Sobel Operator-Based Image Segmentation for Citrus Leaf Disease Detection

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1 Introduction

Effective segmentation of objects in images is critical in applications like leaf diseases detection, where isolating the region of interest (ROI) is essential for feature extraction and classification. This project focuses on using the Sobel operator as a spatial-domain filter for segmenting citrus leaf images. The aim is to extract the main leaf region affected by diseases from complex backgrounds. This region includes diseases characteristics, enhancing the identification and classification of various leaf diseases.

2 Project Definition

The objective of this project is to implement the Sobel operator as a high-pass filter for segmenting citrus leaf images. The project will focus on:

- Developing a segmentation method using the Sobel operator.
- Evaluating the performance of the Sobel-based segmentation against alternative methods like Canny edge detection.

3 Planned Data, Methodology, and Expected Results

3.1 Planned Data

A dataset of citrus leaf images which contains healthy leaves and four types of diseased leaves will be used, similar to the dataset described in [1,2]. These images include indoor and outdoor captures with complex backgrounds and varying lighting conditions.

3.2 Methodology

The process of image segmentation using the Sobel operator involves several steps:

1. **Edge Detection**: The Sobel operator is used to calculate the horizontal and vertical gradients of an image. This operator detects edges by changes in contrast with gradient magnitude computation.
2. **Thresholding**: Apply an adaptive thresholding value to create a binary gradient mask, highlighting lines of high contrast in the image.
3. **Dilation**: The binary gradient mask will be dilated using vertical and horizontal linear structuring elements to enhance the detected edges.
4. **Filling holes and removing small areas**: Interior gaps within the dilated mask will be filled to create a solid leaf region. Then, unwanted small regions will be removed from the filled mask to ensure only the main leaf region remains. A final mask is obtained in this step.
5. **Image Segmentation:** The final mask is applied on the original image to segment the infected region.
6. **Evaluation**: Compare the segmented images with ground truth masks using metrics such as Intersection over Union (IoU) and Pixel Accuracy.

3.3 Expected Results

The Sobel-based segmentation pipeline is expected to effectively isolate the main leaf region in images with complex backgrounds. Quantitative metrics will demonstrate its efficiency compared to other methods.

References

[1] H. Dang-Ngoc, T. N. M. Cao, and C. Dang-Nguyen, "Citrus leaf disease detection and classification using hierarchical support vector machine," in *2021 International Symposium on Electrical and Electronics Engineering (ISEE)*, 2021, pp. 69–74.

[2] H. Rauf, B. Saleem, M. Lali, M. Khan, M. Sharif, and S. Bukhari, "A citrus fruits and leaves dataset for detection and classification of citrus diseases through machine learning," *Data Brief*, vol. 26, p. 104340, 2019.