CS 484 & CS 555: Introduction to Computer Vision

Spring 2021

Instructor: Dr. Sedat Ozer (Office: EA 524, Email: sedat@cs.bilkent.edu.tr)

Teaching Assistant (TA): Will be announced on the class website!

Schedule: Check the class website!

Class website:
http://cs.bilkent.edu.tr/∼sedat/CS484_555/index.html

Catalog description: Image acquisition, sampling and quantization. Spatial domain processing. Image enhancement. Texture analysis. Edge detection. Frequency domain processing. Color image processing. Mathematical morphology. Image segmentation and region representations. Statistical and structural scene descriptions. Deep learning. Introduction to Research. Applications.

Course emphasis and goals: The aim of this introductory course is providing the essentials of computer vision, image understanding and image analysis concepts and tools to the students in different modalities and expose them to current research topics in the field. From one side, the students will be exposed to many different computer vision and image processing techniques in a fast pace. From another side, students will be working in groups to perform research and they will work on their final project on a recent and state of the art vision application to gain research experience.

Prerequisites: Good background on high-level programming including Python, data structures, linear algebra, and vector calculus. No prior knowledge of image processing or computer vision is assumed.

Texts:
- L. G. Shapiro and G. C. Stockman, *Computer Vision*, Prentice Hall, 2001.
- R. Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2010.
- R. C. Gonzalez and R. E. Woods, *Digital Image Processing*, 3rd ed., Prentice Hall, 2008.
- D. A. Forsyth and J. Ponce, *Computer Vision: A Modern Approach*, Prentice Hall, 2002.
- D. H. Ballard and C. M. Brown, *Computer Vision*, Prentice Hall, 1982.

Grading:

Homeworks:	15%
Midterm:	20%
Paper / Survey Presentation:	15%
Final Exam:	15%
Final Project:	35%

Students with more than 1 homework / assignment (or final project) missing will receive the grade: FZ in this class (i.e., in this course, you can only have one missing HW and you must submit and present your final project). You can miss your midterm and still get a grade different than F, if your other grades permit. In general, you will receive penalty on your grades, if you cannot comply with the submission instructions.

Homework: There will be multiple homework assignments that will involve both programming and discussion. Each assignment will have a specific due date and time. You need to upload your homework as instructed in the class before the deadline. Check the homework description carefully about what is required in a submission. You are required to submit your programming assignments in the correct format which will be required by the TA in each assignment. Homework grades will be posted to the STARS system. You can get feedback about your homework from the TA during office hours. No late submission will be accepted so make sure you start working on the assignments early enough.

Midterm Exam: There will be one midterm exam in this class. The format of the exam can change depending on the pandemic conditions. Currently, midterms are expected to be held on campus. However, students are required to have additional webcams in addition to the cameras that they might have on their laptops.

Paper / Survey Presentation: You are expected to study and present papers that are relevant to your final project. Presentations will be done in groups. For details, please check the course website and follow the instructions given in the class. You will also summarize your progress (you must have done at least 30percent of your final project until now). Presentation format and duration will depend on the total number of students / groups.

Final Exam: In this class, there will be a final exam and a final project. The final exam will check students' understanding on all the material that we have covered in the class.

Final Project: There will be a term project that will involve application of one or more techniques covered in the class on different data sets. Project topics will be related to the course material and content. You will need instructor's approval to work on your choice of project. Students will work in groups for the project. You cannot change your final project without the approval of the instructor. Groups that are changing their final projects without instructor's approval will receive 30% penalty on their project grade. You are required to pick a recent computer vision related paper and present it first. Then you need to replicate its results and compare your findings to the paper's reported results. The class requires you to meet with instructor in certain periods to show your progress on your final project. Each group must meet the instructor "at least" three times prior to their final project. Failure to do so, may result in penalty.

Tentative Lecture schedule:

- Introduction
  - Overview
  - Example applications
- Digital Image Fundamentals
  - Acquisition, sampling, quantization
  - Image enhancement
  - Image formats
  - Linear algebra and MATLAB review
- Binary Image Analysis
  - Pixels and neighborhoods
  - Mathematical morphology

  - Connected components analysis
  - Automatic thresholding
- Linear Filtering
  - Spatial domain filtering
  - Frequency domain filtering
  - Image enhancement
- Edge Detection
  - Edges, lines, arcs
  - Hough transform
- Pattern Recognition Overview
  - Brief introduction to pattern recognition
  - Supervised classification
  - Unsupervised clustering
- Introduction to Deep learning
  - Logistic Regression
  - Fully Connected Networks
  - Convolutional Networks
- Local Feature Detectors
  - Corners and other interest points
  - Invariants
- Color Image Processing
  - Color spaces and conversions
- Texture Analysis
  - Statistical approaches
  - Structural approaches
- Image Segmentation
  - Histogram-based approaches
  - Clustering-based approaches
  - Region growing
  - Split-and-merge
  - Morphological approaches
  - Graph-based approaches
- Representation and Description
  - Image representations and descriptors
  - Region representations and descriptors
- Case Studies
  - Image retrieval
  - Image classification
  - Object localization
  - Object detection

Honor code for assignments:

In the Computer Engineering Department at Bilkent, we take academic integrity on homework assignments very seriously and expect you to take it seriously too. The aim of this section is to make our expectations as clear as possible to prevent possible academic integrity violations.

Students naturally want to work together and get help from others when they struggle. We believe that you learn a great deal by doing so and encourage such assistance. However, you should be careful not to violate academic integrity. In response to this, the following rules will be in force for assignments in CS 484 and in CS 555:

- You are allowed to discuss with your classmates in finding strategies for problem solving and debugging, but NOT in writing your codes. In other words, you may not discuss with your classmates how to solve the problem using a particular programming language (either actual code or the pseudocode). Discussion on the actual code or the pseudocode will not be tolerated.

- All work on assignments must be done individually unless stated otherwise. You may not copy code in whole or in part from someone else. You may not share your code. You may not discuss your solution with others in detail (line-by-line, loop-by-loop, etc.).

- If you need detailed help, ask your instructor or your TA. Such detailed discussion is limited to only these people. Rather than these people, you may not receive detailed help on your code from individuals or a book or the Internet unless stated otherwise. Similarly, you may not hire a tutor to get your homework done. If you just use some small hints from other sources (friends, books, websites, etc.), do not forget to cite them.

- If external assistance (from other people, Internet, books) is allowed for a particular assignment, you must indicate the source on your submission. If you make use of such assistance without giving proper credit, you may be guilty of plagiarism. It is also important to make sure that the assistance you receive consists of general advice that does not cross the boundary into having someone else write the actual code.

- You must not look at solution sets or program code from other years. It is a violation of academic integrity and it also will not help you in the long run. Whenever you seek help on an assignment, your goal should be improving your level of understanding and not simply having your homework done.

- You may not show your code to others as a means of helping them. Sometimes, very good students provide their code (sometimes "just a peek" at their code) or detailed help to struggling students for helping them. However, such good intentions may turn into the violation of academic integrity. If you have such struggling friends, direct them to the instructor or the TA.

- You may not leave your code in publicly accessible areas. You may not share computers in any way. If you work in a public lab, delete all files related to the assignment when you leave. Do not forget to empty the recycle bin. You may not use others' storage devices (others' CDs, USBs, etc) to save your work.

- You may not leave any printouts lying around anywhere and you may not dispose them in public trash cans until your assignment has been graded.

- You must be prepared to explain the solutions to any assignment you submit. All the comments regarding program code above are also valid for any essays you write and any theoretical solutions you are asked to provide.
- You may not rely on the assumptions regarding to this issue (experience of your friends or your experience in other courses). If you have any questions, you must ask them to the instructor. Similarly, if any of these rules is not clear for you, ask what they mean to the instructor.

In this course, we may use an automatic code comparison tool to help spot assignments that have been submitted in violation of these rules. It takes all assignments from all students (and several solutions that may exist on the Internet or solutions from past years) and compares them. By making use of its results, we check similar pairs of assignments ourselves carefully and make our own judgment. *Students caught cheating on assignments will be subject to disciplinary action.* Do not forget that it is much easier to explain a poor grade to others than to explain a cheating conviction.