

MATH 6397-07 (Spring 2024)

Spectral and variational methods in image processing

Instructor: Dr. Nicolas Charon, ✉ ncharon@central.uh.edu

Office: PGH 669.

Semester dates: 01/16/2024-05/09/2024.

Class time & location: MWF 10:00am-11:00am in AH 204.

Office hours: T.B.A.

Information contained in this syllabus is provisional and subject to future changes. Students are expected to check Canvas regularly for updates.

1 Prerequisites

- Calculus 3 (MATH 2415 or equivalent)
- Linear Algebra (MATH 2318 or equivalent)
- Real Analysis (MATH 4331 or equivalent)
- Some (even limited) prior experience with MATLAB (or similar scientific computing language such as Python...).

2 Textbook

No textbook is officially required. All material discussed in class will be provided and accessible on Canvas, including course notes, slides and example codes.

For reference, here are examples of textbooks relevant to this course:

- Mathematical Problems in Image Processing: Partial Differential Equations and the Calculus of Variations. Springer. G. Aubert and P. Kornprobst. 2006.
- Digital Image Processing. Pearson. R. Gonzalez and R. Woods. 2018.

3 Course Description

This course is meant to give an overview of the different mathematical aspects underlying the field of image processing and analysis, and derive numerical schemes to tackle these. The concrete imaging problems that we shall aim to tackle include image reconstruction and denoising, segmentation, compression and registration. The course will cover several important mathematical notions that

have been central to the development of image analysis, in particular: Fourier and Wavelet transforms, functional spaces such as Sobolev and BV, calculus of variations as well as certain notions of numerical analysis for optimization and PDE solving. Although our primary focus will be on methods which have direct connections to the fields of spectral and variational analysis, the course will also connect those with recent techniques derived from machine learning and neural networks.

In addition to the theoretical aspects, each part of the course will be illustrated with numerical methods implemented in MATLAB or Python and simulations on natural images as well as images related to diverse area of science (e.g. biology, medicine, astronomy...).

4 Delivery format and attendance policy

This course will be delivered face-to-face (in person). In between class meetings, there may also be asynchronous activities to complete (e.g., homework assignments).

Attendance is not required, but strongly encouraged. Regular class attendance, participation, and engagement in coursework are important contributors to student success. Absences may be excused as provided in the [University of Houston Graduate Excused Absence Policy](#) for reasons including: medical illness of student or close relative, death of a close family member, legal or government proceeding that a student is obligated to attend, recognized professional and educational activities where the student is presenting, and University-sponsored activity or athletic competition. Under these policies, students with excused absences will be provided with an opportunity to make up any quiz, exam or other work that contributes to the course grade or a satisfactory alternative. Please read the full policy for details regarding reasons for excused absences, the approval process, and extended absences. Additional policies address absences related to military service, religious holy days (see paragraph 12), pregnancy and related conditions, and disability.

5 Technical equipment needed

Students will need the following equipment to be able to follow classes: • internet connection, • ability to log in to Canvas for online assignments, • ability to access MS Teams for communications relevant for this class, and • scanner or certain smartphone apps so that you can submit your homework as a PDF file. For technical problems, please contact UH IT Help Desk; your instructor might not be able to help with technical issues. Students that do not have access to the required equipment can find the needed computer equipment in the library. Additional information and technical support is available at <https://www.uh.edu/infotech>.

6 Course evaluation

Evaluation for this course will be based solely on Assignments, with possibly the addition of a final project/presentation at the end of the class. The following information is only provisional and subject to future changes.

Assignments. Assignments will be given on a roughly bi-weekly basis. There should be a total of approximately 7 homeworks by the end of the semester, each of which will consist in a combination of “pencil and paper” problems as well as questions involving some simple implementations in MATLAB (or Python). Digital copies of your completed homework assignments have to be uploaded on Canvas at the specified deadline. In fairness to fellow students and graders, late homework will not be accepted.

Final grade. The final grade for the course will be calculated as a weighted average of the assignment grades obtained during the semester and, if applicable, of the final course project.

7 Dissemination of Course Material

The materials provided by the instructor in this course are for **the use of the students enrolled in the course only**. Course materials and course recordings (if permission was warranted) may not be further disseminated without instructor permission. This includes sharing content to commercial course material suppliers or public domain platforms. Students are also prohibited from sharing materials derived from the instructor's content (e.g., a student's lecture notes).

8 Recording of Class

Students may not record all or part of class, livestream all or part of class, or make/distribute screen captures, without advanced written consent of the instructor. If you have or think you may have a disability such that you need to record class-related activities, please contact the [Justin Dart, Jr. Student Accessibility Center](#). If you have an accommodation to record class-related activities, those recordings may not be shared with any other student, whether in this course or not, or with any other person or on any other platform. Classes may be recorded by the instructor. Students may use instructor's recordings for their own studying and notetaking. Instructor's recordings are not authorized to be shared with anyone without the prior written approval of the instructor. Failure to comply with requirements regarding recordings will result in a disciplinary referral to the Dean of Students Office and may result in disciplinary action.

9 Academic Honesty/Honor Code

High ethical standards are critical to the integrity of any institution, and bear directly on the ultimate value of conferred degrees. All UH community members are expected to contribute to an atmosphere of the highest possible ethical standards. Maintaining such an atmosphere requires that any instances of academic dishonesty be recognized and addressed. The [UH Academic Honesty Policy](#) is designed to handle those instances with fairness to all parties involved: the students, the instructors, and the University itself. All students and faculty of the University of Houston are responsible for being familiar with this policy. Posting answers for homework assignments online (at group chats or other online tools) is considered an academic honesty violation. Students are expected to know the difference between "getting and/or giving help on a problem" and "getting/giving answers to a problem." If a student is caught sharing answers (in person or online), they might be reported to the departmental hearing officer for an academic honesty violation. If a student becomes aware of cheating or any other violations; that student is responsible for informing the instructor.

10 Reasonable Academic Adjustments/Auxiliary Aids

The University of Houston complies with Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990, pertaining to the provision of reasonable academic adjustments/auxiliary aids for disabled students. In accordance with Section 504 and ADA guidelines, UH strives to provide reasonable academic adjustments/auxiliary aids to students who request and require them. If you believe that you have a disability requiring an academic adjustments/auxiliary aid, please contact the [Justin Dart, Jr. Student Accessibility Center](#).

11 Mental Health/CAPS Statement

Counseling and Psychological Services (CAPS) can help students who are having difficulties managing stress, adjusting to college, or feeling sad and hopeless. You can reach CAPS (<https://www.uh.edu/caps>) by calling 713-743-5454 during and after business hours for routine appointments or if you or someone you know is in crisis. Also, there is no appointment necessary for the “Let’s Talk” program (<https://www.uh.edu/caps/outreach/lets-talk>), which is a drop-in consultation service at convenient locations and hours around campus.

12 Religious holidays

Students whose religious beliefs prohibit class attendance or the completion of specific assignments on designated dates may obtain an excused absence. To do so, please make a written request for an excused absence and submit it to your instructor as soon as possible, to allow the instructor to make arrangements. For more information, see the Student Handbook (<http://catalog.uh.edu/index.php>).

13 Title IX/Sexual Misconduct

Per the UHS Sexual Misconduct Policy, your instructor is a “responsible employee” for reporting purposes under Title IX regulations and state law and must report incidents of sexual misconduct (sexual harassment, non-consensual sexual contact, sexual assault, sexual exploitation, sexual intimidation, intimate partner violence, or stalking) about which they become aware to the Title IX office. Please know there are places on campus where you can make a report in confidence. You can find more information about resources on the Title IX website at <https://www.uh.edu/equal-opportunity/title-ix-sexual-misconduct/>.

14 Security Escorts and Cougar Ride

UHPD continually works with the University community to make the campus a safe place to learn, work, and live. Our Security escort service is designed for the community members who have safety concerns and would like to have a Security Officer walk with them, for their safety, as they make their way across campus. Based on availability either a UHPD Security Officer or Police Officer will escort students, faculty, and staff to locations beginning and ending on campus. If you feel that you need a Security Officer to walk with you for your safety please call 713-743-3333. Arrangements may be made for special needs.

Parking and Transportation Services also offers a late-night, on-demand shuttle service called Cougar Ride that provides rides to and from all on-campus shuttle stops, as well as the MD Anderson Library, Cougar Village/Moody Towers and the UH Technology Bridge. Rides can be requested through the UH Go app. Days and hours of operation can be found at <https://uh.edu/parking/cougar-ride/>.