Sandia National Laboratories

DEEP LEARNING FOR SAR ATR: A MULTI-RESOLUTION APPROACH

Matthew Thomas | University of Texas at Austin | B.S Computational Engineering | Spring 2027
Manager: Anton Sumali (5447)|Mentors: Michelle Hummel, Christopher Pitts (5445)| August 2025

Background

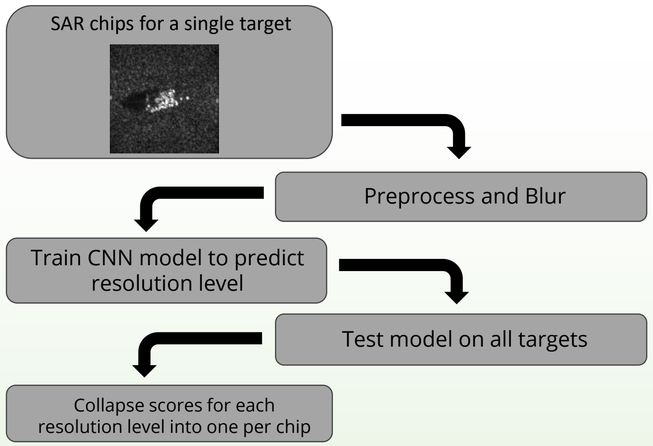
Synthetic Aperture Radar (SAR) is a powerful tool for obtaining imagery in mission scenarios and can be leveraged by Automatic Target Recognition (ATR) software to identify targets of interest. While Convolutional Neural Networks (CNN) have shown success at this purpose, challenges arise from the lack of available SAR data. When trained with purely computer-generated (synthetic) data, CNN's have shown difficulty generalizing to real (measured) data. In addition, ATR needs the ability to reject out of distribution non-targets, which conventional CNNs do not allow.

Data

SAR images (chips) of various military vehicles from the open source SAMPLE[3] dataset were used for this project.

Stage	Data Type	Depression
Train	Synthetic	<75th percentile
Validation	Synthetic	>75th percentile
Test	Measured	<75th percentile

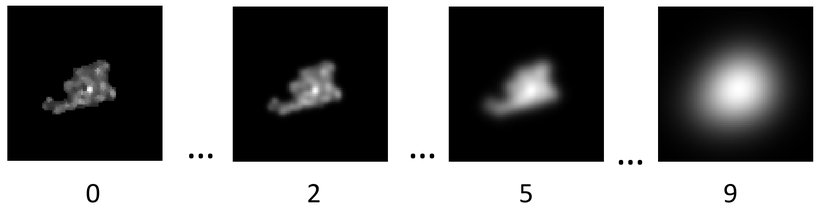
Methods



Purpose

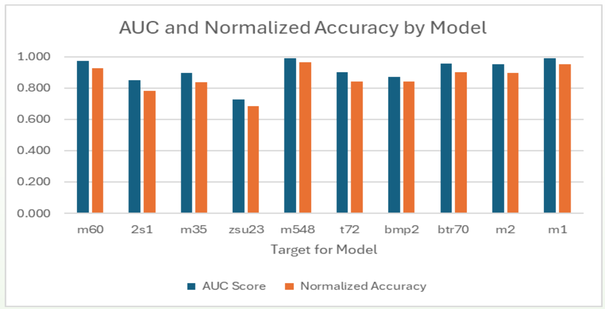
In this presentation, we present a one-class classifier for SAR ATR that uses a blurring method to alleviate the effect of the differences between synthetic and measured image data as well as allow for the ability to reject non-targets [1][2]. With this method, the need for measured data when training CNNs can be decreased, allowing for easier development of ATR.

Resolutions



There exists a resolution M < N, where N is the max number of resolutions, such that predicted and measured data can be considered the same.[2]

Results

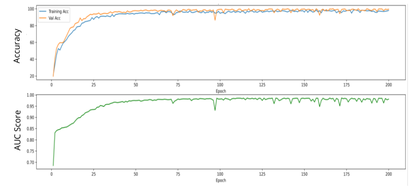


The 10 one-class classifiers were shown to distinguish between targets and non-targets with high accuracies.

Target Asymmetries

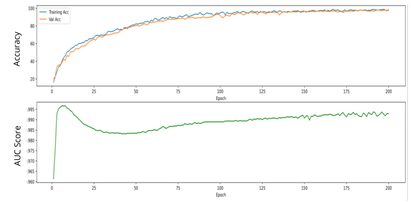
While training and validation accuracies and AUC scores are high for all targets, there is notable variation in test metrics between some targets.

Training



Testing

Target: ZSU23
AUC: 0.682
Accuracy: 0.64



Target: M548
AUC: 0.982
Accuracy: 0.962

Discussion

- With this multi-resolution technique, the models produced an average test accuracy of 0.863 on measured data despite being trained and validated solely on synthetic.
- Given the vast differences in test results between some targets with similar training metrics, it appears that some are more at risk of being overfit, as there may be a higher difference between synthetic and measured data for the targets which produce poorer results.
- This problem can be somewhat alleviated with proper hyperparameter tuning and early stopping during training.
- Next steps include combining the CNN models into a multi-class, open-set classifier and exploring how this method performs on other SAR datasets.

References

[1]Koch, M.W. (2024) *Scale Space CNN Results* [PowerPoint slides]. Sandia National Laboratories, Internal presentation.
[2]Koch, M.W. (2023) *Scale-Space CNN: OOD Generalization and Detection* [PowerPoint slides]. Sandia National Laboratories, Internal presentation.
[3]Lewis, B., Scarnati, T., Sudkamp, E., Nehrbass, J., Rosencrantz, S., & Zelnio, E. (2019). A SAR dataset for ATR development: The Synthetic and measured paired labeled experiment (sample). Algorithms for Synthetic Aperture Radar Imagery XXVI. https://doi.org/10.1117/12.2523460

U.S. DEPARTMENT OF ENERGY
National Nuclear Security Administration

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

SAND2025-09319D

Sandia National Laboratories