Medical Image Processing

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Assignment 3
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Instructions:

- All your code should be uploaded in a folder named as 'Code'.
- The report should be in a '.pdf' format with your roll number as the filename.
- In the case of computing-based questions, the pdf should clearly report the experimental settings, results/observations and a discussion/conclusions based on the results.
- Upload the code and report in a single .zip file which has the following naming format: r_An where r is your full roll no; n is the assignment number.
- Any report without conclusions/recommendations will get only 50% marks.

Outline: *In this assignment, you will work on Bias Correction, Color Transfer and Intensity Standardization algorithms and compare the results across.*

DATA: The data required for this assignment can be downloaded from the following link: https://iiitaphyd-my.sharepoint.com/:f:/g/personal/prathyusha_akundi_research_iiit_ac_in/EkTWJoRzhP5EhfRT1R8hcsUBTF_qftCOdQnOaqQY2g5zxQ?e=7suwSZ

Toolbox installation: There are various toolboxes and libraries available for medical image analysis that have implementations of all the standard algorithms. In the last assignment, you might have already downloaded ITK-SNAP. In this assignment, you will have to install following:

1. **ITK** [1]**:** Follow the procedure given in https://github.com/InsightSoftwareConsortium/ITK and install ITK depending on your OS
2. **ANTs** [2]**:** Once ITK is successfully installed, please install ANTs by following instructions in http://stnava.github.io/ANTs/. You can refer to examples provided in this repository for the sanity check.

The installations will take time, especially if you are using Windows. So, please plan carefully to install the above toolboxes at the earliest.

Question 1a: From ANTs toolbox, use N3 and N4 algorithms for bias correction on following images in the data folder: (i)'BF20.nii',(ii)'BF40.nii'. Report your observations.

Question 1b: Consider 'clean image.nii' which is not effected by bias fields. Now, apply three different bias fields 'rf20 A.nii', 'rf20 B.nii' and 'rf20 C.nii' to it, which are provided to you in the data folder.
Apply N3 and N4 algorithms on these corrupted images and compare the algorithm performance in recovering the original image. Also specify the choice of hyperparameters that gave best performance and report your observations.

Question 2a: Apply Reinhard algorithm [3] to do color transfer from a source image to set of target images and show the results. The images are provided to you in 'color_transfer' folder.

Question 2b: Neural Style Transfer [4]: Given the style S and content C images, the Neural Style Transfer aims to transfer style from S to C. We are providing code that doesn't require any training in this url: https://colab.research.google.com/drive/1d-RPP4ja5GqC3AegDovzIv6WnzeiWgK3?usp=sharing. Upload source and target images in the colab and do the style transfer from Source to target images.
Compare these results with that of Reinhard's method by identifying suitable metrics/methods. Report your choice of evaluation method and the conclusion drawn after the comparison.

Question 3: Read paper titled "New Variants of a Method of MRI Scale Standardization" by Nyul et al. TMI 2000 [5]. Implement the paper on the data provided in Intensity Standardization folder and use the metrics and methods to evaluate both quantitatively and qualitatively as mentioned in the paper.
The Intensity Standardization folder contains following subfolders:

1. 'Original MRI volumes' : original images
2. 'brain' : Skull stripped images
3. 'brain mask' : binary brain mask
4. 'GM mask' : Grey Matter Tissue binary mask
5. 'WM mask' : White Matter Tissue binary mask
6. 'CSF mask' : CerebroSpinal Fluid Tissue binary mask

Use volumes provided in 'brain' folder for all your experiments. Use volumes in 'brain mask' to identify foreground and background in 'brain' volume. Use only foreground of 'brain' vol- ume to identify percentile points. For quantitative analysis of IS, you will be required to use corresponding 'GM mask', 'WM mask' and 'CSF mask'.

References

[1] Matthew Michael McCormick, Xiaoxiao Liu, Luis Ibanez, Julien Jomier, and Charles Marion, "Itk: enabling reproducible research and open science," *Frontiers in neuroinformatics*, vol. 8, pp. 13, 2014.

[2] Brian B Avants, Nick Tustison, and Gang Song, "Advanced normalization tools (ants)," *Insight j*, vol. 2, no. 365, pp. 1–35, 2009.

[3] Erik Reinhard, Michael Adhikhmin, Bruce Gooch, and Peter Shirley, "Color transfer between images," *IEEE Computer graphics and applications*, vol. 21, no. 5, pp. 34–41, 2001.

[4] Leon A. Gatys, Alexander S. Ecker, and M. Bethge, "Image style transfer using convolutional neural networks," *2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 2414–2423, 2016.

[5] László G Nyúl, Jayaram K Udupa, and Xuan Zhang, "New variants of a method of mri scale standardization," *IEEE transactions on medical imaging*, vol. 19, no. 2, pp. 143–150, 2000.