| **Spring 2018** | **Report#1 – 01/07/2018** | **Tianxiao Zhang** |

I. Tasks achieved Last Week (***, **, *: order of priority)

- Project

  Change the method of ReLU to S/P.

II. Feedback and Interaction

- ***Prof. Kuo's feedback***
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- ***Discussion***

III. Report

The Saak transform which was recently proposed by professor Kuo is a very good application of Principal Component Analysis (PCA) to the deep learning. Unlike Convolution Neural Network (CNN) needing 20 to 25 epoch to get a relatively satisfying result, Saak transform only requires one epoch to get a good result. What's more, Saak transform can losslessly recover the original data with the coefficients it generates while CNN cannot. Saak transform is better than CNN in almost all aspects but the accuracy which is the most significant aspect in deep learning. So in this project, we need to improve the test accuracy using some method and K-mean is a good method to improve it.

In the first stage of Saak transform, we have original images as input. According to Saak transform, we need to divide each image into 2-by-2 blocks and each block has 4 elements and we can treat it as a 4-dimensional vector. After that, we utilize the K-mean algorithm to cluster the 4-dimensional vector from all images. Then we do Saak transform in each cluster and do the same process in the next stage again. But in the following stage, we can use the first 4 elements (DC component) of each image as the vector and do the K-mean clustering only use the DC component in each stage. Now what I need to do is to change the augmented kernel vector with ReLU to signal-to-position method. Using the augmented kernel vector with ReLU will generate the Saak coefficients with extra 0 which is not what we want. Thus we have to utilize the signal-to-position method as the paper instructed instead of ReLU. Thus we can get the signed Saak coefficients in each stage and then do the F-test and PCA to reduce the dimensional easily.

The challenge we meet is not only how to solve the problem, but also how to optimize the codes which implement the process. If we improve the transform with some method but spend much more time to implement it, this is not a good method because what we want is to beat CNN. So we must implement Saak transform with better performance but shorter time. There are many packets which can do CNN very fast such as TensorFlow, Keras, Theano, Torch, etc. But we have nothing in Saak transform, so if we want to totally beat CNN, we have a long way to go and a lot work to do. But I believe we can do it and finally replace CNN.

References

[1] C.-C. Jay Kuo, "Understanding convolutional neural networks with a mathematical model," the Journal of Visual Communications and Image Representation, Vol. 41, pp. 406-413, November 2016.
[2] C.-C. Jay Kuo, "The CNN as guided multi-layer RECOS transform," the IEEE Signal Processing Magazine, Vol. 34, No. 3, pp. 81-89, May 2017.
[3] C.-C. Jay Kuo and Yueru Chen, "On data-driven Saak transform," arXiv preprint arXiv: 1710.04176 (2017).

IV. Plan for the next week (***, **, *: order of priority)

- Using K-mean to cluster the coefficients and doing the Saak transform in each cluster for each stage.

V. Milestone