Notebook / Work Journal

Notes regarding PET Imaging on Alzheimer's Disease (AD)

- Positron emission tomography associates various molecular imaging agents which reveals certain aspects of dementia pathopsychology such as:
    - Brain amyloidosis
    - Tau accumulation
    - Neuroreceptor changes
    - Metabolism abnormalities
    - Neuroinflammation in dementia patients
- Provides a quantifiable field while diagnosing AD, monitoring disease progression, ascertaining therapies to their respective brain molecular targets
- Many important contributions of PET in brain molecular abnormalities in AD

Introduction :

- Amyloid plaques and neurofibrillary tangles are one of the first hallmarks of AD
- Extracellular deposition of amyloid-beta (Aβ) aggregates also known as senile plaques
- Intracellular inclusion of tau aggregates, neurofibrillary tangles (NFTs)
- Brain atrophy and cell depletion
- Listed features (above) accumulate over multiple years and lead to clinical and functional decline of the brain
- PET molecular imaging agents are designed to quantify one or more molecular targets
- Helps monitor the key pathophysiological events that occur in the brain throughout AD
- Many imaging biomarkers help during diagnosis and prognosis of AD

PET Biomarkers for Amyloid Deposition :

- Deposition in the Aβ plaques and presence of NFTs are common hallmarks in AD
- Aβ deposits progressively accumulate is specific brain regions throughout AD, starting before the clinical onset
- Specific molecular agent for detecting fibrillary Aβ *in vivo* / "within the living" is: carbon-11 thiorative T derivative 2-(4'-methylaminophenyl)-6-hydroxybenzothiazo, also known as [^{11}C]PIB or Pittsburgh compound B
- Patients with mild cognitive impairment have a 20%-30% higher prevalence of amyloid positivity
- Therefore, MCI (MIld Cognitive Impairment) is directly correlated to AD
- A positive amyloid-PET scan increases the probability of conversion to AD
- The possible interval of the conversion specified above is 1-5 years
- A negative amyloid-PET scan suggest other non-AD pathologies such as types of degeneration, hippocampal sclerosis, etc

Notable Successes & Achievements

- Average runtime of optimized software platform is 99% faster than the naive approach (brute force & iterative method)
- Learned how to utilize multiprocessing & cython (computer science concepts) to optimize program
- Successfully opened a new chapter in medical diagnosis procedures by utilizing a publicly available dataset from OASIS-3
- Utilized colour difference to its full potential to convert an RGB value to the corresponding concentration value of a biomarker

Notables Hurdles & Failures

Hurdles :

- Optimizing an image processing algorithm that was already using optimized libraries in the program
- Measuring the number of pixels on each PET scan, helping create a boundation of each inputted PET scan (very tedious and difficult)
- Having the program run overnight and multiple days to perform tests that would lead to paths that could optimize the program further
- Trimming the size of the text file generated from the image analysis part of the algorithm ⇒ browsers cannot view HTML files (viewable file of the combined PET scans) that have more than 16 000 kB or 16 MB
- Generating more than three colours that would make it easy for the human eye to visualize the 3D brain from multiple biomarkers (had to utilize the gradient of the RGB colour model: red, green, blue)

Failures & Next Steps :

- Failed to create an image processing algorithm that would automatically receive ANY .png or .jpeg file and create cropped cross-sections of the human brain ⇒ algorithm currently works by receiving multiple sets of PET scans in the format provided by OASIS-3 (hard coded to ignore certain boundations of the dimensions of an image)
- Try and develop a self-diagnosis that analyses the coordinates of the concentration of each biomarker on the XYZ plane that holds the 3D brain ⇒ insert the 3D image of the human brain to help doctor's or neurologist's visualize the location of each biomarker EVEN better

Timetable & Log Journal

October / November (research of current PET analysis platforms) :

- Look into the Halide API that integrates with C++
- Research into multiple biomarkers that associate with neurodegenerative diseases -- more specifically Alzheimer's disease
- Research into current PET scan analysis methods & brainstorm new methods

December (start development of the platform // iteration #1) :

- Halide API is currently in BETA and lacks proper documentation for the purposes of this project, therefore I will move away from Halide and look into Python
- Finish writing the project proposal that covers the basics of the project and software platform
- Research into Python image processing methods and libraries
- Retrieve multiple gigabytes of PET scans from the OASIS-3 dataset to use for further testing and development

January / February (finish development of the platform with multiple iterations #2, #3, #4) :

- Read multiple scholarly articles regarding multiprocessing and CPU usage in Python with association of image processing
- Apply multiprocessing & cython into the software platform
- Find and use a data visualization library in Python that meets the design criteria set out in the project proposal
    - Try Plotly -- data visualization platform that MEETS the design criteria by visualizing the brain in 3D space on an HTML file that can be easily accessible on any browser
- Perform data analysis (over two weeks) on multiple sets of PET scans from the OASIS-3 dataset
- Use the data collected (algorithm distribution) and perform statistical analysis regarding the total runtime and runtime distribution of the algorithm

March / and further :

- Finish statistical analysis and write up research report and project presentation
- Perform research on localizations of biomarkers in the brain for the next phase of the project: self-diagnosis