Matthew Mills

YNET Deep Learning Project

Research Summary

Spring 2020

Project Overview

This project was undertaken by Dr. Nguyen in the University of Idaho Math Dept. and Matthew Mills, and undergraduate RA in the Spring and Summer of 2020. The goal of the project was to provide deep learning model that would enhance medical images produced by conventional photoacoustic imaging algorithms. The following paper was used as a primary reference:

Y-Net: Hybrid deep learning image reconstruction for photoacoustic tomography in vivo - ScienceDirect

This paper outlines a method of image enhancement called the *YNET* method, which trains a convolutional neural network using raw sensor data, photoacoustic images of tissue samples, and real images of the tissue samples as the training data. The goal of the project was to reimplement the YNET method with several modifications such as augmentation and segmentation to improve performance. The first step was to acquire and generate the training dataset. The raw sensor data was generated using the kwave MATLAB library. This sensor data was used to generate simulated photoacoustic images using a conventional time reversal method in MATLAB.

The next step of the project involved reimplementing the YNET method and applying modifications. This process began by implementing a simpler method called UNET described in the following link: U-Net: Convolution Neural Network for Image Segmentation – hello ML . The UNET method would train a convolutional neural network to enhance photoacousticly generated images using only the photoacoustic images in the training data. Once this was implemented, the goal was to integrate more layers of convolution allowing the model to train on the raw sensor data as well as the photoacoustic images, thereby imitating the YNET method. The UNET method was trained using images provided by the YNET paper mentioned previously. The UNET implementation was almost completed when the original YNET implementation was discovered on Github at the following link: GitHub - chenyilan/Y-Net: The source code of "Y-Net: A Hybrid Deep Learning Reconstruction Framework for Photoacoustic Imaging in vivo" . A little progress was made on re-implementing this YNET method before the project came to a halt.

Dataset Generation

The MATLAB files used to generate the raw sensor data and time reversal data are found in the following link:

https://drive.google.com/drive/folders/1xbNbSXxIMQfwGuXhAyCAzMdYo-nBNLMr

The raw sensor data files are found at the following link:
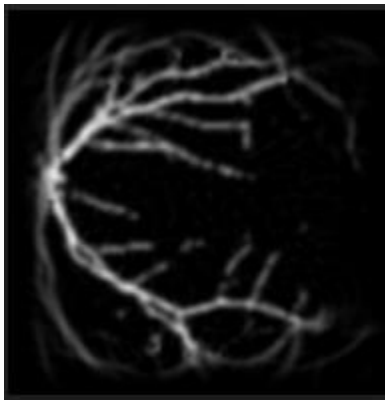
https://drive.google.com/drive/folders/10di1EhtSUTNY-Ry2wGWO4fLMhQrM-nT-

Here is a sample image of the raw sensor data:

The time reversal photoacoustic images are found at the following link:

https://drive.google.com/drive/folders/1qGj60raQI7S7O0gVwXx5UQPGbv1BV96Z

Here is a sample image of the time reversal data:

UNET Model

The entire model as well as its printed output may be found in the Jupyter notebook called *UNET* in the folder at the following link:

https://drive.google.com/drive/folders/1t9oeTJQ-cDOmDNtXjwU0Kv1KGFFn9-3r

Some metrics showing the models performance are shown below. The UNET model was still being debugged when the full YNET implementation was discovered:
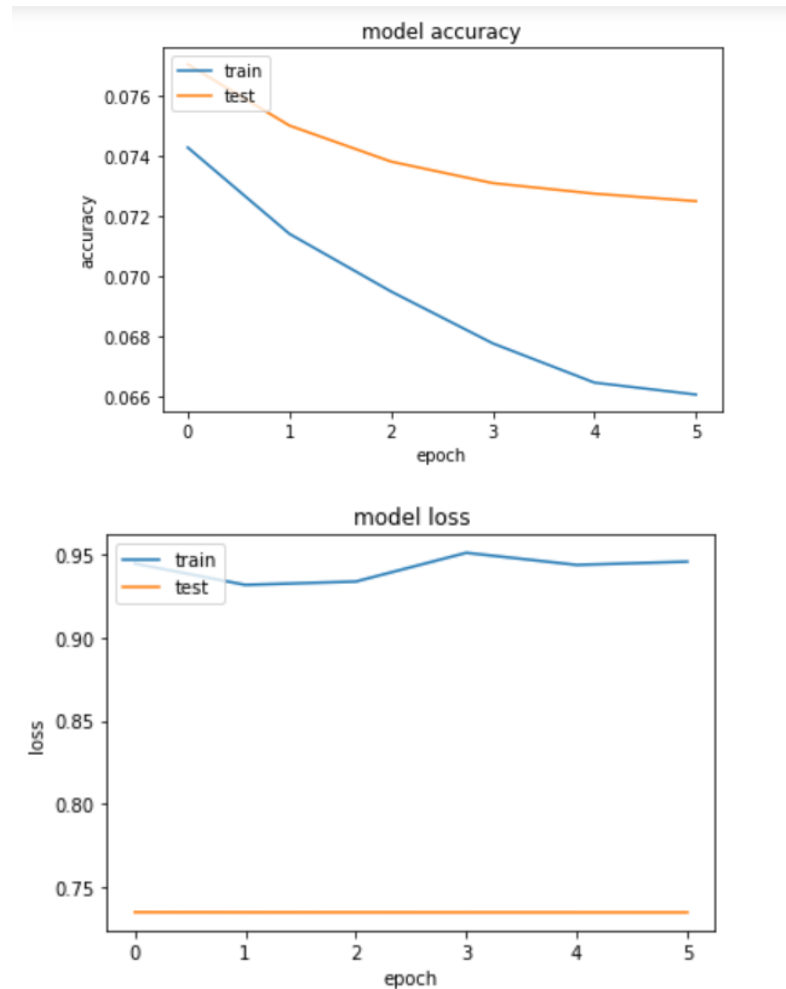

```
Test loss: 0.7346108555793762
Test accuracy: 0.0723978653550148
```