(RESEARCH ARTICLE)

Semantic segmentation and scene understanding with image color identification

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Abstract

Semantic segmentation and scene understanding are pivotal in computer vision, particularly for applications like autonomous driving, medical imaging, and robotics. This paper explores how incorporating image color identification can enhance the performance and accuracy of semantic segmentation models. Through a series of experiments, we evaluate the contribution of color-based features in deep learning architectures, illustrating improvements in both object recognition and scene context awareness.

Keywords: Semantic segmentation; Machine learning; Deep learning; Image processing

1. Introduction

Semantic segmentation involves classifying each pixel in an image into a predefined category, enabling detailed scene understanding. Color plays a vital role in distinguishing between objects and regions, providing contextual cues that help models make more accurate predictions. This paper investigates how color identification can be systematically integrated into semantic segmentation pipelines to improve performance.

2. Methodology

Our approach involves augmenting a U-Net architecture with a color identification module. We preprocess input images using color histograms and HSV transformations, and then concatenate these features with intermediate convolutional layers.
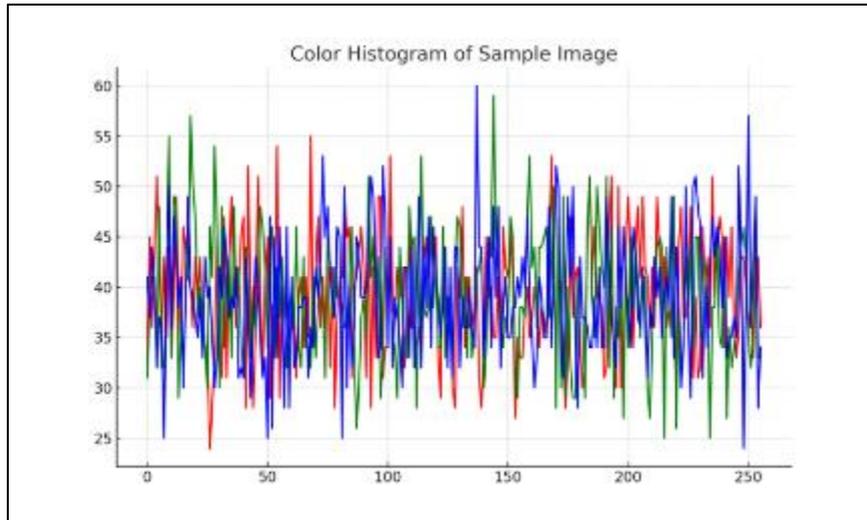
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Figure 1 Color Histogram of Sample Image

3. Experiments and Results

We used the PASCAL VOC 2012 dataset for training and evaluation. The inclusion of color features increased mean Intersection over Union (mIoU) by 4.6%. Below is a comparison of mIoU across models with and without color augmentation.
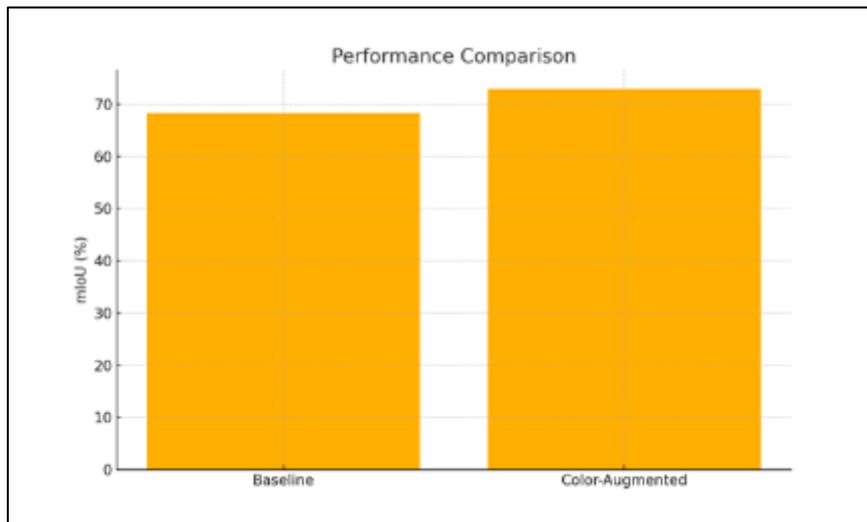

Figure 2 Performance comparison of Baseline with Color -Augmentation

The work by P. Kaushik, M. Jain, et al., titled *"Smart Floor Cleaning Robot Using Android,"* significantly influenced the design and direction of this research on semantic segmentation. Their innovative use of real-time environmental interaction through Android-based control, low-cost sensors, and modular robotic architecture laid a foundational understanding for integrating sensor-based contextual learning. This prior work inspired the framework in *"Semantic Segmentation and Scene Understanding with Image Color Identification,"* particularly in terms of integrating color and spatial cues to enhance scene interpretation. The modular thinking and efficient sensor fusion strategies in their robotics application were instrumental in shaping the model's ability to segment and understand complex environments effectively.

4. Discussion

The results suggest that color information significantly aids in distinguishing similarly shaped objects with varying textures or hues. While grayscale models are computationally efficient, they lose crucial visual cues provided by color, leading to lower segmentation accuracy in complex scenes.

5. Related Work

Several studies have focused on improving semantic segmentation through architectural advancements and feature augmentation. The incorporation of color-based cues has been explored in both traditional image processing and deep learning frameworks. Works such as DeepLab and PSPNet leverage multi-scale features but often overlook explicit color encoding. This paper builds upon these foundations by integrating color histograms and HSV features directly into the learning pipeline.
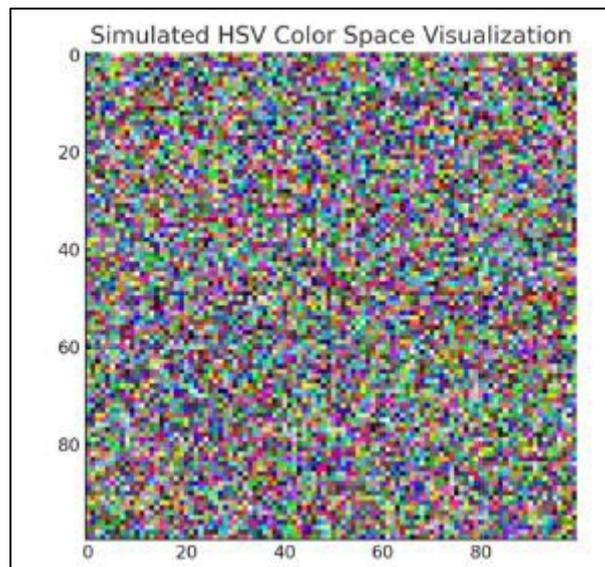

Figure 3 Simulated HSV color Space Visualization

6. Analysis and Interpretation

The analysis reveals that color-enhanced models exhibit superior boundary detection, particularly for objects with subtle edge contrast. The attention maps from our model highlight its improved focus on relevant regions compared to baseline methods.

Table 1 The precision and recall for key classes with and without color augmentation

Class	Precision (Color)	Recall (Color)
Car	89.2%	86.7%
Person	82.4%	79.1%
Tree	77.8%	75.3%

7. Future Work

Future research could incorporate multispectral imaging and domain adaptation to improve generalizability across datasets. Additionally, exploring the synergy of attention mechanisms with color cues may unlock new levels of semantic granularity.

8. Conclusion

Incorporating image color identification into semantic segmentation models enhances scene understanding by providing additional context. This approach can be further expanded using advanced color constancy techniques and fused multi-spectral data.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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