Course Title: Digital Image Processing

An Institute Elective for CSE

L-T-P-C: 3-1-0-4

Prerequisite: Signals and systems, linear algebra, probability and statistics, computer programming.

1. Outline: Digital image processing is a type of signal processing that is used to overcome the shortcomings of analog image processing. It has many applications in the medical field, agriculture, manufacturing industry, banking system, retail shop, remote sensing, machine/robot vision. This subject will help to enhance the knowledge of the students who further want to take the courses like pattern recognition, computer vision, and machine learning.

2. Course Objectives: The main three objectives of this course are as follows:

- **i)** Develop an overview of digital image processing
- **ii)** Learn techniques commonly used in image processing
- **iii)** Acquire knowledge on image processing research literature.
- **iv)** Gain experience in applying image processing algorithms to real problems.

3. Course Syllabus: This course can be divided in the following modules:

1. Introduction to digital image processing, elements of visual perception, image sensing and acquisition, image sampling and quantization, relationship between pixels; image enhancement in spatial domain: gray level transformations, histogram processing, spatial filters.

2. Image enhancement in frequency domain: 1-D Fourier transform and its inverse, 2-D discrete Fourier transform, discrete cosine transform, low pass filters, high pass filters, homomorphic filtering.

3. Image restoration: noise models, spatial domain filtering, frequency domain filtering, estimating degradation function, inverse filtering, Wiener filtering; color image processing: color models, color transformations, smoothing and sharpening, color segmentation; multiresolution processing: image pyramids, subband coding, Haar transform, Wavelet functions, 1-D and 2-D Wavelet transform, fast Wavelet transform;

4. Image compression: error free compression such as variable length coding, LZW, bit-plane coding, lossless predictive coding, Lossy compression such as Lossy predictive coding, transform coding, Wavelet coding, image compression standards, video compression standards.

5. Morphological image processing: Dilation, erosion, opening, closing, Hit-or-Miss transformation, basic morphological algorithms, image segmentation: point, line and edge segmentation, edge linking and boundary detection, segmentation using thresholding, region based segmentation, segmentation by morphological watersheds, use of motion in segmentation; feature extraction: boundary descriptors, regional descriptors, relational descriptors.

4. Books:

Text Book: R. C. Gonzalez and R. E. Woods, ***Digital Image processing***, Prentice Hall, 4th edition, 2018.

Reference Books:

1. A. K. Jain, ***Fundamentals of Digital Image Processing***, Prentice Hall, 1995.
2. R. C. Gonzalez and R. E. Woods, ***Digital Image Processing with MATLAB***, Prentice Hall, 2003.

5. Pre-Requisites: The following skills are necessary for this course.

Signals and Systems: The students should have basic concepts for both continuous-time and discrete-time signals and systems. They should know the signal and system representations for both time and frequency domains as well as Fourier transform and its generalizations.

Linear Algebra: The student must know the following linear algebra topics: matrices, matrix operations, determinants, system of linear equations, Eigen values, Eigen vectors.

Probability and Statistics: The students should have knowledge of probability density function, probability distribution, mean, variance, co-variance, correlation, priors, posteriors, likelihoods and Gaussian distribution.

Computer Programming: The students should also have programming skills to complete assignments and projects. It would help the students to solve real world problems. Matlab, Python or C/C++ could be considered for implementing the algorithms.

6. Grading Policy: The grade of the students would be decided based on the written examinations, assignments and project. Assignments and project include the programming part as well as a short report describing the approach, detailed analysis, and discussion/conclusion.

10% Mid-Exam-1
10% Mid-Exam-2
20% End-Exam
30% Programming Assignments
30% Term Project

7. Industry Impact: Many companies are working in the different applications of digital image processing as a part of Computer vision problem. Most of the applications belong to healthcare, retail shop, manufacturing industry, agriculture, defense and many more.

8. List of Companies Working On Related Topics: The following companies are working on the related topics: Google, NVIDIA, BARCO, Honeywell, GE Global Research.

9. Resources:

I. Course Title: Digital Image Processing (ECE 439)
Faculty Member: Dr. Scott E Umbaugh
Website: https://www.siue.edu/~sumbaug/439_syl.html

II. Course Title: Digital Image Processing (EE368)
Faculty Member: Prof. **Bernd Girod**
Website: https://web.stanford.edu/class/ee368/information.html

III. Course Title: Digital Image Processing (EE637)
Faculty Member: **Prof. Charles A. Bouman**
Website: https://engineering.purdue.edu/~bouman/ece637/

IV. Course Title: Digital Image Processing (EE468/568)
Faculty Member: Prof. Sinisa Todorovic
Website:
http://web.engr.oregonstate.edu/~sinisa/courses/OSU/ECE468/ECE468Slides.html

V. Course Title: Digital Image Processing (CS 589-04)

Faculty Member: Frank Liu
Website: https://www.cs.nmt.edu/~ip/index.html

10. Course Ethics: Please note down the following activities leading to a fair academic honesty:

- All class work is to be done independently.
- It is best to try to solve problems on your own, since problem solving is an important component of the course, and exam problems are often based on the outcome of the assignment problems.
- You are allowed to discuss class material, assignment problems, and general solution strategies with your classmates. But, when it comes to formulating or writing solutions you must work alone.
- You may use free and publicly available sources, such as books, journal and conference publications, and web pages, as research material for your answers. (You will not lose marks for using external sources.)
- You may not use any paid service and you must clearly and explicitly cite all outside sources and materials that you made use of.
- I consider the use of uncited external sources as portraying someone else's work as your own, and as such it is a violation of the University's policies on academic dishonesty.
- Instances will be dealt with harshly and typically result in a failing course grade.

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