EE/CprE/SE 491 WEEKLY REPORT 3

Week 5 – Week 6

Group number: 20-18

Project title: Development of Image Analysis Algorithms for Crack Detection Using a Smartphone

Client &/Advisor: Bo Yang/Halil Ceylan

Team Members/Role: Akira Demoss, Maggie Dalton, Modeste Kenne, Nik Thota

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- **Weekly Summary**

The past 2 weeks were spent labeling images and doing more research on the fundamentals of how convolutional neural networks work in preparation for improving the accuracy of our object detector.

- **Past week accomplishments**
  - Akira
    - Made progress in Tensorflow Tutorial
    - Took 25 pages of notes from Stanford's online Youtube lecture series CS231n: Convolutional Neural Networks for Visual Recognition, a brief summary of what was learned is provided below as well as a statement of its relevance to the project in the final bullet point.
      - **Lecture 3: Loss Functions and Optimizations**
        - Learned how loss functions can be created to make predictions that will most accurately reflect the testing data.
        - Learned about L1 and L2 regularization which can be used to prevent overfitting
        - Learned how gradient descent is used in optimization on

loss functions to minimize the function by iteratively moving in the direction of steepest (most negative) descent.

- **Lecture 4: Introduction to Neural Networks**
  - Learned that backpropagation is what is used to efficiently compute gradient descent in neural networks.
    - Learned that backpropagation is the recursive application of the chain rule (from calculus) to compute the gradients of all of the inputs / parameters / intermediates.
    - Learned that implementation of backpropagation can be modeled using a computational map which when translated to code maintains a graph structure where the nodes implement the forward() and backward() API which correspond to forward and backward passes respectively.
  - Learned how activation functions are used in the forward pass to assist in the efficient evaluation of neural networks.
    - Learned that Neural Networks are essentially a class of functions that have simpler functions, and we stack them on top of each other in a hierarchical way in order to make a more complex nonlinear function.
    - Learned how neural networks can be used to "connect templates" or layers, e.g. 2 linear classifiers of an object containing different pixel colors could be used and weighted to predict a class more accurately than a single template. We can continue to connect layers and this gives us the idea of a deep neural network.
- **Lecture 5: Convolutional Neural Networks**
  - Learned how the convolutional layers preserve the spatial structure of data by convolving the filter with the image.
  - Learned how the output is computed each time the filter is "slid" across the image.
    - There is a one number outcome that results from taking the vector dot product. E.g. a 5x5x3 filter would be matched with corresponding pixel dimensions and

        the outcome would be the 75-dimensional dot product + bias of this.
        - Learned that the output of this will yield an activation map.
    - Learned that layers can contain multiple filters and multiple layers stacked yields a feature hierarchy. These are called convolutional layers because they are related to the convolution of 2 signals.
    - Learned how a common practice is to zero pad the boarders of images to maintain the full sized activation map.
    - Learned how fully-connected layers differ from convolutional layers. In a fully connected layer each neuron is connected to every neuron in the previous layer and each connection has its own weight (and is thus very expensive in terms of computation and memory respectively). In a convolutional layer each neuron is only connected to a few nearby (local) neurons in the previous layer and the same set of weights (and local connection layout) is used for every neuron.
    - Learned how pooling layers make the representations smaller and more manageable. Pools spatially and down samples, a common way to do this is with max pooling.
  - All of the above information is directly related to the project because having a fundamental understanding of how convolutional neural networks work is necessary to create a robust object detection system with high mean Average Precision (mAP). This metric is a popular benchmark for how well the application is performing. We will most likely fine tune a pre-existing convolutional neural network because of time constraints, however a thorough understanding of the basics of how these work is still necessary to achieve an optimal solution under the given constraints.
- Maggie
  - Gathered images of roads in Ames/Des Moines
    - Whittled down some of the images to only include ones with visible cracks to label/remove duplicates
  - Labeled images from the Japanese data set
  - Compiled questions and met with Bo to create a base document to help with standard labeling/answer common labeling issues
- Modeste
  - Completed node.js script and related setup needed to send images to our server

        - Labeled cracks on images from our dataset
    - Nik
        - Collected images of roads in Ames and Des Moines
            - Deleted unnecessary photos
        - Labeled 500 images from the Japanese Data Set
            - Labeled full Chiba Data set
            - Labeled fill Ichihara Data set
            - Labeled about half about the potholes Dataset

- **Pending issues**
    - Nik, Modeste, Maggie
        - A lot of images include questionable instances of cracks (not clear what type it is, if it is a crack/joint, etc). We set up a meeting with Bo to ask many of these questions and begin to create a document that will help us to create a standardized way of labeling these instances
- **Individual contributions**

Name	***Individual Contributions***	***Hours this week***	***Hours Cumulative***
Akira Demoss	Researched Convolutional Neural Networks, Continued Tensorflow Tutorial	15	41
Maggie Dalton	Labeled images, gathered data	14	35
Modeste Kenne	Completed client/server communication setup for images.	14	31
Nik Thota	Labeled images and gathered data	11	28

- **Plans for the upcoming week**
    - Akira
        - Go through all 5 tutorials on Tensorflow Object Detection API.
        - Train a basic neural network by week 8
        - Watch and take notes on lectures 6 and 7 from Stanford's online Youtube lecture series CS231n: Convolutional Neural Networks for Visual Recognition by week 9.

- Maggie
    - Continue gathering images
    - Continue labeling images
    - Add request from Android to server to send image
    - Work with Modeste on SQL functions/Node.js functions to handle storing and retrieving image data
- Modeste
    - Work with Maggie on the image storing system (i.e on MySQL or another suitable database)
    - Label more images
- Nik
    - Finish labeling images
    - Continue work on the web interface

- **Summary of weekly advisor meeting**

We presented the new information that was learned about neural networks as well as our plans for the next two weeks. In addition to the weekly update meeting, we met briefly to go clarify some questions about crack types to help the accuracy of our labeling.