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Segmentation of Brain Tumors using U-Net Architecture

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Introduction

- **Introduction-AI in brain tumor segmentation**
  - Artificial intelligence and deep learning models are currently revolutionizing medical imaging, and can be applied to Brain Tumor Segmentation.
  - Deep learning models, and convolutional neural networks (CNNs), have displayed their ability of segmenting tumors and their boundaries.
- **Deep Learning Challenges**
  - Some challenges when developing a deep learning model is acquiring data sets that contain many brain tumors that contain annotated labels.
  - Brain Tumors are a significant challenge for deep learning models to analyze because of their structures and their make up.
- **U-Net: Deep Learning Architecture for Segmentation**
  - U-net architecture has been specifically designed to tackle segmentation in images as well as helps tackle the problem of scarcity of medical images.
  - U-net will outperform traditional segmentation technologies by using a combination of upscaling for precise localization and down sampling for the context capture.
- **U-Net For Clinical Practices**
  - Implementing U-Net in clinical practices can improve the speed and accuracy of tumor segmentation in MRI images.

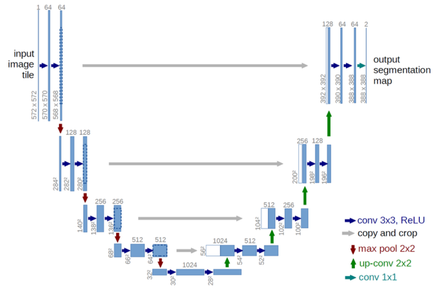
Objective

I aim to develop, train, and test a U-Net segmentation model that takes in a png of a brain MRI and segments the tumor by creating a png mask that will show where the tumor is.

U-Net Method

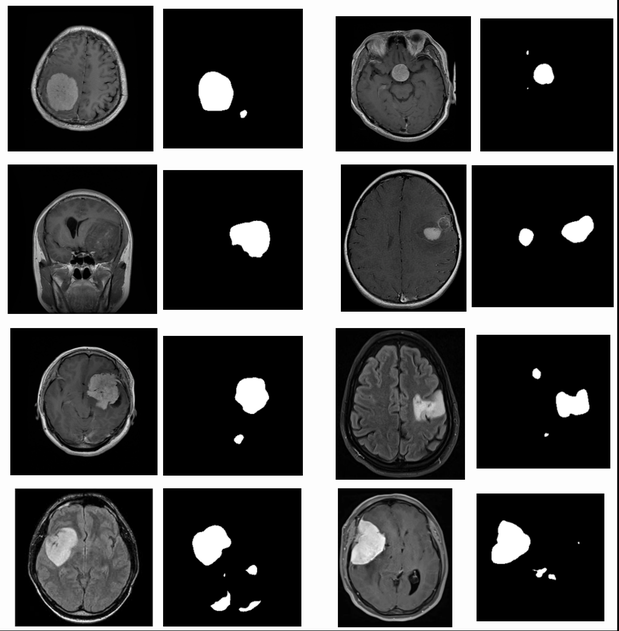
- **U-Net Architecture**
  - U-Net has a “U-shaped” architecture that consists of a contracting path to capture context and also has an expansive path that helps enable localization.
  - U-Net operates within a series of convolutional layers that will progressively down sample the input image, then a series of convolutional layers that will upsample the feature maps to the original input image.
- **My Implementation**
  - I implemented the U-Net model in TensorFlow using custom loss function and metrics that help with model optimization while giving me a performance assessment as well.
  - The U-Net model I implemented is a supervised version where the model was trained on Brain MRI png slices that contained tumors and their corresponding masks on each tumor.

- **Pseudo Code of U-Net**
  - **U-Net Model Implementation**
    - Define the convolution operations used in the U-Net architectures.
    - Define Encoder and Decoder blocks for downsampling and upsampling.
    - Then you build the U-Net model
  - **Training U-Net**
    - First shuffle data sets and split datasets for testing.
    - Compiling the U-Net model with loss function, I used dice loss, and tensorflow optimizer Adam.
    - Then train the model using a dataset while making callbacks.
  - **Testing U-Net**
    - Load Trained model to Test file.
    - Process the test images and their masks.
    - Run the model on test images to predict segmentation masks.
    - Calculate metrics F1 score, Recall, and precision, using the predicted masks against the true masks.
- **Libraries used:** TensorFlow, Numpy, Pandas, SkLearn



Results

F1 Score: 0.50657
Jaccard Score: 0.3789
Recall:0.8474
Precision:0.40279
Images and Predicted Masks:



Discussion

- Results were generally accurate, but occasionally masked structures outside the brain tumor.
- Suggested that longer training cycles may improve performance.
- Encountered compatibility issues with TensorFlow.keras on the new Mac chipset.
- Learned how to set up and run U-Net using TensorFlow and create a supervised deep learning model for image segmentation.
- Limitations included a lack of labeled brain tumor datasets and computational power constraints.
- Proposed next steps:
  - Train the model on a more powerful machine with extended epochs.
  - Explore deployment options, such as using a web app.

Refrences

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- **Walsh, Othmani, Mayank, Soumyabrata Dev. (2022). Using U-Net network for efficient brain tumor segmentation in MRI images. ScienceDirect, Volume 2, November 2022, 100098. DOI: 10.1016/j.health.2022.100098**
- **Nikhil Kumar Tomar, Youtube: Brain Tumor Segmentation using the UNET Architecture in TensorFlow | Image Segmentation**

Acknowledgements

- **Nikhil Tomar, Kaggle.com Dataset Brain Tumor Segmentation, used to train model.**
- **Navoneel Chakrabarty,Kaggle.com, Brain MRI Images for Brain Tumor Detection, used to test model.**
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