

# **MATH4336 Introduction to Mathematics of Image Processing**

## **Course Outline – Fall 2023**

### **1. INSTRUCTOR**

Dr. Shingyu Leung

**Email:** masyleung @ ust.hk

**Office:** 3431

**Office hours:** By appointment

### **2. TA**

**Email:**

### **3. MEETING TIME AND VENUE**

Mon/Wed/Fri 9:30am-10:20am

### **4. COURSE DESCRIPTION**

Credits: 3

Prerequisites: MATH2011/2021/2023 and 2111/2121/2131 and 2351/2352, or MATH2011/2021/2023 and 2350.

Exclusions: COMP4221 and ELEC4130.

This course introduces digital image processing principles and concepts, tools, and techniques with emphasis on their mathematical foundations. Key topics include image representation, image geometry, image transforms, image enhancement, restoration and segmentation, descriptors, and morphology. The course also discusses the implementation of these algorithms using image-processing software.

### **5. INTENDED LEARNING OUTCOMES**

Upon successful completion of this course, students should be able to

| No. | ILOs  |
|-----|---|
| 1   | Be equipped with theoretical knowledge, principles and techniques to image processing problems. |
| 2   | Acquire a good appreciation of roles of mathematics in image processing.                        |
| 3   | Be able to implement image-processing algorithms on computers.                                  |
| 4   | Be able to apply computer algorithms to real-life problems.                                     |
| 5   | Be able to present numerical output from a computer code in a systematical way.                 |

### **6. ASSESSMENT SCHEME**

a. Final examination duration: 2 hours

b. Percentage of coursework, examination, etc.:

| Assessment | Assessing Course ILOs |
|------------|-----------------------|
| Homework   | 1, 2, 3, 5            |
| Midterm    | 1, 4                  |

|       |      |
|-------|------|
| Final | 1, 4 |
|-------|------|

Final exam is comprehensive, i.e. all materials taught in the whole semester will be tested, including those already tested in the midterm exam. But focus will be on those topics not covered in the midterm.

More information will be given in the lecture prior to the exams. No make-up exams.

### Grading

*Scheme A*: 30% HW + 30% Midterm + 40% Final

*Scheme B*: 30% HW + 0% Midterm + 70% Final

Final grade = max (*Scheme A*, *Scheme B*)

## 7. STUDENT LEARNING RESOURCES

Lecture notes

Optional:

- Digital Image Processing – Gonzalez, Woods
- Image Processing and Analysis: Variational, PDE, Wavelet, and Stochastic Methods – Chan, Shen

## 8. TEACHING AND LEARNING ACTIVITIES

Scheduled activities: 3 hours (lecture)

## 9. COURSE SCHEDULE

### Introduction to digital image processing

- Origins and fundamental steps in digital image processing
- Introduction to MATLAB

### Image as Matrix

- Tools: Linear Algebra. Singular value decomposition. Compressed sensing.
- Applications: Histogram processing for image enhancement. Filtering for image enhancement and restoration. Linear signal/image compression. Image segmentation. Image inpainting. Compressed sensing.
- Topics: Image sampling and quantization

### Image in the Frequency Space

- Tools: Fourier transform. FFT.
- Applications: Image enhancement.
- Topics: Fourier series. Fourier transform. (\*) Distribution theory.

### Image as Function

- Tools: Calculus of variation. Partial differential equations.
- Applications: Image restoration. Image segmentation.
- Topics: Linear diffusion. Nonlinear diffusion (Perona-Malik, Rudin-Osher-Fatemi). Snake model for segmentation. (\*) Geodesic active contour. (\*) Chan-Vese mode.

## ACADEMIC HONESTY

You should browse the university website <http://www.ust.hk/vpaa/integrity/> to understand the rules concerning academic honesty.

### **LEARNING ENVIRONMENT**

In classes (lectures and tutorials), we should respect each other. Please arrive on time and avoid leaving early. You may ask questions by raising your hand. Please do not cause rude disturbances. In particular, your mobile phones should be off while you are in class. You are highly encouraged to come to office hours for consultation. This is a difficult course for many, but not all students. Although there are lecture notes, students should attend all lectures and tutorials as lecture notes are only brief records of materials covered in class, which may contain typographical errors. Of course, questions from students and answers from instructors or other digressions will not be recorded. You are advised to take your own notes.

All materials presented in lectures and tutorials as well as proper class conduct are your responsibility. The instructor reserves the right to make any changes to the course throughout the semester. To succeed in this course, you should actively engage in learning and do the assigned works with your own effort.