CS 491E/791E Computer Vision

Spring 2004

Prerequisites: The pre-requisite for this course are CS308 (Data Structures) and CS474/674 (Image Processing and Interpretation), however, I will waive the CS474/674 requirement depending on your background and interests. Good programming skills and mathematical background are essential.

Credit hours: 3.0

Instructor: George Bebis
Office: 235 SEM
Phone: 784 - 6463
E-mail: bebis@cs.unr.edu
URL: http://www.cs.unr.edu/~bebis/
Office Hours: TR: noon - 1:30pm and by appointment.

Required Texts:

Introductory Techniques for 3-D Computer Vision, by E. Trucco, A. Verri, Prentice Hall, 1998.

Optional Texts:

Machine Vision, by R. Jain et. al, McGraw Hill, 1995.
Computer Vision, by Shapiro and Stockman, Prentice Hall, 2001.
A Guided Tour of Computer Vision, by V. Nawla, Addison-Wesley, 1993.
Machine Vision, by E. Davies, Academic Press, 1997 (on reserve - DeLaMare library).
Computer Vision and Image Processing: A Practical Approach Using CVIPtools by S. Umbaugh, Prentice Hall, 1998 (on reserve - DeLaMare library).
Image Processing, Analysis, and Machine Vision, by M. Sonka et. al, Brooks/Cole Pub Co., 1998 (on reserve - DeLaMare library).
Practical Computer Vision, by J. Parker, John Wiley & Sons, 1996 (on reserve - DeLaMare library).

Other Books (available in the DeLaMare library)

M. Sonka et. al *Image Processing, An alysis, and Machine Vision*, Brooks/Cole Pub Co., 1998.
J. Parker *Practical Computer Vision using C*, John Wiley & Sons, 1996.
E. Davies *Machine Vision*, Academic Press, 1996.
Horn, Berthold *Robot vision*, McGraw-Hill, 1986.
Ballard, Dana *Computer vision*, Prentice-Hall, 1982.
Haralick, Robert and Linda G. Shapiro *Computer and robot vision*, Addison-Wesley, 1992-1993.
Baxes, Gregory *Digital image processing: principles and applications*, Wiley, 1994.
S. Umbaugh *Computer Vision and Image Processing: A Practical Approach Using CVIPtools*, Prentice Hall, 1997.
Bow, Sing-Tze *Pattern recognition and image preprocessing*, New York: M. Dekker, 1992.
Hall, Ernest *omputer image processing and recognition, New York: Academic Press, 1979. R. Gonzalez et. al Digital Image Processing*, Addison-Wesley, 1993.
K. Castleman *Digital Image Processing*, Prentice-Hall, 1996.
J. Russ *Image Processing Handbook*, CRC Press, 1998.

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.

Computer Vision systems have many potential applications. *Robots* who can see are more likely to interact with the real world in a satisfactory manner; they can choose objects, avoid obstacles, plan routes, calculate their velocity and orientation, identify dangerous situations, etc. Such robots will be useful in exploring dangerous or very distant environments (e.g. other planets, inside nuclear reactors). Computer Vision can be used to help cameras follow the trajectory of people and vehicles, for example for *traffic monitoring*; it can help in the *identification of faces* for security clearance; it can be used for converting 2D images into *3D models* that can then be rotated and manipulated, for example to present medical or sporting images from a better angle; they can be use for inspecting *medical images* for identifying tumors and other ailments.

Over the next decade, it is anticipated that Computer Vision systems will become commonplace, and that vision technology will be applied across a broad range of business and consumer products. This implies that there will be strong industry demand for computer vision engineers - for people who understand vision technology and know how to apply it in real-world problems. This is 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)

- Computer Vision/Image Processing Review
- Introduction to Computer Vision (Trucco, Chapt 1)
- Image Formation (Nawla, Chapt 2)
- Camera Parameters (Trucco, Chapt 2)
- Camera Calibration (Trucco, Chapt 6)
- Stereo (Trucco, Chapt 7)
- Motion (Trucco, Chapt 8)
- Shape from shading (Trucco, Chapt 9)
- Shape from texture (Trucco, Chapt 9)
- Recognition (Trucco, Chapt 10)
- Applications

Course Policies

Exams: There will be a midterm and a final exam.

Homework: Homework problems will be assigned on a regular basis and will be collected at the beginning of the class on the due date. Solution sets will be provided for all problems assigned.

Programming Assignments: there will about 4-5 programming assignments which should be done on an individual basis. 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. Details of the deliverables will be given for each assignment respectively. 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.

Paper Presentation: each student would be required to present a paper to the rest of the class. The presentations should be professional as if it were presented in a formal conference (i.e., slides/projector). More details will be provided in the class.

Other information: Late homework will not be accepted. Late programming assignments will be penalized 10% of the points assigned per day (weekends count as one day). If you are unable to hand in an assignment by the deadline, you must discuss it with me *before* the deadline. All exams will be closed books, closed notes. If you are unable to attend an exam *you must inform me in advance*. No incomplete grades (INC) will be given in this course and a missed exam may be made up only if it was missed due to an extreme emergency.

Software

Xv: it is an interactive image display program for the X window system that is useful for displaying and editing images in a variety of formats.

CVIPtools: a GUI-based computer vision and image processing tools, ANSI-C source code and libraries for Windows95/NT and UNIX. It contains an extended Tcl shell with all the computer imaging functions. ANSI-C source code and libraries for image analysis, image compression, image enhancement, image restoration, and many imaging utilities. It has been installed on the *Suns* in the */image* directory. To run it, first add the following into your *.cshrc* file:

```
setenv CVIPHOME /image/CVIPtools
setenv CVIP_IMGPATH ./
setenv CVIP_DISPLAY picture
setenv TCL_LIBRARY /image/CVIPtools/CVIPTCL/lib/tcl7.6
setenv TK_LIBRARY /image/CVIPtools/CVIPTCL/lib/tk4.2
setenv XF_LOAD_PATH /image/CVIPtools/CVIPTCL/GUI_SCRIPTS
set path=($path /image/CVIPtools /image/CVIPtools/CVIPTCL /image/CVIPtools/bin)
```

Then enter: *source .cshrc* to update your settings. You can run CVIPtools by entering: *CVIPtools*

Gimp: The GNU image manipulation program.

Intel Computer Vision Library: image processing and computer vision algorithms optimized to run on Intel microprocessors.

Matlab: it is a numeric computation and visualization environment. The image processing and signal processing toolboxes are especially useful.

Microsoft Vision SDK Library: a library for writing image processing and computer vision programs on Microsoft Windows machines.

Xforms: a GUI toolkit based on Xlib for X Window System- Xforms has been installed on the *Suns* in */usr/local/src/xforms* and on the *Linux* boxes in LME 314

Useful Tips

Good programming skills are essential in order for someone to complete the project successfully. Programming can be done using either C, C++ or any other language of your preference. A number of image pro-

cessing software packages are available to assist you in the implementation of your programming assignments and project (visit the course's webpage for more information).

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.

Grading Scheme

Midterm: 20%
Final: 20%
Homework: 20%
Programming Assignments: 30%
Paper Presentation: 10%

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

Important dates

3/11/2004 - Midterm
3/12/2004 - last day for dropping classes
3/13/2004 to 3/21/2004 - Spring Break
5/6/2004 - Final exam (2:15pm to 4:15pm)