

Introduction & Background

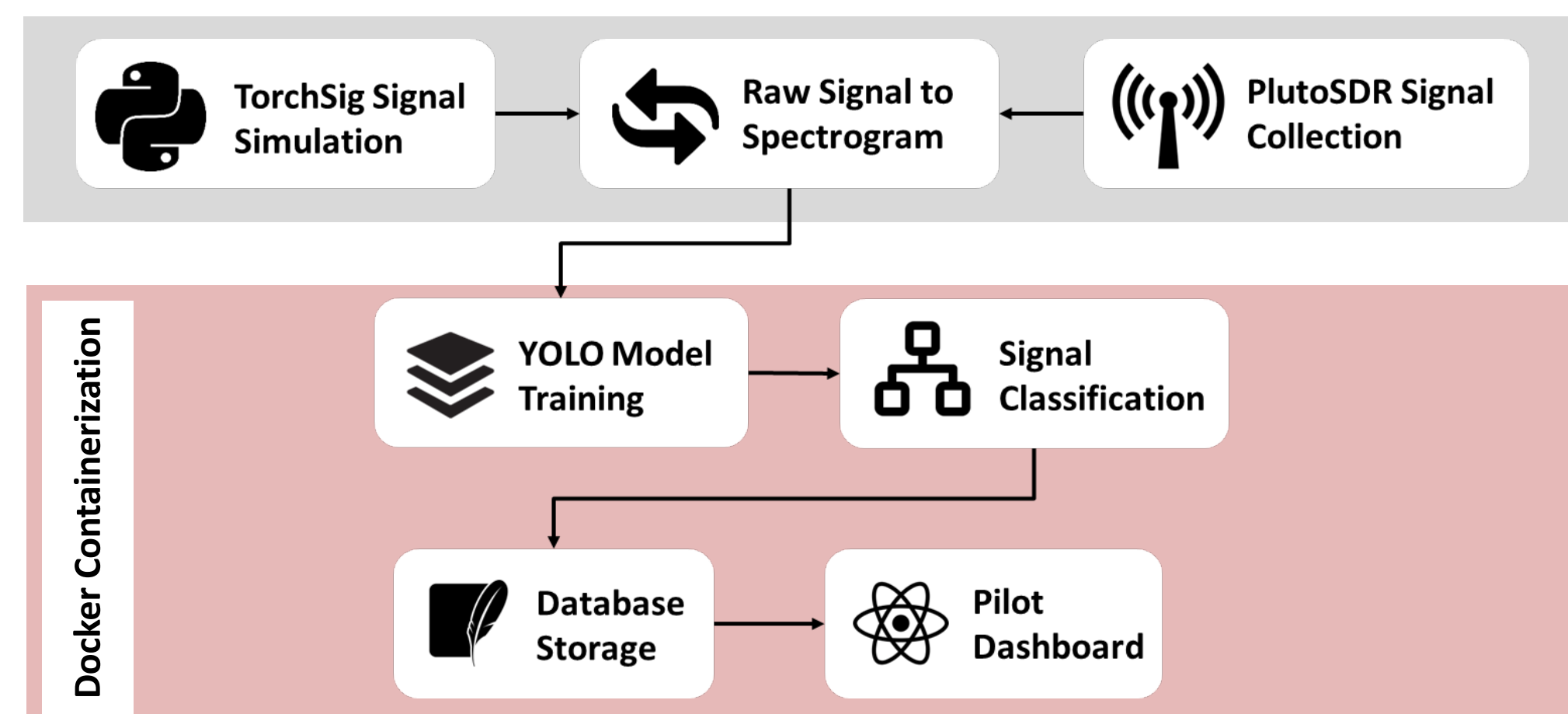
Modern airspace is crowded with radio frequency (RF) signals, from everyday Wi-Fi to critical radar systems. These signals are electromagnetic waves that carry information but distinguishing between benign and anomalous signals in real time is challenging and high-stakes.



This project develops an automated RF signal classification system that identifies signal types quickly and accurately. The goal is to support pilot decision-making and defense applications.



Methodology



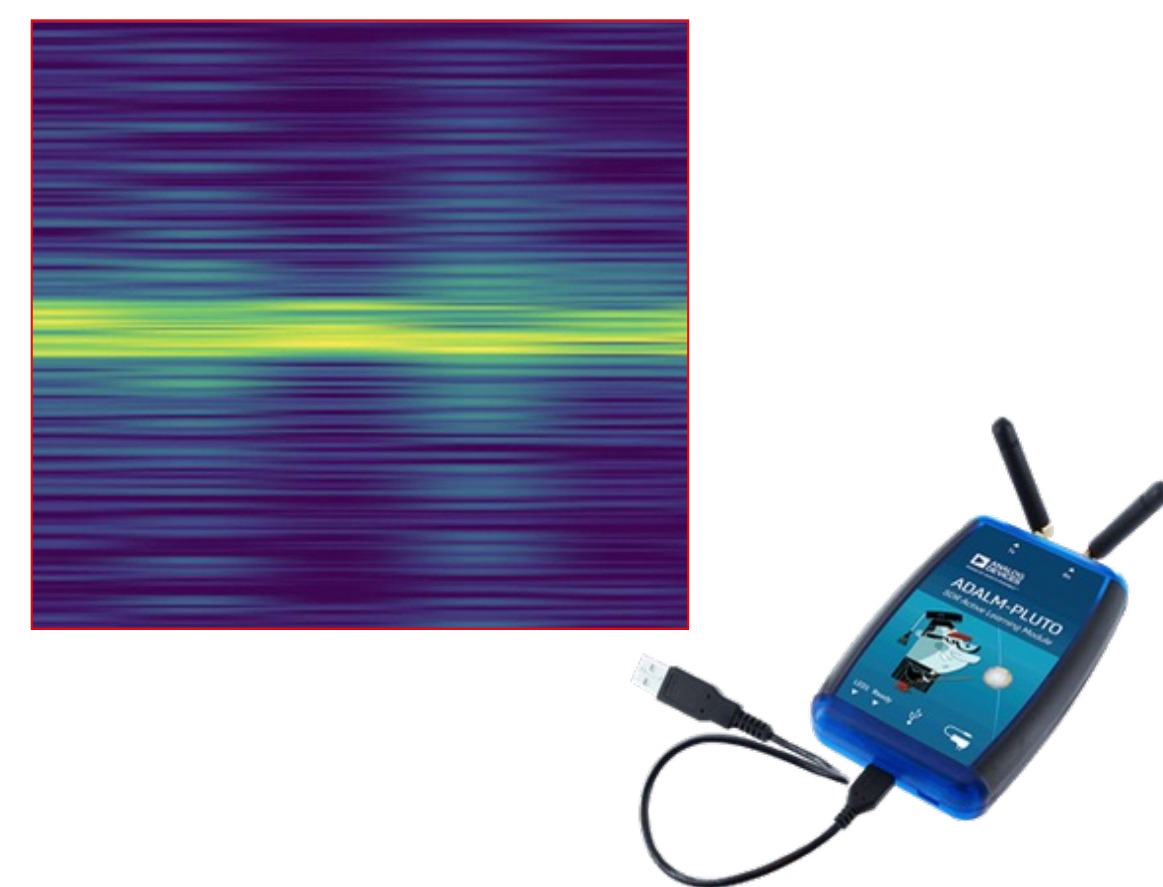
The overall workflow consists of **three main stages**:

- Signal Generation and Spectrogram Conversion:** Raw signal data is simulated or collected, then converted into spectrogram images using TorchSig, a Python library.
- Model Inference:** A YOLO classification machine learning model (CNN) analyzes spectrogram images to identify signal types.
- Logging and Dashboard:** Classification outputs and metadata are stored in a SQLite database for display in pilot dashboard.

Pipeline Implementation

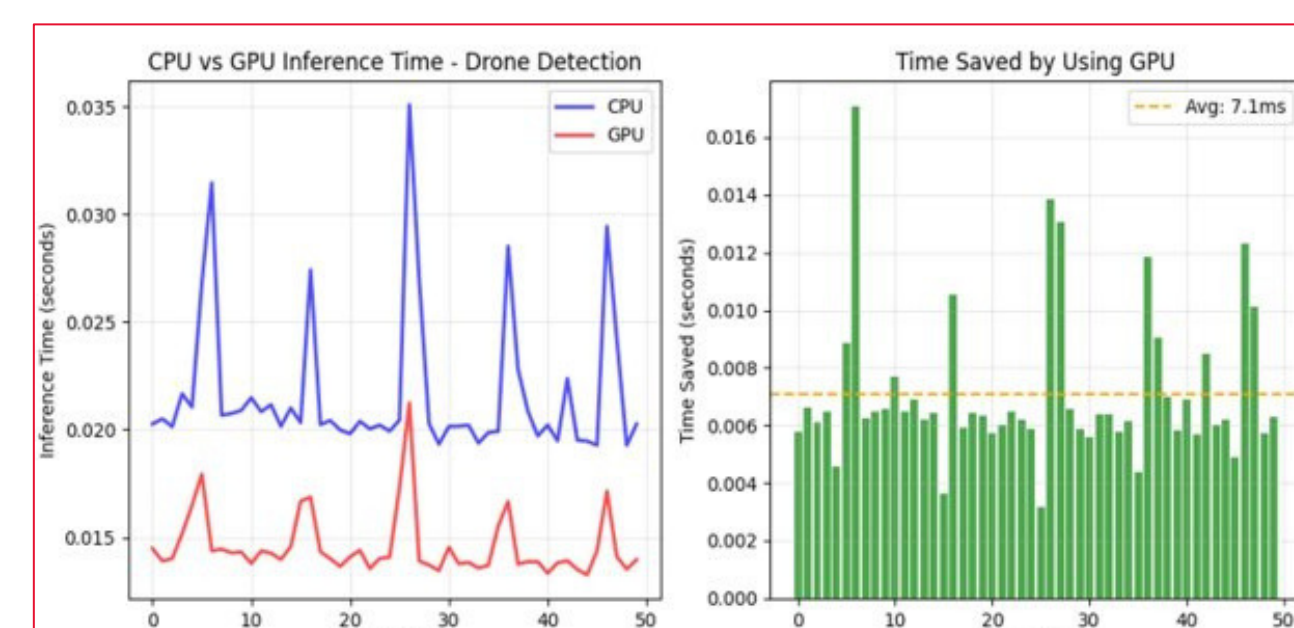
DATA SIMULATION

- Generated simulated RF signals representing a variety of signal types
- Converted signals into a spectrogram images, enabling CNN learning
- Labeled samples to provide the model more context for classification
- Validated on live data collected from PlutoSDR



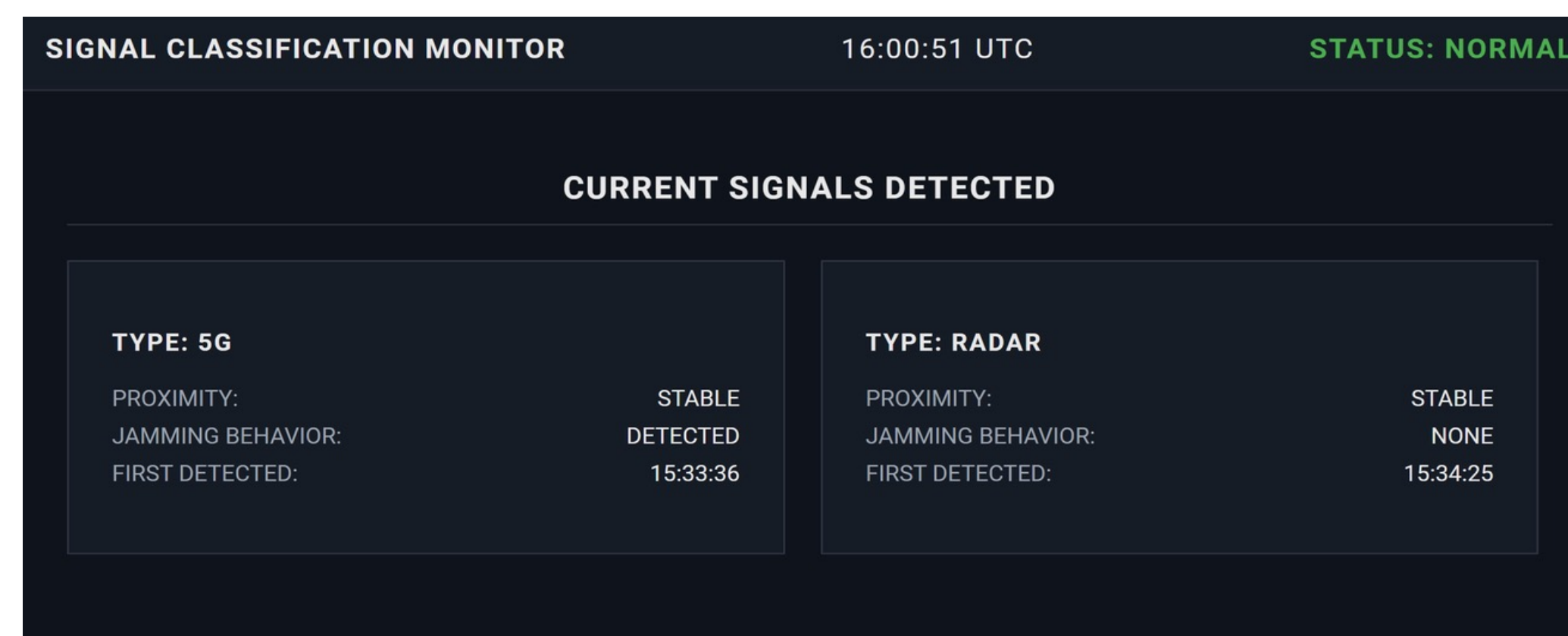
MODEL TRAINING

- YOLO (You Only Look Once) model architecture
- One-pass image processing for speed & performance
- Classifies spectrogram as valid, anomalous, or noise
- Utilizes GPU processing to perform inference and training faster



IN-FLIGHT ARCHITECTURE

- Designed a pilot-focused dashboard that presents classification results
- Deployed the system using Docker containers for portability across environments



Conclusion

- Gained industry-relevant experience working under the mentorship of Raytheon engineers.
- Applied and deepened knowledge across signal processing, machine learning, and UX design throughout the project lifecycle.
- Built a pipeline that simulates RF signals, trains a YOLO model to classify them, and outputs live classification results on pilot's dashboard.
- Developed a functional, deployable system with real-world applications in defense and aviation environments.

Future Work

Improve training

- Expand the dataset with more signal classes and larger sample sizes.
- Gather real-time flight data to train model with accurate data

Model alternatives

- Evaluate alternative model architectures to improve classification accuracy.
- Further model parameter tuning for improved efficiency

Enhance performance

- Same-signal identification to reduce computation on lengthy signals
- Perform in-flight test run for pilot feedback

Acknowledgements

Thank you to our Corporate Partners Mentor Mike Douglass and other RTX employees including Chris Moffatt, Colin Funai, and Erik Davis. Thank you to the Data Mine staff, including Pete Dragnev, Cai Chen, and our TA Rylan.