Poster No: 37

Investigation into Information Extraction from Raw SAR data using Deep Learning

Andrew McAllister Supervisor: Dr Carmine Clemente

University of Strathclyde Engineering

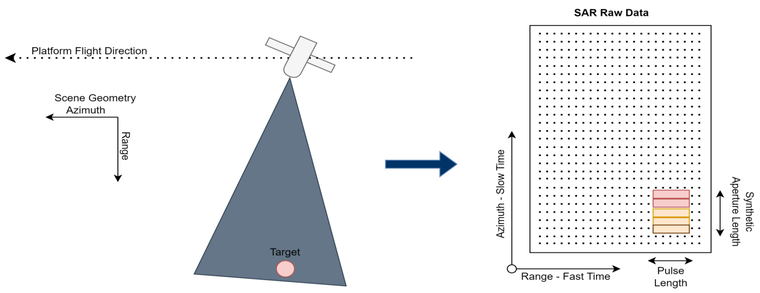
Project Delivery Aims

- Develop a SAR raw data processing framework that improves on wasteful & expensive processing
- Develop a processing framework that is able to perform object detection from raw data
- Conduct a suitable performance assessment to clarify results for direction of further work
- Identify and produce suitable datasets to be used to test framework

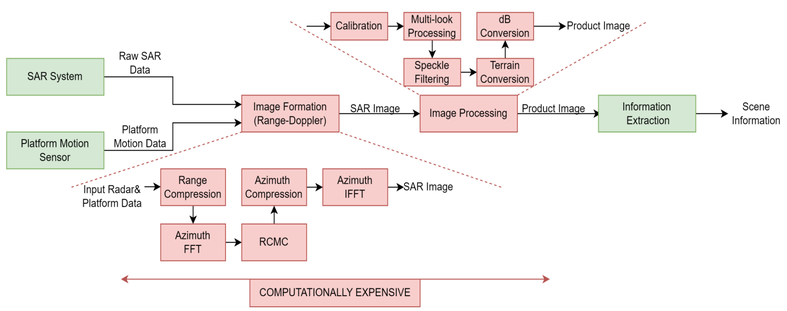
Synthetic Aperture Radar (SAR)

- SAR is a radar commonly used to take greyscale images
- Some advantages of SAR include its non-reliance on visible light allowing night vision and penetrative images through clouds or vegetation
- Applications include Military Surveillance, monitoring of deforestation, detection of oil spills at sea and more
- Raw data returns represented by 2D complex matrix that often contains dozens of thousands of rows and columns
- This creates a large memory occupation and greatly increases downlink requirements from platform
- Complex processing algorithm (eg Range-Doppler) required to convert to an image offboard the platform
- Often images of little info are processed wasting resources

Raw SAR Data Aquisition



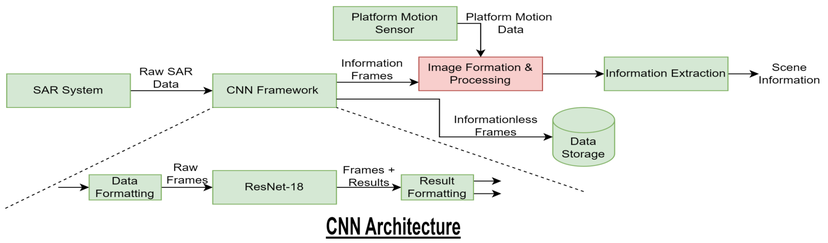
Traditional SAR Data Process



Proposed Solution

- Eliminate wasteful processing by identifying valuable frames
- Convolutional Neural Network (CNN) used on raw data formatted as RGB image to extract complex patterns and find targets
- RGB image formatted Real, Imaginary and Magnitude/Phase
- CNN's designed to mimic structures present in human brain
- Trained Network (ResNet-18 used in framework) can filter out any information-less frames saving processing for valuable frames

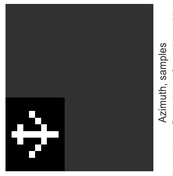
Proposed Processing Framework



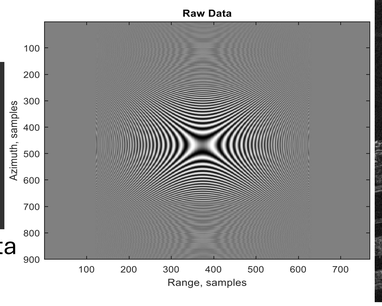
CNN Architecture

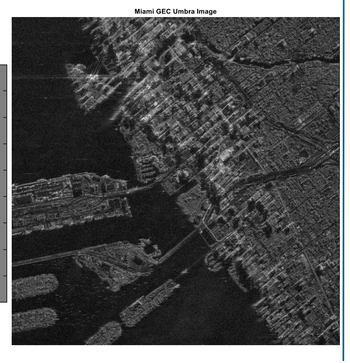
Datasets

- Synthetic and Pseudo Real data sets used for testing
- Synthetic data generated from images of planes/tanks
- Pseudo Real data generated from Umbra SAR images
- Synthetic Data generated at varying noise level from -30dB to 0dB with a random SNR set used for validation
- Umbra Images taken from Miami, Cannes and Melbourne
- Pseudo Real data created with random SNR
- All data generated in Matlab using a script to replicate real SAR complex echoes



Synthetic Data



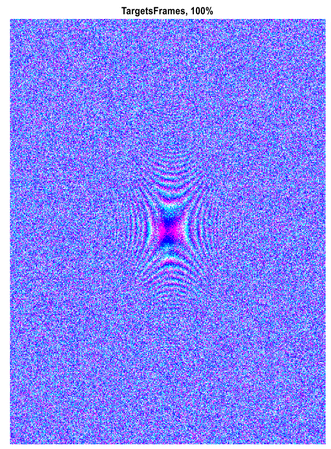


Results

- Synthetic Datasets ran over each implementation of framework to perform either detection or classification
- Pseudo Real Datasets ran over best performing framework as a detection
- Accuracy of network measured as a % of frames detected/classified correctly as well as mean confidence of each frame
- Real, Imaginary, Phase format found to be most successful implementation with ResNet-18

SNR (dB)	Mean Accuracy RIM (%)	Mean Accuracy RIP (%)	Overall Accuracy RIM (%)	Overall Accuracy (%)
0	99.9	99.8	100	100
-5	99.8	99.7	100	100
-10	99.2	99.6	100	100
-15	92	95.9	93.3	100
-20	85.5	89.8	86.8	93.3
-25	60.7	77.5	73.3	76.7
-30	68.3	68.2	73.3	83.3

Table of Synthetic Results for RIM vs RIP Dual Class



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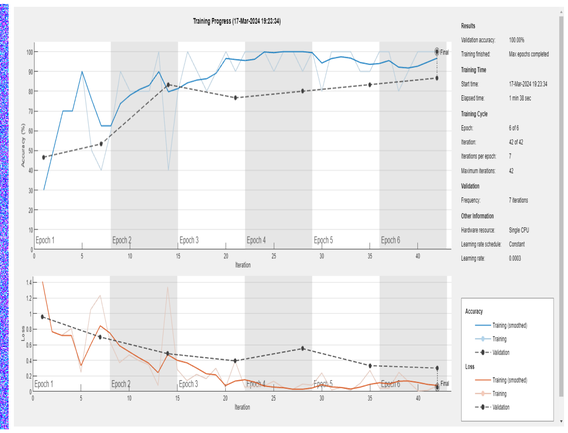

Example Results From Detection Network

Conclusion & Future Work

- Processing Framework using CNN (ResNet-18) developed to mitigate wasteful processing of raw SAR data
- System optimised and tested using synthetic and pseudo real data
- Next steps, further develop framework to process larger datasets of real raw SAR data

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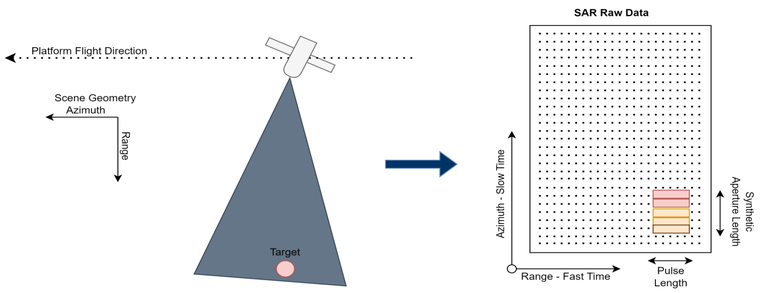

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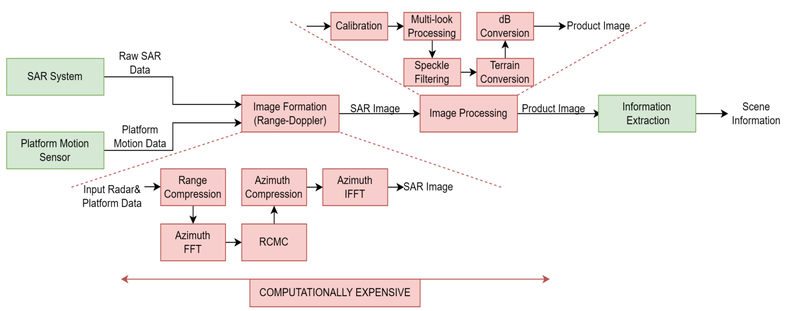

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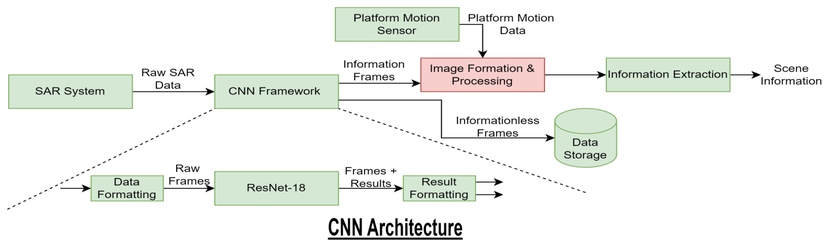

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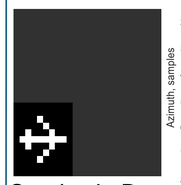

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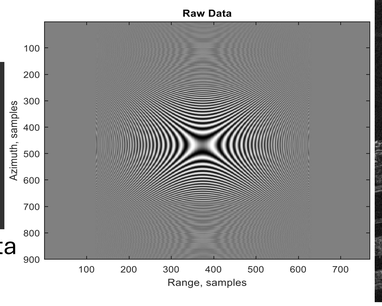

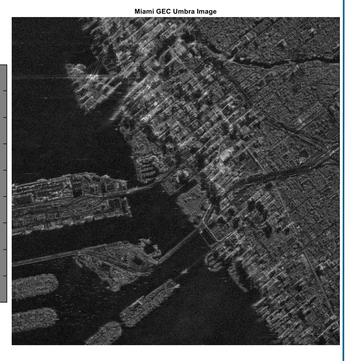

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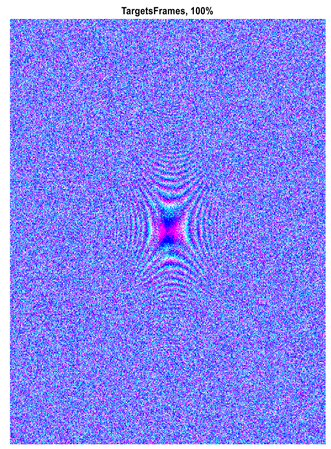

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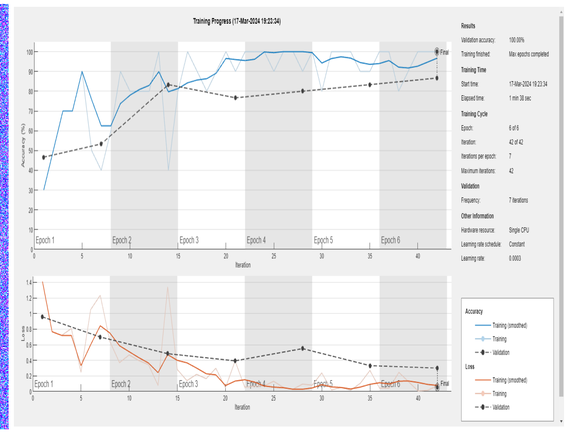

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