Digital Image Processing

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Version: γ.1.000

MCI

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Lecture Structure

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Lecture Structure

- The goal of this lecture is to give you the fundamentals of digital image processing and understanding of mathematical principles.
- This lecture is a total of 4 SWS with a total of sixty (60) hours.
- There are two (2) assignments for this course

  $\mathbf{1}^{\mathbf{st}}$ will be a pre-defined work which is individual based.

  $\mathbf{2}^{\mathbf{nd}}$ will be group based.

> You are to come up with a project that uses DIP using Python.

- You will work with a group of up to three (3) or two (2).
- You are to come up with a group and decide on your topic.

Lecture Structure

- The individual assignment focuses on understanding DIP principles.
- The assignment is uploaded to SAKAI for you to work on along with what is required of you for submission.
  - The assignment contains questions where applications of DIP will be needed.
- The deadline is the end day of **last lecture before presentations**.

A Help in Colour

Due to the nature of the topic, some aspects are to be presented in a colour spectrum some student may not be able to perceive. In situations like this, please let me know if there are some diagrams or some colour choices making the lecture illegible via mail and I will send you a colour correct version based on the condition.

Lecture Structure

- For your project use Python.
- Some possible project ideas:
  - License plate detection,
  - Handwriting detection,
  - Signature verification,
  - Face detection,
  - Image to text conversion,
  - Barcode detection,
  - Convert sudoku drawings to computer code.
  - Book detection.

> The use of AI/ML is allowed as long as clear explanation is given and its process is understood.

Lecture Structure

- The last three (3) appointments are reserved for group presentations.
- You will do a presentation in front of the class for 20 mins.
- The next 20 mins following your presentation will be the Q&A.
- The Q&A will involve two (2) questions from your relevant work.
- You are also to submit a report with your project detailing the work.

> Each student needs to declare the part the student worked on.

- i.e., Student A has done the writing, edge detection
- i.e., Student B has done the data analysis, figure generation.
- You are to submit your reports and all relevant resources to SAKAI no later than 2 weeks before your assigned presentation.

Lecture Structure

Assessment Type	Overall Points	Breakdown	%
Homework	40		
		Report	20
		Solution(s)	60
		Code Analysis	20
Group Project	60		
		Report	40
		Presentation	40
		Q & A	20

Table 1: Assessment Grade breakdown for the lecture.

Lecture Structure

Covered Topic	Appointment
Mathematical Fundamentals	1
Perception	2
Camera	2-3
Display	4
Noise	4-5
Histogram Operations	6
Morphological Operations	7
Blurring Filters	8
Feature Analysis	9
Edge Detection	10
Neural Networks for Image Processing	11-12
Group Assignment Presentations	13-15

Table 2: Distribution of materials across the semester.

Lecture Structure

Mathematical Fundamentals

- 2D Convolution,
- Discrete Fourier Transform,
- Sampling Theorem

Lecture Structure

Perception

- Colour Blindness,
- Colour Standards,
- Colour Models

Lecture Structure

Cameras

- Used sensors,
- Lenses,
- Sensitivity

Lecture Structure

Displays

- Dithering,
- Interlacing,
- Display Technologies

Lecture Structure

Noise

- Types of noises,
- Modelling Noises,
- Random Noise generation

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Histogram Operations

- Colour Channels,
- Masking,
- Dynamic Range

Morphological Operations

- Opening,
- Closing,
- Erosion,
- Dilation.

Lecture Structure

Blurring Filters

- Gaussian Blurring,
- Multivariate Distribution,
- Bilinear Filtering

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Feature Analysis

- ORB Feature Extractor,
- Adaptive Threshold,
- Scale Invariant Feature Transform.

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Egde Detection

- Defining an Edge to the computer,
- Types of Kernels,
- Canny Edge Detection.

Lecture Structure

Neural Networks for Image Processing

- Defining ANNs,
- OCR,
- ResNet.

Lecture Structure

Books

- Forsyth, Ponce "*Computer Vision: A Modern Approach*" Prentice-Hall, 2003.
- Young I. "*Fundamentals of Image Processing*" Delft 1998.
- Szeliski R. "*Computer Vision: Algorithms and Applications*" Springer 2022.
- Nixon M. et. al "*Feature Extraction and Image Processing for Computer Vision*" Academic press 2019.
- Gonzalez R. "*Digital Image Processing*" Pearson 2009

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White Papers

- Luminera "*Getting it Right: Selecting a Lens for a Vision System*",
- Luminera "*The Complete Guide to Industrial Camera Lenses*",
- Fowler B, et. al, *Read Noise Distribution Modeling for CMOS Image Sensors*.
- Oxford Instruments *Understanding Read Noise in sCMOS Cameras*.

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Lecture Notes

- Applied Multi-variable Statistical Analysis "*Lesson 4: Multivariate Normal Distribution*",
- Statistical Theory and Methods I "*Chapter 3: Multivariate Distributions*", Stephen M. Stigler
- The Discrete Fourier Transform "*Signal Processing & Filter Design*", Stephen Roberts.
- Procedural Generation: 2D Perlin Noise *Game Programming*, Mount .E, Eastman R.
- Foundations of computer vision: Lecture notes, Carreira-Perpinan M.
- Computer Vision, CMU School of Computer Science
- Computer Vision, University of Cambridge
- Computer Vision, NYU Computer Science

Web Resources

- Scikit-image documentation
- OpenCV documentation
- Pillow (fork of PIL) documentation