CSE564 Visualization and Visual Computing

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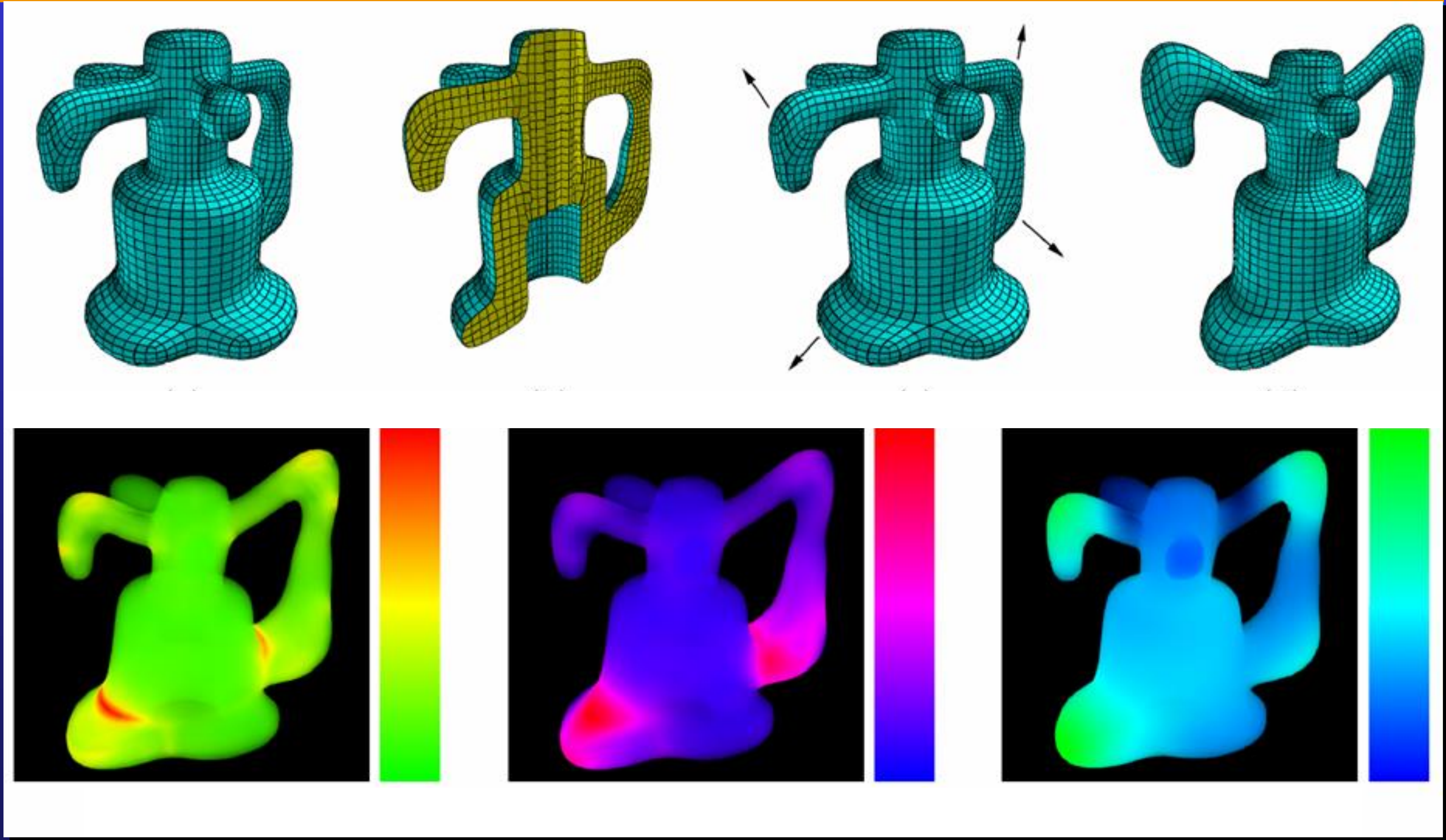
Scientific Visualization Example



CSE564 Visualization and Visual Computing

- **Instructor:** Professor Hong Qin (qin@cs.stonybrook.edu or qin@cs.sunysb.edu)
- **Lecture time and place:** OLD CS 2120, TuTh 1pm-2:20pm
- **Office hours:** TuTh 2:20pm-4pm, or by appointment (Please feel free to email or chat with me about the course!)
- **Course home page:** www3.cs.stonybrook.edu/~qin/courses/visualization/visualization.html
- Be sure to visit the course home page frequently for announcements, handouts, etc.

Course Objectives (Synopsis)

- **Emphasizes a "hands-on" approach to both the better understanding of scientific/information visualization concept/theory/algorithms and the effective utility of scientific/information visualization techniques in various visual computing applications.**
- **Provide a comprehensive knowledge on scientific/information visualization concepts, theory, algorithms, techniques, and applications for data acquisition/simulation procedures, data modeling techniques, commonly-used conventional visualization techniques, visualization and rendering processes, visualization of 2D, volumetric, higher-dimensional, and time-series datasets, human-computer interactions, and other key elements of visual computing.**
- **Demonstrate the significant of these mathematical and computational tools and visualization algorithms in visual computing and relevant areas.**
- **Time permitting, this course will also try to introduce some advanced visualization topics, including (but not just limited to), visual perception, cognitive science, information visualization basics, visual analytics, and the possible coupling of artificial intelligence with visualization.**

Course Topics

Course topics: scientific visualization, visual perception, basic computer graphics and imaging concepts, volume and surface rendering, volume visualization, case studies, advanced research subjects, current research trends, and many more!

Visualization

- Data acquisition, representation, and modeling
- Imaging processing
- Visualization (displaying) methods and algorithms
- More advanced research topics

Visualization Pipeline

- Data acquisition and representation
- Modeling data and their (time-varying) behaviors (e.g., physical experiments or computational simulations)
- Graphics system for data rendering
- Image-based techniques

Data Acquisition and Processing

- Pixels and voxels
- Regular & irregular grids
- Numerical simulations
- Surface or volumetric data
- Scalar, vector, tensor data with multiple attributes
- Higher-dimensional and/or time-varying data
- Popular techniques
  - Contouring, iso-surfaces, triangulation, marching cubes, slicing, segmentation, volume rendering, reconstruction
- Image-based processing techniques
  - Sampling, filtering, anti-aliasing, image analysis and manipulation

Data Sources

- Scanned, computed, modeled data
- The first process is data-gathering
- Large variety of data sources
- Extremely large-scale datasets

Pre-requisites

- **Mathematical skills: fundamental knowledge on calculus, linear algebra, analytic geometry, etc. (Basic mathematical training at the undergraduate level).**
- **Computer science background: programming skills, basic visualization/graphics/visual-computing courses (or knowledge) at the undergraduate level.**
- **Essentially, you will need to have an undergraduate education in computer science or engineering with basic knowledge on visualization/graphics/visual-computing.**
- **You will need to speak to the instructor if you are not sure about your background knowledge and course prerequisites.**

TA Information for CSE564

- TA: (Computer Science PhD student):
- TBA
- TA OFFICE HOURS: TBA (Monday and Wednesday)!!!
- OpenGL Tutorials: 3 lectures in September/October timeframe (tentatively 9/26 or 9/28, 10/10, 10/12 or 10/17)
- http://www3.cs.sunysb.edu/~xyz/cse528/
- My TA is moving these stuff to his own website!

Programming Assignment, Paper Reading, Final Course Project

- On programming assignment (due at 12:50pm on Tuesday 2/20): 10%
- Paper reading and technical report for literature review (total 7 papers, throughout the semester, due at 12:50pm Tuesday 4/24): 10%
- Course project: 50%
- Class attendance and asking questions during office hours: 5%
- Extra, bonus points: 10% extra for additional paper reading and additional functionalities on your final project

Two Mid-term Exams

- Tentatively scheduled on 2/22 and 4/17
- The first mid-term exam is 10%
- The second mid-term exam is 15%

Course Project (50%)

- One-page project proposal (due at 12:50pm, Thursday 3/1): 5%
- Mid-term software demo with preliminary results (Thursday 4/5): (3+6)%
- A working system + software codes (due at 9am 5/5): 30%
- Oral presentation and final demo in class (due at 9am 5/5): 3%
- Final course project report (due at 9am 5/5): 3%

Course Project

- Basic project requirements
  - Interactive interface (graphics-based)
  - Intuitive and easy to understand
  - Efficient (fast, high-performance)
  - Basic functionalities
  - Examples
  - Flexible and easy to generalize

Final Project Submission Schedule

- Technical Report + Software + ppt file for your final presentation: DUE May 5 (Saturday) 9am

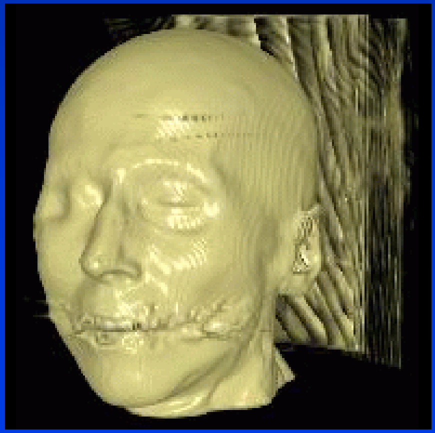
Final Presentations (10-15 Minutes Each)

- Tentatively, May 5 (Saturday) – 6 (Sunday)
- Location: TBA
- Signup sheets will be available late in the semester!!!

Late Submission Penalty

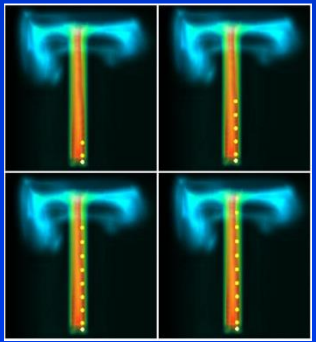
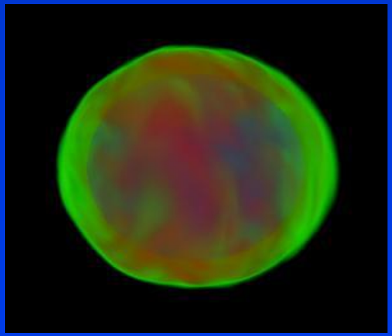
- 25% per day!!!

Introduction to Visualization



What is Visualization

Visualization is a computational method of extracting meaningful information from complex or voluminous datasets through the use of interactive graphics and imaging

Visualization

- What is visualization
  - Visual display of information (data), for example, quantitative information, measured quantities, etc.
  - Transformation of symbols and data into visual and geometric forms
- Visualization is computation
  - A new method of computing
- Why is visualization useful?

What is (Scientific) Visualization?

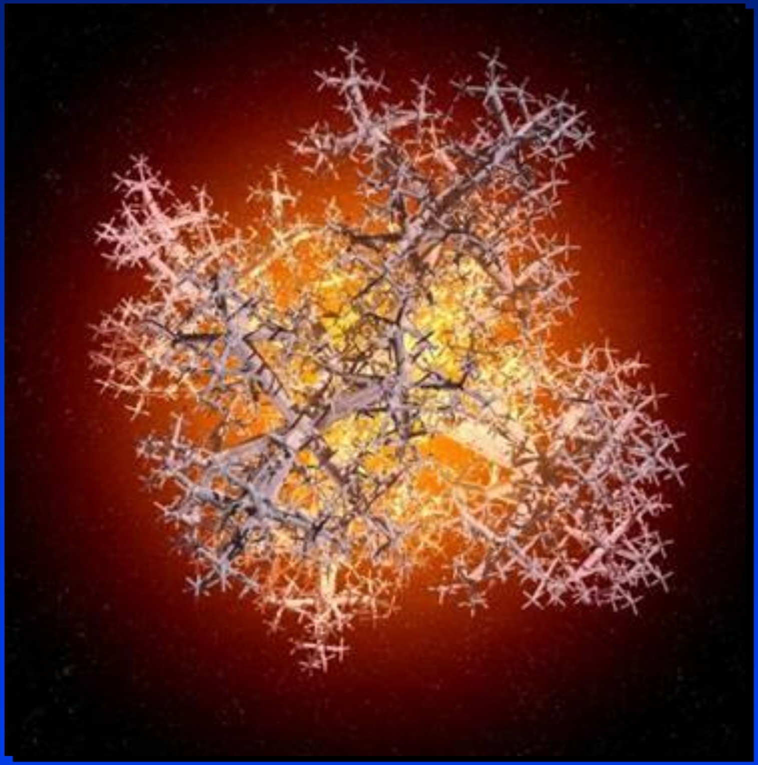
- Transformation of data (or information) into pictures (visual outputs)
- Note this does not necessarily imply the use of computers!
- Classical visualization used hand-drawn figures and illustration (primarily 2D means for visualization)
- Modern visualization is primarily 3D (via digital imaging for 3D visualization)
- In both cases, the ultimate goal is to understand something important (a.k.a. important insights) about the data through *visual means*
- We really do not care *how* we get the picture in visualization – *what* picture we get is most important
- The technical ways to arrive at visual outputs are mainly depending on computer graphics techniques

Visualization Definition

Visualization……

- Is a method of computing
- Transforms the symbolic into the visual
- Allows researchers / engineers / physicians / scientists to observe their simulations and computations
- Offers a method of seeing the unseen
- Enriches the process of scientific / engineering / medical discovery and fosters profound and sometimes unexpected insight
- In some fields, revolutionizes the way scientists / engineers / doctors practice their fields

Visualization Example



What Are Our Ultimate Goals?

- A large variety of datasets (acquired via scanning devices, super-computer simulation, mathematical descriptions, etc.)
- A pipeline of data processing that consists of data modeling (reconstruction), representation, manipulation (rigid transformation or deformation), classification (segmentation), feature extraction, simulation, analysis, visual display, conversion, storage, etc.

What Are Our Ultimate Goals?

- Datasets that are huge, multi-dimensional, time-evolving, unstructured, multi-attributes (geometric info. + material distributions), scattered (both temporal and spatial)…
- We are investigating mathematical tools and computational techniques for data modeling, reconstruction, manipulation, simulation, analysis, and display

Why Visualization and Graphics

- A Chinese proverb: “ a picture is worth a thousand words.”
- **“A picture is worth more than a thousand words.” – ancient proverb**

Visualization and Visual Computing

- Mathematical concepts, principles, and theory for images, perception, and display
- Fundamental computational (algorithmic) components that enable the entire graphics rendering pipeline
- Data modeling, representation, simulation, manipulation, display techniques and processes
- A large variety of applications in visualization as well as other visual computing areas
- Several advanced topics and they are all research-oriented, representing the most sophisticated ones

Our Course

- A subset of key principles, theory, algorithms, techniques, and applications
- Extensive topics with a main focus on our unique course mission
- Comprehensive lectures (focusing on graphics rendering, image and signal processing, data modeling, and application needs)
- Numerous slides, figures, images, and videos for easy understanding (after all, this is the nature of visualization)
- Active students' involvements (classroom attendance and asking questions, worth 5% of the final grade)

How to Get an "A"?

- Programming assignment
- Two mid-term exams
- Paper reading and technical report on literature review
- Final course project

Course Facts

- This is a graduate course!
- Can I take this course? YES, if YOU
  - Are a graduate student with CS background, have skills in calculus and linear algebra, have BASIC knowledge on graphics and visualization, or talk to the instructor
- You do NOT need to take CSE328/CSE332 prior to this course. However, you need to have gained equivalent knowledge elsewhere (similar to CSE328, CSE332, or other relevant courses)
- Several required and suggested textbooks (you don’t have to buy them though)
- Lecture notes are important!!! Class attendance in critical!!!

Course Facts

- NOT a graphics course
- NOT a course to teach OpenGL or relevant programming tools/languages comprehensively (basic knowledge for programming skills should be acquired elsewhere)
- Though we are using graphics techniques (display pipeline) to visualize datasets, our course emphases and foci are different from CSE528
- Study visualization processes and related applications!
- Course projects lead to MS thesis (project) or Ph.D dissertation topics

Key Components

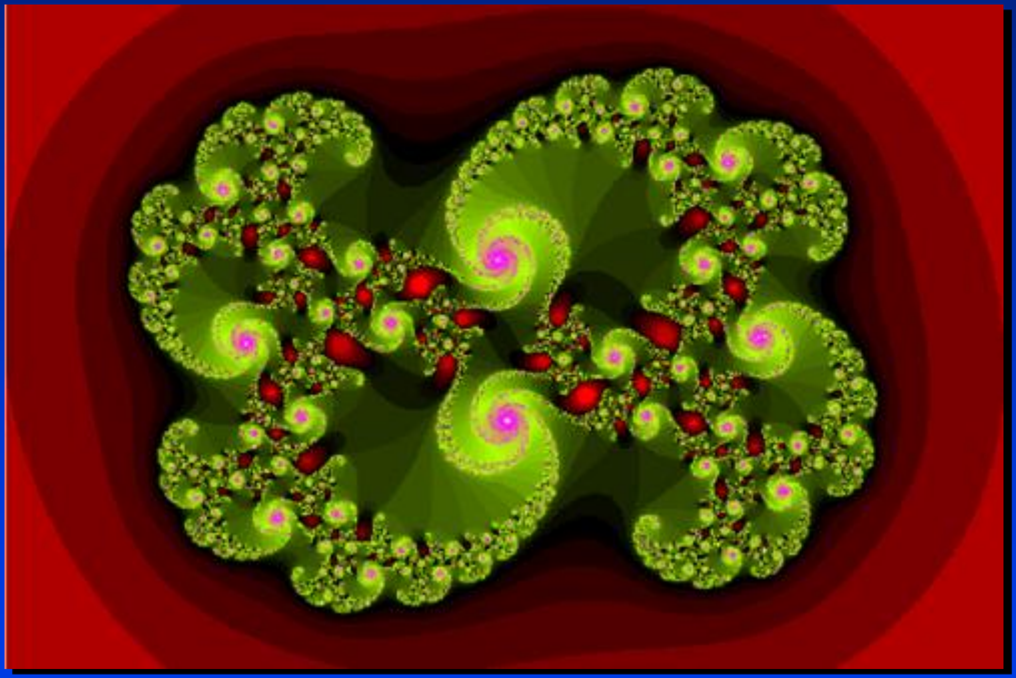
- Pictures and images
  - Motivation, traditional visualization, visual perception, visualization process
- Basic imaging and graphics (display) concepts and pipelines
  - Image processing, filter design, spatial transformation, viewing, shading (illumination), rendering
- Volume graphics basics
  - Iso-surfaces, volume rendering, transfer functions, data modeling and acquisition, multi-dimensional data visualization
- Information visualization and beyond

Why Visualization

- A Chinese proverb: “ a picture is worth a thousand words.”
- **“A picture is worth more than a thousand words.” – ancient proverb**

One Picture (Julia Set)

What on earth is this??



"A picture is worth more than a thousand words." – ancient proverb

Many Words…

1000 words (or just 94 words), many letters though…

It looks like a swirl. There are smaller swirls at the edges. It has different shades of red at the outside, and is mostly green at the inside. The smaller swirls have purple highlights. The green has also different shades. Each small swirl is composed of even smaller ones. The swirls go clockwise. Inside the object, there are also red highlights. Those have different shades of red also. The green shades vary in a fan, while the purple ones are more uni-color. The green shades get darker towards the outside of the fan…………………………………………..

Why is Visualization Useful and Important ?

- Which is more helpful: A or B?

16 million 3D points:

5, 34, 22, 56, 114, …

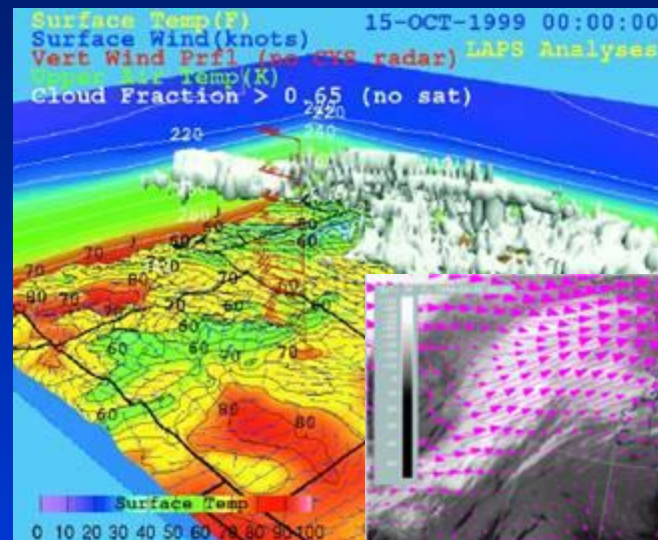
A

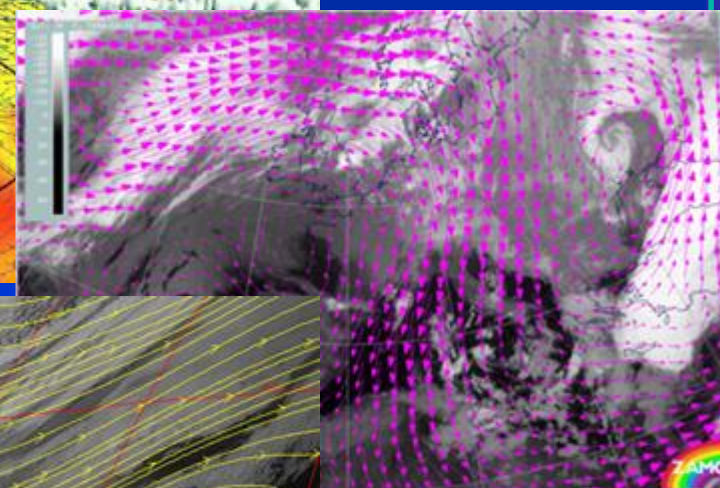
B

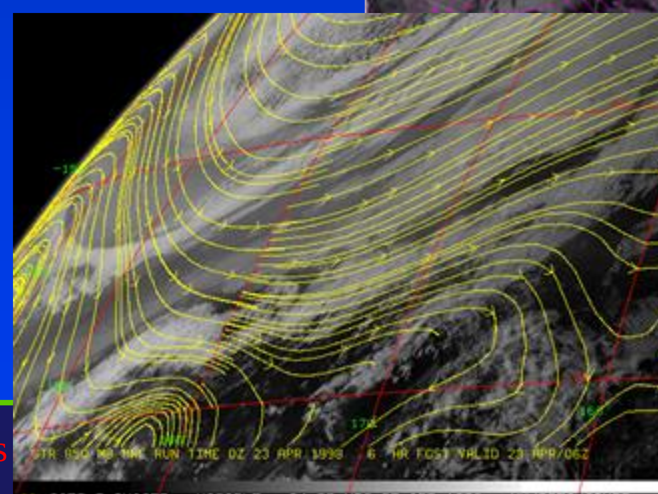
Why Do We Need Visualization?

"A picture is worth more than a thousand *numbers*." – new take on ancient proverb

- Terrain geometry
  - x, y, z (elevation)
- Terrain texture
  - r, g, b (colors)
- Time-varying info:
  - Cloud cover (s)
  - Wind vectors (x,y,z)
  - What else?
- That's a lot of data!

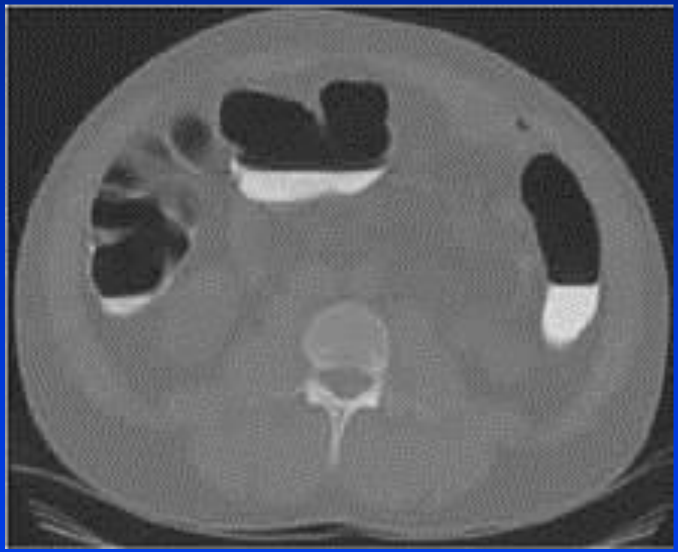


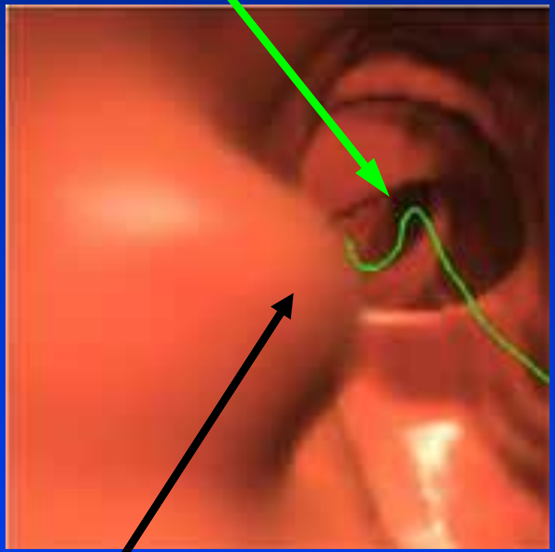


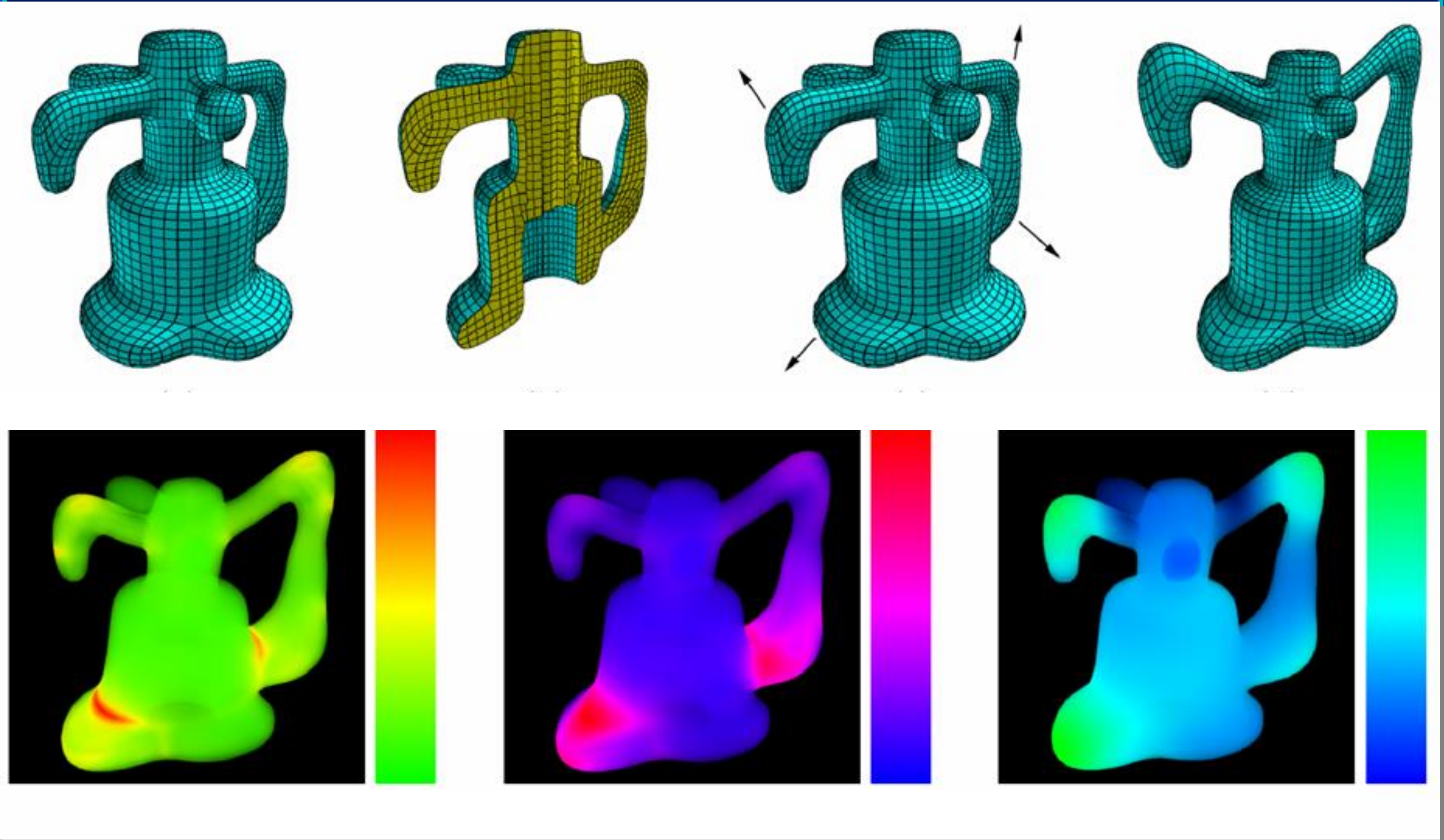


Example: Virtual Colonoscopy

- Enables doctors to use CT (Computed Tomography – X-rays) to perform *virtual exploration* and *endoscopy* inside the human body
- Advantages: safer, cheaper, faster







Visualization Examples

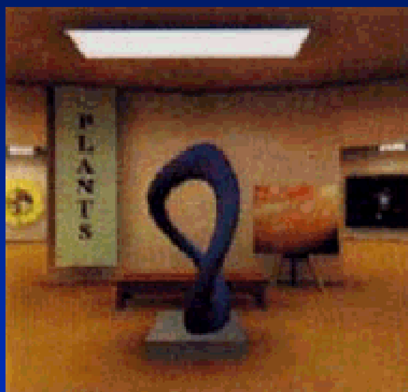
Why Visualization

- Enable scientists (also engineers, physicians, general users) to observe their simulation and computation
- Enable them to describe, explore, and summarize their datasets (models) and gain insights
- Offer a method of SEEING the UNSEEN
- Reason about quantitative information
- Enrich the discovery process and facilitate new inventions

Why Visualization

- Analyze and communicate information
- Revolutionize the way scientists/engineers/physicians conduct research and advance technologies
- About 50% of the brain neurons are associated with vision
- The gigabit bandwidth of human eye/visual system permits much faster perception of visual information and identify their spatial relationships than any other modes
  - Computerized human face recognition

More Examples

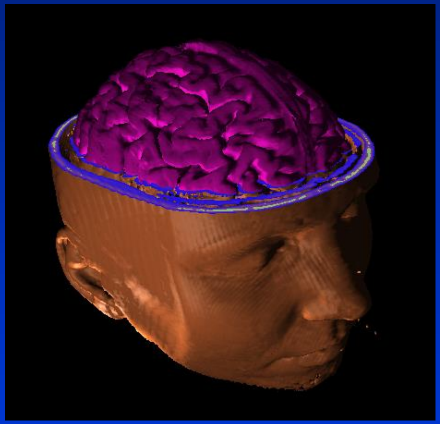


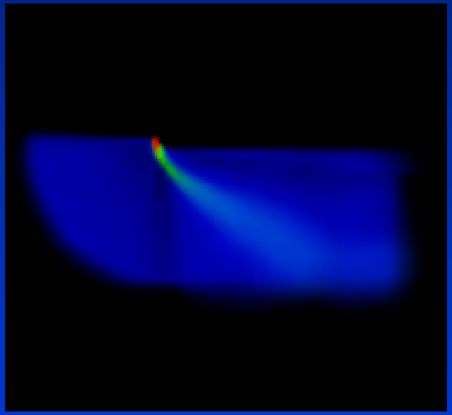
Images

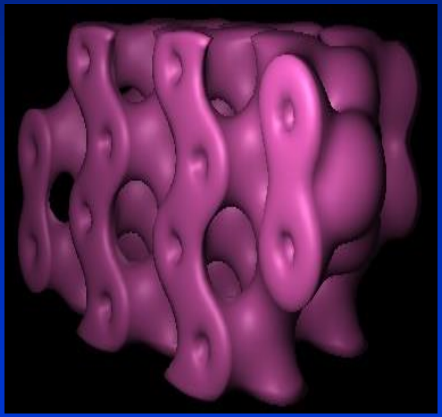
Points

Volumes

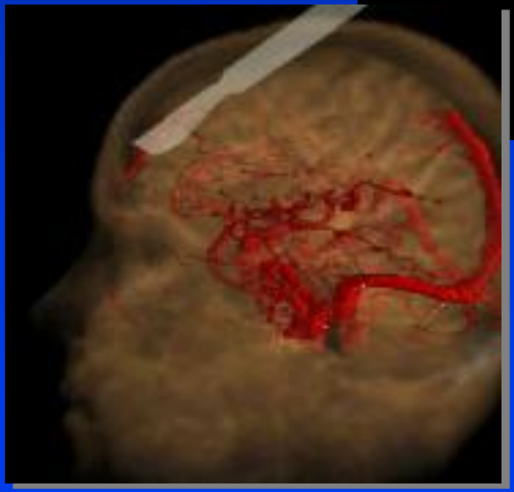
More Examples





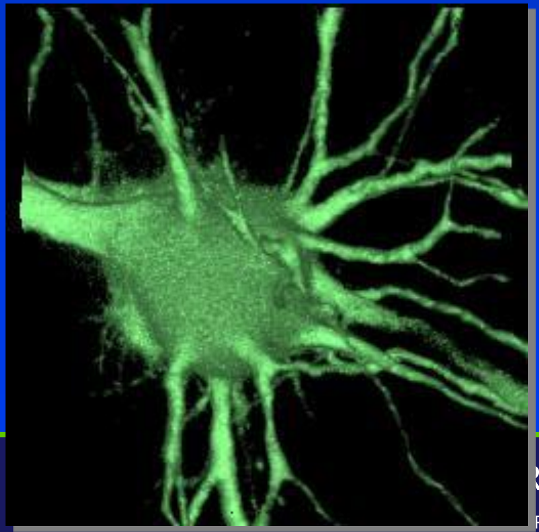


Medicine and Health-care



Visualization Terminology

- Different fields of visualization
- *Scientific visualization*
  - discipline of computer science
  - visualization of scientific and engineering data-sets
- Scientific visualization touches on a number of areas:
  - data representations
  - data processing algorithms
  - visual representations
  - user interfaces

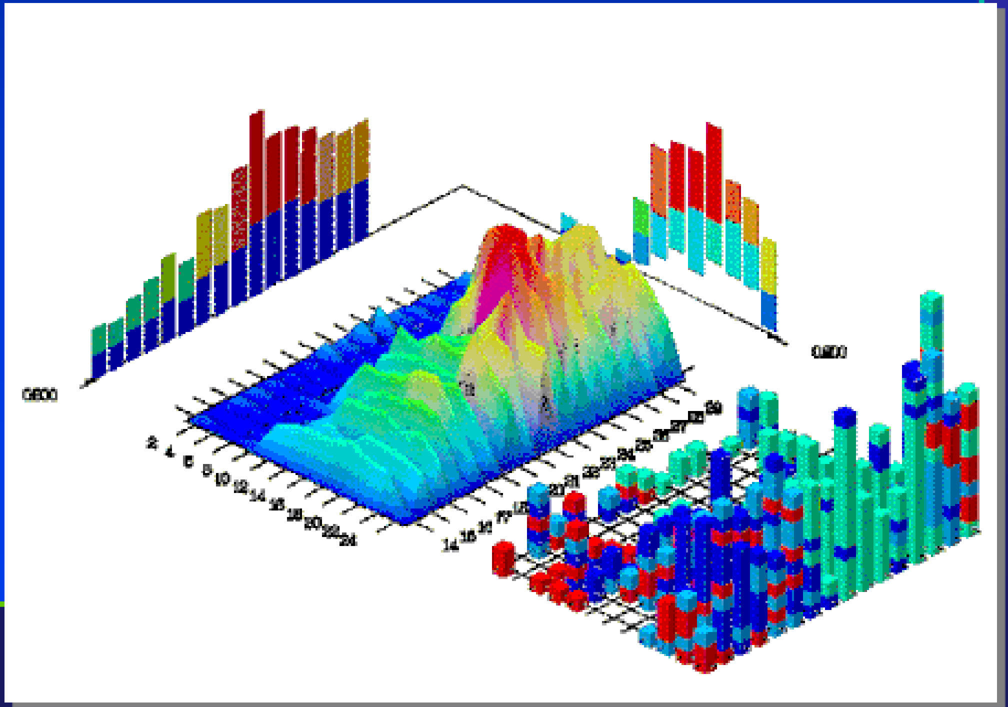


Visualization Terminology

- *Data visualization* – includes data from other sources, such as financial, marketing, business
- Sometimes involves statistical analysis and other analysis techniques not employed in scientific visualization (analytics)
- Can you think of an example of financial information we might want to visualize?
- So we might say that scientific visualization is a type or subset of data visualization
- We will be studying scientific visualization primarily, but look at more general data visualization occasionally

Visualization Terminology

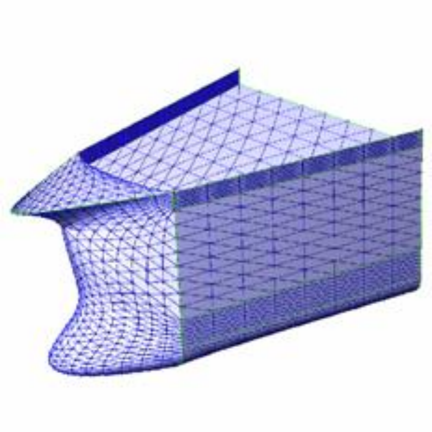
- *Information visualization* – abstract data sources, like WWW pages and databases
- No natural mapping to spatial domain (2D, 3D or n-D)
- How/what would we visualize in Amazon.com’s book database?
- Visual analysis of customer call center performance at British Telecommunications:

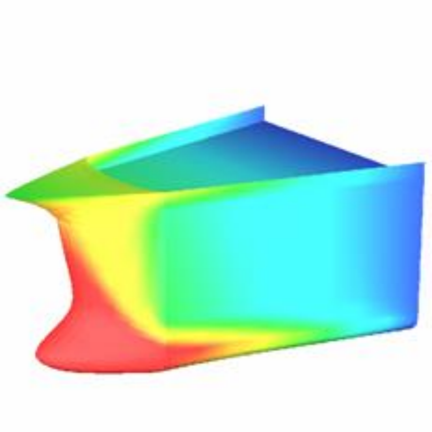


Motivations of Visualization

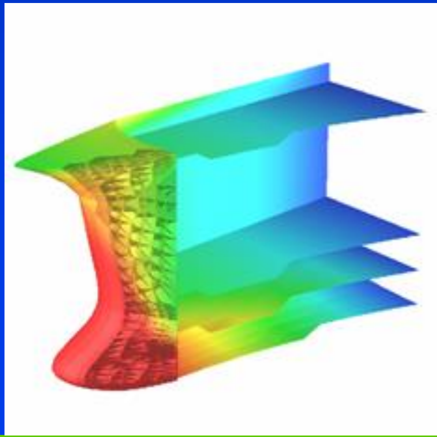
- Make sense of huge data-sets
  - NYSE makes hundreds of millions of transactions per day
  - RHIC at BNL produces terabytes (2^{40}) of data with each experiment
- Uncover insights hidden in the data
- Extract important features/aspects and meaningful knowledge of the data to assist in the decision-making process
- But why use visual means?

Motivations of Visualization



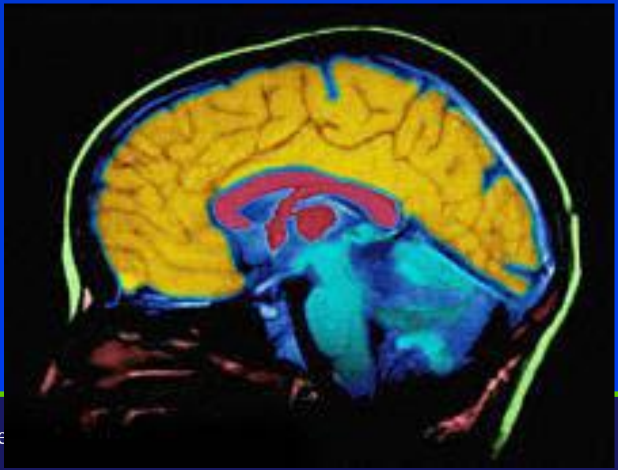


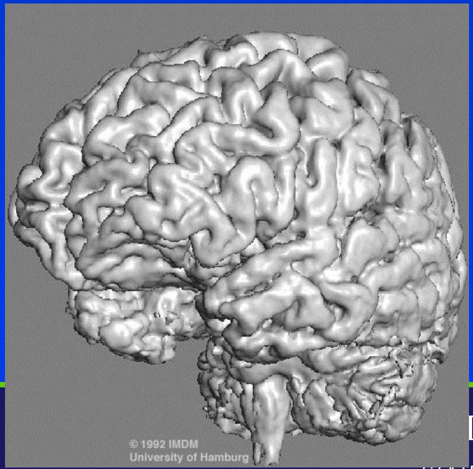
- Reduce time and save money
- Digital prototyping
  - Design model in virtual reality (VR)
  - Test model in VR
  - Refine and re-test
- Flight simulation
  - Why?
- Virtual training
  - Why?



Examples of Visualization

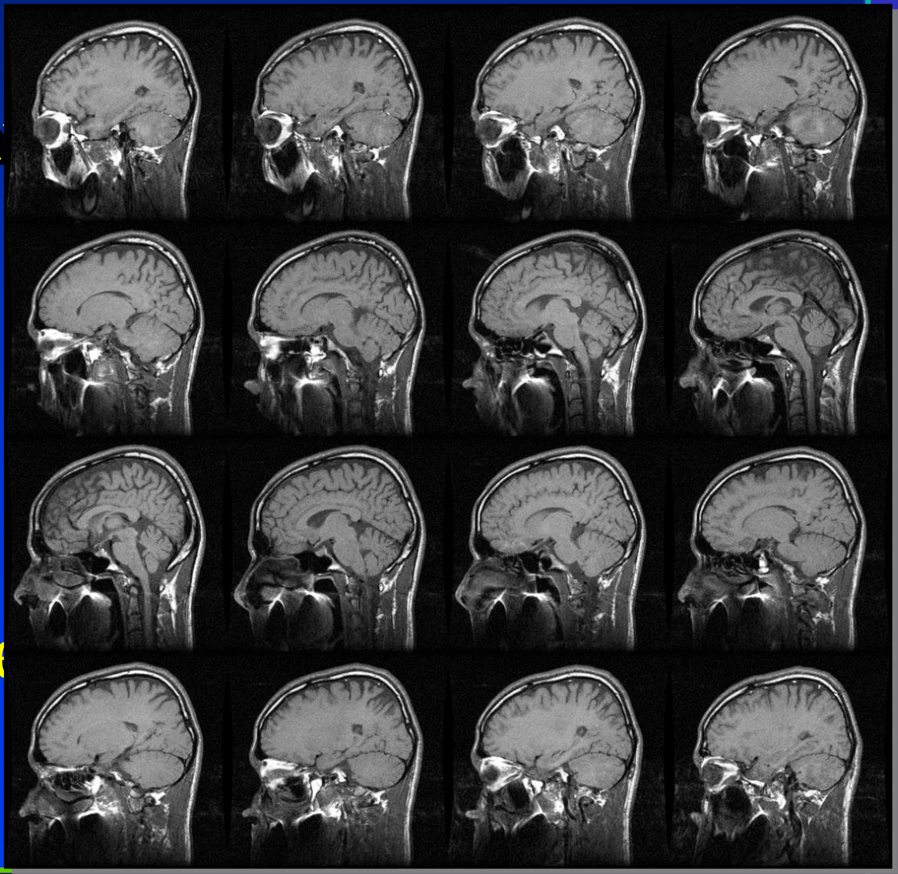
- <u>Medical imaging</u>
- X-ray Computed Tomography (CT)
  – pronounced as both “cat” or “see-tee”
- Magnetic Resonance Imaging (MRI)
  – uses very powerful magnetic fields





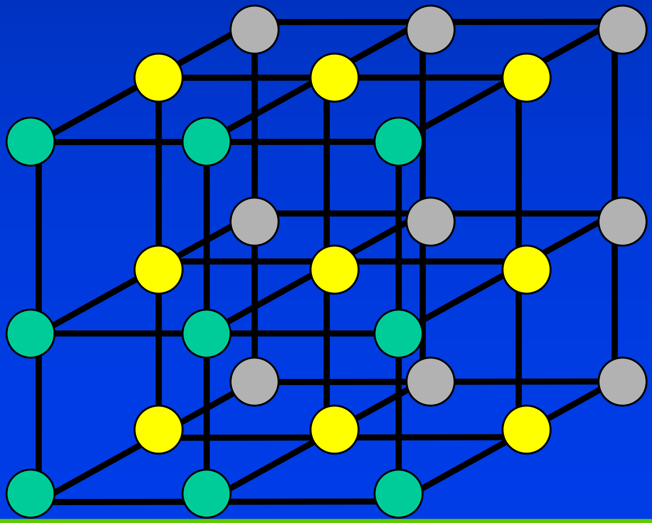
Examples of Visualization

- CT and MRI produce *slice planes*
- Cross-sections of the patient
- Slices are combined to produce a *volumetric representation*
- But CT and MRI machines just output numbers – where do the gray values come from?

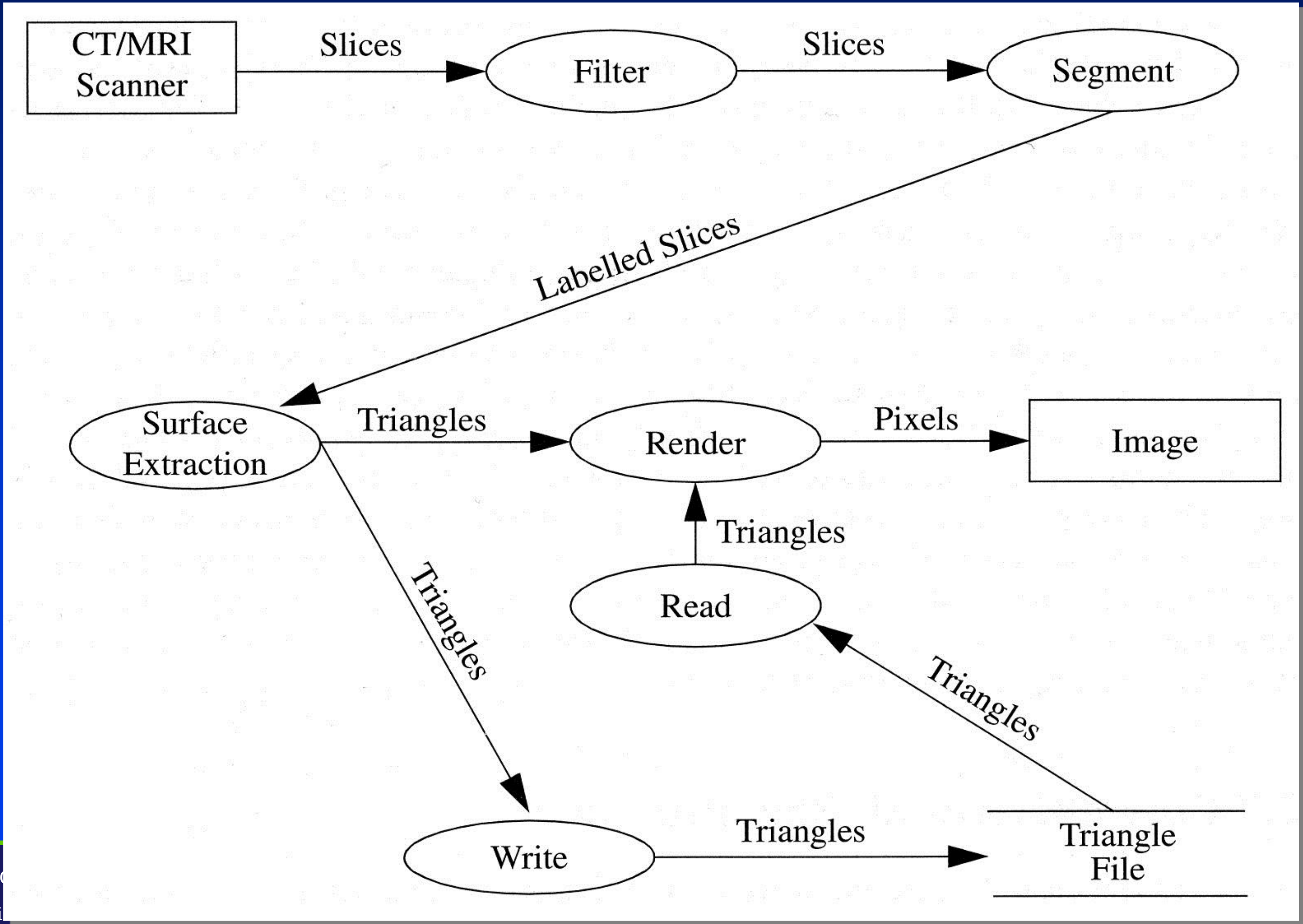


Examples of Visualization

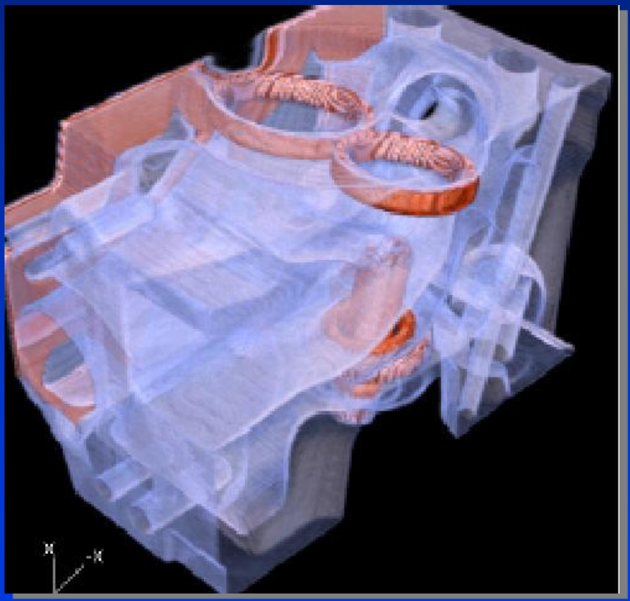
- A volumetric data-set is a 3D regular grid, or *3D raster*, of numbers that we map to a gray scale or gray level
- An 8-bit volume could represent 256 values [0,255]
- Human visual system naturally groups like-colored points, or *voxels*, into regions



CT/MRI Data Flow

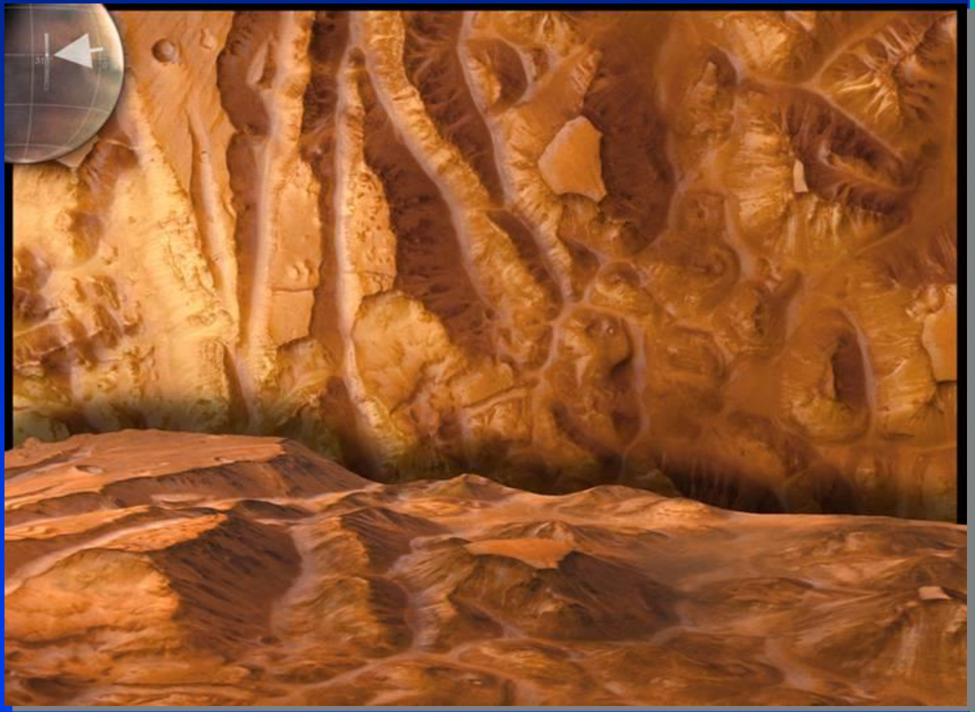


Volume Visualization Examples



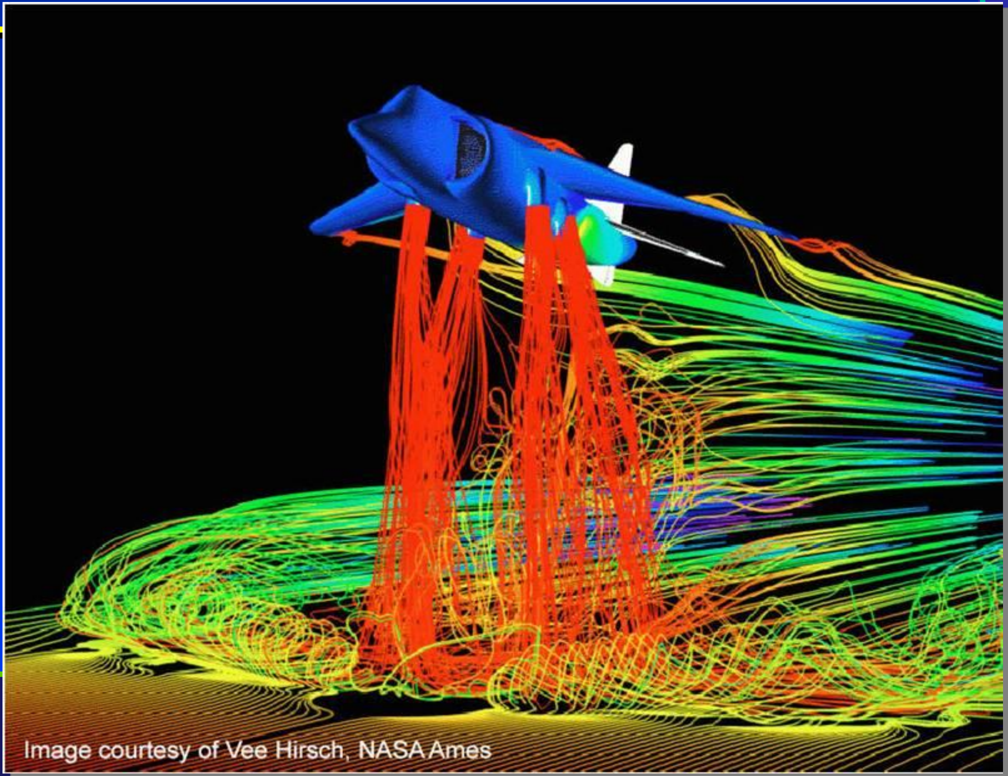
Examples of Visualization

- Terrain visualization (Geographical Information System)
- What are some applications?
- Satellite imaging
- x, y, elevation
- Terrain texture (photographs)
- Cloud cover
- What are some others?



Examples of Visualization

- Scientific simulations (Computational Fluid Dynamics)
- Visualize the results of very sophisticated super-computer simulations
- Computational fluid dynamics example:
- What quantities are being visualized?
- Why bother?



Visualization Examples

- Non-destructive exploration and dissection of:
  - prehistoric artifacts (dinosaur eggs, fossils embedded in soil)
  - artifacts from ancient cultures

1

2

3

The new way

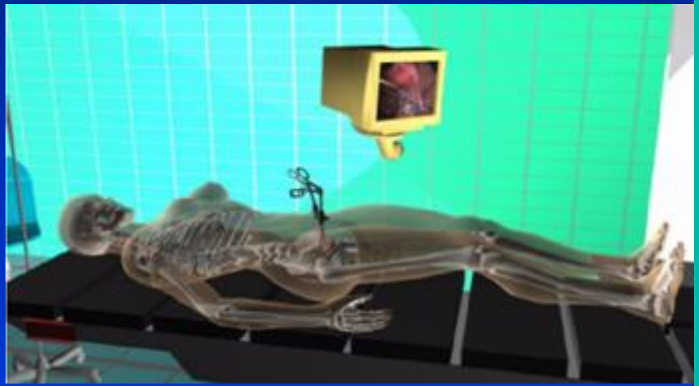
The old way

Examples of Visualization

- Virtual archaeology
- How is a mummy examined? A fossilized dinosaur egg?
- What's wrong with those methods?

Visualization Examples

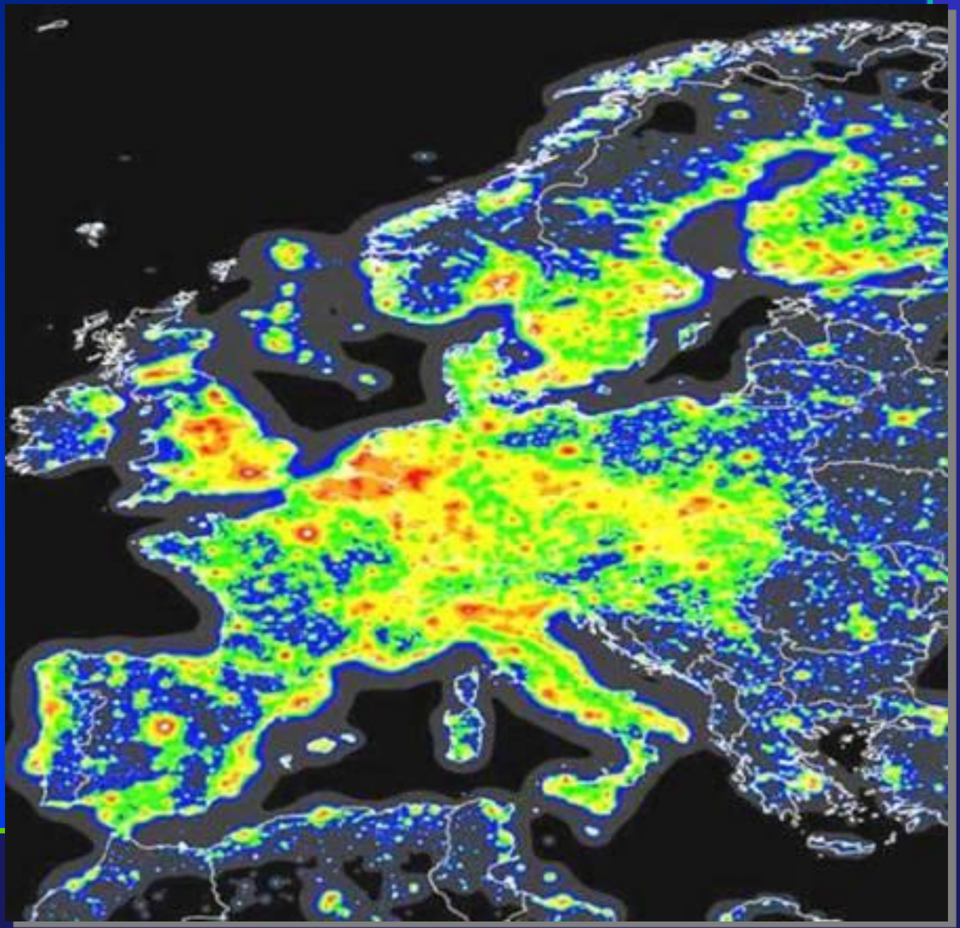
- Classic application for volume rendering since datasets are inherently volumetric
- Modalities are: CT, MRI, Ultrasound, others
- Doctors use volume rendering to visualize organs, structures, and tissue of interest
  - can render unimportant structures (semi-) transparent and emphasize important ones
  - for example: render a brain tumor opaque and the surrounding brain tissue as a faint hull



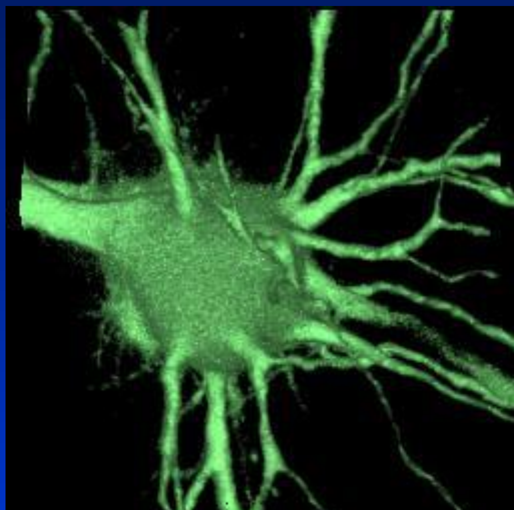
- The medical check-up of the future:
  - get a full body scan with CT and MRI
  - specialist doctors use volume visualization to investigate the state of the discretized patient:
  - a cardiologist checks coronary arteries for arteriosclerotic plaque
  - a radiologist/proctologist flies through the virtual colon and checks for cancer
  - simulate and plan a surgery or procedure on the digital patient if necessary
  - keep the scan as a digital record of the patient for future reference

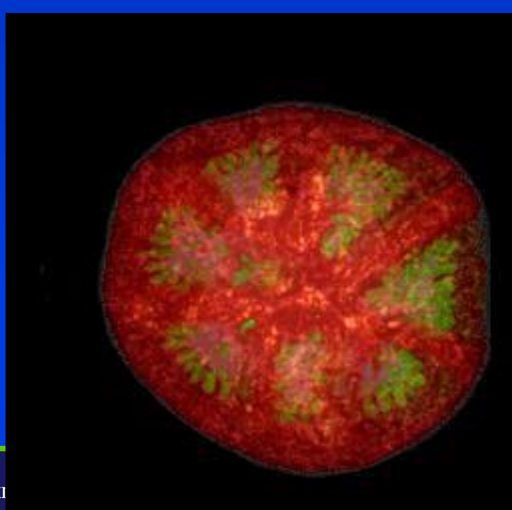
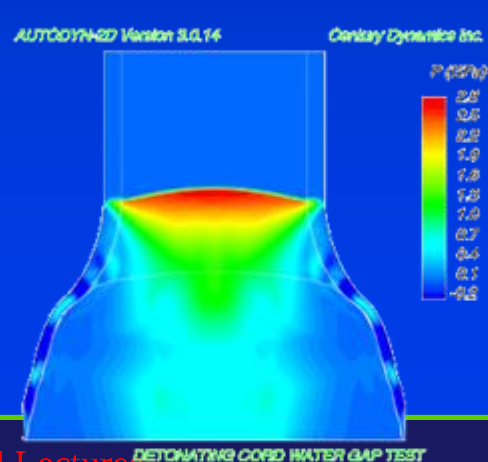
Examples of Visualization

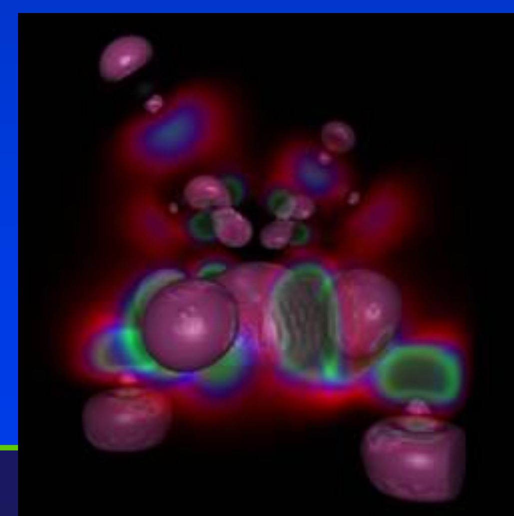
- Map of artificial sky brightness over Europe. This is an effective tool for measuring "light pollution:" brightness of lights on ground affect ability to see starlight. Black: many stars visible. Red: few stars visible.



Visualization Examples

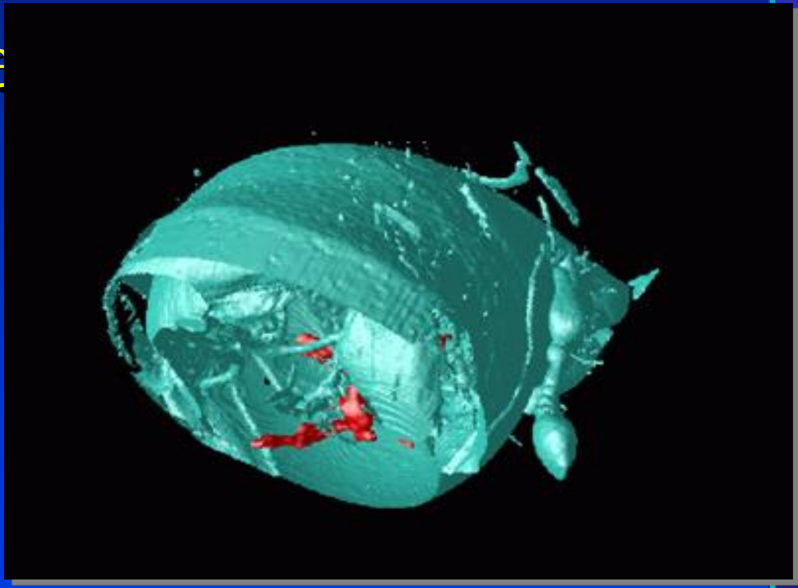




Examples of Visualization

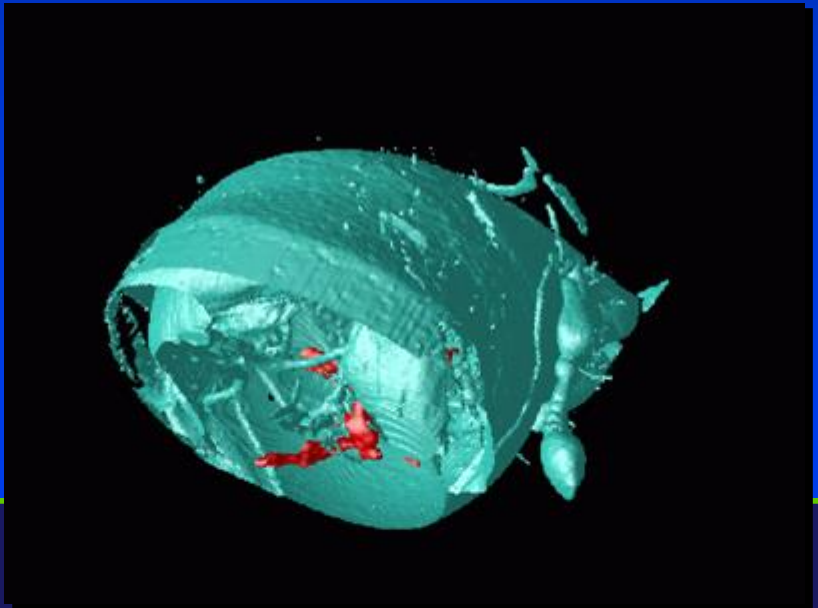
- Microtomography of Alaskan bark beetle
- Correlation between bark beetle and dying trees in Alaskan forest
- Manganese discovered in stomach of insects
- Poisonous to trees!
- Beetles exterminated, forest recovered



Visualization Examples

Alaskan bark beetle

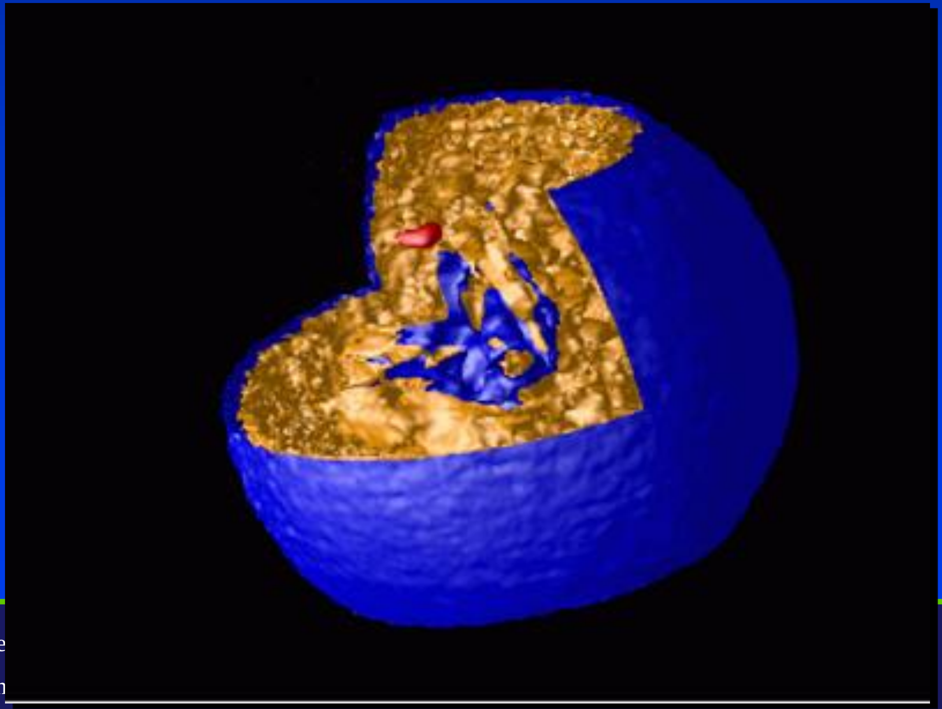
- A few years ago, there was a high incidence of dying trees in the Alaskan forest. Barbara Illman from University of Wisconsin obtained a grant from the U.S. Forest Service to investigate the issue. The study revealed that in all areas with dying trees, the Alaskan bark beetle was also present. A few bugs were collected and brought to BNL. They were CT scanned at the BNL microtomography facility, and the CT scans were then visualized using volume rendering. Dense areas (colored in red) inside the bug became immediately apparent. A biologist was brought in and the dense areas were identified as the gastro-intestinal tract. The substance in the gastro-intestinal tract was analyzed and turned out to be manganese, which is poisonous to trees but apparently harmless to the beetle. After ridding the forest from the bugs, the trees have fully recovered.



source: Microtomography facility at the Brookhaven National Synchrotron Light Source

Micrometeorite

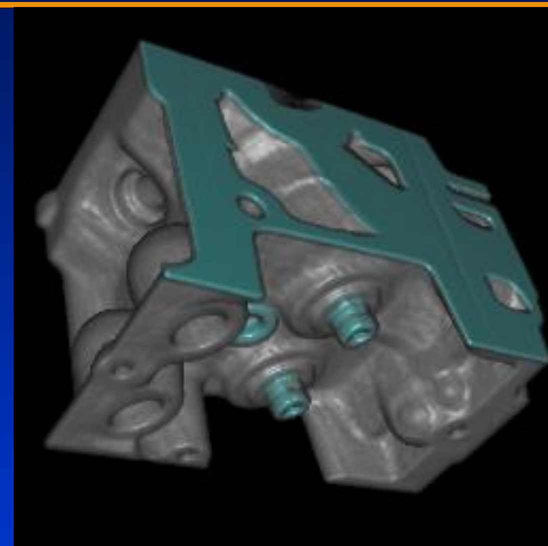
- Shown above is a micrometeorite (0.2 mm diameter) with its outer surface (blue) cut away with virtual visualization tools. The red mass at the upper left is a platinum nugget. The meteorites are picked up off the ocean floor via a metal plate as they are magnetic. Three isosurfaces are shown. The red platinum nugget has been found in every sample so far and is thought to be an important clue in the meteorite's formation.

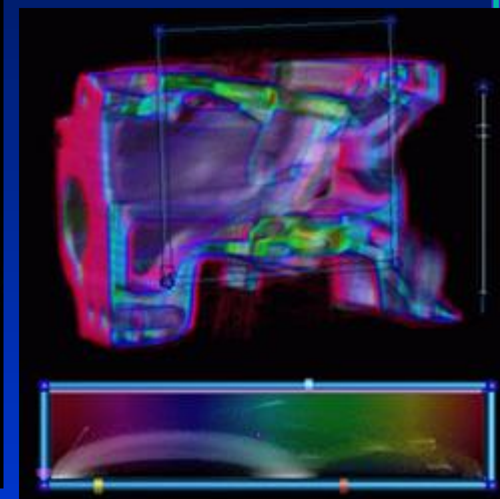


source: Microtomography facility at the Brookhaven National Synchrotron Light Source

Visualization Examples

- Industrial CT
  - reverse engineering
  - inspection for structural failures





- Security
  - airport luggage CT

Typical Threat Objects
Dual Energy Organic/Inorganic Identification

The Visualization Pipeline

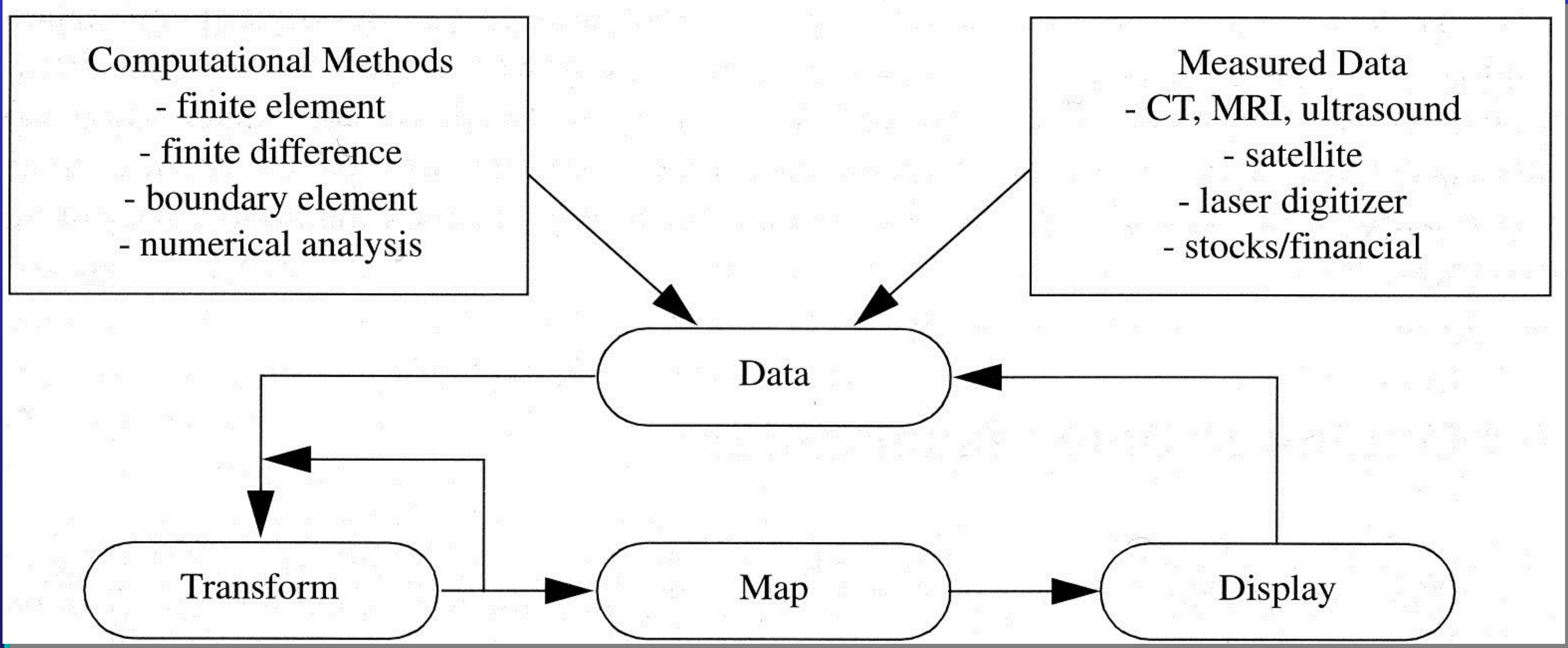


Image Processing, Computer Graphics & Visualization

- *Image processing*
  - study and analysis of 2D pictures or images
- *Computer graphics*
  - process of creating images with a computer
- *Visualization*
  - process of exploring, transforming and viewing data as images
- What's in common?
- How do these three fields overlap?

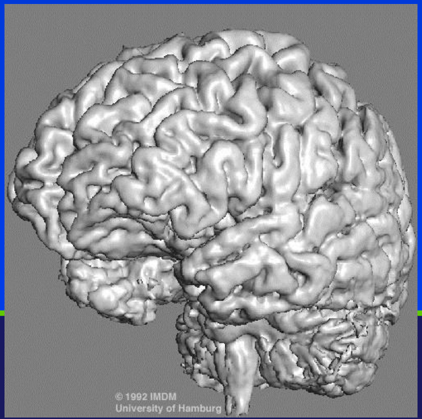
Image Processing, Computer Graphics & Visualization

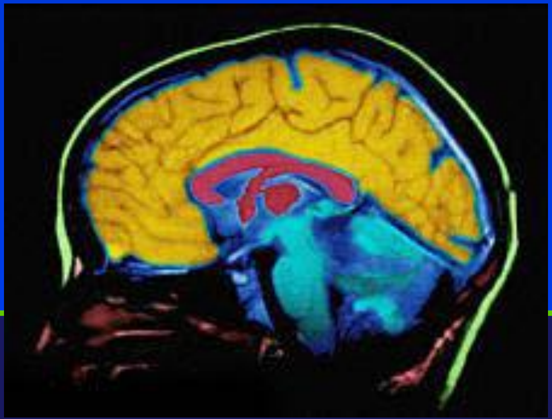
- Computer graphics outputs an image
- Visualization may employ graphics to generate images
- Visualization may employ image processing to study images
- Visualization
  - usually works with 3D or n-D data, for n >= 3
  - employs data transformation to enhance meaning of the data
  - is usually interactive and required human intervention

The Visualization Processes

1. Data acquisition/simulation/modeling
2. Data transformation
3. Data mapping (e.g., to shapes & color)
4. Data display/rendering (via computer graphics)

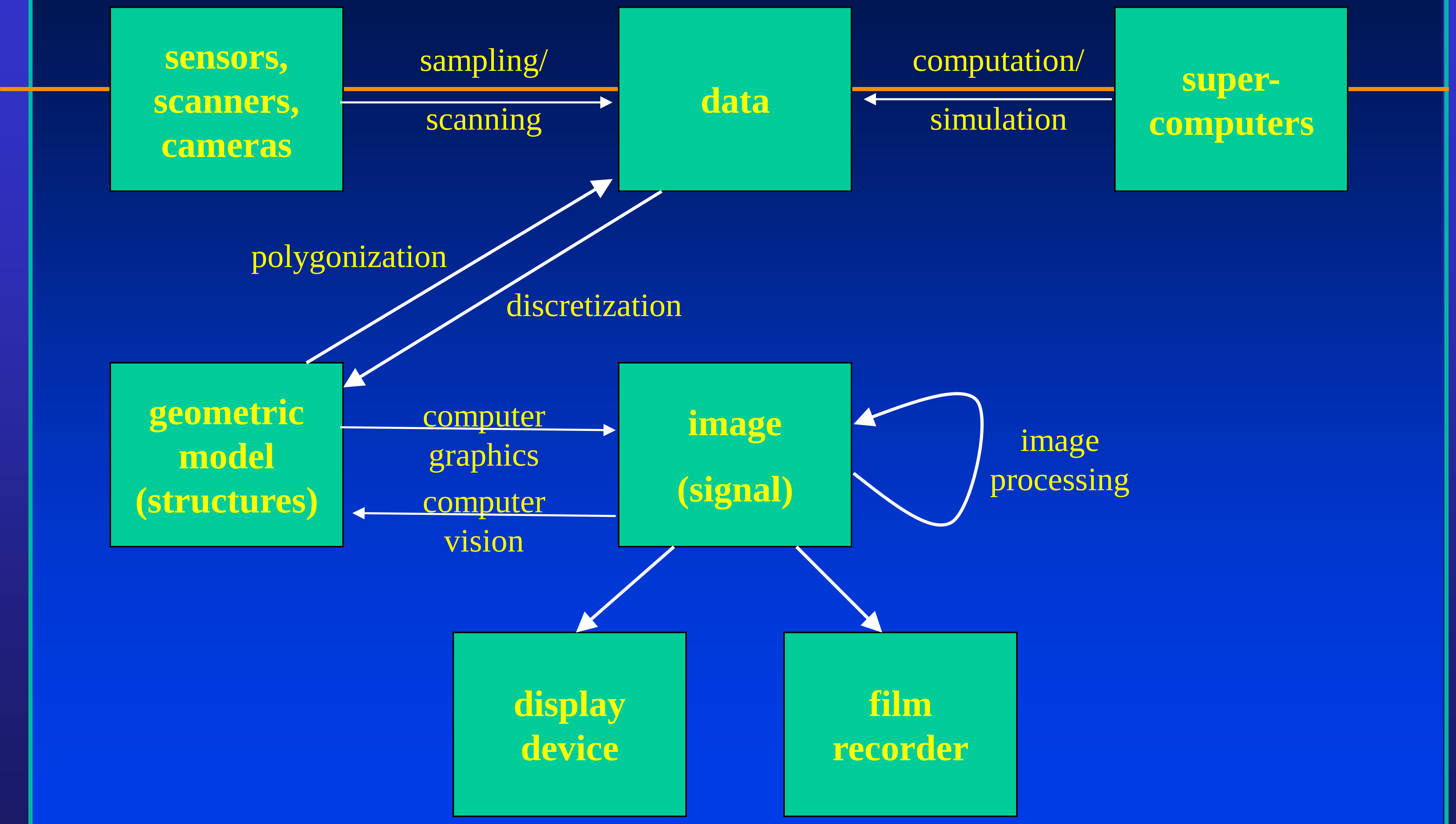
- Steps 2-4 are repeated as necessary to generate multiple visualizations





Visualization Taxomomy

An (Alternate) Visualization Pipeline


sensors, scanners, cameras
sampling/
scanning
data
computation/
simulation
super-computers
polygonization
discretization
geometric model (structures)
computer graphics
computer vision
image (signal)
image processing
display device
film recorder

Relation to Other Fields

Visualization employs these largely independent but convergent fields:

- Computer Graphics (image synthesis): display (rendering)
- Image Processing: analysis or reconstruction of objects from image data. Basically, this is the inverse of computer graphics in that it starts with the image and works from there.
- Computational Vision: image understanding and pattern recognition
- Computer Generated Imagery (CGI): Production of imagery using computers. Includes both computer graphics and image processing.
- Computer Aided Design: integrated engineering
- User Interface Studies: HCI, human factors and evaluations
- Signal Processing:
- Human-computer interaction: mechanisms to communicate, use, perceive visual information
- Neurological/ physiological studies on human brain and our visual system

What is Computer Graphics

- *Computer Graphics*: The pictorial synthesis of real or imaginary objects from their computer-generated-models.
- Computer graphics is the production of (usually) images where none existed before.

Visualization Domain as Data Sources

- Scanned, computed, modeled data
- The first process is data-gathering
- Large variety of data sources and attributes
- Extremely large-scale datasets
- Require real-time processing

Information Domain

- Sciences (e.g., statistics, physics)
- Engineering (e.g., empirical observations for quality control)
- Social events (e.g., population census)
- Economic activities (e.g., stock trading)
- Medicine (e.g., computed tomograph (CT), magnetic resonance imaging (MRI), X-rays, ultrasound, various imaging modalities)
- Geology

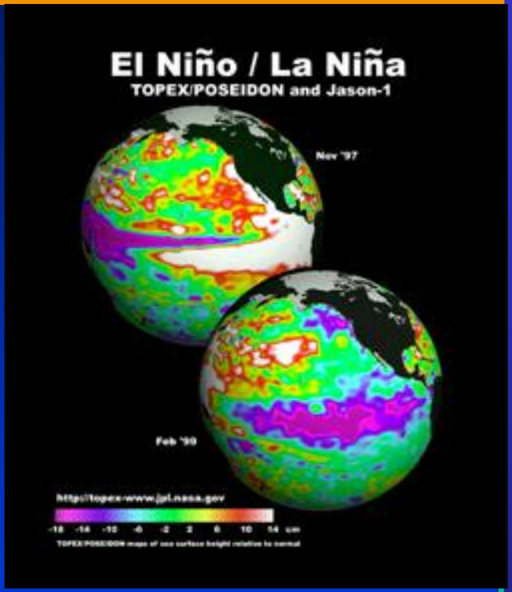
Information Domain

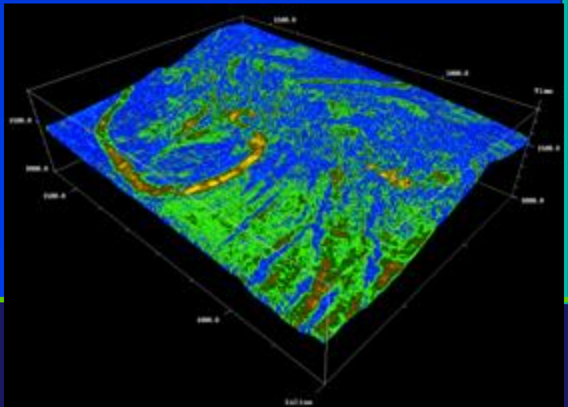
- Biology (e.g., electronic microscopes, DNA sequences, molecular models, drug design)
- Computer-based simulations (e.g., computational fluid dynamics, differential equation solver, finite element analysis)
- Satellite data (e.g., earth resource, military intelligence, weather and atmospheric data)
- Spacecraft data (e.g., planetary data)
- Radio telescope, atmospheric radar, ocean sonar, etc.
- Instrumental devices recording geophysical and seismic activities (e.g., earthquake)

Frequently, Volumetric Data

Are produced by:

- Medical scanners (MRI, CT, SPECT, PET, ultrasound)
- Some (e.g., CT) are also used for industrial purposes (quality control, security)
- Biological scanners, electronic microscopes, confocal microscopes
- Supercomputer simulations, such as computational fluid dynamics, finite element analysis, PDEs
- Orbiting satellites, for military intelligence, weather and atmospheric studies
- Spacecraft sending planetary and interplanetary data
- Geometric models in engineering
- Seismic devices for oil, precious metal exploitation, and earthquake studies





Data Acquisition and Processing

- Pixels and voxels
- Regular & irregular grids
- Numerical simulations
- Surface or volumetric data
- Scalar, vector, tensor data with multiple attributes
- Higher-dimensional and/or time-varying data
- Popular techniques
  - Contouring, iso-surfaces, triangulation, marching cubes, slicing, segmentation, volume rendering, reconstruction
- Image-based processing techniques
  - Sampling, filtering, anti-aliasing, image analysis and manipulation

Visualization and Components

- Data acquisition, representation, and modeling
- Imaging processing
- Visualization (displaying) methods and algorithms
- More advanced research topics

Applications

- Simulation and training: flight, driving
- Scientific visualization: weather, natural phenomena, physical process, chemical reaction, nuclear process
- Science: Mathematics, physics (differential equations) biology (molecular dynamics, structural biology)
- Environments sciences
- Engineering (computational fluid dynamics)
- Computer-aided design/manufacturing (CAD/CAM): architecture, mechanical part, electrical design (VLSI)

Applications

- Art and Entertainment, animation, commercial advertising, movies, games, and video
- Education, and graphical presentation
- Medicine: 3D medical imaging and analysis
- Financial world
- Law
- WWW: graphical design and e-commerce
- Communications, interface, interaction
- Military
- Others: geographic information system, graphical user interfaces, image and geometric databases, virtual reality, etc.

Key Components

- Data acquisition/simulation/modeling and processing: representation choices of different datasets via different modeling techniques
- Transformation and pipelining: conversion of data to visual formats in physical space
- Rendering: simulating light and shadow, camera control, visibility, discretization of models, enrich datasets with graphical means such as color, texture, etc.

Historic Overview

- Visualization
  - Scientific visualization
  - Visualization in scientific computing
- BUT, visualization also includes
  - Biomedical, financial, information data, and many more!
- What are the information (data) from?

Current Trends in Visualization

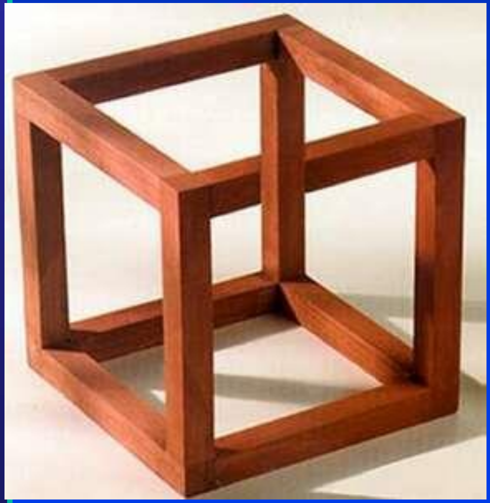
- Scanning technologies (esp. MRI, CT) continue to improve
- New applications (virtual medical exam) for an aging population
- Multidimensional data (vector fields)
- Information visualization is very hot
- Homeland security generating new applications (threat planning in NYC)
- Visual analytics, data mining, machine learning, artificial intelligence, big data, cloud computing, etc.

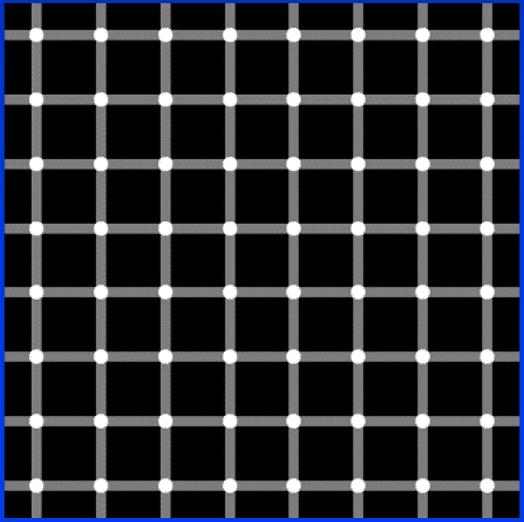
Other Important Issues

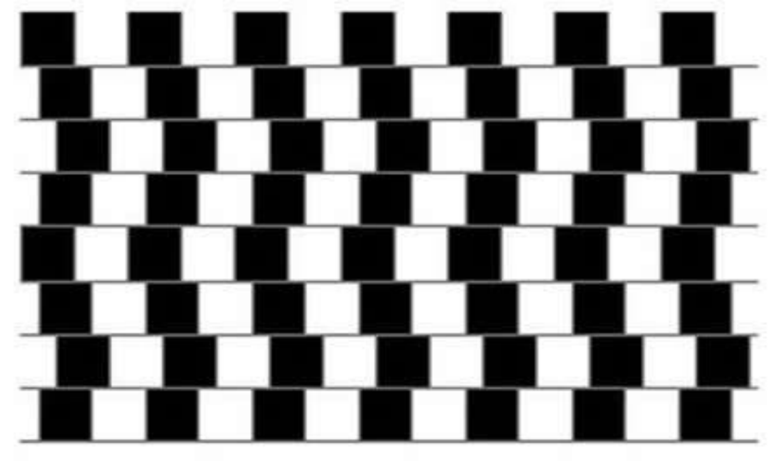
- Accuracy
  - Safety, time, money, efficiency, robustness
- Ethics
  - What are some ethical concerns in visualization? (consider medical visualization)
- Psychological
  - Human visual/perception system
  - What makes an effective visualization?

Visualization Trickery!!!

- Visualization can fool our perceptive system
  - Imperfect image sampling by our eyes
  - Imperfect image interpretation by our brains
  - Beware of mischievous uses of visualization
  - Optical illusions







Visualization as an Integrated Tool

- Primary education (Lawrence Berkeley National Lab virtual frog dissection)
- Medical education for surgery (medical imaging)
- Part removal in engineering designs (virtual assembly)
- Surgical simulation for treatment planning
- Illustration of medical procedures to the patient
- Computational steering: feedback loop of visualization and parameter adjustment
- Intra-operative visualization in brain surgery, biopsies, etc.
- Games with realistic 3D effects
- All of these can be coupled with haptic feedback devices
- Can you think of some other examples? (hint: daily news content)

What Do We Want to Achieve?

Challenges (Big Data)

- TOO MUCH data
- The number of data sources keeps increasing
- Sensor quality and resolution are increasing
- Existing instruments are still available
- The speed of supercomputer is faster than ever
- We must do something (besides collecting and storing the datasets)
- We must deal with the huge datasets effectively
- Visual communication, improve our visual interaction with data

Challenges

- Data-driving, scientific computing to steer calculations
- Real-time interaction with computer and data experimentation
- Drive and gain insight into the scientific discovery process

- “The purpose of scientific computing is insight, not numbers,” by Richard Hamming many years ago
- These fields are all within computer science and engineering, yet visualization spans multi-disciplines
- Visualization (another definition)
  - Application of computers to the disciplines of sciences/engineering

Any Questions?

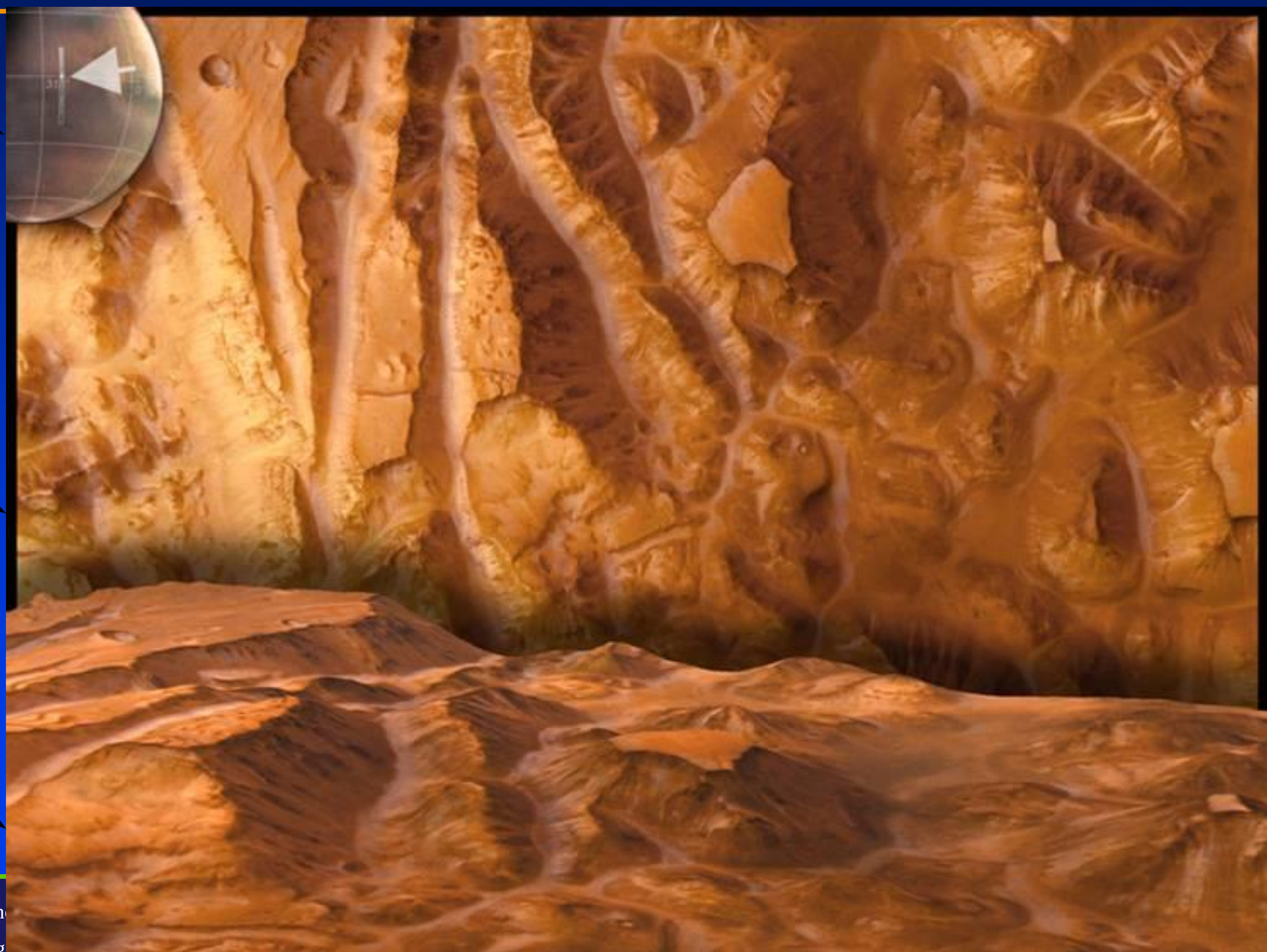
From European Space Agency

portion of planet shown

2D image & elevation map

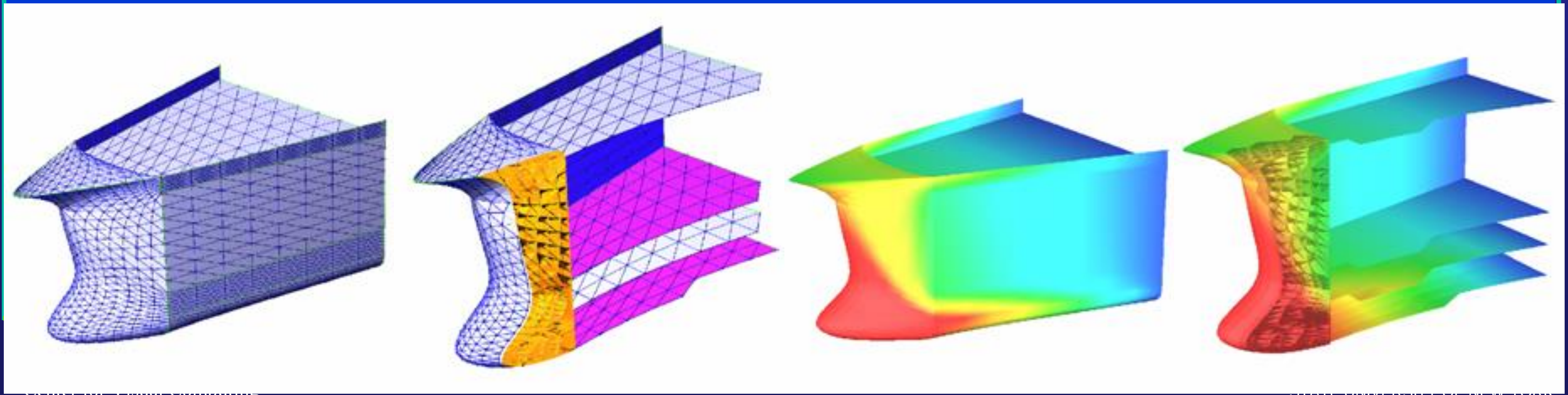
3D rendering

Why bother with 3D?



Special Events

- From time to time we will have invited speakers who are experts in particular aspects of visualization
- These will be excellent opportunities for you to learn about current projects in the Department and search for project/thesis topics

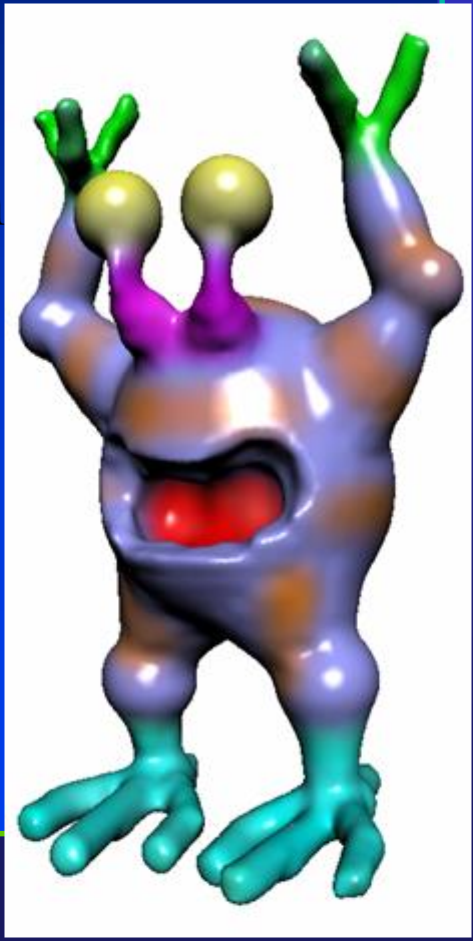


Final Projects

- This course is a project-oriented graduate course
- Course (final) projects are based on recent research published in scientific conference proceedings and journals
- I will meet with each of you briefly so you can tell me your topic
- It is my hope that everyone will select a different project
- Then you will write a short project proposal and keep a log on your home page of your progresses
- Be sure to come talk to me if you are having difficulty with your project so I can point you in the right direction
- At the end of the term, you will hand in a project summary and give a short (10-15 minute) presentation of your work

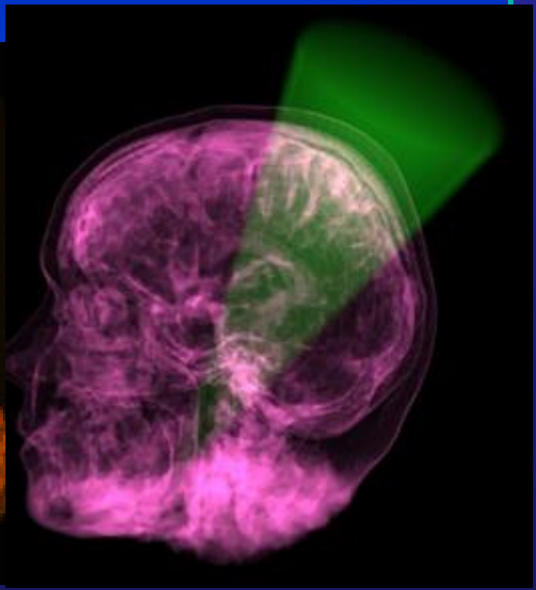
Class Participation

- I am a strong believer that frequent in-class discussion greatly aids the learning process and makes classes much more interesting
- I expect that throughout the term there will be ample opportunity for you to participate directly in the class
- Based on our discussions, I can cover different material in visualization that is of general interest to everyone
- Plus, participating in class will give you some practice for your final project presentation, which you will all give orally during the last week of the semester



CSE564 Visualization and Visual Computing

- **Textbook:** *NO required textbooks*
- **Please carefully follow my lecture notes (published online)**
- Also, reading papers is critical
- Grading policy:
  - Assignment: 10%
  - Paper review: 10%
  - Two exams: 25%
  - Final project: 50%
  - Class participation: 5%
  - Bonus (up to 10%)



Important Deadlines for CSE564

- February 20 (Tuesday, at 12:50pm): programming assignment
- February 22 (Thursday, 1-2:20pm): mid-term one
- March 1 (Thursday, at 12:50pm): One-page proposal for your final course project
- April 5 (Thursday): mid-term system demo
- April 17 (Tuesday, 1-2:20pm): mid-term two
- April 24 (Tuesday, at 12:50pm): technical report on paper review (total 7 papers)
- May 5 (Saturday, 9am): final course project (report+software+ppt) due
- May 5-6: final course project presentation

Summary & Questions

- Visualization overview
- Important visualization terminology
- Fundamental techniques for scientific visualization and computer graphics
- Applications of visualization
- Connection with other fields
- What's the difference between computer graphics and visualization?

Questionnaire

1. List your background courses/knowledge/education related to graphics/visualization, your current education level
2. What is the main goal/purpose for you to take this course (e.g., learn the knowledge, pursue a career in this area)
3. How does this course help your future professional career
4. Your expectations on the course
5. Your studying plan
6. Other important issues that you can think of about the course

Pathway to Success

- Highly-motivated
- Hard-working
- Start as soon as possible
- Meet with Hong on a regular basis
- Actively interact with your fellow students
- Visit library and scholar.google.com frequently

If You are Serious

- Study on-line, electronic course notes
- Review the programming assignment carefully and start to implement them
- Think about your course project
- Form a team (up to 2 people), write a proposal on your project, and start to work on it
- Finish your project by the end of this semester
- Try to submit a paper if your project is really really new
- You are welcome to communicate with the instructors via emails