# Visualization in the Sciences

## Bulletin Description

This is a graduate course with no prerequisites that studies how to best present scientific and medical data sets using computer-generated images.

## General Course Info

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| Term: | 2014 Spring |
| Department: | COMP/Phys/MTSC |
| Course Number: | 715 |
| Section Number: | 069 |
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| Time: | TTh, 3:30 – 4:45 |
| Location: | Brooks 007 |
| Website: | http://www.cs.unc.edu/Courses/comp715-s14/ |

## Instructor Info


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| Name: | Russell Taylor |
| Office: | Sitterson 258 |
| Email: | taylorr@cs.unc.edu |
| Phone: | 919-590-6001 |
| Web: | http://www.cs.unc.edu/~taylorr |
| Office Hours: | Monday 10-11, Thursday 9-10 |


## Textbooks and Resources

*Information Visualization: Perception for Design*, third edition, by Colin Ware, published in 2012 by Morgan Kaufmann. ISBN-13: 978-0123814647.

*Visual Cues: Practical Data Visualization*, by Peter R. Keller and Mary M. Keller, published in 1992 by IEEE Computer Society Press. ISBN 0-8186-3102-3. This book has gone out of print; there is a class set available for students taking the class. They are on reserve in Sitterson 208, the reading room overlooking the bus stop. They are to the right as you come in, at about knee level, on the East wall right behind the pillar (sometimes there is a chair pushed back against this bookshelf that hides them).

Several downloadable documents from Kitware that describe the visualization software to be used in the course. In the past, this has been VTK, Paraview, and VolView will be used as part of teaching the use of a visualization toolkit. These include the Paraview user's guide, and the VolView user's guide.

Other useful (not required) texts: The three wonderful books by Edward R. Tufte are also on reserve in the reading room.

## Course Description

This course describes the current state of the art in computer-based visualization as applied in the natural and medical sciences. It includes teaching the available visualization techniques and their characteristics (including enough description of perception to enable understanding why some techniques work and others do not). It is aimed both at computer science students (who would design and implement such visualizations) and at natural science students (who would design and use them). It includes teaching each student how to use an available visualization toolkit to enable rapid development of visualizations. A final project teams students to develop a visualization tuned for a particular problem, either using a toolkit or custom code.

## Target Audience

This course is aimed at graduate students and senior undergraduates in both computer science and the natural sciences. Students from mathematics and drama have also taken the course.

## Prerequisites

***There are no prerequisites*** other than being a graduate student in a natural sciences (examples: Biology, Chemistry, Physics, Materials Science, Gene Therapy) or Computer Science. Computer science students will benefit from experience in computer graphics and image analysis. Natural science students will benefit from having a data set they are interested in visualizing.

## Goals and Key Learning Objectives

Students will learn the value of visualization (what are the likely benefits, example applications), the use of visualization toolkits (what is available, how easy are they to use, what techniques they provide, how do you get your data into them), and how to apply techniques for many data sets: Scalar-field visualization in 2D (color, height field, isovalue contours, glyphs, clustering, patterns) and 3D (isosurface contours, direct volume rendering, slicing, glyphs). Vector-field and Tensor visualization techniques in 2D and 3D (particle advection, streamlines, streaklines, rakes, tufts, line-integral convolution, spot noise). Multivariate visualization (discrete data, glyphs, textures, dimensional reduction). Advanced and combined visualization techniques (which combine, which don't, how can you predict?). Other methods (animation, haptic display of data, auditory display of data). They will learn enough of the basics of human visual perception (what impacts region perception, shape perception, color perception, etc.) to select effective techniques and avoid pitfalls. Tying analysis into visualization. Evaluating the effectiveness of visualization.

## Course Requirements

The course will include lectures on the above topics, weekly "hands-on" homework application of visualization techniques to data sets from a variety of scientific fields, and a final project. The hands-on application will give participants a feeling for how each technique works in a variety of settings. The project will team students to develop a new visualization technique beyond what comes standard in toolkits. The level of these projects is such that the most successful ones are suitable to be written up as application papers for the IEEE Visualization conference.

The course will include posting your designs on a class Wiki and reviewing the designs of others in this forum. These designs will (whenever possible) be for real-world problem sets, and will be used by actual scientists and medical researchers. The best of the designs have been published on posters throughout campus, at Sandia National Labs, and other web sites.

## Key Dates

Homeworks (done in teams of two) will be due weekly for the part of the course before Spring break. A final project will be due at the date of the exam for the course, and a preliminary presentation will be made in class after Spring break.

## Grading Criteria

50% of the course grade will be based on performance on the homework assignments. 50% will be based on the final project.

The homework grade will be based on completion of specified tasks (30%), effectiveness of visualization design (and explanation of the reasons behind the design) (60%), peer ratings by your partners (5%), and your critiques of the designs by other teams (5%).

The project grade will be based on a Goals and Data Specification (5%), Visualization Design (35%), Visualization Implementation (30%), Evaluation of the Design (10%), an in-class Presentation (10%), and teammate evaluation (10%).

## Course Policies

Attendance at lectures is expected and will be critical for gaining experience in designs, critiques, and learning of the material. It is not directly part of the course grade.

Because the homework and final project are all team efforts, and because the review schedule for the homeworks includes posting the solutions for all teams on a common web site, late homeworks are not accepted for this course.

The final project is due according to the UNC Final Exam calendar.

Honor Code

Students will work together in teams for both the homeworks and the final project. There will be a public mailing list for questions about how to use the visualization technology, but questions of design must be discussed only within a team and with the instructor. Online materials and published work can be used if cited.

Course Schedule

An example schedule of lecture topics for the course follows:

Introduction
Motivation and the use of Toolkits
Visualization and data characteristics, the use of props
Lessons learned from ineffective visualizations; Interviewing a client
Trichromacy, color spaces, properties of color, application
2D Scalar: Color, contour, height field, glyphs, texture
Receptive fields, brightness illusions, simultaneous contrast, etc.
Preattentive: Information the pops out. In-class visualization design
Multivariate visualization techniques
In-class presentation and design review of homework 1, in-class design
3D Scalar: Direct volume rendering, isosurfaces, glyphs
In-class presentation and design review of homework 2, in-class design
Vector: Particles, streamlines, rakes, ribbons, glyphs, textures, color
In-class presentation and design review of homework 3, in-class design
Evaluation of Visualization Techniques
In-class presentation and design review of homework 4, in-class design
Visualization System design examples
In-class presentation and design review of homework 5, in-class design
Tensor: Glyphs, surfaces, textures
Perceived contours, patterns, uncertainty
In-class presentations and critiques of projects
Information visualization, Tufte
Visualization lab tour
Bioinformatics visualization
Custom applications for nanoscale science
Presentation of final projects

Disclaimer

The professor reserves to right to make changes to the syllabus, including project due dates and test dates. These changes will be announced as early as possible.