A NOVEL ASSISTIVE DIAGNOSTIC TOOL FOR BRAIN TUMOR DETECTION AND SEGMENTATION USING COMPUTER VISION

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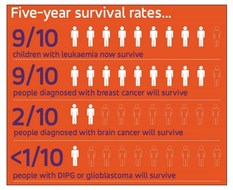
RESEARCH PROBLEM

- Today, over 700,000 people are living with brain tumors in the United States.
- Brain tumors can spread very quickly to other parts of the brain and the spinal cord, if proper action isn't taken.
- Survival rate is less than 40% for both men and women, and just 1% of national cancer research is dedicated to brain cancer
- Early detection could be the difference between life and death



PURPOSE AND GOAL

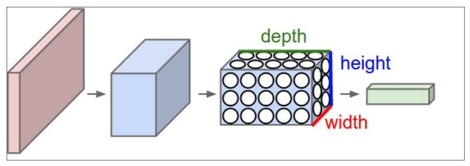
- The use of Artificial Intelligence (AI) and more specifically Convolutional Neural Networks can mitigate the possibility of human error while increasing prediction accuracy rates.
- Goal is to develop a system that assists in a fast, accurate, and accessible way to diagnose and segment brain tumors

DESIGN REQUIRMENTS

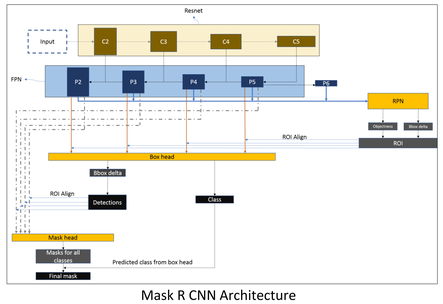
- A mAP and IoU score greater than 0.5, which signifies accurate segmentation and predictions
- A final application of which medical care professionals can easily use in everyday patient visits.

BACKGROUND

- Machine Learning (ML) is a general data analysis technique that uses computational models and methods to "learn" information directly from data without rule-based programming. Subset of ML includes Computer Vison (CV)
- Convolutional neural networks (CNNs) are special CV algorithms designed to take in an image and assign various weights in order to differentiate between images. CNNs consist of neurons with learnable weights and biases. Unlike a regular neural net, a CNN has it's neurons arranged into 3 dimensions: width, height and depth.
- A Mask R-CNN can be used for segmentation. This model's architecture is overlaid and built on top of the Faster R-CNN. A Faster R-CNN uses a CNN to extract attribute maps from the images. The maps act as inputs for the next layer and are then passed through a Region Proposal Network (RPN) , which determines the candidate's bounding boxes.



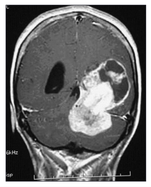
CNN Input Representation



Mask R CNN Architecture

DATA and FEATURES

- A publicly available supervised data set provided by Kaggle was used to train the Mask R CNN
- Data set contains a total of 310 images, with 155 in each class (yes and no)



Example image from data set

METHODS

1. SETUP: Jupyter notebook environment was setup by Anaconda, a package manager system, which had to be downloaded. Training on a local computer did not provide enough computing power. Thus, Google Cloud Services were used to setup a computing engine with a Machine type of "32 vCPUs 120 GB memory" , and GPU type of "Nvidia Tesla P100 4 GPU" to train the model.

METHODS

2. IMPORTS: numpy was imported to help read and analyze the data. Matplotlib was imported for data visualization techniques. Keras was imported to serve as the neural network framework. The Mask R CNN configuration was also imported in order to implement transfer learning.

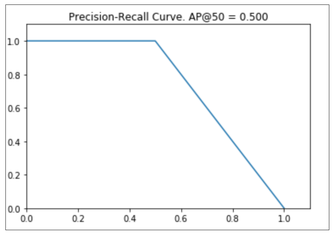
3. CHANGE CONFIGURATIONS: the Mask R CNN configuration is extended through transfer learning, and certain parameters are changed to match the brain tumor detection problem. The dataset class is also extended to implement certain methods such as loading the brain scan dataset, mask etc.

4. PREPARE FOR TRAINING: the model directory, weights and configuration are put together.

5. TRAIN MODEL: the testing, training and validation sets are determined. The model is accordingly trained with 20 epochs.

6. DISPLAY SEGMENTATION: the model is first recreated using inference mode. This picks up the last iteration of the model trained above, the most updated version, for prediction. Model is tested and new data is predicted. Finally, the predictions are displayed which includes the segmentation on the image.

RESULTS



- **Precision** = True Positives / (True Positives + False Positives)
- **Recall** = True Positives / (True Positives + False Negatives)
- The graph, to a moderate extent, bows towards (1,1) signifying a decent trained model.

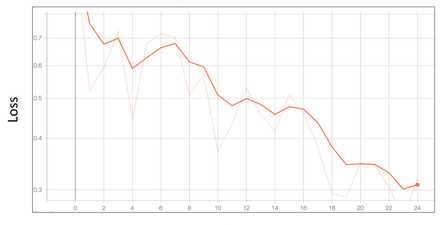
Ground Truth

- Shown is the confusion matrix
- The model was able to correctly segment majority of the images

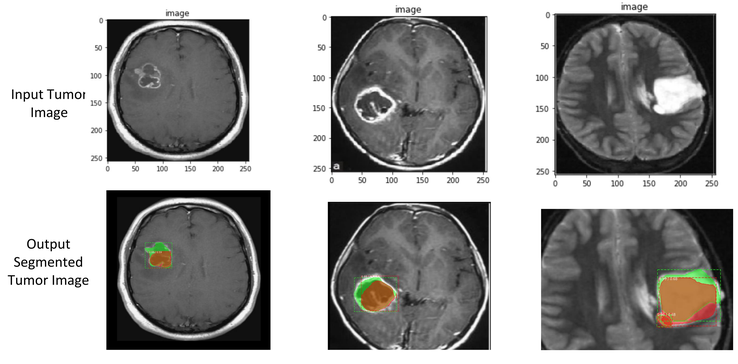
$$\text{MAP} = \frac{\sum_{q=1}^{Q} \text{AveP(q)}}{Q}$$

- Average precision computes the average precision value for recall value over 0 to 1
- The model has a **mAP score of 0.60**
- The value is greater than 0.5, highlighting the model's high skill

Epochs vs Loss

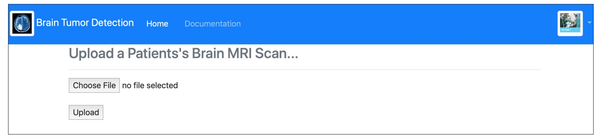


- Shown is the loss in comparison to the epochs
- There is a general downward trend for the loss as the epochs increase, illustrating that the model can learn well.

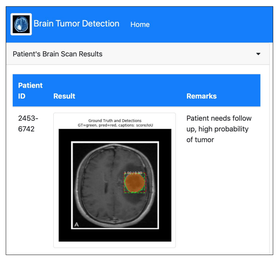


APPLICATION

- The application is developed for medical professionals, by allowing them to upload patient MRI scans, and then get immediate results on the diagnosis for each patient.
- First, the model was exported using the scikit learn machine learning API. The application was created using Python Flask REST API, and the user interface was developed using Bootstrap.
- When uploading the MRI Scan, it's put into a location defined in the program. Once saved to the correct location, the image is passed to the Mask R CNN for diagnosis and segmentation of the brain tumors
- Additionally, the patient ID column was initially removed as it's not needed for the diagnosis through the model, and at the end was later appended when displaying the results.



Depiction of Input Screen



Depiction of output screen

CONCLUSION

- The Mask R-CNN was correctly able to diagnose, and segment majority of the Brain MRI images
- The model design criteria was met deeming the project successful

FUTURE STEPS

- Future work includes using Augmented Reality (AR) to allow physicians to incorporate real time data visualization during surgical procedures.
- AR provides the ability to see inside the patient without deep incisions, greatly reducing the risk during surgery.
- Additionally, doctors will not need to depend on screens as much during surgery. Their eyes are on the patient the entire time, decreasing more risk as well.
- Real time 3D visualization through AR along with the current Mask R CNN detection and segmentation will allow for a highly useful tool that can detect and segment in real time during surgery.

REFERENCES

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