CAPSTONE DESIGN EXPO | Multi-Departmental | MULTI 25-607

Machine Learning for RF Spectrum Sensing

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PROBLEM STATEMENT

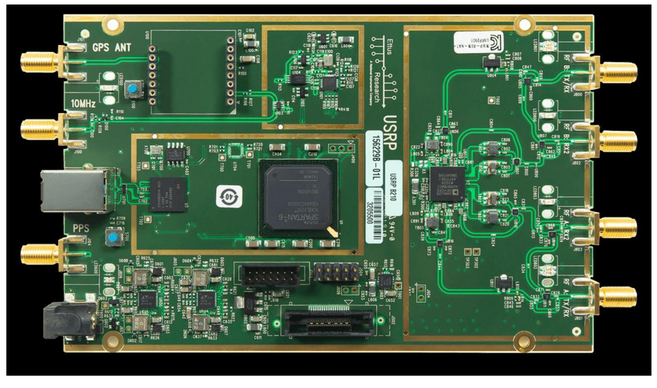
- Develop a system to classify between radio frequency (RF) signals with a primary focus on Bluetooth and Wi-Fi at 2.4 GHz
- Currently the Navy relies heavily on manual classification of signals
- This system will utilize a machine learning algorithm to automate this process

ADVANTGES

- Avoids human error
- Vastly speeds up detection/decision making process
- Requires far less training to operate over current methods

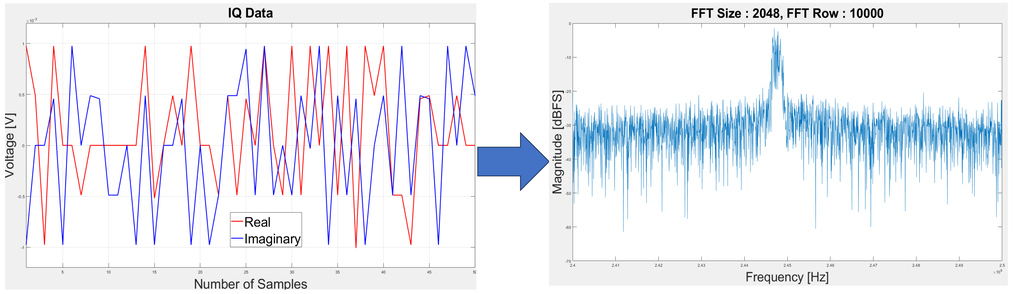
DATA COLLECTION

- Capture IQ data from the B210 SDR (software defined radio), providing a complete signal representation with both amplitude and phase
- IQ data represents the real in-phase (I) and imaginary out of phase quadrature (Q) components of the signal
- IQ data is dense and requires powerful computing for real-time processing.



B210 SDR used for data capture

IQ Data → PSD Data



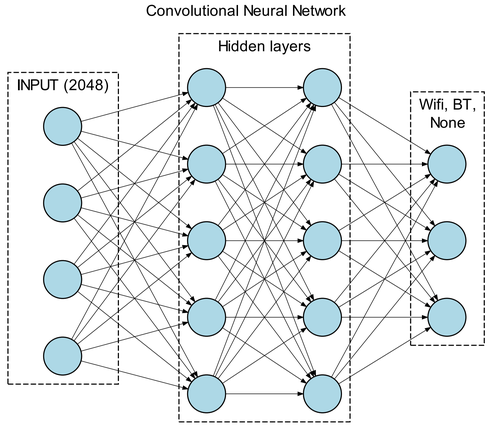
- An FFT is used to convert IQ data into Power Spectral Density (PSD) for clearer frequency domain analysis
- PSD data gives the power versus frequency of the signal

PSD is much less dense than IQ data, enabling faster computation and more efficient analysis

These individual PSD slices are then combined into a waterfall plot

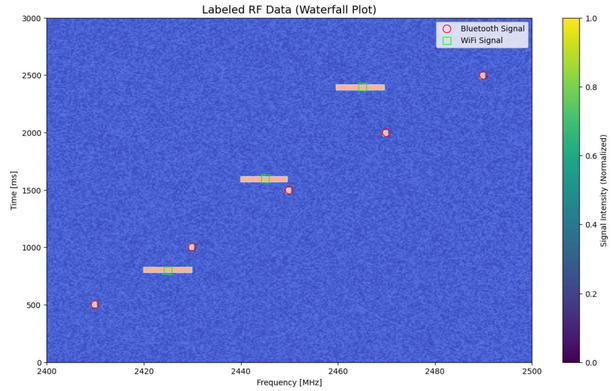
Time is the Y-axis, frequency is the X-axis, and the amount of power is given by the color

PSD Data → CNN



- The input size matches the FFT size (2048), representing the PSD data.
- The PSD data is processed through two fully connected hidden layers.
- Finally trinary output layer of BT, Wi-Fi, or None.

SIGNAL IDENTIFICATION



- **Bluetooth Signals**:
  - Marked with red circles.
  - Narrow 1 MHz bandwidth.
- **Wi-Fi Signals**:
  - Marked with green squares.
  - Wider 10 MHz bandwidth.
- **Highlighted Frequencies**:
  - Orange regions indicate active transmissions.
  - Markers distinguish signal types for spectrum sensing.

WHY IT MATTERS

- This technology can be expanded to look at other parts of the RF spectrum, such as the various radar windows used by the military
- Cuts down on manpower required to monitor radar systems
- Ensures accurate identification in time-sensitive situations

NEXT STEPS

- Test multiple data collection methods and train multiple models to determine best method
- Maximize model's accuracy in distinguishing between Wi-Fi and Bluetooth datasets
- Test model's ability to distinguish between data in a live setting

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