Syllabus for the course: Image and Video Processing: From Mars to Hollywood with a Stop at the Hospital

A course for the undergraduate students of educational program "Journalism"
Course type: elective (blended)
The part of course: https://www.coursera.org/learn/image-processing/home/welcome

Course description

In this course, you will learn the science behind how digital images and video are made, altered, stored, and used. We will look at the vast world of digital imaging, from how computers and digital cameras form images to how digital special effects are used in Hollywood movies to how the Mars Rover was able to send photographs across millions of miles of space.

The course starts by looking at how the human visual system works and then teaches you about the engineering, mathematics, and computer science that makes digital images work. You will learn the basic algorithms used for adjusting images, explore JPEG and MPEG standards for encoding and compressing video images, and go on to learn about image segmentation, noise removal and filtering. Finally, we will end with image processing techniques used in medicine.

Course plan

Introduction to image and video processing

Learn what is image and video processing. Learn the very basic concepts of human perception needed for understanding image processing. Learn simple tools in signal processing needed to understand following units.

Image and video compression

JPEG and MPEG are the most successful algorithms in the area, widely used by everybody in a daily basis, and the goal of this unit is to understand how they work. Also to understand why these techniques are important and why they are enabling technologies. Also will describe what is done in the Mars expedition.

Spatial processing

Some of the most basic tools in image processing, like median filtering and histogram equalization, are still among the most powerful. We will describe these and provide a modern interpretation of these basic tools. Students will then become familiar with simple and still popular approaches. We will also include non-local means, a more modern technique that still uses classical tools.

Image restoration

The goal of this unit is to complement Unit 3 by adding prior information about the sources of degradation. Students will learn that if we know about the degradation process, we can do better. The objective of this unit is to complete the training with basic and powerful classical tools.

Image segmentation

Not all parts of the image are the same, and students will learn the basic techniques to partition an image, from simple threshold to more advanced graph cuts and active contours. This is the first unit where student will learn about image analysis and image interpretation, and will learn why this is important, e.g., in medical imaging and object recognition.

Geometric PDEs

This is all optional material. It will help the students that are more mathematically oriented and want to better understand the math behind next unit's lectures. But you will be able to handle without it.The quiz is therefore practice only. This is the first “advanced” unit and smoothly follows from the previous one. Students will learn very modern tools, widely used today, and will contrast with units 3,4 to illustrate how significantly more advanced mathematical tools are also very useful in image and video analysis. We will connect some of these advanced tools with classical ones, e.g., average with heat flow and median with anisotropic diffusion. This will help to provide unified views to the students.

Image and video inpainting

Students will get involved with a very exciting topic, since image and video inpainting is one of the most used tools in the movie industry. They will learn the problem, and also how they can approach it from multiple directions. This will also help to illustrate how the same problem can be approached from multiple mathematical angles. We will connect this with Shanon’s work providing yet another angle. If you watched the lectures on PDEs you will have more mathematical background, but you will enjoy this unit and learn without it as well.

Sparse modeling and compressed sensing

Here the goal is to present one of the most modern tools in image and video processing, and students will learn something that is today at the top of active research. This will also help to illustrate the use of linear algebra and optimization in image and video processing. This is the last formal unit of the course.

Medical imaging

This is a bonus unit. Enjoy it. Image processing has been very successful in medical imaging, and we will use examples from HIV and brain research to illustrate the importance of image processing in solving societal problems. We will describe the basic tools in these exciting applications, from the acquisition to the analysis.

Reading list

a. Required

1. Alan C. Bovik. Handbook of Image and Video Processing. Elsevier Science & Technology, 2005 – URL: https://ebookcentral.proquest.com/lib/hselibrary-ebooks/detail.action?docID=328547&query=Video+Processing
2. D. Sundararajan. Digital Image Processing. Springer, Singapore, 2017 – URL: https://link.springer.com/book/10.1007%2F978-981-10-6113-4
3. Michael E. Sparse and Redundant Representations. Springer, 2010 – URL: https://link.springer.com/book/10.1007%2F978-1-4419-7011-4

b. Optional

1. Enrico V., Matteo N., Antonin C. Geometric Partial Differential Equations. Scuola Normale Superiore, 2013 – URL: https://link.springer.com/book/10.1007%2F978-88-7642-473-1

Grading system

Cumulative grade according to 10-point system includes all the for required assignments. The cumulative grade will be determined in advance of the final exam. It includes percentages for the various activities as follows:

Quiz №1 - 15%

Quiz №2 - 15%

Quiz №3 - 14%

Quiz №4 - 14%

Quiz №5 - 14%

Quiz №6 – 14%

Quiz №7 - 14%

Quiz №8 - 14.00%

When converting the grade into a 10-point grading system to determine the final result, the following formula will be applied.

Final grade is formed as follows:

- Cumulative grade – 80%;
- Final exam – 20 %.

The final exam contains questions studied during online course.

Special Equipment and Software Support

Special equipment is not required.