

MA3113: Topics in Mathematical Image Processing I

Syllabus and Introduction



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Syllabus

- **Instructors:** Profs. Ching-Hsiao Cheng/Suh-Yuh Yang
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Phone: 03-4227151 extension 65111/65130
- **Office hours:** Tuesday 10:00 ~ 12:00 am or by appointment.
- **Teaching assistant:** 廖育暄 (yuhuan2023@g.ncu.edu.tw)
- **Prerequisites:** MA3111 and some knowledge of MATLAB:
<https://portal.ncu.edu.tw/>
校園授權軟體服務網裡面有關於Matlab的下載方式說明！
- **Grading policy:** *oral presentations (20%) × 3, a poster of project results (30%), and others (10%).*

Course objective

This is a companion course of the “MA3111: Mathematical Image Processing.”

- (1) We will continue to introduce advanced mathematical techniques for image processing based on partial differential equations and variational methods.
- (2) This course emphasizes practical implementation and computer simulations.
- (3) In addition, every student must complete a research project on image processing and make several presentations.

References

No textbook, but we will provide some slides and journal papers.
Below are some references:

- (1) [AK2002] G. Aubert and P. Kornprobst, *Mathematical Problems in Image Processing: Partial Differential Equations and the Calculus of Variations, Second Edition*, Springer Verlag, New York, 2002.
- (2) [CS2005] T. F. Chan and J. Shen, *Image Processing and Analysis: Variational, PDE, Wavelet, and Stochastic Methods*, Society for Industrial and Applied Mathematics, Philadelphia, 2005.
- (3) [TUM2019] D. Cremers, *Computer Vision I: Variational Methods, Online Resources*, Departments of Informatics & Mathematics, Technical University of Munich, Germany, 2019/2020.
<https://vision.in.tum.de/teaching/online/cvwm>
- (4) [GW2018] R. C. Gonzalez and R. E. Woods, *Digital Image Processing, Fourth Edition*, Pearson Education Limited, New York, 2018.

Important dates

- The period for adding and dropping: February 12-26, 2025
- The period for withdrawing: March 31-May 09, 2025
- Spring break: **April 02 (Wed), 2025, recess, no class!**
- First oral presentation: March 18-19, 2025 (5th week)
- Second oral presentation: May 6-7, 2025 (12th week)
- Third oral presentation: June 10-11, 2025 (17th week)
- The poster of project results: June 18, 2025 (18th week)

This course will cover the following topics

- (1) Advanced topics in variational methods for image processing.
- (2) Sparse representation and dictionary learning with applications to image processing.
- (3) Basics of wavelet analysis and applications in image processing.

Below, we glance at some topics we have learned (or not yet) in
“MA3111: Mathematical Image Processing.”

Image denoising



original



noisy



ROF model



adaptive

Image deblurring



original



blurry



blurry & noisy



deblurring

Image fusion



source1



source2

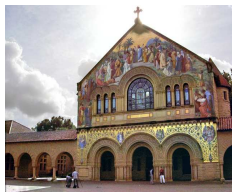


LSDGF1



LSDGF2

Image contrast enhancement



low-light images

contrast enhanced

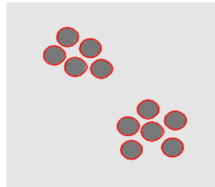
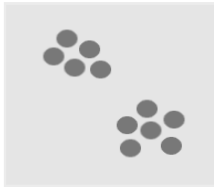
Image inpainting



corrupted

inpainted

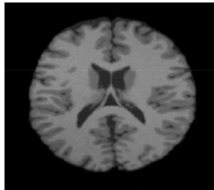
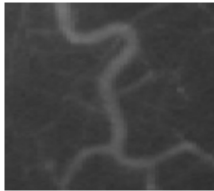
Image segmentation (level set function)



input

segmented

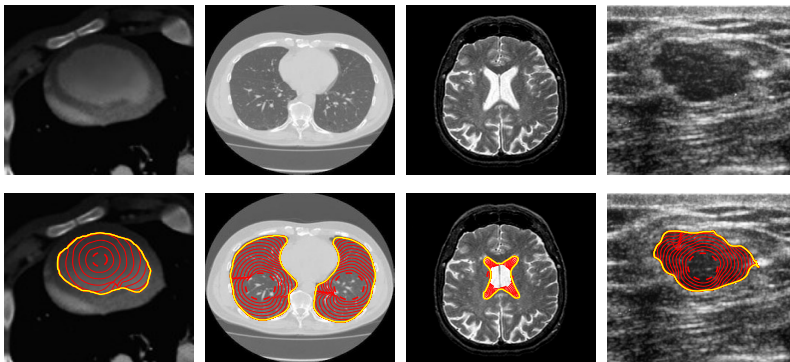
Medical image segmentation (characteristic function)



input

segmented

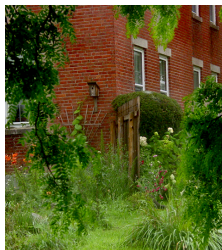
Medical image segmentation (snake method)



(1st row) Human's cardiac CT, human's lung CT, brain CT, and ultrasound images

(2nd row) Deformation processes by AeGVF

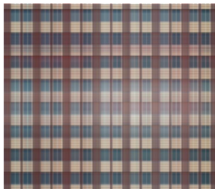
Image dehazing



input

dehazed

Background recovering (principal component pursuit)



input

recovered