Digital Image Processing using Python
ECE 447
cross-listed as ECE 247, TEE 447

Spring 2019, Credit Hours: 4
Monday and Wednesday, 10:25 – 11:40 AM
Harkness 114

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TA: TBD

Required Materials

- Gonzales and Woods, ***Digital Image Processing,*** 4th Edition; ISBN-13: 978-0133356724. This will be the main textbook for the course; it is highly readable, and illustrated with numerous examples of practical significance. This book introduces the basic concepts and methodologies for digital image processing by focusing on *contemporary* developments in *all* mainstream areas of image processing. Completely self-contained, heavily illustrated, and mathematically accessible, it has a scope of application that is not limited to the solution of specialized problems. Digital Image Fundamentals. Image Enhancement in the Spatial Domain. Image Enhancement in the Frequency Domain. Image Restoration. The book is available at the UR Bookstore and at amazon.com.

- Mark Lutz, **Learning Python**, 5th Edition; ISBN-13: 978-1449355739. Gives a comprehensive, in-depth introduction to the core Python language. The book is based on author Mark Lutz's popular training course, this updated fifth edition will help you quickly write efficient, high-quality code with Python. Complete with quizzes, exercises, and helpful illustrations. You'll also learn some advanced language features that recently have become more common in Python code. The book is available at the UR Bookstore and at amazon.com.

Course Description

My goals are a) to introduce you to basic concepts of digital image processing, and b) to establish a good foundation for further study and research in this field. I will present the theoretical components of this course at a level that seniors and first year graduate students who have taken introductory courses in vectors, matrices, probability, statistics, linear systems, and computer programming should be comfortable with. The topics I will cover include intensity transformation and spatial filtering, filtering in the frequency domain, image restoration, morphological image processing, image segmentation, and image registration. Due to the hands-on nature of the course, I will assume that you are proficient in the Python programming language, which will be the primary programming environment that I will recommend for solving problems in class as well as take-home assignments.

Course Purpose

Image processing has matured from ad hoc, empirical approaches to a sound science based on well-established principles in mathematics and physical sciences. My principal goal is to introduce and demonstrate the fundamental principles of image processing with real world applications. I will assign a variety of computational and numerical problems to reinforce the material covered in our weekly lectures. There is no final examination, however I required all students to complete a group project.

Course Learning Outcomes

1. To understand the fundamental principles of human perception, image sensing and acquisition, image sampling and quantization, and basic mathematical tools used in digital image processing (DIP).
2. To understand the principles and use of intensity and spatial transformation functions.
3. To construct filters for filtering images in the Spatial and Fourier Domain and understand pros and cons of each approach.
4. To understand the principles and limitations of Morphological imaging processing.
5. To understand the underlying concepts of image registration.
6. To understand the basic principles of machine learning.

Classroom Procedures

I expect each student to spend approximately 10 hours per week in order to successfully achieve learning outcomes (2.5 hours formal lectures, 7.5 hours activities outside the classroom). I will typically use the following format for each class: 15 minutes reviewing material covered in the previous class; 40 minutes delivering formal lectures; and 20 minutes giving practical demonstration and/or solving problems. I will use homework assignments and the mid-term examination as the primary vehicles for evaluating your knowledge and abilities according to the learning outcomes. There will be no final examination; your project will fulfill that role. All course materials (syllabus, homework, Python scripts, and lecture notes) will be placed on Blackboard in the appropriate folders.

Assessment Breakdown

Homework Assignments (8)	20%
Mid-term Examination	40%
Final Examination	40%

Assignment Descriptions

- **Homework**

  I will assign homework that consists of problems similar to those covered in class, and Python exercises. All exercise must be saved using the IPython Notebook **(.ipynb**) and pdf format and uploaded to blackboard. You will be expected to hand them in at the beginning of class approximately 1 week after they are assigned. **All codes must be by included in with your IPython Notebook, and references included for those obtained from other sources (including the Internet). If you work in a group, then you should also include the names of the members of your group – remember, you may work in a group, but you must submit your own independent work. Failure to do this will result in disciplinary action (please see the section on Academic Honesty below).**

- **Midterm Examination**
  I am planning to assign a take home midterm on 3/23, due 3/27. Mid-term solution should be saved as an IPython Notebook (.ipynb) and uploaded to blackboard.

- **Final examination**

  Like the mid-term, you will have a take home final examination on 4/27, due 5/1. The final exam solution should be saved as an IPyton Notebook (.ipynb) and uploaded to blackboard.

Course Schedule

Please note that the instructor reserves the right to change the Course Schedule depending on the students' needs or course delays

Date	Lectures and Topic
1/16	Intensity transformation (basic transformations)
1/21	**No class** – Martin Luther King Day
1/23	Intensity transformation (histogram equalization)
1/28	Intensity transformation (histogram matching)
1/30	Spatial filtering
2/4	Spatial filtering
2/5	**Make up class:** Frequency Domain Filtering
2/6	Filtering in frequency domain
2/11	Filtering in frequency domain
2/13	Image restoration
2/18	**No class—Away at conference**
2/20	**No class—Away at conference**
2/25	Image restoration
2/27	**Make up class:** Image restoration
3/4	Morphological Image processing
3/6	Morphological Image processing
3/11	**No class** – Spring break
3/13	**No class** – Spring break
3/18	Image Segmentation
3/20	Image Segmentation
3/23	**Take home mid-term Assigned**
3/27	**Take home mid-term due (5 pm)**
4/1	Machine Learning
4/3	Machine Learning
4/8	Machine Learning
4/10	Machine Learning
4/15	Image compression using cosine transform
4/17	Image compression using single value decomposition
4/22	Jpeg compression
4/24	Jpeg compression
4/27	**Take home examination assigned**
5/1	**Take home examination due (5pm)**

Course Policies

- **Late Work**
  Assignments are due at the beginning of class unless otherwise indicated. Assignments turned in late will be penalized and will not be accepted after a week (except in the case of emergencies).

- **Academic Honesty**
  In keeping with the principles of the University of Rochester Honor Code, students are expected to be hones in all of their academic work. Academic honesty means, most fundamentally, that all work you present as your own must in fact be your own work and not that of another. Violations of this principle may result in a failing grade in the course and additional disciplinary action by the University. The academic honesty policy of the University of Rochester can be found at:
  http://www.rochester.edu/college/ccas/AdviserHandbook/AcadHonesty.html
  In addition to the general guidelines mentioned in the above policy, for this course I require that: in examinations, you must work individually with no communication with others and use only materials/tools that have been explicitly allowed. For homework, you may discuss problems with your colleagues, but final solutions need to be worked out, written, and submitted individually. Any external material should be cited, this includes websites.