Lab1 Report

Introduction

This project aimed to develop a computer vision application capable of accurately identifying sky regions in images. The task presents unique challenges due to the varying appearances of the sky under different weather conditions and times of day. The project leveraged traditional computer vision techniques, focusing on color-based segmentation.

Chosen Techniques and Rationale

Color Space Conversion (RGB to HSV)

- Rationale: The HSV color space is preferred over RGB for color segmentation tasks due to its ability to separate color information from luminance. This separation is crucial for identifying sky pixels which are predominantly blue but can vary in intensity and saturation.
- Implementation: OpenCV's `cv2.cvtColor` function was utilized to convert images from RGB to HSV color space.

HSV Thresholding

- Rationale: The blue sky generally falls within a specific range in the HSV color space. By defining a threshold within this range, the algorithm can effectively isolate sky pixels.
- Implementation: The `cv2.inRange` function created a binary mask to extract pixels falling within the predefined blue color range.

Implementation Process and Code Snippets

Initial Implementation

The initial step involved loading images and converting them to the HSV color space for effective color segmentation. The following code snippet was crucial:

```python
hsv_image = cv2.cvtColor(image, cv2.COLOR_BGR2HSV)
mask = cv2.inRange(hsv_image, [95, 40, 40], [135, 255, 255])
sky = cv2.bitwise_and(image, image, mask=mask)
```

Refinement

The initial results included some false positives and missed certain areas of the sky. To address this, the HSV thresholds were fine-tuned, and morphological operations were employed to refine the segmentation.

Challenges and Solutions

Over-Segmentation

- Problem: Initial attempts resulted in the inclusion of non-sky regions.

- Solution: The HSV thresholds were adjusted to a narrower range to reduce false positives. Additionally, morphological opening was applied to remove small spurious regions.

Under-Segmentation
- Problem: Certain parts of the sky, especially lighter or less saturated regions, were missed.
- Solution: Adaptive thresholding was introduced, allowing the algorithm to dynamically adjust to varying lighting conditions and sky appearances.

Reflection

Effectiveness of Approach
The approach demonstrated effectiveness primarily in clear weather conditions, where the sky presented a distinct blue hue. However, it showed limitations in overcast conditions and during times with lower light levels, such as dawn and dusk.

Limitations and Potential Improvements
- Limitations: The technique was less effective in distinguishing sky from similarly colored objects and struggled in low contrast situations.
- Improvements: Implementing machine learning algorithms, particularly convolutional neural networks, could significantly enhance the application's ability to generalize across a broader range of sky conditions and scenes.

Learning Outcomes
- Understanding Color Spaces: The project underscored the importance of choosing the right color space for specific image processing tasks.
- Challenges of Rule-Based Systems: It highlighted the limitations of rule-based systems in dealing with the complexity and variability of natural scenes.