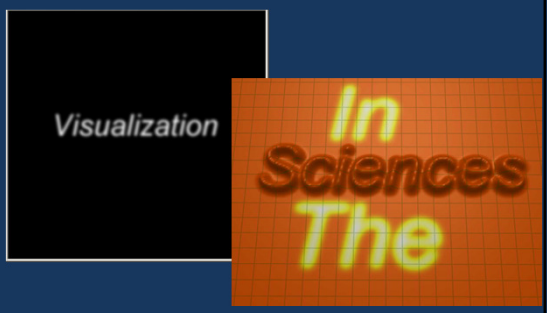
Welcome to Comp/Phys/Mtsc 715



Me

- Research Professor of:
  - Computer Science (by training)
  - Physics & Astronomy, Applied Sciences(by association)
- VisWeek 2012 SciVis Chair
- I think of myself as a Toolsmith
  - Virtual environment interfaces to novel scientific instruments is my specialty
  - Scientific visualization is one of my passions
- Please call me "Russ," not "Dr. Taylor."
- I'm a scientist, and a Christian, but not a Christian Scientist

My Lecture Style

- I talk *way* too fast, especially when excited
  - Toss in questions to slow me down
  - Gentle stomping of feet if that doesn't work
- Questions:
  - Clarification, repetition of a strange phrase, etc.: raise your hand or interrupt
  - New idea, new topic, or disagreement: Make a note and interrupt at the end of the current topic or lecture
  - "If in doubt, speak it out"

Warning!

- You may never see things the same again…

Outline for Today

- What is Scientific Visualization?
- What is this Course About?
  - Course Home Page
  - Course Texts
  - Reading Assignments
  - Homework Assignments
  - Final Project
- Grading
- Fast-Forward Course Preview
- Call for Visualization Applications

What is Scientific Visualization?

- Definitions
- For the purpose of this course…
- Brief history of the field

Sci Vis: Some Definitions

"To visualize": form a mental vision, image, or picture of (something not visible or present to sight, or of an abstraction); to make visible to the mind or imagination

– The Oxford English Dictionary, 1989

Sci Vis: Some Definitions

"The purpose of computing is insight, not numbers"

– Richard Hamming

"Visualization is the use of graphical techniques to convey information and to support reasoning."

– Pat Hanrahan

Sci Vis: Some Definitions

"Visual Analytics is the science of analytical reasoning facilitated by interactive visual interfaces: *detecting the expected, discovering the unexpected*."

– Jim Thomas

Sci Vis: Some Definitions

- "Underlying the concept of visualization is the idea that an observer can build a mental model, the visual attributes of which represent data attributes in a definable manner. This raises several questions:
  - *What mental models most effectively carry various kinds of information?*
  - *Which definable and recognizable visual attributes of these models are most useful for conveying specific information either independently or in conjunction with other attributes ?*
  - *How can we most effectively induce chosen mental models in the mind of an observer?*
  - *How can we provide guidance on choosing appropriate models and their attributes to a human or automated display designer?*

  Choosing the appropriate representation can provide the key to critical and comprehensive appreciation of the data, thus benefiting subsequent analysis, processing, or decision making." [P.K. Robertson, 1991]

Sci Vis: Some Definitions

"Art is the lie that tells the truth"
– Pablo Picasso

But avoid misleading lies…
Misinterpretation due to false-color distortions
Mars vertical scale
Sound track with clear beat pattern

Sci Vis: In this Course

- What we emphasize in this course
  - *Spatially-embeddable* scientific data sets from experiments and simulations
  - Medical images, 2D and 3D (images → view)
  - Other *spatially-embedded* modalities (touch, sound)
  - Visualization/display for presentation/teaching
- What we don't emphasize
  - Information visualization
    - non-spatially-embeddable – another whole course
  - Computational image analysis
    - images → models/numbers

Sci Vis: Brief History

- visualization finds ancestry in pictograms
  - e.g. caves, travel, Da Vinci´s airplanes, architecture
  - human generated
- computer-generated since late 40's
  - Large tables expressed as plots
  - statistical data for exploration
- mid 1980's: need and opportunity grew: data "fire hose"
  - measuring devices: e.g. space missions, medical instruments
  - scientific computing: e.g. start of national supercomputer centers, computational sciences (CFD, Molecular Modeling)
- Now: mature and cheap displays: powerful graphical workstations, color, stereo display, interaction devices

Lessons from The Princess Bride

What does it take to succeed?

- Learning a set of techniques
- Knowing when to use them, singly and in combination, given the terrain and other factors
- Practice, practice, practice

What is this Course About?

- Learning…
  - available visualization techniques, their strengths and weaknesses
  - how to combine techniques to effectively display multiple data sets
  - enough perception to avoid pitfalls
  - to use a visualization toolkit
  - to work on a multidisciplinary team to develop visualizations

What we'll be doing

- Learning available visualization techniques
  - By seeing examples and descriptions
  - By *trying* the techniques out on data sets
- Learning to use a visualization toolkit
  - By *using* VTK-derived tools to visualize data sets
- Learning to design visualizations
  - By learning how visual perception works (and doesn't)
  - By *designing* and *critiquing* visualizations
- Learning to be part of problem-solving teams
  - By *being part of such teams*

Sci Vis: Some Examples

- Video clips from Vis conference
  - Start most classes
  - Help provide breadth
  - Some good examples, some poor
  - Some exotic, some more standard
- #1: SIGGRAPH 93: How *not* to do visualization
- #2: Vis 2011: ttg2011121822s.mov: Flow Features
- #3: Vis 2011: ttg2011122106s.mp4: WYSIWYG Volvis

Course Home Page

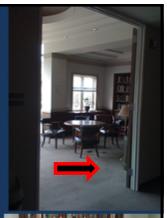
- http://www.cs.unc.edu/~taylorr has link
- www.cs.unc.edu/Courses/comp715-s14
  - Course description
  - Textbooks
  - Schedule of reading assignments
  - Schedule of lectures
  - Links to slides for lectures already given
  - Homework assignments
  - Final project description
  - Related links

Course Texts

- Information Visualization: Perception for Design, (version 3) by Colin Ware, published in 2012 by Morgan Kaufmann. ISBN 1-55860-511-8.
  - Student stores
  - Amazon.com
- 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. (Classroom set in reading room, see web page.)
- Tutorials and other reference materials for VTK and the toolkits we'll be using.

Administrative

- Keller & Keller
  - On reserve in the Sitterson Reading room
    - 2nd floor, NW corner
- Homework Policy
  - Due by midnight on the day it is due



Administrative

- First HW, Running ParaView on sample datasets due Thursday after next
  - See course schedule page for link
  - Try downloading them soon if you haven't yet
  - Let me know if you have any problems (taylorr@cs.unc.edu)
  - I plan to post responses to the whole class using the mailing list

Reading Assignments

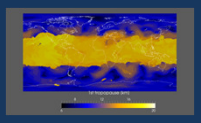
- The readings for each class meeting are found on the course schedule page.
- Readings are split between the Keller & Keller book (K&K), the Colin Ware book (Ware), toolkit documentation, and reference papers associated with various techniques (available on the web page).
- WARNING: Chapters 1-4 come on fast! Overfull scheduling constraints caused this

Homework Assignments

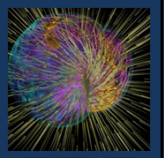
- Using visualization tools
  - Installing and running visualization toolkits
  - Applying visualization techniques to sample data sets and reporting on the results
- Evaluating effectiveness
  - Comparing multiple techniques on the same data set
  - Visualization design based on perceptual information from Ware, implemented in ParaView.
    - What other techniques could be used, and would they be better or worse at supporting the intended task?

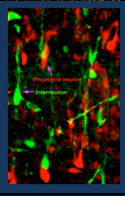
Homework Opportunities This Year

- Real-world data sets & challenges
  - MADAI: High-energy physics
  - Neural Development
  - Vis Contest



  - Your Research Here!
    - TELL ME ABOUT IT!





Administrative

- Your homework exercises could be famous!
  - Starting points for other team projects
  - Examples for MADAI and Sandia researchers
  - Posters sent around the country
  - New ParaView plug-ins
  - …

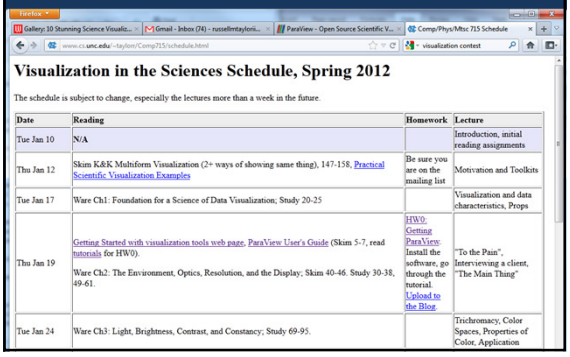
Final Project

- Teams develop a visualization tuned for a particular set of goals and data.
- Written reports:
  - Visualization goals and data characteristics
  - Visualization system design and implementation
  - Visualization system evaluation
- Project demonstrations the last days of class.
- Check out homework projects for your favorites!

Grading

- 50% Homework assignments
- 50% Final Project
  - 5% Goals and Data Specification
  - 35% Design
  - 30% Implementation
  - 10% Evaluation
  - 10% In-class Presentation
  - 10% Teammate Evaluation

Course Schedule Page



Visualization in the Sciences Schedule, Spring 2012

The schedule is subject to change, especially the lectures more than a week in the future.

Date	Reading	Homework	Lecture
Tue Jan 10	N/A		Introduction, initial reading assignments
Thu Jan 12	Skim K&K Multiform Visualization (2+ ways of showing same thing), 147-158, Practical Scientific Visualization Examples	Be sure you are on the mailing list	Motivation and Toolkits
Tue Jan 17	Ware Ch1: Foundation for a Science of Data Visualization; Study 20-25		Visualization and data characteristics, Props
Thu Jan 19	Getting Started with visualization tools web page, ParaView User's Guide (Skim 5-7, read tutorials for HW0). Ware Ch2: The Environment, Optics, Resolution, and the Display; Skim 40-46. Study 30-38, 49-61.	HW0: Getting ParaView: Install the software, go through the tutorial. Upload to the Blog	"To the Pain", Interviewing a client, "The Main Thing"
Tue Jan 24	Ware Ch3: Light, Brightness, Contrast, and Constancy; Study 69-95.		Trichromacy, Color Spaces, Properties of Color, Application

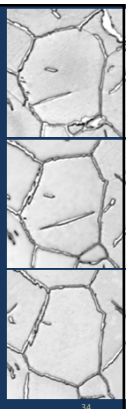
In Class

- Lectures: Human perceptual characteristics
  - Color, Surface, Texture, Depth, …
- Lectures: Techniques
  - 2D, 3D, Vector, Tensor, Multivariate, Haptic, …
- Design
  - Design quizzes comparing potential solutions
  - Designs for problems not in homework
  - Review homework critiques

Fast-Forward Course Preview!

- This is for overview, not content
- Now we see how fast I can talk…

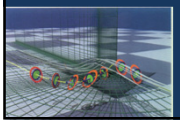
Lecture: Motivation and Toolkits

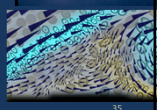


- Why Visualize?
  - Domain scientist would rather be in lab
  - Computer scientist would rather develop algs.
- Multidisciplinary Science
  - Able to attack more complex problems
  - Getting over the barriers: Jargon, Funding, Credit, "Wasted" time

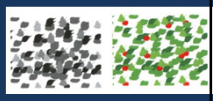
Lecture: Visualization Goals and Data Characteristics

- Stages of visualization: Data collection, transformation, display, interact, modify
- Sensory representations and visual illusions
- What makes a visualization good?
  - Turns out to depend on the data!
  - Turns out to depend on the goal!

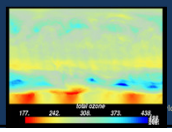


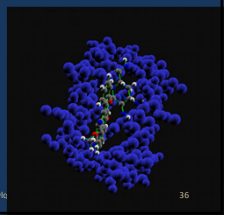


Lecture: Perception of Color



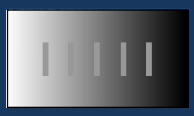
- Color: Irrelevant or critical?
- Uses of color
  - What is it good at, poor at?
  - Displaying data using color
  - Selecting a color map
- Color models





Lecture: Surface perception, visual illusions

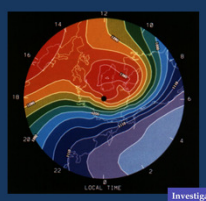
- Visual system characteristics cause illusions
  - Relative values seen
- Luminance for shape

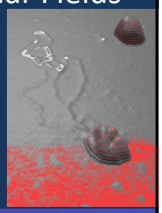


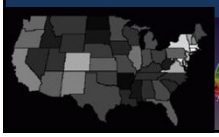
More detail → More contrast

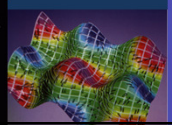
Lecture: Displaying 2D Scalar Fields

- Color maps
- Contour lines
- Height Fields
- Textures
- Transparency



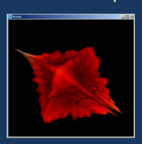


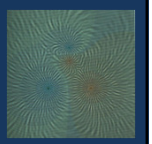




Lecture: Information that "Pops out", Textures

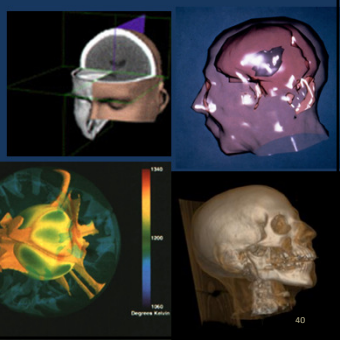
- Attracting viewer attention
  - Features that can be processed in parallel
  - Features that can't
- Textures





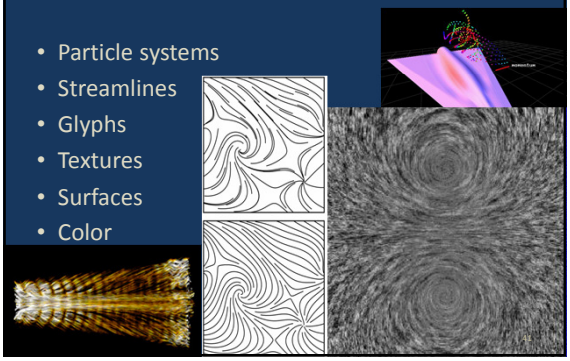
Lecture: 3D Scalar Field Visualization

- Slices
- Surfaces
- Direct Volume Rendering
- Glyphs



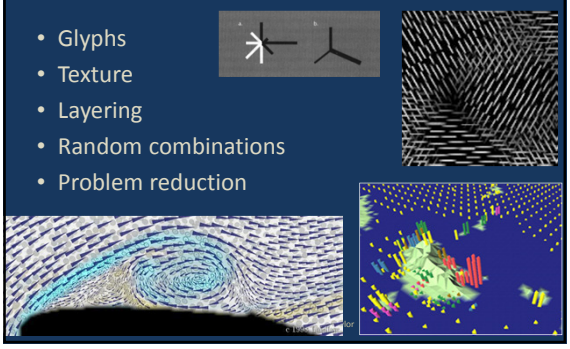
Lecture: Vector Visualization

- Particle systems
- Streamlines
- Glyphs
- Textures
- Surfaces
- Color



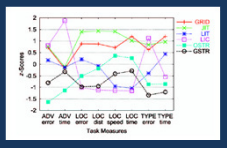
Lecture: Multivariate

- Glyphs
- Texture
- Layering
- Random combinations
- Problem reduction

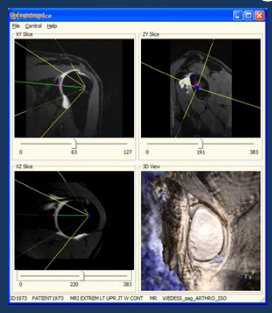


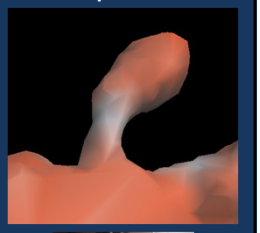
Lecture: Evaluation

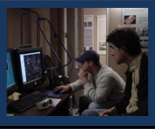
- User Studies
- Informal Feedback
- Expert Design



Lecture: Design Examples

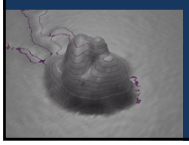


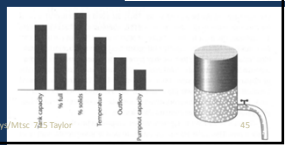




Lecture: Surface Shape

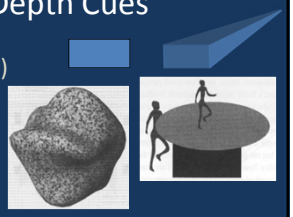
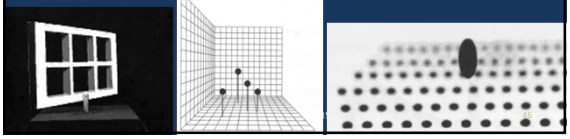
- What makes a perceptual object?
- Silhouettes
- Object-based data display
- Surface shape perception





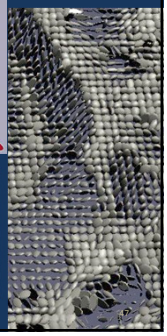
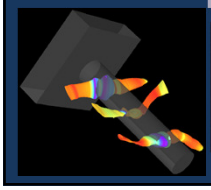
Lecture: Depth Cues

- Monocular (one-eyed)
  - Static (not moving)
  - Dynamic (moving)
- Binocular
- Artificial

Lecture: Tensor Visualization

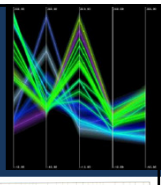
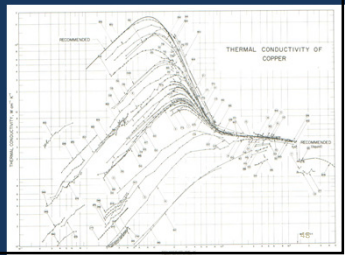
- Glyphs
- Traces
- Surfaces

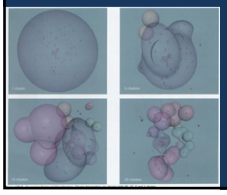





Comp/Phys/Mtsc 715 Taylor

Lecture: In Brief

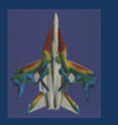
- Animation (videos)
- Auditory Display
- Information Visualization
- Tufte

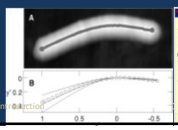



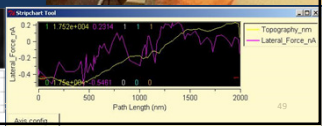


Lecture: In Brief

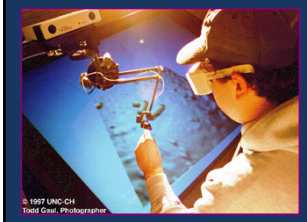
- Tying Analysis to Visualization
- Props for visualization context

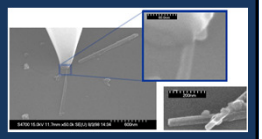


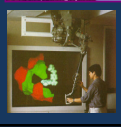


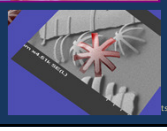


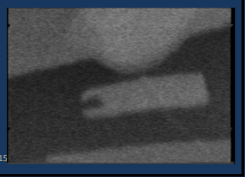
Lecture: Nanoscale Science







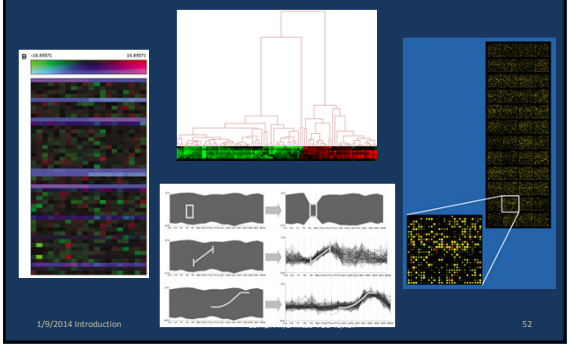




Lecture: Haptic Display?

- "Touching your data" – Force feedback
- Devices
- Applications
- Usefulness
- Concerns
- Cue Conflicts

Lecture: Bioinformatics?



Lectures: Final Projects

- Y'all Lecture to me…

You

- Introduction:
  - Your name
  - What department/curriculum you are in
  - What do you hope to get out of this course beyond what I've already described?

Order Colin Ware Book

- Student stores had some
- Amazon
- I hear there is a Kindle version

Get VTK/Paraview

- There is a set of instructions that are linked from the schedule page on the web page
- We will install them on machines in the Glab if someone doesn't have access to a computer to run them on at UNC – let me know if you need this

Get on the Mailing List

- I'll add those signed up for course
- Google Group for the course
  - All subscribers can send
  - Archive of all postings
  - Send mail to comp715@cs.unc.edu
  - Sign up by sending me an email request
  - All of this information is on the web page.

Submit Project Ideas

- Those of interest to you personally
  - Must have data set(s) within a week
  - Send scientific goals/questions you have
- Send to taylorr@cs.unc.edu

References

- The history and various definitions of scientific visualization come from a lecture by Dr. Gitta Domik that is included in the ACM tutorial on visualization:
- Gershon, N., "From Perception to Visualization," in Scientific Visualization, 1994, Advances and Challenges, Ed: L. Rosenblum, R.A. Earnshaw, J. Encarnacao, H. Hagen, A. Kaufman, S. Klimenko, G. Nielson, F. Post, D. Thalmann, Academic Press.

References

- McCormick, B.H., T.A. DeFanti, M.D. Brown (ed), "Visualization in Scientific Computing," Computer Graphics, Vol. 21, No. 6, Nov. 1987.
- Robertson, P.K., 1991, "A Methodology for Choosing Data Representations," IEEE Computer Graphics and Applications, Vol. 11, No. 3, May 1991, pp. 56-68.