



CS Computer Vision: Foundations and Applications 5680/6680

Instructor: Xiaojun Qi

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Office Hours: Mondays 11:30 a.m. to 12:30 p.m. and Fridays 10:00 a.m. to 11:00; Other hours by appointment only.

Course Schedule: TR 9:00 a.m. to 10:15 a.m. (ESLC 053).

Course Fees

\$180 for Graduate Teaching Assistant

Course Description

The course will provide an introduction to theories and techniques of machine intelligence, with an emphasis on image processing, pattern recognition, and computer vision.

Prerequisites

Computer Science students should have completed the equivalent of CS2420 or CS5050. Students in other fields should have familiarity with programming in C, C++, Python, or Java.

Course Objectives



By the end of this course, you will be able to:

1. Understand basic concepts and methodologies for digital image processing and pattern

recognition.

2. Learn to manipulate and analyze digital images (pictorial information) by computer.
3. Learn to classify what is inside of the image.
4. Gain hands-on experiences in using tools such as Matlab or Python to process digital images and analyze the images.

Student Outcomes

Materials in this course support the following Computer Science student outcomes:

1. SO1 - Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions.
2. SO2 - Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.
3. SO6 - Apply computer science theory and software development fundamentals to produce computing-based solutions.

Course Materials

Optional textbook:

Rafael C. Gonzalez and Richard E. Woods. Digital Image Processing, 4th Edition, Pearson Prentice Hall, 2017. ISBN-13: 978-0133356724
ISBN-10: 9780133356724

Course Topics

Some adjustments may be made in the progress of the course. Some additional materials will be used as well.

Chapter 1 Introduction to Computer Vision and Their Potential Applications

Chapter 2 Digital Image Fundamentals

Chapter 3 Basic (Low-Level) Digital Image Processing

3.1 Image Enhancement in the Spatial Domain

 3.2 Image Enhancement in the Frequency Domain

3.2.1 Fourier Transform

3.2.2 Wavelet Transform

Chapter 4 Advanced (Mid-Level) Digital Image Processing

- 4.1 Image Morphology
- 4.2 Introduction to Dilation and Erosion
- 4.3 Introduction to Opening and Closing
- 4.4 Introduction to Some Basic Morphological Algorithms

Chapter 5 Advanced (High-Level) Digital Image Processing

- 5.1 Basic Image Segmentation Strategies
- 5.2 Data Structures for Segmentation
- 5.3 Watersheds and Region-Based Algorithms

Chapter 6 Basic Pattern Recognition

- 6.1 Object Representation and Recognition
- 6.2 Patterns and Pattern Classes

Chapter 7 Advanced Pattern Recognition

- 7.1 Statistics (Distribution)-Based Pattern Recognition and Classification
 - 7.1.1 Perceptron Algorithm
 - 7.1.2 Neural Network
 - 7.1.3 Deep Convolutional Neural Network
 - 7.1.4 Support Vector Machines
- 7.2 Distance-Based Pattern Recognition and Classification
 - 7.2.1 Minimum-Distance Pattern Classification (Single Prototypes and Multiple Prototypes)
 - 7.2.2 K-Means Clustering Algorithm
 - 7.2.3 Hierarchical Clustering Algorithm
- 7.3 Model-Based Pattern Recognition and Classification
 - 7.3.1 Principal Component Analysis
 - 7.3.2 Linear Discriminant Analysis

Chapter 8 Computer Vision

8.1 Introduction

8.2 Applications

Chapter 9 The Presentation of the Final Project


Assignments

- You will submit your assignment using the Canvas System. Each assignment is due by 11:59 p.m. on its due date. **No late assignment will be accepted.** However, I will grant one gift (e.g., turn in the assignment up to 2 days beyond the submission deadline) for the entire semester with an email request to **GTA (name: Soheila Farokhi; email: soheila.farokhi@usu.edu)** before the due date.
- You are required to do your own work. You will be responsible to ensure that your assignment is submitted correctly. If you have multiple files to submit, you need to zip multiple files into one file before submission. **Please make sure to delete original images before you zip your files.** Please verify the information in the confirmation email. If the assignment is submitted incorrectly, you can resubmit it. The system keeps track of the last file submitted for each assignment. If you do not get the confirmation information within a few minutes, you can assume the assignment has not been submitted.
- All assignments are programming assignments. You need to use the Matlab or Python programming language to do each assignment.
- At the top of each assignment, please include comments that consist of your name, contact email, and assignment name or number. For each function, please clearly explain each input and output parameter. **Please clearly add comments for each important variable and section.**

GTA

- Name: Soheila Farokhi;
- Email: soheila.farokhi@usu.edu. Email is the best way to communicate with her.

Exams


There will be two exams - one midterm exam and one final take-home exam. The midterm exam will be given on October 31 (Thursday). The final take-home exam contains a written exam and a programming project. The written part of the final will be due before 9:00 a.m. on Dec. 12 (Thursday) and the programming part of the final will be due at 11:59 p.m. on Dec. 10 (Tuesday). The  entation of the final project will be scheduled from 9:00 a.m. to 11:20 a.m. on Dec. 12 (Thursday). Exams cover materials presented in class, in the book, and on the assignments. I do not give make-up exams. Please verify that you are able to take the exams.

Assignment/Exam Schedule and Points Possible

Assignments/Exam	Due Dates	Points
Assignment 1	September 8, 2024 (Sunday)	25
Assignment 2	September 22, 2024 (Sunday)	35
Assignment 3	October 6, 2024 (Sunday)	35
Assignment 4	October 20, 2024 (Sunday)	50
Assignment 5	October 29, 2024 (Tuesday)	45
Midterm Exam	October 31, 2024 (Thursday)	100
Assignment 6	November 8, 2024 (Friday)	60
Research Proposal	November 15, 2024 (Friday)	10
Final Project	December 10, 2024 (Tuesday)	80
Final Take-Home Exam	December 12, 2024 (Thursday)	50
Final Presentation	December 12, 2024 (Thursday)	10

Grading Scheme

The following grading standards will be used in this class:

Grade	Range
A	100 % to 94.0%
A-	< 94.0 % to 90.0%
 B	< 90.0 % to 86.0%
B	< 86.0 % to 82.0%
B-	< 82.0 % to 78.0%

Grade	Range
C+	< 78.0 % to 74.0%
C	< 74.0 % to 70.0%
C-	< 70.0 % to 66.0%
D+	< 66.0 % to 62.0%
D	< 62.0 % to 58.0%
F	< 58.0 % to 0.0%

Grading Policy and Grades

- Each programming assignment is graded based on the following factors: **code efficiency, code structure, technique difficulty, code readability, etc.**
- Your scores for each assignment and exam will be available through the Canvas System. You will be shown a score, your percentage to date, and any comments. You will be notified via email whenever you receive a score or when a change is made to a score.
- If you want to dispute a score, contact the GTA Soheila (soheila.farokhi@usu.edu) **within two days of having received the original score**. If the disagreement is not resolved after communicating with the GTA, contact me by email (Xiaojun.Qi@usu.edu). I will review your submission, talk to the GTA and then respond to you. **I will not consider changes in scores if you do not contact me within one week of when the score is sent to you.**


Important Dates

- Late Adds: The last day to add this class is September 16 (Monday). Attending this class beyond that date, without being officially registered, will not be approved by the Dean's Office. Students must be officially registered for this course. No assignments or tests of any kind will be graded for students whose names do not appear on the class list.
- Drop Date: The last day to drop classes is:
 1. Monday, September 16 - without a "W" notation on the transcript.
 2. Monday, October 28 - with a "W" notation on the transcript.


Nonattendance Policy

Students May Be Dropped For Nonattendance

If a student does not attend a class during the first week of the term or by the second class meeting, whichever comes first, the instructor may submit a request to have the student dropped from the course. **(This does not remove responsibility from the student to drop courses which he or she does not plan to attend.)** This option is typically used for classes that are full and the instructor is




trying to make a seat available for another student, but may be considered for other courses. Requests must be made during the first 20 percent of the course and will be considered on an individual student basis. Students who are dropped from courses will be notified by the Registrar's Office through their preferred e-mail account (see [USU nonattendance policy](https://catalog.usu.edu/content.php?catoid=38&navoid=29183)  <https://catalog.usu.edu/content.php?catoid=38&navoid=29183>).

Library Services


All USU students attending classes in Logan, at our Regional Campuses, or online can access all databases, e-journals, and e-books regardless of location. Additionally, the library will mail printed books to students, at no charge to them. Students can also borrow books from any Utah academic library. Take advantage of all library services and learn more at <https://libguides.usu.edu/statewide>  <https://libguides.usu.edu/statewide>).

University Policies & Procedures

Appropriate Use of Canvas and Other IT Resources

Canvas and all other course technologies are information technology services provided as tools to further the mission of the university. By using these services, users agree to comply with [USU Policy 550: Appropriate Use of Computing, Networking, and Information Resources](https://www.usu.edu/policies/550/)  <https://www.usu.edu/policies/550/> and the accompanying [Terms of use for USU IT](https://usu.service-now.com/aggies?id=kb_article_view&sysparm_article=KB0015388)  https://usu.service-now.com/aggies?id=kb_article_view&sysparm_article=KB0015388 resources, as well as [Article V-3.B.25.c](https://www.usu.edu/student-conduct/student-code/article5)  <https://www.usu.edu/student-conduct/student-code/article5> of the USU Student Code. Using course technologies in ways that are inconsistent with the university's mission or are disruptive will not be tolerated. Disruptive behavior includes any activity that interferes with either the faculty member's ability to conduct the class or the ability of other students to profit from the instructional program.


Classroom Behavior

Utah State University supports the principle of freedom of expression for both faculty and students. The University respects the rights of faculty to teach and students to learn. Maintenance of these rights requires classroom conditions that do not impede the learning process. Disruptive classroom behavior will not be tolerated. An individual engaging in such behavior may be subject to disciplinary action. Read [Student Code Article V Section V-3](https://www.usu.edu/student-conduct/student-code/article5)  <https://www.usu.edu/student-conduct/student-code/article5> for more information.



Academic Freedom and Professional Responsibilities

Academic freedom is the right to teach, study, discuss, investigate, discover, create, and publish

freely. Academic freedom protects the rights of faculty members in teaching and of students in learning. Freedom in research is fundamental to the advancement of truth. Faculty members are entitled to full freedom in teaching, research, and creative activities, subject to the limitations imposed by professional responsibility. [Faculty Code Policy #403](https://www.usu.edu/policies/403/)  (<https://www.usu.edu/policies/403/>) further defines academic freedom and professional responsibilities.

Academic Integrity – "The Honor System"

Each student has the right and duty to pursue his or her academic experience free of dishonesty. To enhance the learning environment at Utah State University and to develop student academic integrity, each student agrees to the following Honor Pledge:


"I pledge, on my honor, to conduct myself with the foremost level of academic integrity."

A student who lives by the Honor Pledge is a student who does more than not cheat, falsify, or plagiarize. A student who lives by the Honor Pledge:


- Espouses academic integrity as an underlying and essential principle of the Utah State University community;
- Understands that each act of academic dishonesty devalues every degree that is awarded by this institution; and
- Is a welcomed and valued member of Utah State University.

Academic Dishonesty

The instructor of this course will take appropriate actions in response to Academic Dishonesty, as defined the University's Student Code. Acts of academic dishonesty include but are not limited to:






- **Cheating:** using, attempting to use, or providing others with any unauthorized assistance in taking quizzes, tests, examinations, or in any other academic exercise or activity. Unauthorized assistance includes:
 - Working in a group when the instructor has designated that the quiz, test, examination, or any other academic exercise or activity be done "individually;"
 - Depending on the aid of sources beyond those authorized by the instructor in writing papers, preparing reports, solving problems, or carrying out other assignments;
 - Substituting for another student, or permitting another student to substitute for oneself, in taking an examination or preparing academic work;
 - Acquiring tests or other academic material belonging to a faculty member, staff member, or another student without express permission;
 - Continuing to write after time has been called on a quiz, test, examination, or any other academic exercise or activity;
 -  Submitting substantially the same work for credit in more than one class, except with prior approval of the instructor; or engaging in any form of research fraud.
- **Falsification:** altering or fabricating any information or citation in an academic exercise or activity.

- **Plagiarism:** representing, by paraphrase or direct quotation, the published or unpublished work of another person as one's own in any academic exercise or activity without full and clear acknowledgment. It also includes using materials prepared by another person or by an agency engaged in the sale of term papers or other academic materials.


For additional information go to: [ARTICLE VI. University Regulations Regarding Academic Integrity](https://www.usu.edu/student-conduct/student-code/article6)  [. \(https://www.usu.edu/student-conduct/student-code/article6\)](https://www.usu.edu/student-conduct/student-code/article6)








Discrimination and Sexual Misconduct

General Overview

USU strives to provide an environment for students and employees that is free from [discrimination](https://www.usu.edu/equity/non-discrimination)  [. \(https://www.usu.edu/equity/non-discrimination\)](https://www.usu.edu/equity/non-discrimination) and [sexual misconduct](https://www.usu.edu/equity/sexual-misconduct/Sexual-Misconduct-Terms)  [. \(https://www.usu.edu/equity/sexual-misconduct/Sexual-Misconduct-Terms\)](https://www.usu.edu/equity/sexual-misconduct/Sexual-Misconduct-Terms). If you experience sexual misconduct or discrimination at any point during the semester inside or outside of class, you are encouraged to contact the USU Title IX Coordinator via Distance Education room 400 in Logan, 435-797-1266, titleix@usu.edu (<mailto:titleix@usu.edu>), or at [equity.usu.edu/report](https://www.usu.edu/equity/report)  [. \(https://www.usu.edu/equity/report\)](https://www.usu.edu/equity/report). You can learn more about the USU resources available for individuals who have experienced sexual misconduct at [sexualrespect.usu.edu](https://www.usu.edu/sexual-respect/)  [. \(https://www.usu.edu/sexual-respect/\)](https://www.usu.edu/sexual-respect/). Resources for individuals who have experienced discrimination are listed at [equity.usu.edu/resources](https://www.usu.edu/equity/resources)  [. \(https://www.usu.edu/equity/resources\)](https://www.usu.edu/equity/resources).

Required Reporting of Sexual Misconduct and Threats of Harm

USU cares about our students and provides a number of resources and supportive measures to students who may be experiencing thoughts of self-harm or who have experienced sexual misconduct. To ensure students are informed about resources and services available to them, including available grievance or criminal processes for incidents of sexual misconduct, USU has implemented [reporting policies and practices](https://www.usu.edu/policies/340/)  [. \(https://www.usu.edu/policies/340/\)](https://www.usu.edu/policies/340/) that require designated employees to report any information they receive about incidents of sexual misconduct. This reporting policy also assists USU with its efforts to prevent sexual misconduct and keep our campus community safe.

Under USU's sexual misconduct reporting policy, I am designated as a "[reporting employee](https://www.usu.edu/equity/sexual-misconduct/employees.php)  [. \(https://www.usu.edu/equity/sexual-misconduct/employees.php\)](https://www.usu.edu/equity/sexual-misconduct/employees.php)." This means that if you share information with me about incidents of [sexual misconduct](https://www.usu.edu/equity/sexual-misconduct/Sexual-Misconduct-Terms.php)  [. \(https://www.usu.edu/equity/sexual-misconduct/Sexual-Misconduct-Terms.php\)](https://www.usu.edu/equity/sexual-misconduct/Sexual-Misconduct-Terms.php) (sexual harassment, sexual assault, relationship violence, or sex-based stalking), including within a course assignment, , I *will report* that information to the [USU Title IX Coordinator](https://www.usu.edu/equity/sexual-misconduct/Title-IX-Coordinator.php)  [. \(https://www.usu.edu/equity/sexual-misconduct/Title-IX-Coordinator.php\)](https://www.usu.edu/equity/sexual-misconduct/Title-IX-Coordinator.php). I will  share with you information about [designated confidential resources](https://www.usu.edu/equity/sexual-misconduct/confidential-resources)  [. \(https://www.usu.edu/equity/sexual-misconduct/confidential-resources\)](https://www.usu.edu/equity/sexual-misconduct/confidential-resources), [supportive measures](https://www.usu.edu/equity/Supportive-Measures.php)  [. \(https://www.usu.edu/equity/Supportive-Measures.php\)](https://www.usu.edu/equity/Supportive-Measures.php), and [how you can file a report](https://www.usu.edu/equity/)  [. \(https://www.usu.edu/equity/\)](https://www.usu.edu/equity/)

[report.php](#)) with the USU Title IX Coordinator.

Self-disclosures about sexual misconduct that you experienced are not required for your course work.

Similarly, if you disclose thoughts of harm to self or a threat to others to me, including within a course assignment, I will report the information to the appropriate campus administrators. I will also share with you information about the [mental health and wellness resources](https://www.usu.edu/aggiewellness/caps/) [\(https://www.usu.edu/aggiewellness/caps/\)](https://www.usu.edu/aggiewellness/caps/) available to you.

Withdrawal Policy and "I" Grade Policy

Students are required to complete all courses for which they are registered by the end of the semester. In some cases, a student may be unable to complete all of the coursework because of extenuating circumstances, but not due to poor performance or to retain financial aid. The term 'extenuating' circumstances includes: (1) incapacitating illness which prevents a student from attending classes for a minimum period of two weeks, (2) a death in the immediate family, (3) financial responsibilities requiring a student to alter a work schedule to secure employment, (4) change in work schedule as required by an employer, or (5) other emergencies deemed appropriate by the instructor.

Students with Disabilities


USU welcomes students with disabilities. If you have, or suspect you may have, a physical, mental health, or learning disability that may require accommodations in this course, please contact the [Disability Resource Center \(DRC\)](http://www.usu.edu/drc/) [\(http://www.usu.edu/drc/\)](http://www.usu.edu/drc/) as early in the semester as possible (University Inn # 101, (435) 797-2444, drc@usu.edu (<mailto:drc@usu.edu>)). All disability related accommodations must be approved by the DRC. Once approved, the DRC will coordinate with faculty to provide accommodations.

Students Who are Pregnant or Have a Pregnancy-Related Condition


If you need academic accommodations related to pregnancy, childbirth, false pregnancy, termination of pregnancy, recovery, or other pregnancy related conditions, please contact the Office of Equity as early as possible. All accommodations related to pregnancy must be approved by the Office of Equity. The Office of Equity will then coordinate with instructors to provide accommodations. The University will not exclude a student from participating in any part of an educational program based on the student's pregnancy or pregnancy related conditions.

Office of Equity: Distance Education, Room 400, Logan Campus, 435-797-1266, [Office of Equity: Pregnancy and Pregnancy Related Conditions](https://www.usu.edu/equity/pregnancy-mmmodations) [mmmodations](https://www.usu.edu/equity/pregnancy-mmmodations)).


Inclusive Excellence

USU provides resources to help all students feel included as part of the campus and broader USU community. To learn more about the resources available and how to access them, visit the [Inclusive Excellence Office](https://www.usu.edu/inclusive-excellence/)  [\(https://www.usu.edu/inclusive-excellence/\)](https://www.usu.edu/inclusive-excellence/).


Grievance Process

Students who feel they have been unfairly treated may file a grievance through the channels and procedures described in the [Academic Grievances section of the Course Catalog](https://catalog.usu.edu/content.php?catoid=39&navoid=30452)  [.\(https://catalog.usu.edu/content.php?catoid=39&navoid=30452\)](https://catalog.usu.edu/content.php?catoid=39&navoid=30452).

Full details for USU Academic Policies and Procedures

- [Acceptable Use of University Computing Resources](https://www.usu.edu/policies/550/) [\(https://www.usu.edu/policies/550/\)](https://www.usu.edu/policies/550/)
- [Academic Policies and Practices \(USU Catalog\)](https://catalog.usu.edu/content.php?catoid=39&navoid=29998)  [.\(https://catalog.usu.edu/content.php?catoid=39&navoid=29998\)](https://catalog.usu.edu/content.php?catoid=39&navoid=29998)
- [Student Conduct](http://www.usu.edu/studentconduct) [\(http://www.usu.edu/studentconduct\)](http://www.usu.edu/studentconduct)
- [Student Code](https://www.usu.edu/student-conduct/student-code/) [\(https://www.usu.edu/student-conduct/student-code/\)](https://www.usu.edu/student-conduct/student-code/)
- [Academic Freedom and Professional Responsibility Policy](https://catalog.usu.edu/content.php?catoid=38&navoid=28932) [\(https://www.usu.edu/policies/403/\)](https://www.usu.edu/policies/403/)


Emergency Procedures


In the case of a drill or real emergency, classes will be notified to evacuate the building via USU official communication channels. Those channels will be: an audible alarm, such as a fire alarm; an Aggie Alert notification; or notification by a USU representative. In the event of a disaster that does not permit enough time for notifications, evacuate as the situation dictates (i.e., when shaking ceases in an earthquake; immediately when a fire is discovered or in the event of other immediate life safety concerns). If it does not inhibit safety, turn off computers and take any personal items with you. Elevators should not be used; instead, use the closest stairs. See [USU Emergency Management](https://www.usu.edu/dps/emergency/)  [\(https://www.usu.edu/dps/emergency/\)](https://www.usu.edu/dps/emergency/) for more information.


General Health Protocols

The cold, flu, COVID-19, and other illnesses can have an impact on the health of our university community. USU welcomes the wearing of masks in all university buildings and encourages taking measures to mitigate risk as recommended by federal and state public health officials: getting vaccinated, staying home if you are sick, and frequent hand washing.

Mental Health

Mental health is critically important for the success of USU students. As a student, you may  experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic

performance or reduce your ability to participate in daily activities. Utah State University provides free services for students to assist them with addressing these and other concerns. You can learn more about the broad range of confidential mental health services available on campus at [Counseling and Psychological Services \(CAPS\)](https://counseling.usu.edu)  [. \(https://counseling.usu.edu\)](https://counseling.usu.edu).

Students are also encouraged to download the [“SafeUT App”](https://safeut.org/)  [\(https://safeut.org/\)](https://safeut.org/) to their smartphones. The SafeUT application is a 24/7 statewide crisis text and tip service that provides real-time crisis intervention to students through texting and a confidential tip program that can help anyone with emotional crises, bullying, relationship problems, mental health, or suicide related issues.

Course Summary:

Date	Details	Due
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