Banana Ripeness Classification using a Convolutional Neural Network

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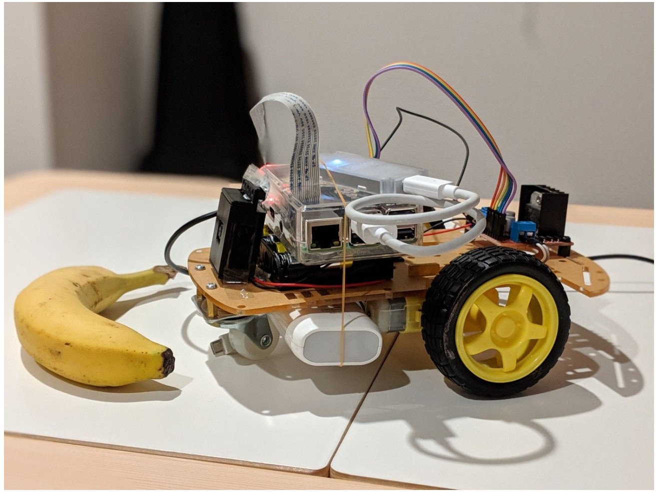
Why Bananas?

- Bananas are one of the most popular fruits in the world, eaten by millions world wide on a daily basis.
- Most traded fruit in the world!
- Global export value estimated at 8 billion dollars as of 2016 and a retail value between 20 and 25 billion.
- Americans throw away 5 billion bananas every year!

Our Solution

- Develop a classifier trained on varying images of bananas that classifies pictures of the fruit into three separate categories
    1. Unripe Bananas
    2. Ripe Bananas
    3. Over-ripe Bananas
- Deploy via robotic system in supermarkets
- Sorting bananas by ripeness on display shelfs



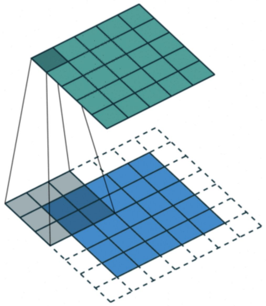
Methodology

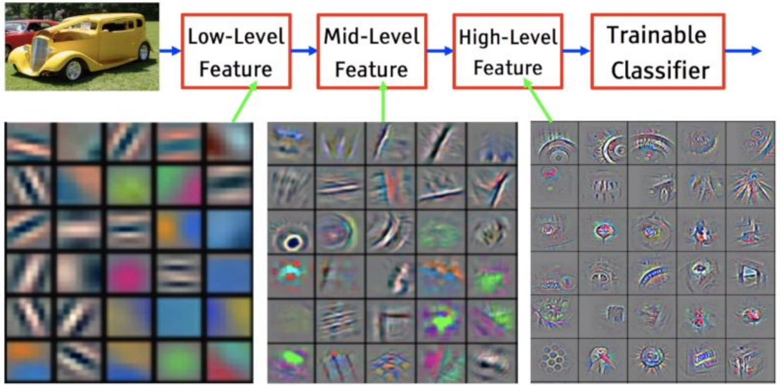
What is our neural network based off of?

- Slightly altered version of the popular AlexNet architecture
- Famous for “ImageNet Large Scale Visual Recognition Challenge performance”
- Consists of multiple blocks of
  - Convolutional Layers
  - ReLU Activation Layers
  - Max Pooling Layers

Convolutional Layers

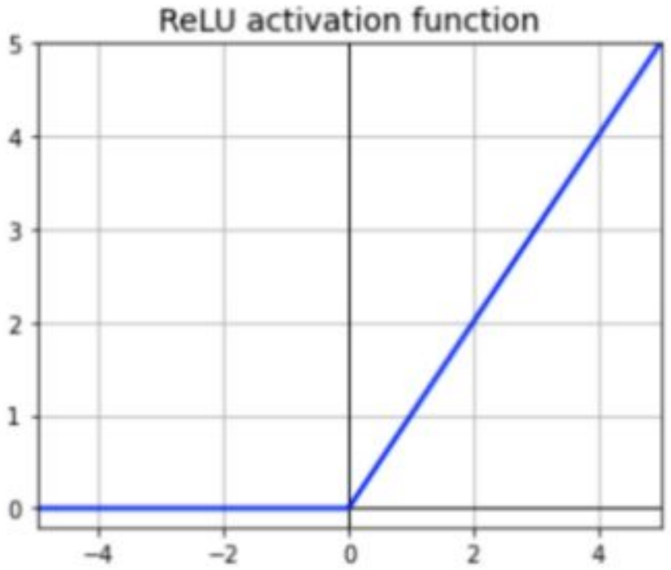
- Each convolutional layer has many filters
- For each filter which is a matrix of values, we can adjust
  - Stride
  - Zero Padding
- Filter will traverse the image producing an Activation Map
- First convolutional layers ↠ elementary features
- Last convolutional layers ↠ more complex features





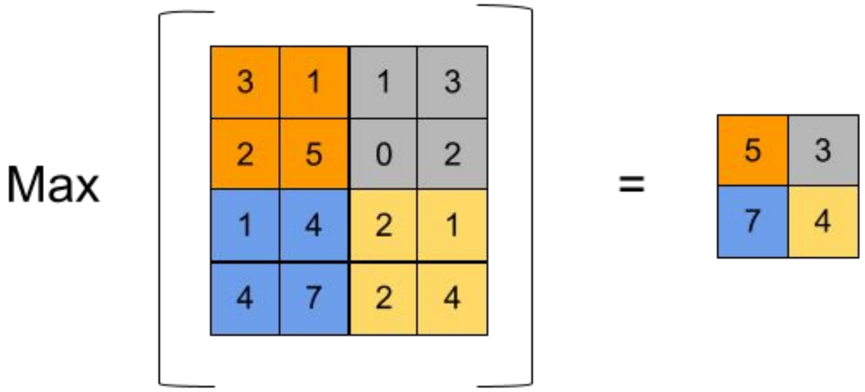
ReLU

- ReLU ⤜ Rectified Linear Unit
- Activation function applied to activation map output of convolutional layer
- Used to normalize data
- All values less than zero ⤜ equal zero



Max Pooling

- Used to downsize image
- For AlexNet architecture, max pooling is used 3 times
    1. After first convolutional layer
    2. After second convolutional layer
    3. After the final convolutional layer
- 3x3 pooling filter with stride of 2
- Takes the maximum value over the filtered space of the image



Results

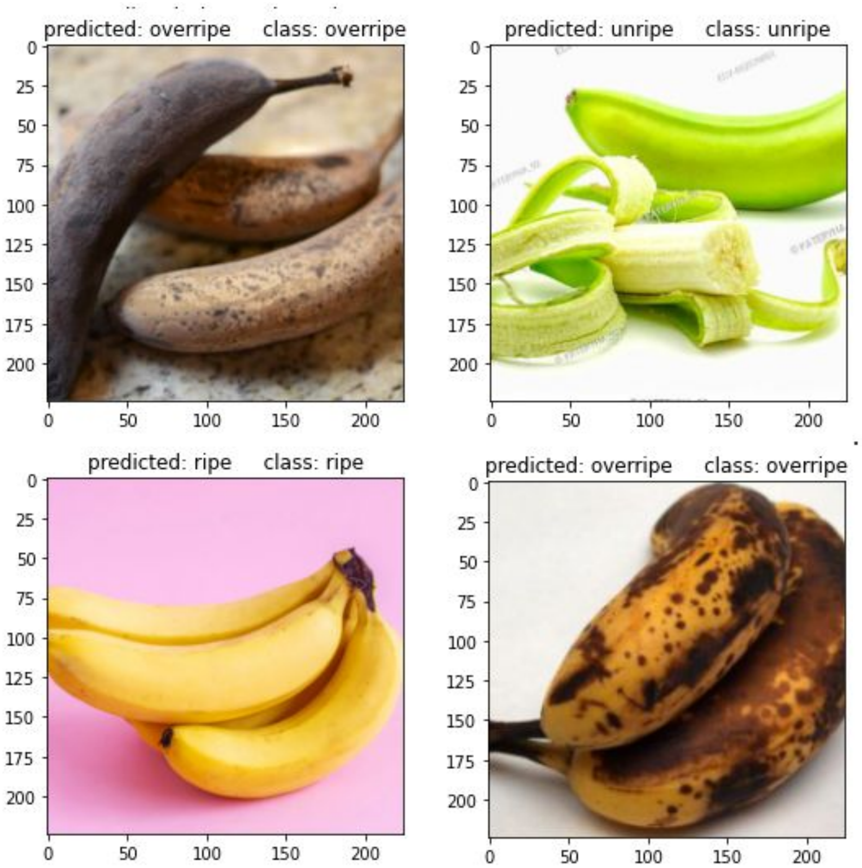
What did we find?

Setup:

- 30 epochs
- 0.003 learning rate
- 16 batch size
- 80 images for each class
- 20% validation data
- 80% training data
- Training data augmentation

Outcome

- Final training accuracy after 30 epochs
  - 99 percent correct
- Final valid accuracy after 30 epochs
  - 95 percent correct



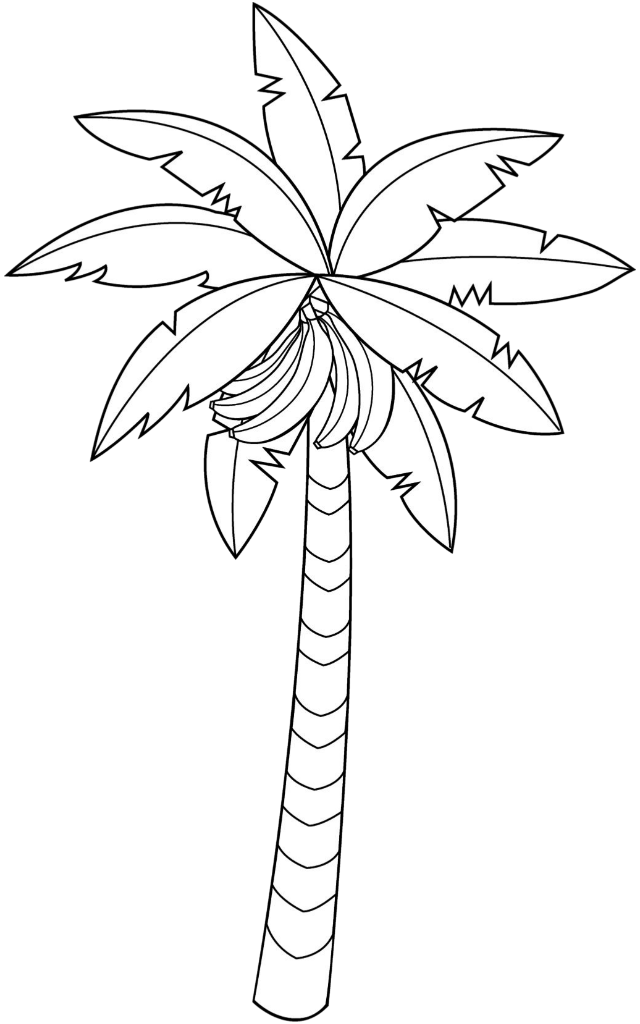
Discussion

- Incorrectly classified bananas were often
  - Dimly lit
  - Minimal brown spots (classified over-ripe when actually ripe)
- Why?
  - Personal bias in training data
  - Not enough training data

Are these bananas ripe to you?

Future Work

- Focus more attention on training data
- Collect more training data, retrain model
- Explore different machine learning techniques
- Future Goal
    - Analog classification on a spectrum of ripeness rather than digital classification



Questions?

References

[1] A. Caublot. "Bananalink." (), [Online]. Available: https://www.bananalink.org.uk/all-about-bananas/.

[2] D. Gunders. "5 billion bananas get thrown away each year — how reducing food waste can help solve the climate crisis." (), [Online]. Available: https://www.chicagotribune.com/opinion/commentary/ct-opinion-food-waste-20210409-3k3llled4fbmlp3nwhiej3o354-story.html.

[3] A. Krizhevsky, I. Sutskever, and G. E. Hinton, "Imagenet classification with deep convolutional neural networks," in *Advances in Neural Information Processing Systems*, F. Pereira, C. Burges, L. Bottou, and K. Weinberger, Eds., vol. 25, Curran Associates, Inc., 2012. [Online]. Available: https://proceedings.neurips.cc/paper/2012/file/c399862d3b9d6b76c8436e924a68c45b-Paper.pdf.