CS 485/685 Computer Vision
Spring 2012 – Dr. George Bebis

Catalog Description: The principles, design, and implementation of vision-based systems, including the following topics: Camera models and image formation, Feature detection, Segmentation, Camera calibration, Stereo vision. An introduction to other advanced topics will be included as time allows.

Prerequisites: CS302 (Data Structures). Good programming skills and mathematical background are essential. Knowledge of Image Processing (CS474/674) is desired but not required. *Credit hours:* 3.0

Course Webpage: http://www.cse.unr.edu/~bebis/CS485

Meets: TR 11:00AM-12:15PM (SEM 347)
Instructor: Dr. George Bebis
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Office Hours: TR 4:00 pm - 5:30 pm and by appointment

Texts

No specific text is required for this class. We will be covering material from several different textbooks (see list below) and research papers. Lecture slides and reading material will be available from the course's webpage.

- **[Szeliski11]** *Computer Vision: Algorithms and Applications*, by R. Szeliski, Springer-Verlag, 2011 (freely available online: **http://szeliski.org/Book/**)
- **[Jain95]** *Machine Vision*, by R. Jain et. al, McGraw Hill, 1995.
- **[Trucco98]** *Introductory Techniques for 3-D Computer Vision,* by E. Trucco, and A. Verri, Prentice Hall, 1998.
- **[Nawla93]** *A Guided Tour of Computer Vision*, by V. Nawla, Addison-Wesley, 1993.

Objectives

The goal of computer vision is to develop the theoretical and algorithmic basis by which useful information about the world can be automatically extracted and analyzed from a single image or a set of images. Since images are two-dimensional projections of the three-dimensional world, the information is not directly available and must be recovered. This is a very difficult problem given that the inversion is a many-to-one mapping. To recover the information, knowledge about the objects in the scene and projection geometry is required. This course will cover the fundamentals of Computer Vision. It is suited for mainly students who are interested in doing research in the area of Computer Vision. For graduate students, there are many open problems in this area suitable for investigation leading to a Master thesis or a Ph.D. dissertation.

Course Outline (tentative)

- Introduction to Computer Vision
- Image Formation and Representation
- Image Filtering (spatial domain)
    - Mask-based (e.g., correlation, convolution)
    - Smoothing (e.g., Gaussian), Sharpening (e.g., gradient)
- Edge Detection (e.g., Canny, Laplacian of Gaussian)
- Interest Point Detection (e.g., Moravec, Harris)
- Segmentation
    - Edge-based (e.g., voting, optimization, perceptual grouping)
    - Pixel-based (e.g., clustering)
- Feature Extraction, Description and Matching
    - Geometric features (e.g., lines, circles, ellipses)
    - Blobs
    - Examples: SIFT, SURF, HOG, WLD, LBP
- Recognition
    - Geometry-based (e.g., alignment, geometric hashing)
    - Appearance-based (e.g., subspace, bag-of-features)
    - Applications (i.e., 2D/3D object recognition, face recognition)
- Camera Calibration (i.e., 3D to 2D transformation)
- Stereo Vision (i.e., 3D reconstruction from pairs of images)

Exams, Assignments, and Presentations

Grading will be based on two exams and several programming assignments. Some homework might be assigned but will not be collected for grading. Graduate students will be required to present a research paper to the rest of the class. Details are provided below:

- There will be two exams, a midterm and a final.
- There will be several programming assignments which should be done on an individual basis. Extra work will be assigned to the graduate students. For each programming assignment, you are to turn in a brief report which should include a description of the problem, a description of your approach, and your evaluation of the results.
- A research paper will be assigned to each graduate student for presentation to the rest of the class. The topic will be decided in coordination with the instructor.

Software

There are several different image processing and computer vision software packages available on the web. In this course, you will not need to use any software package most of the time. However, there might 1-2 programming assignments where you would need to use *OpenCV*. See **http://opencv.willowgarage.com/wiki/** for more information as well as for instructions on how to download and install OpenCV on your machine. You might find the book below useful as it contains many examples. Keep in mind that *OpenCv* is a "research" product which is still under development. Therefore, it is not always very well documented and certain functions might contain bugs.

- **[OpenCV08]** *Learning OpenCV: Computer Vision with the OpenCV Library,* by G. Bradski and A. Kaehler, O'Reilly Press, 2008.

Course Policies

- Lecture slides, assignments, and other useful information will be posted on the course's web page.
- Regular attendance is highly recommended. If you miss a class, you are responsible for all material covered or assigned in class. .
- A missed quiz/exam may be made up **only** if it was missed due to an extreme emergency.
- **No** late programming assignments will be accepted unless there is an extreme emergency.
- Discussion of the programming assignments is allowed and encouraged. However, each student should do his/her own work. **Assignments which are too similar will receive a zero.**
- **No** incomplete grades (INC) will be given in this course unless there is an extreme emergency.

Extra Credit

Class participation is highly encouraged and will be rewarded with extra credit. Also, extra credit will be offered to the students who attend the departmental colloquia. You will be reminded in class about upcoming talks but you should also check the colloquia page on a regular basis (http://www.cse.unr.edu/get-involved/colloquia/)

Useful Tips

Don't get behind in the programming assignments. Probably the main reason for students doing poorly in a course like this is getting behind in the assignments. Design and implement in a top-down, modular fashion. Get something working that has the skeleton structure of what you need and then add features to it. Each time you add a feature, test it and make sure everything is still working. It can be tough to debug big programs if all you know is that the output is wrong and you are not sure any one module is working. In addition, partial credit will be given for a program which at least partially works while it is very difficult to give credit for a program which may have many features but is not doing anything correctly.

Academic Dishonesty

Your continued enrollment in this course implies that you have read the section on Academic Dishonesty found in the UNR Student Handbook (see http://www.unr.edu/stsv/acdispol.html) and that you subscribe to the principles stated therein.

Disability Statement

Any student with a disability needing academic accommodations is requested to speak with me or contact the Disability Resource Center (Thompson Building, Suite 101), as soon as possible to arrange for appropriate accommodations.

Unauthorized class audio recording or video-taping

Surreptitious or covert video-taping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy. This class may be videotaped or audio recorded only with the written permission of the instructor. In order to accommodate students with disabilities, some students may have been given permission to record class lectures and discussions. Therefore, students should understand that their comments during class may be recorded.

Grading Scheme

Midterm: 25%
Final: 25%
Prog Assign: 50%

Presentation: 10%
(grad students only)

A 90 and above
B 80-89
C 70-79
D 60-69
F<59

Important dates

March 15, 2012 – Midterm exam
March 23, 2012 – Final Day to Drop Classes
March 17-25, 2012 – Spring Break (no classes)
May 9, 2012 – Prep Day
May 10, 2012 - Final exam (8:00am – 10:00am)

Course Assessment Matrix

CS 485 Computer Vision

Program Outcomes	Course Outcomes	Assessment Methods/Metrics	CSE Program Objectives Impacted
1	Students demonstrate a thorough understanding of fundamental concepts in computer vision (camera and projection models, image formation, image features, calibration, stereo).	Homework, examinations and programming assignments.	1, 2
2	Students must be able to design and conduct experimental validation for a computational approach to a computer vision problem, and interpret the results to assess the performance (accuracy, efficiency, robustness) of the method.	Specific programming assignments.	2,3
3	Students are familiar with methods used in various vision-based applications – image feature detection, camera calibration, 3-D reconstruction, segmentation.	Programming assignments.	2,3
5	Students are better prepared to analyze a problem and assess the strengths and weaknesses of different methods and techniques for solving it.	Specific programming assignments.	1, 4
9	Students should demonstrate the ability to present and discuss a body of research work in computer vision.	Class presentations of various computer vision papers, and discussions on their scientific merits.	4

Program Outcomes:

Our graduates will have achieved:

1. an ability to apply knowledge of computing, mathematics, science, and engineering.
2. an ability to design and conduct experiments, as well as to analyze and interpret data.
3. an ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs, within realistic constraints specific to the field.
4. an ability to function effectively on multi-disciplinary teams.
5. an ability to analyze a problem, and identify, formulate and use the appropriate computing and engineering requirements for obtaining its solution.
6. an understanding of professional, ethical, legal, security and social issues and responsibilities.
7. an ability to communicate effectively with a range of audiences.
8. the broad education necessary to analyze the local and global impact of computing and engineering solutions on individuals, organizations, and society.
9. a recognition of the need for, and an ability to engage in continuing professional development and life-long learning.
10. a knowledge of contemporary issues.
11. an ability to use current techniques, skills, and tools necessary for computing and engineering practice.
12. an ability to apply mathematical foundations, algorithmic principles, and computer science and engineering theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices.
13. an ability to apply design and development principles in the construction of software systems or computer systems of varying complexity.

Computer Science and Engineering Program Objectives:

Within 3 to 5 years of graduation our graduates will:

1. be employed as computer science and engineering professionals beyond entry level positions or be making satisfactory progress in graduate programs.
2. have peer-recognized expertise together with the ability to articulate that expertise as computer science and engineering professionals.
3. apply good analytic, design, and implementation skills required to formulate and solve computer science and engineering problems.
4. demonstrate that they can function, communicate, collaborate and continue to learn effectively as ethically and socially responsible computer science or computer engineering professionals.