Using Machine Learning to Locate Copper Rods within a Portable Microwave Detection Device

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INTRODUCTION

Breast cancer comprised 24.5% of female cases in 2020, with high mortality rates in low/middle economic countries where early detection is difficult [1].

Mammography

[2]

- Requires breast Compression
- Uses ionizing Radiation
- Need for trained technicians to operate
- Expensive, heavy equipment

vs **Microwave Detection**

- No breast compression
- Uses non-ionizing radiation
- Cheaper, smaller, portable equipment

[3]

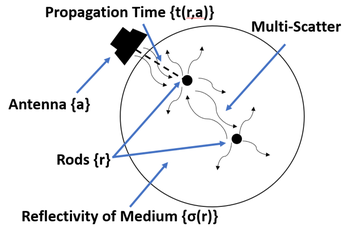
Machine Learning

- Microwave signals can be measured and used for imaging and machine learning.
- Allows tumour detection, classification, location, and/or mapping.
- Automatic function desirable for portable devices.
- Transfer learning allows smaller data set sizes

OBJECTIVE: Develop a learning network to detect and locate rods from signal data

METHODS

Forward Projections



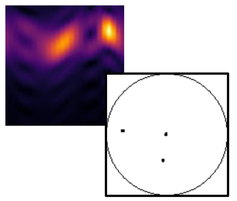
X 128 Frequencies
(0.7 – 3 GHz)
X 26 Antenna Positions

Data Augmentation

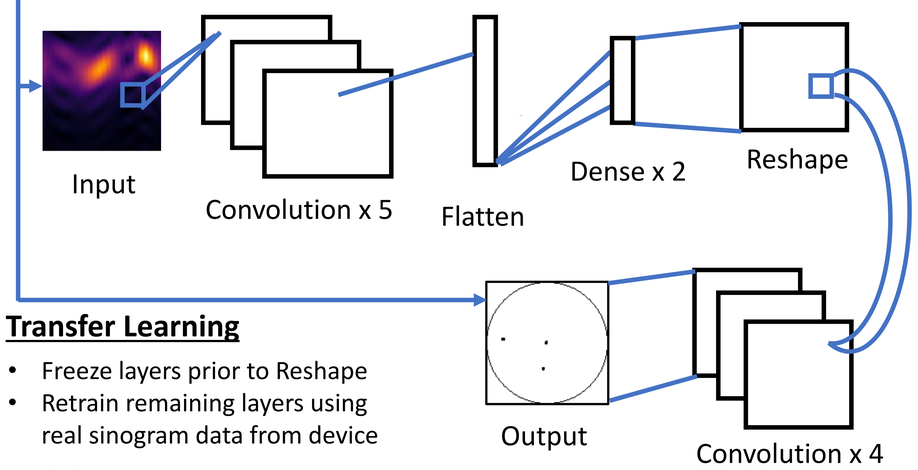
For each integer **n** in the range **[1,25]**:
1) Rod model rotated **~13n°**
2) Sinogram shifted **n** columns to the left.
25 Data Augmentations per Unique Projection

Data Set

- Sinogram Input, Rod Model Output
- Total Data Set Size of 195 000
- Uniquely Generated Models:
  2500 Single Rod / 2500 Dual-Rod / 2500 Tri-Rod
- Training/Testing Split: 70/30



Network



Transfer Learning

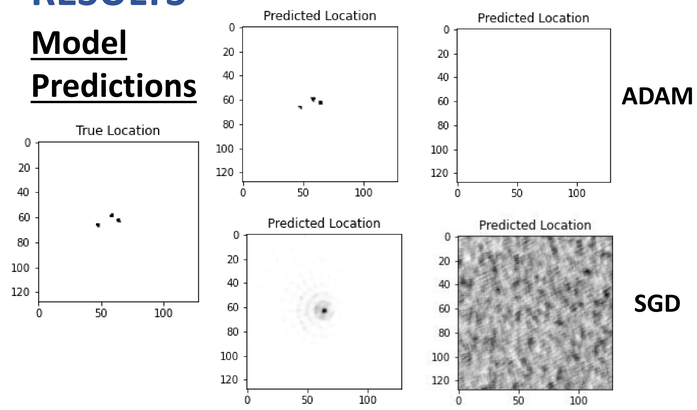
- Freeze layers prior to Reshape
- Retrain remaining layers using real sinogram data from device

Training Parameters

- **Loss Functions (calculates accuracy of predictions):**
  - Binary Cross-Entropy (BCE), Mean Squared Error (MSE)
- **Optimizers (changes network based on loss function) :**
  - ADAM, Stochastic Gradient Descent (SGD)

RESULTS

Model Predictions



Model Predictions (BCE/ADAM)

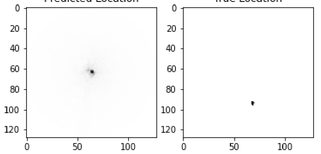
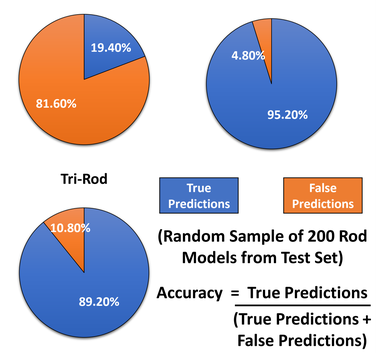


Image Accuracy Test (BCE/ADAM)



(Random Sample of 200 Rod Models from Test Set)

$$\text{Accuracy} = \frac{\text{True Predictions}}{\text{(True Predictions + False Predictions)}}$$

Conclusion

A learning network has been created for rod detection and location. The network was good for detecting different rod model, but struggled to locate single-rod models. In the future, a better representation of single-rod models can be used in the data set to reduce this issue. Transfer learning will later be used on the network with a small data set of real sinogram data.

References

- [1] Sung, H, Ferlay, J, Siegel, RL, Laversanne, M, Soerjomataram, I, Jemal, A, Bray, F. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2021: 71: 209- 249. https://doi.org/10.3322/caac.21660.
- [2] Maden, Ashley. "3D Mammography Coming to HGH." Nevada News Group, 30 Aug. 2019, insidenorthernnevada.com/Content/NEWS-Homepage-Rotator-/NEWS-Homepage-Main/Article/3D-Mammography-coming-to-HGH/31/175/42228.
- [3] Shere, M. et al. "MARIA® M5: A multicentre clinical study to evaluate the ability of the Micrima radio-wave radar breast imaging system (MARIA®) to detect lesions in the symptomatic breast." European journal of radiology 116 (2019): 61-67 .