**Course Overview:**

Vision is arguably the most important of the five senses, and is commonly used by humans in many daily tasks (e.g., for recognizing objects or locations, as well as for safe navigation). Endowing robots with such an expert and autonomous sense of vision has been a dream of scientists and engineers for over half a century. Potential fields of interest are space exploration, home-, industrial-, and medical-robotics.

In this course, students will be introduced to the basic techniques of autonomous vision-based robot perception, recognition, localization and navigation. The topics covered include a description of the main robotic and vision-sensing devices, as well as of the basic techniques for image processing. Particular attention will be given to recognition and 3D scene and robot estimation techniques that use single and multiple images. Emphasis will be given to introducing the main up-to-date strategies for vision-based robot navigation (Position-, Image- and Hybrid-Based Visual Servoing).

Throughout the course, students will work individually and in groups to analyze vision-based robotics problems and to design software solutions. Matlab will be the primary programming language/environment used in the assignments. After successfully completing this course, students will be able to apply a variety of techniques for the design of efficient algorithms in order to address complex problems of vision-based sensing, localization and navigation.

**CSE, EE, MAE, BioE students are encouraged to register.**

**Course Prerequisites:**
- CSE 4392/5369 is self-contained and does not need special prerequisites.
- Matlab programming experience is required. If you are unfamiliar, please check this: [http://www.math.ucsd.edu/~bdriver/21d-s99/matlab-primer.html](http://www.math.ucsd.edu/~bdriver/21d-s99/matlab-primer.html). During the course we will also make use of the MATLAB’s Epipolar Geometry Toolbox, which can be efficiently used for creating vision-based robot simulations.

**Course Goals:**

CSE 4392/5369 is designed to:
- Introduce the student to fundamentals of robotics and vision-based sensing.
- Explore the mathematical/algebraic foundations of single- and multi-view geometry for pose and 3-D scene estimation.
- Explore and familiarize with vision-based robot navigation techniques.
Course Outcomes:
Upon successful completion of the course, each student will be able to:
- Recognize the features and peculiarities of different robotic and vision devices.
- Understand rigid body kinematics and relationships between 3-D reference frames.
- Describe image formation and camera models. Discuss/compare the characteristics of
different vision sensing devices (pinhole, omnidirectional, stereo, etc.)
- Understand and discuss different strategies for feature detection, matching and tracking.
- Understand and implement 3D structure and motion estimation algorithms.
- Understand and design vision-based robot navigation algorithms.

Course topics:
1. Basics on robotics and image formation
   Rigid body kinematics: ref. frames, transformations, ...
   Camera models (pinhole, stereo, omnidirectional).
2. Feature detection, matching and tracking
   Feature extraction (corner, edges, etc.);
   Scale-Invariant Feature Transform (SIFT) features;
   Matching among SIFT features;
   Feature tracking techniques.
3. Vision-Based Estimation
   Camera intrinsic calibration;
   The Direct Linear Transformation (DLT) algorithm;
   Multi-view pose and scene estimation.
4. Vision-Based Robot Navigation
   Position-based visual servoing (PBVS);
   Image-based visual servoing (IBVS);
   Hybrid (2-1/2-D) visual servoing.

(please note that these course topics are preliminary and might undergo slight changes)

Course text:
There is no required textbook for this course.
Other course material [pdf of the lecture slides, technical papers, exercises,...] will be made available on the course webpage (see pg.1).
However, some suggested references are:

B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo

E. Trucco, A. Verri

R. Hartley, A. Zisserman

Y. Ma, S. Soatto, J. Kosecka, S. Sastry
“An Invitation to 3-D Vision. From Images to Geometric Models”, Springer 2003
Office Hours
The instructor is generally available before or after class and by appointment, as well as at the office hours scheduled above.
Since this is a special-topic course in robotics, and since each presented topic contains many exciting sub-fields, the interested students who want to know more about a specific problem are encouraged to schedule an appointment with Dr. Mariottini for additional material.

Course Assignments, Exams and Policies
Class attendance and participation
In CSE 4392/5369, the students will be presented with the state-of-the-art in vision-based robot control, localization and navigation technologies. Most of the topics are active fields of research in the robotics community. I strongly encourage the students to attend each class and to actively contribute with in-class discussion, when necessary. Students must arrive on time at class.

During the whole semester, I like to interact with the participants and ask them to actively participate to complete informal small in-class exercises. These informal activities will not be graded but will be used as a feedback or plan activities.

Homeworks and Course Project
Students will be graded based on homework assignments and a major course project.
Homeworks will mostly consist of theoretical questions, programming assignments in MATLAB, etc. related to the topics of the course. Dates for the homeworks will be announced in class. Regarding homeworks policies, please refer also to the Course Policy section.

The course project will focus on designing and implementing a particular algorithm from a list provided in class, and walking through details related to its analysis and design. For their final project, students will have the possibility to also use up to 4 iCreate robotic platforms (by iRobot) for the course project. USB cameras and laptops are also available to program the robot and process data from the sensors.

Additional projects related to the course topics and proposed by students can be added to the list. In evaluating the projects design, particular attention will be given to the projects that excel in creativity and effectiveness of their result. The course project can be done either individually or in a team. Students will report their findings in a 8-10 page research report, and an in-class oral presentation (with Power Point slides) during last day of class.

For students enrolled in the graduate section CSE 5369 the homework assignments, as well as the course project, will contain additional problems which are not required for students of CSE 4392.

Grading policy
Tentatively, course grades will based on the following:

<table>
<thead>
<tr>
<th>Assignments</th>
<th>% of final grade</th>
<th>Percent Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeworks (total)</td>
<td>50 %</td>
<td>90% - 100% A</td>
</tr>
<tr>
<td>Course Project</td>
<td>40 %</td>
<td>80% - 89.9% B</td>
</tr>
<tr>
<td>- Proj. Presentation</td>
<td>10 %</td>
<td>70% - 79.9% C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60% - 69.9% D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 60% F</td>
</tr>
</tbody>
</table>
Final Project/Homework Late Submission Policy
Late submissions for the final project and homeworks will be penalized according to:
- Late by 1-24 hrs: 5% deducted from actual score.
- Late by 24-48 hrs: 15% deducted from actual score.
- Late by 48-72 hrs: 25% deducted from actual score.
- Late by more than 72 hrs: Will receive a zero.

Course/University Policies and Services

Attendance and Participation
As stated above (see pg.3), attendance is strongly suggested at the first day and each class session. Students are encouraged to arrive on time and attend the full class period.

Participants who need to miss class for religious observance or for a pressing personal or family matter, should contact the instructor prior to missing class or as soon as possible. Participants should plan on getting the information about the missed class from a peer.

I strongly encourage in-class collegial behaviour as well as between the project group members. NON collegial behavior includes working on other tasks during class time (text messaging, e-mailing, Web surfing, doing crosswords/Sudoku, having private conversations, etc.). Another example of non collegial behavior could be the creation of unconstructive conflicts inside a group.

Finally, I positively value the students' active participation to in-class discussions. This is extremely important because gives the instructor (and the students too!) a feedback on the audience understanding.

Academic Honesty
All students are expected to pursue their academic careers with honesty and integrity. "Scholastic dishonesty includes, but is not limited to, cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts" (Regents' Rules and Regulations, Part One, Chapter VI, Section 3, Subsection 3.2, Subdivision 3.22.).

Students found guilty of dishonesty in their academic pursuits are subject to penalties that may include suspension from the university. Any student found guilty of academic dishonesty will receive a -100% for that work (homeworks, project, etc.) as well as having the course grade lowered one full letter grade - in addition to any other penalties assessed (suspension, expulsion, probation). These and other applying UTA rules, will be strictly enforced. Any case of academic dishonesty will be treated in accordance with the UTA Handbook of Operating Procedures or the Judicial Affairs website at http://www2.uta.edu/discipline. If you do not understand this policy, it is your responsibility to obtain clarification or any additional information you may require.

Students are allowed to discuss homework with classmates, but are not allowed to copy the solutions of others or share solutions with others. All work turned in for grading must be the student's own work.

Accommodations for Students With Disabilities
I will do my best to provide, on a flexible and individualized basis, reasonable accommodations to students who have documented disability conditions (e.g., physical, learning, psychiatric, vision, hearing, or systemic) that may affect their ability to participate in course activities or to meet course requirements. If you require any accommodation based on disability, please meet with the Instructor (with your supporting papers) in the privacy of his office the first week of the semester to be sure you are appropriately accommodated.
**Grievance Procedure**

Anyone feeling that a dispute exists after the grading of any assignment or exam may submit a written grievance. This grievance should identify the item in dispute and arguments supporting the student’s position. Grievances must be submitted in writing within two class periods following the return of the assignment.

The instructor agrees to return a written response to the student’s grievance within two class periods from receipt of the grievance. If the error is due to wrongful calculation of points, then no grievance needs to be submitted. If a written grievance is received, the instructor reserves the right to re-grade the entire exam (not just the specific point in question).

**Student Support Services Available**

The University of Texas at Arlington supports a variety of student success programs to help you connect with the University and achieve academic success. These programs include learning assistance, developmental education, advising and mentoring, admission and transition, and federally funded programs. Students requiring assistance academically, personally, or socially should contact the Office of Student Success Programs at 817-272-6107 for more information and appropriate referrals.

**Electronic Communication Policy**

The University of Texas at Arlington has adopted the University “MavMail” address as the sole official means of communication with students. MavMail is used to remind students of important deadlines, advertise events and activities, and permit the University to conduct official transactions exclusively by electronic means. For example, important information concerning registration, financial aid, payment of bills, and graduation are now sent to students through the MavMail system.

All students are assigned a MavMail account. Students are responsible for checking their MavMail regularly. Information about activating and using MavMail is available at [http://www.uta.edu/oit/email/](http://www.uta.edu/oit/email/).