Deep Learning Application in Medical Image

RSNA Intracranial Hemorrhage Detection

Project Proposal

10-28-2019

1 Project Overview

Deep Learning techniques have recently been widely used for medical image analysis, which has shown encouraging results especially for large healthcare and medical image datasets. In the computer vision field, the deep learning model, such as Convolutional Neural Network(CNN) has shown better capabilities to segment and/or classify medical images like ultrasound and CT scan images in comparison to traditional machine learning techniques.

Recently, Deep Learning applications, in particular in applying the CNN model for analyzing Medical Images have achieved very promising results. The major application fields can be broadly separated into two categories: classification application and segmentation applications.

- Classification Applications

For a given set of labeled images, using the deep learning model to find the patterns between the input images and its corresponding class labels. The related applications, such as lung images detection from CT scanning to classify images patches into 7 classes[1]. This paper describes how to use the CNN model to classify the healthy tissue and six different interstitial lung disease patterns. The other example is to identify the thyroid nodules as malignant or benign from the chest X-ray and Ultrasound images[2].

- Segmentation Application

The other important application for Medical Image Analysis is to identify organs, lesions or substructures of organs from the Ultrasound, MRI or X-Ray images. Now, you can use deep learning models to segment the brain tumors from MRI images.[3]

With recent progress in Deep Learning field, this project will build a model and application to detect acute intracranial hemorrhage and its subtypes based on the rich medical image dataset which is provided by the Radiological Society of North America (RSNA®) in collaboration with members of the American Society of Neuroradiology and MD.ai. This is also a Kaggle Featured Prediction Competition launched months ago.[4]

[1] "Lung Pattern Classification for Interstitial Lung Diseases Using ...." https://ieeexplore.ieee.org/iel7/42/7463083/07422082.pdf.

[2] "Classification of thyroid nodules in ultrasound images using ...." https://ieeexplore.ieee.org/document/7952290.

[3] "Brain Tumor Segmentation - Papers With Code." https://paperswithcode.com/task/brain-tumor-segmentation.

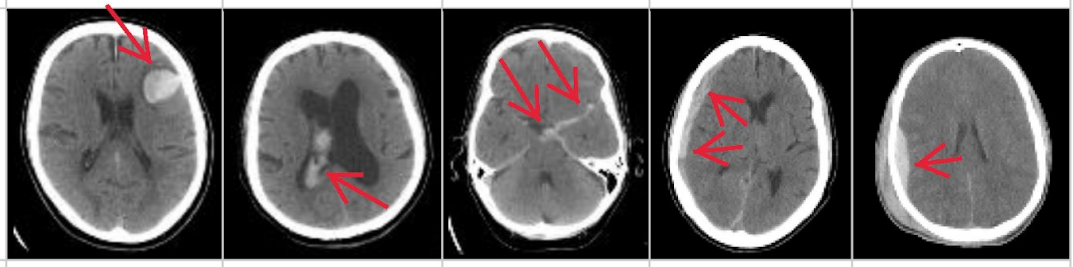
[4] "RSNA Intracranial Hemorrhage Detection." https://www.kaggle.com/c/rsna-intracranial-hemorrhage-detection/overview/description.

2 Problem Statement

Intracranial hemorrhage, bleeding that occurs inside the cranium, is a serious health problem requiring rapid and often intensive medical treatment. For example, intracranial hemorrhages account for approximately 10% of strokes in the U.S., where stroke is the fifth-leading cause of death. Identifying the location and type of any hemorrhage present is a critical step in treating the patient.

Diagnosis requires an urgent procedure. When a patient shows acute neurological symptoms such as severe headache or loss of consciousness, highly trained specialists review medical images of the patient's cranium to look for the presence, location and type of hemorrhage. The process is complicated and often time consuming.

This project is to develop a Classification/Segmentation model and build a web application to identify the five Hemorrhage sub-Types: Intraparenchymal, Intraventricular, Subarachnoid, Subdural and Epidural.

	Intraparenchymal	Intraventricular	Subarachnoid	Subdural	Epidural
Location	Inside of the brain	Inside of the ventricle	Between the arachnoid and the pia mater	Between the Dura and the arachnoid	Between the dura and the skull
Imaging					
Mechanism	High blood pressure, trauma, arteriovenous malformation, tumor, etc	Can be associated with both intraparenchymal and subarachnoid hemorrhages	Rupture of aneurysms or arteriovenous malformations or trauma	Trauma	Trauma or after surgery
Source	Arterial or venous	Arterial or venous	Predominantly arterial	Venous (bridging veins)	Arterial
Shape	Typically rounded	Conforms to ventricular shape	Tracks along the sulci and fissures	Crescent	Lentiform
Presentation	Acute (sudden onset of headache, nausea, vomiting)	Acute (sudden onset of headache, nausea, vomiting)	Acute (worst headache of life)	May be insidious (worsening headache)	Acute (skull fracture and altered mental status)

3 Metrics

- This project are are evaluated using a weighted multi-label logarithmic loss. Each hemorrhage sub-type is its own row for every image, and the model will predict a probability for that sub-type of hemorrhage. There is also an '**any**' label, which indicates that a hemorrhage of

ANY kind exists in the image. The **'any'** label is weighted more highly than specific hemorrhage sub-types.

- For each image `Id`, prediction will have a set of predicted probabilities (a separate row for each sub-type). Then taking the log loss[5] for each predicted probability versus its true label. The ***loss*** is averaged across all samples.
- When calculating a weighted multi-label logarithmic loss, predicted input values of 0 and 1 are undefined. To avoid this problem, log loss functions typically adjust the predicted probabilities (p) by a small value (epsilon) and use the MinMax Rule: $max(min(p,\ 1-10^{-15}),\ 10^{-15})$

4 Development Framework

In Deep learning application field, there are two major deep learning frameworks: TensorFlow and PyTorch. The competitive strengths for each framework are:

- TensorFlow is mainly adopted by the industrial companies and PyTorch is mainly focused on research communities.
- TensorFlow has a large, well established user base, and industry is typically slower to pick up on new technologies. TensorFlow is much more efficient than PyTorch. Even modest savings in model run times can help a company's bottom line.
- PyTorch integrates neatly with Python, making the code simple to use and easy to debug.

Based on top of PyTorch, Fastai is first deep learning library to provide a single consistent interface to all the most commonly used deep learning applications for vision, text,tabular data, time series and collaborative filtering. Fastai can provide more neat, more integrate APIs to build deep learning pipelines: from the data clean to model tuning and optimization.
So for the rapid proto-typing the model, this project will use Fastai/PyTorch to implement.

5 Dataset

The original Dataset is hosted on the Kaggle platform[6]. The download API :
kaggle competitions download -c rsna-intracranial-hemorrhage-detection

There are two-part data:

- Train.csv: include the ID and Label:
  ID is a combined string that includes the image filename and Hemorrhage type.
  Label is a target column, indicating the probability of whether that type of hemorrhage exists in the indicated image.
  Format:
  `[Image Id]_[Sub-type_Name]`, as follows:

```
Id,Label
1_epidural_hemorrhage,0
1_intraparenchymal_hemorrhage,0
1_intraventricular_hemorrhage,0
```

[5] "What is Log Loss? | Kaggle." https://www.kaggle.com/dansbecker/what-is-log-loss.
[6] "RSNA Intracranial Hemorrhage Detection | Kaggle." https://www.kaggle.com/c/rsna-intracranial-hemorrhage-detection/data.

`1_subarachnoid_hemorrhage,0.6`
`1_subdural_hemorrhage,0`
`1_any,0.9`

- DICOM Images:
  DICOM is the standard for the communication and management of medical imaging information and related data. DICOM files can be exchanged between two entities that are capable of receiving image and patient data in DICOM format.
  DICOM images contain associated metadata. This will include `PatientID`, `StudyInstanceUID`, `SeriesInstanceUID`, and other features.

6 Pipeline

Pipeline is important in machine learning project. Based on Fastai/PyTorch framework, this project's pipeline is as follows:

- Create a meta dataset from DICOM image Dataset
  Path, label, DICOM Meta format understanding
- Explore the DICOM Dataset
  Read DICOM image and analysis image data, Windowing Scaling, Normalizing Dataset
- Clean the Dataset
  Remove useless images, resample the dataset to a small dataset to quick prototyping, crop images that only include important information, e.g. only have brain tissues, rescaling into 256*256 px image
- Model (Transfer Learning with Pretrained Model)
  Train and Valid dataset split, prepare DataBunch(fastai api) for model, Use the pretrained xResNet50 Model to train and fine tune, save the model
- Build a Web application to classify the Hemorrhage subtype