CS130: Project Part A - Proposal

BRAIN.AI

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First version

1. Motivation & Novelty

Our project is a web application that perform deep-learning-based brain extraction for medical imaging researchers. In most research of brain imaging, skull needs to be removed from brain tissue since it is likely to create interference and confusion in later analysis. Our application could allow researchers to train a deep-learning model from a small number of training examples. Then, they could run brain extraction with our model on the rest of their brain images. This automated tool could reduce their work of manual brain segmentation while offering them a relatively good accuracy.

There are many automated brain extraction tools available to researchers. However, most automated brain extraction tools are using relative old, non-deep learning models and have relatively bad accuracy. As a result, researchers may have to refine all brain extraction results manually after using such tools. Deep learning models, on the other hand, are recently developed and proved to be very useful in this task. However, each image type require the training of a different model. As a result, no commercial solution of brain extraction is using deep learning since they tend to use better-generalized early models that could work on most types of image.

Our proposed project attacks this problem by allowing the researchers to train and share the model. The web site would store the trained models and make them available to other users. In this way, the community could contribute trained deep learning models for each image type. As a result, its very likely that most image types will have brain extraction models available. For those image types with no model, the researchers could manually segment a small number of images and train a model that segment the rest part of data for them. In this case, if the amount of images if relatively large, our application should be more time-efficient than the current segment-and-refine approach based on existing software.

2. Feasibility

There are 4 components in this project: Front end, Back end, deep learning model, and workers that run the deep learning training and predictions.

As for the deep learning model, the U-net model is proved to be suitable to this task in many papers[http://en.wikibooks.org/wiki/LaTeX/]. The model also has many open source implementations for us to use. In most of those implementations, we need to provide data in PNG or TIFF format. The user-provided file format should be DICOM or NII, which are specialized in medical imaging. The file type conversion must be done in pre-processing steps, which can be achieved with pydicom and cv2 Python package.

We need a scalable infrastructure that hosts the python model training. This can be accomplished with Google cloud VMs. Those virtual machines can be created with google cloud API dynamically. This allows us to scale up the number of workers as the user demand grows.

The front end framework of this project can be React. Its easy to use it to create reusable components and thanks to its functional programming style, it may help to reduce bugs.

The backend framework can just be a regular web framework that both communicate with front end and deep learning workers. Spring and Spring Boot are suitable candidates that could fulfill this requirement. Spring is the most common backend framework used for Java. Spring Boot allows our backend developers to quickly set up the backend server. The dependency injection of Spring greatly simplifies the job of backend and results in a more reusable, more testable, and more readable code.

In addition to Spring and Spring Boot, we will use Lomok for code auto-generation to reduce tedious and repetitive coding. We will use SQL database with the Mybatis framework to simplify access to the database. To document and test the APIs of the backend, we will use the Swagger framework.

Since the training may need a lot of computation resources, our application may not create a worker for each user. Instead, the limited size of workers will retrieve their task from a queue. This message queue should be implemented with the backend Database.

3. Capability

Jiayu Hu: He has an internship experience of software engineering, in which he has maintained a large scaled back-end server using the Spring Boot framework. Also, he has his personal project regarding deep learning and artificial intelligence. In that project, he has successfully trained a deep neural network combined with tree search to perform actions in the game of Gomoku. In our project, he is able to use Spring Boot framework to build up the beck-end part of our web application. Also, he can help to develop and debug the models of neural network.

Hao Zhuang: He has interned as a backend developer in a private medical company. He developed a back-end server for a hospital system using Spring and Spring Boot framework. Additionally, he has experience with deep learning in course CS168 where he and his partner trained a deep neural network that can predict legion growth in a brain MRI image. In our project, he is responsible for back-end development. He may also participate in the neural network training for this project.

Yash Choudhary: He has experience with 2 professional internships in which he created a python data pipeline to enhance the backend architecture to support multiple users and helped with merging the front-end using AngularJS. He has also been part of teams that have built scalable web applications that were tested and deployed on cloud infrastructures like AWS Cloud Google Cloud VM. In our project, he is responsible for back-end database architecture, front-end development and any additional help needed to test the neural net training models involved.

Taixing Shi: He has taken an undergraduate machine learning course and learned the fundamental concepts and algorithms in machine learning. Also, he is taking an undergraduate database systems course and he is expected to become proficient in SQL. In this project, he can help to train the deep learning model and work with SQL database.

Sichen Song: He is currently working as an undergraduate research assistant in neural science department of UCLA. He is familiar with various medical imaging file formats and has experience performing deep learning on them. Also, he has front-end develop experiences and is very familiar with React framework. In our project, he is responsible for the design of deep learning workers, and may help the web development.