📓 Photorealistic Image Compositing – Assignment Report

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☑️ Objective

The goal of this assignment is to implement a detailed step-by-step process to place a person into a new background scene and blend them seamlessly. This involves background removal, shadow/light estimation, color correction, and photorealistic compositing using manual techniques as well as AI-powered tools.

🧠 AI Techniques Used

To enhance realism and automate portions of the pipeline, the following **AI techniques** are referenced and/or utilized:

- **CNN (Convolutional Neural Networks):** Used in person segmentation and background removal.
- **U-Net Architecture:** Employed for semantic segmentation tasks like mask generation.
- **Generative Adversarial Networks (GANs):** Helpful in photorealistic image-to-image translation.
- **Deep Shadow Estimation:** CNN-based networks trained to estimate lighting and cast shadows.
- **Color Matching Algorithms:** Histogram matching and neural style transfer techniques for tone harmonization.

🗂️ Algorithm Overview

🔷 Task 1: Capturing and Preparing the Person's Image

Step 1.1: Capture High-Quality Person Image

- Use a camera or smartphone in daylight with a neutral wall behind.
- The subject should face forward and be fully visible from knees up.

Step 1.2: Remove Background

- Tools used: **Remove.bg**, **Adobe Photoshop AI**, or **U^2-Net via Deep Learning**.
- Output: Transparent PNG of person.
- AI Note: **CNNs (like U^2-Net)** enable precise pixel-wise segmentation.

◈ Task 2: Analyzing Shadows and Lighting of the Background Scene

Step 2.1: Detect and Classify Shadows

- Use OpenCV + thresholding to generate **binary shadow masks**.
- Shadow Types:
    - **Hard Shadows:** Sharp and directional. Easily seen on sunny days.
    - **Soft Shadows:** Blurred, ambient occlusions seen indoors or overcast days.
- Use AI-based models like **Shadow Detection GANs** for better results.

Step 2.2: Generate Shadow Masks

- Use image subtraction and gradient analysis to find and classify shadows.
- Shadow mask can be overlaid on the new image to make the shadow match the environment.

◈ Task 3: Determining Light Direction

Step 3.1: Outdoor Light Direction

- Analyze shadows in the scene (if any) and compute the angle between person and shadow length.
- Use vanishing point geometry or sun-position modeling.

Step 3.2: Indoor Light Direction

- Estimate lighting via:
  - Brightest pixels in the room
  - Multiple shadows from objects
  - CNN-based model to analyze 3D lighting using inverse rendering.

◈ Task 4: Coloring and Blending

Step 4.1: Harmonizing Person with Background

1. **Histogram Matching:** Align color distribution of the person to the background.
2. **Lighting Simulation:** Adjust highlights and shadows on the person using tools like Photoshop's dodge/burn.
3. **Edge Softening:** Gaussian blur at person-background boundaries to avoid harsh cutouts.
4. **Shadow Creation:**
   a. Create a shadow layer under the person.
   b. Blur and adjust opacity for realism.
   c. Use AI tools like **ShadowNet** for shadow shape prediction.

Missing Steps (Added):

- **Perspective Matching:** Align camera angle and perspective between person and background.
- **Scaling:** Match size of person to background (based on objects in scene).
- **Ambient Occlusion Simulation:** Add slight shading where person contacts ground.

◈ Task 5: Generating Final Output

Final Steps:

1. Place person PNG onto background using Photoshop or GIMP.
2. Add shadows and adjust lighting (manually or with neural networks).
3. Apply color grading and harmonization.
4. Export final image.

🗁 Tools and Software Used

- **Image Editing:** Photoshop / GIMP / Canva
- **Background Removal:** remove.bg / U^2-Net / Cutout Pro
- **AI Libraries:** OpenCV, PyTorch, TensorFlow (for advanced lighting/shadow)
- **Visualization:** Matplotlib, PIL, Seaborn (optional for mask generation)
- **Flow Automation:** Figma (for planning), GitHub (for submission)

🗋 Folder Structure

photorealistic-compositing/

```
**│**
**├── input/**
**│   ├── person.jpg**
**│   ├── person_no_bg.png**
**│   └── background.jpg**
**│**
**├── output/**
**│   └── final_composite.jpg**
**│**
**├── shadows/**
**│   ├── shadow_mask_soft.png**
```

│ └── shadow_mask_hard.png
│
├── docs/
│ └── Algorithm_Documentation.pdf
│
└── README.md

🎯 Result and Justification

- The final image demonstrates **realistic lighting**, **correct shadow positioning**, and **color tone consistency**.
- All visual artifacts are minimized through proper **blending and edge smoothing**.
- Leveraging AI ensured automation and enhanced quality in:
  - Background removal
  - Shadow estimation
  - Color correction

☑️ Conclusion

This assignment demonstrates a mix of **manual digital artistry** and **AI-enhanced automation** to achieve photorealistic image compositing. With the use of CNNs and other AI-based shadow estimation methods, the integration appears natural and professional.