CSE 564
Visualization & Visual Analytics

Introduction

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Computer Science Department
Stony Brook University
You might be here because of this curve.

The growth of jobs mentioning “data visualization” as a skill from 2010 through 2017 has steadily increased from only 1,888 jobs in 2010 to 30,327 jobs in 2017 (16× growth).

"Visualization" Skill... is needed everywhere

### Top Job Titles Listing "Data Visualization" as a Skill

<table>
<thead>
<tr>
<th>Job Title</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Analyst</td>
<td>34.77%</td>
</tr>
<tr>
<td>Business Analyst</td>
<td>15.82%</td>
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<tr>
<td>Software Development Engineer</td>
<td>13.35%</td>
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<tr>
<td>Business Intelligence Analyst</td>
<td>10.32%</td>
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<tr>
<td>Business Intelligence Developer</td>
<td>6.48%</td>
</tr>
<tr>
<td>Data Architect</td>
<td>5.31%</td>
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<tr>
<td>Software Developer</td>
<td>4.57%</td>
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<tr>
<td>Business Consultant</td>
<td>3.90%</td>
</tr>
<tr>
<td>Graphic Designer</td>
<td>2.76%</td>
</tr>
<tr>
<td>User Experience (UX) Designer</td>
<td>2.71%</td>
</tr>
</tbody>
</table>

### Top Jobs with "Visualization" in Title

Only 3% of total data visualization related jobs included the word "visualization" in the title. Of these 3%, the top jobs were: Data Visualization Specialist (14.29%), Senior Data Visualization Engineer (14.29%), Data Visualization Developer (11.82%), Data Visualization Engineer (10.84%), and Data Visualization Consultant (6.90%).

Baseline, or “soft” skills listed for these 30k “Data Visualization” jobs.

Communication, when mentioned in conjunction with data visualization really means:

- communication of information derived from data
- visual story telling with data
- half of the data analytics projects fail due to poor communication (according to L. Kart, N. Neudecker, F. Buytendijk, Gartner Report GG0255160, 2013)

Apart from the specialized skills, these general skills (or proficiencies) are also often listed:

- SQL
- Tableau (41%),
- Excel (34%), PowerPoint (16%)
- Python (30%), SAS (22%), R (16%), Plotly (?%)
- JavaScript & JavaScript-based data-driven documents D3.js (13%)

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Visualization is not new
Let’s go back some 160 years to 1854, London, England
The most terrible outbreak of cholera which ever occurred in this kingdom, is probably that which is taking place in Broad Street, Golden Square, and adjoining streets.

Within two hundred and fifty yards of the spot where Cambridge Street joins Broad Street, there are upwards of five hundred fatal attacks of cholera in ten days.

The mortality in this limited area probably equals any that was ever caused in this country, even by the plague; and it is much more sudden, as the greater number of cases terminated in a few hours.
What Can We Do?

What Is The Cause?

How Can We Eliminate It?
Time For “Imagination”
Hypothesis: cholera spreads through water
- and not via some other fantastic causes
- one said it rose out of the burying grounds of plague victims from two centuries earlier
- the bacteria was discovered later, in 1886

A real-life experiment (often the case with observational data)
- established the mode of cholera transmission
- and consequently the method of prevention: keep drinking water, food, and hands clear of infected sewage

Visualization provided
- inspiration
- convincing arguments to justify actions
- led to Dr. John Snow’s historic immortality
- a bar near the old Broad Street pump bears his name (safe drinking)
COVID-19 Risk Map

Use pattern analysis of US county socio-economic vulnerability risk factors to predict the initial spread of the virus.
Color mapping:
• the number of times a U.S. county is part of a “high risk” set
• the higher level of risk a county has for high COVID-19 death rates the darker the color

Only counties with at least 1 death on May 10, 2020 are shown.
Pattern-Based Predictions (2020)

D. Coelho, N. Gupta, E. Papenhausen, K. Mueller, "Patterns of Social Vulnerability – An Interactive Dashboard to Explore Risks to Public Health on the US County Level," Workshop on Visual Analytics in Healthcare (VAHC, jointly held with AMIA), Washington, DC, November, 2022. (won Best Paper Award)

link
What Is Needed for Visualization?

Data (wide variety)

Algorithms
- data mining
- data analytics

Computer
- run those algorithms
- data storage

Humans
- with a purpose/need to understand their data
- endowed with cognitive faculties, creative thought, intuition
- domain expertise

Understanding of humans
- perception, cognition, HCI issues
- we can gain it through experimentation with humans
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= Visual Analytics
Dr. John Snow’s London Cholera Map of 1854

- data collection
- data assimilation
- statistical testing
- visualization
- computational analysis (brain)
- domain knowledge

Very early example of visual analytics
Let’s go back some 40 years to 1986, JFK Space Center, FL

73 Seconds After Lift-off
The Day of The Launch

36 degrees F on Launch Pad 39
The field joint that leaked.

Rubber O-rings, nearly 38 feet (11.6 meters) in circumference; 1/4 inch (6.4 mm) thick.

Upon ignition, smoke leaked from this joint. A flame burned through 59 seconds later.
Fast Forward
58 Seconds After Ignition
What Happened?

What Was The Cause?

Could It Have Been Prevented?
Two days before launch they presented their concerns
  - created 13 charts to make their case

Slide #1:

- SRM – Solid Rocket Motor
**SLIDE #2**

Teaches about past damages to O-ring

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### HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

<table>
<thead>
<tr>
<th>SRM No.</th>
<th>Cross Sectional View</th>
<th>Top View</th>
<th>Clocking Location (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Erosion Depth (in.)</td>
<td>Erosion Perimeter (deg)</td>
<td>Length Of Max Erosion (in.)</td>
</tr>
<tr>
<td>22A</td>
<td>None</td>
<td>None</td>
<td>0.280</td>
</tr>
<tr>
<td>22A</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>15A</td>
<td>0.010</td>
<td>154.0</td>
<td>0.280</td>
</tr>
<tr>
<td>15B</td>
<td>0.038</td>
<td>130.0</td>
<td>0.280</td>
</tr>
<tr>
<td>15B</td>
<td>None</td>
<td>45.0</td>
<td>None</td>
</tr>
<tr>
<td>15B</td>
<td>None</td>
<td>None</td>
<td>0.280</td>
</tr>
<tr>
<td>13B</td>
<td>0.028</td>
<td>110.0</td>
<td>0.280</td>
</tr>
<tr>
<td>11A</td>
<td>None</td>
<td>None</td>
<td>0.280</td>
</tr>
<tr>
<td>10A</td>
<td>0.040</td>
<td>217.0</td>
<td>0.280</td>
</tr>
<tr>
<td>2B</td>
<td>0.053</td>
<td>116.0</td>
<td>0.280</td>
</tr>
</tbody>
</table>

---

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.  
**Soot behind primary O-ring.  
***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking location of leak check port - 0 deg.

**OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.**

**SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.**
Teaches about O-ring damage mechanics and erosion

**PRIMARY CONCERNS -**

**FIELD JOINT - HIGHEST CONCERN**

- **EROSION PENETrATION OF primary SEAL requires RELIABLE SECONDARY SEAL FOR PRESSURE INTEGRITY**
  - **IGNITION TRANSIENT - (0-600 MS)**
    - (0-170 MS) HIGH PROBABILITY OF RELIABLE SECONDARY SEAL
    - (170-330 MS) REDUCED PROBABILITY OF RELIABLE SECONDARY SEAL
    - (330-500 MS) HIGH PROBABILITY OF NO SECONDARY SEAL CAPABILITY

- **STEADY STATE - (600 MS - 2 MINUTES)**
  - IF EROSION PENEtrates PRIMARY O-RING SEAL - HIGH PROBABILITY OF NO SECONDARY SEAL CAPABILITY
  - BENCH TESTING SHOwed O-RING NOT capable OF MAINTAINING CONTACT WITH METAL PArTS GAP OPENING RATE TO PEOP
  - BENCH TESTING SHOWED CAPABILITY TO MAINTAIN O-RING CONTACT DURING INITIAL PHASE (0-170 MS) OF TRANSIENT
**Slides #4 and 5**

Lists temperature and blow-by history for two SRMs

**Blow By History**
- **SRM-15 worst blow-by**
  - 2 case joints (80°, 110°) arc
  - Much worse visually than SRM-22

- **SRM-22 blow-by**
  - 2 Case Joints (30-40°)

- **SRM-13 A, 15, 16A, 18, 23A, 24A**
  - Nozzle blow-by

<table>
<thead>
<tr>
<th>MOTOR</th>
<th>MBT</th>
<th>AMB</th>
<th>O-RING</th>
<th>WIND</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM-2</td>
<td>53</td>
<td>10</td>
<td>67</td>
<td>0</td>
</tr>
<tr>
<td>DM-3</td>
<td>76</td>
<td>56</td>
<td>65</td>
<td>10</td>
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<tr>
<td>DM-4</td>
<td>68</td>
<td>45</td>
<td>54</td>
<td>10</td>
</tr>
<tr>
<td>DM-5</td>
<td>72</td>
<td>40</td>
<td>51</td>
<td>10</td>
</tr>
<tr>
<td>DM-6</td>
<td>78</td>
<td>26</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>DM-7</td>
<td>55</td>
<td>26</td>
<td>29</td>
<td>25</td>
</tr>
<tr>
<td>DM-8</td>
<td>72</td>
<td>72</td>
<td>75</td>
<td>0</td>
</tr>
</tbody>
</table>
Given the information provided in the company slides

- would you vote for a launch?
- ignore you know about the consequences

Be keenly aware of the immense PR pressures

- President Reagan’s upcoming State of the Union speech
- the first civilian in space
- NASA’s funding problems

Launch:

- No: OK with a PR disaster & possible budget cuts down the road
- Yes: the rocket company is too cautious & concerns are unproven
Presentation only has exactly two shuttle flights
  - one with two blow-by’s and high temperature
  - one with two blow-by’s and low temperature
  - ignores all other 22 shuttle flights (SRM)

Statistically weak

Recommendation
  - “O-ring temp must be >53°F at launch”

  - is only based on a sample size of 1
  - context of other flights is missing
  - no statistical leverage
Deficiencies

Lots of numbers and facts

But no causal evidence that could predict

What is needed?
What Is Needed?

Need a measure for damage
# Damage Index

<table>
<thead>
<tr>
<th>Flight</th>
<th>Date</th>
<th>Temperature °F</th>
<th>Erosion incidents</th>
<th>Blow-by incidents</th>
<th>Damage index</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>51-C</td>
<td>01.24.85</td>
<td>53°</td>
<td>3</td>
<td>2</td>
<td>11</td>
<td>Most erosion any flight; blow-by; back-up rings heated. Deep, extensive erosion.</td>
</tr>
<tr>
<td>41-B</td>
<td>02.03.84</td>
<td>57°</td>
<td>1</td>
<td></td>
<td>4</td>
<td>O-ring erosion on launch two weeks before Challenger.</td>
</tr>
<tr>
<td>61-C</td>
<td>01.12.86</td>
<td>58°</td>
<td>1</td>
<td></td>
<td>4</td>
<td>O-rings showed signs of heating, but no damage.</td>
</tr>
<tr>
<td>41-C</td>
<td>04.06.84</td>
<td>63°</td>
<td>1</td>
<td></td>
<td>2</td>
<td>Coolest (66°) launch without O-ring problems.</td>
</tr>
<tr>
<td>1</td>
<td>04.12.81</td>
<td>66°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>04.04.83</td>
<td>67°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>51-A</td>
<td>11.08.84</td>
<td>67°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>51-D</td>
<td>04.12.85</td>
<td>67°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
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<tr>
<td>5</td>
<td>11.11.82</td>
<td>68°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>03.22.82</td>
<td>69°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>11.12.81</td>
<td>70°</td>
<td>1</td>
<td></td>
<td>4</td>
<td>Coolest (66°) launch without O-ring problems.</td>
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<tr>
<td>9</td>
<td>11.28.83</td>
<td>70°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
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<tr>
<td>41-D</td>
<td>08.30.84</td>
<td>70°</td>
<td>1</td>
<td></td>
<td>4</td>
<td></td>
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<tr>
<td>51-G</td>
<td>06.17.85</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>7</td>
<td>06.18.83</td>
<td>72°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>08.30.83</td>
<td>73°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>51-B</td>
<td>04.29.85</td>
<td>75°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>61-A</td>
<td>10.30.85</td>
<td>75°</td>
<td>2</td>
<td></td>
<td>4</td>
<td>No erosion. Soot found behind two primary O-rings.</td>
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<tr>
<td>51-I</td>
<td>08.27.85</td>
<td>76°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>61-B</td>
<td>11.26.85</td>
<td>76°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
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<tr>
<td>41-G</td>
<td>10.05.84</td>
<td>78°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
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<tr>
<td>51-J</td>
<td>10.03.85</td>
<td>79°</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>51-F</td>
<td>07.29.85</td>
<td>81°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
O-ring damage index, each launch

26°–29° range of forecasted temperatures (as of January 27, 1986) for the launch of space shuttle Challenger on January 28

Temperature (°F) of field joints at time of launch
Extrapolation of damage curve to the cold
Challenger launch: 31° forecasted
temperature for January 28, 1986

Dots indicate temperature and O-ring damage for 24
successful launches prior to Challenger. Curve shows
increasing damage is related to cooler temperatures.
Used these charts

All information is there

- but very hard to identify and assimilate
- why?
Four seminal books

- standard literature for every visualization enthusiast

- taught information design at Princeton University
- now a professor at Yale University
Course Topics

CSE 564 Visualization & Visual Analytics

- Non-Spatial Data
- Spatial Data
- Display Technology
- Perception & Cognition
- Large & Big Data
- Domain Knowledge
- High Performance Computing
- Data Mining
- Insight
- Knowledge
- Visualization
- Interaction
- Analysis
Spatial Data

- shock wave
- virtual frog
- spiral flow
- nerve cell
- transparent MRI head
- wind flow
- semi-transparent tomato
- MRI head
Spatial Data

- shock wave
- virtual frog
- nerve cell
- spiral flow
- transparent MRI head
- wind flow
- semi-transparent tomato
- MRI head
Spatial Data

Example: Datasets obtained by 3D volumetric scans (CT, MRI)
- what are some questions you might have?
Example: Datasets obtained by 3D Simulations

- what are some questions you might have?

Hypothesis: matter clumps together and attracts more matter
Spatial Data

Example: Data obtained by observation-supported simulations

- what are some questions you might have?

How did hurricane Katrina evolve?
The salient features of a car:
- miles per gallon (MPG)
- top speed
- acceleration
- number of cylinders
- horsepower
- weight

- year
- country origin
- brand
- number of seats
- number of doors
- reliability (# of breakdowns)
- and so on...
How are MPG, weight, HP, and reliability related? Are there tradeoffs? Which car is best for me?
HIGH-DIMENSIONAL DATA VISUALIZATION
Big Data

12+ TBs of tweet data every day

30 billion RFID tags today (1.3B in 2005)

4.6 billion camera phones worldwide

100s of millions of GPS enabled devices sold annually

2+ billion people on the Web by end 2011

25+ TBs of log data every day

76 million smart meters in 2009... 200M by 2014
The Scientific Method

In the Age of Data Science

- Formulate Question
- Generate Hypothesis
- Form Experiment (find data sources)
- Collect Data (scrape, mine)
- Analyze Data
- Test Prediction (visualize)
- Publish Results

Form Testable Prediction
**Explainable AI**

### Today

- **Training Data** → **Machine Learning Process** → **Learned Function** → **Decision or Recommendation** → **Task**

### Visual explanations

- Why did you do that?
- Why not something else?
- When do you succeed?
- When do you fail?
- When can I trust you?
- How do I correct an error?

### XAI

- **Training Data** → **New Machine Learning Process** → **Explainable Model** → **Explanation Interface** → **Task**

### Visual explanations

- I understand why
- I understand why not
- I know when you succeed
- I know when you fail
- I know when to trust you
- I know why you erred
VISUAL ANALYTICS VS. DATA SCIENCE

Scope of Visual Analytics

- Information Analytics
- Geospatial Analytics
- Scientific Analytics
- Statistical Analytics

- Interaction
- Cognitive and Perceptual Science
- Presentation, production, and dissemination
- Data Management & Knowledge Representation
- Knowledge Discovery

Data Science

- Domain Expertise
- Data Engineering
- Scientific Method
- Math
- Statistics
- Advanced Computing
- Visualization
- Hacker Mindset
MODERN DATA SCIENTIST

MATH & STATISTICS
- Machine learning
- Statistical modeling
- Experiment design
- Bayesian inference
- Supervised learning: decision trees, random forests, logistic regression

DOMAIN KNOWLEDGE & SOFT SKILLS
- Passionate about the business
- Curious about data
- Influence without authority
- Hacker mindset
- Problem solver
- Strategic, proactive, creative, innovative and collaborative

PROGRAMMING & DATABASE
- Computer science fundamentals
- Scripting language e.g. Python
- Statistical computing packages, e.g., R
- Databases: SQL and NoSQL
- Relational algebra
- Parallel databases and parallel query processing

COMMUNICATION & VISUALIZATION
- Able to engage with senior management
- Story telling skills
- Translate data-driven insights into decisions and actions
- Visual art design
- R packages like ggplot or lattice
- Knowledge of any of visualization tools e.g. Flare, D3.js, Tableau
Make decisions based on data

- not purely on intuition and long business experience
- use a combination of these
Visualization Can Be Beautiful
Visualization Is Fast

< 200 ms to recognize the red dot
Visualization Is Fast
Vision is massively parallel

more than 50% of the brain
Visualization Can Be Beautiful
Visualization Can Be Interactive

D3 Demo

Data-Driven Documents
Visualization Has a Long History
Visualization Can be Inspired by Art
Visualization Can be Deceptive
Visualization Can be Deceptive
Visualization Can be Deceptive

Count the number of black dots
Visualization Can be Deceptive
Visualization Can be Deceptive

Are the horizontal lines parallel or do they slope?
Visualization Can be Deceptive

How many legs does this elephant have?
Visualization Can be Deceptive

Julian Beever
Which circle in the middle is bigger?
Visualization Can Be Deceptive

Gun deaths in Florida

Number of murders committed using firearms

2005 Florida enacted its ‘Stand Your Ground’ law

Source: Florida Department of Law Enforcement

C. Chan 16/02/2014
The human visual system is not perfect, but it’s extremely powerful.

Vision is an integral part of life.

Vision is the gateway to higher-level regions of the brain.

Exploit this fast and powerful processor for:
- complex data analyses, creative tasks, communicating ideas

→ The science of visualization and visual analytics
Text Books

Required

Optional
Tentative Schedule
<table>
<thead>
<tr>
<th>Lecture</th>
<th>Topic</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intro, schedule, and logistics</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Applications of visual analytics, basic tasks, data types</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Introduction to D3, basic vis techniques for non-spatial data</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Data assimilation and preparation</td>
<td>Project #1 out</td>
</tr>
<tr>
<td>5</td>
<td>Data assimilation and preparation</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Bias in visualization</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Data reduction and dimension reduction</td>
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</tr>
<tr>
<td>8</td>
<td>Visual perception</td>
<td>Project #2(a) out</td>
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<tr>
<td>9</td>
<td>Visual cognition</td>
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<tr>
<td>10</td>
<td>Visual design and aesthetics</td>
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<tr>
<td>11</td>
<td>Cluster analysis: numerical data</td>
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<tr>
<td>12</td>
<td>Cluster analysis: categorical data</td>
<td>Project #2(b) out</td>
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<td>13</td>
<td>High-dimensional data visualization</td>
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<td>14</td>
<td>Dimensionality reduction and embedding methods</td>
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<tr>
<td>15</td>
<td>Principles of interaction</td>
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<tr>
<td>16</td>
<td>Midterm #1</td>
<td></td>
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<tr>
<td>17</td>
<td>Visual analytics</td>
<td>Final project proposal call out</td>
</tr>
<tr>
<td>18</td>
<td>The visual sense making process</td>
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<tr>
<td>19</td>
<td>Maps</td>
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<tr>
<td>20</td>
<td>Visualization of hierarchies</td>
<td>Final project proposal due</td>
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<tr>
<td>21</td>
<td>Visualization of time-varying and time-series data</td>
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<tr>
<td>22</td>
<td>Foundations of scientific and medical visualization</td>
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<tr>
<td>23</td>
<td>Volume rendering</td>
<td>Project 3 out</td>
</tr>
<tr>
<td>24</td>
<td>Scientific and medical visualization</td>
<td>Final Project preliminary report due</td>
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<tr>
<td>25</td>
<td>Visual analytics system design and evaluation</td>
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<tr>
<td>26</td>
<td>Memorable visualization and embellishments</td>
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<td>27</td>
<td>Infographics design</td>
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<tr>
<td>28</td>
<td>Midterm #2</td>
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</tbody>
</table>
Everything you need is there:

- syllabus
- course notes (slides) posted shortly after the lecture
- lab assignments
- course policy

There will also be (soon to be announced)

- a server for lab assignments
- piazza for online support
Grading

Projects (3): 10% each
Midterm (2): 20% each
Final Project: 30%
  • proposal: 5%
  • prelim report: 5%
  • final report and presentation: 20%

Extra credits
  • will be given for projects but can only be applied in project grade

Participation
  • not graded
  • but I hope you will attend regularly and participate actively

For late submission policy see website
All communications will use Piazza
Choose among two options:

A research project with some visual analytics theme
- a new technique to solve a human-in-the-loop analytics task
- might even lead to a research paper for publication

A visual analytics (VA) dashboard that enables analytical tasks
- has synergy with one or more datasets you will identify
- needs to support brushing and linking and fit on the screen

Both options will require a proposal
See a really good example on youtube

Programmed with:
- python
- html
- JavaScript
- D3 API

Your path to this:
- a dashboard is a collection of data visualizations linked together
- you will program most (but probably not all) of the individual dashboard components in lab 2 and 3
- the dashboard puts them all on one page and connect them in a meaningful way so they together can support users in interactive data analysis explorations
You will need to know html and js
  - better get ready now if you do not know it

Fortunately there is a great and easy resource
  - W3schools html
  - W3schools JavaScript

HTML part, focus on:
  - HTML Tutorial (specifically the sections Home to Layout)
  - HTML Graphics
  - will take you 2 days max

JavaScript part, focus on:
  - JS Tutorial
  - JS Objects, JS Functions, JS Async
  - JS HTML DOM (Document Object Model)
  - JS JSON (JavaScript Object Notation)
  - will take you 2 weeks (one hour each day, ~15-20 hours total)
Several free code development environments are available

- Visual Studio Code (recommended)
- Atom
- Sublime Text

Browsers to run and develop your code

- Chrome
- Firefox
- IE and Edge are not overly suitable
- Chrome and Firefox also have panels where you can see and edit your code
- comes in handy when you want to change values of variables
If you are not a CS student can instead used **plotly**

- Plotly Dash lets you build/deploy analytic web apps via Python
- no JavaScript required.
- downside is that it does not support brushing and linking
Visualization Libraries etc.
D3, **Vega, Vega-LITE**

**D3 – Data Driven Documents (we will use for this course)**
- creates interactive webpages from data
- lots of creations are [here](#)

**Vega (see [here](#))**
- higher-level visualization specification language on top of D3
- D3 is still more “expressive” and allows for more creative freedom

**Vega-Lite (see [here](#))**
- a high-level grammar of interactive graphics
- built on top of Vega
- more concise & convenient form to author common visualizations
- supports data analytics (both data and visual transformations)
- better support for interactions
Tableau is a leading commercial visual analytics platform

- founded in 2003 by a group of Stanford University researchers (Chris Stolte, Pat Hanrahan, and Christian Chabot)
- recently acquired by Salesforce
- goal was to make data more accessible through visualization
- key tech was VizQL – visualizes data by translating drag-and-drop actions into data queries through an intuitive interface
Example Tableau Dashboards

Account tracking

Quarterly results

Top accounts

Opportunity overview

Opportunity tracking

Marketing leads
Essentially, **Tableau** is great for expediently-developed in-house use. **D3** is better for external use, real-time interactive web, and embedding into a product.