CUSP-GX-6006 Data Visualization

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Course Prerequisites

The coursework includes projects that require visual programming using Python/Matplotlib (but any language for your final project with freeform choice). While previous knowledge is not required, being proficient and comfortable with programming is a fundamental prerequisite for this course. Previous experience with computer graphics, algebra, geometry, data science, and analysis can also help but is not required.

Course Description

Being able to analyze and present data visually has become one of the most important skills for work in data science, finance, and related fields. Information Visualization teaches you how to design effective interactive visualizations of complex data for data understanding discovery and presentation.

The course is a blend of theoretical and practical knowledge aimed at developing a well-rounded set of skills to ideate, design, implement, and evaluate sophisticated data visualization projects. The course will proceed with 3 meta sections: 1) information visualization techniques/models of visual encoding, perception, and practical applications; 2) fundamental data processing and basic computer graphics; 3) modern medium visualization topics such as VR/AR, deep learning visualization, and multimodal interfaces. Through the course as an example, you will develop core academic and industrial skillset including reading/writing, presentation, and mathematical/computational skills.

The theoretical part contains low-level optical and computational methods of how individual pixels are drawn on the screen, and how they are perceived by the human eyeball, the retina, and the brain. The practical part aims at teaching the skills needed to develop effective interactive data visualizations for analysis and presentation.

The course also includes a series of small practical projects which enable students to gain experience with the development of fully-working interactive graphics/visualization techniques. The final project, with the freedom to select among several topics, is organized in a way to simulate conditions happening in real-world data analysis and communication projects and includes activities to gain feedback from the instructor and the teaching assistants.

Course Objectives

- Develop low-level knowledge of visual computing, including basic algebra, computer graphics, and optics

- Develop an understanding of the unique human visual and cognitive system while perceiving digital content
- Identify what kind of problems visualization can solve
- Explain why and when visualization works
- Develop analytical questions for a data analysis problem and develop appropriate data manipulations and graphs to answer them
- Describe how to evaluate a visualization project: identify the elements of a project that need to be evaluated and strategies to carry out effective evaluations
- Identify the right type of graph for a data analysis and presentation problem based on tabular data
- Identify the appropriate graph for a given problem
- Describe what the limitations of a visualization method are and how they can be overcome
- Recall the set of marks and channels visualization methods can use and describe their advantages and disadvantages
- Describe a visualization in terms of its encoding strategy (marks and channels used) and identify its potential limitations
- Describe the concepts of channel effectiveness and expressiveness and demonstrate how to apply them in the design and evaluation of data visualizations
- Use appropriate visual representations for a problem with geographical, time-oriented, and network data
- Read and summarize the state-of-the-art research literature
- Gain hands-on experience on modern and interdisciplinary visualization topics and platforms, such as VR/AR and deep learning.

Course Structure

The course includes lectures, mini (programming) assignment, readings, reports, and design/development of visual computing projects.

Textbooks

There are no required textbooks. However, the following books are those that contain most of the information taught in the course:

Visualization Analysis and Design, Tamara Munzner, CRC Press 2014

Envisioning Information, Edward Tufte, 1990

Other recommended texts are:

Fund of Computer Graphics, Steve Marschner, Taylor & Francis Group, LLC 2016

Published articles in IEEE Vis/TVCG and ACM ToG/SIGGRAPH

Course requirements

The course requires:

- Attendance: full attendance of weekly classes;
- Projects: development and submission of assigned mini-assignments and projects;
- Literature reading and survey: based on your selected project, summarize and present previous literature.

Grading breakdown:

- Mini-projects: 15% x 4
- Article survey report: 10%
- Final project: 30%

For special situations such as sickness, quarantine, religious festivities, family issues, etc, the deadlines of each element may be extended and flexible to accommodate your need. You should send me a note ahead to discuss and for approval.

Mini and Final Projects

Five mini-projects consist of an assigned data set and a problem the visualization is supposed to solve. The solution requires designing a solution and implementing it in Python.

Examples of the final project can be 1) applying visualization for your own interested application or data, or 2) your current research project with a visualization component, or 3)a larger-scale implementation of state-of-the-art research. You can freely choose any topic/article that you like. Various options will be provided. Early discussion with the instructor on the final project topic and scope is **strongly recommended**.

Literature reading and survey

An essential skill is to read and summarize prior work and literature. After selecting the final project topic, you will start searching and summarizing prior literature along the same direction. A 4-page survey will be written to assess your domain-specific knowledge in both breadth and depth.

Schedule

This is the tentative schedule for the course. Note that the schedule may change to adapt to the specific needs of the class.

1 Introduction and syllabus
2 Latex and Fundamental Data Processing

3	Color and color space
4	Visual encoding & perception
5	2D visualization - spatial data Guest lecture on Color and Accessibility
6	2D visualization - temporal data
7	2D visualization - network data Fall Break - No Class
8	3D visualization - basic projection and graphics
9	3D Urban visualization case study
10	Urban visualization case study
11	Guest lecture on AI Content Generation (AIGC)
12	Modern topics - deep learning/VR/AR/Interaction
13	Final project presentation

Note that the schedule may slightly vary during the semester. Make sure to check frequently for possible changes!

Quoting Policy and Collaboration

The work students submit for individual assignments and class projects must be their own original work. When ideas are borrowed from existing work it is necessary to provide citations and a clear statement that describes which part has been adopted and which is original.

For all projects, students are NOT allowed to collaborate with their peers or copy from open-source solutions. The submitted projects must be produced and submitted individually.

Academic Dishonesty

It's always annoying having to explain that copying work or cheating is not allowed. I like to totally trust each and every one of you. But bad things happen and I have to warn you that academic dishonesty is a very serious thing and you might get in very serious trouble if caught cheating. Students caught in dishonest behavior get an F score for the course and are reported to the school.

Please refer to NYU Tandon's code of conduct to guide your academic behavior: https://engineering.nyu.edu/campus-and-community/student-life/office-student-affairs/policies/student-code-conduct

Moses Center Statement of Disability

If you are a student with a disability who is requesting accommodations, please contact New York University's Moses Center for Students with Disabilities at 212-998-4980 or mosescsd@nyu.edu. You must be registered with CSD to receive accommodations. Information about the Moses Center can be found at www.nyu.edu/csd. The Moses Center is located at 726 Broadway on the 2nd floor.