Brain Tumor Segmentation Using Convolutional Neural Networks in MRI Images

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Introduction

In case of brain tumors, treatment planning is a key stage to improve the quality of cancer patients.Magnetic resonance imaging (MRI) is a widely used imaging technique to identify tumors but manual segmentation of MRI data in reasonable time is a tedious task. So automatic and reliable segmentation methods are need of the hour.

Agenda

1. Introduction
2. Brain tumors - Grade,Type,Cause
3. Magnetic Resonance Imaging (MRI) -What,How,Where
4. Convolutional Neural Networks (CNN)
5. Dataset Description
6. Method and Model
7. Evaluation
8. Results
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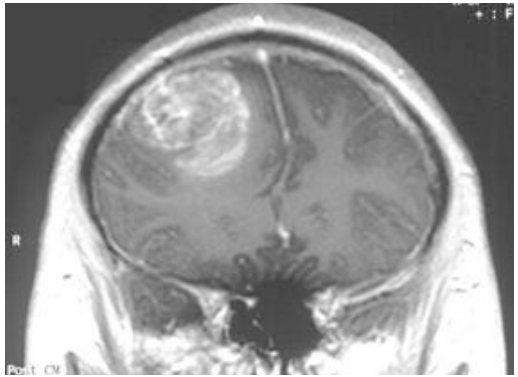
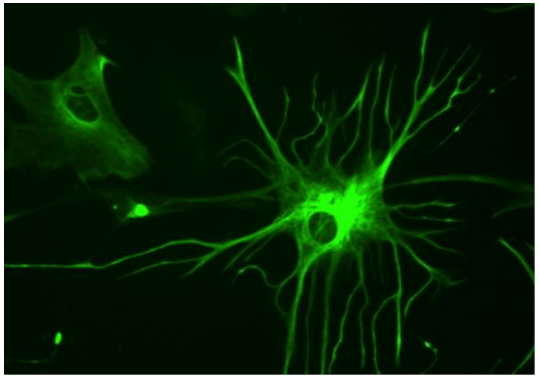
Brain Tumors - Glioma

- We are working on a particular kind of brain tumor called Glioma.
- A glioma is a type of tumor that starts in the glial cells of the brain or the spine.
- Glia, also called glial cells or neuroglia, are non-neuronal cells in the central nervous system (brain and spinal cord) and the peripheral nervous system.



GLIOMA

- **Gliomas comprise about 30 percent of all brain tumors and central nervous system tumors, and 80 percent of all malignant brain tumors.**
- **They can spread via the cerebrospinal fluid.**
- **Even under treatment, patients do not survive on average more than 14 months after diagnosis.**



GLIAL CELL

Tumor Grading:

1. **Grade:** Determined by pathologic evaluation of the tumor, is a measure of the cell appearance in tumors and other neoplasms.
2. The grade score (numerical: G1 up to G4) increases with the lack of cellular differentiation - it reflects how much the tumor cells differ from the cells of the normal tissue they have originated from.

GRADE 1	Low Grade	Well-differentiated
GRADE 2	Intermediate Grade	Moderately differentiated
GRADE 3	High Grade	Poorly differentiated
GRADE 4	Anaplastic	Undifferentiated

Types of Glioma

- *High-grade gliomas(HGG)*:

1. Highly vascular tumors and have a tendency to infiltrate,have extensive areas of necrosis and hypoxia.
2. WHO grades III–IV ,thus anaplastic; these are malignant and carry a worse prognosis.
3. Often, tumor growth causes a breakdown of the blood–brain barrier in the vicinity of the tumor. As a rule, high-grade gliomas almost always grow back even after complete surgical excision, so are commonly called recurrent cancer of the brain.
4. **HGG survival rate** : The median overall survival of anaplastic (WHO grade III) gliomas is approximately 3 years, glioblastoma multiforme has a poor median overall survival of 15 months.

Types of Glioma - contd.

- *Low-grade gliomas (LGG):*

1. Grow slowly, often over many years, and can be followed without treatment unless they grow and cause symptoms.
2. Low-grade gliomas [WHO grade II] are well-differentiated (not anaplastic).
3. These tend to exhibit benign tendencies and portend a better prognosis for the patient.
4. However, they have a uniform rate of recurrence and increase in grade over time so should be classified as malignant.
5. **LGG survival rate**: The age-standardized 10-year relative survival rate was 47%. One study reported that low-grade oligodendroglioma patients have a median survival of 11.6 years

Causes :

- Hereditary disorders such as neurofibromatosis (type 1 and type 2) and tuberous sclerosis complex are known to predispose to the development.
- Consumption of diets high in cured foods, nitrites and low in vitamin C-rich fruits and vegetables.
- Infection with cytomegalovirus
- **DNA Mutations**

Tumor suppressor protein 53 (p53) is mutated early in the disease.p53 is the "guardian of the genome", which, during DNA and cell duplication, makes sure the DNA is copied correctly and destroys the cell (apoptosis) if the DNA is mutated and cannot be fixed. When p53 itself is mutated, other mutations can survive. Phosphatase and tensin homolog (PTEN), another tumor suppressor gene, is itself lost or mutated. Epidermal growth factor receptor, a growth factor that normally stimulates cells to divide, is amplified and stimulates cells to divide too much. Together, these mutations lead to cells dividing uncontrollably, a hallmark of cancer.

Magnetic Resonance Imaging (MRI)

- MRI is a pain-free, noninvasive medical test used to produce two- or three-dimensional images of the structures inside your body using a strong magnetic field and radio waves.
- MRI gives detailed views of your organs, tissues, and skeleton, which can be used to help diagnose and monitor a wide variety of medical conditions.
- Radiologists use MRI exams, each of which consists of a series of cross-sectional gray-scale images, to diagnose disease, quantify tissue growth or atrophy over time, and guide surgical procedures.

How MRI works :

- At a high level, MRI works by measuring the radio waves emitted by atoms subjected to a magnetic field.
- The appearance of tissue in an MRI depends on the tissue's chemical composition and which particular MR "sequence" is employed.
- The most common of sequence is T2-weighted MRI, in which tissues with more water or fat appear brighter due to their relatively high number of hydrogen atoms.
- In contrast, bone (as well as air) has low signal and appears dark on T2-weighted images.

For brain MRIs, T1-weighted, T1-weighted with gadolinium contrast enhancement (T1-Gd) and Fluid Attenuated Inversion Recovery (FLAIR) are commonly used sequences along with T2-weighted images.

Where MRI test is performed

MRI's unrivaled soft-tissue contrast makes it useful for detecting abnormal tissue known as "tumors" or "lesions". MRI is used to help diagnose include:

1.Brain and spinal cord conditions such as stroke, brain or spinal cord injuries,tumors.

2.Heart and blood vessel structure issues, damage from a heart attack or heart disease,blockages and other heart problems.

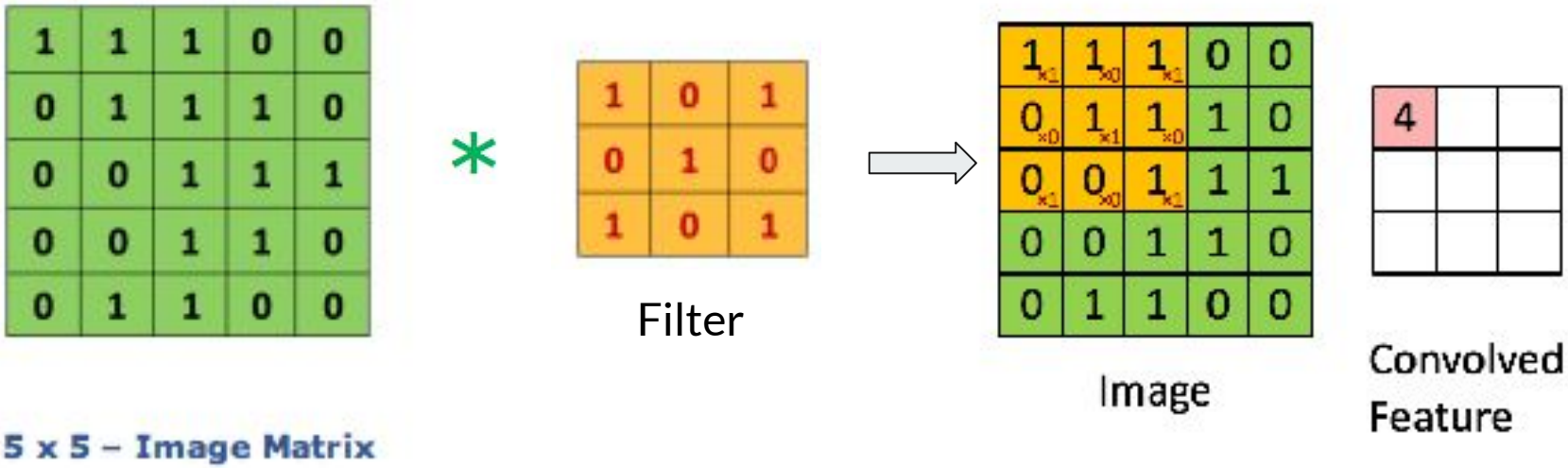
3.Liver diseases like cirrhosis

4.Joint and bone irregularities, tumors, abnormalities, and infections

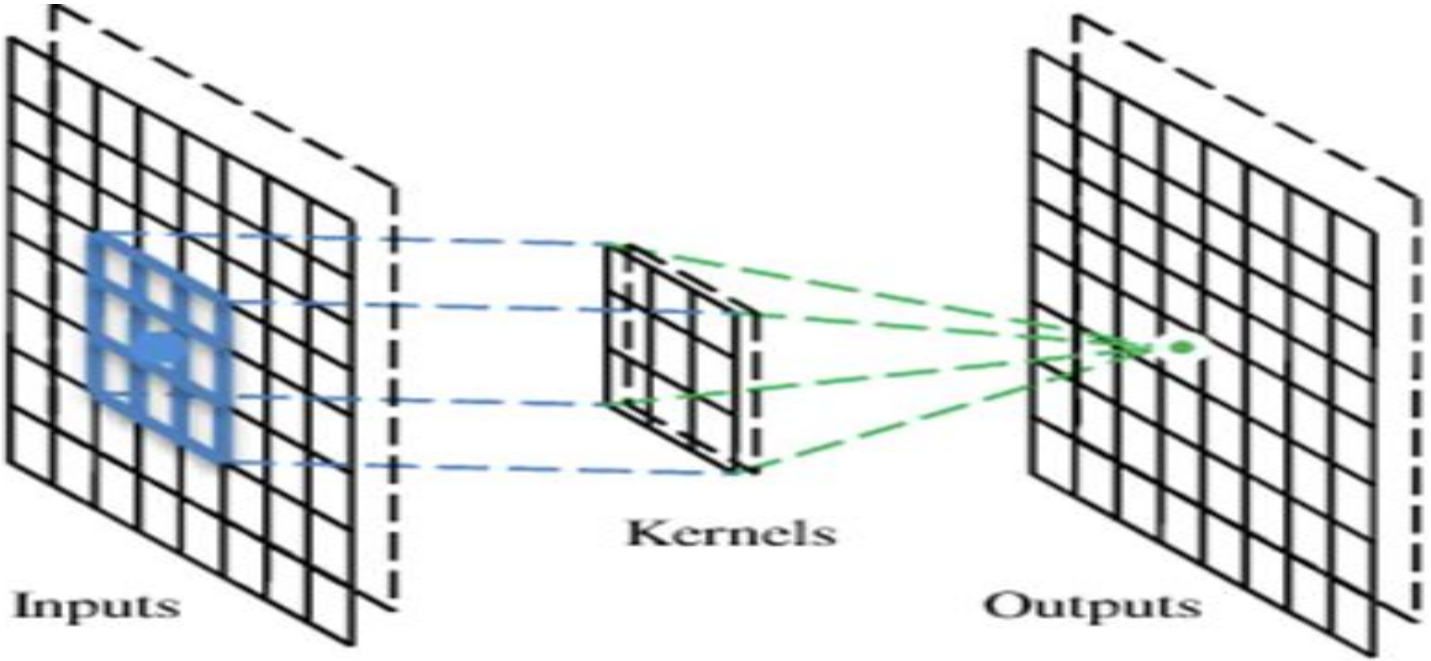
Convolution Neural Network

Convolutional Neural Networks (CNN or ConvNet) are complex feed forward neural networks. CNNs are used for image classification and recognition because of its high accuracy.The CNN follows a hierarchical model which works on building a network, like a funnel, and finally gives out a fully-connected layer where all the neurons are connected to each other and the output is processed.

What is Convolution?



How it Applied in images



Stride

Stride is the number of pixels shifts over the input matrix. When the stride is 1 then we move the filters to 1 pixel at a time. When the stride is 2 then we move the filters to 2 pixels at a time and so on.

Padding

Sometimes filter does not fit perfectly fit the input image. We have two options:

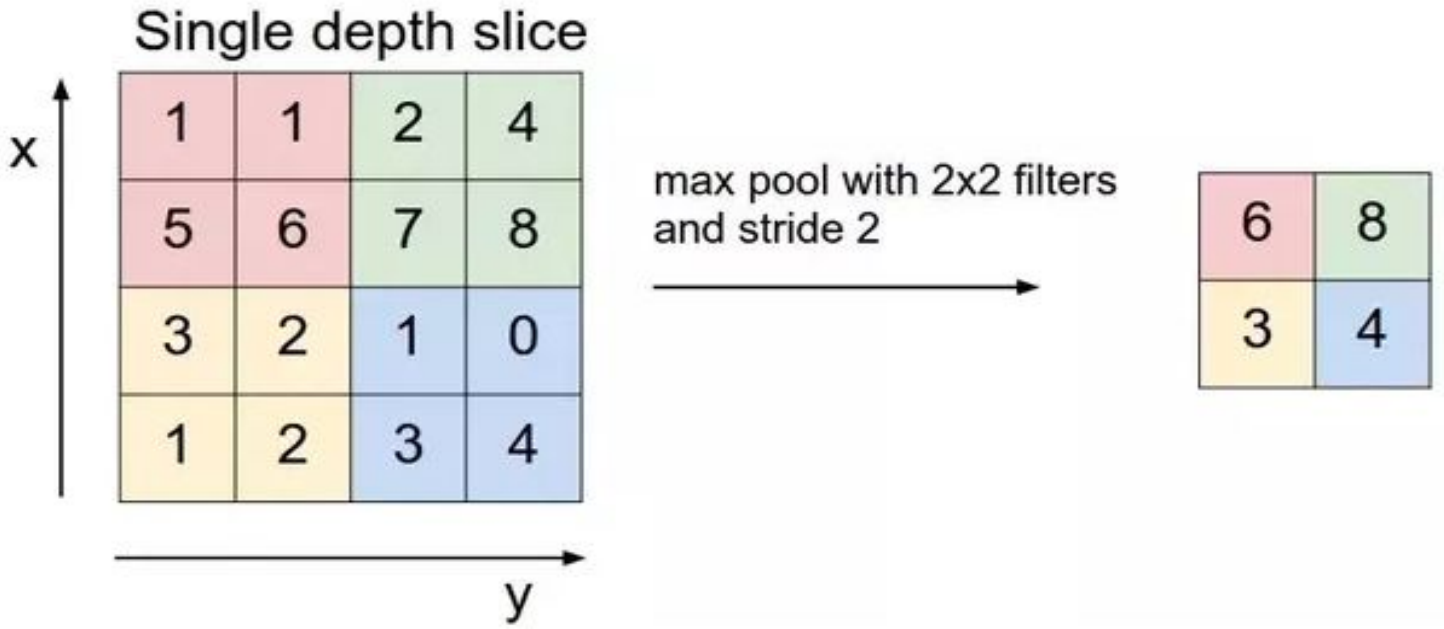
1) Pad the picture with zeros (zero-padding) so that it fits.
2) Drop the part of the image where the filter did not fit. This is called valid padding which keeps only valid part of the image.

What is Pooling?

Pooling layers section would reduce the number of parameters when the images are too large. Spatial pooling also called subsampling or downsampling which reduces the dimensionality of each map but retains the important information.pooling can be of different types:

1. Max Pooling
2. Avg Pooling
3. Sum Pooling

How Pooling is done



Why Pooling

Subsampling Pixel will not change the object.

Subsampling

Affine Layer

The layer we call as FC layer, we flattened our matrix into vector and feed it into a fully connected layer like neural network.feature map matrix will be converted as vector (x1, x2, x3, …). With the fully connected layers, we combined these features together to create a model. Finally, we have an activation function such as softmax or sigmoid to classify the outputs as cat, dog, car, truck etc.,

The whole CNN

Convolution

Max Pooling

Convolution

Max Pooling

Can repeat many times

Flattened

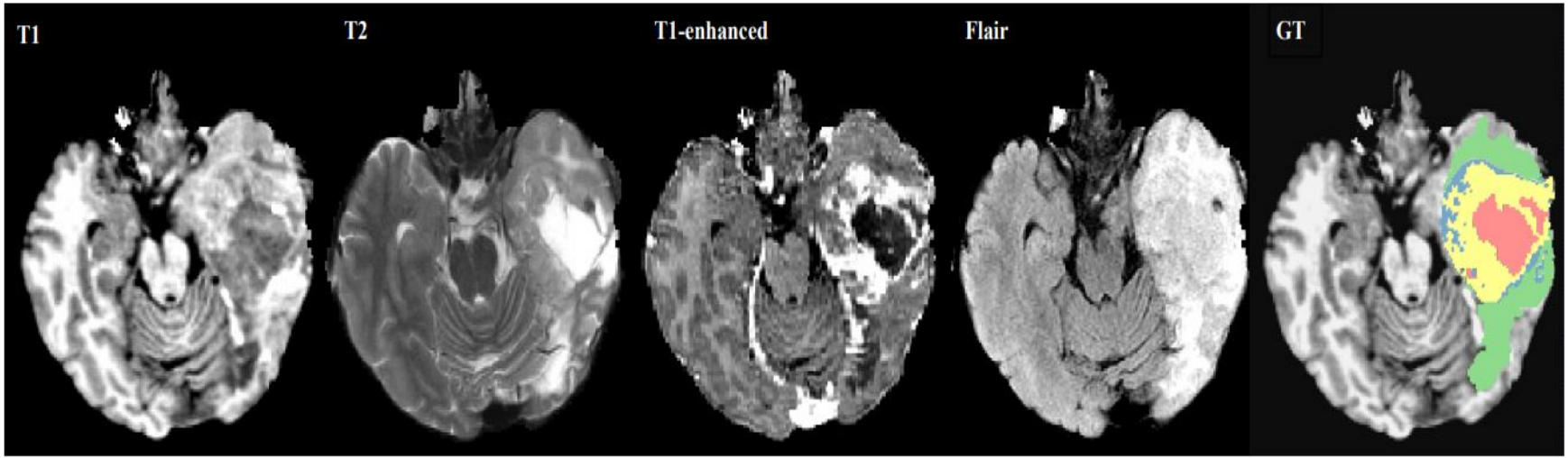
Fully Connected Feedforward network

cat dog .....

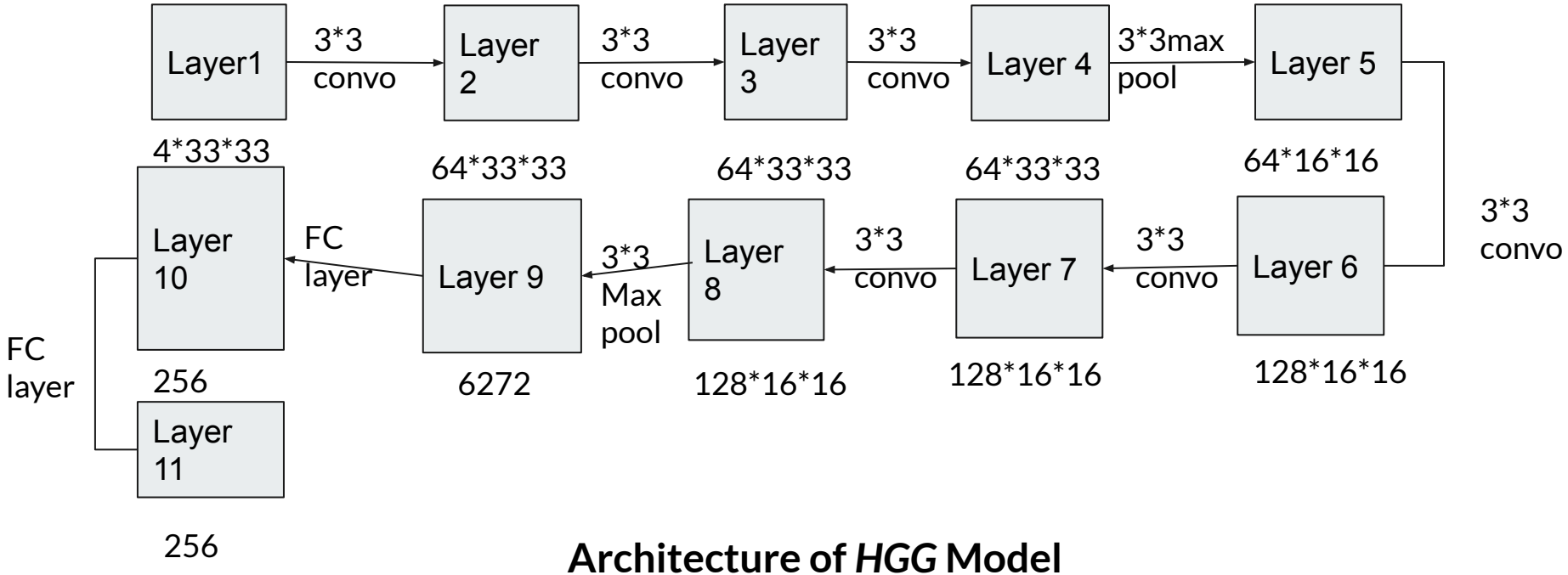
About the Data

Brain tumor image data used in by researcher were obtained from the MICCAI 2013 Challenge on Multimodal Brain Tumor Segmentation. The dataset comprises of 30 patient datasets and 50 synthetic datasets. Each patient’s data comprises of HGG and LGG and each one of them contain 5 MRI including ground truth. A single MRI scan is a image with 176*216*160 dimensions.

A Single channel of image:

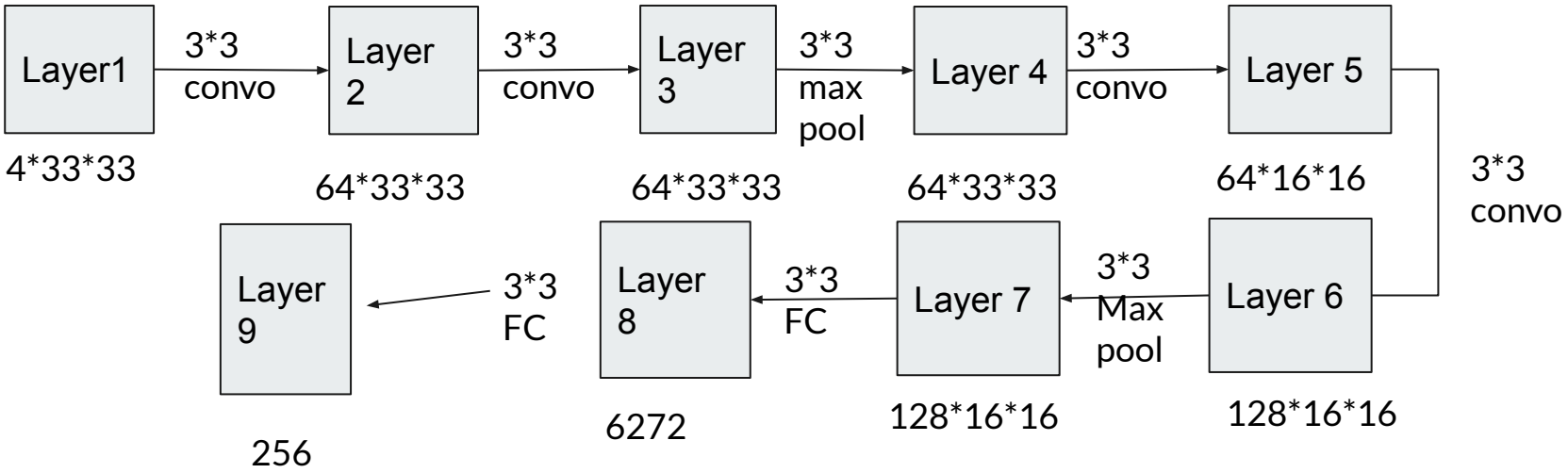


Model Architecture



Architecture of *HGG* Model

Architecture of LGG model



Transfer Learning

Transfer learning is a machine learning technique where a model trained on one task is re-purposed on a second related task.Transfer learning is popular in deep learning given the enormous resources required to train deep learning models or the large and challenging datasets on which deep learning models are trained.

Evaluation

We have used performance measure(F1 score) for checking how good our model is

$$F1 = 2 \times \frac{Precision * Recall}{Precision + Recall}$$

$$Recall = \frac{True\ Positive}{True\ Positive + False\ Negative}$$

$$Precision = \frac{True\ Positive}{True\ Positive + False\ Positive}$$

Results

We get considerable good F1 score value as: **0.928.** These result we have got from a pretrained model whose architecture is described in the above slides.

Reference

https://www.verywellhealth.com/what-is-an-mri-and-what-does-it-do-3157069

https://www.youtube.com/redirect?q=https%3A%2F%2Fwww.edureka.co%2Fai-deep-learning-with-tensorflow&redir_token=LEMGz6jzAJuEMwdBaWpz83lHKGp8MTU2OTY0NjQyNkAxNTY5NTYwMDI2&v=umGJ30-15_A&event=video_description