Automated Glaucoma Detection using Optic Disc and Cup Segmentation

Statement:

Glaucoma is an eye disease that can cause loss of vision by damaging the optic nerve. It is the second leading cause of blindness worldwide after cataract. Early diagnosis of glaucoma is a key to prevent permanent blindness, yet it has no noticeable early symptoms. Color fundus photography allows the optic disk to be examined which is a fundamental step to diagnose glaucoma. This is done by measuring the vertical cup-to-disk ratio (CDR).

Significance:

This project contributes to the advancement of automated glaucoma detection using retinal image analysis. By developing a robust and accurate segmentation algorithm, the project aims to:

- Improve the efficiency and objectivity of glaucoma diagnosis.
- Reduce reliance on subjective visual assessment by ophthalmologists.
- Facilitate early detection of glaucoma, leading to improved patient outcomes.

Methodology:

Develop a novel image segmentation algorithm to automatically delineate the optic disc (OD) and optic cup (OC) within retinal fundus images from the ORIGA dataset. This segmentation will facilitate the calculation of the cup-to-disc ratio (CDR), a crucial parameter for glaucoma detection.

Hint: The flow of the problem can be the following:

1. **Optic Disc Segmentation:** The algorithm will be designed to first segment the OD region. This can be achieved by employing deep learning architectures, such as convolutional neural networks (CNNs) or U-Nets, trained on a set of labeled fundus images where the OD is accurately outlined.
2. **Optic Cup Segmentation:** Following successful OD segmentation, the algorithm will focus on delineating the OC within the previously identified OD region. This can be achieved by refining the initial segmentation or employing a separate method specifically trained for OC segmentation within pre-segmented OD regions.

3. **Cup-to-Disc Ratio (CDR) Calculation:** Once both OD and OC are segmented, the CDR will be automatically calculated as the ratio of the OC area to the OD area. This quantitative measure serves as a vital indicator for glaucoma diagnosis.

Evaluation:

1. Employ standard metrics like accuracy, precision, recall, and Intersection over Union (IoU) to assess segmentation performance.
2. Compare calculated CDR with established clinical criteria for glaucoma diagnosis.

Constraints:

Develop an algorithm meeting the below time and accuracy/sensitivity requirements.

1. Time complexity between 10-30 seconds per image for unsupervised method.
2. Time complexity between 10-30 milliseconds per image for supervised method
3. Segmentation accuracy of OD and OC between 90-95%.
4. Segmentation sensitivity/recall of OD and OC between 80-90%.

Deliverables:

The project on Automated Glaucoma Detection using Optic Disc and Cup Segmentation will require the following deliverables:

1. GUI/Code: (Optional)

A functional Graphical User Interface (GUI) is not strictly necessary for this project. However, if you choose to develop a GUI, it should allow users to:

- Load retinal fundus images from the ORIGA dataset.
- Run the segmentation algorithm on the selected image.
- Visualize the segmented optic disc and optic cup.
- Calculate and display the cup-to-disc ratio (CDR).

Alternatively, you can provide well-documented code that can be executed to perform segmentation and CDR calculation.

2. Technical Details:

This document should provide a comprehensive explanation of the developed algorithm, including:

- Chosen deep learning architecture (e.g., CNN or U-Net) with a justification for the selection.
- Network architecture details (number of layers, filter sizes, activation functions).
- Training process details (data augmentation techniques, optimizer choice, learning rate schedule).
- Post-processing techniques applied to refine segmentation results (if any).

3. Project Report:

The report should comprehensively describe the project and its findings:

- **Introduction:** Briefly explain glaucoma, its diagnosis challenges, and the importance of the project.
- **Methodology:** Detail the steps involved, including pre-processing, segmentation approach, and CDR calculation.
- **Results:** Present the achieved accuracy, sensitivity, and time complexity of the algorithm.
- **Discussion:** Analyze the results, discuss limitations, and suggest potential improvements.
- **Conclusion:** Summarize the project's contribution to automated glaucoma detection.

4. Project Presentation:

Prepare a clear and concise presentation that effectively communicates the project to a wider audience. This may include:

- Introduction to glaucoma and its detection challenges.
- Project objectives and methodology overview.
- Key findings regarding segmentation performance and CDR calculation.
- Discussion of the algorithm's potential impact on clinical practice.
- Conclusion and future directions (areas for further exploration).

Note:

The GUI development is optional. However, a well-documented code with clear instructions for execution is essential.