Middle East Technical University Department of Computer Engineering

CENG 466

Fundamentals of Image Processing

Fall '2024-2025

Take Home Exam 1

Due date: November 4, 2024, Monday , 17:00

1 Objectives

The purpose of this assignment is to familiarize you with the mathematical tools for image processing techniques. You are required to develop your own algorithm based on the techniques you learned in the lectures.

2 Specifications

You should solve the given task with your own algorithms. In addition to the solutions, you are required to prepare a report that explains your methodology and includes the analysis of the results and your comments on them. The report should be **3-5 pages** long and should be prepared in IEEE Conferance Proceedings Template (LaTeXis recommended) provided in the following link.

`https://www.ieee.org/conferences_events/conferences/publishing/templates.html`

- Grading will be based on the quality of the outputs, script contents and the report
- The report should clearly explain the methodology and rationale behind the algorithm design. It should also explain the difficulties encountered in the design, implementation and experimentation stages, and your solutions on them. Last but not least, the report should contain your comments on the results. Even if the results does not match your expectations you should discuss the encountered situation.

2.1 Question 1 - Image Interpolation - 33 Points

In this question you are given two images that are downsampled and rotated (See Figure 1). Your task is rotate them back to their original shape and upsample them using either bilinear or bicubic interpolation. You should also implement mean squared error distance between any two images in order to analyse the interpolation algorithms. In order to complete given tasks, follow the steps below;

- Explain the concept of interpolation in general. Explain 'bilinear' and 'bicubic' interpolation in detail. Explanations should be your own work, otherwise you may lose points. Provide proper references, AVOID PLAGIARISM!
- Write a function *rotate_upsample(img, scale, degree, interpolation_type)* with following inputs:

- img: Image to be rotated and upsampled
- scale: Upsampling scale. e.g. if current width and height is 64x64, and scale is 4, width and height of the output should be 256x256
- degree: Shows the degree of rotation. e.g. if degree = 30, that means the original image was rotated 30 degrees counterclockwise.
- interpolation_type: Type of interpolation. Either 'linear' or 'cubic'

This function should rotate and resize the given image.

- Comparison between bilinear and bicubic interpolation may not be obvious to the human eye. We provide original images for comparison. Write a function *compute_distance(img1, img2)* that computes the mean squared error distance between the original image and the images you generated.
- Comment on your findings. Based on your results compare bilinear and bicubic interpolation. Discuss whether any of the interpolation algorithms are superior to the other. Justify your reasoning based on your knowledge from the lectures and your findings from the previous step.
- Is mean squared error a good distance measure in this case. Discuss what other measures can we use.

(a) Downscaled by factor 4 and rotated by degree 30

(b) Downscaled by factor 8 and rotated by degree 45

Figure 1: Sample images for q1

2.2 Question 2 - Object Recognition - 33 Points

If you are given an image database where the objects have a similar color, you can classify any other image by color histograms. In order to give an example, we produced a sample scenario. In this question, you are given a pair of desert or forest images which will act as your database (see Figures 2c,2d,2e,2f). For another set of images (see Figure 2a, 2b), you will compare their histograms with the ones from the database and classify the images as desert or forest images.

In order to complete this task follow the steps below:

- Write a function *desert_or_forest(img1, img2)* that takes an image and also loads the images from the database. Convert all of the images to the HSI color space
- Since deserts and forest will have different hues, using only the hue channel will be sufficient. Compute histograms of the hue channels.
- Compute KL Divergences between the given images, and the images from the database. Based on these distances you can classify the given images as desert or forest.

- The given images are relatively easy. Discuss different scenarios where we can or cannot use this solution to classify images. **Hint:** Analyse the different channels in HSI and RGB channels. Can we differentiate all of the colors or objects easily?

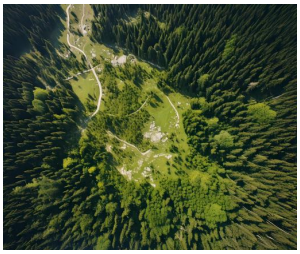
(a) q2 a1

(b) q2 a2

(c) Database image 1

(d) Database image 2

(e) Database image 3



(f) Database image 4

Figure 2: Sample images for q2

2.3 Question 3 - Image Subtraction - 34 Points

In this task, you are given two pairs of images of the same scene where an object is removed from the scene in one of the images. One pair is grayscale and the second is in RGB. (See Figure 3). Your task is to mask this missing object. In order to complete this task follow the steps below:

- Explain image subtraction. Provide proper references, AVOID PLAGIARISM!
- Write a function *difference_images(img1, img2)* that masks out the difference between two images. Note that in the given images, an object will be absent in the first image, and it will exist in the second image. Subtract these two images and find a mask that will show the location of the object. Apply this mask to image 2.

  Hint: You can create a mask with the same size as the images that will have 1 where the object exists, and 0 otherwise, and multiply this mask with image2.

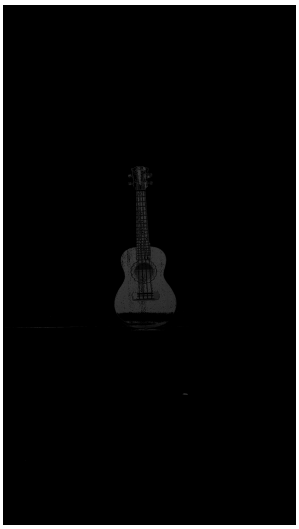
  Hint 2: There can be several differences between two images due to camera positioning and lighting conditions. You can use histogram thresholding to remove these small differences. For the RGB image try analysing different channels in different color spaces. (You can write a different function to solve RGB image pair.)
- Discuss your findings.

3 Regulations

1. **Group:** You are required to do your assignment in a group of two students. If there is an unclear part in your code, we may ask any of the group member to describe that code segment. Also group

(a) q3 a1

(b) q3 a2



(c) Expected output

(d) q3 b1

(e) q3 b2

Figure 3: Sample images for q3

members may get **different** grades. We reserve the right to evaluate some or all of the groups to determine the contribution of each group member to the assignment.

2. **Programming Language:** You must code your program in Python. Your submission will be tested on department lab machines. You are expected make sure your code runs successfully on department lab machines.

3. **Late Submission:** Late Submission is **not** allowed!

4. **Newsgroup:** You must follow the odtuclass for discussions and possible updates on a daily basis.

4 Submission

Submission will be done via odtuclass. Create a tar.gz file named THEX.tar.gz that contains all your source code files and the report as a PDF file. Do not send the input and output images. Only one member should submit the homework. Hence, do not forget to **write your names and student id's at the beginning of the scripts.**

5 Cheating

We have zero tolerance policy for cheating. People involved in cheating will be punished according to the university regulations.

Cheating Policy: Students/Groups may discuss the concepts among themselves or with the instructor or the asistants. However, when it comes to doing the actual work, it must be done by the student/group alone. As soon as you start to write your solution or type it, you should work alone. In other words, if you are copying text directly from someone else - whether copying files or typing from someone else's nots or typing while they dictate - then you are cheating (committing plagiarism, to be more exact). This is true regardless of whether the source is a classmate, a former student, a website, a program listing found in the thrash, or whatever. Furthermore, plagiarism even on a small part of the program is cheating. Also, starting out with code that you did not write, and modifying it to look like your own is cheating. Aiding someone else's cheating also constitutes cheating. Leaving your program in plain sight or leaving your computer without logging out, thereby leaving your programs open to copying, may constitute cheating depending upon the circumstances. Consequently, you should always take care to prevent others from copying your programs, as it certainly leaves you open to accusations of cheating. We have automated tools to determine cheating. Both parties involved in cheating will be subject to disciplinary action. [Adapted from http://www.seas.upenn.edu/cis330/main.html]