**Project Documentation: Image Preprocessing for Autonomous Driving**

**Introduction**

This project focuses on preprocessing images to enhance their quality and suitability for various computer vision tasks, including semantic segmentation, lane detection, object detection, and stop sign detection. Proper preprocessing is crucial for achieving high performance in machine learning models, as it prepares the raw data by normalizing, enhancing contrast, and applying necessary transformations to make features more discernible.

**Dataset and Methodology (Exploration)**

The input dataset consists of images captured in urban environments, specifically targeting scenes that include roads, traffic signs, and various objects. The preprocessing is divided into four main modules, each with its specific methodology:

**1. Semantic Segmentation**

- Resizing: Each image is resized to a uniform dimension of 512x256 pixels to standardize input for neural networks.

- Color Space Conversion: The RGB images are converted to the HSV (Hue, Saturation, Value) color space, which provides better separation of color components, especially in varying lighting conditions.

- Histogram Equalization: The value channel is enhanced using histogram equalization to improve contrast, making it easier for models to distinguish different segments in the image.

- Normalization: The output is normalized to a range of [0, 1] to ensure consistent input for subsequent processing.

**2. Lane Detection**

- Resizing: The images are resized to 512x256 pixels.

- Grayscale Conversion: The images are converted to grayscale, reducing complexity while retaining essential features.

- Canny Edge Detection: The Canny edge detector is applied to highlight the edges of the lanes in the images, which are critical for lane detection tasks.

- Normalization: The resulting edge map is normalized to a range of [0, 1].

**3. Object Detection**

- Resizing: Each image is resized to 512x256 pixels.

- Grayscale Conversion: Images are converted to grayscale to simplify processing.

- Gaussian Blur: A Gaussian blur is applied to reduce noise and detail, allowing for better detection of larger objects.

- Normalization: The processed grayscale image is normalized to a range of [0, 1].

**4. Stop Sign Detection**

- Resizing: The images are resized to a uniform size of 512x256 pixels.

- Color Space Conversion: The images are converted to the LAB color space, which helps in color detection tasks.

- Thresholding: A binary mask is created to isolate red colors, which are characteristic of stop signs.

- Isolation: The mask is applied to the original image to highlight the stop signs.

- Normalization: The output image is normalized to a range of [0, 1].

**Results**

The preprocessing techniques applied significantly improved the quality and usability of the images for subsequent tasks. The following results were observed:

1. Semantic Segmentation: The enhanced contrast allowed for better differentiation between various segments in urban environments.

2. Lane Detection: The edge detection successfully highlighted lane markings, facilitating easier recognition by models.

3. Object Detection: The reduction in noise and blur improved the clarity of objects in the images, aiding in detection accuracy.

4. Stop Sign Detection: The red isolation method effectively highlighted stop signs, which is critical for automated driving systems.

**Sample Outputs**

Original Image

A car on the road

Description automatically generated

1 . Preprocessed Image for Semantic Segmentation

A car on a street

Description automatically generated

2. Edge Detection Result for Lane Detection

A black and white image of a street

Description automatically generated

3. Grayscale Output for Object Detection

A car on a street

Description automatically generated

4. Stop Sign Isolation Result

A black screen with white text

Description automatically generated

**Conclusion**

The preprocessing strategies implemented were effective in enhancing the quality of images for different computer vision tasks. Each module's tailored approach allowed for optimal feature extraction and prepared the dataset for training machine learning models. The project demonstrated the importance of preprocessing in achieving better accuracy and performance in real-world applications.