Computer Science Department
cs.salemstate.edu

CSC 485 Robotics and Computer Vision **4 cr.**

Instructor: TBA **Office:** location **Phone:** (978) 542-extension
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Section	Time	Room	Final Exam
nn	days and times	location	date and time
Lnn	days and times	location	

Catalog description:

This course presents the basic science behind mobile robotics, robotic manipulation, and computer vision. The course examines key aspects of autonomous systems including sensors, map making, and path planning. The fundamentals of robotic manipulation will be presented, including coordinate transformations, manipulator kinematics, and motion. Topics in computer vision include image formation and sensing, region and edge extraction, feature identification, camera calibration, and optical measurement. The course concludes with techniques for integrating vision, mobile robots, and manipulators into a complete system. Three hours of lecture and three hours of scheduled laboratory time per week.

Prerequisite: Pre- or Co-Requisite: MAT 221; Prerequisite: CSC 260; CSC 279 strongly recommended.

Course Goals:

The purpose of this course is to:

CG01: develop an understanding of image sensing and processing;
CG02: understand the fundamental mathematics behind robot kinematics and dynamics;
CG03: present a unified description of sensing, path planning, and motion for autonomous systems;
CG04: present a consistent methodology for describing manipulator kinematics and motion;
CG05: present design methods for integrated robotic systems.

Course Objectives:

Upon successful completion of the course, a student will be able to:

CO01: develop software for basic computer vision tasks;
CO02: identify key sensors and their roles in autonomous systems;
CO03: describe basic path planning algorithms;
CO04: analyze the structure of a simple robotic manipulator;
CO05: describe basic motion algorithms;
CO06: identify strategies for integrating vision, autonomous systems, and manipulators into a complete system;
CO07: produce clear documentation for problems assigned in the course and their solutions.

Student Outcome vs. Course Objectives matrix

SO	CO01	CO02	CO03	CO04	CO05	CO06	CO07
SO-1	✓	✓	✓	✓	✓	✓	✓
SO-2	✓	✓	✓	✓	✓	✓	✓
SO-3							✓
SO-4							
SO-5							
SO-6	✓	✓	✓	✓	✓	✓	✓

Notes:

SO-1: Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions.

SO-2: Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.

SO-3: Communicate effectively in a variety of professional contexts.

SO-4: Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.

SO-5: Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline. Apply computer science theory and software development fundamentals to produce computing-based solutions.

SO-6: Apply computer science theory and software development fundamentals to produce computing-based solutions.

Topics:

- Overview: problems and progress **IS11 (0, 0, 2)**
  - state-of-the-art robot systems
  - overview of sensor and sensor processing
  - robot control architecture
  - inherent uncertainty in sensing and control
- Sensors **IS11 (0, 0, 2)**
  - introduction
  - sensor characteristics
  - sensors types
- Actuators and drive systems **IS11 (0, 0, 2)**
  - introduction
  - characteristics of actuating systems
  - actuating system types
- Motion control systems **IS11 (0, 0, 4)**
  - basic components and terminology
  - block diagram algebra
  - system dynamics
- Kinematics of robots **IS11 (0, 0, 2)**
- Navigation and control **IS11 (0, 0, 2)**
- Motion planning **IS11 (0, 0, 2)**
- Computer Vision **IS12 (0, 0, 2)**
  - image formation
  - light and color
- Images **IS12 (0, 0, 2)**
  - image acquisition
  - image representation
- Image processing **IS12 (0, 0, 8)**
  - histograms

    - monodic and diadic operations
    - shape changing
        - cropping
        - resizing
        - pyramids
        - warping
- Image smoothing **IS12 (0, 0, 2)**
- Image sharpening **IS12 (0, 0, 2)**
- Image feature extraction **IS12 (0, 0, 8)**
    - edge detection
    - line features
    - point features
    - region features
        - classification
        - representation
- Systems Integration **IS11(0, 0, 2)**
    - Integration of sensing, motion, manipulation
    - Network architectures for distributed robotics
    - Representative systems

Assignments: Six to eight homework assignments will be given to reinforce learning of the mathematics and algorithms behind vision, map making, path planning, and manipulation. Four to six laboratory programming assignments will be given in three of the major areas of the course: vision processing, mobile robot navigation, and manipulation of objects.

Quizzes, Tests and Examinations: There will be two examinations plus a comprehensive final exam that will be administered during the final exam period.

Grading: The final grades will be determined according to the formula: final 20%, hour exams 15% each, laboratory work 30%, homework 20%.

Course Objective / Assessment Mechanism matrix

	Homework Assignments	Tests	Labs	Final Examination
CO01	✓	✓	✓	✓
CO02	✓	✓	✓	✓
CO03	✓	✓	✓	✓
CO04	✓	✓	✓	✓
CO05	✓	✓	✓	✓
CO06	✓	✓	✓	✓
CO07	✓		✓	

Bibliography:

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- Brauni, T. Embedded Robotics: Mobile Robot Design and Application with Embedded Systems, Springer, 2008.
- David, E. R. **Machine Vision: Theory, Algorithms, Practicalities**, Elsevier, 2005.
- David A. Forsyth and Jean Ponce. **Computer Vision: A Modern Approach.** Second Edition. Pearson Publications 2011.
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- Gareth Halfacree. **Raspberry Pi User Guide.** Wiley Publications 2012.
- Jazar, Reza N. **Theory of Applied Robotics: Kinematics, Dynamics and Control**. Springer, 2007.
- John J. Craig. **Introduction to Robotics: Mechanics and Control.** Fourth Edition Pearson Publications 2017.
- Kenneth Dawson-Howe. **A Practical Introduction to Computer Vision with OpenCV.** Wiley Publications 2014.
- Milan Sonka, Vaclav Hlavac, and Roger Boyle. **Image Processing, Analysis, and Machine Vision.** Fourth Edition**.** Cengage

Learning 2014.
- Parker, J. R. **Algorithms for Image Processing and Computer Vision**, 2nd ed., Wiley, 2010.
- Peter Corke. **Robotics, Vision and Control: Fundamental Algorithms in MATLAB**. Second Edition. Springer 2017.
- Rafael C. Gonzalez. **Digital Image Processing.** Fourth Edition. Pearson Publications 2018.
- Saeed B. Niku. **Introduction to Robotics: Analysis, Control, Applications.** Second Edition. Wiley Publications 2010.
- Siegwart, Roland; Nourbakhsh, Illah R., Scaramuzza, Davide, **Introduction to Autonomous Mobile Robots**. MIT Press, 2011.
- Stan Birchfield. **Image Processing and Analysis.** Cengage Learning. 2017.

Academic Integrity Statement:

"Salem State University assumes that all students come to the University with serious educational intent and expects them to be mature, responsible individuals who will exhibit high standards of honesty and personal conduct in their academic life. All forms of academic dishonesty are considered to be serious offences against the University community. The University will apply sanctions when student conduct interferes with the University primary responsibility of ensuring its educational objectives." Consult the University catalog for further details on Academic Integrity Regulations and, in particular, the University definition of academic dishonesty.

The Academic Integrity Policy and Regulations can be found in the University Catalog and on the University website (http://catalog.salemstate.edu/content.php?catoid=13&navoid=1295#Academic_Integrity). The formal regulations are extensive and detailed - familiarize yourself with them if you have not previously done so. A concise summary of and direct quote from the regulations: "Materials (written or otherwise) submitted to fulfill academic requirements must represent a student's own efforts". *Submission of other's work as one's own without proper attribution is in direct violation of the University's Policy* and will be dealt with according to the University's formal Procedures. *Copying without attribution is considered cheating in an academic environment - simply put,* ***do not do it!***

University-Declared Critical Emergency Statement:

In the event of a university-declared emergency, Salem State University reserves the right to alter this course plan. Students should refer to www.salemstate.edu for further information and updates. The course attendance policy stays in effect until there is a university-declared critical emergency.

In the event of an emergency, please refer to the alternative educational plans for this course, which will be distributed via standing class communication protocols. Students should review the plans and act accordingly. Any required material that may be necessary will have been previously distributed to students electronically or will be made available as needed via email and/or Internet access.

Equal Access Statement:

"Salem State University is committed to providing equal access to the educational experience for all students in compliance with Section 504 of The Rehabilitation Act and The Americans with Disabilities Act and to providing all reasonable academic accommodations, aids and adjustments. **Any student who has a documented disability requiring an accommodation, aid or adjustment should speak with the instructor immediately.** Students with Disabilities who have not previously done so should provide documentation to and schedule an appointment with the Office for Students with Disabilities and obtain appropriate services."

Note: This syllabus represents the intended structure of the course for the semester. If changes are necessary, students will be notified in writing and via email.