Implementing Convolutional Neural Networks in Cyber Security

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Introduction

- Neural Networks are implemented all over the modern world [3,5]
  - US Postal Service in 1980's for hand-written digits [2]
  - Goal of network is to train by minimizing a *Loss Function* [4]
  - Frequent use makes them targets for Cyber Attacks
  - Possibly prone to security threats
- What Happens when someone *Attacks* a Neural Network?
  - How does the performance change?
  - What signs show an attack has taken place?
  - Can we take protective measures?
- We demonstrate initial concepts that Network designers can consider
  - Prepare defense mechanisms against attacks

Mathematical Models

$$\vec{x}^{(l+1)} = f\left[\hat{W}^{(l)}\vec{x}^{(l)} + \vec{b}^{(l)}\right] \qquad (1)$$

$$\vec{x}^{(l+1)} = f\left[A\left(\hat{W}^{(l)}\vec{x}^{(l)}\right) + \vec{b}^{(l)}\right] \qquad (2)$$

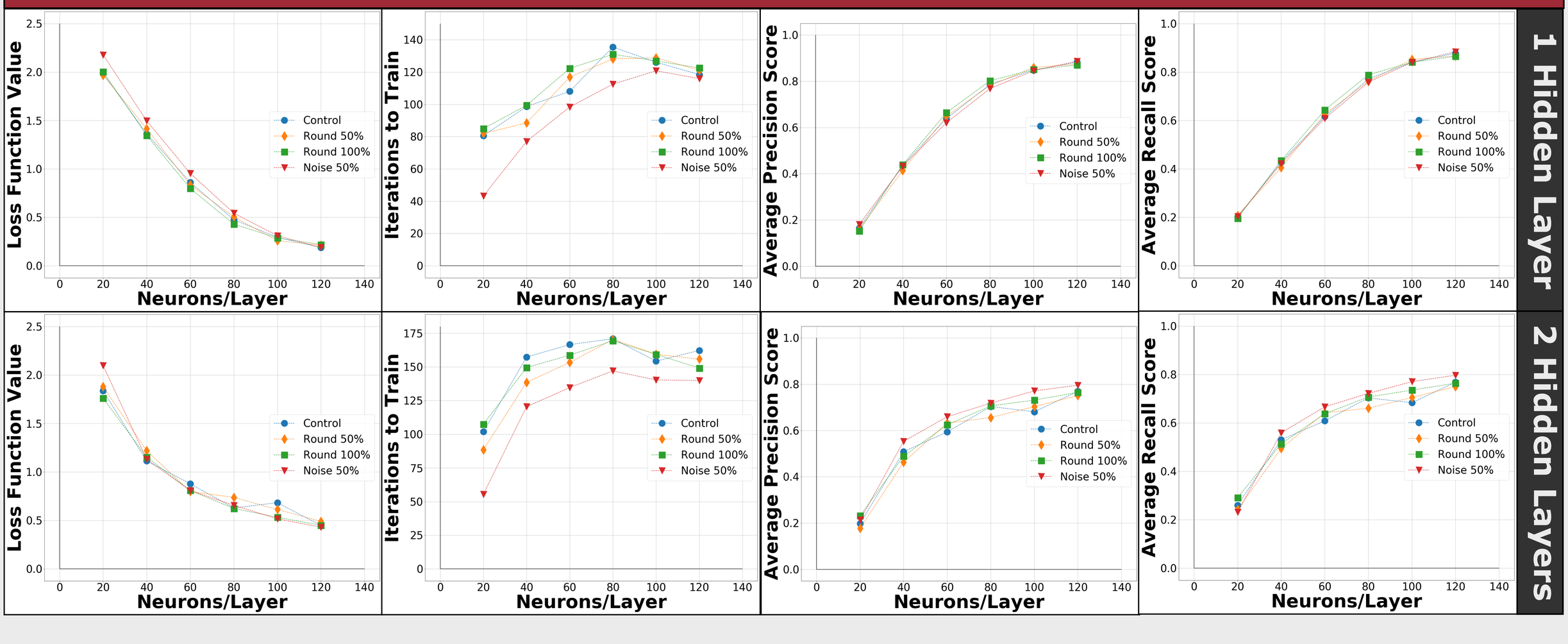
Data Set Examples

- Use MNIST data set—images of digits
  - 28 x 28 Pixels, 8-bit color scale [2]
  - Train w/ 12,000 samples, Test w/ 4,000

Experimental Methodology

- Multilayer Perceptron is a type of Linear Neural Network Architecture [2,3]
  - Layers of neurons, modeled by vectors [5]
  - Scikit-Learn "*MLPClassifier*" in Python 3.8 [1,7]
  - Information is passed through network with Eqn. (1)
  - We introduce *Attack Function* in Eqn. (2)
- Attack Function Variants
  - Reduce Numerical Accuracy (round FP numbers)
  - Introduce *Noise* Function
  - Combine with different *Trigger Conditions*
  - Compare with "Control" baseline
- Changing Model Architecture
  - Test each variant for single & double hidden layers
  - Neuron densities (20,40,60,80,100,120)
  - Train 100 models and average results for each

Experiment Results



Experiment Conclusions

- Attack Functions Affect Lower Level Metrics
  - Changes prevalent in *Loss Function Value* and *Training Iterations*
  - Models converge on higher loss function values, with few iterations
  - No substantial changes in classification metrics
  - *Stopping parameter* [3] met before parameters converge near minimum
- Other Considerations and Questions
  - Attack only acts on decision process, not correction process
  - Only forward pass is modified, Back Propagation still operates
  - Results about neuron density or layer depth is still inclusive
  - Results are averages, can a *single* attack be detected?

References

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