MP4

1. Overview

In `main.py`, I implement:

- Computation of 2D color histograms in different color spaces (RGB, nRGB, HSI) over masked image regions.
- Visualization of the resulting histogram as a grayscale images.
- Segmentation of images using the computed 2D histograms by thresholding the color probability.

For generating training data, I used Segment Anything Model 2 (SAM 2) to generate masks as **ground truth**:

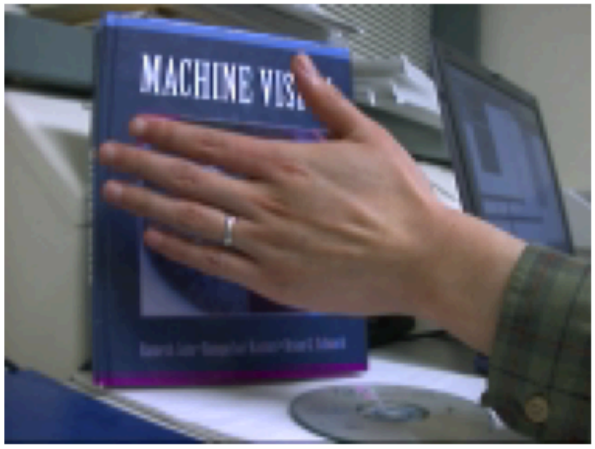
Original Image

MGround Truth Mask from SAM 2

Original Image

MGround Truth Mask from SAM 2

Original Image



MGround Truth Mask from SAM 2

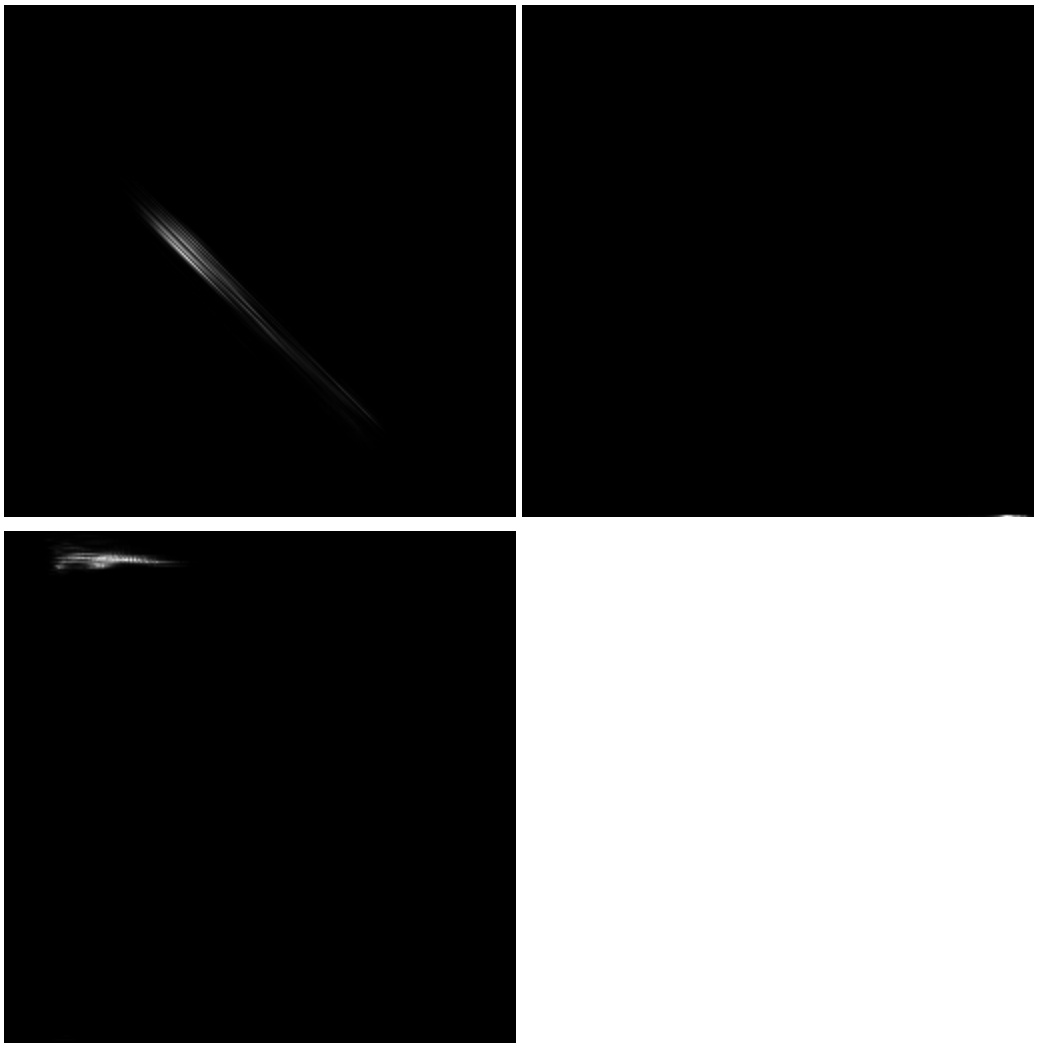
2. Algorithm Description

- **2D Histogram Computation**
    1. Traverse each `*rgb.png` and its corresponding `*mask.png` in the dataset directory.
    2. Load the image in the chosen color space (`rgb`, `nrgb`, or `hsi`).
    3. Apply the binary mask to select valid pixels.
    4. Accumulate counts for each channel pair (R,G) into a 256×256 histogram array with `np.add.at`.
    5. Normalize counts by the total number of masked pixels to obtain a probability distribution.
- **Normalization**
    - **Non-zero scaling**: scale only non-zero histogram bins so that the maximum becomes 1.
- **Visualization**
    1. Normalize histogram values to [0..1] or directly use probabilities.
    2. Multiply by 255 and convert to `uint8` to form a grayscale image.
    3. Display using PIL's `Image.show()`.
- **Segmentation**
    1. For a test image, look up each pixel's (r,g) probability from the histogram.
    2. Optionally normalize the histogram's non-zero values.
    3. Apply a probability threshold to generate a binary mask (0 or 255).
    4. Mask the original RGB image for visualization.

3. Results

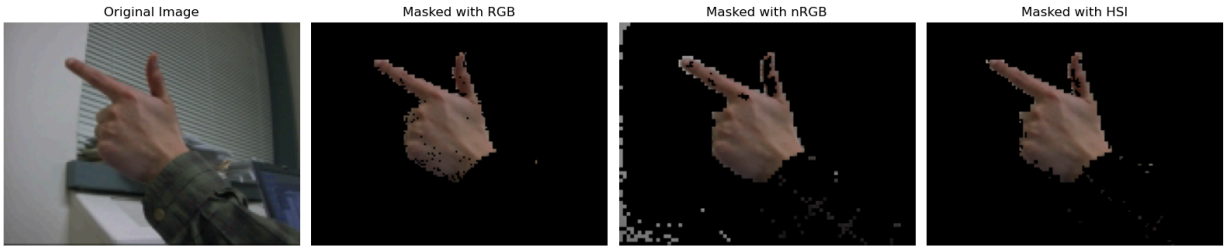
2D Histograms

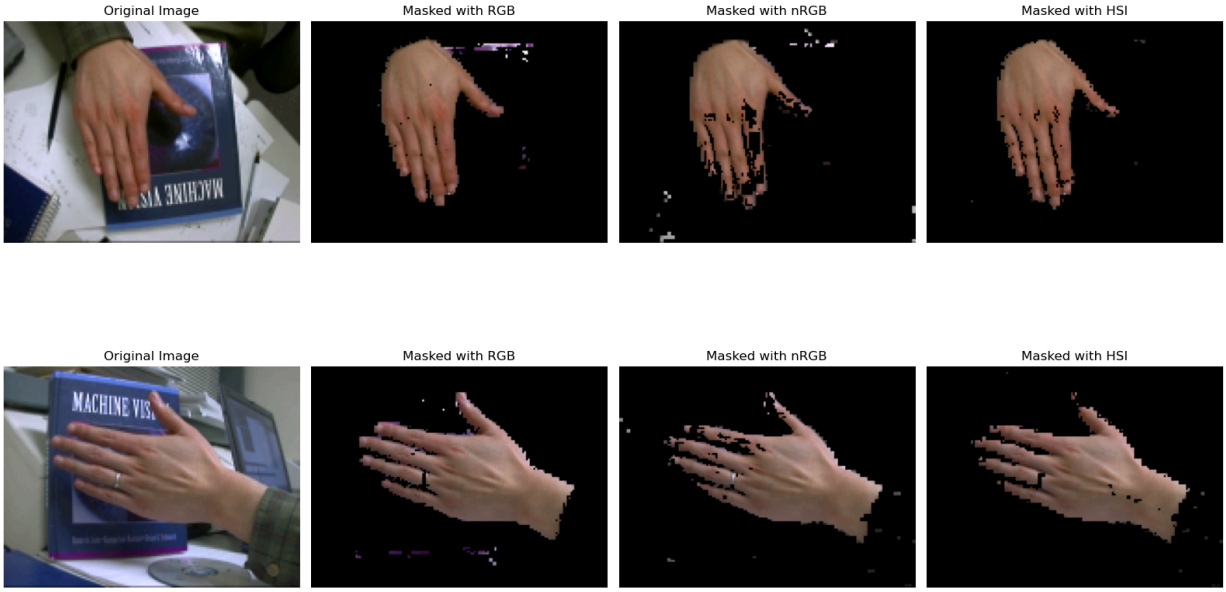
I'm displaying the rescaled R–G, nR–nG, and H–S 2D histograms as 256×256 grayscale images, where each pixel's intensity encodes its probability (0–1).



Masked Results

As illustrated below, I've applied various 2D-histogram thresholds to segment the hands in each image, and a quick glance shows the HSI-based method produces the most accurate masks.




Original Image
Masked with RGB
Masked with nRGB
Masked with HSI
Original Image
Masked with RGB
Masked with nRGB
Masked with HSI