Hacettepe University

Computer Engineering Department

BBM480 Term Study Plan

Project Details

Title	A labeling, learning and visualization tool for brain imagery
Supervisor	Erkut Erdem

Group Members

	Full Name	**Student ID**
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Current State (/ 50 Points)

Explain the current state of the project at the beginning of the term. Especially, emphasize the changes and development progress since the End of Term Development Report of BBM479. At this point you are expected to include solid evidence that you are making progress, such as screenshots, proofs, experiment results, data outcomes etc.

To restate, our development plan comprise of 3 development phases as proposed in the End of Term Development report, given below

1. Discovering and experimentation with the annotation tools
    a. Exploring the annotation tools available to use for our problem domain, which is radiology. Which tools require significant hardware requirements on the client side?
    b. Experiment with the annotation tools that have been collected. Target the tools that have active learning as an option.
    c. Focusing on one annotation tool and investigating its capabilities thoroughly.
    d. Prepare a demo for a sample annotation session with the selected tool and show it to clients. Get feedback, and improvise if necessary.
2. Learning **state-of-the-art** (SOTA) techniques and models through academic research
    a. Investigate the performance of SOTA techniques for brain MRI segmentation and determine if the performance satisfies our requirements.
        i. If requirements are not satisfied, research for a deep learning model will be necessary. The research for a deep learning model that satisfies our requirements is not one of our goals, but we are planning to also improvise the SOTA models if we have enough time.
    b. Select a handful of models that satisfy our performance requirements. In our project, we also plan to use active learning features which combine the deep learning model training process with annotation sessions, enabling the annotators to use deep learning models on the go for an initial segmentation while still annotating the images. To achieve this, we need to select at least one model for annotation sessions and one model for the heavy training session which will be used out of the annotation sessions.
3. Building visualization tools using VR/AR/MR technologies
    a. Extraction of model segmentations to VR/AR/MR environments. After the inference session of our trained deep learning model, it is necessary to find ways to convert the model output to a VR/AR/MR environment.
    b. Setting up a VR/AR/MR playground for investigating the segmented 3D brain MRIs. Our project's goal is to eventually provide brain surgeons to use these segmented models to understand the patient's brain better. To do this we need to provide surgeons with capabilities in VR/AR/MR environments such that they can interact with the model. Enabling or disabling view of several parts of the brain (e.g. don't show gray matter), drawing lines on the 3d model to take notes/attract attention, etc…
4. Integrating our VR/AR/MR playground with physical tools. After the development of the environment of the playground, it is necessary to integrate it with the VR/MR/AR tools to enable surgeons to interact with the 3d models.

At the time we reported the End of Term Development Report, we were dealing with the point ***1.c: Focusing on one annotation tool and investigating its capabilities thoroughly*.** Within the context of the point we were investigating two main candidates for the main annotation tool,

namely, **3D Slicer** and **OHIF Viewer**.
After careful investigation and discussions with our advisor we've decided to move forward with the 3D Slicer, putting an end to our investigation point and moving to the ***1.d: Prepare a demo for a sample annotation session with the selected tool and show it to clients. Get feedback, and improvise if necessary.***

During 1.d, we were preparing to explain our annotation tool to some of our stakeholders, to gather feedback and decide if our tool of choice met their expectations. However, during our preparations something unexpected happened, the stakeholders aforementioned, sent us a couple of annotated samples and the tool they used was the same with the one we chose. This was great news on our side, since they experimented with the tool before we made a demo with them. With this update, we believe that we **finished the first part of our development phase**.

We quickly started the second phase of the development phase, ***Learning state-of-the-art (SOTA) techniques and models through academic research.*** Within this phase we have made an extensive investigation on models and datasets used for the brain segmentation task. The investigation results are documented and located in the: **MONAI Model Investigation**

To summarize our results, and our learnings on this investigation:

- We have learned about the existing **challenges** for a subset of our task; brain tumor segmentation
- Discovered the available **open datasets** for the task, and documented them
    - One of our main learning in here is the **realization of different MRI image types**, and how our samples differ from the samples of the these datasets
- Investigated and documented the **state-of-the-art models** for the brain segmentation task
- Made a list of the candidate models to experiment with our samples

This investigation overlaps with the ***2.a*** and ***2.b*** of our development phases.

The investigation gave us several candidates for experimenting with our samples within the context of the development phase ***2.b***. We have started experimenting with SwinUNETR, the current state-of-the-art model for the brain tumor segmentation task.

Making use of the open source implementation provided by MONAI, we have built our very first training and inference pipelines for the SwinUNETR model. Following the built pipelines, we retrieved our first predictions based on our samples. A small subset of the predictions are provided in the Prediction section in Appendix.

To summarize our progress since the End of Term Development Report;

- We have finished the annotation tooling investigation and decided on the annotation tool
- Experimented with the samples gathered from the stakeholders
- Investigated the Machine Learning models for the brain segmentation task in the MONAI repository and ecosystem.
- Built the very first version of the model training and evaluation pipeline for the brain segmentation task
- Trained an initial version of model with low-to-no hyperparameter search based on the samples previously obtained from the stakeholders
- Analyzed the outputs of the initial model version

Term Plan (/ 50 Points)

Outline your work plan for the second term of the project. Do you have any changes, worth mentioning, related to the time management of the project? Clearly show who is working on what and the personal responsibilities. Are there any changes in the workload distribution?

Our second term plan is consistent with our 3-phased development plan explained in detail in the previous section. However, we make some major changes and decouple some points into several detailed points to have a better vision of our past and future progress. The revised development of the second and third phases are as follows:

1. Inferring segmentation masks of the brain with the help of the Machine Learning models.
    a. Investigate the performance of state-of-the-art techniques for brain MRI segmentation techniques, including Machine Learning models, and determine if their performance satisfies our requirements.
        i. If requirements are not satisfied, research for a deep learning model will be necessary. The research for a deep learning model that satisfies our requirements is not one of our goals, but we are planning to also improvise the SOTA models if we have enough time.
        ii. List candidate models based on the performance requirements.
    b. Experiment with the candidate models, document the results, and choose the top k models.
    c. Build the standardized model training and evaluation pipelines.
    d. Extensive model prediction analysis and hyperparameter tuning.
        i. Pair analysis with stakeholders in an iterative way. Note that iteration does not have a deadline.
2. Building visualization tools using VR/AR/MR technologies
    a. Research on how to visualize model predictions in the VR/AR/MR environments
    b. Requirements elicitation for the VR/AR/MR tools
    c. Investigation of ready-to-use potential VR/AR/MR tools
    d. Experiment with the candidate tools using 3D models built upon the Machine Learning model predictions
    e. Set up a demo VR/AR/MR environment
    f. Pair analysis of the demo environment with the stakeholders.

It is worth mentioning that step ***1.e*** is actually an iteration, and hence we do not expect to finish it until the end of the project. The same also applies to the steps between ***1.e*** and ***1.f***. Our progress on this will be heavily affected by the stakeholders' feedback.

We plan to spend 1.5 months on the first phase and the remaining 1.5 months on the second phase. However, since some of the steps will be done in iterations we actually do not plan to finish the first phase in 1.5 months, but to cover the points stated in the first phase and have a quick iterating pipeline. Since the iteration phase will mainly be time intensive, we will start working on the second phase while at the same time making iterations for the ***1.e***.

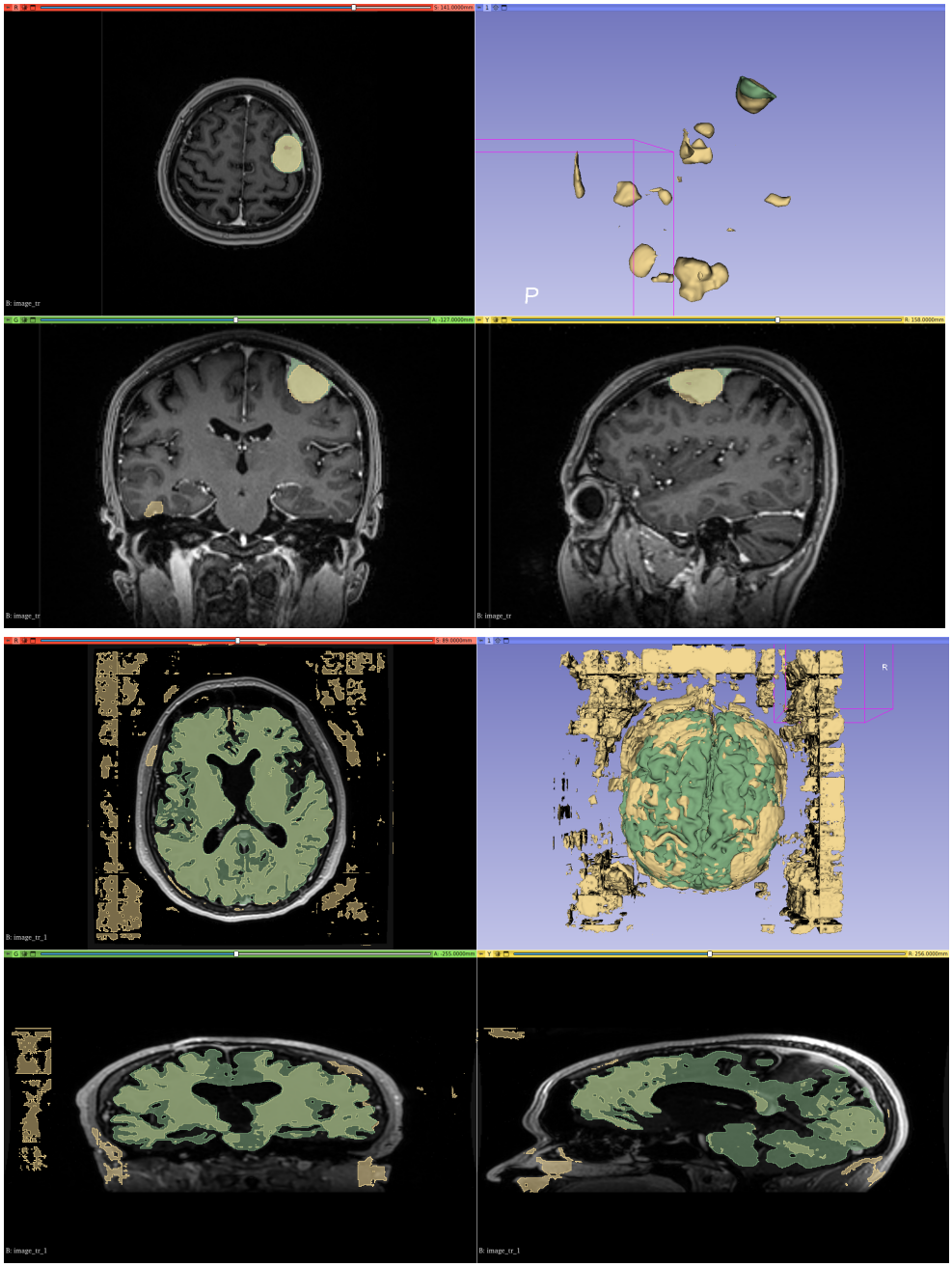
A similar approach will be taken for the second phase too. We will sequentially progress until the **1.e** and after that we will be working on iterations.

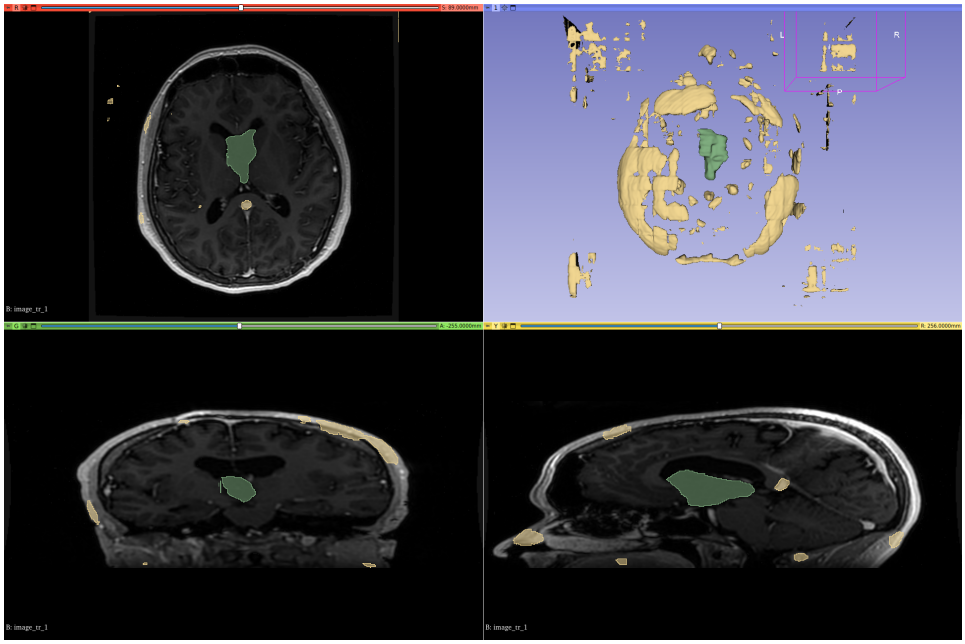
At the time being, we do not have strict task assignments to the group members. We create tasks for the job to be done, and group members assign the task if they do not already have a task assigned. Since each group member works on the task as the task previously assigned to him/her is finished, it is not possible to provide a clear workload distribution. However, we strongly believe that the workload is distributed equally on the group members.

Personal responsibilities that are common for all group members is to documentation of every result, outcome, and learning for the investigation tasks that are assigned to members.

Appendix

Initial Predictions

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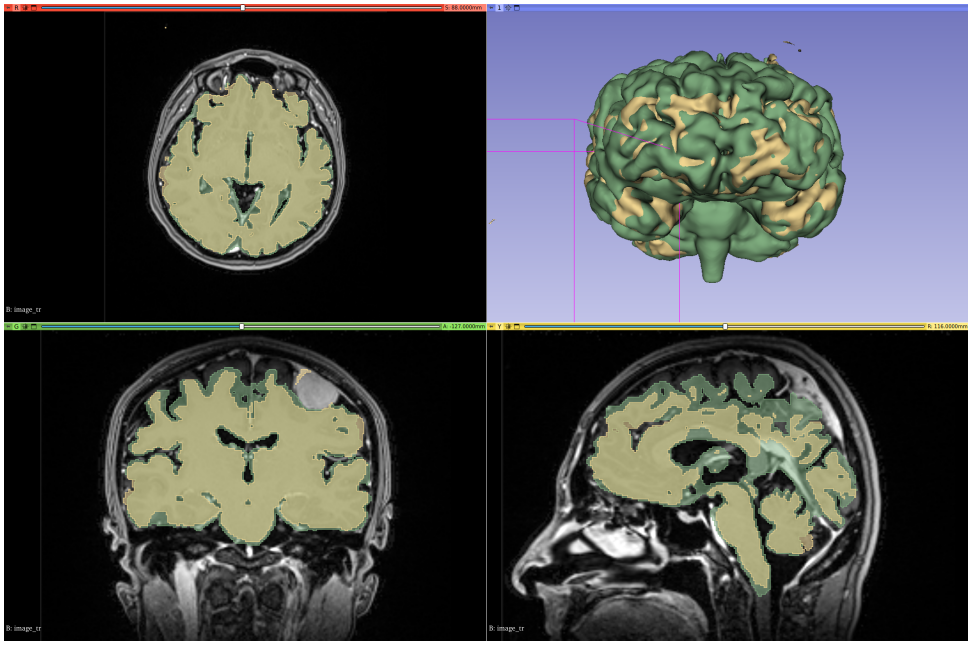
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