Deep Learning Brain Tumor Classifier Project

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Background

Brain tumor is known to be one of the most aggressive and fatal diseases.* The lack of qualified experts and lack of knowledge makes it time consuming to analyze.

A neuroradiologist can examine about 2-4 MRI scan/hr but machine learning can examine hundreds of scan/hr.

It is important to find a more cost-effective way to first triage of brain tumors so that the patients can get timely treatments before the brain tumor grows.

* The 5-year survival rate for people with a cancerous brain or CNS tumor is 36%. The 10-year survival rate is about 31%.

The goal

Build out an **automated classifier** that takes MRI scans of the brain as an input and classify those scans into 4 multi-classes, including:

- No tumor
- Glioma tumor
- Meningioma tumor
- Pituitary tumor

The Hypothesis

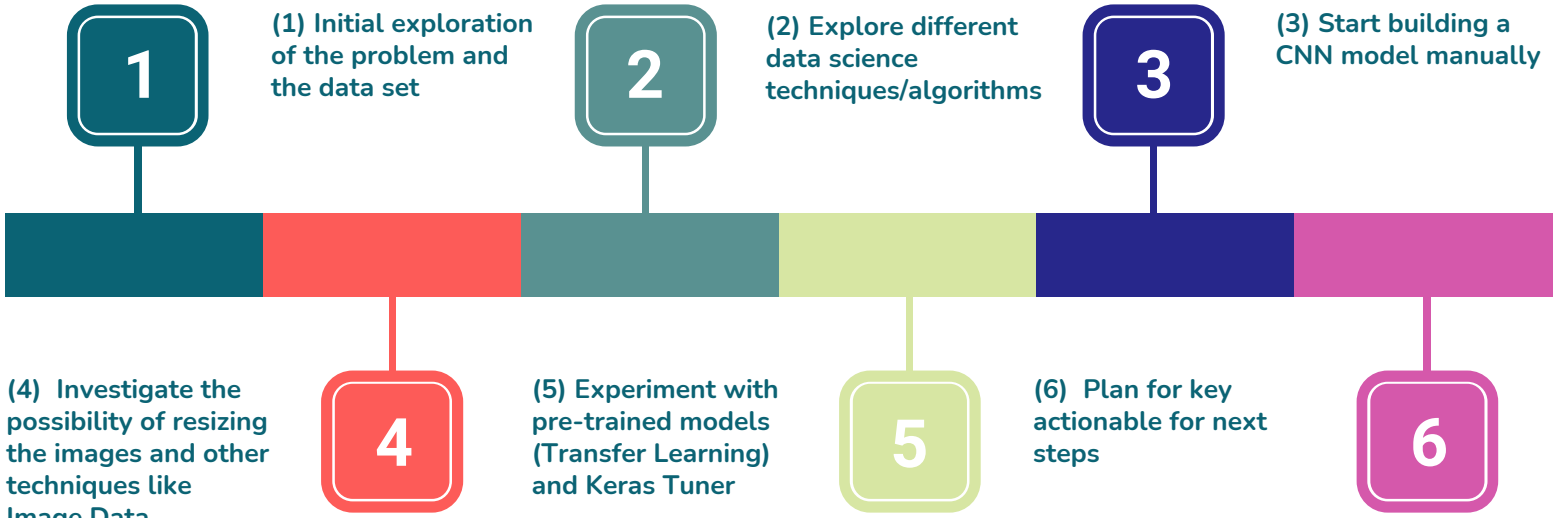
By helping the initial triage automatically, the medical staff can prioritize the those patients potentially with malignant tumors faster and in an accurate way. If those patients get **timely treatments**, they will have a **higher chance to survive**.

This pre-triage classifier can also help **developing countries** having fewer well-trained neuroradiologists to **improve the quality of medical care**.

Starting the problem

- What type of MRI scans/images do we need to build this model?
- How many the images is sufficient to build out a good classification model?
- What type of data preprocessing do we need?
- What is the size of the images that we need to resize the images?
- What data science and machine learning techniques/algorithms are applicable to this problem?

Journey: Research Approach



Data Exploration

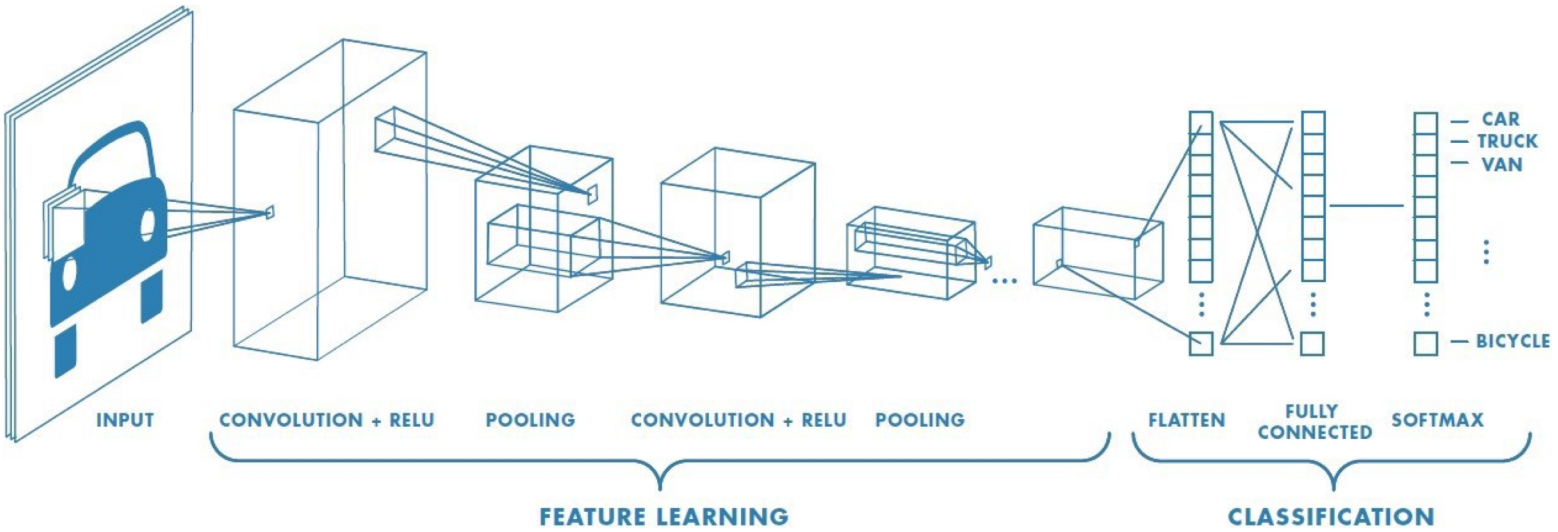
Professional MRI scans:

- Taken in different angles
- 2D images in greyscale
- 3168 MRI brain scan images
- Split 80-20 for training and validation

Why CNN?

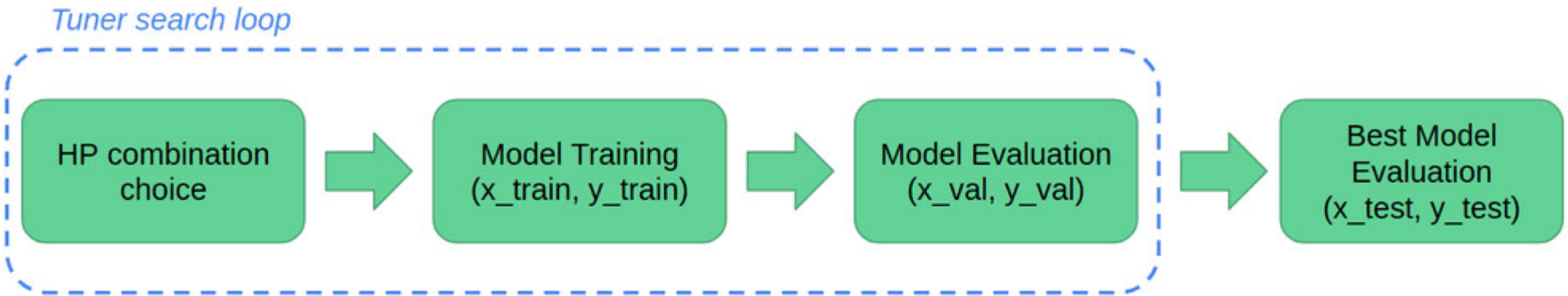
- CNNs are known for working well with object detection, image classification, esp. good at feature extractions
- Performance is good: Overall accuracy is ~0.9
- Across all different types of tumors, this model can maintain the relatively high in all the precisions, recalls

Proposed Solution - Convolutional Neural Network



Source: https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53

Solution enhancement: Keras Tuner



Source: https://www.sicara.ai/blog/hyperparameter-tuning-keras-tuner
More about Keras tuner: https://blog.tensorflow.org/2020/01/hyperparameter-tuning-with-keras-tuner.html

Metrics of evaluations

1. Confusion Matrix
2. Accuracy
3. Precision
4. Recall
5. F1 Score

Solution summary

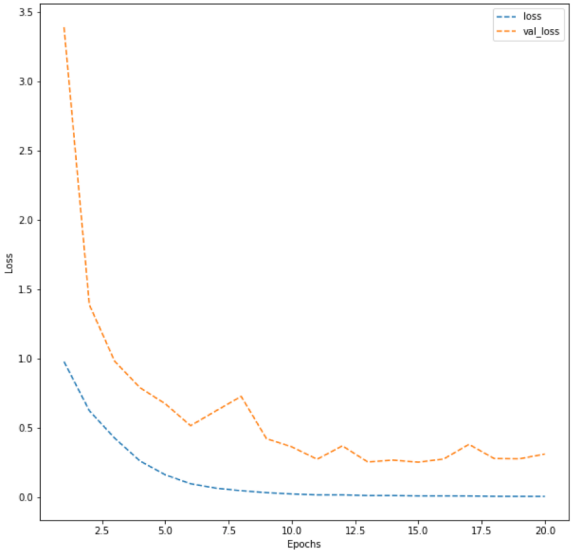
Key points of the final proposed solution design:

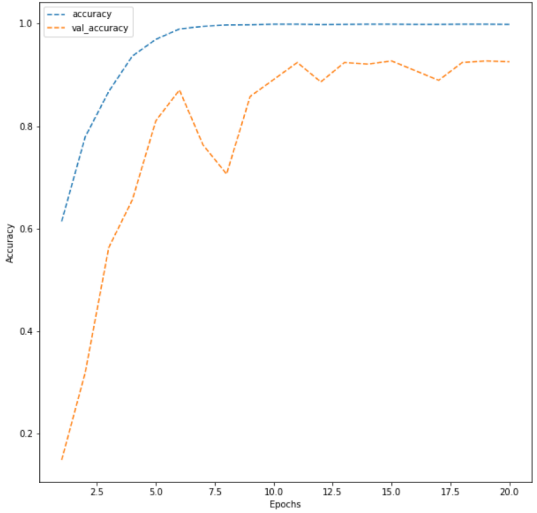
A Convolutional Neural Network using the Keras tuner to pick the optimal hyperparameters, such as, learning rate

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 224, 224, 16)	160
max_pooling2d (MaxPooling2D)	(None, 112, 112, 16)	0
dropout (Dropout)	(None, 112, 112, 16)	0
conv2d_1 (Conv2D)	(None, 112, 112, 32)	4640
max_pooling2d_1 (MaxPooling2	(None, 56, 56, 32)	0
dropout_1 (Dropout)	(None, 56, 56, 32)	0
conv2d_2 (Conv2D)	(None, 56, 56, 64)	18496
max_pooling2d_2 (MaxPooling2	(None, 28, 28, 64)	0
flatten (Flatten)	(None, 50176)	0
dense (Dense)	(None, 64)	3211328
batch_normalization (BatchNo	(None, 64)	256
dense_1 (Dense)	(None, 16)	1040
batch_normalization_1 (Batch	(None, 16)	64
dense_2 (Dense)	(None, 4)	68

Total params: 3,236,052
Trainable params: 3,235,892
Non-trainable params: 160

Results



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Confusion Matrix:  [[170  10   6   1]
 [  9 142  11   7]
 [  2   0  91   1]
 [  0   0   0 184]]
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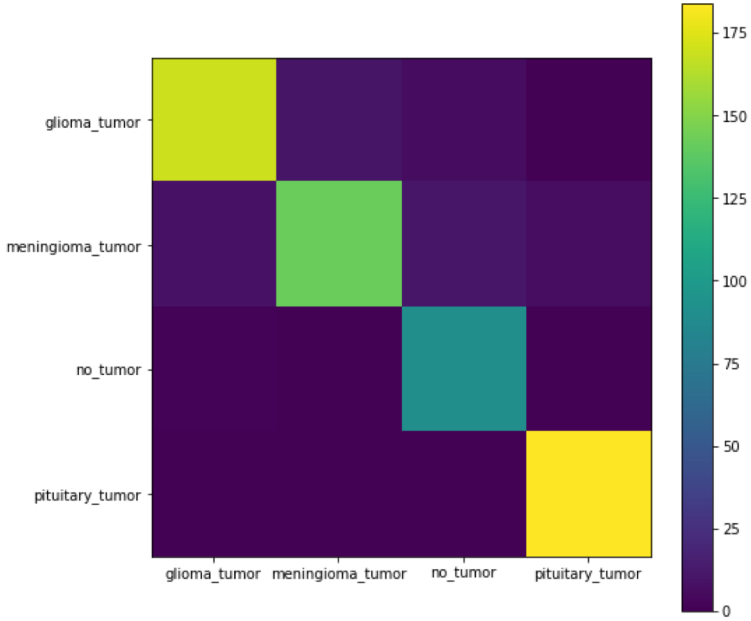


Classification Report

	precision	recall	f1-score	support
glioma_tumor	0.94	0.91	0.92	187
meningioma_tumor	0.93	0.84	0.88	169
no_tumor	0.84	0.97	0.90	94
pituitary_tumor	0.95	1.00	0.98	184
accuracy			0.93	634
macro avg	0.92	0.93	0.92	634
weighted avg	0.93	0.93	0.93	634

Key Takeaways

- Automated classification ML/Deep learning models such as, **Convolutional Neural Network(CNNs)**works well in **image classifications** and **object detections**
- Libraries like **TensorFlow Keras Tuner**, embrace the possibility of **quick optimization** of the classifier with millions of combinations in hyperparameters

Other experiments: Transfer Learning

- Transfer Learning to train the model for more accurate results

- Pre-trained model are experimented (as starting point on computer vision projects):
  1. Resnet 50
  2. Resnet 101
  3. EfficientNetB0
  4. VGGNet16

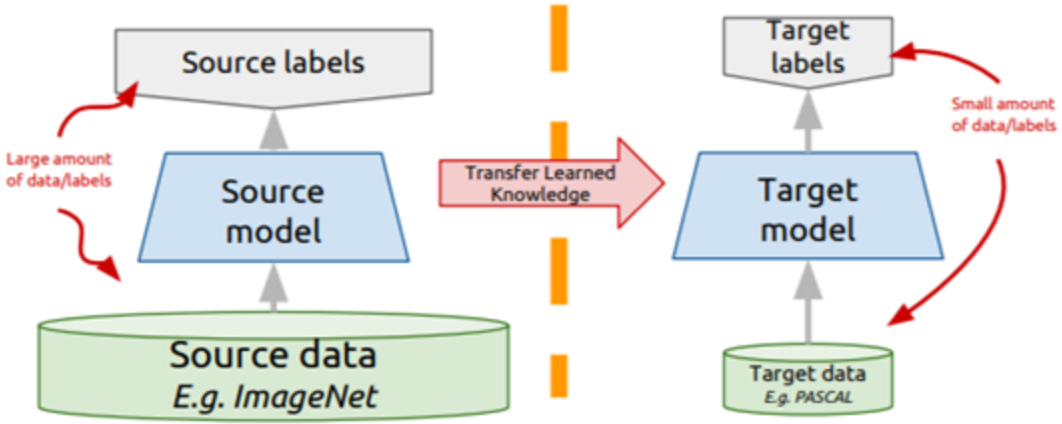
Transfer learning: idea

Instead of training a deep network from scratch for your task:

- Take a network trained on a different domain for a different **source task**
- Adapt it for your domain and your **target task**

Variations:

- Same domain, different task
- Different domain, same task



Source: https://towardsdatascience.com/a-comprehensive-hands-on-guide-to-transfer-learning-with-real-world-applications-in-deep-learning-212bf3b2f27a

Summary

- Huge potential to build pre-triage engine to help Neurosurgery departments to **prioritize the patients with a higher chance of having malignant tumors** (e.g. Recalls for Gilomas)
- All the results (esp. Gilomas) should be double verified by specialists
- Since MRI technology is improving quickly, the pre-triage model should be retrained constantly

Potential Next Steps

- Experiment and benchmark by using more **advanced/pre-trained Deep Learning models**, e.g., VolumeNet, SliceNet, VGGNet, ResNet
- **Transfer learning** for the best hypermodels and hyperparameters
- Use a much larger dataset **(MRI scans from reliable sources)** to ensure no overfitting
- Try different data augmentation techniques
- Use more scalable cloud ML platform, such as, AWS SageMaker, GCP AI, Azure Machine Learning etc

Advanced references

[1] Subhashis Banerjee, Sushmita Mitra, Francesco Masulli, Stefano Rovetta: Brain Tumor Detection and Classification from Multi-sequence MRI: Study Using ConvNets. BrainLes@MICCAI (1) 2018: 170-179

[2] Zhiguan Huang, Xiaohao Du, Liangming Chen, Yuhe Li, Mei Liu, Yao Chou, Long Jin: Convolutional Neural Network Based on Complex Networks for Brain Tumor Image Classification With a Modified Activation Function. IEEE Access 8: 89281-89290 (2020)

[3]Navid Ghassemi, Afshin Shoeibi, Modjtaba Rouhani:Deep neural network with generative adversarial networks pre-training for brain tumor classification based on MR images. Biomed. Signal Process. Control. 57 (2020)

[4] S. Deepak, P. M. Ameer: Brain tumor classification using deep CNN features via transfer learning. Comput. Biol. Medicine 111 (2019)