*Course Syllabus*

*Data Visualization Tools and Applications*

*Tuesday & Thursday, 5:30 PM – 6:45 PM*

Instructor(s): Vetria L. Byrd, PhD Course: CGT 57500 / ASM 59100

Office: KNOY 371 Term: Spring 2024

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Office Hour: TBD Time: 5:30 PM – 6:45 PM

Other by appointment

Zoom: Meeting information provided in Brightspace

Instructor: Dharmendra Saraswat, PhD

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Office Hour: TBD

Other by appointment

Zoom: Meeting information provided in Brightspace

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Office Hour: TBD

Other by appointment

**Join Slack:** <https://join.slack.com/t/slack-bjw9743/shared_invite/zt-1mreniecl-h_Dnd6_h_alCFKzNqnVRXg>

*COURSE DESCRIPTION*

This course is designed for students with little or no background in Data Visualization. It provides an introductory examination of the visualization process through lectures, readings, and hands-on experience with current visualization tools. Students will be provided with hands-on experience in Internet of Things (IoTs) sensors for real-time data acquisition, processing, and visualization using edge computing. They will be involved in running

deep learning models on the edge device for computer vision. Participatory collaboration among students will be encouraged. By the end of this course, foundational knowledge and experience with analyzing data, visualization techniques & tools, and edge computing will enable students to visualize their own data and be prepared for intensive applications of edge devices in subsequent courses.

*PREREQUISITES*

No prerequisites required.

*COURSE GOALS*

By the end of this course, students will:

1. Critically assess the data visualization process
2. Critically assess data visualization tools
3. Use edge computing for acquiring, processing, and visualizing data
4. Apply skills and concepts learned from the course to their own research and visualization projects

*LEARNING OBJECTIVES*

The following *objectives* are designed to reach each course goal.

* Critically assess the data visualization process
  + Describe the seven stages of visualizing data
  + Articulate thought processes during the visualization process
  + Evaluate and critique visualizations from various sources
* Critically assess data visualization tools
  + Assess visualization tools and their applicability to different types of data
  + Compare and contrast visualization frameworks for discipline specific tools and applications
  + Discuss the effectiveness of different visual representations of data
* Use edge computing for acquiring, processing, and visualizing data
  + Acquire and process data from different sensors
  + Use appropriate visualization techniques / tools to display the analyzed data
  + Run deep learning models on the edge device for computer vision applications
* Apply skills and concepts learned from the course to their own research and visualization projects
  + Demonstrate the ability to map conceptual and physical space concepts covered in class to the visualization of their own research
  + Select the appropriate visualization tool for visualizing data in their own discipline
  + Select deep learning models and run them on edge devices for intensive applications in their own discipline

*COURSE REQUIREMENTS*

The following are required for each student with the associated impact on the final grade:

***Class Participation and Engagement – 10%***

***Visualization Training – 5%***

***Assignments - 25%***

***Visualization Dashboard Presentation – 25%***

***Final Project – 35%***

*Class Participation and Engagement– 10%*

*Physical presence in the classroom is not the same as engagement. Students are expected to demonstrate their engagement.* Class participation will consist of participating in class discussions and in-class exercises and include, but not limited to, completing visualization activity worksheets, reading assigned material before class, engaging in scholarly dialog, and participating in class discussions on the class discussion forum on Brightspace.

*Visualization activity worksheets* are designed to help students form topics, generate questions for projects and more closely understand the visualization process. They will be assigned to build skills in techniques needed to analyze and process data in preparation for the visualization process. With few exceptions, activity worksheets will be assigned in class and students will have a few days to complete and submit the worksheet.

In-class participation (20 pts)

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| --- | --- | --- |
| **Score** | **Description** | **Points** |
| 3 | Participated regularly in class discussions, never arrived late | 20 |
| 2.5 | Participated regularly in class discussions, seldom arrived late | 15 |
| 2 | Participated sometimes in class discussions and/or arrived late often | 10 |
| 1.5 | Participated when asked but rarely volunteered | 5 |
| 1 | Participated in class discussions but often distracted | 2 |
| 0 | Did not participate in class discussions | 0 |

*Visualization Training – 5%*

The course will provide an *“Introduction”* to Tableau, Gephi and ParaView, and ArcGIS.

User licenses keys will be provided for ***Tableau*** for student installation of Tableau on their personal laptops. The software will also be installed on computers in KNOY 314. Tableau Training materials are available on Brightspace. Students are expected to complete the Tableau training at their own pace. In order to become proficient with Tableau, students are recommended to complete at least 80% of the training (that’s a minimum of 36 trainings) that is provided. Training exercises will also be made available for practice. Students will be asked to post their Tableau workbooks to the Tableau online collaborative workspace. Details on how to create your Tableau online profile will be provided on Brightspace. This space will be accessible to the class and all enrolled students. Students are also encouraged to explore and use additional tools to build their visualization toolbox.

Additional training will be provided for Gephi, ParaView and ArcGIS. Resulting outputs will be shared with the class. Additional visualization tools and links are provided on the Resources page on the course webpage on Brightspace. Students are encouraged to explore this page and its content.

*Assignments– 25%*

Assignments are designed to provide hands-on experience utilizing the data visualization process. You will demonstrate factual, conceptual and procedural knowledge of the data visualization workflow to develop data visualizations that allow for the transformation of data into insight.

In addition, each student will be provided with edge device developer kits. The developer kits will be comprised of a NVIDIA Jetson edge computer, breadboard & wire kit, and sensors. The developer kits will be used to help students gain hands-on experience for acquiring, processing, and visualizing real-time data from various sensors using edge computing. The Python programming language will be used for processing the data and appropriate visualization tools will be used for presenting the data in a creative manner. Training will also be provided for students to acquire imagery datasets and run deep learning models on the edge for computer vision applications by utilizing camera sensors. Additional details, guidelines, references, and tutorials will also be provided to further explore the capabilities of edge computing.

*Visualization Dashboard Presentation – 25%*

You will be required to explore visualization tools that are independent of the tools listed in the syllabus. The course will provide a broad scope of visualization tools leaving room for students to explore tools specific to their research needs and interests. A list of tools will be provided to choose from or you may choose another tool that is available to all students. You will be required to introduce those tools to the class in the form of short tutorials. Tutorials, will feature an overview of the tool of your choosing presented to the class, in the form of hands-on examples and basic usage of the tool. You should plan for a 20- 30-minute demo of your visualization dashboard. The demo should be in the form of a pre-recorded, short video. You will determine three objectives and expected outcomes for the dashboard to ensure relevant content is learned and attention is paid to key concepts. As a presenter, you will post to the course webpage on Brightspace a one (1) page reflection of the visualization dashboard. Students enrolled in the class will post critiques to the reflection and presentation on Brightspace to encourage continued class participation and stimulate in-class discussion.

*Final Project – 35%*

Throughout the course, you will assemble a toolbox of the various visualization tools to use with different types of data acquired using the edge device developer kit. The rationale for this component of the course is to provide you with various ways of looking at data, to understand that the first visualization tool will not be your last tool, to provide experience using various tools to visualize the same data and to provide experience with edge computing. You will be encouraged to apply the content learned to future work and courses. **You will develop a scholarly research paper** that can be used in the results section of your thesis or submitted to an academic or professional venue. At the beginning of the course, you will be asked to choose a paper topic. You will choose your own data (publicly available, custom, or acquired using the edge device) for the final research paper and identify which tools will tentatively be used to visualize your data. Early in the course, you will propose a topic and identify data sources for instructor approval. Midway through the course, you will give a short oral presentation on the status of your paper for feedback. The oral presentation will most likely be student-prepared video presentations. You will post progress updates on the class discussion board on Brightspace/Slack leading up to the final submission. Your final submission will be submitted to the instructor at the end of the semester for grading. Format and visualization content will be discussed in class.

*Primary Reading List (will be updated)*

Aigner, W., S. Miksch, W. Muller, H. Schumann, C. Tominski, "Visual Methods for Analyzing Time-Oriented Data", IEEE Trans. on Visualization and Computer Graphics, Vol. 14, No. 1, Jan.-Feb. 2008, pp. 47-60.

Carr, D. (1999). Guidelines for designing information visualization applications. In ECUE'99: 01/12/1999-03/12/1999.

**Caldarola, E. G., & Rinaldi, A. M. (2017). Big Data Visualization Tools: A Survey. Research Gate.**

Daniel Dorling, Anna Barford, Mark Newman, "Worldmapper: The World as You've Never Seen it Before," IEEE Transactions on Visualization and Computer Graphics, Vol. 12, No. 5, Sep-Oct 2006, pp. 757-764.

Dykes, J., and Brunsdon, C. (2007). Geographically weighted visualization - interactive graphics for scale-varying exploratory analysis, IEEE Trans. on Visualization and Computer Graphics, Vol. 13, No. 6, Nov-Dec 2007, pp. 1161-1168.

Eick, S. (2000). Visual Discovery and Analysis, IEEE Transactions on Visualization and Computer Graphics, Vol. 6, No. 1, Jan-Mar 2000, pp. 44-58.

Fry, B. (2007). Visualizing data: Exploring and explaining data with the processing environment. " O'Reilly Media, Inc.".

Heer, J., Bostock, M. and Ogievetsky, V. (2010). A Tour through the Visualization Zoo, Communications of the ACM, Vol. 53, No. 6, June 2010, pp. 59-67.

Hullman, J. and Diakopoulos, N. (2011). Visualization Rhetoric: Framing Effects in Narrative Visualization. IEEE Trans. on Visualization and Computer Graphics, Vol. 17, No. 12, Dec. 2011, pp. 2231-2240.

Kosara, R., and Mackinlay, J. (2013). Storytelling: The Next Step for Visualization. *Computer*, Vol. 46, No. 5, May 2013, pp. 44-50.

Laramee, R. S. (2011). How to read a visualization research paper: Extracting the essentials. IEEE computer graphics and applications, 31(3), 78-82.

Myatt, G. J. & Johnson, W. P. (2014). Making sense of data: a practical guide to exploratory data analysis and data mining. 2nd Edition. John Wiley & Sons.

Myatt, G. J., & Johnson, W.P. (2009). Making sense of data II: A practical guide to data visualization, advanced data mining methods, and applications. John Wiley & Sons.

Po, L., Bikakis, N., Desimoni, F., & Papastefanatos, G. (2020). Linked Data Visualization: Techniques, Tools, and Big Data. Synthesis Lectures on Semantic Web: Theory and Technology, 10(1), 1-157. [Book]

Quispel, & Maes. (2014). Would you prefer pie or cupcakes? Preferences for data visualization designs of professionals and laypeople in graphic design. Journal of Visual Languages and Computing, 25(2), 107-116.

Data + Design: A Simple introduction to preparing and visualizing information. This interactive eBook provides an introduction to data collection and visualization with many examples and links to additional resources. <https://infoactive.co/data-design/>

Segel, E. and J. Heer, J. (2010). "Narrative Visualization: Telling Stories with Data", IEEE Trans. on Visualization and Computer Graphics, Vol. 16, No. 6, Nov.-Dec. 2010, pp. 1139-1148.

Shneiderman, B. The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. Proc. 1996 IEEE Visual Languages, Boulder, CO, Sept. 1996, pp. 336-343.

Shneiderman, B., & Plaisant, C. (2006, May). Strategies for evaluating information visualization tools: multi-dimensional in-depth long-term case studies. In Proceedings of the 2006 AVI workshop on BEyond time and errors: novel evaluation methods for information visualization (pp. 1-7). ACM.

Secondary Reading List

Kurkowski, P. (2007). 7 things you should know about data visualization. EDUCAUSE Learning Initiative.

Wong, D. M. (2010). The Wall Street Journal guide to information graphics: The dos and don'ts of presenting data, facts, and figures. WW Norton.

Yau, N. (2011). Visualize this: the FlowingData guide to design, visualization, and statistics. John Wiley & Sons.

Tufte, E., & Graves-Morris, P. (2014). The visual display of quantitative information.; 1983.

Data Visualization Tools and Books <https://keshif.me/demo/VisTools?utm_content=26335725&utm_medium=social&utm_source=twitter>

Myatt, G. J., & Johnson, W. P. (2011). Making sense of data III: A practical guide to designing interactive data visualizations (Vol. 3). John Wiley & Sons.

Additional Resources (Software)

* Tableau Desktop Software
* Gephi Software
* ParaView
* ArcGIS

Grading

To earn a good grade in this class, students must attend classes, participate regularly and intelligently in class discussions, articulate themselves in a clear, critical and well-informed manner, and clearly articulate how ideas from the course readings are translated into their own research interests. Grades for course activities will be awarded on a percentage scale, and activity or course grades may be adjusted by a curve.

A+ >100% C+ 78 - 80

A 97 - 100 C 74 - 77

A- 92 - 96 C- 71 - 73

B+ 89 - 91 D+ 68 - 70

B 85 - 88 D 64 - 67

B- 81 – 84 D- 61 – 63

F < 61

Class Schedule

* Readings and videos should be read and watched before class on the assigned date.
* The class schedule is subject to change. You will be notified in Brightspace of any changes.

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| **Week** | **Lecture Topic** | **Assignment** | **Semester Project** |
| 0 | Introduction to Data Visualization & Data Visualization Pioneers | Watch Blue Waters Video  <https://bluewaters.ncsa.illinois.edu/webinars/visualization/introduction> | 1-minute Introduction video. |
| 1 | A tour through the visualization zoo and workflows | Acquiring and parsing data | Team Building |
| 2 | Data Visualization Best Practices | Parsing & Mining Data | Identifying Topics  Topics to Questions |
| 3 | Introduction to Tableau  Interfacing with Commonly Used Sensors | Filter & Represent  Obtain edge device kit. Start the edge device and set it up by installing all required libraries (ML, CV, etc.). | Questions to a Problem  Problem to Data Sources |
| 4 | Choosing the Right Chart Types  Interfacing with IMU sensor | Use IMU sensors for acquiring data in real-time. | Critique & Refine |
| 5 | Introduction to Excel Pivot Tables and Pivot Charts  Using Camera Sensors with Edge Devices | Connect sensors to the device for interfacing. Acquire data using cameras. |  |
| 6 | Introduction to Dashboards  Color and Perception  Computer Vision using Deep Learning on the Edge | Train image classification models using TensorFlow on edge device. Utilize TensorFlow-GPU. Use MNIST and custom datasets. | Projects First Draft Approved. |
| 7 | Interactive Data Visualization  Storytelling  Image metadata extraction and feature visualization on the Edge | Introduction to Scientific Visualization using ParaView  Deploy models on a simple web and smartphone application. | Semester Project Proposal;  Team Presentation |
| 8 | “Insert Data Vis Component”  Introduction to ArcGIS | Using ArcGIS to develop a Visualization Dashboard | Semester Project Check-in  Presentation for teams for pitching their ideas on how they would like to integrate kits in their project proposals |
| 9 | Diversity, Equity and Inclusion in Data Visualization  Introduction to ArcGIS Dashboard | Do No Harm with Data Visualization | Project help and feedback from instructors. What diversity do you bring to the class? |
| 10 | SPRING BREAK |  |  |
| 11 | “Insert Data Vis Component”  Object detection using Edge Computers | Become familiar with object detection using YOLO and load a pre-trained model for live object detection using the camera sensor on edge device.  Using UAS and handheld imagery acquired in agricultural setting for extracting image metadata, geolocation, and mark the location on a map. | Project help and feedback from instructors. |
| 12 | “Insert Data Vis Component”  Deep Learning: Image Classification for Computer Vision & Deployment onto Web and Smartphone Applications | Train deep learning-based image classification model for disease/weed identification. | Project help and feedback from instructors. |
| 13 | **Final group presentations** | | |
| 14 |
| 15 |
| 16 |