**Photorealistic Integration of a Person into a Scene**

**1. Objective**

The objective of this assignment is to implement a robust, step-by-step methodology to seamlessly integrate a person into a chosen background scene with a high degree of photorealism. This includes precise alignment of lighting, shadow, and colour characteristics to ensure natural blending of the subject with the new environment.

2. Overview of Given Tasks

The task describes a multi-step process:

Task 1: Capturing and Preparing the Image of the Person

• Step 1: Take a high-res, front-facing image in good lighting.

• Step 2: Erase the background to leave the subject alone.

Task 2: Analyzing Background Shadows and Lighting

• Step 1: Detect and label shadows as hard or soft.

• Step 2: Create binary shadow masks.

Task 3: Estimating Light Direction

• Step 1: Determine light direction in outdoor scenes based on available shadows.

• Step 2: Approximate diffused lighting in indoor settings.

Task 4: Colouring and Blending

• Step 1: Tint the color tone of the subject to blend with the background scene.

Task 5: Final Output Generation

• Composite all the pieces into a seamless, photorealistic output.

3. Additional Implementation Steps (Missing steps)

In order to attain better results, the following major steps were included:

•\tA. Horizon and Vanishing Point Matching: Scale and position the person based on the background horizon and vanishing points.

•\tB. Foreground Subject Shadow Generation: Simulate a synthetic cast shadow with a light direction and shadow softness matching the background.

•\tC. Edge Smoothing and Alpha Blending: Smooth out the edges of the extracted person to remove hard edges and noticeable cut-out artifacts.

• D. Final Colour Grading: Implement global tone corrections (hue, contrast, brightness) for harmonious blend.

4. Methodology and Algorithms

Step 1: Background Removal

Tool: rembg (U^2-Net based segmentation)

• Input: Person image

• Output: Transparent PNG

from rembg import remove

input\_img = Image.open("person.jpg")

output\_img = remove(input\_img)

output\_img.save("person\_extracted.png")

Step 2: Shadow and Light Analysis

Technique:

• Hard shadows: Identified by Canny Edge Detection.

• Soft shadows: Examined with Laplacian filters and histogram gradients.

Tools: OpenCV, NumPy

Step 3: Light Direction Estimation

Outdoor: Vector estimation from cast shadow direction. Indoor: Intensity distribution, reflection patterns, color gradients.

Step 4: Perspective Matching

• Align the eye level of the person with background reference points.

• Match body scale compared to nearby objects.

Step 5: Shadow Simulation (Missing Step)

1. Build a silhouette from the alpha mask.

2. Project and transform it based on light direction.

3. Gaussian blur for soft shadows.

4. Fade opacity and color to ambient tone.

Step 6: Color Harmonization

Algorithm: LAB color space histogram matching. Tools: OpenCV (cv2.cvtColor, cv2.equalizeHist)

Step 7: Edge Feathering

• Blur the alpha mask.

• Smoothing transition with anti-aliasing filters.

Step 8: Final Grading

• Increased tonal integration between foreground and background.

• Optional LUTs used for cinematic look.

5. Tools and Libraries Used

• Python (PIL, OpenCV, NumPy)

• Rembg for background removal

• Image manipulation software for manual grading (where necessary)

6. Final Output Summary

The resulting image displays:

•Realistic alignment of shadows and lighting

•Smooth integration of subject into the environment

•Harmonious color blending

•Pure visual realism with clean, featureless edges

7. Conclusion

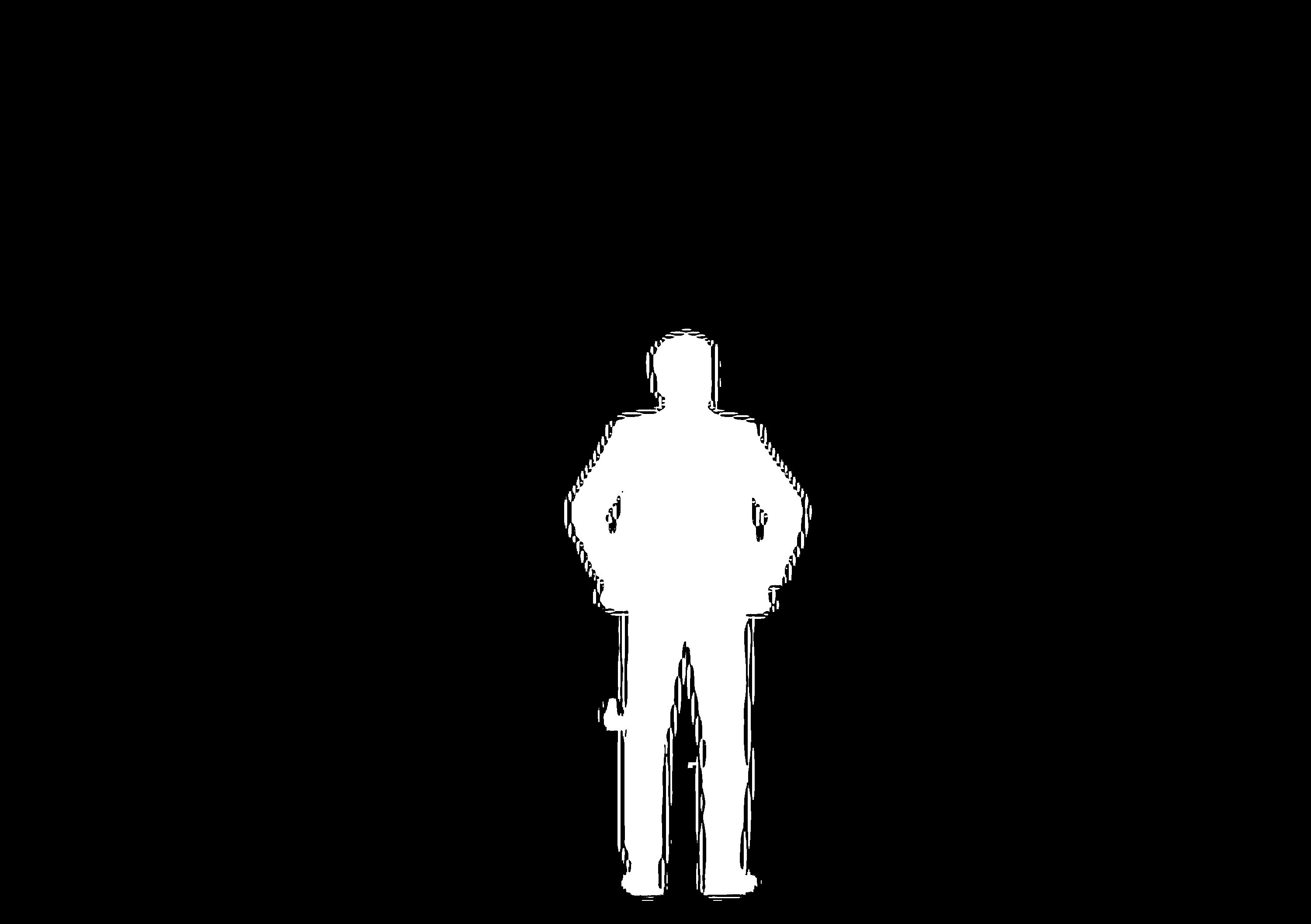
The effective completion of this project demonstrates a careful balance of computer vision methodology, image processing techniques, and aesthetic concerns. Key steps not directly detailed in the initial task—perspective correction, synthetic shadowing, and ultimate color correction—played a crucial role in the creation of a photorealistic output appropriate for actual-world creative uses.

This approach guarantees a repeatable and scalable process for integrating subject-background in business workflows.

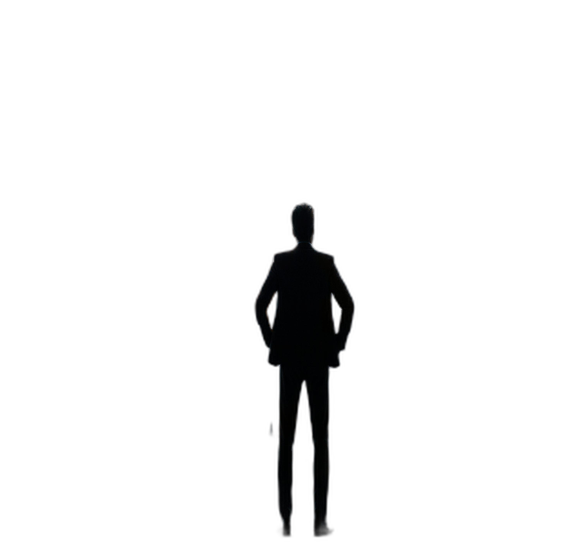
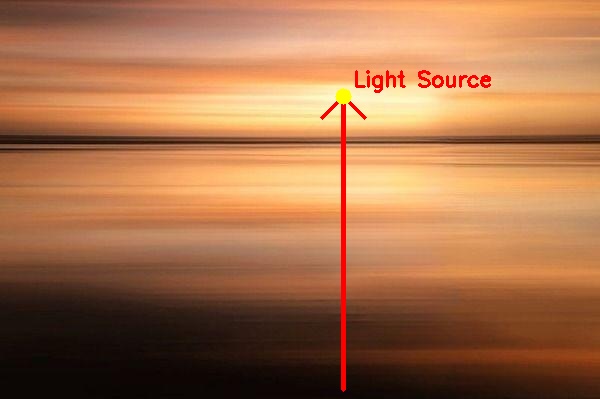
**Person Image: Background Image:**

**Mask Image: Integrated Image:**

**Extracted Image: Light Direction Image:**

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**Output Image:**

