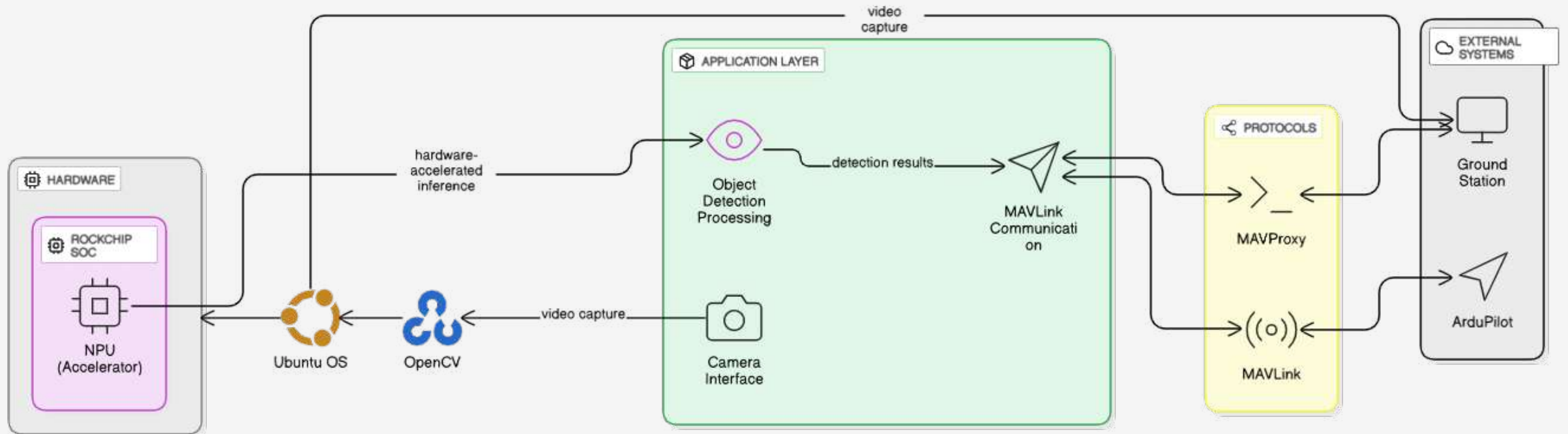


Supply chain disruptions due to political turbulence

Objectives

- Implement HITL testing for safe computer vision development
- Enable secure boot on Rockchip-based SBC for tamper protection
- Find and benchmark hardware alternatives for deployment diversity

System Overview



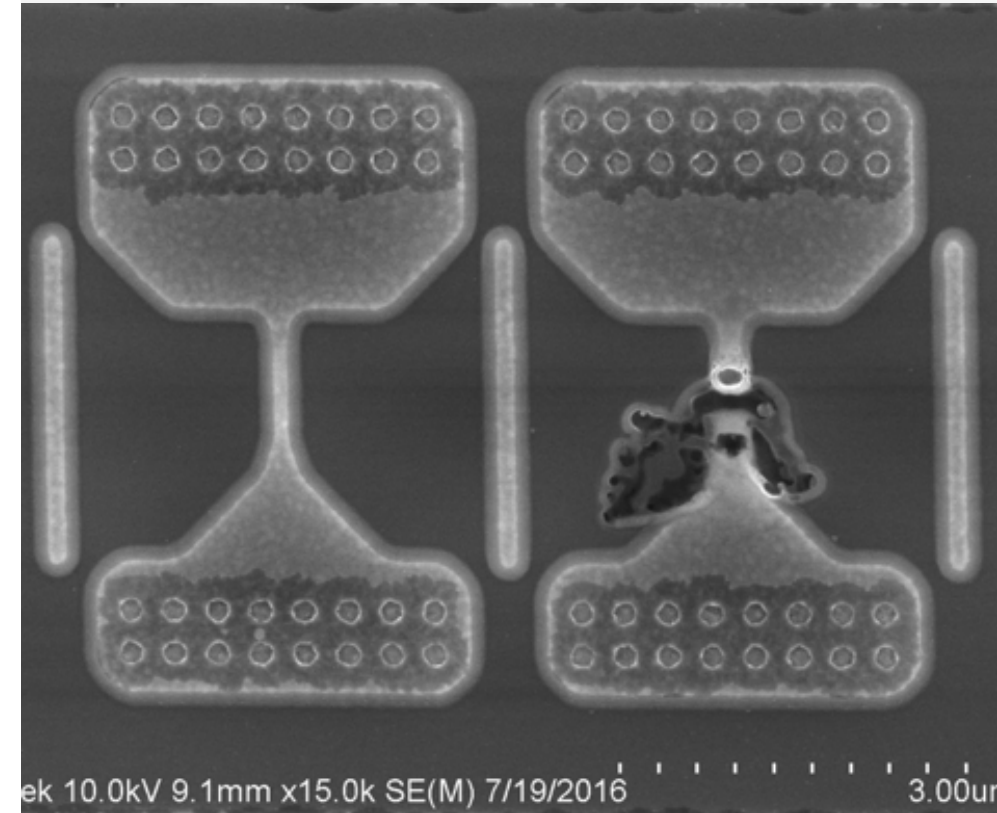
Hardware-in-the-Loop

- Custom OpenCV compilation with GStreamer support for real-time video transmission
- Built network video streaming from Gazebo simulation to physical companion computer
- Enables algorithm testing on real hardware without physical UAV flights

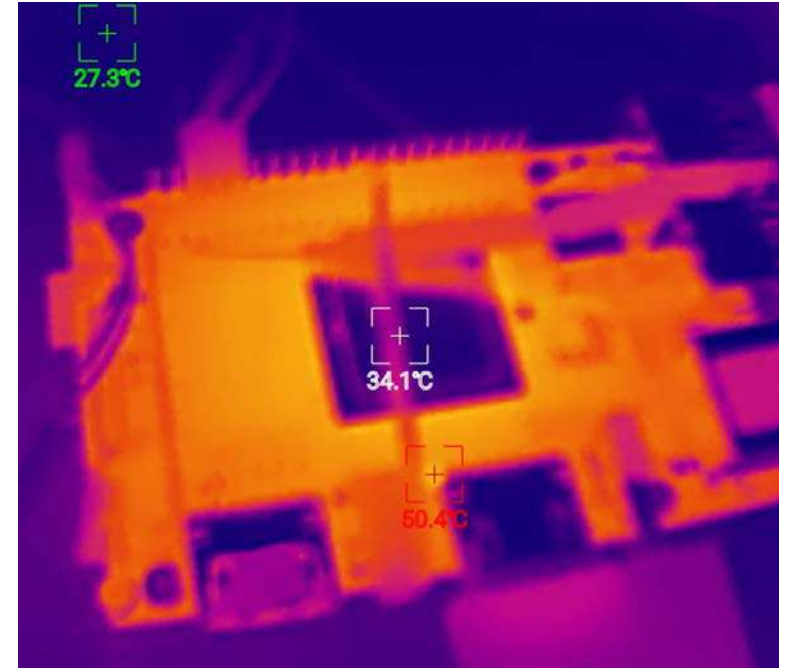
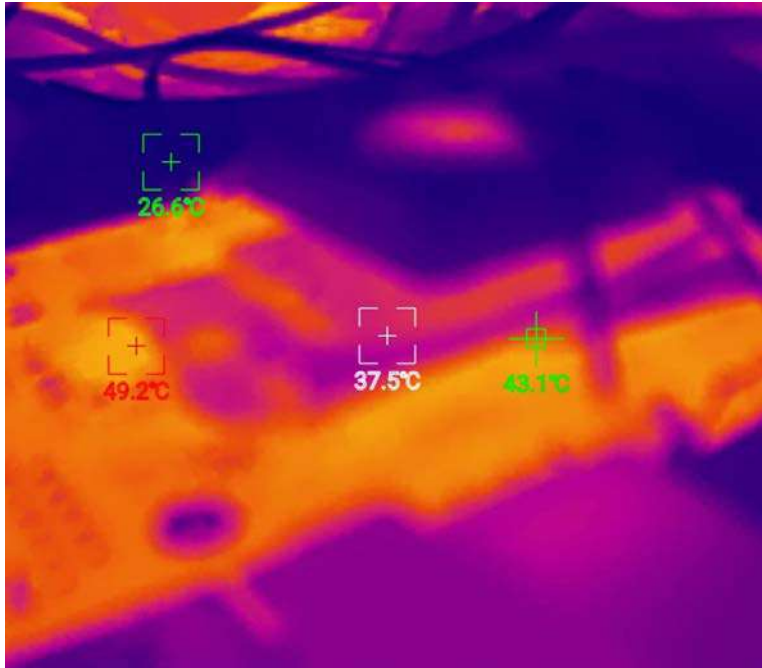


Security Implementation

- Developed Secure Boot build system for Rockchip-based SBCs
- Created automated build scripts preventing hardware damage during key programming
- Two-stage firmware deployment methodology for production safety



Hardware Acceleration Evaluation



Systematic benchmarking framework compares CPU, Rockchip NPU, and Hailo-8L platforms using standardized test conditions

Automated testing pipeline processes YOLOv8 object detection across all acceleration platforms

Cross-platform driver adaptation ports Raspberry Pi drivers for Hailo-8L compatibility on Rockchip-based platform

Hardware Acceleration Performance Comparison

Platform	TOPs	Video 1 (FPS)	Video 2 (FPS)	Video 3 (FPS)	Video 4 (FPS)	Avg Power Consumption (W)
CPU	–	1.90	2.32	2.24	2.25	2.81
NPU	6	17.70	20.88	17.36	16.92	0.83
Hailo-8L	13	60.67	66.52	63.58	64.21	1.48

Results

- Working Secure Boot with safe OTP key programming that prevents hardware damage during deployment
- Real-time video streaming from Gazebo simulation to physical hardware
- Cross-platform benchmarking automation with a standardized evaluation framework for CPU, NPU, and Hailo platforms
- Successful Hailo-8L driver adaptation from Raspberry Pi to ARM64 Rockchip-based platform
- Performance benchmarks across CPU, Rockchip NPU, and Hailo-8L confirmed Rockchip NPU as the most optimal choice for UAV edge computing, still maintaining Hailo as viable alternative

Conclusions and Future Work

What this means

UAVs can operate autonomously under jamming

Captured devices won't compromise technology

Practical path to mass production

Future

Network Latency Optimization

Thermal Management Strategies

Production Automation

Q&A