TECHNISCHE UNIVERSITAT BERLIN

Fakultät IV – Elektrotechnik und Informatik
Fachgebiet INET
Prof. Dr. Stefan Schmid
Naveed Khan, Max Franke

2nd Assignment: 20 Points Multimedia and Wireless Lab [SoSe 2025]

For the following tasks, you need Python, Matplotlib1 , and the Open Source Computer Vision Library (openCV)2 . We also advise you to use numpy3 , scipy4 , and Image (from PIL)5.

Download the two images lena.png and northcap.png from **https://isis.tu-berlin.de/course/view.php?id=37820**

Question 1: (5 Points) Image analysis

(a) Transform the Lena image to the RGB color space, plot the single components (R,G,B), and plot the distributions of the component's intensities.
(b) Compute the entropy of R,G, and B component, for the North Cap and the Lena image! What can you see?
(c) Transform the Lena and North Cap images to the YCbCr color space and plot the single components as well as the distribution of their intensities!
(d) Compute the entropy of the Y, Cb, and Cr-component of both images. Compare the results to those obtained in (d), what can you see?
(e) What is the difference between subsampling and a mean filter?
(f) Perform subsampling (4:4:4 → 4:2:2/4:2:0) on the Cb and Cr components of Lena. Compute the entropies of YUV 4:4:4, 4:2:2, and 4:2:0. Afterwards, subjectively rate the quality of the resulting images.

Question 2: (5 Points) Image and frequency space Load the Lena image and transform it to the YUV space. For the following tasks, only consider the Y component.
(a) Transorm the image using numpy.fft2 and plot the absolute value of the transformed Y-channel. What can you see? What happens when you additionally use fftshift?
(b) Implement a mean filter and perform a convolution with the image. Vary the filter size (n = 3, 4, 5, ..). At which values of n can you recognize differences in the resulting image?
(c) Add a Gaussian noise to the image. Consider 1) $\mu = 0$, $\sigma = 10$ and 2) $\mu = 0$, $\sigma = 50$. Transform the image to the frequency domain. How do you recognize the noise?

Question 3: (5 Points) JPEG Compression and PSNR

(a) Write your own function to compute the Peak Signal to Noise Ratio (PSNR) to measure the distortion of a compressed image (you only need to consider the images' Y-channels for this function). You can find the definition of PSNR at the end of this document.

(b) Take the Lena and Northcap image and save them as JPEG using the save function from PIL Image. Repeat this with different values for the quality flag, i.e. quality = {10, 20, 30, 40, 50, 60, 70, 80, 90, 100}. Visualize the resulting file size and PSNR values!
(c) Use the smartphone of one of your team members and take a picture. Send the image via a messenger of your choice (WhatsApp, Telegram, etc.) to another team member. What can you observe when comparing the original image to the one received by your colleague?
(d) Plot a part of the original and received picture, so that the difference is made visible.
(e) You are a software developer working on a messenger app and responsible for implementing the compression. Which aspects would you consider when deciding about the way images and videos are compressed?

Comments

$$PSNR = 10 * log_{10} \frac{R^2}{MSE}$$

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M * N}$$

R denotes the maximum value, i.e. 255 when pixels are represented using 8 bits per sample

Question 4: (5 Points) Simulating Image Transmission over a Network: Effects of Compression and Noise on Image Quality

You are tasked with simulating the transmission of a digital image over a network. Your goal is to observe and analyze how network operations—such as compression and the introduction of noise—affect the quality of the transmitted image.

Specifically, you will:

- Write a sender script that transmits an image (e.g., Lenna.png) over a network socket, optionally applying compression or noise to simulate real-world network effects.
- Write a receiver script that receives and saves the transmitted image.
- Use an analysis script to compare the original and received images, both visually and quantitatively, using metrics such as Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), and Structural Similarity Index (SSIM).
- Visualize the original and received images side by side, and interpret the results of your analysis.

Your report should include:

- A brief description of your approach and any parameters you chose (e.g., compression level, noise).
- The computed values for MSE, PSNR, and SSIM.
- Visualizations of the original and received images.
- A discussion of the observed differences and what they reveal about the impact of network operations on image quality.

Due Date: Monday, May 26, 2025, 10:00 am

Upload all relevant files (answers to theoretical questions as either PDF/JPGE or .txt/DOC plus Python/Matlab code, etc.) to ISIS:
https://isis.tu-berlin.de/course/view.php?id=37820
Put the names and Student ID numbers (Matrikelnummer) of **all** your group members on your solution!