Traffic Light Color Change Detection

1.Introduction

This project presents a computer vision-based solution for detecting traffic light color changes in a video stream. The system combines a deep learning object detector for locating the traffic light in the image and a classical color-based approach for determining the active light color. Screenshots are automatically saved whenever a color change is detected.

2. System Overview

The system processes a video file containing traffic lights and performs the following tasks:

1. Detects traffic lights automatically using a YOLO object detection model
2. Selects the correct traffic light when multiple are present in the frame
3. Determines the active traffic light color (red, yellow or green)
4. Detects transitions between colors
5. Saves a screenshot at each detected color change

3. Implementation Tools and Resources

- OpenCV – image and video processing
- NumPy – numerical operations and image masking
- datetime and os – folder manipulation
- Python – programming language
- YOLOv8 (Ultralytics) – deep learning object detection model

4. Traffic Light Detection Using YOLO

To locate the traffic light automatically in each video frame, the YOLOv8 object detection model was used. A pre-trained model (YOLOv8s) trained on the COCO dataset was used, which already includes a “traffic light” class.

Yolo is used only to determine the ROI of the traffic light. This approach allows the system to work even if the traffic light position changes across different videos or camera angles.

When multiple traffic lights are detected in the same frame, the system evaluates each detected traffic light candidate and selects the one that is currently active, based on color intensity analysis.

5. Color Detection Using HSV

After extracting the ROI of the traffic light, the system determines the active color using the HSV color space. HSV is more robust than RGB for color detection because it separates color information from brightness.

Fixed HSV ranges are defined for:

- Red (two ranges due to HSV circularity)
- Yellow
- Green

For each color, a binary mask is created using thresholding. The number of non-zero pixels in each mask is counted, and the color with the highest number of detected pixels is considered the active traffic light color.

6. Color Detection Using HSV

In some scenarios, multiple traffic lights are visible in the same frame, such as traffic lights facing different directions. YOLO detects all of them, but only one in relevant.

To solve this, a color activity score is computed for each detected traffic light ROI. This score represents the maximum number of colored pixels present in the ROI. The traffic light with the highest color activity score is selected as the correct one.

This method reliably ignores inactive or rear-facing lights and ensures that only the visible, illuminated traffic light is analyzed.

7. Color Change Detection and Screenshot Capture

The system continuously tracks the detected traffic light color across video frames. A color change is triggered only when the current detected color is different from the previously detected color.

To handle temporary detection instability, the system does not reset the previous color when no color is detected in a frame. This stabilization prevents false negatives and ensures that all real color transitions are captured.

When a valid color change is detected, a screenshot of the current video frame is saved automatically, including the timestamp and the transition details in the filename.

8. Results and Observations

The implemented system successfully detects traffic light color changes across different video sequences. It performs reliably under varying lighting conditions and camera angles.

The combination of YOLO-based object detection and HSV-based color analysis provides both flexibility and accuracy. YOLO ensures correct localization of the traffic light, while HSV ensures precise color recognition.

Some limitations remain, such as sensitivity to extreme lighting conditions or very small traffic lights in the image. However, these limitations can be addressed by fine-tuning the model or adding temporal smoothing techniques.

9. Conclusion

This project demonstrates an effective hybrid approach for traffic light color change detection using both deep learning and classical computer vision techniques. By combining YOLO for object detection with HSV-based color analysis, the system achieves reliable performance without complex model retraining.