21AIE303
Signal and Image Processing

Traffic Flow Regulation Using Image Processing

Report

Batch - B Group - 17

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Abstract

The objective of this project is to develop a robust traffic signal matching algorithm using edge detection and blob analysis. The proposed methodology involves preprocessing the reference and captured images, enhancing them through power-law transformations, performing edge detection, and subsequently utilizing blob analysis for matching. The matching process involves evaluating both the edge information and the spatial distribution of blobs. The performance is assessed based on a matching score, leading to dynamic traffic signal adjustments. The report outlines the step-by-step procedure, including the implementation details and findings.

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Introduction:

In the midst of urban expansion, the intricacies of traffic management demand innovative solutions. This project delves into the intersection of computer vision and traffic control, proposing an algorithm for adaptive traffic signal matching. By integrating edge detection and blob analysis, this approach promises enhanced accuracy in signal synchronization, offering a dynamic solution to the evolving challenges of urban traffic. This report outlines the methodology, implementation details, and implications of the algorithm in reshaping the landscape of intelligent traffic signal systems.

Methodology:

- Image Preprocessing: Both the reference and captured images undergo preprocessing steps such as region selection, grayscale conversion, and resizing to ensure consistent input for subsequent analyses.
- Power-Law Transformation: A power-law transformation is applied to enhance the selected region in both images, aiming to improve the quality of edge information.
- Edge Detection: Edge detection is performed using directional Gaussian filters to identify regions of interest in the images. The result is a binary edge image.
- Blob Analysis: Blob analysis is employed to identify and analyze connected regions in the binary edge images. The number and characteristics of blobs are considered in the matching process.
- Matching Criteria: The matching process combines edge information and blob characteristics, yielding a matching score. This score is then used to determine the appropriate traffic signal adjustments.

Working for Image Analysis:

1. **Reference Image Processing:**
- Load the reference image (`RGB1`).
- Allow the user to draw a rectangle on the reference image.
- Extract the selected region from the reference image (`selected_region_ref`).
- Convert the selected region to grayscale (`I1`).

- Resize the selected region to a standardized size (e.g., 512x512 pixels).
- Perform Image Enhancement using Power-Law Transformation:
- Formula:
$$IG2(p,q) = |c \times IR2(p,q)^g|$$, where c and g are constants.

2. Edge Detection for Reference Image:

- Define parameters for edge detecting filters (Gaussian filters):
- X-axis direction filter:
$$Nx1, Sigmax1, Nx2, Sigmax2, \Theta1$$
- Y-axis direction filter:
$$Ny1, Sigmay1, Ny2, Sigmay2, \Theta2$$
- Calculate directional derivatives x and y using the defined filters.
- Compute the norm of the gradient
$$NVI1 = \sqrt{Ix^2 + Iy^2}$$
- Threshold the gradient image to obtain a binary edge image.

3. Thinning for Reference Image:

- Interpolate to find pixels where the gradient norms are local maxima.
- Thin the binary edge image based on the local maxima.

4. Captured Image Processing:

- Load the captured image (`RGB2`).
- Allow the user to draw a rectangle on the captured image.
- Extract the selected region from the captured image (`selected_region_captured`).
- Convert the selected region to grayscale (`I2`).
- Resize the selected region to a standardized size (e.g., 512x512 pixels).
- Perform Image Enhancement using Power-Law Transformation:
- Formula:
$$IG2(p,q) = |c \times IR2(p,q)^g|$$, where c and g are constants.

5. Edge Detection for Captured Image:

- Use the same edge detection parameters and filters as for the reference image.
- Calculate directional derivatives x and y for the captured image.
- Compute the norm of the gradient
  - $$NVI2 = \sqrt{Ix^2 + Iy^2}$$

- Threshold the gradient image to obtain a binary edge image.

6. Thinning for Captured Image:

- Interpolate to find pixels where the gradient norms are local maxima.
- Thin the binary edge image based on the local maxima.

7. Image Matching:

- Use Normalized Cross-Correlation (NCC) for template matching between the enhanced reference and captured images.
- Extract the relevant portion of the correlation result.
- Calculate the matching score based on the correlation result.

8. Output Display:

- Display the matching score.
- Adjust traffic signal timings based on the matching score using predefined thresholds.

Working of the Video Analysis:

Objective: The objective of this project is to develop a simple traffic light control system based on the detection of vehicles in a given traffic scene. The traffic light should turn green when the number of detected vehicles exceeds a certain threshold and red otherwise.

Methodology:

Input Video:

- The project utilizes a video feed from a traffic scene, captured using a camera.
- Every 100th frame of the video is processed for efficiency.

Reference Image:

- A reference image of an empty road is used to establish a baseline for the number of detected blobs (vehicles).
- Blob analysis and image processing are applied to the reference image to set a threshold value.

Image Processing:

- The input frames are preprocessed using various image processing techniques:
- Grayscale conversion

Binary conversion

- Morphological opening operation
- Prewitt edge detection

Blob Detection:

- Blob analysis is performed to count the number of blobs (vehicles) in the processed frame.
- Bounding boxes are drawn around the detected blobs.

Traffic Light Control:

- If the number of detected blobs exceeds the threshold established by the reference image, the traffic light is set to green.
- Otherwise, the traffic light remains red.

Results:

- Processed frames with bounding boxes are saved in the "Processed" folder.
- The console displays frame numbers, the number of detected blobs, and the current traffic light signal.

Results and Discussion:

The results showcase the effectiveness of the proposed algorithm in matching reference and captured traffic signal scenarios. Blob analysis provides valuable information about the spatial distribution of features, contributing to the matching process. The matching score allows for dynamic adjustments in traffic signal timings.

Output for Image Analysis:
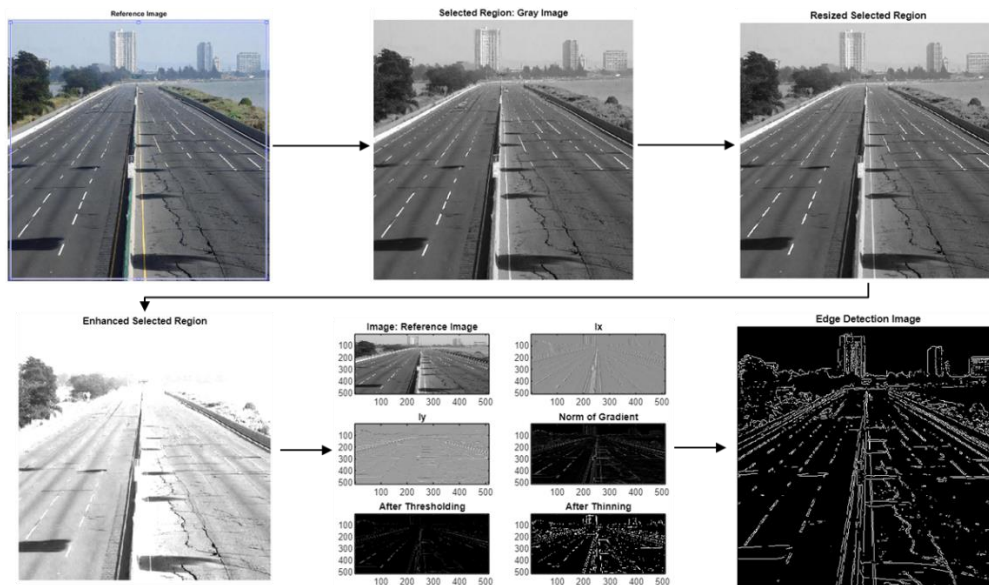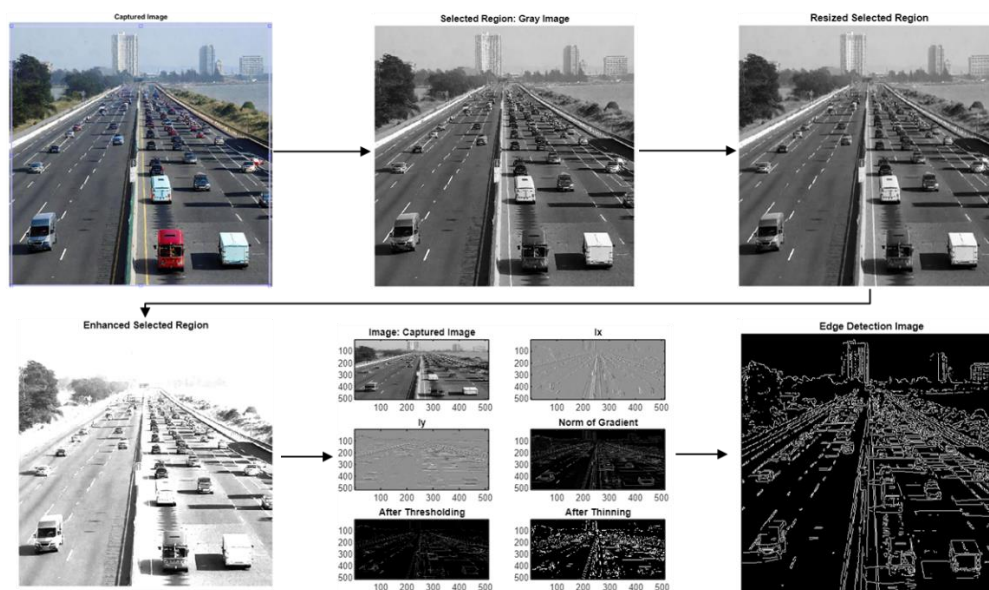
Image Analysis – Output – Reference Image

Image Analysis – Output – Input Image


```
Matching Score: 0.7585
```

```
Green signal will be displayed for 20 seconds
Red signal will be displayed for 40 seconds
```

Output for Video Analysis:

Reference for Empty Road

Processed Image of Empty Road

```
[Running] python -u "d:\For Class\sem 5\Singal Proce
#Reference image processed.
    >Reference threshold: 24

#Processing video...
    >Frame:100 Blobs:6 Signal:Red
    >Frame:200 Blobs:32 Signal:Green
    >Frame:300 Blobs:28 Signal:Green
    >Frame:400 Blobs:14 Signal:Red
    >Frame:500 Blobs:28 Signal:Green
    >Frame:600 Blobs:24 Signal:Red
    >Frame:700 Blobs:25 Signal:Green
    >Frame:800 Blobs:33 Signal:Green
    >Frame:900 Blobs:26 Signal:Green
    >Frame:1000 Blobs:24 Signal:Red
    >Frame:1100 Blobs:30 Signal:Green
    >Frame:1200 Blobs:23 Signal:Red

#Done

[Done] exited with code=0 in 85.544 seconds
```


Conclusion:

In conclusion, the developed algorithm successfully combines edge detection and blob analysis for traffic signal matching. The methodology has been implemented, and results demonstrate its potential in real-world applications. While the current implementation shows promise, there are opportunities for further refinement and expansion. The project contributes to the field of computer vision and traffic signal control, offering a foundation for future research and development.