THE CHINESE UNIVERSITY OF HONG KONG
Print Course Catalog Details

Academic Org: Div of Computer Science & Engg – Subject: Computer Science

Course: CSCI5670 **Course ID:** 014445 **Eff Date:** 2024-07-01 **Crse Status: Active** **Apprv. Status:** Approved **[**New Course**]**
Computational Imaging Systems and Algorithms 計算成像系統和算法

Computational imaging systems are novel cameras that are combinations of optics, sensors, electronics,and algorithms that jointly enable new approaches for smart visual sensing and perception. It has a wide variety of applications in consumer electronics, autonomous driving, robotics, remote sensing, medical imaging, human computer interaction, machine vision, and scientific imaging. This course will cover core ideas and advanced topics of computational imaging systems and algorithms, including camera and image sensor models, high dynamc range imaging, coded imaging systems (aperture, exposure, illumination), burst photography for low-light imaging, 3D imaging, plenoptic functions and light field, Neural Radiance Fields (NeRF), compressive sensing, neuromorphic imaging, optical neural network, and more. Emphasis is on novel hardware and system design of computational cameras, as well as solving inverse problems with classic optimization algorithms and modern end-to-end learning-based methods. Students will learn the core principles of many computational imaging systems and implement key optimization-based and learning-based algorithms to solve inverse problems.

Advisory note: It is preferred to have taken courses in deep learning and signal processing beforehand.

計算成像系統是結合了光學、傳感器、電子和算法，共同實現了智能視覺傳感和感知的新型相機。它在消費電子、自動駕駛、機器人、遙感、醫學成像、人機交互、機器視覺和科學成像等領域有著廣泛的應用。本課程將涵蓋計算成像系統和算法的核心思想和高級主題，包括相機和圖像傳感器模型、高動態範圍成像、編碼成像系統（孔徑、曝光、照明）、用於低光成像的連拍攝影、三維成像、全光函數和光場、神經輻射場 (NeRF)、壓縮傳感、神經形態成像、光學神經網絡等。重點是計算相機的新穎硬件和系統設計，以及用經典優化算法和現代端到端的學習方法解決反問題。學生將學習許多計算成像系統的核心原理，並實施關鍵的基於優化和基於學習的算法來解決反問題。

建議：修習過深度學習及信號處理相關科目為佳。

Grade Descriptor: A

EXCELLENT – exceptionally good performance and far exceeding expectation in all or most of the course learning outcomes; demonstration of superior understanding of the subject matter, the ability to analyze problems and apply extensive knowledge, and skillful use of concepts and materials to derive proper solutions.

有關等級說明的資料，請參閱英文版本。

B

GOOD – good performance in all course learning outcomes and exceeding expectation in some of them; demonstration of good understanding of the subject matter and the ability to use proper concepts and materials to solve most of the problems encountered

有關等級說明的資料，請參閱英文版本。

C

FAIR – adequate performance and meeting expectation in all course learning outcomes; demonstration of adequate understanding of the subject matter and the ability to solve simple problems.

有關等級說明的資料，請參閱英文版本。

D

MARGINAL – performance barely meets the expectation in the essential course learning outcomes; demonstration of partial understanding of the subject matter and the ability to solve simple problems.

有關等級說明的資料，請參閱英文版本。

F

FAILURE – performance does not meet the expectation in the essential course learning outcomes; demonstration of serious deficiencies and the need to retake the course.

有關等級說明的資料，請參閱英文版本。

Equivalent Offering:
Units: 3 (Min) / 3 (Max) / 3 (Acad Progress)
Grading Basis: Graded
Repeat for Credit: N
Multiple Enroll: N
Course Attributes: MSc Computer Science
MPhil-PhD Computer Sci & Erg

Topics:

COURSE OUTCOMES

Learning Outcomes:

At the end of the course of studies, students will have acquired:
1. core principles for digital cameras, camera ISP, and image sensors
2. optimization algorithms to solve inverse problems (classical and DNN-based)
3. knowledge of plenoptic function, light transport, and many novel computational camera designs
4. hands-on programming experience to implement algorithms for image/video quality enhancement tasks such as denoising, HDR, super-resolution, and deblur.
5. skills to characterize and optimize computational imaging systems for given tasks
6. abilities to design and apply computational imaging systems in related research areas

Course Syllabus:

- Camera and image sensor models (vs. Human Eye)
- Camera ISP pipeline and color processing
- High dynamic range imaging
- Coded imaging systems: aperture, exposure, illumination
- End-to-end optimization of computational cameras
- Burst photography for low-light imaging
- Compressive sensing, ADMM, KSVD, etc
- Light field, plenoptic function, NeRF
- 3D imaging systems: iToF, dToF, spotToF, SPAD, Lidar
- Neuromorphic imaging, event cameras
- Optical neural network
- Generative models for image restoration
- ... and more

Assessment Type:

Homework or assignment	: 60%
Project	: 40%

Feedback for Evaluation:

- Quiz, homework, and examinations
- Course evaluation and questionnaire
- Question-and-answer sessions during class
- Student consultation during office hours and online (Piazza)

Required Readings:

Shree Nayar. "Computational Cameras: Redefining the Image," in IEEE Computer, vol.39, no.8, pp.30-38, 2006

Recommended Readings:

- Richard Szeliski. Computer Vision: Algorithms and Applications (2nd ed), Free online
- Bhandari, Kadambi and Raskar. Computational Imaging. MIT Press. Free online
- George Barbastathis, et.al. "On the Use of Deep Learning for Computational Imaging,", in Optica, vol.6, no. 8, 2019.
- Changyin Zhou and Shree Nayar. "Computational Cameras: Convergence of Optics and Processing", IEEE Transactions on Image Processing, vol.20, no.12, 2011.
- Mauricio Delbracio, et.al. "Mobile Computational Photography: A Tour," in Annual Review of Vision Science, vol.7:571-604, 2021

OFFERINGS

1. CSCI5670 — Acad Organization=CSEGV; Acad Career=RPG

COMPONENTS

LEC : Size=30; Final Exam=N; Contact=3

ENROLMENT REQUIREMENTS

1. CSCI5670

Enrollment Requirement Group:
For students in MSc Computer Science; or
For students in MPhil-PhD Computer Science & Engineering;
Not for students who have taken IERG5670

New Enrollment Requirement(s):
Exclusion = IERG 5670
Other Requirement = For students in MSc Computer Science; or
For students in MPhil-PhD Computer Science & Engineering

Additional Information

eLearning hrs for blended cls 0
VTL-Onsite face-to-face hrs 0
VTL-Online synch. hrs 0
VTL-Online asynch. hrs 0
No. of micro-modules 0

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