Classifying Lung Nodules with Deep Learning

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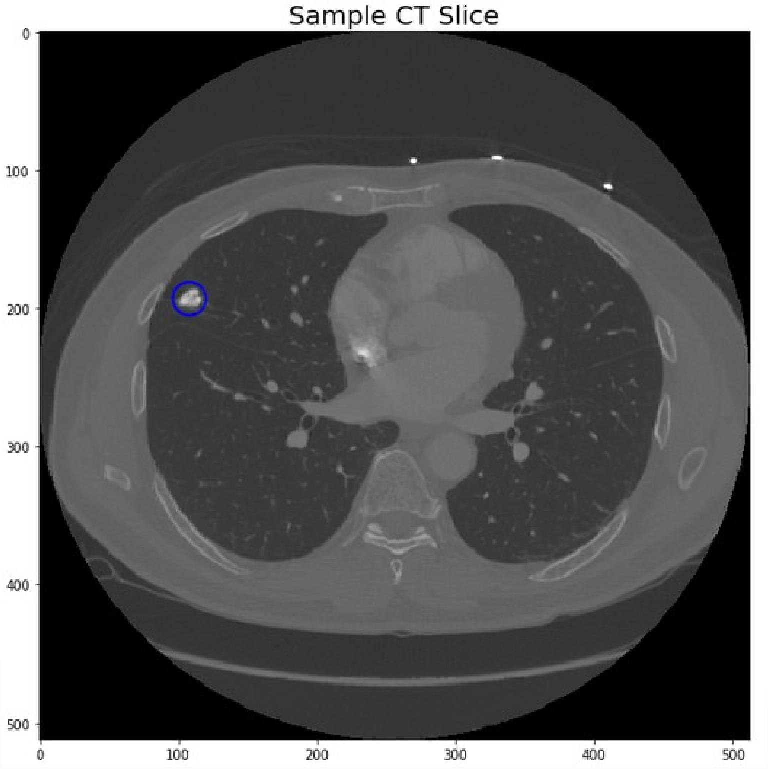
The Problem(s)

- Nodules are a risk factor for lung disease
- Difficult to identify
- Size and location are important for risk classification
- Radiologists often disagree about their classifications

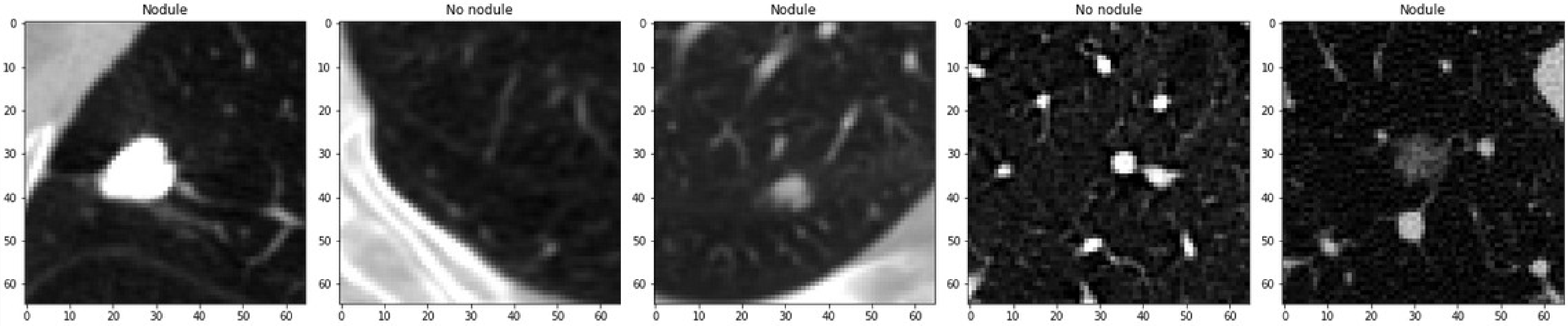


How could deep learning help?

- Quicker nodule detection
- Provide a second opinion for the radiologist
  - There were many disagreements when labeling this dataset!
- Easily evaluate previous records
- Provide nodule detection access to low-income areas
- These tools could allow for low-cost (or free) second-opinions to patients in low-income areas

Data

- Data were taken from the Luna16 Challenge website
- Approximately 118GB of CT images included
- Lung nodules were identified by 4 independent radiologists
- Inclusion criteria; >3mm and 3 of 4 radiologist agreement



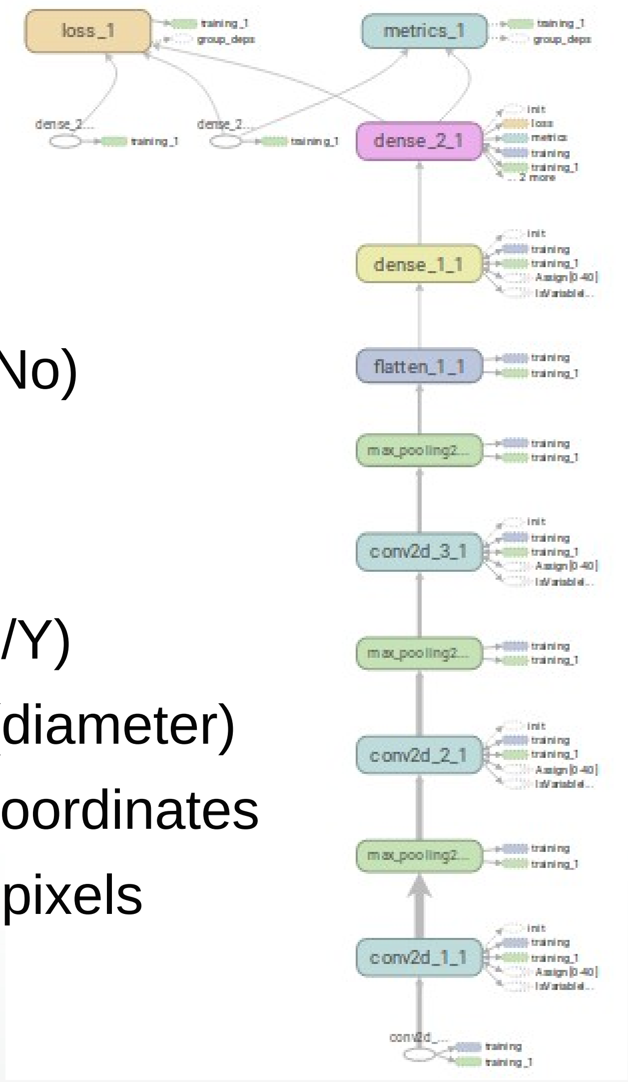
Data processing

- 1177 nodules were found
- Roughly 70% training, 20% validation, 10% test splits
- Hounsfield units were restricted to -1000 to 400
- Coordinates were transformed to pixel coordinates
- Patches with, and without, nodules were extracted for training

Modeling Pipeline

1. Split raw data into test, train, validation directories
2. Extract positive/negative patches from each directory
3. Train classification and localization models separately
4. Save the classification model with highest val accuracy, save the localization model with lowest val error
5. Compute performance in the test set

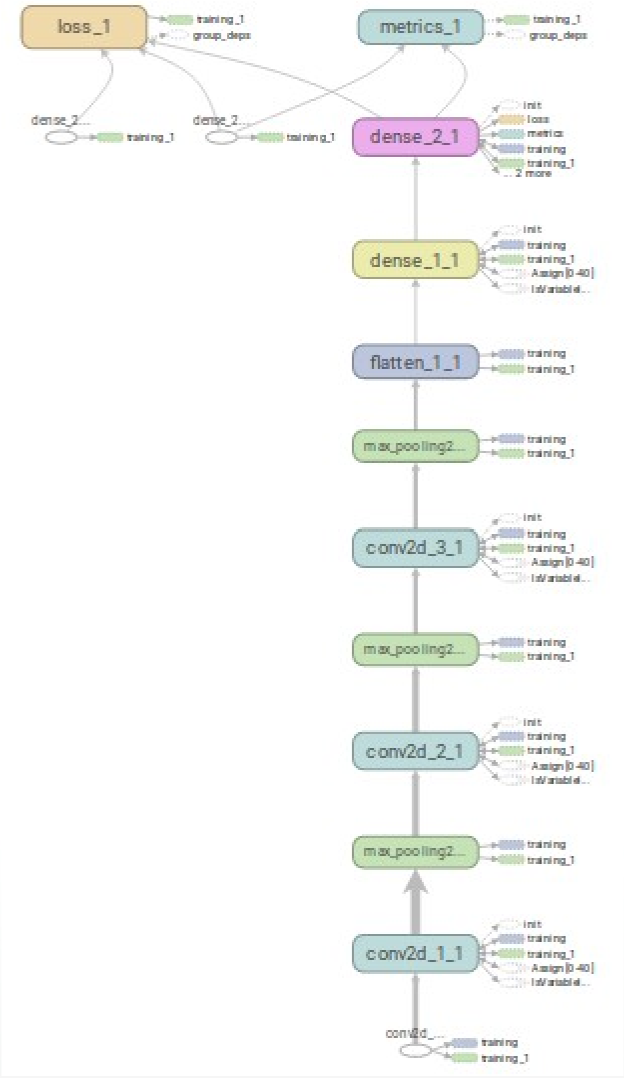
Modeling



- 1 for classification
  - Is there a nodule in this image? (Yes/No)
  - 1 output (0 to 1 value, > 0.5 = Yes)
- 1 for localization
  - Where is the nodule in this image? (X/Y)
  - How big is the nodule in this image? (diameter)
  - 2 outputs representing the X/Y pixel coordinates
  - 1 output representing the diameter in pixels

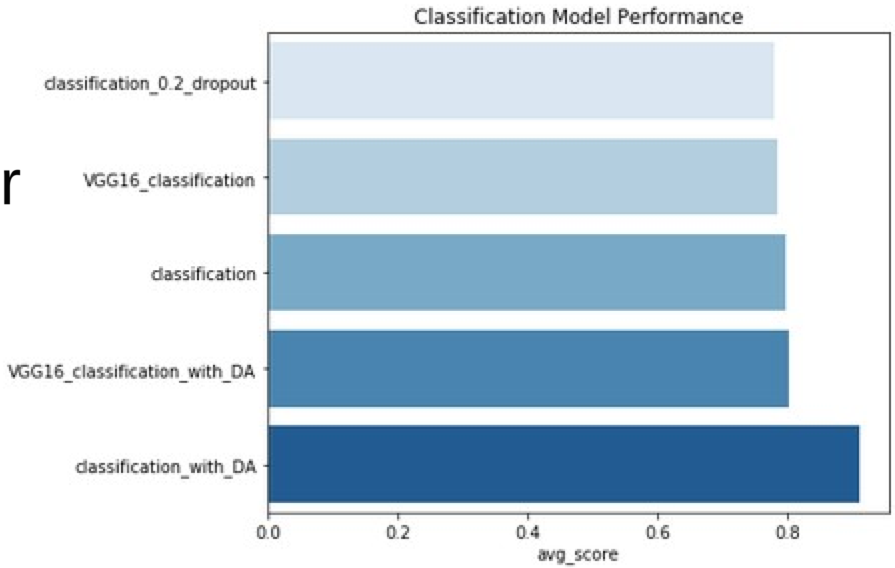
Modeling Techniques

- Convolutional Neural Networks
- Transfer learning via VGG16
- Dropout
- Data augmentation
  - Classification
    - Rotation, flip, shear, zoom, shift
  - Localization
    - Flip

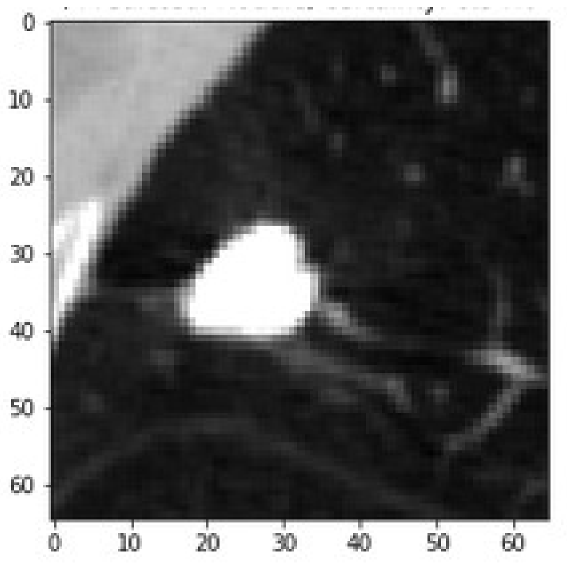


Classification Performance

- 5 primary models were created
- 2 models used VGG16 for transfer learning
- Top performer had 90% accuracy, 89% precision, 94% recall, and 91% f1 score in test set

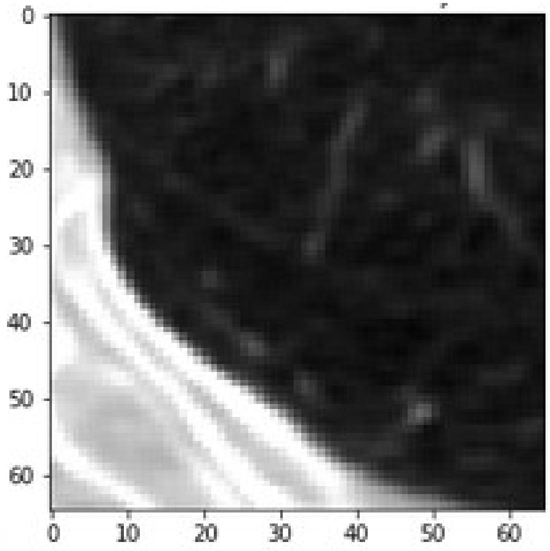


Classification Examples



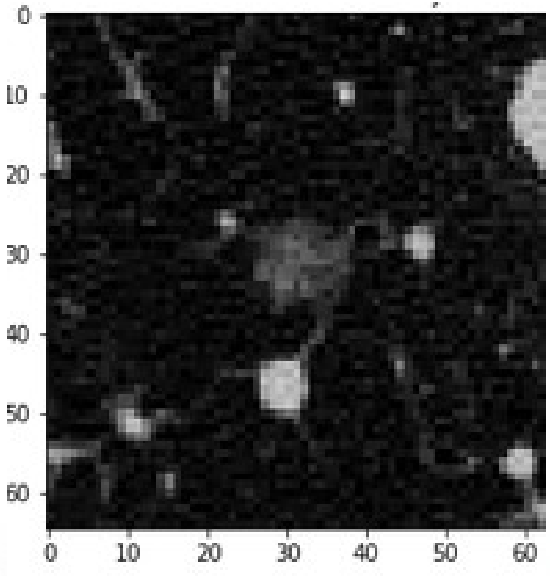
- True label: Nodule
- Predicted: Nodule
- Output Value: 94%

Classification Examples



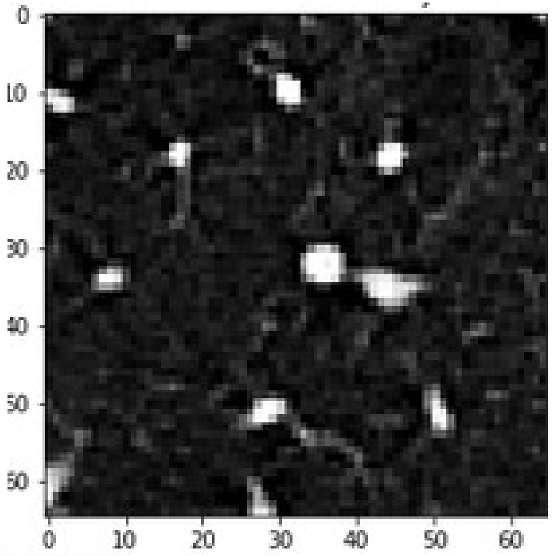
- True label: No nodule
- Predicted: No nodule
- Output Value: 11%

Classification Examples



- True label: Nodule
- Predicted: Nodule
- Output Value: 86%

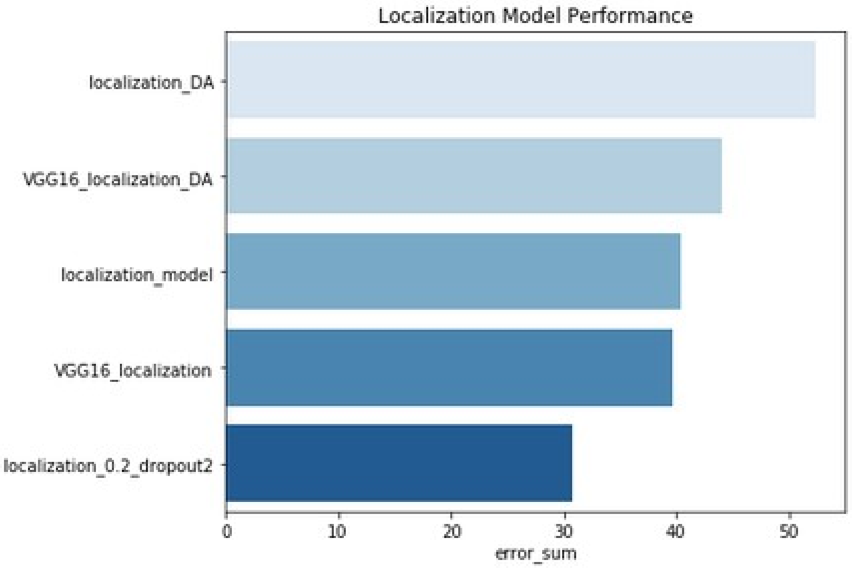
Classification Examples



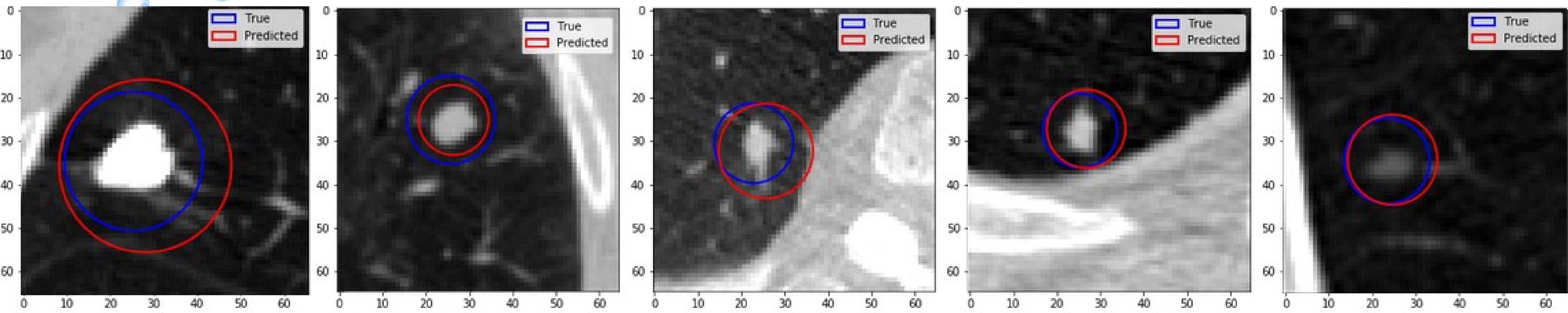
- True label: No nodule
- Predicted: Nodule
- Output Value: 95%

Localization Performance

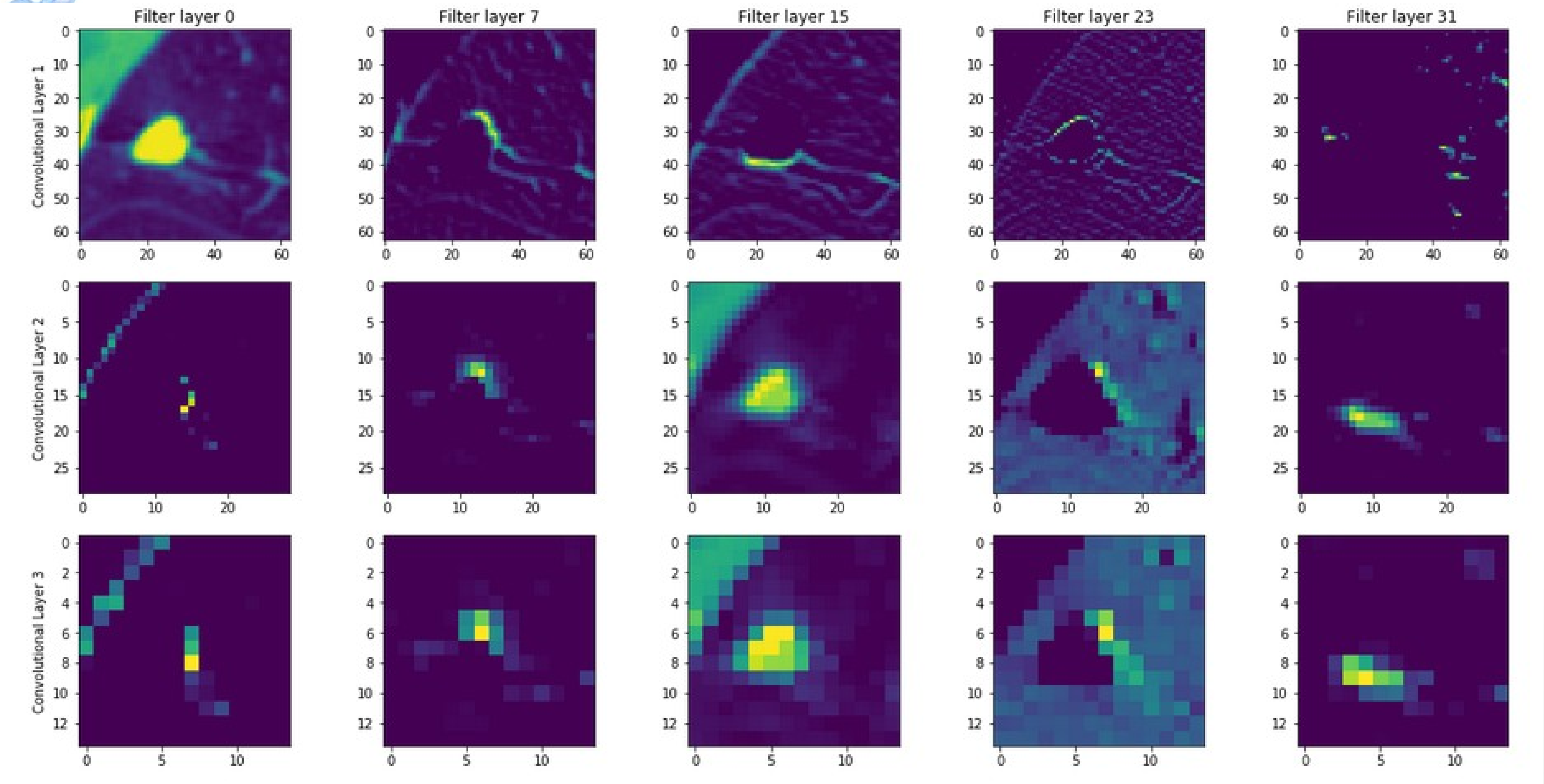
- 5 primary models were created
- 2 models used VGG16 for transfer learning
- Top performer had mean absolute error of 2.5px in X, 2.4px in Y, and 2.5px in diameter in test set



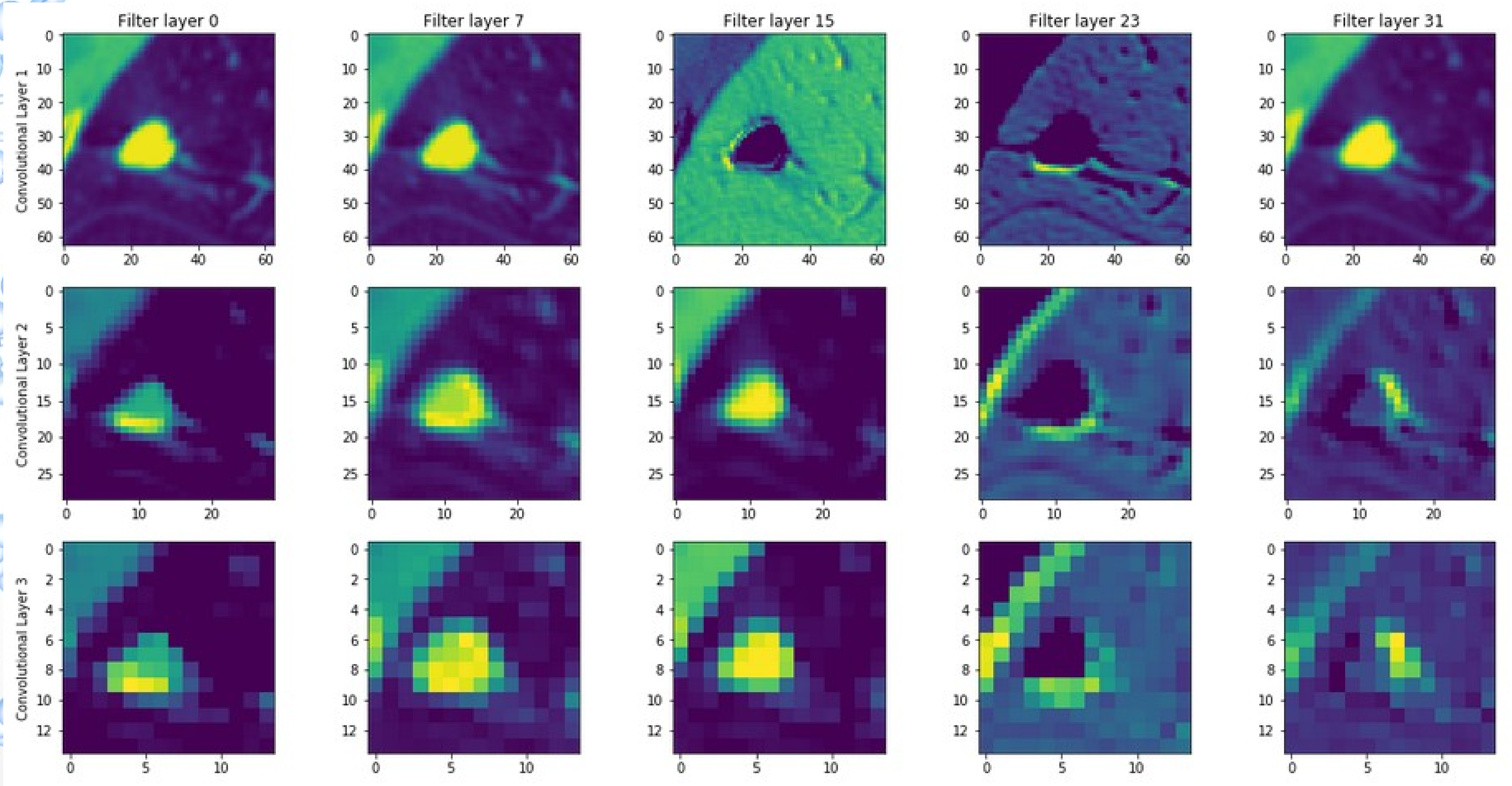
Localization Examples



Classification- What is the model doing?



Localization- What is the model doing?



Summary and Next Steps

- Deep learning models prove to be useful for classifying lung nodules in CT Scans
- An application which accepts CT scans, partitions them into 65x65 patches, feeds them into the models, and aggregates the results
- Models may be further improved from a more complex architecture and more training data