MLDL

Machine Learning and Deep Learning Conference 2019

SAND2019-9054C

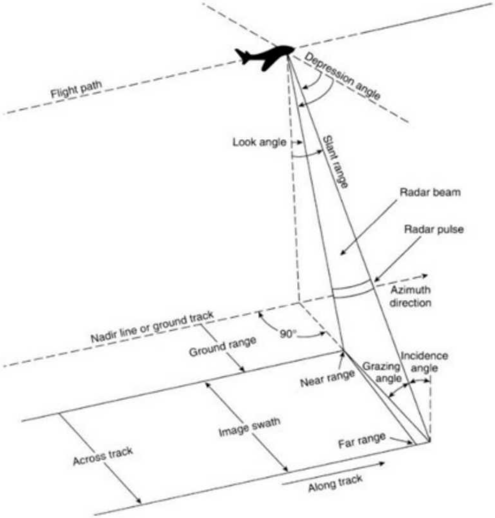
SAR ATR Using Deep Latent Spaces

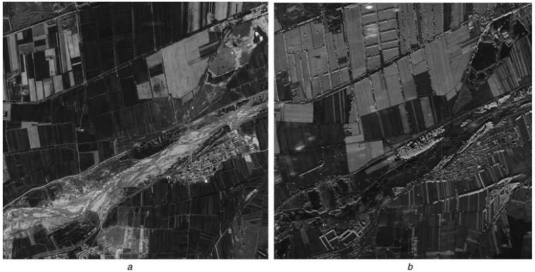
July 29, 2019

Matt Kagie | 5448

Funded by LDRD

SAR images are significantly different than optical images.

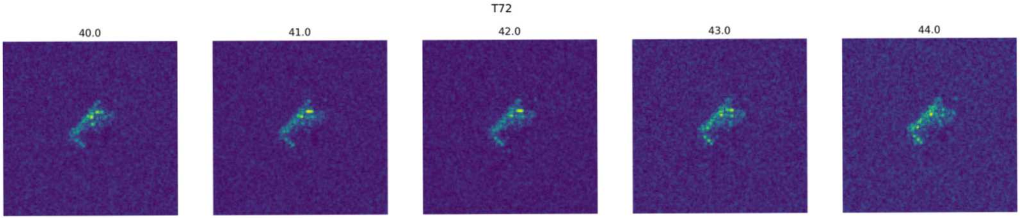


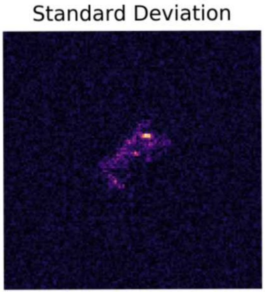


a. Optical b. SAR

Image from https://www.researchgate.net/figure/Comparison-of-the-optical-images-of-Earth-surface-and-the-SAR-image-a-Optical-satellite_fig2_301598943

SAR Automatic Target Recognition (ATR) is difficult.





Problem Overview

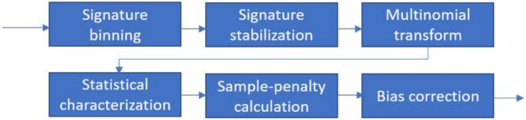
State-of-the-Art

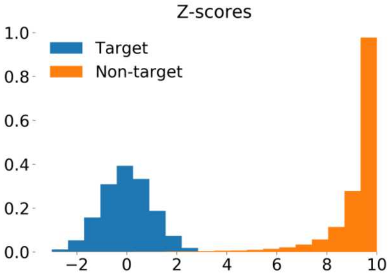
Siamese Variational Autoencoder

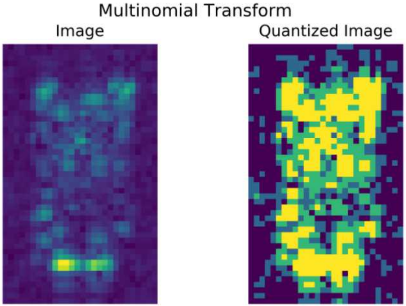
Results

Future Work

The state-of-the-art SAR ATR algorithm is Multinomial Pattern Matching (MPM).



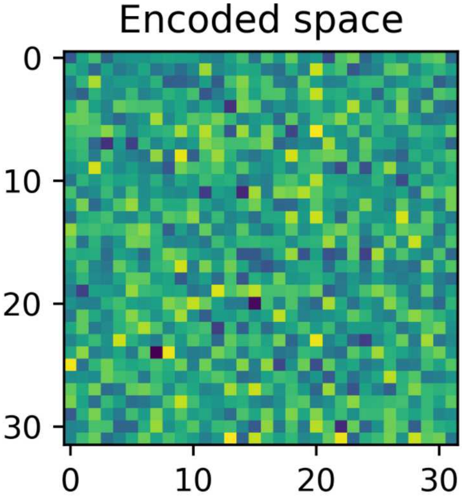




$$Z = \frac{1}{C} \sum_{k=1}^{K} t_{k,q_k}$$

We would like to improve upon MPM using deep learning.

- Can we bin at larger geometry bins?
- Can we become shift invariant?
- Can we remove the need for a mask?
- Can we enable low-shot learning by synthesizing data?



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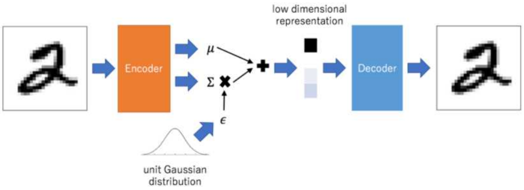
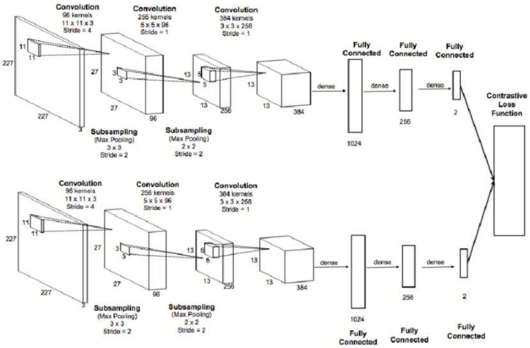
Some background on applicable deep architectures.

Variational Autoencoder



Siamese Network



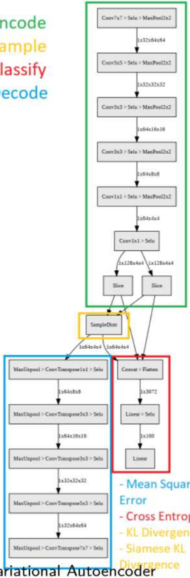
https://www.semanticscholar.org/paper/

A-Deep-Siamese-Neural-Network-Learns-the-Similarity-Rao-Wang/

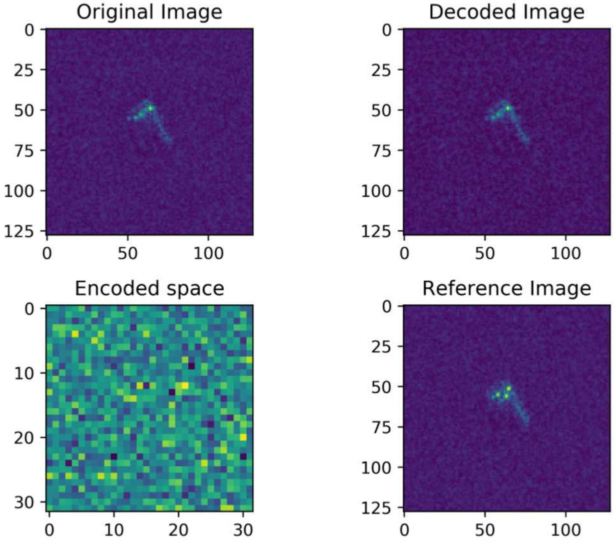
3e16932979250e66cd2cb4d8c9a5411e195273be

We propose a Siamese Variational Autoencoder (SVAE).

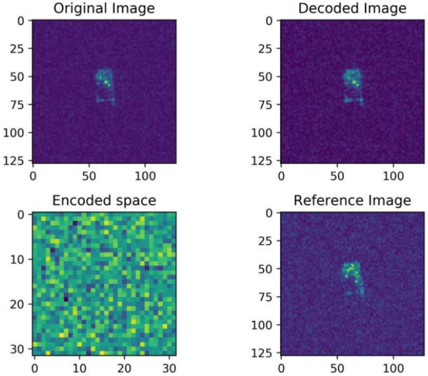
Encode
Sample
Classify
Decode

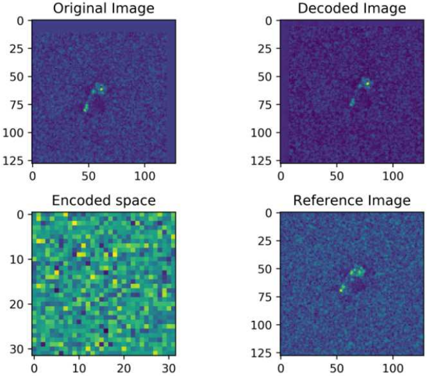


- Mean Square Error
- Cross Entropy
- KL Divergence
- Siamese KL Divergence



Example outputs from SVAE.





We have run several experiments for MPM.

SVAE Training Information

- Trained using synthetic data spanning 25-35 degrees depression angle
- Trained using binning of 20 degrees aspect angle for reference

TMPM Training Information

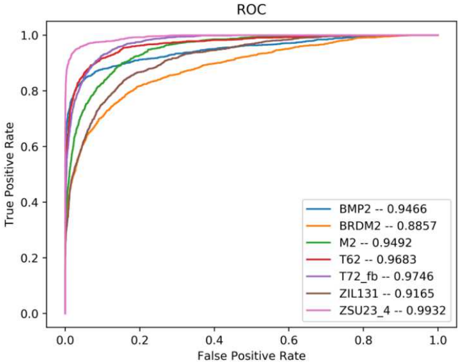
- Trained on 25-30 degrees depression angle
- Tested on 31-35 degrees depression angle

Experiments

- Train TMPM directly on data, bin in 5 degrees and 20 degrees, with masks
- Train TMPM directly on data, bin in 5 degrees and 20 degrees, without masks
- Train TMPM on embedding, bin in 5 degrees and 20 degrees
- Train TMPM on embedding, bin in 5 degrees and 20 degrees, with shifts in data

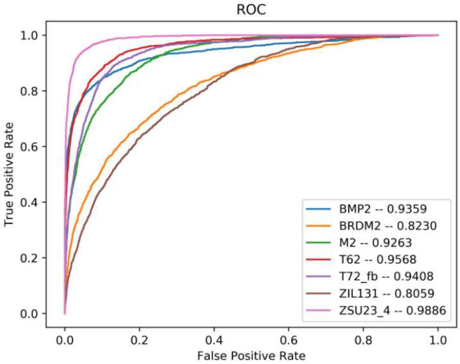
Baseline MPM – with masks

5 degrees



84.5% Accurate

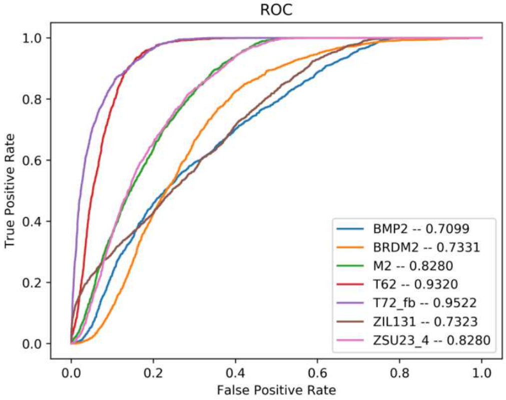
20 degrees



73.5% Accurate

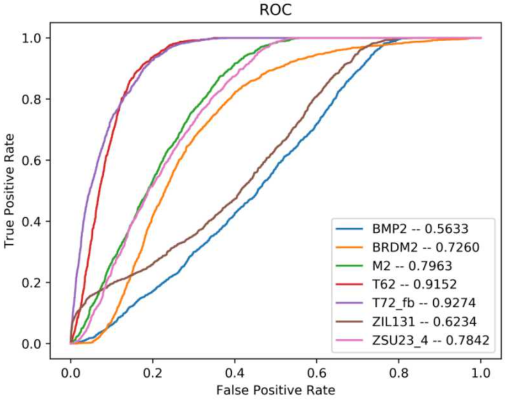
Baseline MPM – no masks

5 degrees



76.4% Accurate

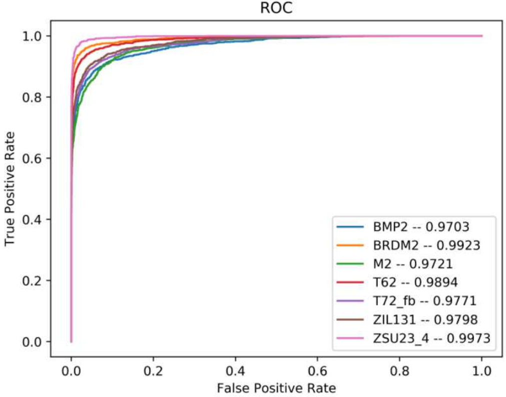
20 degrees



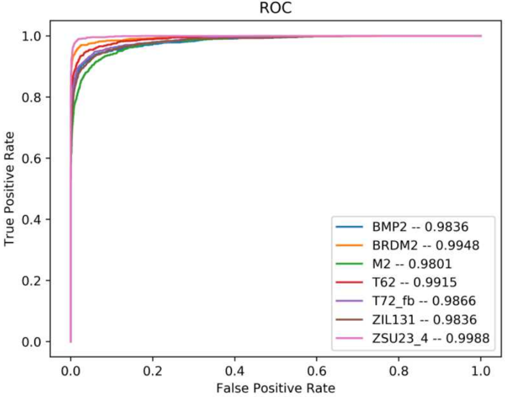
55.6% Accurate

SVAE

5 degrees	20 degrees



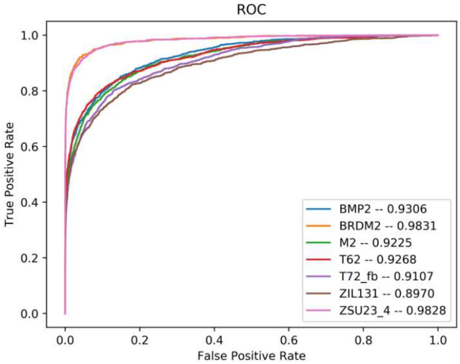
99.9% Accurate



99.97% Accurate

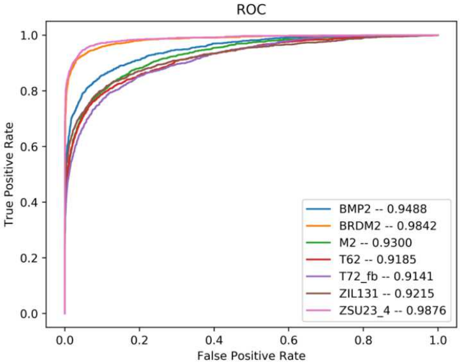
SVAE – shifted

5 degrees



97.6% Accurate

20 degrees



98.6% Accurate

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Future Work

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and 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.

Future Work

- Train SVAE on reduced number of targets to reduce data overlap
- Low-shot learning using SVAE from synthetic data
- Hyperparameter tuning of TMPM in this new space
- Analyze trade-offs between bin geometry and performance
- Train on synthetic, test on real
- Evaluate on data from multiple sensor models