Brain Lesion Segmentation

Nathan Tsai 304575323
Bradley Zhu 304627529
University of California, Los Angeles

Background

- Effective diagnosis of medical conditions, including brain tumors and strokes, requires accurately distinguishing between unhealthy brain tissues and tumors from healthy brain tissue
- Image segmentation is crucial in analyzing medical images and is considered the first and critical step in many clinical applications, including accurate detection of brain lesions
- Current techniques use FLAIR, DW, and CAT to image the brain for brain lesion detection and image segmentation implementation.
  - **FLAIR** (fluid attenuation inversion recovery) removes cerebrospinal fluid from images by implementing an inversion recovery sequence
  - **DWI-MRI** (diffusion weighted magnetic resonance imaging) measures the restricted diffusion of water within known tissues in order to produce neural tract images
  - **CAT** (Computerized Axial Tomography) scans utilize X-ray tests to produce cross- sectional images of bones, muscles, fats, and organs, including the brain
- We will focus on analyzing the **DWI-MRI** technique by observing and studying abnormalities within the brain by observing areas appearing unusually brighter or darker than normal brain tissue

Methods

- Obtained a combination of data from the BRATS (BRAin Tumor Segmentation) and other online brain tumor datasets (figshare)
- Modified the TensorFlow pix2pix, an open source machine learning library in order to train, tune, build, and test our neural network with Python
- Processed MRI brain scans to manually identify the location of brain lesions in order to train the neural network
- Utilized image modifying software to highlight brain lesions
  - Potential source of error due to lack of professional brain lesion identification
- Constructed scripts to
  - Prepare images for training
  - Split images into training and testing datasets
  - Train, tune, and test the model
  - Modify the max_epochs parameter of each model
  - Compute accuracy of each model
  - Display testing results into an HTML file

Training

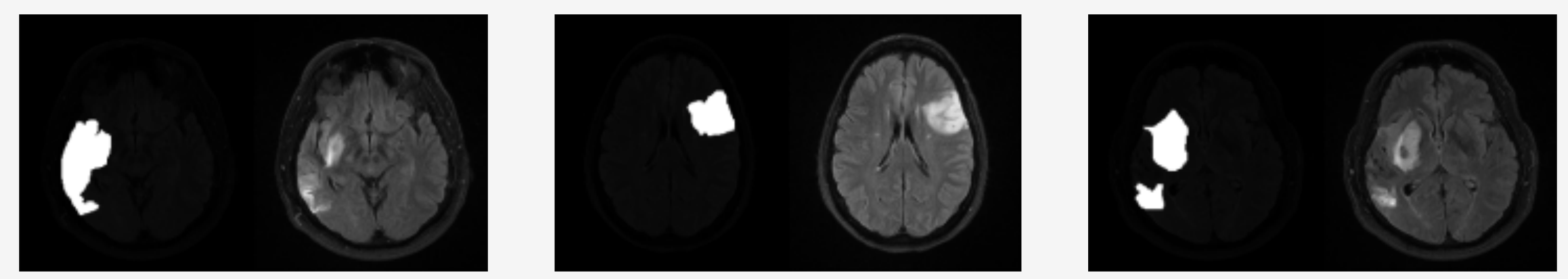

Figure 1: Training Data
Left half of each image is the ground truth (isolated brain lesion)
Right half of each image is the original MRI brain scan

- Paired ground truth lesions with corresponding brain scans
- Randomly split data set into training and testing directories
  - Trained on 35 brain scans, tested on 9
    - ■ Relatively small dataset may be a potential source of error
- Trained data set on 10 models by modifying the maximum number of epochs (iterations) from 20 to 200 in increments of 20
- Compared the accuracy of each model by averaging the Structural Similarity Image Index (SSIM) of each model's guess/truth pair

Testing

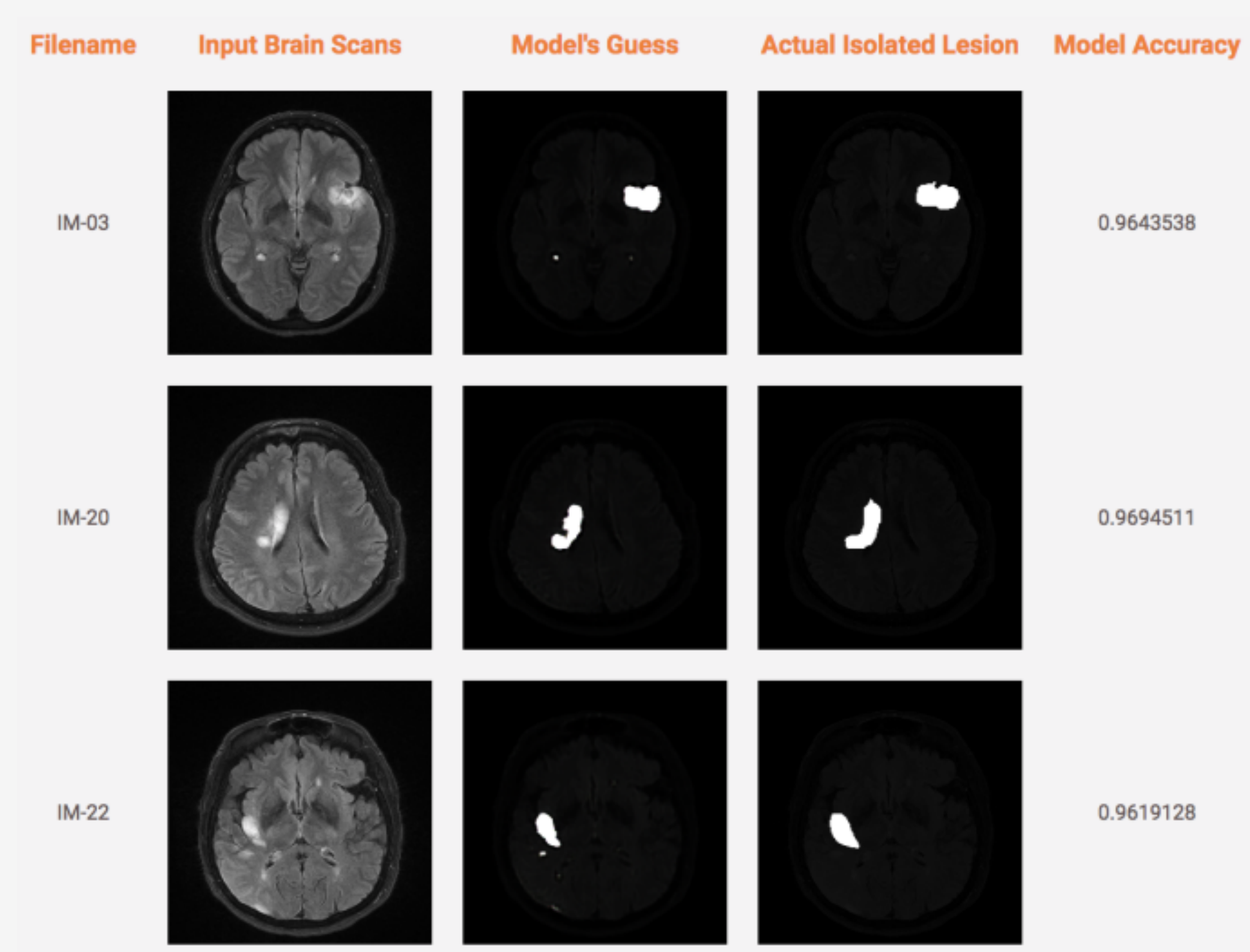

Figure 2: Testing Data
Trained model outputs a guess for each unseen brain scan
Model accuracy computed between guess and actual lesion against the SSIM index

Results

- Machine learning algorithm accurately identified brain lesions when the max_epochs parameter approached 200
- However, there is an accuracy and performance trade-off
  - Training the model at 200 epochs took 8 hours on a personal laptop while only taking 20 minutes at 20 epochs

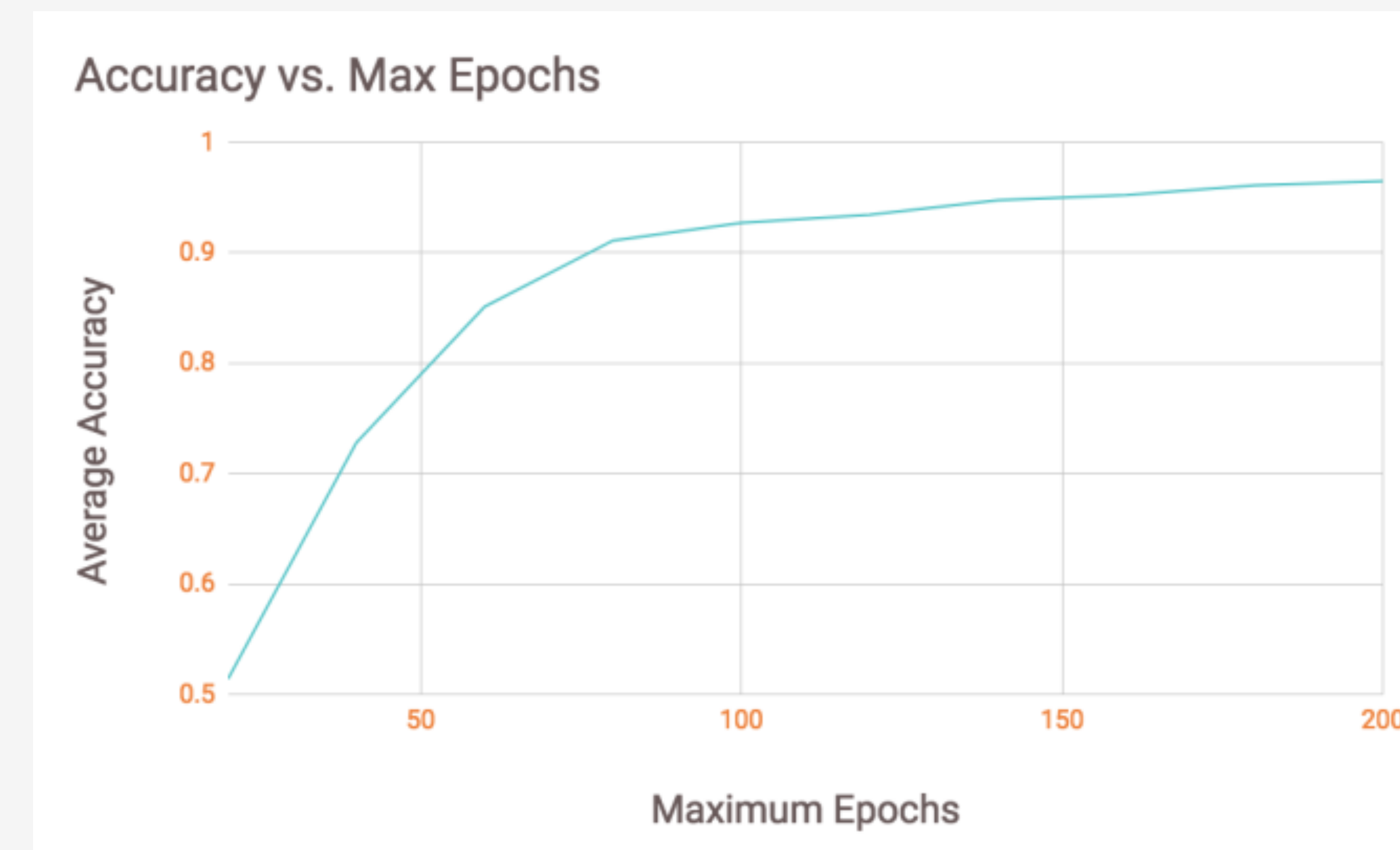

Figure 3: Accuracy vs. Max Epochs
Increasing the max_epochs parameter increases the average accuracy of the model but also increases the training time

Conclusion

- The neural network automates the tedious but crucial step of identifying abnormalities within the brain
- With further training, tuning, and testing on a larger dataset, the neural network should be able to highlight brain lesions more quickly and accurately
- A well-trained doctor utilizing a neural network with minimal error could increase the confidence of their diagnosis
- This could save lives by detecting lesions when doctors miss them and prevent unnecessary surgeries when doctors misinterpret an MRI scan

References

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