Deep Learning Method for Brain Tumor Classification using MR Images

Proposal for Master Thesis Project

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1. Problem Description

Brain tumor grading describes a brain tumor's growth or spread, which is essential to guide medical doctors to make treatment decisions. In general, brain tumors are graded based on what morphology the tumor cells appear under a microscope, which is also known as biospy. In this way, it is necessary to extract some tumor tissues through an invasive operation. Although there are conventional machine learning methods to grade brain tumors in medical images, manual features extraction causes those methods impractical. Therefore, a non-invasive and effective approach for grading brain tumors is in demand.

2. Proposed Solution

To grade brain tumors effectively, in this project, a deep learning method will be investigated to automatically detect features and grade tumors by analyzing MR image sequences of brains. The study focuses on two network models, including convolutional neural network (CNN) and recurrent neural network (RNN). Apply different models to grade tumors and evaluate performance respectively. Main steps of the project is listed as follows:

(1) Literature review and learn relevant programming skills;
(2) Select dataset and carry out preprocessing and augmentation on the dataset;
(3) Build CNN and RNN models, training weights and tuning parameters;
(4) Performance comparison and assessment;
(5) Write master thesis and give thesis presentation.

3. Plan for Solution

3.1 Programming language and deep learning library
The project will be programmed in Python with the support of the latest Tensorflow.

3.2 Available dataset
BraTS2017 is a dataset of brain MR image sequences for brain tumor segmentation challenge in 2017. BraTS2017 has 243 cases in total that can be grouped into three grades (II, III, IV), in which 167 cases are contained in training set that is available now. The testing set consists of the rest cases which will be released in 2018. Each case has a mask of its tumor, in order that the tumor region can be easily located and extracted. Thus, BraTS2017 fits this project very well.

3.3 MR image sequences preprocessing
Two steps are included in preprocessing: (1) bias field correction (BFC); (2) intensity scale standardization (ISS). BFC is able to remove bias field signal caused by old MR imaging equipment from a brain sequence. MR sequences in dataset were generated by many devices from various patients so that there are considerable intensity differences among sequences which should not be ignored. ISS can adjust every case's distribution to obviously reduce this intensity difference.

3.4 Patches generation and augmentation

Bounding box, a square cube, of each tumor' core is firstly extracted according to the tumor mask. All bounding boxes are resized into the same shape. Several augmentation approaches, such as making mirrors, modifying intensity and partial extraction, are applied to increase the number of cases. Forming training and validating set is the next step to prepare train the model.

3.5 Build models

The basic structure of CNN is shown as Figure 3.1. In this case, 3D tumor patches are input into the model. Features are generated after convolving, max pooling and fully connecting stages. The probability of each grade group will be computed in output layer. What the figure shows is a very simple CNN structure. Deeper model shall be built if the simple one works. As to RNN, more specifically, long-short term memory (LSTM), its input layer consists of all slices of 3D tumor patches as shown in Figure 3.2. Features are extracted after all LSTM cells. More complicated model will be applied after the simple LSTM model has been tested.
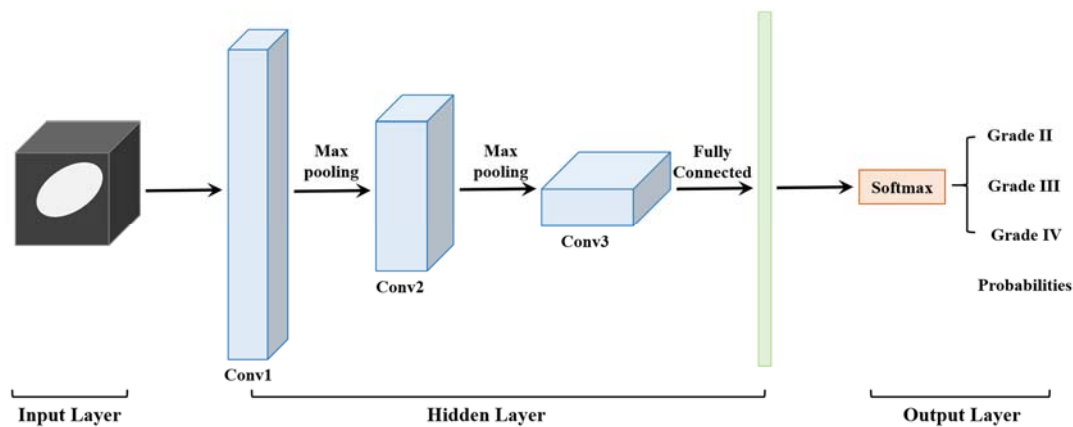

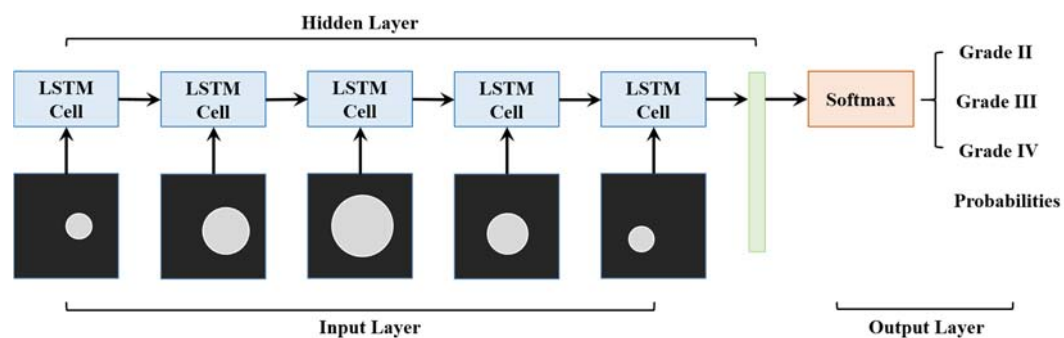*Figure 3.1 Basic Structure of CNN for Classification Problem*

Figure 3.2 Basic Structure of LSTM for Classification Problem

3.6 Train models and tune hyper-parameters

To obtain satisfied results, a lot of hyper-parameters need to be assigned by keeping on training and testing models. Those hyper-parameters, such as weights initialization method, activation function, batch normalization, optimizer type, dropout rates, batch size, number of epochs, learning rates and so on, are going to be adjusted based on the simple models. Then, fine-tuning parameters of complicated models.

3.7 Performance evaluation

Tumors in test set shall be graded through different trained models. The performance of classification results can be described as four metrics, which are accuracy, recall, precision and receiver operating characteristic curve. Evaluation of every model is carried out by comparing these four metrics with other models' results.

4. Schedule

Stages	Time
(1) Read literature and learn programming skills	whole course
(2) Preprocessing on dataset	now – 2017/10/01
(3) Patches generation and augmentation	2017/10/02 – 2017/10/16
(4) Build simple models	
(5) Train simple models	2017/10/17 – 2017/12/16
(6) Tuning hyper-parameters	
(7) Build complicated models	
(8) Train complicated models	2017/12/17 – 2018/03/30
(9) Tuning hyper-parameters	
(10) Performance evaluation	2018/04/01 – 2018/04/15
(11) Write master thesis	2018/04/16 – 2018/06/15
(12) Prepare for presentation	2018/05/16 – 2018/06/15