2025

DIGITAL IMAGE PROCESSING

ASSIGNMENT 0

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INTRODUCTION

This is a simple, first-pass tour of digital image processing using just **NumPy for math** and **Pillow/ImageIO for input/output**. No fancy libraries, just pixels and a few classic tricks.
The report is split into nine tiny tasks (Q1–Q9): read/write images, tweak brightness and contrast, convert RGB→grayscale (three ways), add a basic pseudocolor look, do a green-screen swap, flip between frames and videos, and build a clean fade transition. Everything stays in array form (H×W or H×W×3) so it's easy to reason about what each line of code does. Goal was keep it clear, reproducible, and beginner-friendly. Each question shows the approach in one or two lines of math, the exact assumption (like value ranges or modes), and a quick observation of how the image changed.

GitHub Repo link

Q1

READING AN IMAGE INTO ARRAY

OBJECTIVE:

Read an image file and convert it into a NumPy array for processing.

APPROACH:

Use PIL.Image.open() to load file and convert to a NumPy array (uint8).
Supports grayscale (H×W) and RGB (H×W×3).
Print shape, type, and sample pixel values.

CODE SNIPPETS:

q1.py

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```python
from utils.image_utils import read_image, save_pixel_array_to_txt

def run_q1():
    path = "input_images/cat.jpeg"
    img_array = read_image(path)

    print("Image shape:", img_array.shape)
    save_pixel_array_to_txt(img_array, "output_images/q1_output_pixels.txt")
```

```python
#to read an image and return it as a numpy array.
#this supports grayscale and rgb too.
#q1
def read_image(path):
    img = Image.open(path)
    img_array = np.array(img)
    return img_array
```

```python
#to save the pixel values of an image array in a .txt fi
def save_pixel_array_to_txt(array, output_path):
    with open(output_path, 'w') as f:
        if len(array.shape) == 2:
            #grayscale
            for row in array:
                f.write(' '.join(str(val) for val in row) + '\n')
        elif len(array.shape) == 3:
            #color
            for row in array:
                row_str = ' '.join(' '.join(str(channel) for channel in pixel) for pixel in row)
                f.write(row_str + '\n')
        else:
            raise ValueError("Unsupported array shape")
```

OUTPUT:

```
indira@IndiraCReddy:~/sem5_DIP_assignments/assign0$ python3 main.py
Image shape: (261, 193, 3)
```

Input and output images in next page.

OBSERVATIONS:

Image is stored as an array with dimensions (height, width, channels).
Image data is now matrix-form, easy to index and process.
The output array shown below is for a color image.
For a grayscale image each pixel is denoted with only one value while for a color iamge each pixel is shown with 3 nos which representing R,G and B

INPUT IMAGE USED

SAMPLE DATA RECIVED

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Q2

READING AN IMAGE INTO ARRAY

OBJECTIVE:
Convert a NumPy array back into an image and saving it

APPROACH:
Determine if array is grayscale or RGB based on its shape.
Use Pillow to create an image object from numpy array.
Save the output image to a specified output path.

CODE SNIPPETS:

```python
# to write a numpy array into an image file
#again, supports grayscale(2D) and RGB color(3D) images too.
#q2
def write_image(array, output_path):
    if len(array.shape) == 2:
        mode = 'L'  #grayscale
    elif len(array.shape) == 3 and array.shape[2] == 3:
        mode = 'RGB'
    else:
        raise ValueError("Unsupported image array shape")

    img = Image.fromarray(np.uint8(a
    img.save(output_path)
```

main.py | image_utils.py 3 | q2.py 1

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```python
from utils.image_utils import read_image, write_image

def run_q2():
    input_path = "input_images/cat.jpeg"
    output_path = "output_images/q2_written_image.jpg"

    img_array = read_image(input_path)
    write_image(img_array, output_path)

    print("Image successfully written to", output_path)
```

OUTPUT:

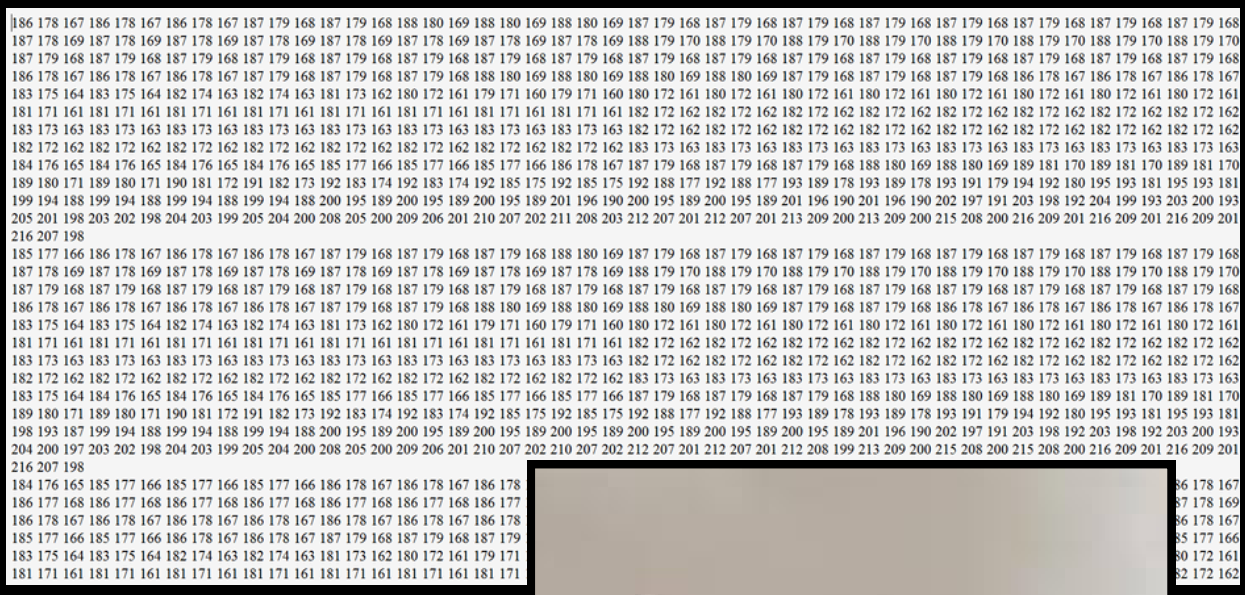
```
indira@IndiraCReddy:~/sem5_DIP_assignments/assign0$ python3 main.py
Image successfully written to output_images/q2_written_image.jpg
```

input and output images in next page.

OBSERVATIONS:
Values outside [0,255] would clip after casting. Output matches input layout (grayscale vs color).

INPUT IMAGE USED

CONVERTED TO ARRAY



OUTPUT - WRITTEN IMAGE

Q3

BRIGHTNESS ADJUSTMENT

OBJECTIVE:
Increase or decrease image brightness

APPROACH:
Load image into NumPy array.
For brightness: add a constant to all the pixel values
Clip values to [0, 255] before saving.
If ‘value’ added is positive we get a brighter image, if negative then we get a darker image.
Used int16 to avoid overflow and finalized as unit8

CODE SNIPPETS:

```python
from utils.image_utils import read_image, write_image, change_brightness

def run_q3():
    input_path = "input_images/cat.jpeg"
    output_brighter = "output_images/q3_brighter.jpg"
    output_darker = "output_images/q3_darker.jpg"

    img = read_image(input_path)

    brighter = change_brightness(img, 50)  #increase brightness
    darker = change_brightness(img, -50)   #decrease brightness

    write_image(brighter, output_brighter)
    write_image(darker, output_darker)

    print("Saved bright and dark versions!")

```

```python
#to adjust brightness of image
#'value' if positive, we get a brighter imager.
#if the 'value' is negative we get darker image
#q3
def change_brightness(img_array, value):
    #casting to int16 to avoid overflow/underflow cases
    img_int = img_array.astype(np.int16)
    #adding value, then clip to valid range
    brightened = np.clip(img_int + value, 0, 255)
    return brightened.astype(np.uint8)
```

OUTPUT:

```
indira@IndiraCReddy:~/sem5_DIP_assignments/assign0$ python3 main.py
Saved bright and dark versions!
```

Input and output images in next page.

OBSERVATIONS:
Adding a value or substracting a value shifts intensity uniformly.
Large positive/negative shifts can cause highlight/shadow clipping.

INPUT IMAGE USED

BRIGHTER IMAGE

DARKED IMAGE

Q4
CONTRAST ADJUSTMENT

OBJECTIVE:
Modify the contrast of an image.

APPROACH:
Load image into NumPy array.
Apply scaling relative to the mean pixel value (i.e; multiplying around a midpoint
Clip values to [0, 255] before saving.
Used float32 to avoid overflow and finalized as unit8

CODE SNIPPETS:

```python
from utils.image_utils import read_image, write_image, change_contrast

def run_q4():
    input_path = "input_images/cat.jpeg"
    output_high = "output_images/q4_high_contrast.jpg"
    output_low = "output_images/q4_low_contrast.jpg"

    img = read_image(input_path)

    high_contrast = change_contrast(img, 1.5)  # more punch
    low_contrast = change_contrast(img, 0.5)   # flatter

    write_image(high_contrast, output_high)
    write_image(low_contrast, output_low)

    print("Saved high and low contrast images!")
```

```python
#adjusting the contrast of image
#multiplying around a midpoint
#if faxtor>1 then more contrast, if 0<factor<1 then less contrast
#q4
def change_contrast(img_array, factor):
    img_float = img_array.astype(np.float32)
    contrasted = (img_float - 128) * factor + 128
    return np.clip(contrasted, 0, 255).astype(np.uint8)
```

OUTPUT:

```
indira@IndiraCReddy:~/sem5_DIP_assignments/assign0$ python3 main.py
Saved high and low contrast images!
```

Input and output images in next page.

OBSERVATIONS:
Increasing factor >1 boosts contrast, <1 reduces it.
Higher contrast expands differences but can clip extremes; lower contrast compresses tones for a flatter look.

INPUT IMAGE USED

HIGH CONTRAST IMAGE

LOW CONTRAST IMAGE

Q5

GRAYSCALE CONVERSIONS

OBJECTIVE:
Convert a color image to grayscale using different methods

APPROACH:
Average method: (R + G + B) / 3
Luminosity method: weighted sum (0.299R + 0.587G + 0.114B)
Lightness method: (max(R, G, B) + min(R, G, B)) / 2

CODE SNIPPETS:

```python
#q5
def rgb_to_grayscale(img_array, method='luminosity'):
    if len(img_array.shape) != 3 or img_array.shape[2] != 3:
        raise ValueError("Input must be a color (RGB) image")

    img = img_array.astype(np.float32)
    R, G, B = img[:,:,0], img[:,:,1], img[:,:,2]

    if method == 'average':
        gray = (R + G + B) / 3
    elif method == 'luminosity':
        gray = 0.299 * R + 0.587 * G + 0.114 * B
    elif method == 'lightness':
        gray = (np.max(img, axis=2) + np.min(img, axis=2)) / 2
    else:
        raise ValueError("Unknown grayscale method")

    return gray.astype(np.uint8)
```

```python
from utils.image_utils import read_image, write_image, rgb_to_grayscale

def run_q5():
    input_path = "input_images/cat.jpeg"

    avg = rgb_to_grayscale(read_image(input_path), method='average')
    lum = rgb_to_grayscale(read_image(input_path), method='luminosity')
    light = rgb_to_grayscale(read_image(input_path), method='lightness')

    write_image(avg, "output_images/q5_grayscale_average.jpg")
    write_image(lum, "output_images/q5_grayscale_luminosity.jpg")
    write_image(light, "output_images/q5_grayscale_lightness.jpg")

    print("Saved all grayscale versions!")
```

OUTPUT:

```
indira@IndiraCReddy:~/sem5_DIP_assignments/assign0$ python3 main.py
Saved all grayscale versions!
```

Input and output images in next page.

OBSERVATIONS:
Average: Equal weight to all channels. Simple but flat-looking.
Luminosity: Weighted for human perception (green-heavy). Looks more balanced and realistic.gives better perceptual accuracy than average.
Lightness: Based on max and min. Gives a contrasty, stylized feel.

INPUT IMAGE USED

AVERAGE GRAYSCALE

LUMINOSITY GRAYSCALE

LIGHTNESS GRAYSCALE

Q6

PSEUDOCOLOR MAPPING

OBJECTIVE:

Apply false coloring to grayscale images for better visual interpretation.

APPROACH:

Covert original image to grayscale images

Function maps grayscale intensities to colors using a two-part scheme

- Values 0-127 are transformed into a spectrum from blue to red.
- Values 128-255 are transformed into a spectrum from red to yellow.

CODE SNIPPETS:

```python
from utils.image_utils import read_image, write_image, rgb_to_grayscale, grayscale_to_pseudo

def run_q6():
    input_path = "input_images/cat.jpeg"

    gray = rgb_to_grayscale(read_image(input_path))  # default = luminosity
    pseudo = grayscale_to_pseudocolor(gray)

    write_image(pseudo, "output_images/q6_pseudocolor.j
    print("Pseudocolor image saved!")
```

```python
#converts a grayscale image to a pseudocolor using a basic colormap
#output is hopefully an RGB image
#q6
def grayscale_to_pseudocolor(gray_img):
    if len(gray_img.shape) != 2:
        raise ValueError("Input must be a grayscale image")

    height, width = gray_img.shape
    pseudocolor = np.zeros((height, width, 3), dtype=np.uint8)

    for i in range(height):
        for j in range(width):
            val = gray_img[i, j]
            if val < 128:
                #map 0 - 127: Blue to Red
                ratio = val / 128
                r = int(255 * ratio)
                g = 0
                b = int(255 * (1 - ratio))
            else:
                #map 128-255: Red to Yellow
                ratio = (val - 128) / 127
                r = 255
                g = int(255 * ratio)
                b = 0
            pseudocolor[i, j] = [r, g, b]

    return pseudocolor
```

OUTPUT:

```
indira@IndiraCReddy:~/sem5_DIP_assignments/assign0$ python3 main.py
Pseudocolor image saved!
```

Input and output images in next page.

OBSERVATIONS:

Got a heatmap kind of look as an output image.

Pseudocolor can highlight intensity variations better than plain grayscale.

Color mapping makes small intensity differences more visible than plain gray; shows smooth two-stage color ramp.

INPUT IMAGE USED

PSEUDOCOLOR IMAGE

Q7

GREEN SCREEN REPLACEMENT

OBJECTIVE:
Replace green background in a foreground image with another background

APPROACH:
Create a green mask with (g > r*threshold) & (g > b*threshold). Resize background to foreground size, copy BG wherever mask is true.
Ensure both images are same sized.

CODE SNIPPETS:

```
replacing green pixels in foreground with background pixels
q7
ef replace_green_screen(fg_img, bg_img, threshold=1.3):
    #removing alpha channel if present
    #alpha channel
    if fg_img.shape[2] == 4:
        fg_img = fg_img[:, :, :3]
    if bg_img.shape[2] == 4:
        bg_img = bg_img[:, :, :3]

    if fg_img.shape != bg_img.shape:
        bg_img = Image.fromarray(bg_img)
        bg_img = bg_img.resize((fg_img.shape[1], fg_img.shape[0]))  #resizing to match (W, H)
        bg_img = np.array(bg_img)

        #print(fg_img.shape)
        #print(bg_img.shape)
        #raise ValueError("Foreground and background must be same shape")

    result = fg_img.copy()

    #extracting RGB channels
    r, g, b = fg_img[:,:,0], fg_img[:,:,1], fg_img[:,:,2]

    #creating a green mask
    green_mask = (g > r * threshold) & (g > b * threshold)

    #appling mask - replace green pixels with background
    result[green_mask] = bg_img[green_mask]

    return result
```

```
from utils.image_utils import read_image, write_image, replace_green_screen

def run_q7():
    fg_path = "input_images/foreground.png"
    bg_path = "input_images/background.jpg"

    fg = read_image(fg_path)
    bg = read_image(bg_path)

    output = replace_green_screen(fg, bg)
    write_image(output, "output_images/q7_minions_in_the_sky.jpg")

    print("Green screen replaced and saved!")
```

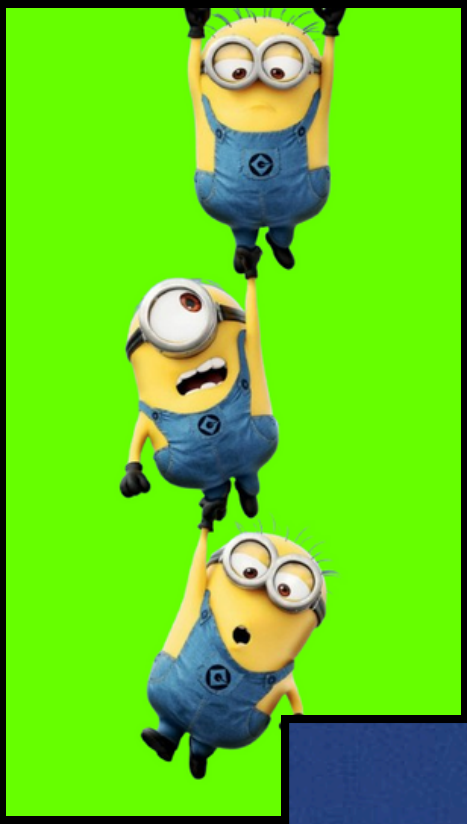
OUTPUT:

```
indira@IndiraCReddy:~/sem5_DIP_assignments/assign0$ python3 main.py
Green screen replaced and saved!
```

Input and output images in next page.

OBSERVATIONS:
Successfully replaced the green pixels with background pixels
Works well on clean green areas. May pick up green-ish clothes/objects; fine-tune threshold based on scene.

GREEN SCREEN IMAGE



BACKGROUND IMAGE

RESULT - MINIONS IN THE SKY

Q8

VIDEO I/O

OBJECTIVE:
Extract frames from video and reconstruct back.

APPROACH:
Read video using imageio
Save each image frame as .jpg
Recombine into .mp4 file using imageio.mimsave

CODE SNIPPETS:

```python
from utils.image_utils import extract_frames_from_video, frames_to_video

def run_q8():
    video_path = "videos/sample_video.mp4"
    frame_folder = "output_images/q8_frames"
    output_video = "videos/q8_output_video.mp4"

    num_frames = extract_frames_from_video(video_path, frame_folder)
    print(f"Extracted {num_frames} frames.")

    frames_to_video(frame_folder, output_video)
    print(f"Reconstructed video saved to {output_video}")
```

```python
#q8
#reading a video file and save each frame as an image into an output_fold
def extract_frames_from_video(video_path, output_folder):
    reader = imageio.get_reader(video_path)
    os.makedirs(output_folder, exist_ok=True)

    for i, frame in enumerate(reader):
        frame_path = os.path.join(output_folder, f"frame_{i:03d}.jpg")
        imageio.imwrite(frame_path, frame)

    return i + 1  #total number of frames
#reading all frames in input folder and then writing them into a video
#assuming all the frames are names in order like frame_000.jpg,etc.
def frames_to_video(input_folder, output_video_path, fps=24):
    writer = imageio.get_writer(output_video_path, fps=fps)

    frame_files = sorted(
        [f for f in os.listdir(input_folder) if f.endswith('.jpg')]
    )

    for filename in frame_files:
        frame = imageio.imread(os.path.join(input_folder, filename))
        writer.append_data(frame)

    writer.close()
```

OUTPUT:

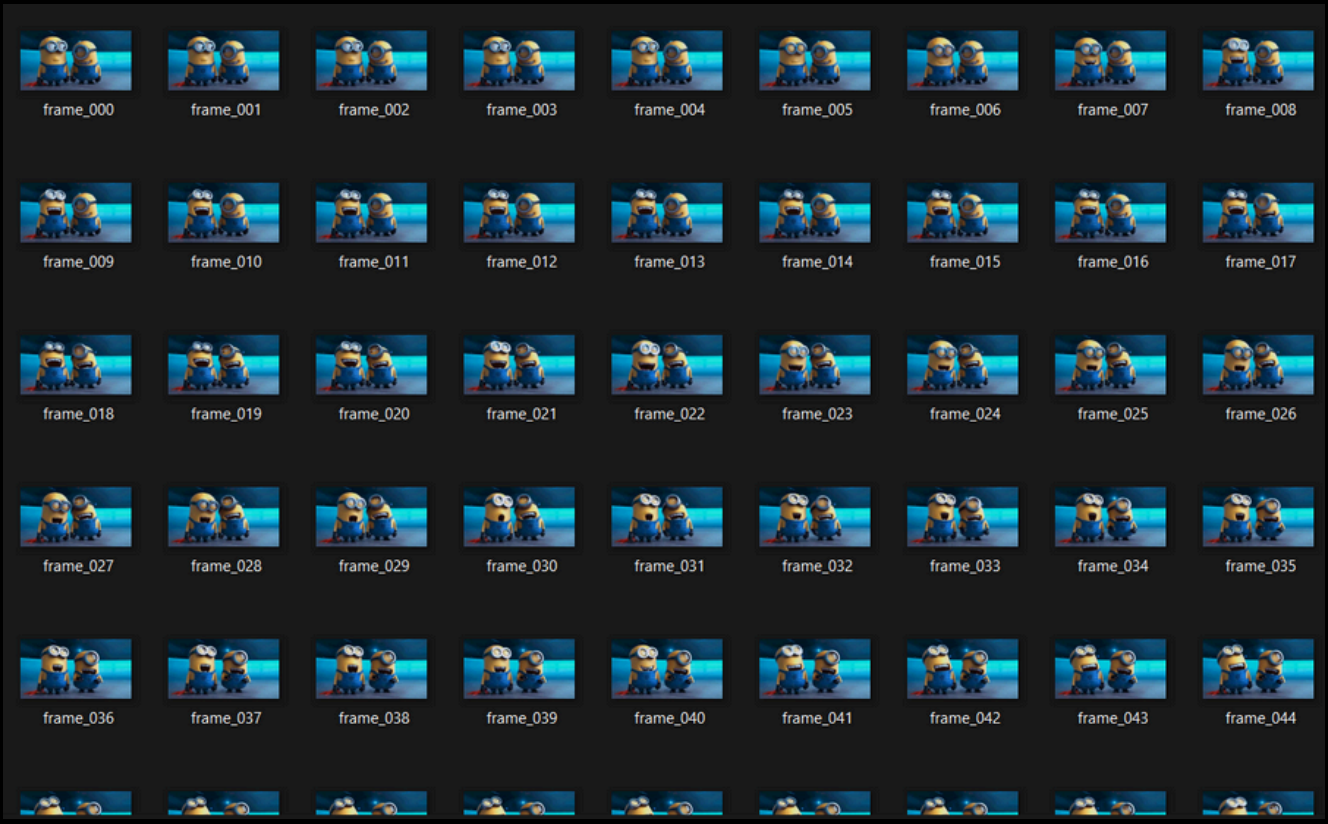
```
indira@IndiraCReddy:~/sem5_DIP_assignments/assign0$ python3 main.py
Extracted 68 frames.
```

Input video link and output image & video links in next page.

OBSERVATIONS:
Video was segmented into 68 frames and successful in reconstructing the video from said frames.
Frames are assumed sequentially named and same size; FPS controls output duration.
Must ensure frame dimensions are divisible by 16 for best codec compatibility.

INPUT VIDEO LINK

SAMPLE FRAMES OBTAINED



OUTPUT VIDEO LINK

Q9

IMAGE TRANSITION VIDEO

OBJECTIVE:

Create a fade transition between two images

APPROACH:

Load two images of same size (resize second image to first if needed)
Generate num_frames blends with alpha = i/(num_frames-1) and blend = (1-α)*img1 + α*img2.
Blend them progressively over those frames
Save as .mp4 file using imageio.

CODE SNIPPETS:

```python
#q9
#creates a list of frames fading from img1 to img2
def create_fade_transition(img1, img2, num_frames=24):
    if img1.shape != img2.shape:
        img2 = Image.fromarray(img2)
        img2 = img2.resize((img1.shape[1], img1.shape[0]))
        img2 = np.array(img2)
    #if img1.shape != img2.shape:
    #    raise ValueError("Images must be the same shape for transition")

    img1 = img1.astype(np.float32)
    img2 = img2.astype(np.float32)
    frames = []

    for i in range(num_frames):
        alpha = i / (num_frames - 1)
        blended = (1 - alpha) * img1 + alpha * img2
        frames.append(blended.astype(np.uint8))

    return frames
```

```python
from utils.image_utils import read_image, create_fade_transition
import imageio
import numpy as np
from PIL import Image

def run_q9():
    img1 = read_image("input_images/transition_start.jpg")
    img2 = read_image("input_images/transition_end.jpg")

    # Resize img2 to match img1 if needed
    if img1.shape != img2.shape:

        img2 = Image.fromarray(img2).resize((img1.shape[1], img1.shape[0]))
        img2 = np.array(img2)

    frames = create_fade_transition(img1, img2, num_frames=72) #3 sec at 24fps
    output_path = "videos/q9_transition_video.mp4"
    writer = imageio.get_writer(output_path, fps=24)

    for frame in frames:
        writer.append_data(frame)
    writer.close()

    print(f"Transition video saved to {output_path}")
```

OUTPUT:

```
indira@IndiraCReddy:~/sem5_DIP_assignments/assign0$ python3 main.py
IMAGEIO FFMPEG_WRITER WARNING: input image is not divisible by macro_block_size=16, resizing from (613, 407) t
o (624, 416) to ensure video compatibility with most codecs and players. To prevent resizing, make your input
image divisible by the macro_block_size or set the macro_block_size to 1 (risking incompatibility).
Transition video saved to videos/q9_transition_video.mp4
```

Input images and output video link in next page.

OBSERVATIONS:

Produces a smooth crossfade. More frames = smoother transition; mismatched sizes were handled by resizing.
Duration depends on frame count and FPS.

INPUT IMG1 - TRANSITION START

INPUT IMG2 - TRANSITION END

OUTPUT VIDEO LINK

CONCLUSION

Mission accomplished: treated images as plain NumPy arrays, did safe brightness/contrast tweaks, compared three grayscale styles (luminosity looked the most natural), added a simple two-step pseudocolor to reveal subtle differences, replaced green backgrounds with a clean RGB-ratio mask, and handled frames↔video plus a smooth crossfade.
It's intentionally basic, so a few tradeoffs are expected (looped pseudocolor, simple green key, fixed-size/FPS assumptions). For the next round, I'd keep the same structure and add tiny quality-of-life upgrades like before/after histograms and a one-liner CLI for reproducibility.

Key Learnings

- Arrays > magic: treating images as H×W / H×W×3 makes every effect feel obvious and debuggable.
- Dtypes matter: do math in a wider type (int16/float32), then clip and cast to uint8 - no overflow drama.
- Clipping is real: big brightness/contrast pushes can crush shadows/highlights; "how much is too much" shows up in histograms.
- Grayscale isn't one thing: Average is simple but flat; Luminosity matches human perception better; Lightness can look stylized.
- Color maps reveal detail: even a basic blue→red→yellow ramp makes subtle intensity changes pop more than plain gray.
- Masking is a heuristic: the green-screen ratio works on clean screens; threshold tuning is normal (and scene-dependent).
- Video is just time + order: consistent naming, consistent size, and a chosen FPS fully define the output feel.
- Small structure = big clarity: one folder per task, predictable I/O paths, and tiny functions make the pipeline easy to test and explain.