DIGITAL IMAGE PROCESSING

(EC-312)

PROJECT REPORT

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CE-37-A

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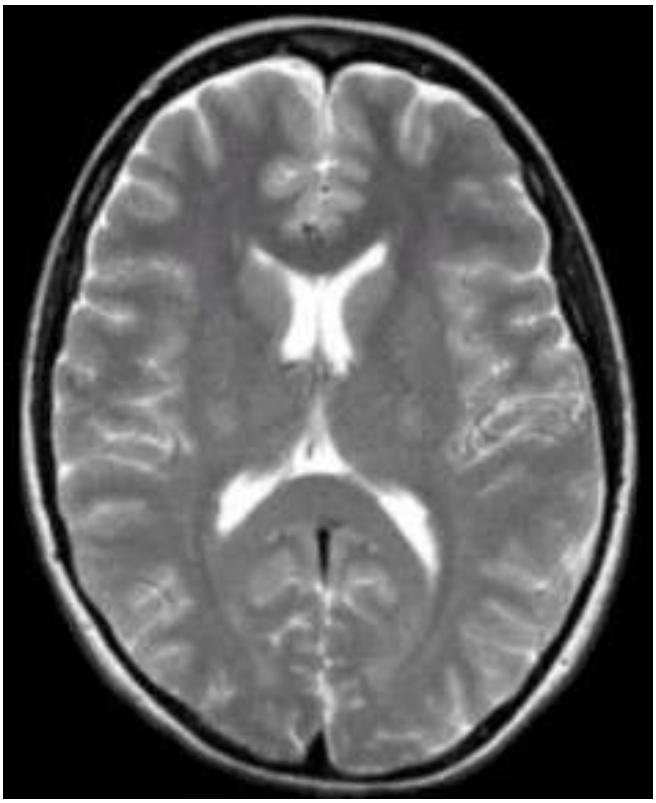
Objectives:

The aims of the project were to identify the regions of Cerebrospinal Fluid, White Matter and Grey Matter, by making an image segmentation algorithm that can work on T1 and T2 weighted MRI scans of brain.

The scans will be like examples shown below:



T1 scan is shown on the left and T2 on the right. The required regions are in different colors in both scans.

Pseudo code:

The algorithm takes 2 inputs; the image and the type number. The type number will be 1 if a T1 image was provided and 2 for a T2 image.

The algorithm will then perform the following steps:

1. For T1 images, first perform histogram equalization, as the differentiating details only occupy a small portion of histogram. No need for this step with T2 images as there already is enough contrast.

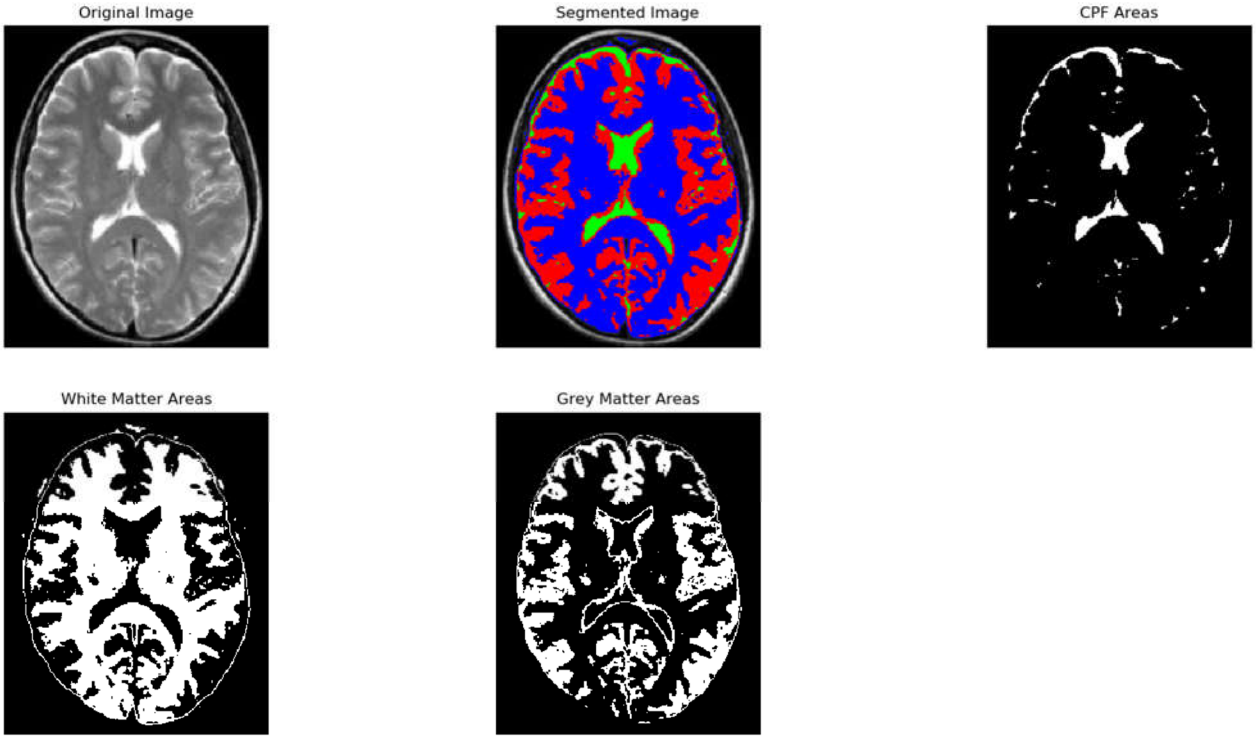
2. Apply K-Means Clustering method, with 4 clusters and centroids of the clusters evenly spaced from 0-255 for the first iteration. This will ensure that 1st cluster is always the background and can be ignored. Meanwhile, 2nd, 3rd and 4th clusters are our required regions which will always be in the same clusters for the same type of images (T1 or T2).

3. The pixels related to the skull will also get incorporated in our clusters. We can perform an operation called as skull stripping to remove the pixels related to the skull from our clusters. For the vast majority of T2 images, skull usually ends up as a ring that is disconnected from any of our required regions. Thus we can perform connected component analysis and the first object detected will be the skull and all pixels related to it can be converted to the color of the background. For T1 images however, there isn't enough data after clustering to separate skull as it is connected from multiple places to our regions of interest and this step is hence skipped for T1 images.

4. The areas corresponding to Cerebrospinal Fluid, White Matter and Grey Matter are then shown separately as well as on the original diagram colored in Green, Blue and Red respectively.

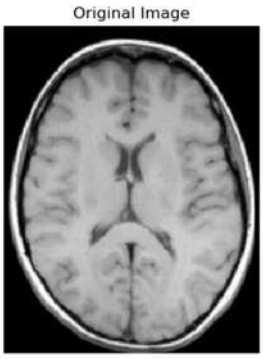
Results:

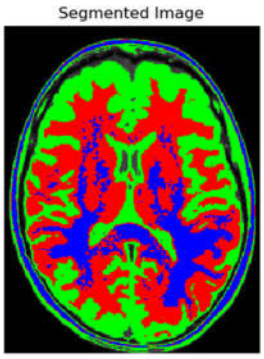
The results of T2 image is shown below:



As we can see, due to good contrast of T2 images, all the areas are detected quite accurately and skull stripping also worked to remove skull portion as much as possible from our results. The Cerebrospinal Fluid (CPF), White Matter and Grey Matter areas are shown independently as well as shown in color overlaid on the original image, in the order Green, Blue and Red respectively.

The results of T1 image is shown on the next page. Although performing histogram equalization helped a lot, but still since the original image has very small differences between the pixels of white matter and grey matter, these regions are less distinguishable except for some places.





Moreover, skull stripping is also not possible due to regions of Cerebrospinal getting in contact with the skull.

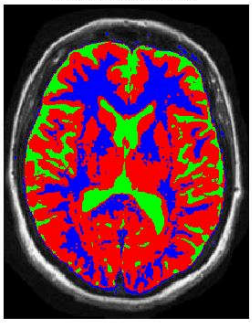
This trend is visible for other examples, such as the results of another pair of T2 and T1 images respectively on the next page.

The T2 image was again much easier to segment and label the regions of interest as compared to the T1 image.

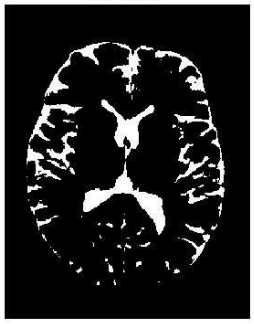
T2 Image

Original Image

Segmented Image



CPF Areas

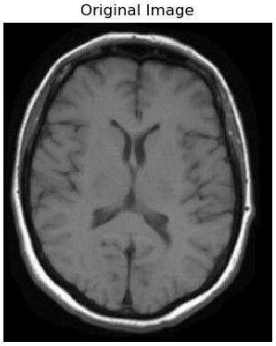


White Matter Areas

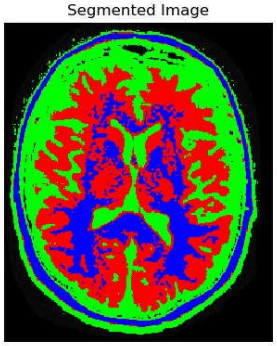
Grey Matter Areas

T1 Image

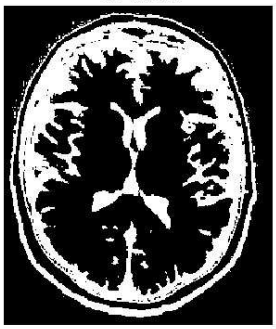
Original Image



Segmented Image



CPF Areas



White Matter Areas

Grey Matter Areas

Conclusion:

The project involved several of the concepts learned in the course like histogram equalization, connected component analysis and K-Means Clustering. Thus completing the project helped us apply those concepts in a real world use case.

References:

1. "NEATBrainS15 Challenge" for Project Idea
   http://neatbrains15.isi.uu.nl/

2. "Magnetic Resonance Imaging (MRI) of the Brain and Spine: Basics" for MRI Scans
   http://casemed.case.edu/clerkships/neurology/Web%20Neurorad/MRI%20Basics.htm

3. An article on "Magnetic Resonance Imaging" for MRI Scans
   http://casemed.case.edu/clerkships/neurology/NeurLrngObjectives/MRI.htm