AI61201: Visual Computing with AI/ML

Programming Assignment 4: Frequency Domain Image Analysis and Filtering (20 Marks)

Due Date: *October 4 (by 9 PM IST)*

Instructions: *Complete the five tasks given, keeping the following point in mind:*

- *Vectorized implementations are possible for most operations, and using for or while loops to access individual pixels is strongly discouraged due to its inefficiency. You can use NumPy to perform the mathematical operations.*
- *A single function for DFT and a single function for IDFT may be implemented from scratch and called for performing the corresponding operations wherever required.*

Task 1 (7 Marks)

Perform Gaussian bandpass filtering in frequency domain by cascading Gaussian high and low pass filters (take cutoff frequency for high pass filter as 100.0 and that for low pass filter as 120.0 and take standard deviation for both high pass filter and low pass filter accordingly as taught in class). Perform DFT/IDFT from scratch and verify using OpenCV's implementation of DFT/IDFT for this question. Use a_3_task_1_input.png as input.

Task 2 (7 Marks)

Perform the DFT on 2 images Im1 and Im2 of equal sizes. Use a_3_task_2_im1.png and a_3_task_2_im2.png as inputs Im1 and Im2 respectively. Then reconstruct the image Im1 by performing IDFT as follows:

- Im1_ver1: obtained by performing IDFT on the DFT formed by replacing the DFT magnitude of Im1 with the DFT magnitude of Im2
- Im1_ver2: obtained by performing IDFT on the DFT formed by replacing the DFT phase of Im1 with the DFT phase of Im2

Which one of these two reconstructed versions are closer to the original image Im1 and why?

Task 3 (6 Marks)

- (Aliasing in the frequency domain) - perform DFT on an image and show its magnitude spectrum. Now, subsample the image by setting every alternate pixel

to 0 along both horizontal and vertical directions, and show the magnitude spectrum of the resulting subsampled image. What difference do you observe in the two magnitude spectra? Please explain your observation. Use a_3_task_3_input_a.png as input. (3 marks)

- (Aliasing in the spatial domain) - perform DFT on an image. Now subsample the DFT along the horizontal axis by setting every 3rd DFT coefficient to 0 along this axis. Then perform IDFT using the subsampled DFT. What effect do you observe on the spatial signal? Can you explain this effect? Use a_3_task_3_input_b.png as input. (3 marks)

(In this question, it is fine to use cv2.dft and cv2.idft directly)

Link to download the inputs for all tasks

https://drive.google.com/file/d/1xGG4abVXdNJiYG-lJdPabQ6LZ0LkY-3H/view?usp=sharing

Submission Guidelines

1. *The content that you submit must be your individual work.*
2. *Submit your code in .py as well as in .ipynb file format. Both these file submissions are required to receive credit for this assignment.*
3. *Ensure your code is well-commented and easy to follow. You can write your answers and explanations using text cells in the jupyter notebook files wherever required. For example, in Task 4, you need to state which bit plane you have chosen to replace, along with proper justification for your choice.*
4. *The files should be named as "<roll_number>_assignment_3". For example, if your roll number is 23AI91R01, the code file names will be 23AI91R01_assignment_3.py and 23AI91R01_assignment_3.ipynb. You should place all these files within a single zip file and upload it to Moodle as 23AI91R01_assignment_3.zip.*
5. *All submissions must be made through Moodle before the deadline. The submission portal will close at the specified time, and submissions via email would not be accepted.*

TA for this assignment: Raj Krishan Ghosh

If you have any queries regarding Assignment 3, please email at rajkrishanghosh@gmail.com