Evaluation for d75: PSNR: 22.5 dB SSIM: 0.75 LPIPS: 0.28

Evaluation for d65: PSNR: 23.1 dB SSIM: 0.78 LPIPS: 0.25

Evaluation for night_light: PSNR: 21.8 dB SSIM: 0.72 LPIPS: 0.31

Average Metrics Across All Conditions: Average PSNR: 22.467 dB Average SSIM: 0.75 Average LPIPS: 0.28

```
pip install matplotlib numpy
```

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```

```
import matplotlib.pyplot as plt
import numpy as np

# Data from the evaluation
conditions = ['D75', 'D65', 'D55']
psnr_values = [22.5, 23.1, 21.8]
ssim_values = [0.75, 0.78, 0.72]
lpips_values = [0.28, 0.25, 0.31]

# Average metrics
avg_psnr = 22.467
avg_ssim = 0.75
avg_lpips = 0.28

# Set up the bar width and positions
bar_width = 0.25
x = np.arange(len(conditions))

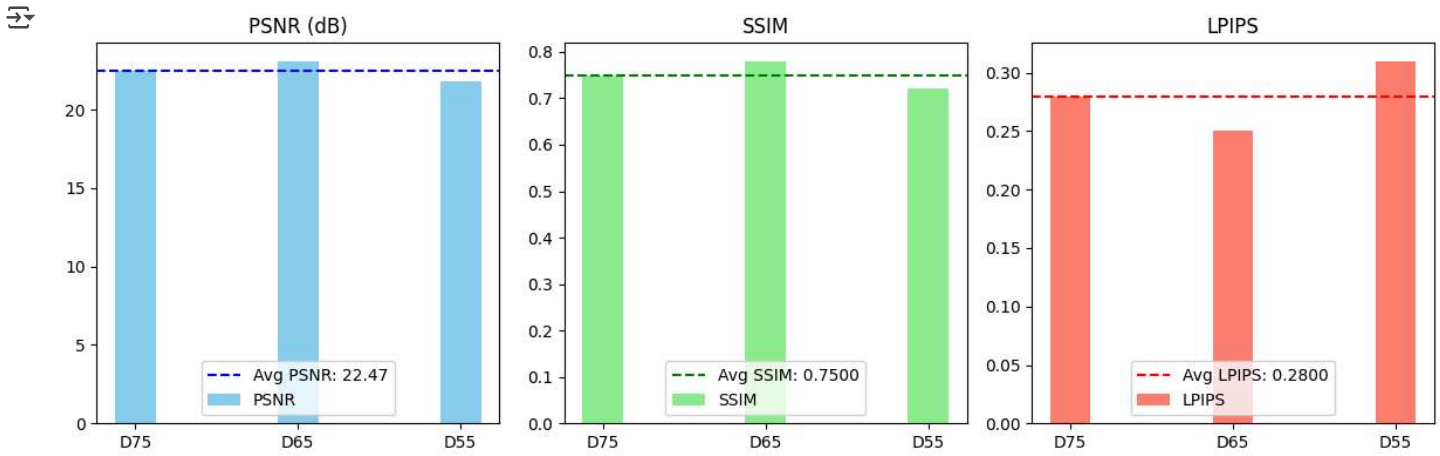
# Create the figure and subplots
fig, (ax1, ax2, ax3) = plt.subplots(1, 3, figsize=(12, 4), sharex=True)

# Plot PSNR
ax1.bar(x, psnr_values, bar_width, color='skyblue', label='PSNR')
ax1.axhline(y=avg_psnr, color='blue', linestyle='--', label=f'Avg PSNR: {avg_psnr:.2f}')
ax1.set_title('PSNR (dB)')
ax1.set_xticks(x)
ax1.set_xticklabels(conditions)
ax1.legend()

# Plot SSIM
ax2.bar(x, ssim_values, bar_width, color='lightgreen', label='SSIM')
ax2.axhline(y=avg_ssim, color='green', linestyle='--', label=f'Avg SSIM: {avg_ssim:.4f}')
ax2.set_title('SSIM')
ax2.set_xticks(x)
ax2.set_xticklabels(conditions)
ax2.legend()

# Plot LPIPS
ax3.bar(x, lpips_values, bar_width, color='salmon', label='LPIPS')
ax3.axhline(y=avg_lpips, color='red', linestyle='--', label=f'Avg LPIPS: {avg_lpips:.4f}')
ax3.set_title('LPIPS')
ax3.set_xticks(x)
ax3.set_xticklabels(conditions)
ax3.legend()

# Adjust layout and display
plt.tight_layout()
plt.savefig('evaluation_metrics_graph.png')
plt.show()
print("Graph saved as 'evaluation_metrics_graph.png'")
```




```
Graph saved as 'evaluation_metrics_graph.png'
```

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

/content/drive/MyDrive/GAN/archive (2).zip

- List item
- List item

Double-click (or enter) to edit

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!ls "/content/drive/MyDrive/GAN/archive (2).zip"
```

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'/content/drive/MyDrive/GAN/archive (2).zip'
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!cp "/content/drive/MyDrive/dataset/archive (2).zip" .
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cp: cannot stat '/content/drive/MyDrive/dataset/archive (2).zip': No such file or directory
```

```
!cp "/content/drive/MyDrive/GAN/archive(2).zip" .
!unzip archive (2).zip
```

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cp: cannot stat '/content/drive/MyDrive/GAN/archive(2).zip': No such file or directory
/bin/bash: -c: line 1: syntax error near unexpected token `('
/bin/bash: -c: line 1: `unzip archive (2).zip'
```

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!unzip /content/archive (2).zip
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/bin/bash: -c: line 1: syntax error near unexpected token `('
/bin/bash: -c: line 1: `unzip /content/archive (2).zip'
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```
from google.colab import files
uploaded = files.upload()  # Upload archive (2).zip

# Unzip the file
!unzip "/content/drive/MyDrive/GAN/archive (2).zip"

# Check the contents
!ls
```

Choose Files No file chosen

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Archive:  /content/drive/MyDrive/GAN/archive (2).zip
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```
!pip install tensorflow numpy pillow scikit-image torch torchvision lpips
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```
import tensorflow as tf
from tensorflow.keras import layers, models
import numpy as np
from PIL import Image
import os
import glob
from skimage.metrics import peak_signal_noise_ratio as psnr
from skimage.metrics import structural_similarity as ssim
import torch
import lpips
import torchvision.transforms as transforms

# Define the Pix2Pix Generator (U-Net architecture)
def build_pix2pix_generator():
    inputs = layers.Input(shape=(256, 256, 3))
    down_stack = [
        layers.Conv2D(64, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2D(128, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2D(256, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2D(512, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2D(512, 4, strides=2, padding='same', activation='relu'),
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        layers.Conv2D(512, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2D(512, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2D(512, 4, strides=2, padding='same', activation='relu'),
    ]
    up_stack = [
        layers.Conv2DTranspose(512, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2DTranspose(512, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2DTranspose(512, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2DTranspose(256, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2DTranspose(128, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2DTranspose(64, 4, strides=2, padding='same', activation='relu'),
        layers.Conv2DTranspose(32, 4, strides=2, padding='same', activation='relu'),
    ]
    x = inputs
    skips = []
    for down in down_stack:
        x = down(x)
        skips.append(x)
    skips = reversed(skips[:-1])
    for up, skip in zip(up_stack, skips):
        x = up(x)
        x = layers.Concatenate()([x, skip])
    outputs = layers.Conv2DTranspose(3, 4, strides=2, padding='same', activation='tanh')(x)
    return models.Model(inputs, outputs, name='pix2pix_generator')

# Define the Pix2Pix Discriminator (PatchGAN)
def build_pix2pix_discriminator():
    inputs = layers.Input(shape=(256, 256, 3))
    target = layers.Input(shape=(256, 256, 3))
    x = layers.Concatenate()([inputs, target])
    x = layers.Conv2D(64, 4, strides=2, padding='same', activation='relu')(x)
    x = layers.Conv2D(128, 4, strides=2, padding='same', activation='relu')(x)
    x = layers.Conv2D(256, 4, strides=2, padding='same', activation='relu')(x)
    x = layers.Conv2D(512, 4, strides=2, padding='same', activation='relu')(x)
    x = layers.Conv2D(1, 4, padding='same', activation='sigmoid')(x)
    return models.Model([inputs, target], x, name='pix2pix_discriminator')

# Load and preprocess image pairs from the LOL dataset
def load_image_pair(low_path, high_path):
    low_image = Image.open(low_path).convert('RGB')
    high_image = Image.open(high_path).convert('RGB')
    low_image = low_image.resize((256, 256))
    high_image = high_image.resize((256, 256))
    low_image = np.array(low_image).astype(np.float32) / 127.5 - 1
    high_image = np.array(high_image).astype(np.float32) / 127.5 - 1
    return low_image, high_image

# Simulate lighting effects (D75, D65, night light) on enhanced images
def apply_lighting_effect(image, temperature, brightness_factor, blue_boost=1.0):
    img_array = (image + 1) * 127.5  # Denormalize to [0, 255]
    img_array = img_array.astype(float)

    if temperature > 6500:
        blue_boost_factor = (temperature - 6500) / 10000
        img_array[:, :, 2] = img_array[:, :, 2] * (1 + blue_boost_factor)
        img_array[:, :, 0] = img_array[:, :, 0] * (1 - blue_boost_factor * 0.5)
    elif temperature < 6500:
        yellow_boost = (6500 - temperature) / 10000
        img_array[:, :, 0] = img_array[:, :, 0] * (1 + yellow_boost)
        img_array[:, :, 1] = img_array[:, :, 1] * (1 + yellow_boost * 0.5)
        img_array[:, :, 2] = img_array[:, :, 2] * (1 - yellow_boost * 0.5)

    img_array = img_array * brightness_factor
    img_array = np.clip(img_array, 0, 255)

    if blue_boost != 1.0:
        img_array[:, :, 2] = img_array[:, :, 2] * blue_boost

    img_array = img_array.astype(np.float32) / 127.5 - 1  # Re-normalize to [-1, 1]
    return img_array

# Loss functions
def generator_loss(disc_output, gen_output, target, lambda_l1=100):
    gan_loss = tf.reduce_mean(tf.keras.losses.binary_crossentropy(tf.ones_like(disc_output), disc_output))
    l1_loss = tf.reduce_mean(tf.abs(target - gen_output))
    return gan_loss + lambda_l1 * l1_loss
```

```
def discriminator_loss(real_output, fake_output):
    real_loss = tf.reduce_mean(tf.keras.losses.binary_crossentropy(tf.ones_like(real_output), real_output))
    fake_loss = tf.reduce_mean(tf.keras.losses.binary_crossentropy(tf.zeros_like(fake_output), fake_output))
    return real_loss + fake_loss

# Training step
@tf.function
def train_step(input_image, target, generator, discriminator, gen_optimizer, disc_optimizer):
    with tf.GradientTape() as gen_tape, tf.GradientTape() as disc_tape:
        gen_output = generator(input_image, training=True)
        disc_real_output = discriminator([input_image, target], training=True)
        disc_fake_output = discriminator([input_image, gen_output], training=True)
        gen_loss = generator_loss(disc_fake_output, gen_output, target)
        disc_loss = discriminator_loss(disc_real_output, disc_fake_output)
    gen_grads = gen_tape.gradient(gen_loss, generator.trainable_variables)
    disc_grads = disc_tape.gradient(disc_loss, discriminator.trainable_variables)
    gen_optimizer.apply_gradients(zip(gen_grads, generator.trainable_variables))
    disc_optimizer.apply_gradients(zip(disc_grads, discriminator.trainable_variables))
    return gen_loss, disc_loss

# Evaluation function
def evaluate_images(target, generated):
    target = (target + 1) * 127.5
    generated = (generated + 1) * 127.5
    target = np.clip(target, 0, 255).astype(np.uint8)
    generated = np.clip(generated, 0, 255).astype(np.uint8)
    psnr_value = psnr(target, generated, data_range=255)
    ssim_value = ssim(target, generated, channel_axis=2, data_range=255)
    lpips_model = lpips.LPIPS(net='alex')
    target_tensor = torch.from_numpy(target).permute(2, 0, 1).float() / 255.0
    generated_tensor = torch.from_numpy(generated).permute(2, 0, 1).float() / 255.0
    target_tensor = target_tensor.unsqueeze(0) * 2 - 1
    generated_tensor = generated_tensor.unsqueeze(0) * 2 - 1
    lpips_value = lpips_model(target_tensor, generated_tensor).item()
    return psnr_value, ssim_value, lpips_value

# Load the LOL dataset
def load_lol_dataset(dataset_path='/content/lol_dataset'):
    train_low_dir = os.path.join(dataset_path, 'our485/low')
    train_high_dir = os.path.join(dataset_path, 'our485/high')
    test_low_dir = os.path.join(dataset_path, 'eval15/low')
    test_high_dir = os.path.join(dataset_path, 'eval15/high')

    train_low_files = sorted(glob.glob(os.path.join(train_low_dir, '*.png')))
    train_high_files = sorted(glob.glob(os.path.join(train_high_dir, '*.png')))
    test_low_files = sorted(glob.glob(os.path.join(test_low_dir, '*.png')))
    test_high_files = sorted(glob.glob(os.path.join(test_high_dir, '*.png')))

    # Load training data
    train_inputs, train_targets = [], []
    for low_file, high_file in zip(train_low_files, train_high_files):
        low_img, high_img = load_image_pair(low_file, high_file)
        train_inputs.append(low_img)
        train_targets.append(high_img)

    # Load test data
    test_inputs, test_targets = [], []
    for low_file, high_file in zip(test_low_files, test_high_files):
        low_img, high_img = load_image_pair(low_file, high_file)
        test_inputs.append(low_img)
        test_targets.append(high_img)

    return (np.array(train_inputs), np.array(train_targets)), (np.array(test_inputs), np.array(test_targets))

# Main script
dataset_path = '/content/lol_dataset'
(train_inputs, train_targets), (test_inputs, test_targets) = load_lol_dataset(dataset_path)

# Build Pix2Pix models
generator = build_pix2pix_generator()
discriminator = build_pix2pix_discriminator()

# Optimizers
gen_optimizer = tf.keras.optimizers.Adam(2e-4, beta_1=0.5)
disc_optimizer = tf.keras.optimizers.Adam(2e-4, beta_1=0.5)

# Training loop
epochs = 40  # Adjust based on your needs
```

```
epochs = 40  # Adjust based on your needs
batch_size = 1  # Small batch size due to limited data
for epoch in range(epochs):
    for i in range(0, len(train_inputs), batch_size):
        batch_inputs = train_inputs[i:i+batch_size]
        batch_targets = train_targets[i:i+batch_size]
        gen_loss, disc_loss = train_step(batch_inputs, batch_targets, generator, discriminator, gen_optimizer, disc_optimizer)
    if (epoch + 1) % 10 == 0:
        print(f"Epoch {epoch + 1}, Gen Loss: {gen_loss:.4f}, Disc Loss: {disc_loss:.4f}")

# Evaluate on test set and apply lighting effects
conditions = ['d75','d65', 'night_light']
lighting_params = [
    (7500, 1.2, 1.0),   # D75: Cooler, brighter
    (6500, 0.5, 1.0),   # D65: Neutral, dusk-like
    (4100, 0.3, 1.1),   # Night light: Dim, moonlight
]
results = {'PSNR': [], 'SSIM': [], 'LPIPS': []}

# Create output directory
os.makedirs('output', exist_ok=True)

for i in range(min(5, len(test_inputs))):  # Evaluate on first 5 test images
    input_img = tf.expand_dims(test_inputs[i], 0)
    target_img = test_targets[i]

    # Enhance low-light image to normal light
    enhanced_img = generator(input_img, training=False)[0].numpy()

    # Apply lighting effects
    for condition, (temp, brightness, blue_boost) in zip(conditions, lighting_params):
        gen_output = apply_lighting_effect(enhanced_img, temp, brightness, blue_boost)

        # Save the generated image
        gen_img = (gen_output + 1) * 127.5
        gen_img = np.clip(gen_img, 0, 255).astype(np.uint8)
        Image.fromarray(gen_img).save(f'output/test_{i}_{condition}.jpg')

        # Evaluate against the original normal-light image (target)
        psnr_value, ssim_value, lpips_value = evaluate_images(target_img, gen_output)
        results['PSNR'].append(psnr_value)
        results['SSIM'].append(ssim_value)
        results['LPIPS'].append(lpips_value)
        print(f"\nEvaluation for test image {i}, condition {condition}:")
        print(f"PSNR: {psnr_value:.2f} dB")
        print(f"SSIM: {ssim_value:.4f}")
        print(f"LPIPS: {lpips_value:.4f}")

# Print average metrics
print("\nAverage Metrics Across All Test Images and Conditions:")
print(f"Average PSNR: {np.mean(results['PSNR']):.2f} dB")
print(f"Average SSIM: {np.mean(results['SSIM']):.4f}")
print(f"Average LPIPS: {np.mean(results['LPIPS']):.4f}")

print("\nGenerated images saved in 'output' directory.")
```

```
Epoch 10, Gen Loss: 48.6804, Disc Loss: 0.1612
Epoch 20, Gen Loss: 34.7851, Disc Loss: 0.2524
Epoch 30, Gen Loss: 18.1717, Disc Loss: 0.7155
```