Comp/Phys/APSc 715

Visualization System Design Examples
In-Class Design

Example Videos

- cad-glyph.avi: Meyer Vis 2008
  - Glyphs for multivariate surface visualization
- vis-1006_mpeg4.avi: Termeer Vis 2008
  - Blood supply to heart surface multivariate

Administrative

- Be talking with your client
  - Questions/Goals
  - Getting final data sets

Example Final Projects++

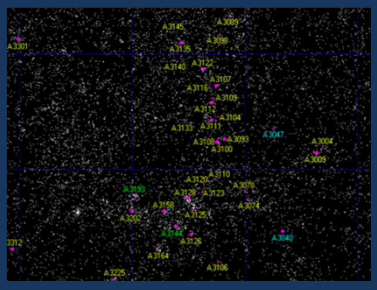
- GyVe - supercluster of galaxies
- ImageSurfer - confocal microscopy data
- InnerSpace - virtual arthroscopy
- Ensemble vector field display

Galaxy Viewer (2005)

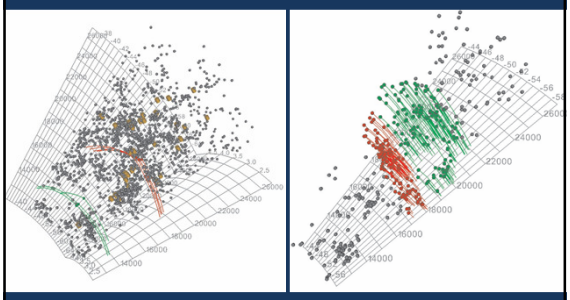
- Clients
  - Matthew Fleenor, Astronomy graduate student
  - James Rose, Astronomer
- Team
  - Jameson Miller, CS student
  - Cory Quammen, CS student
- Problem:
  - Seeing structure in Horologium Reticulum data

Gyve Advertisement

Link

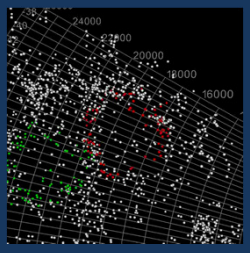


Gyve Display



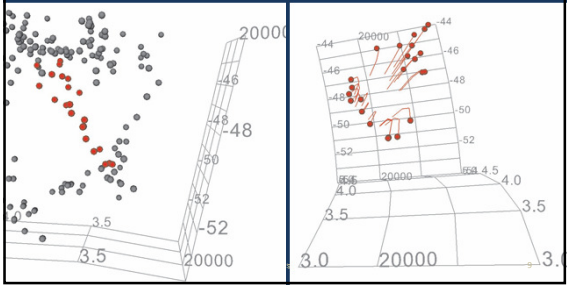
Gyve Results

- Revealed Spherical Voids



Gyve Results

- Disproved incorrect filament structures



Gyve: What Helped?

- Stereo
- Torsional Rocking
- Curved drop shadows
  - Tied to previous technique's views
  - Showed appropriate space warping

Measures of Success

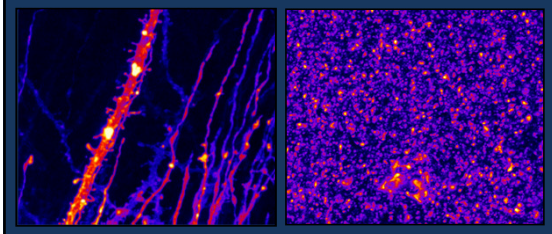
- Scientists trooped over to CS repeatedly to use the stereo display!
- Linux version to run on scientists' computers
- http://sourceforge.net/projects/gyve
- Jameson Miller, Cory W. Quammen, and Matthew C. Fleenor, Interactive Visualization of Intercluster Galaxy Structures in the Horologium-Reticulum Supercluster, IEEE Transactions on Visualization and Computer Graphics (Proceedings Visualization / Information Visualization 2006), vol. 12, no. 5, pp. 1149–1155, Sept.–Oct. 2006.

ImageSurfer (2002)

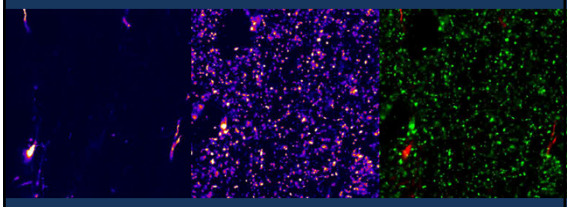
- Clients:
  - Alain Burette, Cell Bio Postdoc
  - Richard Weinberg, Cell and Developmental Bio
- Team:
  - Dennis Jen, CS student
  - Peter Parente, CS student
- Problem:
  - How to correlate membrane and calcium?

How is the concentration of PMCA distributed along a dendrite?

DiO PMCA

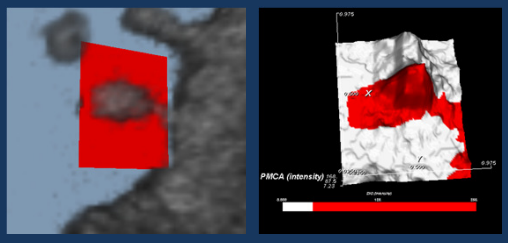


Looking through the stacks…



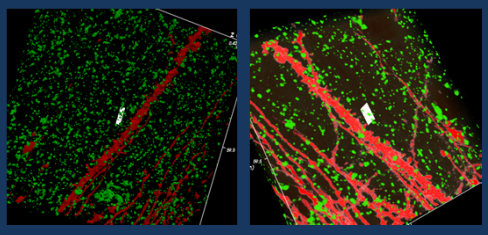
End of Course

- Two views, 3D volume and 2D slice

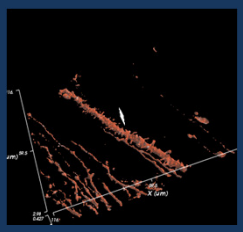


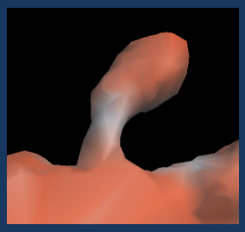
Going Beyond the Course

Failed Attempts

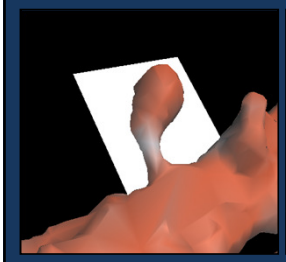


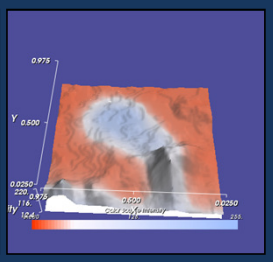
CISMM-sponsored additions



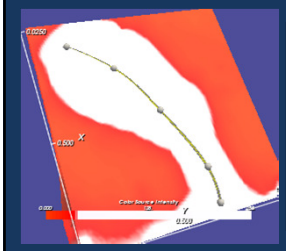


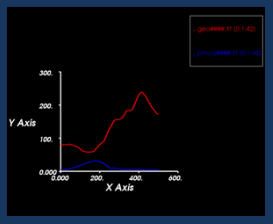
… easing the pain





… adding analysis

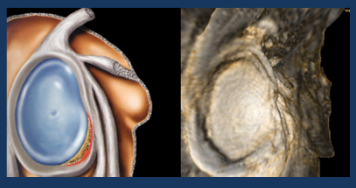




Measures of Success

- http://www.imagesurfer.org
  - Maintained by scientist collaborators!
  - ~3 downloads per day
- Dennis Jen, Peter Parente, Jonathan Robbins, Christopher Weigle, Alain Burette, Richard Weinberg, and Russell M. Taylor II, "ImageSurfer: A Tool for Visualizing Correlations between Two Volume Scalar Fields," *IEEE Visualization 2004 Proceedings*, October 10-15, Austin Texas, pp. 529-536.
- David Feng, David Marshburn, Dennis Jen, Richard Weinberg, Russell M. Taylor II, Alain Burette, "ToolBox: Stepping into the third dimension," *Journal of Neuroscience*, 27(47), Nov. 21, 2007, pp. 12757-12760.

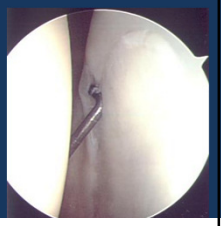
Innerspace



- David Borland's dissertation work

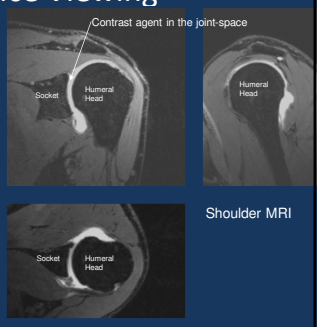
Arthroscopy

- Use fiber-optic camera and surgical tools to investigate joint for pathology
- Problems
  - Invasive
  - Costs time and money
  - Very cramped area to maneuver in



MRI Slice Viewing

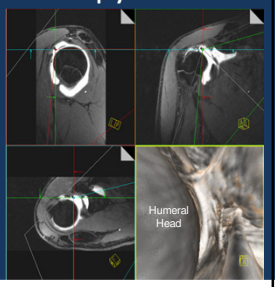
- Current standard for joint pathology diagnosis
- Features
  - Less invasive
  - Contrast agent routinely injected to aid imaging
- Problems
  - Requires tedious selection of slices
  - Requires non-intuitive mental reconstruction of 3D features



Shoulder MRI

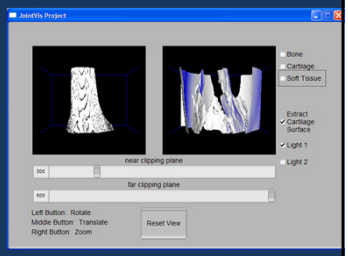
Virtual Arthroscopy

- Work by John Clarke from UNC Radiology
- Features
  - Also less invasive
  - More intuitive visualization
- Problems
  - Viewpoints limited to the joint-space
  - Must maneuver the virtual camera across the entire joint surface for evaluation
  - "Like looking at the palm of your hand with it touching your nose."



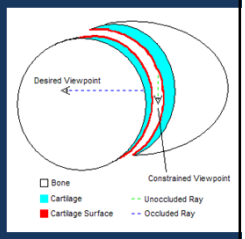
Visualization Course Project

- Sean Hanlon, Karl Strohmaier, Kelly Van Busum
- DVR for context
- Extracted isosurface for detail
  - Slow…
- Adjustable clipping planes
  - Problem…



If at first you don't succeed…

- Volume Rendering?
  - –Still have occlusion problem
- Transparency?
  - –Confusion



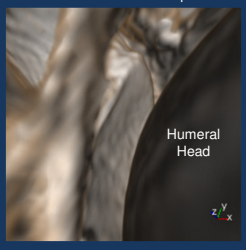
Volumetric Depth Peeling (VDP)

- Extension to standard ray-casting Volume Rendering algorithm
- Enables anatomical views not possible with standard clinical techniques
- Works with complicated structures for which no clipping plane will suffice
- Requires no pre-segmentation
- Works for self-occlusion and tube-like structures
- Takes advantage of routine contrast enhancement

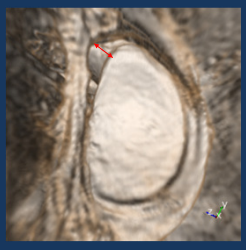
Presented at Visualizaton and Data Analysis 2006

Standard Volume Rendering vs. VDP

Constrained to Joint-Space

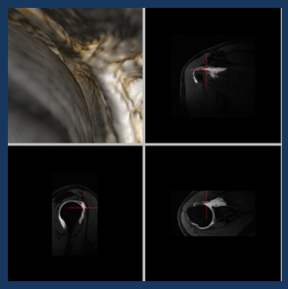


VDP

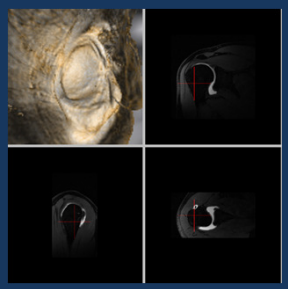


Ligament and Labrum (Ring of Cartilage) Tear

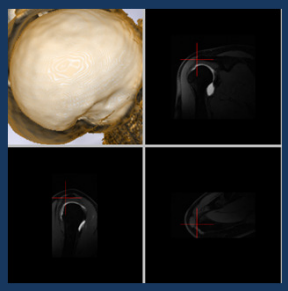
Movie 1



Movie 2

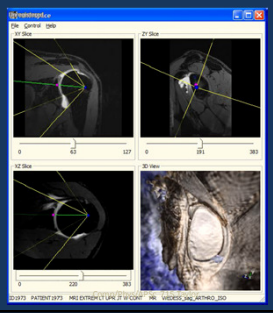


Movie 3



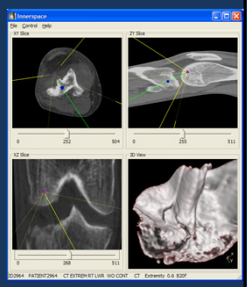
Movie 4

1973_repeat.mpg from F:\taylorr\Supervision\Borland



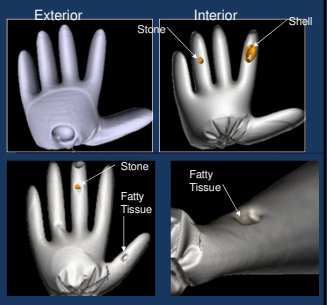
Innerspace

- Built with VTK, wxWidgets, and gdcm
- Loads DICOM format
- Visualization features
  - 3 slice views
  - 3D render view
  - Axes
  - Camera widget in slice views updated with 3D motion
  - Slices updated with 3D motion
  - 3D view updated with camera widget motion
  - Simple sliders and full transfer function control
  - View threshold value in slice views



Additional Work: Glove Phantom Study

- Proof of concept for VDP of urinary system
- Performed on 3 contrast-filled rubber gloves with various objects placed inside

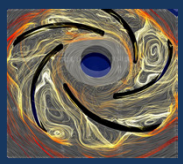


Measures of Success

- Collaborator found funding to support student
- Two domain-science publications
- UNC Ph.D. dissertation
- Patent issued
- Summer internship for student at Siemens
- Patent licensed to Siemens and put into Syngo software

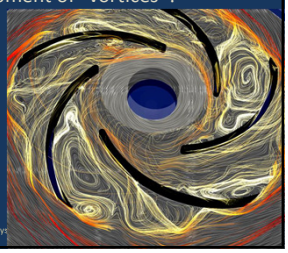
Ensemble Vector Display (2011)

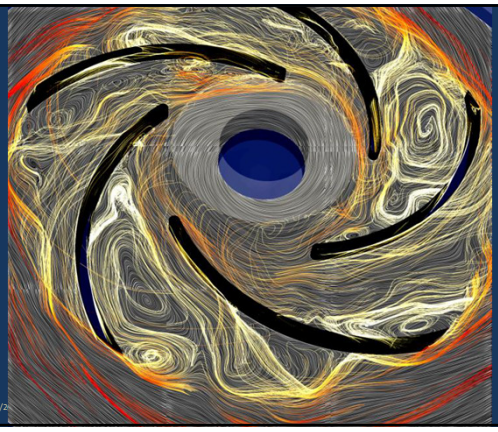
- Clients
  - IEEE Visualization Design Contest
  - Centrifugal pumps
- Team
  - Alexis Yee Lyn Chan
  - Joohwi Lee
- Problem:
  - Where do the simulations differ? Where vortices?



Goal 1: Contextual Flow

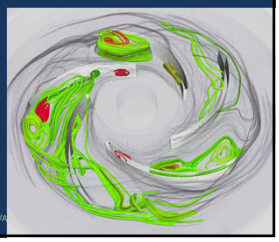
- What is the flow structure surrounding the turbine blades? Does high flow separation from the blades coincide with the development of "vortices"?
- LIC background
- Sparse Streamlines
  - Seeded in vortices
- Geometry prop

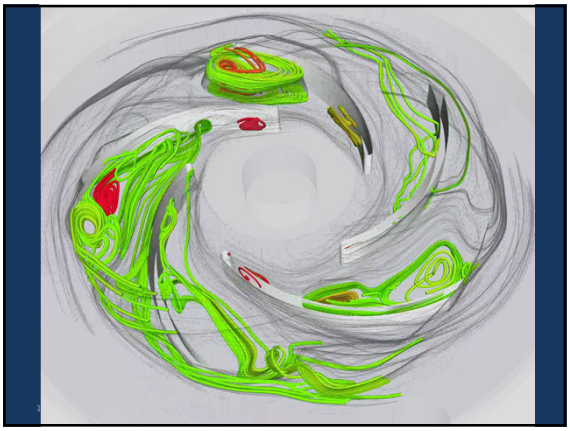




Goal 2: Vortex Visualization

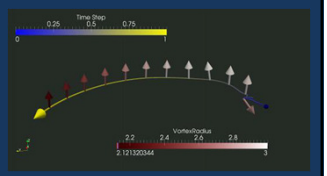
- Identify regions of the dataset that contain swirling flow that is not laminar (i.e. parallel to the circular boundary of the turbine geometry or the boundary of the blades).
  - Solved for vortex location
  - Streamtubes near there
    - R/Y/G Winding angle
  - Streamlines for context





Goal 3: Unsteady vortex tracking

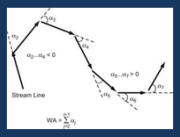
- Identify "vortices" that drift over time (i.e. the ones that are not stationary). Do the "vortices" move between turbine blades? Do the axis of rotation of these "vortices" change over time?
  - Designed
  - Not implemented

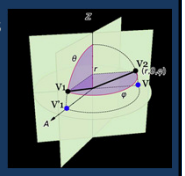


Immersive System

Computational Support

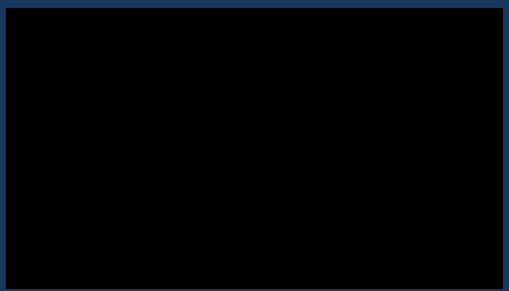
- Learned a lot about vortex identification
  - Wikipedia, reading domain papers
  - Winding angles





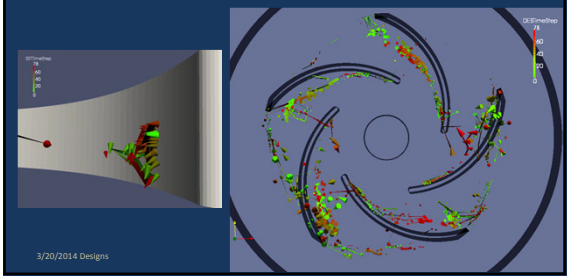
- Implemented vortex detection to seed vis.

Beyond the Course



Beyond the course

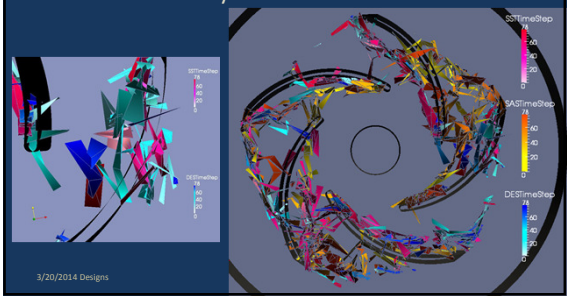
- Vortex Core timeline



3/20/2014 Designs

Beyond the course

- Ribbon summary



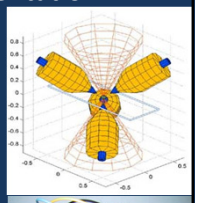
3/20/2014 Designs

Measures of Success

- Scientist reviewers saw useful things.
- 2nd place in Visualization Design Contest
- Presented technique at the conference
- SPIE publication the following year: Alexis Yee Lyn Chan, Joohwi Lee, Russell M. Taylor II, "Vortex Core Timelines and Ribbon Summarizations: Flow Summarization over Time and Simulation Ensembles," Proceedings of SPIE Visualization and Data Analysis 2013. Proceedings of the SPIE, Volume 8654. pp. V1-V8. 2013.

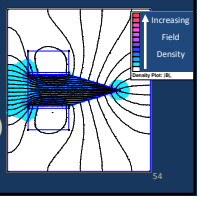
Example Visualization Design
Example AVS Implementation

- The Research Questions
  - Which directions can four magnetic poles located at the corners of a tetrahedron pull a magnetic bead that is centered between them?
  - How uniform is the pull in each direction?



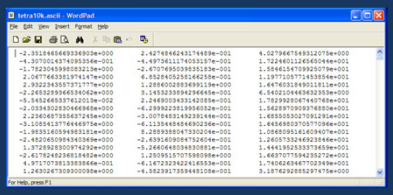
The Raw Data

- Magnetic field simulation for four poles
  - 10,000 sets of random currents on each pole
  - Computes direction of force (Phi, Theta)
  - Computes force magnitude for each
- Data Type
  - 2D Ratio Scalar Field (mag)
  - Unstructured (scatter phi/theta)



Discussion: How Best to Visualize?

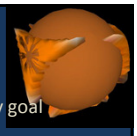
- No fair helping if you peeked at today's notes or have seen this before
  - Unless you have a better idea for how to do it!



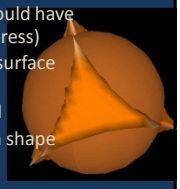
Cooking the Data

- Convert from unstructured set of points
  - Place points into regular set of bins in phi, theta
  - Average all points falling within each bin
  - Produces regular grid with missing values
  - Expect high-frequency changes across the grid
- Put back into natural space for the problem
  - Convert (phi, theta, magnitude) to (x,y,z)
    - Spherical coordinates to Cartesian coordinates
  - 2D surface embedded in 3-space

Visualization Design

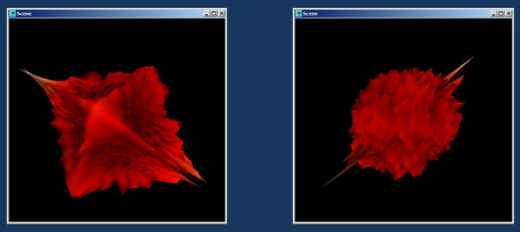


- Height field encodes force magnitude for primary goal of estimating coverage of directions
- Color redundantly encodes magnitude to show uniformity of force (banded, isoluminant would have been better than the one I found in AVS Express)
- Missing values leave holes in the displayed surface
- Iso-height sphere model added to improve understanding of fraction of sphere covered
- Enable user to rotate view to explore region shape

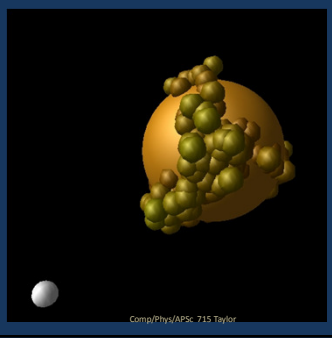


Six Poles? Eight Poles?

- Really want max in each bin, not average?

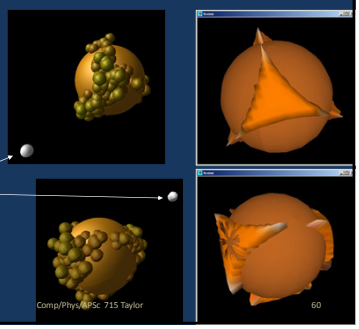


What the real data looks like



Real vs. Simulated

- Real is all data, simulated is averaged in direction



Note the outlying white sphere