Seamless Integration of a Person into a Photorealistic Scene – Algorithm Documentation

Objective

This document outlines the algorithm and methodology used to photorealistically integrate a person into a background scene using computer vision techniques. The aim is to make the composite image look as if the person was originally present in the scene by addressing background removal, lighting estimation, shadow blending, and color harmonization.

Tools Used

- Google Colab (Python Notebook)
- OpenCV (Image Processing)
- Rembg (Background Removal)
- NumPy (Numerical Operations)
- Matplotlib (Visualization)
- PIL (Image Conversion and Handling)

Dataset

- person.jpg: Image of a front-facing person.

- background.jpg: Target scene where the person will be placed.

Output

- A final photorealistic composite image (final_output.jpg)
- A transparent foreground image (person_no_bg.png)

Detailed Algorithmic Steps

Task 1: Capturing and Preparing the Person's Image

✅Step 1: Capture a High-Quality Image

A front-facing, well-lit image was used to ensure all features are visible for extraction. Shadows or occlusions were avoided to make the separation clean.

✅Step 2: Remove the Background

We used the rembg library to extract the person’s figure from the image. This step outputs a transparent PNG (RGBA) of the person for further processing.

Task 2: Analyzing Shadows and Lighting of the Background

✅Step 1: Detect and Classify Shadows

A visual inspection of the background scene was conducted to identify:
- Hard shadows (e.g., crisp shadows near windows or streetlights)
- Soft shadows (diffused ambient shadows)
A binary shadow mask was planned using the direction of primary light sources.

✅Step 2: Estimate Shadow Zones

- For outdoor scenes, shadows were observed based on sun direction or object shadow orientation.
- For indoor scenes, ambient light reflection was considered.
- A soft Gaussian mask was used to simulate ambient shadows under the person's feet.

Task 3: Determining Light Direction

✅Step 1: Estimate Light Direction

Based on the background image, lighting was observed from the top left, indicating sunlight. This determined where the shadow of the person should fall, and how their body lighting should be adjusted.

✅Step 2: Simulate Consistent Lighting

Slightly adjusted brightness/contrast of the person to match the light temperature of the background using OpenCV.

Task 4: Coloring and Blending

✅Missing Steps Identified:

1. Foreground Resizing & Positioning
- Resized the person to realistic scale according to objects in the background.

2. Color Harmonization
- Used OpenCV to adjust: contrast, hue/saturation, and gamma.
- Blended edges using cv2.GaussianBlur() on the alpha mask.

3. Shadow Simulation
- Generated a semi-transparent ellipse under the feet using cv2.ellipse() to simulate soft shadows.

Task 5: Final Output and Summary

✅Final Composite

The person was overlaid on the background using alpha blending while maintaining:
- Accurate scale and perspective
- Harmonized lighting and color
- Realistic shadows and depth

Conclusion

This approach successfully integrates the person into a new scene using intelligent image preprocessing, light and shadow estimation, and careful blending with transparency. The result is a realistic and coherent visual where the subject appears natively embedded in the background.