RF-Based Drone Detection Using RFSoC and SDR: Analysis and Automation Foundations

HONORS THESIS PRESENTATION BY MICHAEL TUNG

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

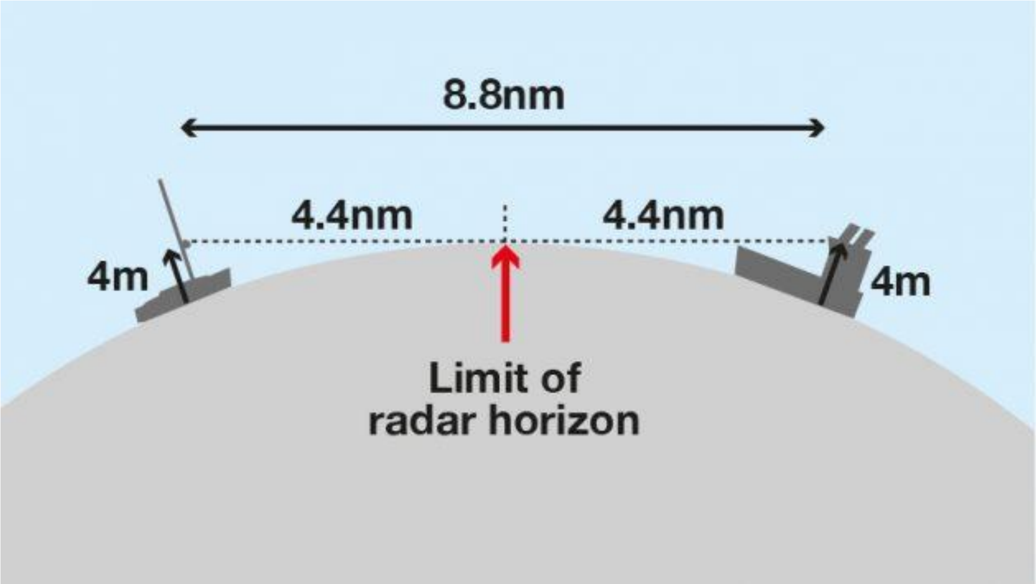
UNIVERSITY OF FLORIDA

I. Background and Motivation

- UAVs revolutionizing civilian & military applications
- Growing security concerns:
- 1. Unauthorized surveillance
- 2. Military tactical applications in Ukraine

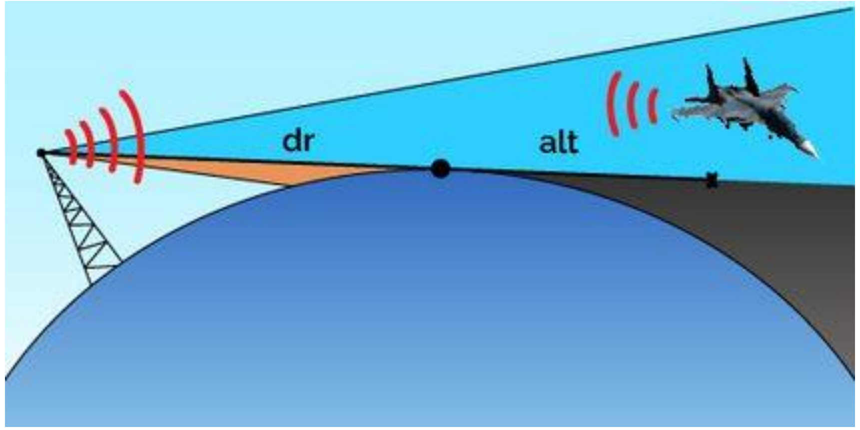
I. Background and Motivation

- Detection challenges:
- Need for real-time processing
- Traditional methods have limitations



I. Literature review

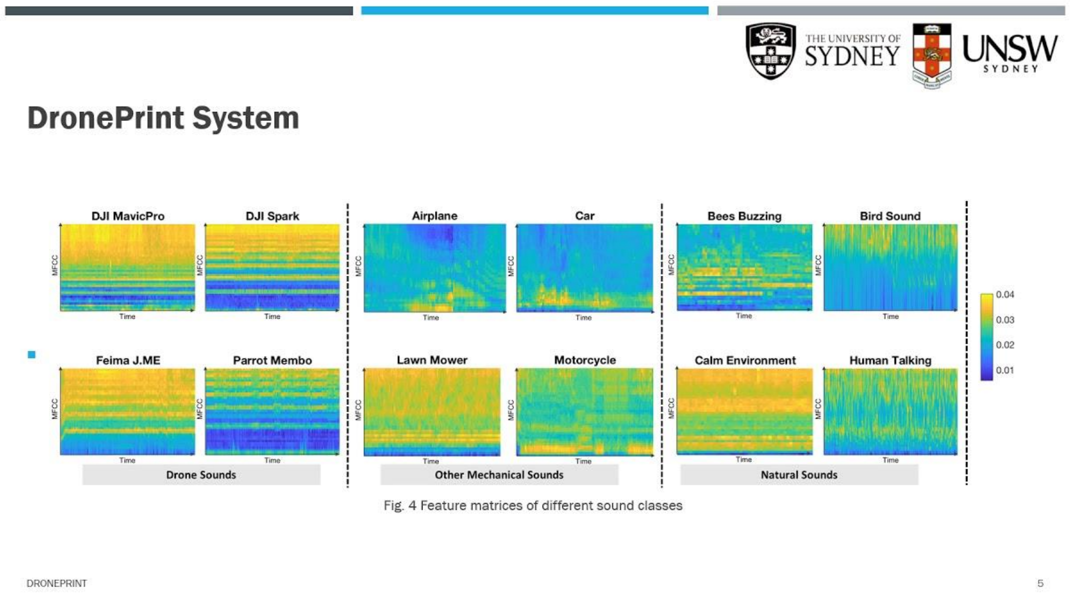
- 1) Traditional Detection Methods
- • Radar-Based Detection



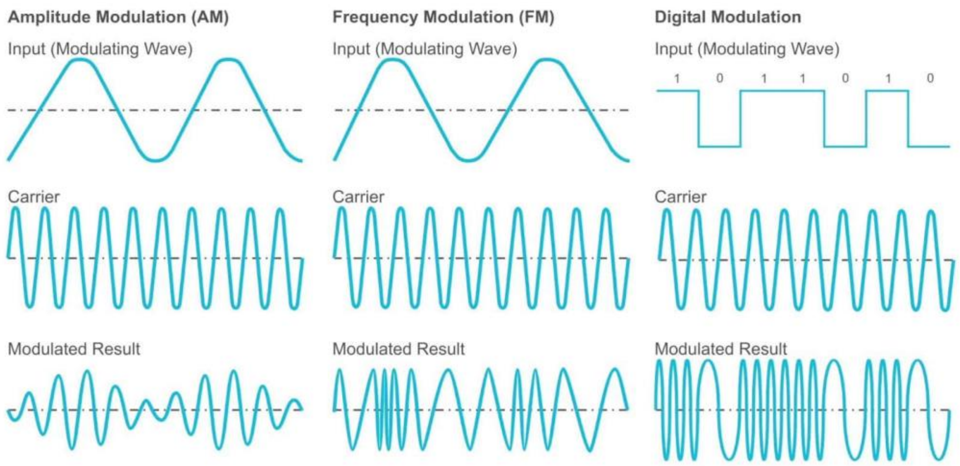
- • Vision-Based Detection

I. Literature review

- 1) Traditional Detection Methods
- • Acoustic Detection

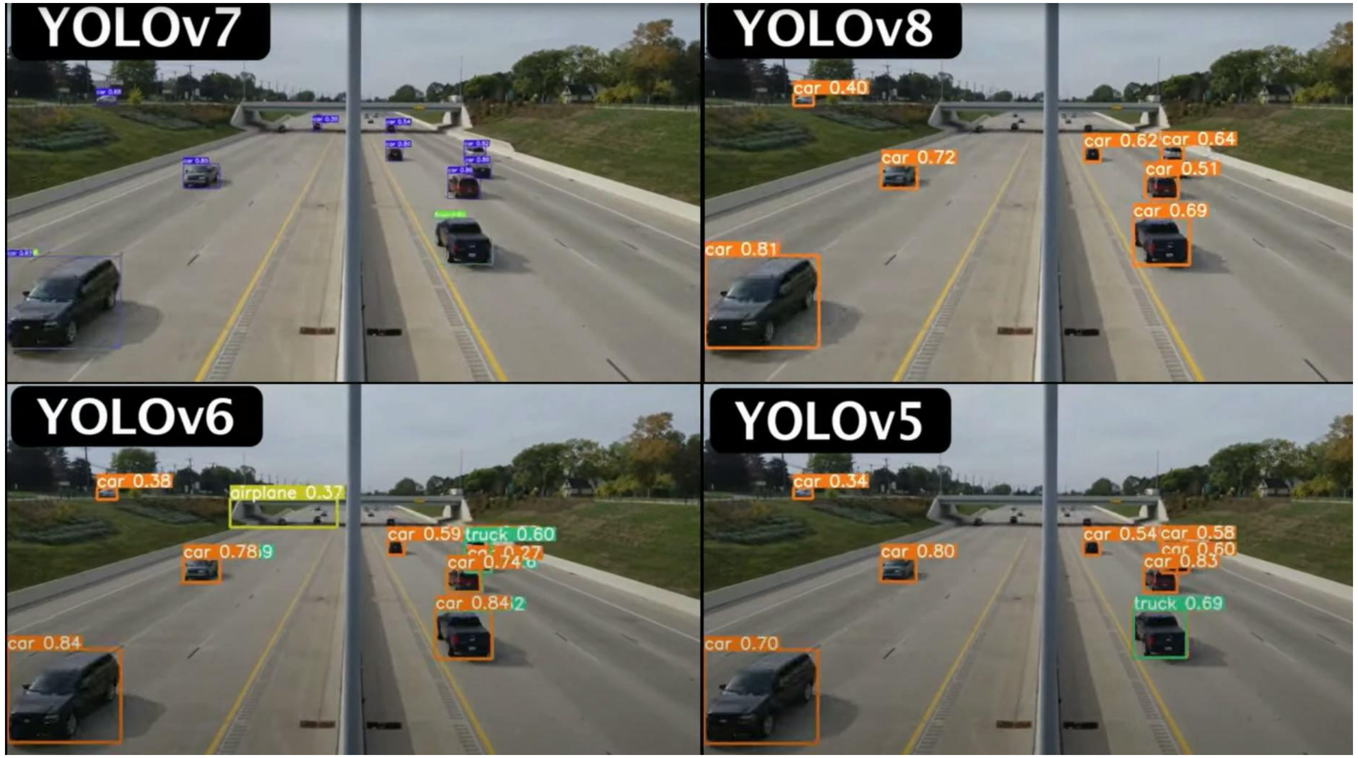


- • Radio Frequency (RF) Detection



I. Literature review

- 2) Advancements in Vision-Based Drone Detection
- Deep Learning Model: YOLO and ResNet
- Still limited by obstructions and environmental factors



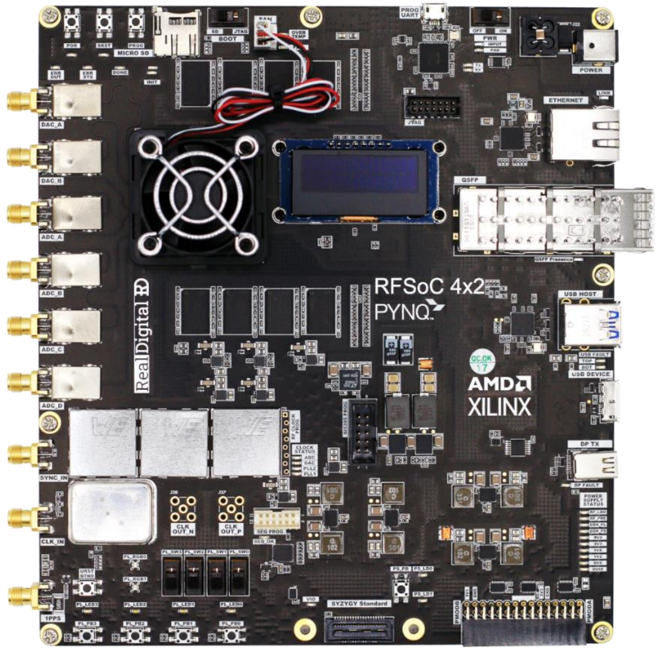
I. Literature review

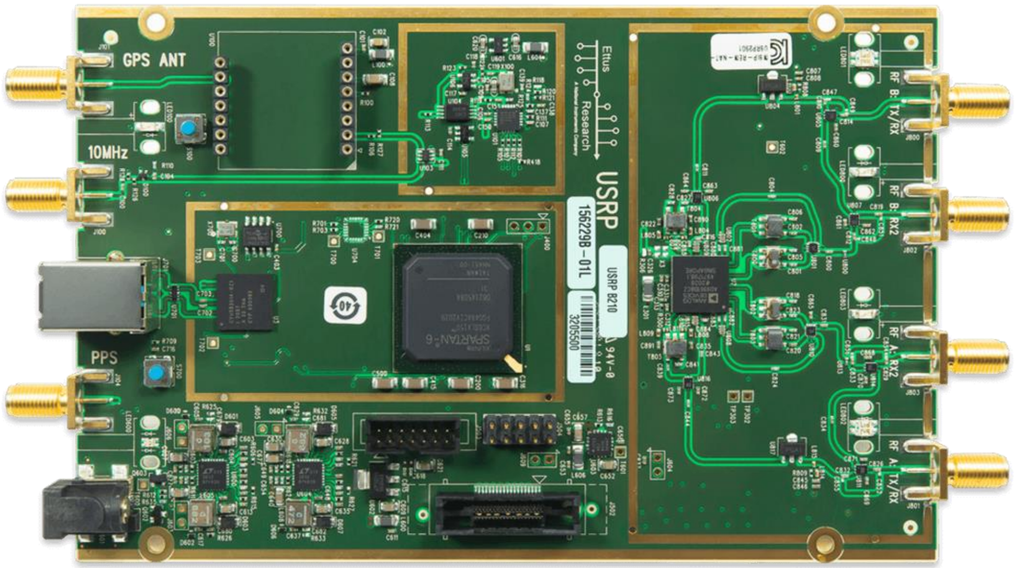
- 3) Limitations of Current RF-Based Detection Research
- • Non-Standardized Communication Protocols
- • Environmental Noise and Frequency Interference
- • Frequency Hopping
- • Multipath Effects

- 4) Addressing the Gap in RF-Based Methods
- Advantage: Stability over all weather (robustness)

I. Research Goals and Objectives

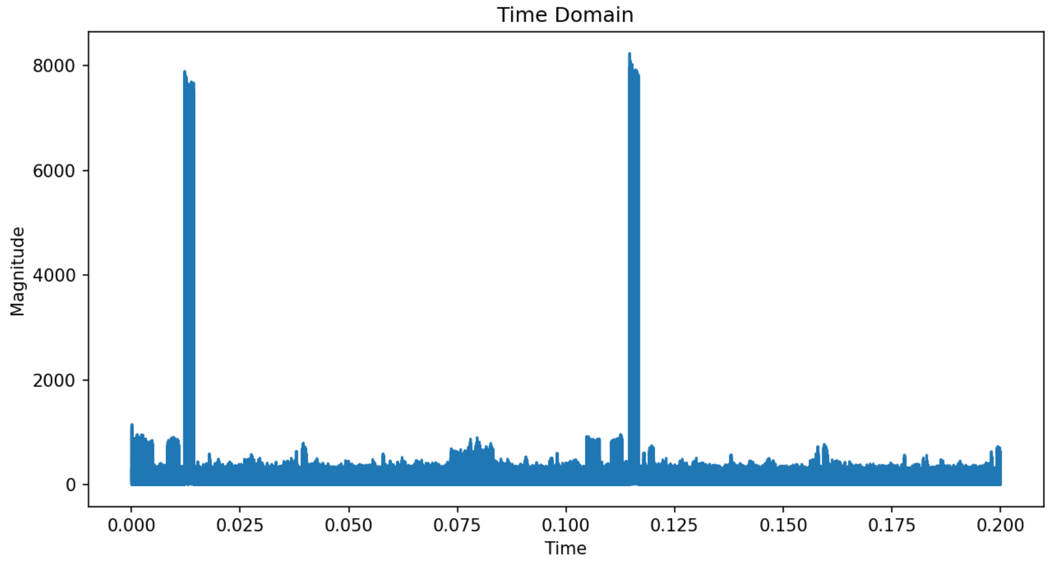
- Primary Goal: Develop scalable drone detection framework using RFSoC and SDR





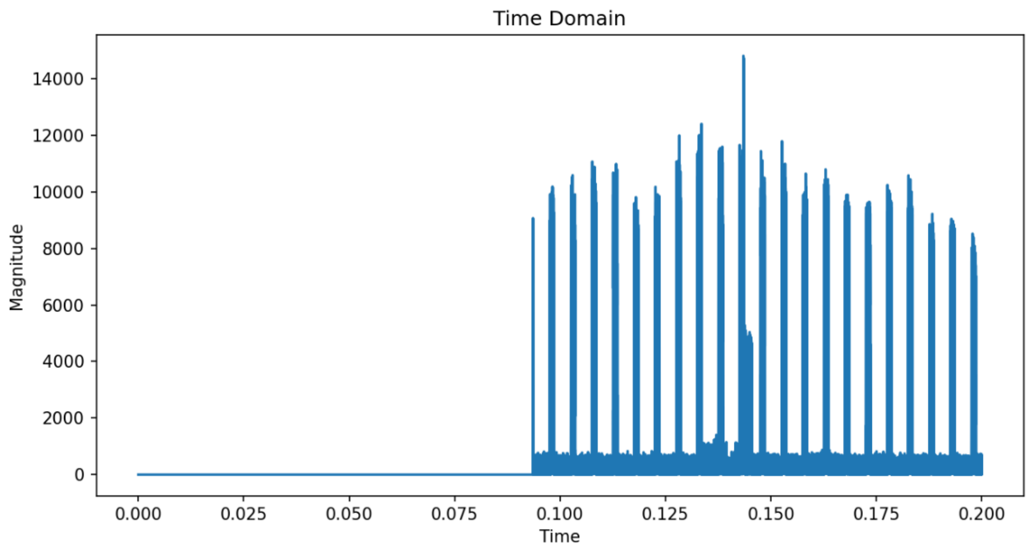
I. Research Goals and Objectives

- Current Status:
- Advanced understanding of drone signals
- Working toward an autonomous real-time system



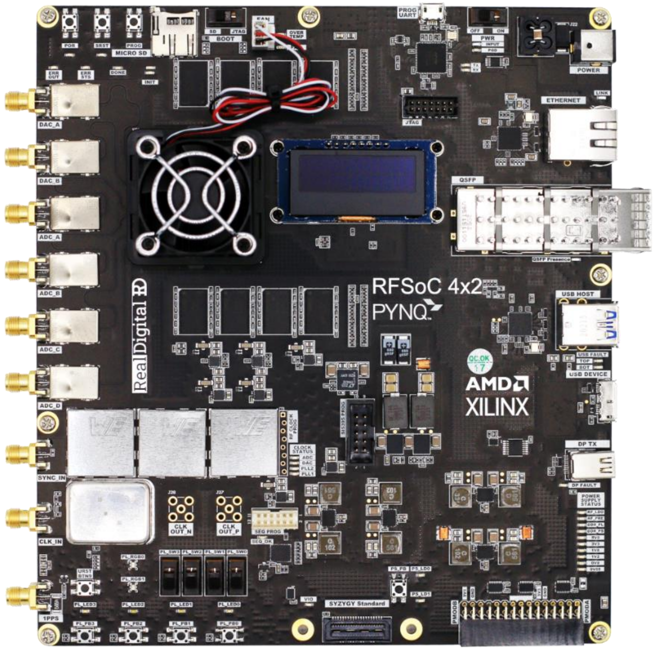
I. Research Goals and Objectives

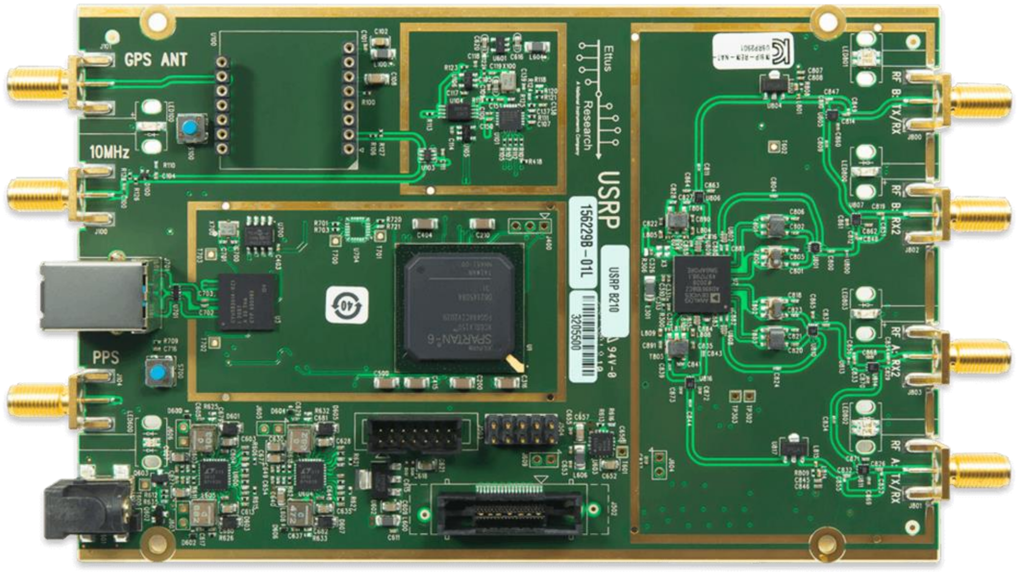
- Design & Technique:
- Utilize RFSoC's high-speed ADC/DACs + FPGA
- Python-based signal processing and computer vision technique



II. Methodology

- A. Data collection
- • RFSoC 4x2 Platform
- • Ettus USRP B210 Software-Defined Radio (SDR)





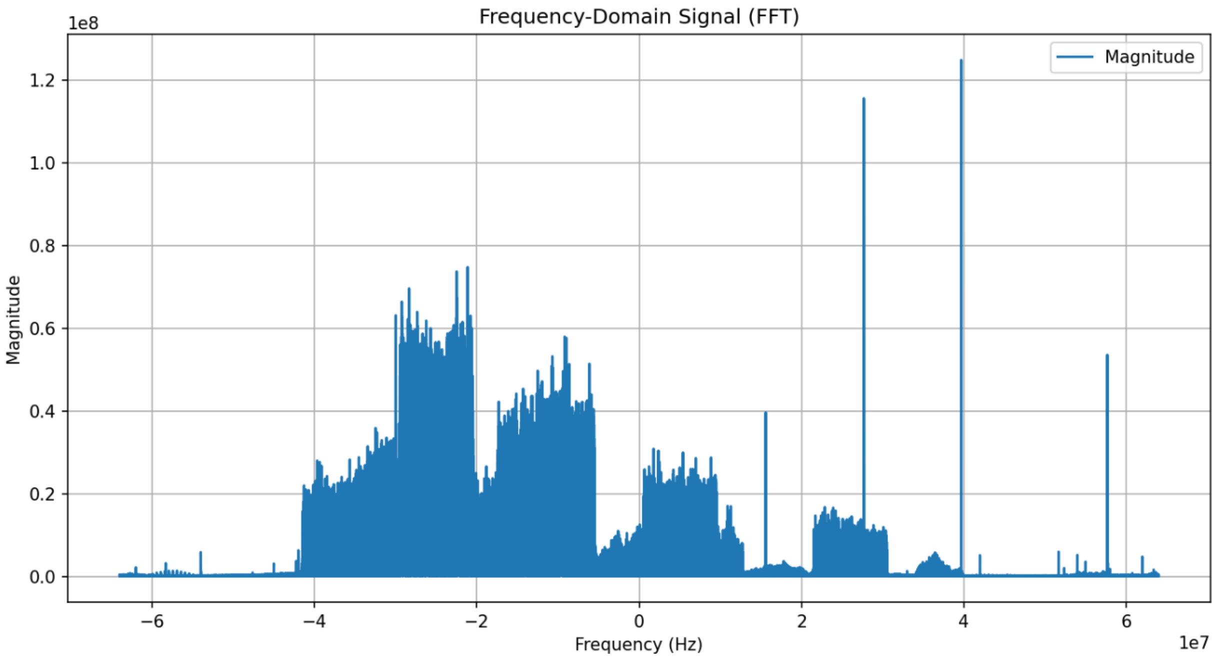
II. Methodology

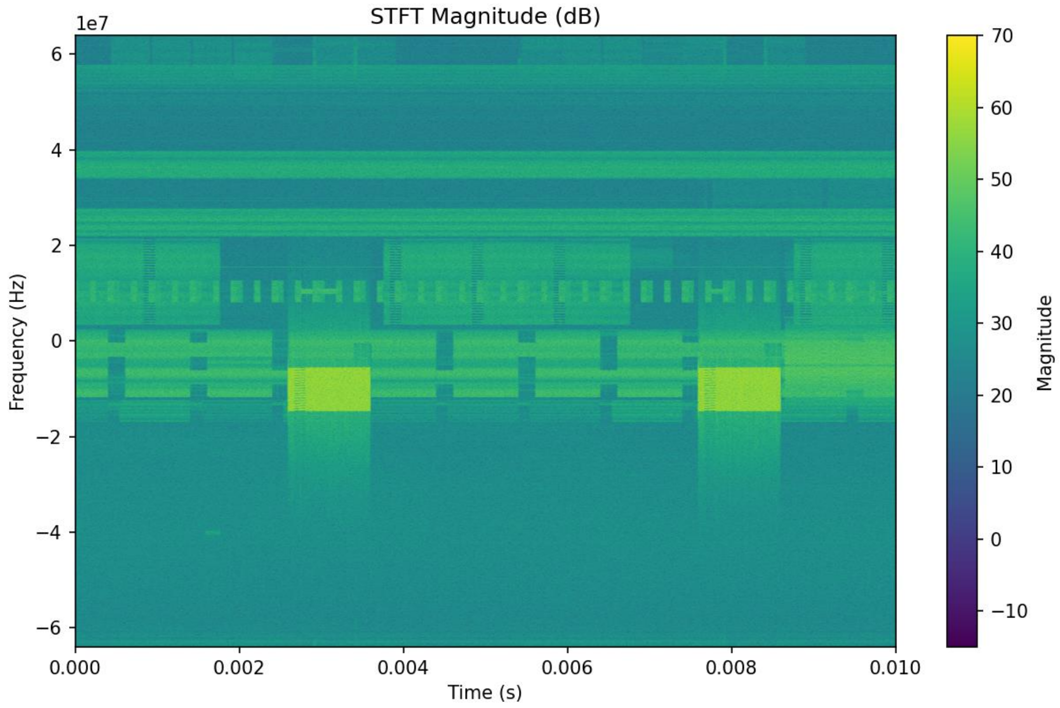
- 2) Field Testing Locations
- UF Autonomy Park

- 3) Drone Signal Capturing
- Astro quadrotor drones from Freefly Systems
- Many drone operations

II. Methodology

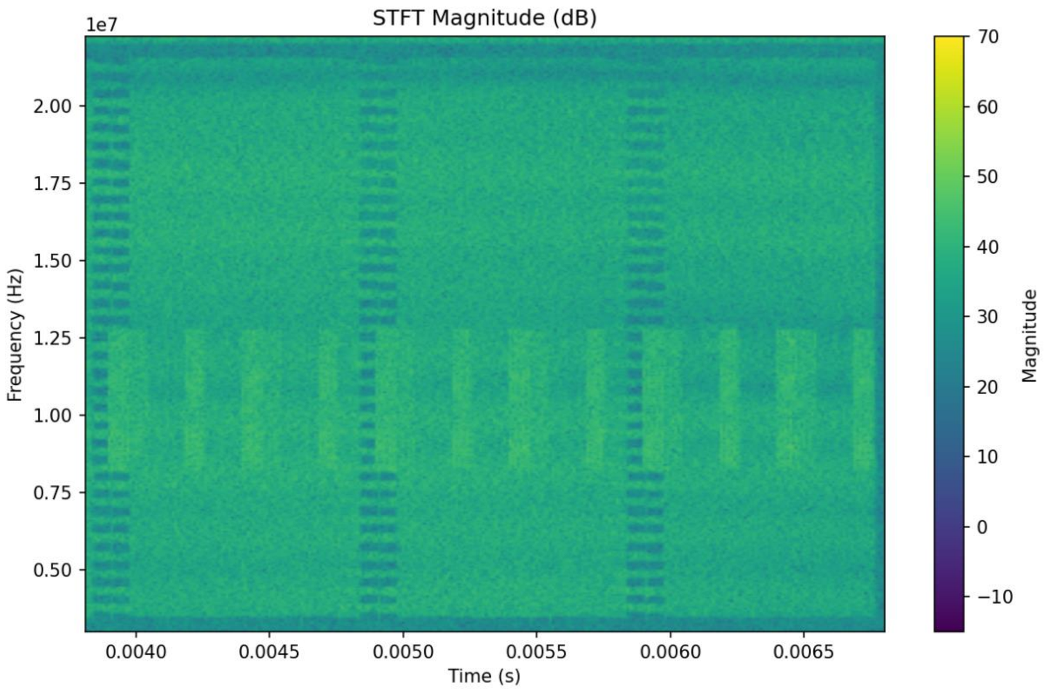
- B. Data Analysis
- a. Analysis in the Time and Frequency Domains
- Perform FFT, STFT and Spectrogram Analysis

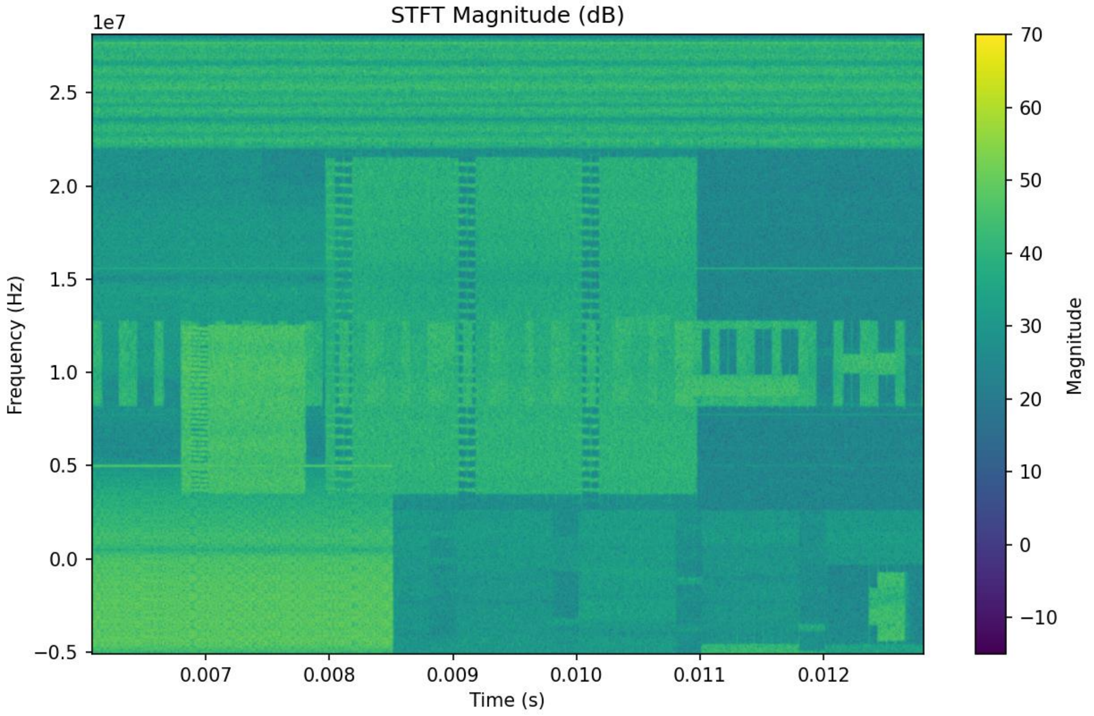




III. Results and Discussions

- A. Observation
- 1) Drone Packets





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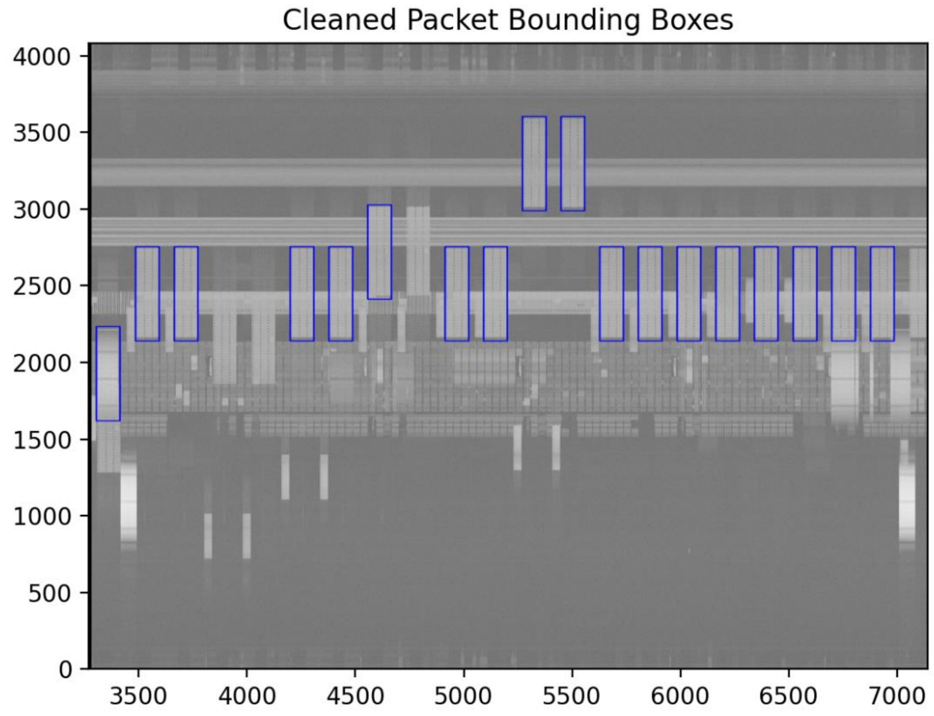
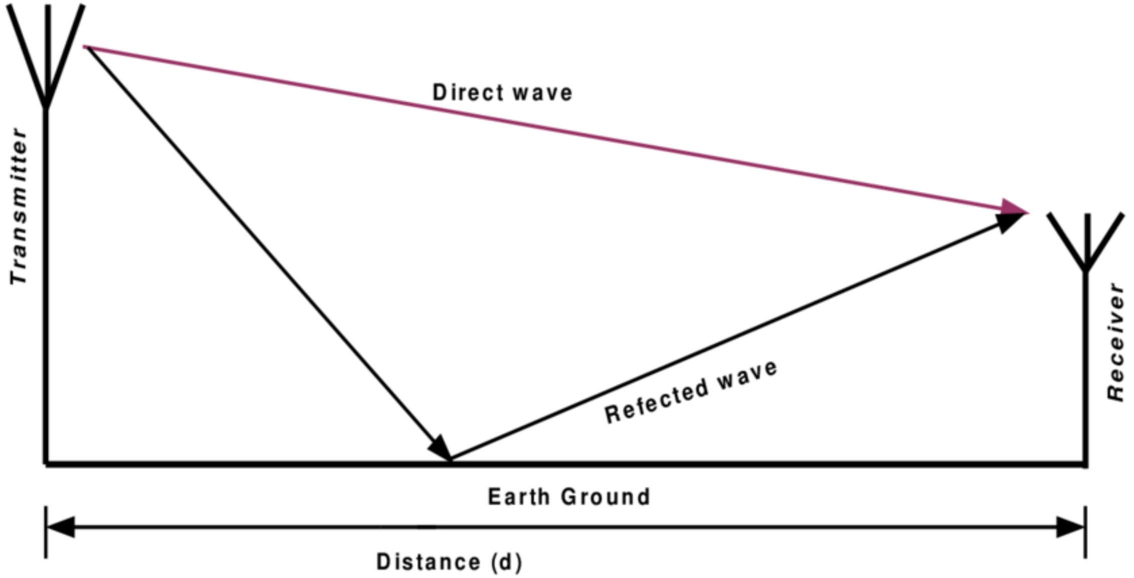
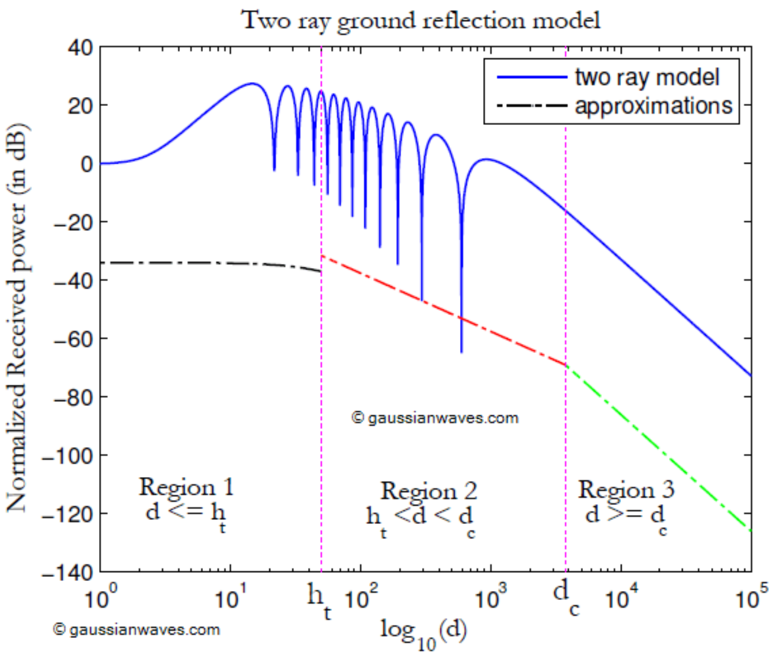
- A. Observation
- 2) Dynamic Channel-Hopping Behavior



III. Results and Discussions

- A. Observation
- 3) Signal Nulls and Propagation Behavior





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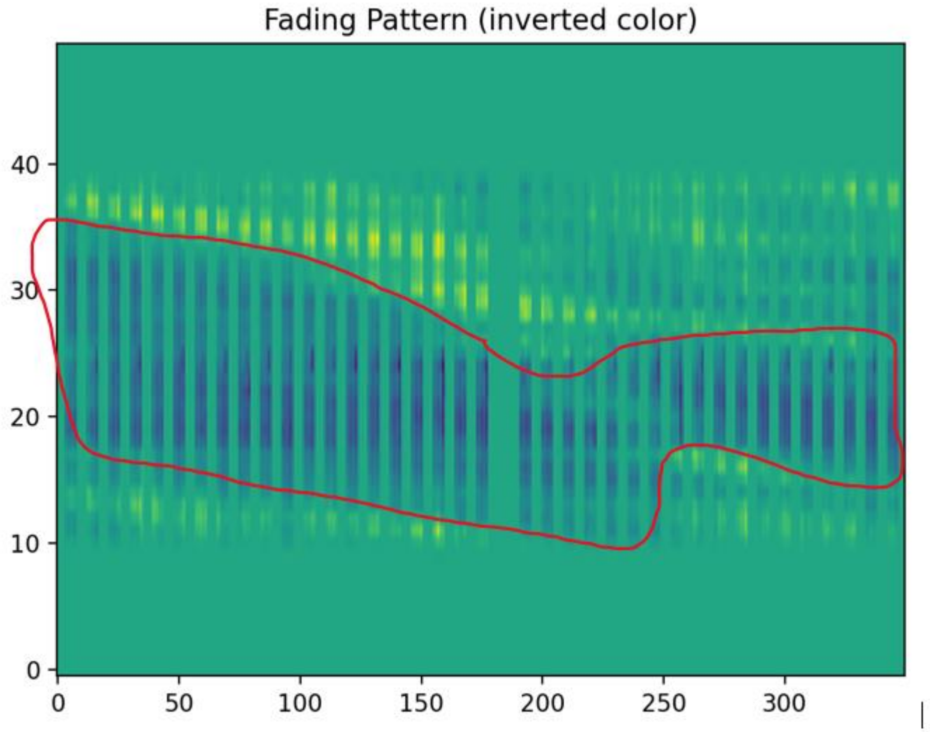
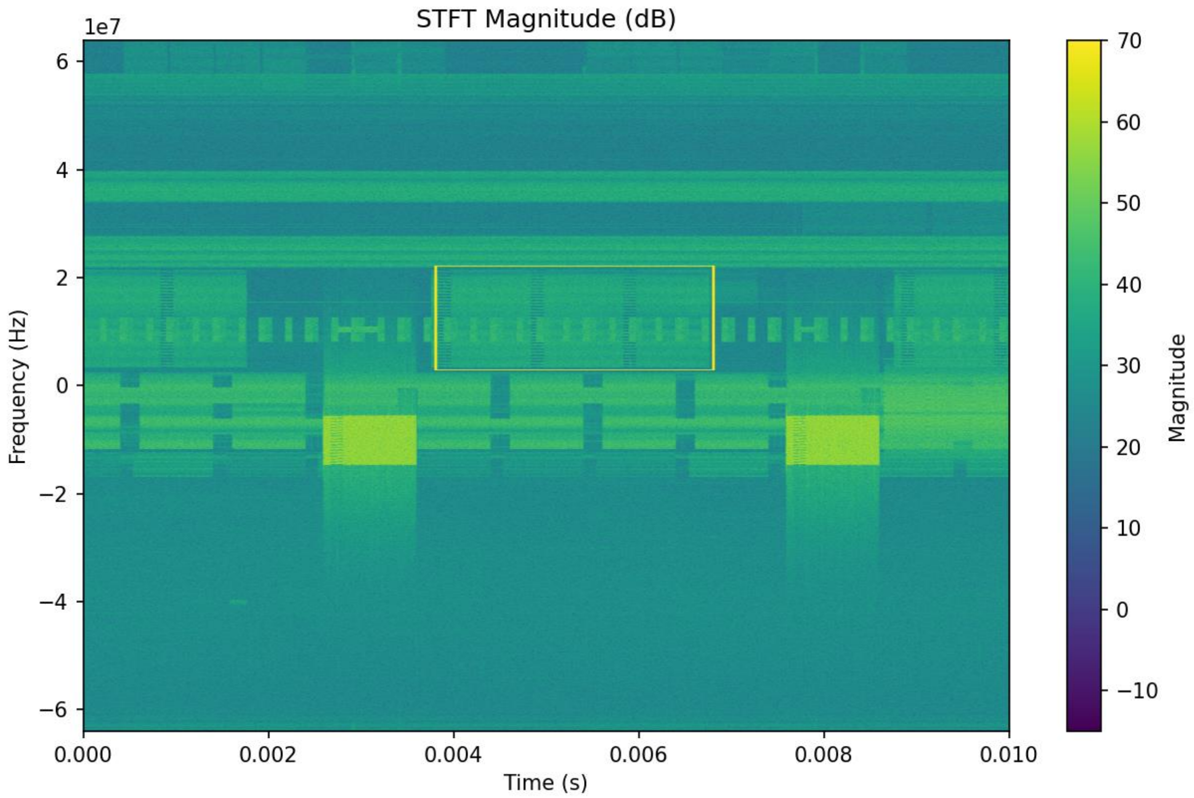


III. Results and Discussions

- A. Observation
- 4) Correlation Analysis for Packet Identification



IV. Conclusion

- Demonstrated Feasibility

1. Successfully utilized RFSoC and SDR for drone detection
2. Captured and analyzed RF signals across various drone operations

- Key Findings:

1. Dynamic Channel-Hopping Behavior
2. Signal Propagation Modeling
3. Correlation-Based Packet Identification

V. Future Work

- A. Challenges and Limitations
- Regulatory constraints
- Limited access to diverse commercial drones

- B. Advancing Toward Full Automation
- 1. Machine Learning Integration
- 2. Real-Time Implementation of RFSoC and FPGA
- 3. Dataset Expansion

Acknowledgments

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- Collaborators: William Davis, Quintin Lopez-Scarim and Raul Valle
- Family member

Thank You!
Questions?