2022 ERAU REU:
Ensemble Deep Learning

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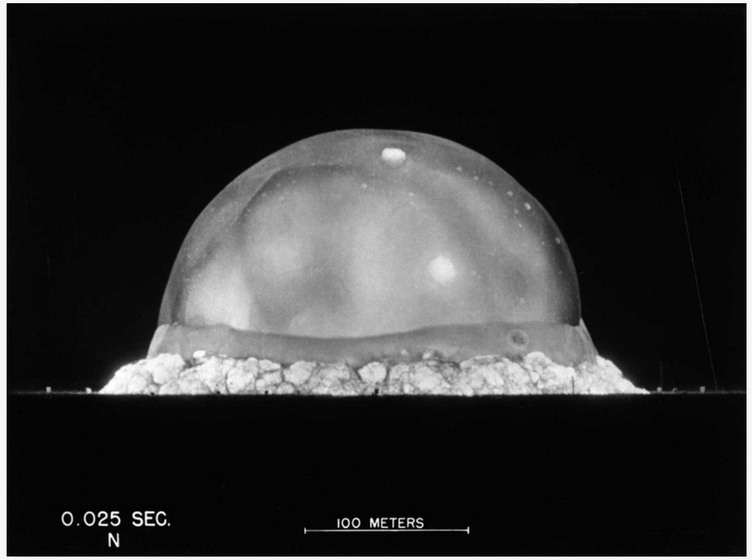
Nevada National Security Site (NNSS)

- Nuclear weapons science
- Environmental protection
- National security programs

Problem Introduction

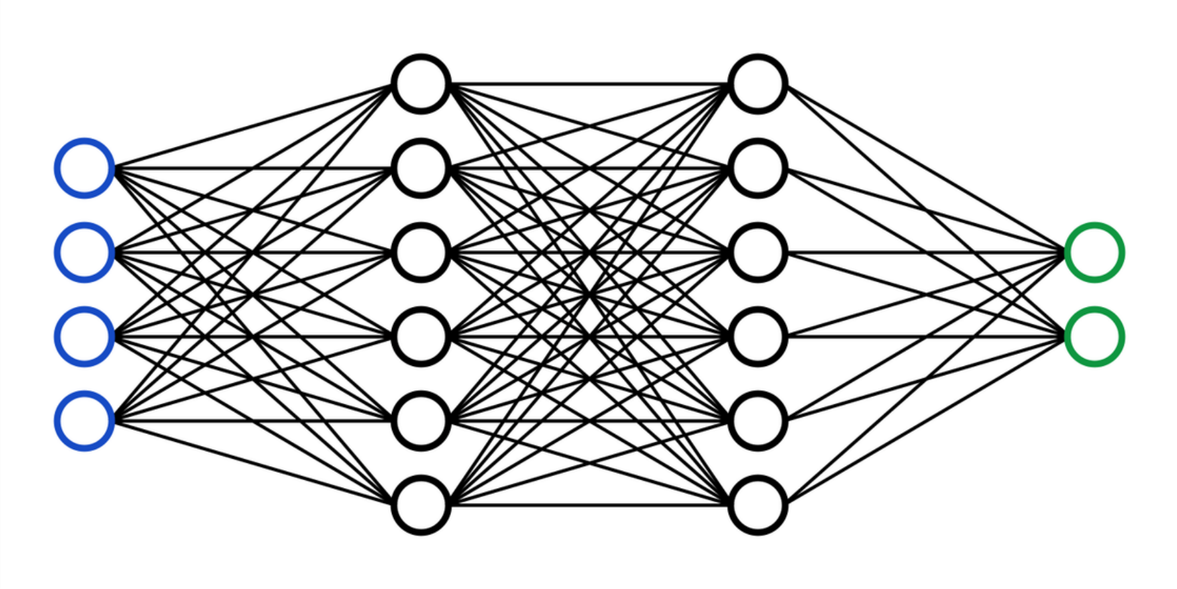
- Radiographic image analysis using convolutional neural networks

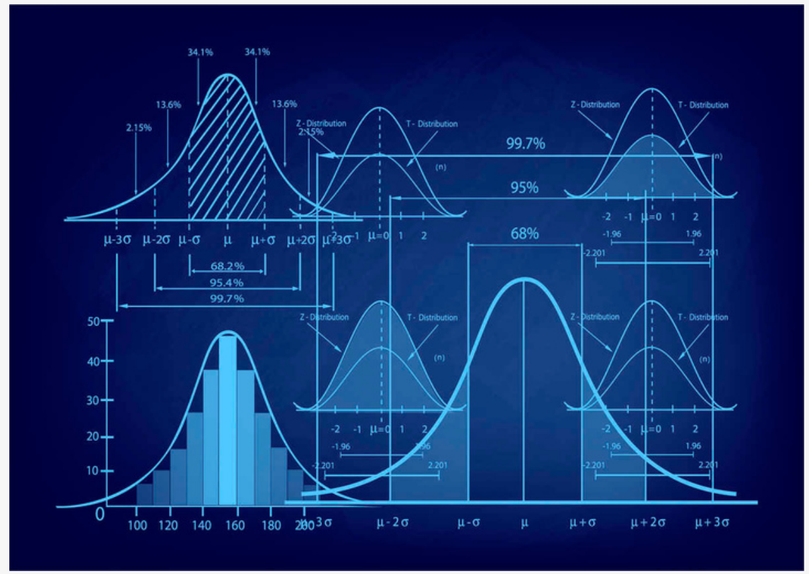


- Aids in NNSS tests analysis
  - National security
  - Nuclear stockpile safety

Project Scope

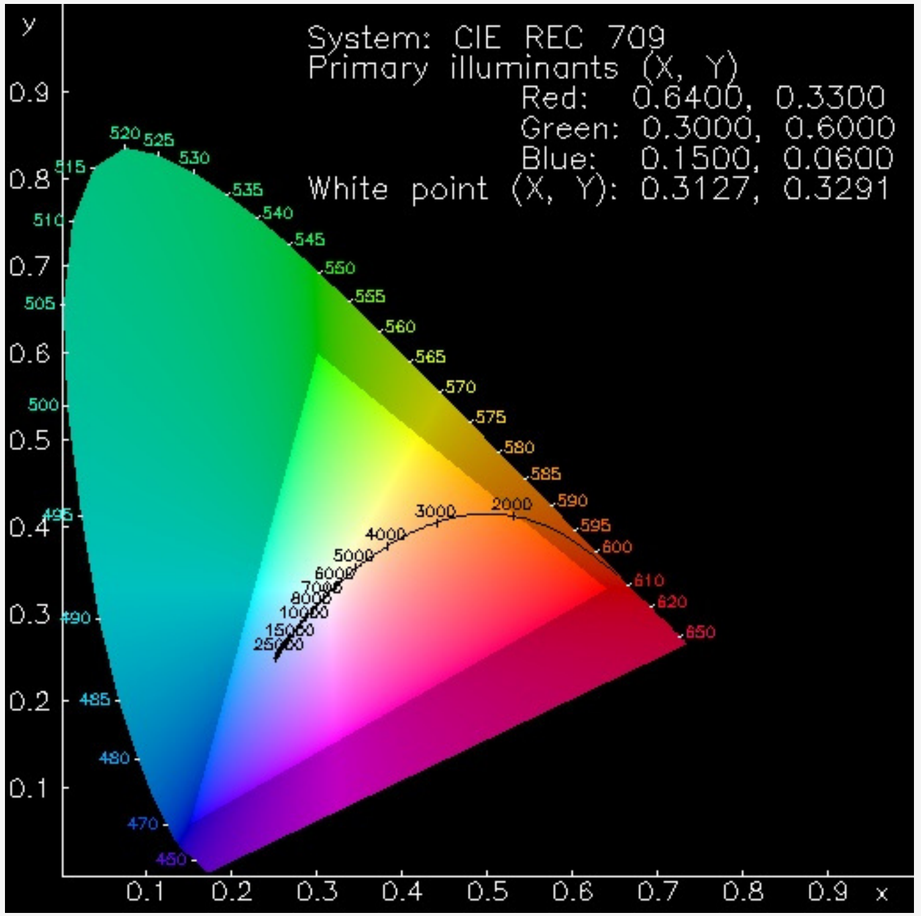
- Develop a network using Python and train it using image data
- Probability model and uncertainty quantification





Initial Strategy

- Develop neural networks and decide on an architecture
- Create an ensemble and train the architecture *n* times
- Start working on uncertainty quantification

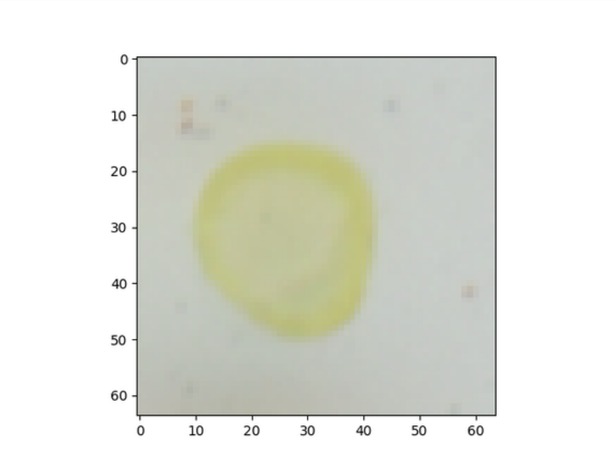


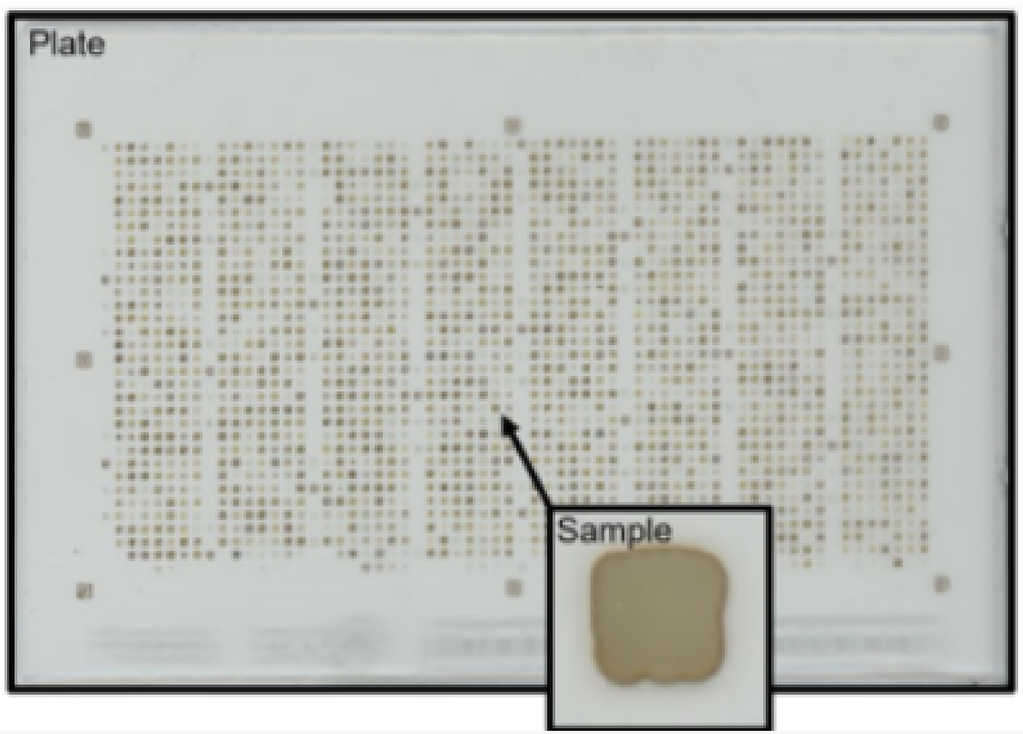
Dataset: Absorption spectroscopy data for 179072 metal oxides

Image size: (64, 64, 3, 180902)

Channel values: RGB

Normalized: 0-1 for every channel

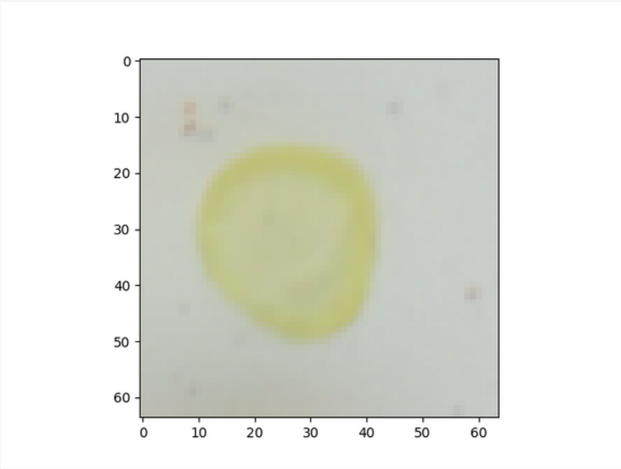


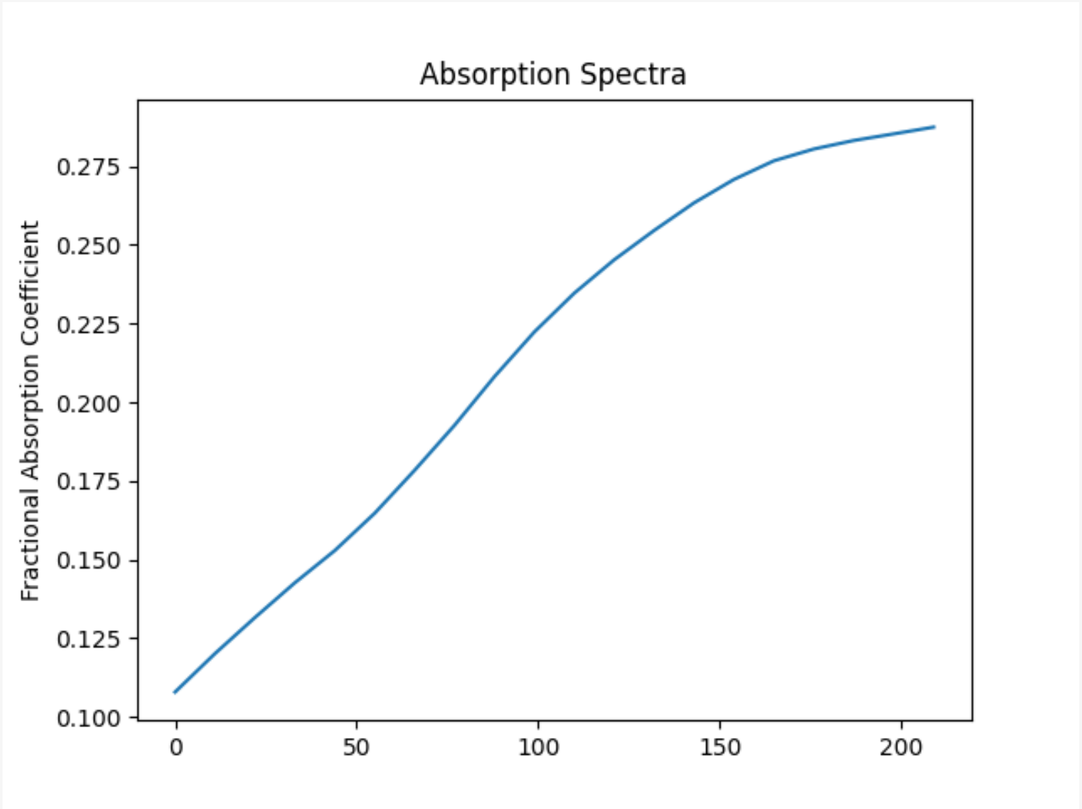


Stein, H. S., Soedarmadji, E., Newhouse, P. F., Guevarra, D. & Gregoire, J. M. Synthesis, optical imaging, and absorption spectroscopy data for 179072 metal oxides https://doi.org/10.6084/m9.fgshare.7502207 (2019).

Output

- Spectra
- Originally 220 values
- 20 values with linear interpolation between

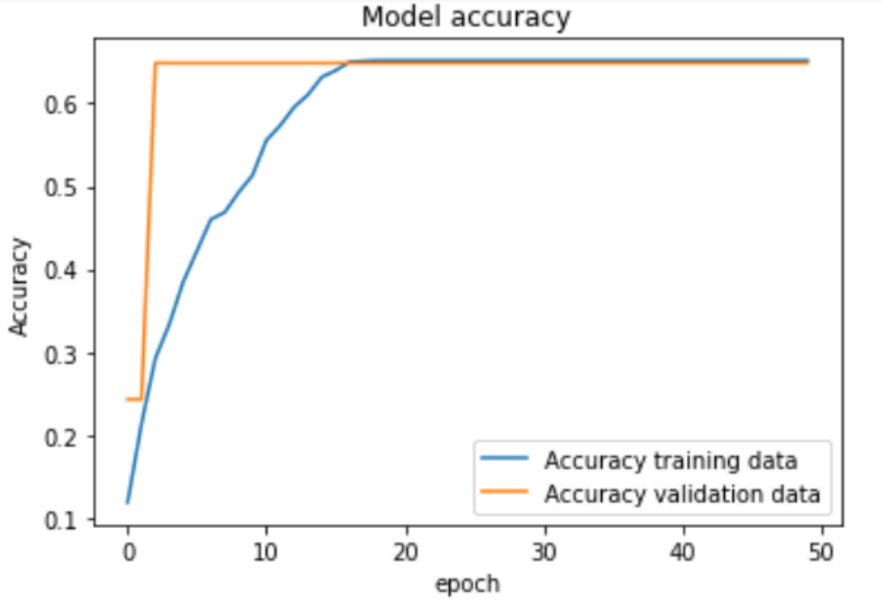


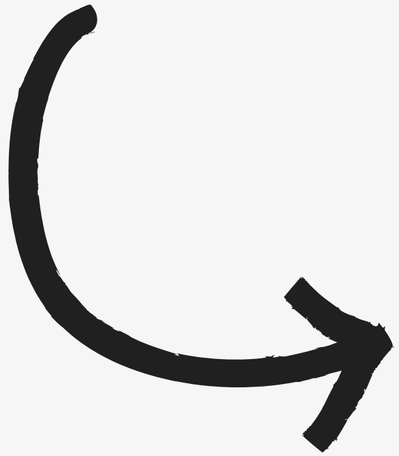


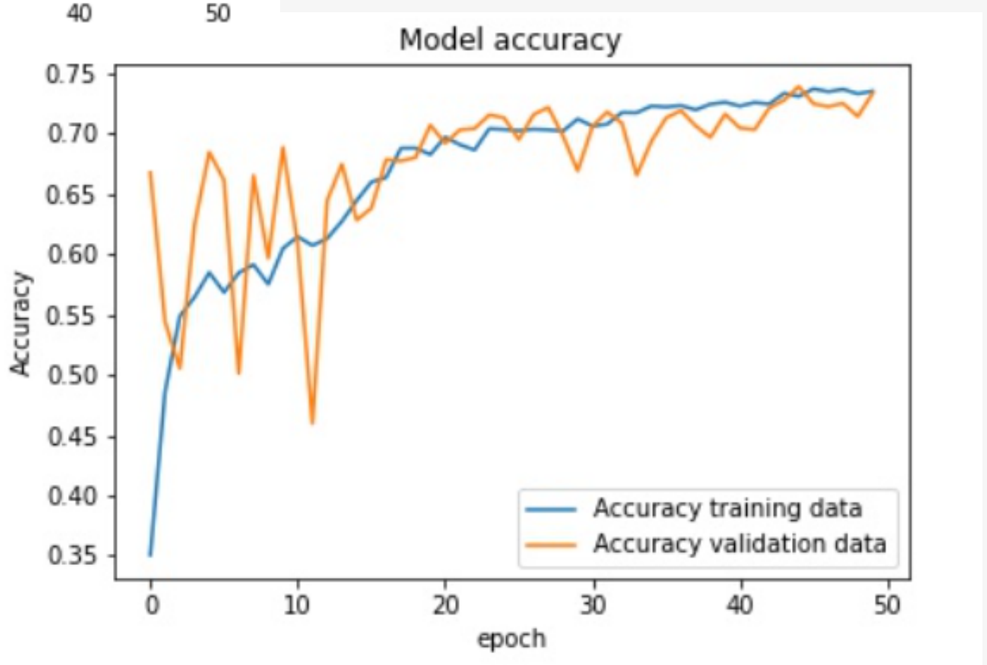
Initial Results

Layers:

1. Convolutional
2. Dense
3. Max Pooling
4. Convolutional
5. Dense
6. Max Pooling
7. Convolutional
8. Convolutional
9. Max Pooling
10. Flatten
11. Dense
12. Dense
13. Dense



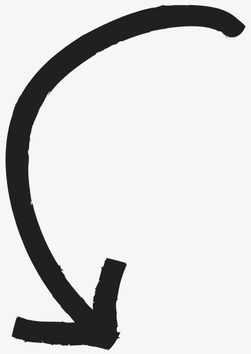


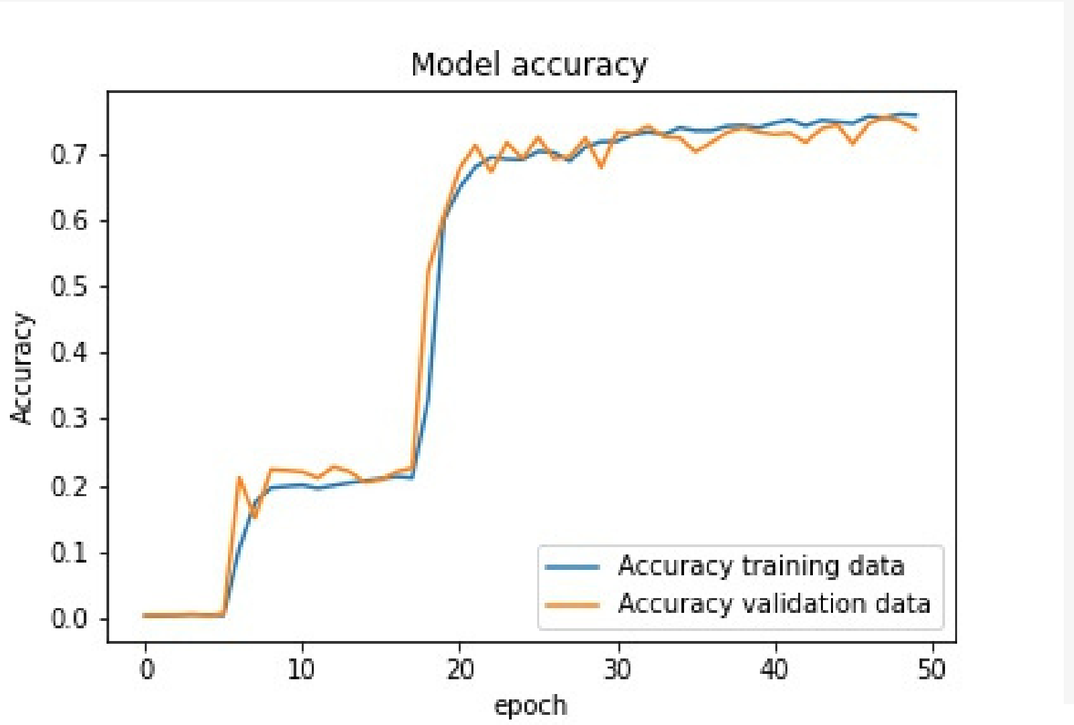


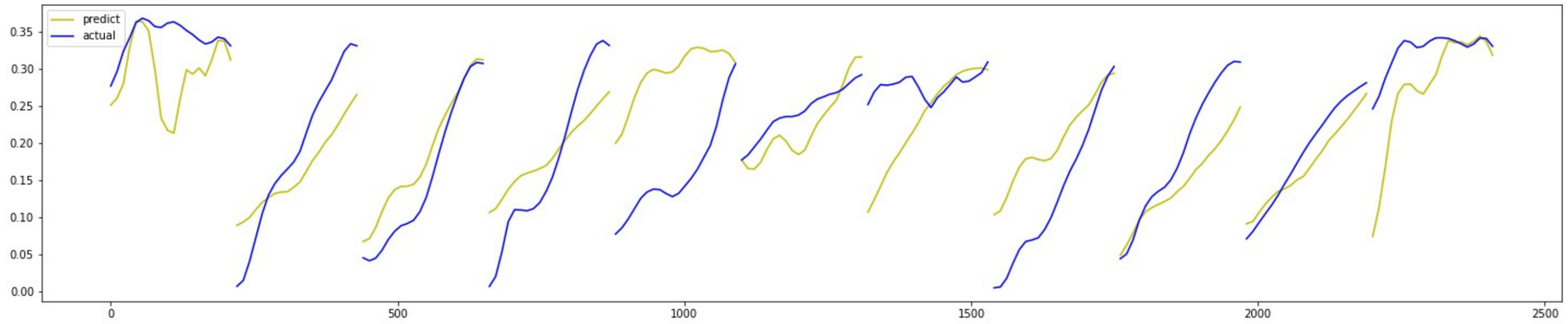
Layers:

1. Convolutional
2. Dense
3. Max Pooling
4. Flatten
5. Dense
6. Dense
7. Dense

Uncertainty



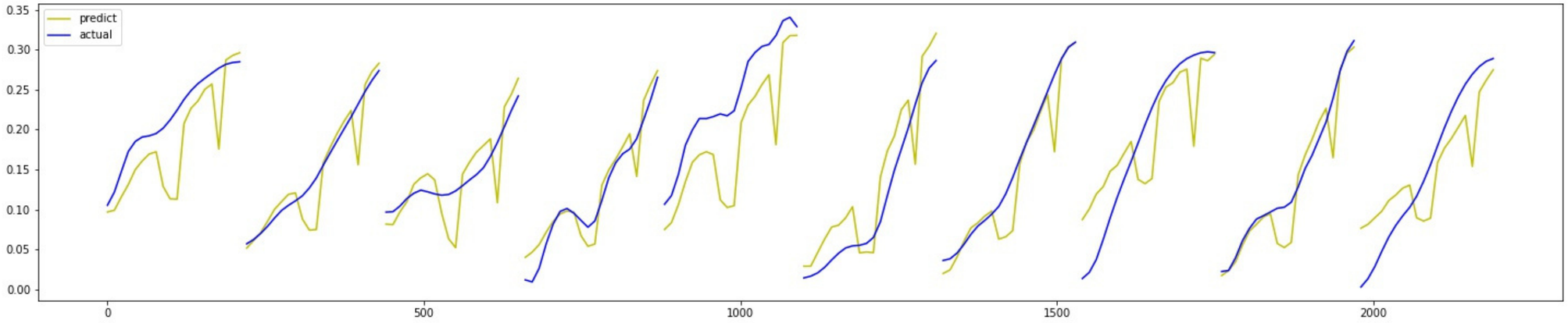




Conclusion: Need to quantify uncertainty

Ensemble Neural Network

- 5 neural networks
- Trained on 4000 images
- Averages result of each neural network



Next Steps

- Implement neural network to handle ensemble
- Batch normalization/layer normalization
- Experiment more with layers
- Uncertainty quantification