ECE 695D - INTRODUCTION TO VISUAL ANALYTICS

The Internet of Things (IoT), exascale computing systems and powerful new scientific instruments has created an unprecedented growth of digital data that permeates every field. Unfortunately, this sea of data has not yet had the expected transformational effect that, but has instead become a bottleneck in itself. Fundamental new techniques are needed to turn this data deluge into the useful, understandable information and knowledge necessary for transformational changes in business, science, agriculture, engineering, and decision making, creating interactive knowledge environments for exploration, design, and discovery. The emerging fields of data science and visual analytics have been created to address this problem.

Visual analytics---the science of combining interactive visual interfaces with automatic algorithms to support analytical reasoning and build synergies between humans and computers---is a recent field of science that has been created to address this challenge. Originally launched in 2004 to enable harnessing the data deluge in tackling the overarching economic, environmental, and security-related challenges facing society, the discipline is now rapidly growing across the globe and being harnessed to solve problems across society.

Visual analytics is used in all areas spanning science, engineering, business and government; examples of specific application areas include intelligence analysis for homeland security, business intelligence support to help businesses acquire a better understanding of their commercial context, mobile graphics for emergency first responders, network log analysis for computer security, and health monitoring for disease outbreak prediction and response.

This course will serve as an introduction to the science and technology of visual analytics. The course contents will include both theoretical foundations of this interdisciplinary science as well as practical applications of integrated visual analysis techniques on real-world problems.

Overview
This course will cover topics in visual analytics. The format for the course will be group discussions of papers, lectures by the instructor, and student presentations of papers. There will also be a class project, paper summaries in an annotated bibliography, and a take-home midterm exam. The grading will be based on participation in class, critical assignments, and class projects. Class projects may be done individually or in groups. Projects have the potential of leading to work that forms the basis of an undergraduate research project, Master's thesis, or Ph.D. research topic.

Assessment Methods
The course outcomes will be assessed through student demonstration of a completed visual analytics project, submission of working program(s), oral and written presentation of results (literature survey, alpha release report, beta release report, regular meetings of project teams with the instructor, and the final project report), and a take-home midterm exam. The overall knowledge acquisition of visual analytics will be assessed by student oral presentations of papers, through the completion of a literature review, and through several initial project assignments.

Grades will be assigned on the following:

- Paper summaries (reading and evaluation) - 20%
- Analytical exercise - 10%
- Paper presentations and class participation - 10%
- Midterm exam - 10%
- Class project - 50%

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COURSE DETAILS

- **Instructor:**
  David Ebert
  Silicon Valley Professor, ECE
  E-mail: ebertd@purdue.edu
  Phone: (765) 494-9064
  Room: Potter 228
  Office hours: M,W 11:30-12:30.
- **Lectures**: M,W,F 10.30am – 11.20am, ME 1009
- **Textbook**: No official textbook, research papers (see the ReadingList).
- **Course website**: https://engineering.purdue.edu/~elm/teaching/ece695d/ (also see the Purdue Blackboard Vista site for the course)
- **Prerequisites**: Introductory knowledge of one or more of the following areas: data analysis, knowledge management, statistics, computer graphics, visualization.

COURSE GOALS AND OUTCOMES

A student who successfully fulfills the course requirements will have demonstrated:

- Understanding of the fundamentals of visual analytics and its applications
- Understanding of the analytical reasoning process
- Understanding of cognition, perception, and designing for human users
- Ability to design, build, and evaluate suitable visual representations to a real-world dataset
- Ability to apply automatic analysis algorithms (such as statistics, aggregation, or knowledge discovery) to real-world datasets

READINGS

There is no official textbook for this course. Students will read and discuss seminal and current technical research papers. A list of readings (in progress and subject to frequent update) is available on the ReadingList.

The following books may be useful as references.

- ILLUMINATING THE PATH: THE R&D AGENDA FOR VISUAL ANALYTICS, Editors: James J. Thomas and Kristin A. Cook (online version)
- THE VISUALIZATION HANDBOOK, by Charles Hansen and Christopher Johnson, Academic Press, 2005
- THE VISUALIZATION TOOLKIT: AN OBJECT-ORIENTED APPROACH TO 3D GRAPHICS, by William Schroeder, Ken Martin, Bill Lorensen, 2nd Edition, 1997, (ISBN 0-13-954694-4).
- READINGS IN INFORMATION VISUALIZATION: USING VISION TO THINK, by Stuart K. Card, Jock D. Mackinlay, and Ben Shneiderman, Morgan Kaufmann

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GRADES

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- Paper summaries (reading and evaluation) - 20%
- Analytical exercise - 10%
- Paper presentations and class participation - 10%
- Midterm exam - 10%
- Class project - 50%

Submissions may be turned in up to one week after the due date with a 30% grade penalty. Phases will not be accepted more than a week late. If you have a research deadline or other permissible excuse, please speak with the instructor ASAP to resolve late and missed submissions.

Plus/minus grading will be used in this class.

ASSIGNMENTS

This course has five types of assignments: an introductory visualization assignment, weekly paper critiques, paper presentations, and the course project. More details on these are given below:

- **Analytical Exercise:** To get a firsthand experience of some of the problems that our potential end users face, you will perform an analytical reasoning exercise to find a hidden threat in collection of police and intelligence reports. The exercise will not involve any programming and can be done entirely by hand on paper.
    - Released: Tuesday, Aug 20 (Week 1)
    - Deadline (Phase 1): Thursday, Aug 29 (Week 2)
    - Deadline (Phase 2): Thursday, Sep 5 (Week 3)
- **Paper Summaries:** Each student taking this course for credit must write a summary of a research paper every week (see the PaperSummaries document).
    - Deadline: every Sunday at midnight (with some exceptions)
- **Paper Presentations:** Students must present two (2) research papers in-class during the course. Presentations should be 10-15 minutes.
- **Course Project:**
    - Released: Wed Aug 22 (Week 1)
    - Deadlines: several milestones
        - Wed, Sep 5 (Week 3) - Project Proposal
        - Sunday, Sep 23 (Week 5) - Literature Review
        - Sunday, Sep 30 (Week 6) - Design
        - Sunday, Oct 21 (Week 8) - Alpha Release
        - Sunday, Nov 11 (Week 12) - Beta Release
        - Sunday, Nov 18 (Week 13) - Paper Draft
        - Sunday, Nov 25 (Week 14) - Final Paper
        - Last week of classes (Week 16) - Presentations

- Sunday, Dec 9 (Week 16) - Final Release
- Sunday, Dec 9 (Week 16) - Final Reviews

There is **no** final exam in this course. There is, however, a take-home midterm exam that will be administered halfway through the course.

ACADEMIC INTEGRITY

Students must conform to Purdue's policy on academic integrity. More specifically, Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [University Regulations, Part 5, Section III, B, 2, a]

Please see the detailed page on AcademicIntegrity. Note that you are responsible for knowing this information---ignorance is not a valid excuse.

CAMPUS EMERGENCIES

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Information about changes in this course can be received from the course website, or the Blackboard site, or by contacting the instructor by email (ebertd@purdue.edu) or office phone (765-494-9064).

Please see the detailed page on CampusEmergencies for more information.

COURSE OUTLINE

Below is a rough outline of the course. Detailed reading lists (including paper selections for in-class presentations) will be made available on the course website. Please note that this is a tentative outline and it is subject to **change** during the course of the semester!

Week 1: Introduction
Week 2: Analytical Reasoning and Critical Thinking
Week 3: Analytical Reasoning and Critical Thinking
Week 4: Perception
Week 5: Cognition
Week 6: Data Representations, Transformations, and Statistics
Week 7: Data Representations, Transformations, and Statistics
Week 8: Machine learning and VA
Week 9: Visual Representations
Week 10: IEEE VisWeek 2009 (October break, Oct 12-13) (NO CLASSES)
Week 11: Interaction and Interface Design
Week 12: Communication
Week 13: Evaluation
Week 14: Collaboration (only 1 lecture this week)
Week 15: Advanced Topics
Week 16: Project Presentations