DHS SCIENCE AND TECHNOLOGY

DeepXplore: Automated Whitebox Testing for Neural Networks

Homeland Security

Science and Technology

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Science and Technology Directorate

So What? Who Cares?

- Space: DeepXplore can be used for testing Deep Learning (DL) based Automatic Target Recognition (ATR) algorithms in Advanced Imaging Technology (AIT) systems.
- Problem: The blackbox nature of neural networks can make it difficult to identify learned features and edge case examples
- Solution: DeepXplore's Automated Whitebox Testing Framework
- Conclusion: Utilized DeepXplore to create image augmentations realistic to Advanced Imaging Technology (AIT) systems and test ATR algorithms.
- Future Work:
    - Refine image augmentations to cover realistic bounds of change and extend AIT augmentations to cover adversarial augmentations.
    - Design physical data collection to match synthetically generated data and quantify weaknesses in algorithm performance.

DeepXplore Testing

- Uses unlabeled test inputs to generate new, synthetic inputs using augmentations that both activate a large number of neurons within a DNN and cause similar DNN's to behave differently.

- Paper: DeepXplore – Automated Whitebox Testing of Deep Learning Systems https://arxiv.org/abs/1705.06640

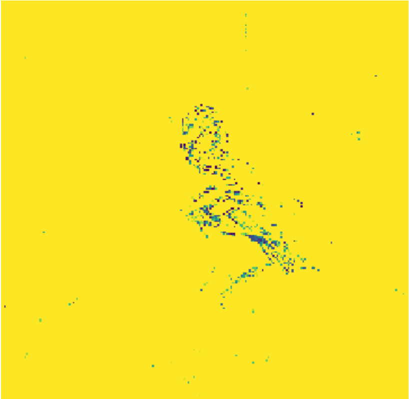
- Github: https://github.com/peikexin9/deepxplore

DeepXplore with ImageNet

Example from DeepXplore runs with ImageNet

Orig: All Brambling

Light:
VGG16: Ruffled Grouse
VGG19: Brambling
ResNet50: Brambling



Lighting difference invisible to human eye caused one model to misclassify

DeepXplore with AIT Algorithms

- Created image augmentations realistic to Advanced Imaging Technology (AIT) systems to test ATR algorithms.

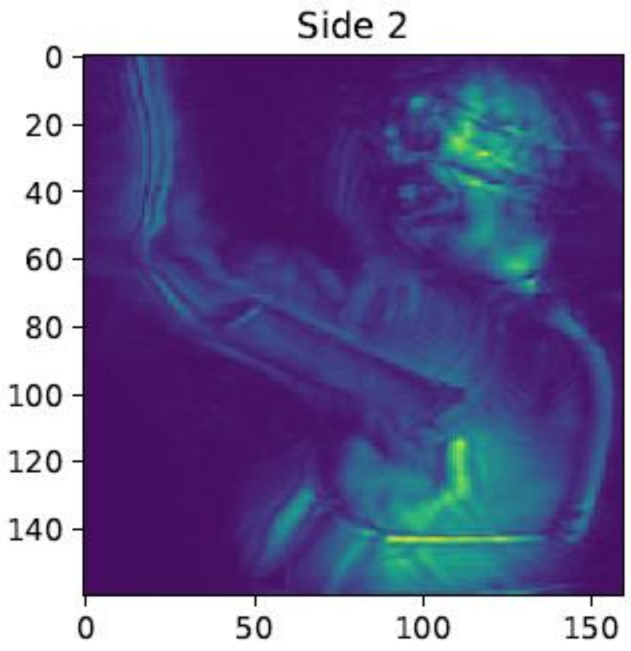
- Blurs to simulate moving arms, horizontal bars to simulate dead sensors.

- Added data collection features such as heatmaps and scatter plots.

Image Augmentations: Lighting

Original Image

Image: 20161014_0001 Zone: 3
Prediction: 0.9992055 Truth: 1
Iteration: 0



Transformation: LIGHT Behavior: Incorrect

Image: 20161014_0001 Zone: 3
Prediction: 0.0059422944 Truth: 1
Iteration: 1

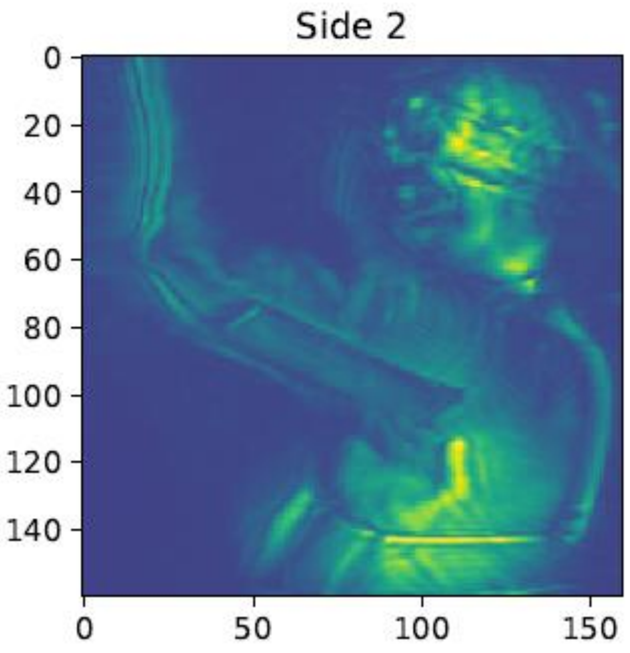


Image Augmentations: Dead Detector

False Negative

Transformation: BAR Behavior: Incorrect

Image: 20161014_0002 Zone: 15
Prediction: 0.27435794 Truth: 1
Iteration: 7

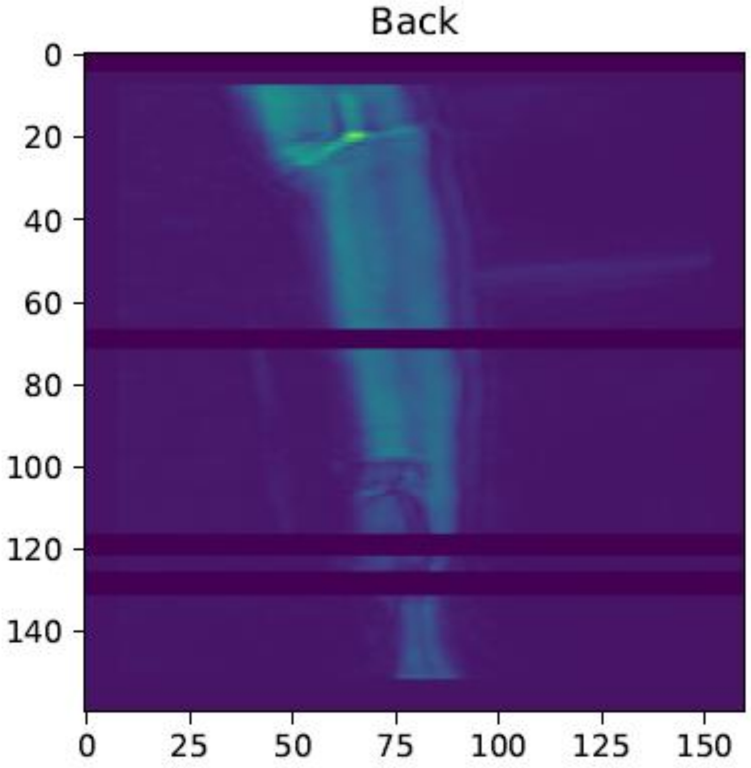
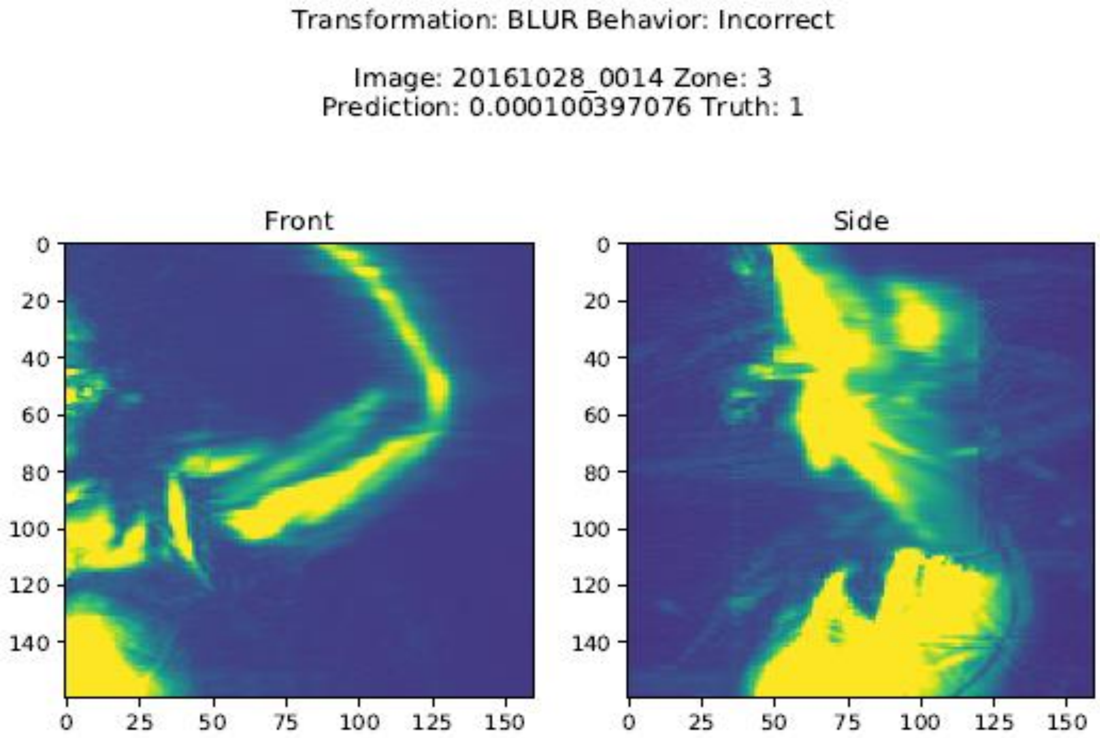


Image Augmentations: Blurs

False Negative

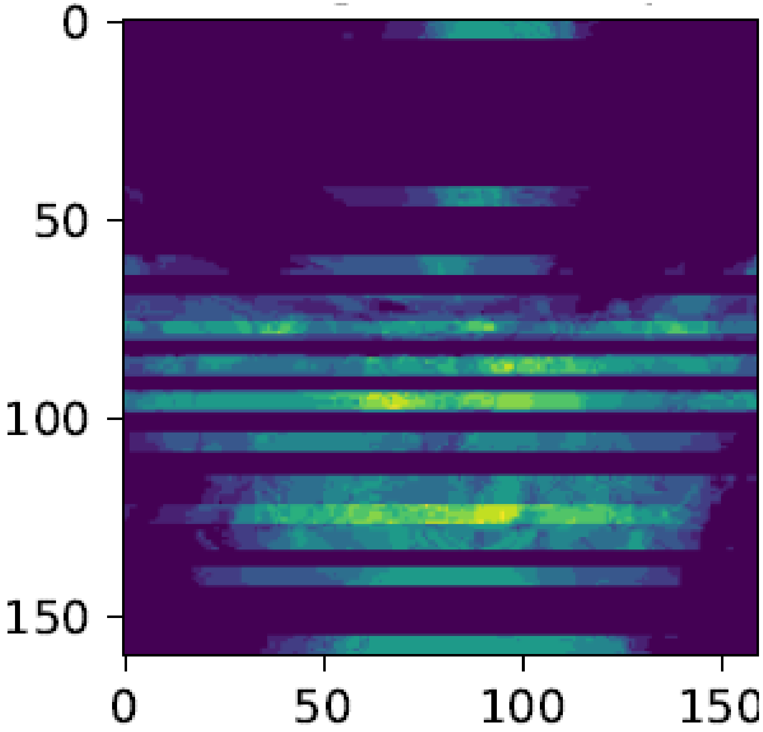


Transformation: BLUR Behavior: Incorrect

Image: 20161028_0014 Zone: 3
Prediction: 0.000100397076 Truth: 1

Data Collection: Heatmaps

Zone 5 Heatmap



Future Plans for DeepXplore

- Integration with other test algorithms.
- Refine system specific image augmentations to cover realistic bounds of change.
- Extend AIT augmentations to cover adversarial augmentations.
- Design physical data collection to match synthetically generated data.
- Analyze and quantify weaknesses in test algorithm detection performance.
- Extend to another detection modality (CT, projection X-ray).

Point of Contact(s)

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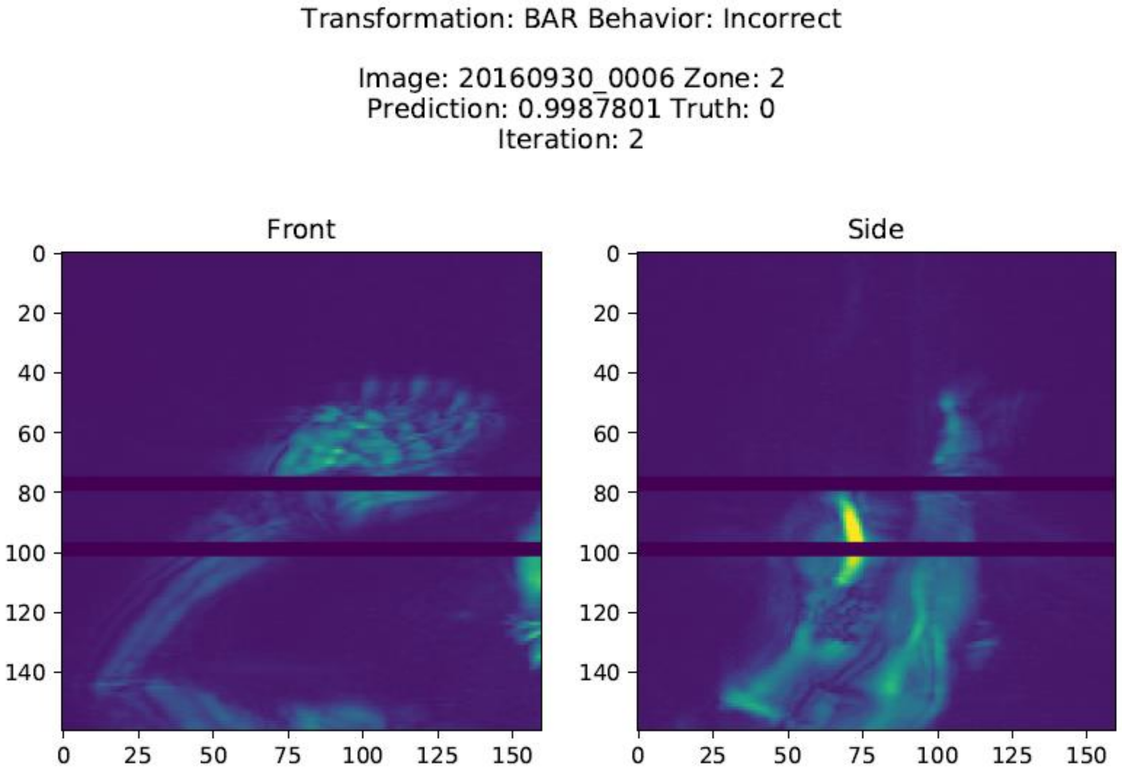
Image Augmentations: Dead Detector

False Positive

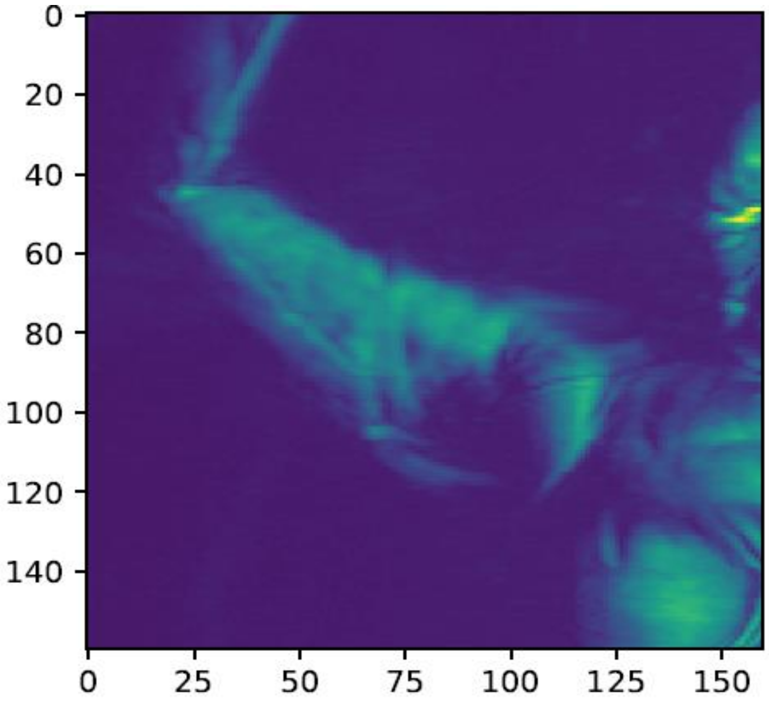


Transformation: BAR Behavior: Incorrect

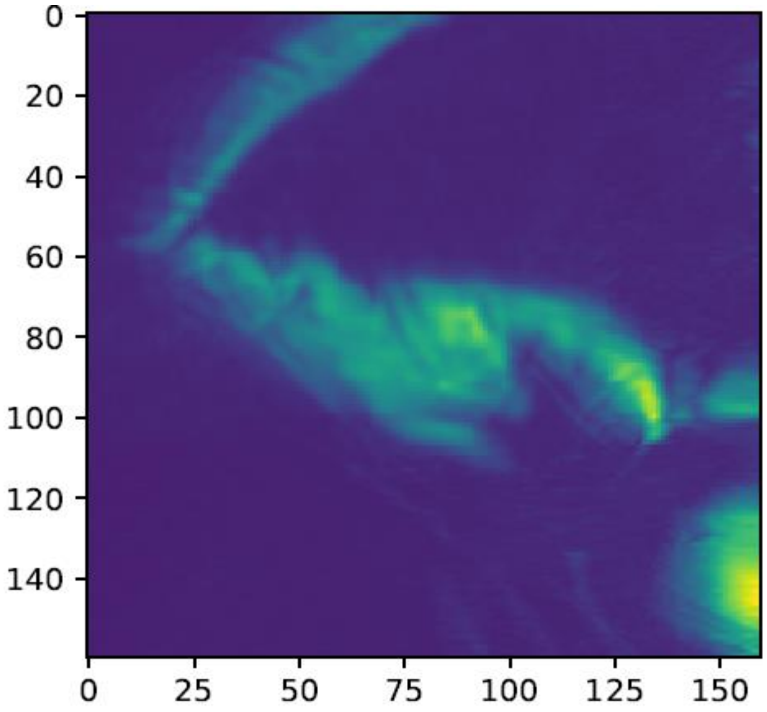
Image: 20160930_0006 Zone: 2
Prediction: 0.9987801 Truth: 0
Iteration: 2

Real vs. Synthetic Blur Comparison

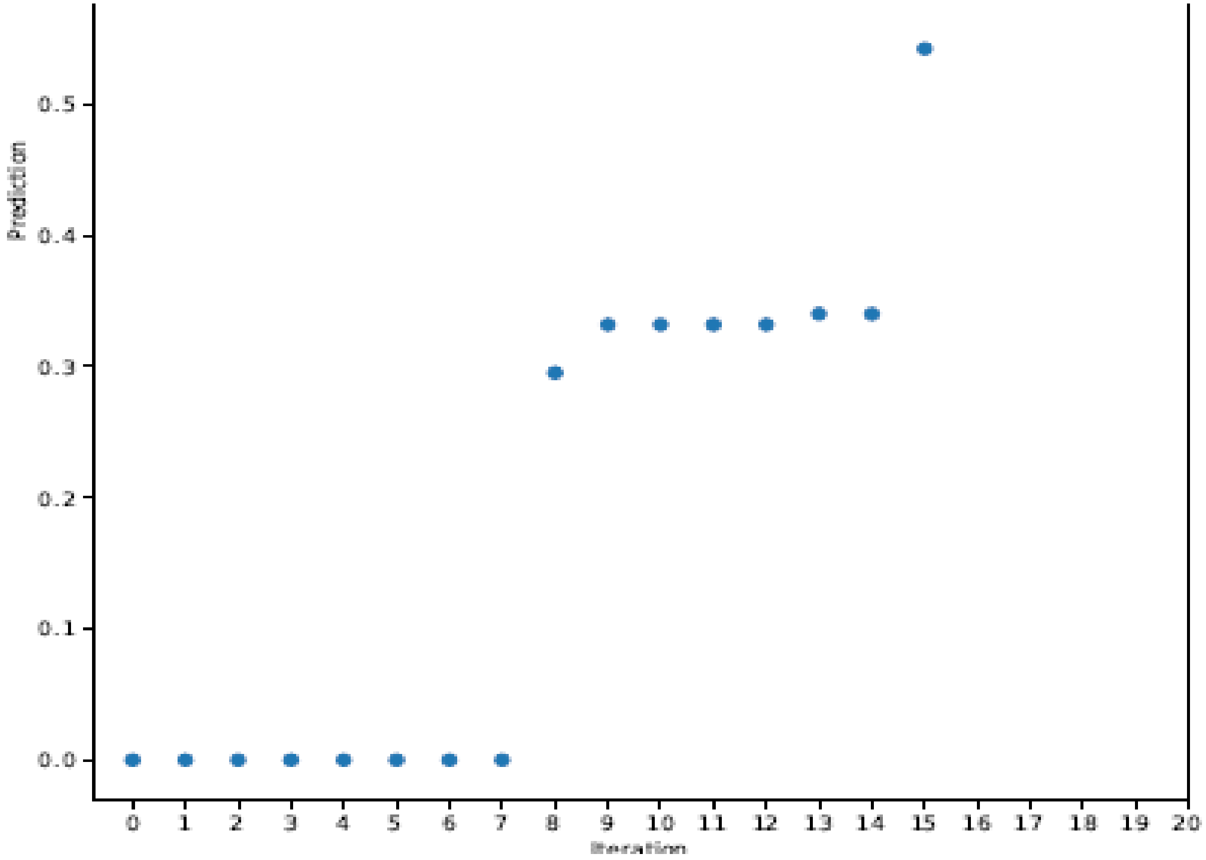
Real Blur



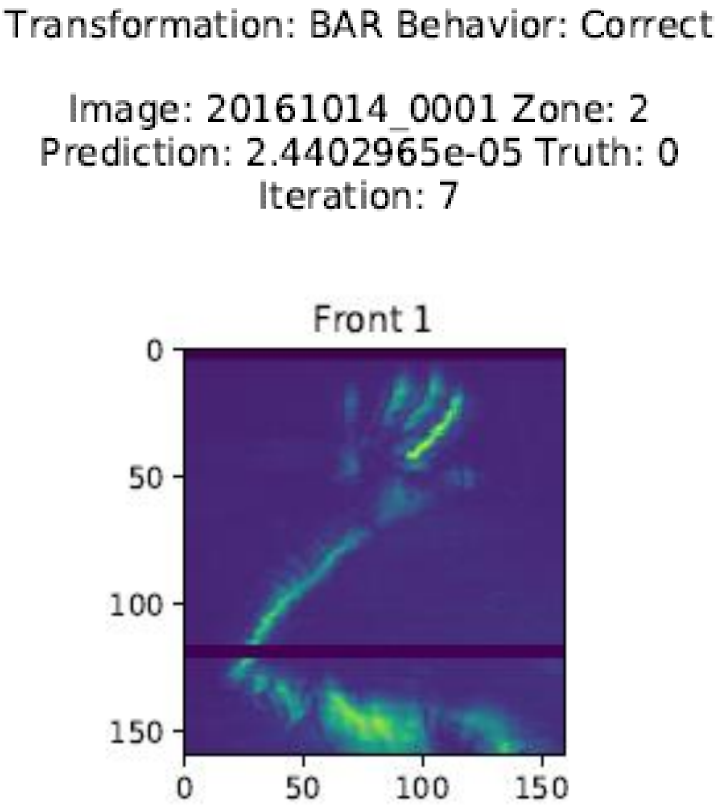
Synthetic Blur



Data Collection: Scatter Plots

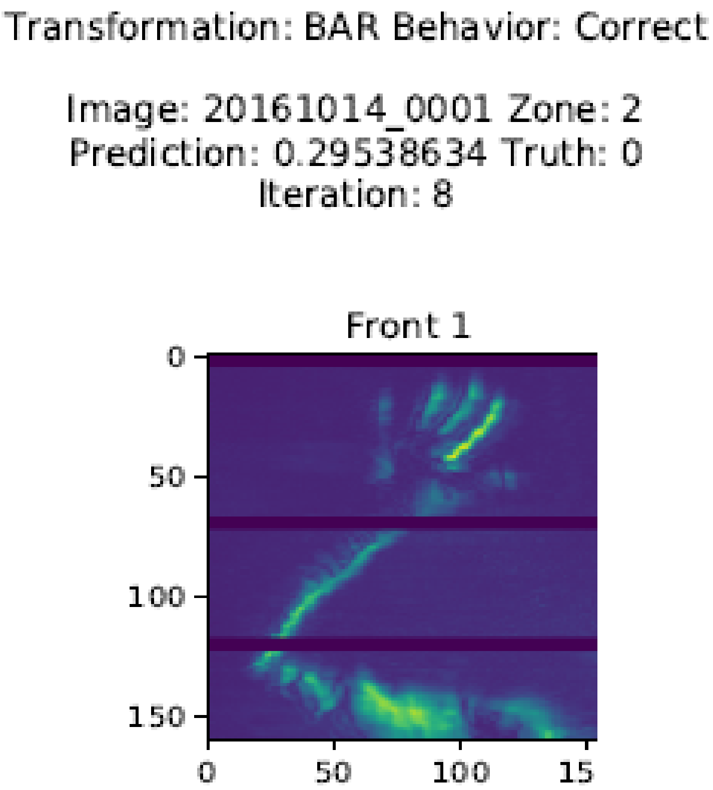


Significant Jumps in Scatter



Transformation: BAR Behavior: Correct

Image: 20161014_0001 Zone: 2
Prediction: 2.4402965e-05 Truth: 0
Iteration: 7



Transformation: BAR Behavior: Correct

Image: 20161014_0001 Zone: 2
Prediction: 0.29538634 Truth: 0
Iteration: 8