CDS6334 Visual Information Processing

Trimester 2430

Assignment (20%)

1 Introduction

1.1 Objective

To design an algorithm that automatically segments retinal vessels from fundus images. A set of 80 images, along with the corresponding ground truth, are provided for you to design the segmentation algorithm. The images are extracted from various existing research datasets that are publicly available [1,2,3] and Figure 1 shows samples of the fundus images with their respective segmentation.

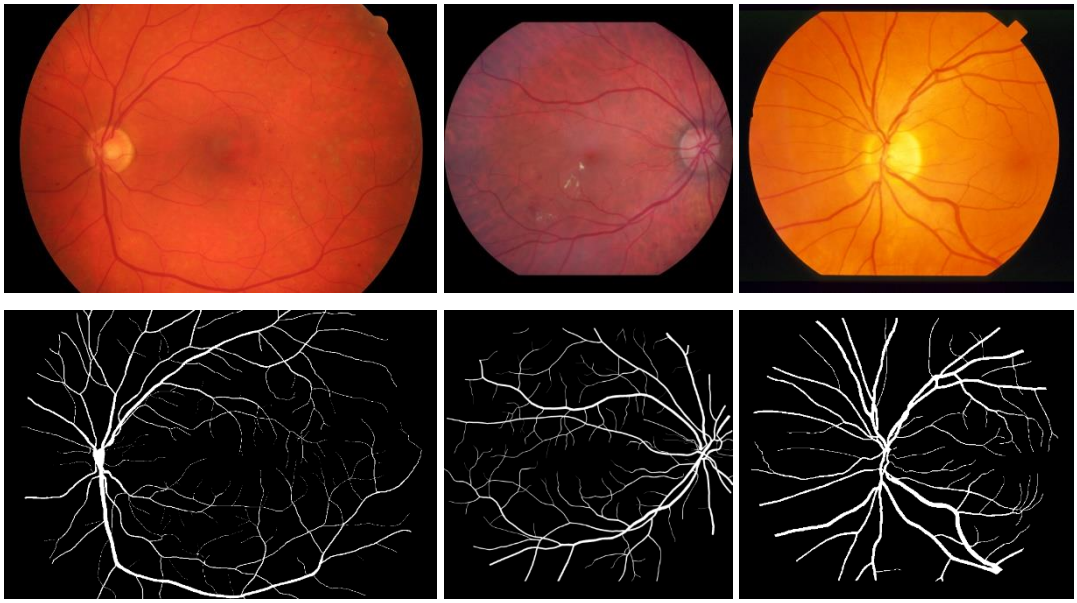

Figure 1: Fundus images (top) and their corresponding ground truth (GT) segmentation (bottom). (GT: White represents the retinal vessels, and black represents background)

[1] Hoover, A. D., Kouznetsova, V., & Goldbaum, M. (2000). Locating blood vessels in retinal images by piecewise threshold probing of a matched filter response. *IEEE Transactions on Medical Imaging*, *19*(3), 203-210.

[2] Budai, A., Bock, R., Maier, A., Hornegger, J., & Michelson, G. (2013). Robust vessel segmentation in fundus images. *International Journal of Biomedical Imaging*, *2013*(1), 154860.

[3] Kiefer, R., Abid, M., Steen, J., Ardali, M. R., & Amjadian, E. (2023, May). A Catalog of Public Glaucoma Datasets for Machine Learning Applications: A detailed description and analysis of public glaucoma datasets available to machine learning engineers tackling glaucoma-related problems using retinal fundus images and OCT images. In *Proceedings of the 2023 7th International Conference on Information System and Data Mining* (pp. 24-31).

1.2 Guidelines

- This is an individual assignment.
- Partial collaboration policy applies. You can lightly discuss the task with your course mates when you are working on the assignment, but you need to declare with whom you had discussed with as responsible collaborators. Include a statement at the end of the report to indicate the nature of your collaboration.
- In regard to the objective of this assignment, you are **NOT** allowed to use third-party packages to assist you in this problem (including deep learning models). Packages 'pip'-ed from Python Package Index (PyPI) are acceptable.
- *Important*: Do not upload your own packages or algorithms that you have created for this assignment to public repositories such as Github/BitBucket, which may allow others to "use" portions of these packages to solve the same assignment. (You can do so after the assignment is over).
- You can use Spyder (which comes with iPython console), but you can use your own favourite IDE or opt for the basic text editor and command line.
- This assignment is worth 20% of coursework marks.
- Late-Day policy applies (10% deduction per day late from deadline)
- Submission deadline**: 3rd January 2025, 11.59PM**.

2 Scripts and Functions

2.1 Codes to Write

Your working function `**segmentImage**' that you need to write is contained within **'imageSegment.py'**

```
def segmentImage (img):
    # write your code here
    …
    return outputImg
```

The inputs and output of the **'segmentImage'** function are as specified follows:

inputImg : Input image, a 3D numpy array of row*col*3 in BGR format

outputImg : A 2D numpy array segmentation mask where the retinal vessels and background are represented with the following intensity values:

Segment	Background	Retinal Vessels
Intensity	0	1

No visualization codes or functions are provided. You can write your own in a separate script for purpose of visualizing the outputs or to generate nice figure/plots for reporting.

2.2 Evaluation Functions

An evaluation function is provided to test your algorithm:

`evaluateSegment.py`:

Evaluate the *Adapted Rand Error* [4], *pixel wise precision and recall*, and the *Intersection over Union* (IoU) between a set of output segmentation with the corresponding ground truth segmentation. It also returns the average evaluations for the image set.

The functions are runnable on Anaconda Prompt or standard command-line prompt (if necessary path settings have been configured). You can use the `-h' switch to get further help on how to use these functions, and what other options are there.

[4] Arganda-Carreras, Ignacio, et al. "Crowdsourcing the creation of image segmentation algorithms for connectomics." *Frontiers in neuroanatomy* 9 (2015): 142.

NOTE: You are NOT ALLOWED to change the code of this function except changing the **Default Parameters**, which include the image directories, number of images in the directory, and verbose to select the evaluation output.

2.2.1 Package Requirement

The vanilla Anaconda installation does not come with the `PrettyTable` package. Please install via pip at Anaconda Prompt.

```
>>pip install prettytable
```

2.2.2 Example of Usages

These commands can be used in the command prompt to evaluate all images:

```
>>python evaluateSegment.py
>>python evaluateSegment.py -v
```

The second command segments and evaluates the whole image set in the directories specified under the **Default Parameters** with the simple result display generated by prettytable as follows:

DETAILED RESULTS

Image	Error	Precision	Recall	IoU
1	0.4174	0.9998	0.4111	0.411
2	0.2415	0.9989	0.6113	0.6109
3	0.5461	1.0	0.2935	0.2935
4	0.1751	0.8584	0.7939	0.7019
5	0.3487	0.9977	0.4834	0.4829
All	0.2555	0.9623	0.6395	0.6132

To perform this full evaluation on another image set, simply change the Default Parameters in the evaluate.py file to specify the file directories and the number of images.

2.3 Evaluation Sets

There are 2 sets of fundus images for evaluation. One is released earlier for you to design your algorithm under the '**dataset**' folder. (Getting good results in this dataset is a job well done already).

The second set will be released two weeks before submission deadline, consisting of images with more challenging appearances and backgrounds.

3 Submission

Submit the following in a ZIP file in eBwise:

- **Code**: `imageSegment.py` and all other additional support codes (if any)
- Report (in PDF): Proposed outline:
  - **Abstract** (short) – overall summary of the work done and results
  - **Introduction** (short) – brief information about the task, motivation, and possible applications
  - **Description of Methods** – explanation about the steps to achieve final results (not just copy pasting the code), explain the steps you used to come up with the solution and settings
  - **Results & Analysis** – reporting the results with analysis about the high/low scores and possible factors that caused them
  - **Suggestions for Improvement** – provide reasons for suggestions (not just because they are trendy/popular)

Please **do not submit the dataset**, and do not submit anything in hardcopy (report) or in stored media (CD/DVD) form.

3.1 Mark Distribution

The following table shows the mark distribution for this assignment:

Code (12%)	Methods Used	4
	Creativity/Originality in Solution	3
	Visual Results	3
	Clarity/Readability	2
Report (8%)	Abstract (short) & Introduction	1
	Description of Methods	3
	Results & Analysis	3
	Suggestions for Improvement	1
TOTAL		**20 marks (20%)**
Bonus (max. 1%) — for exceptional achievement in scores and qualitative analysis.		

End of Assignment Guideline

Yuen Peng Loh, 2024