**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:

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

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

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

• 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**

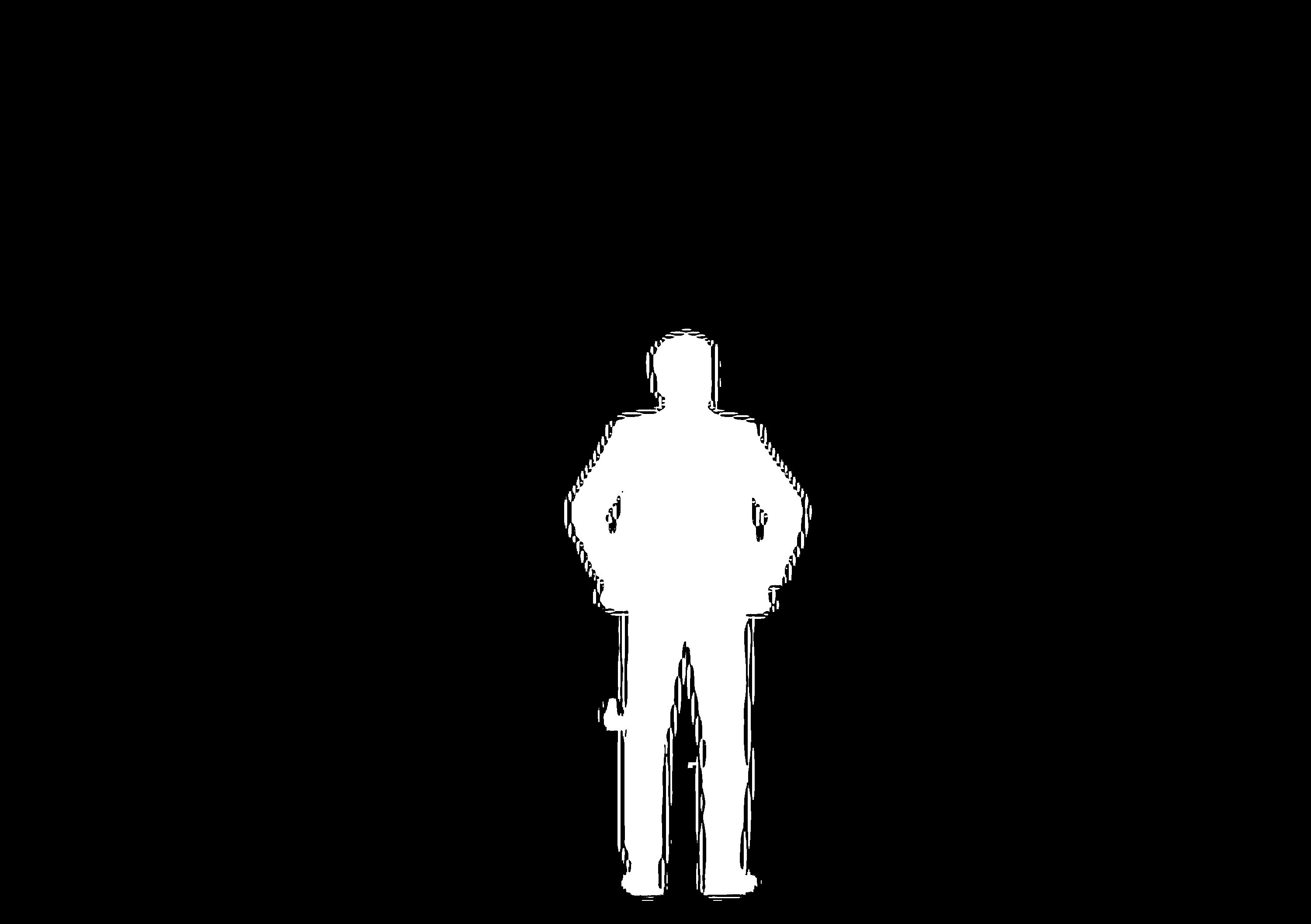
The effective completion of this project demonstrates a careful balance of computer vision methodology, image processing techniques, and aesthetic concerns. Key steps not directly detailed in the initial task—perspective correction, synthetic shadowing, and ultimate color correction—played a crucial 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.

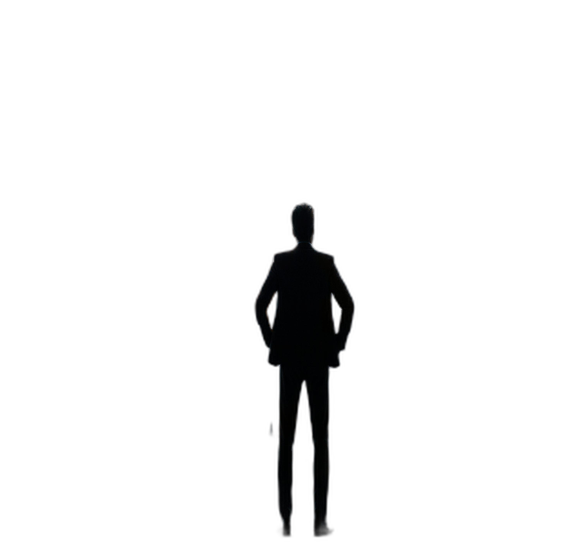
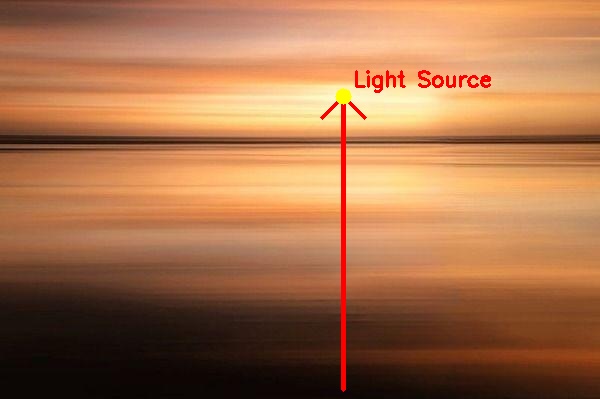
**Person Image: Background Image:**

**Mask Image: Integrated Image:**

**Extracted Image: Light Direction Image:**

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**Output Image:**

