**Aardvark: Composite Visualizations of Trees, Time-Series, and Images**

1. Abstract
   1. State-of-the-art visualization methods for such data use independent line charts, tree diagrams, and images in separate views. However, this spatial separation requires the viewer of these charts to combine the relevant pieces of data in memory. To simplify this challenging task, we describe design principles for weaving cell images, time-series data, and tree data into a cohesive visualization. Our design principles are based on choosing a primary data type that drives the layout and integrates the other data types into that layout.
2. Introduction
3. Related Work
4. Data
5. Domain task
   1. Task Abstraction: Topological, trends, spatial[Trees, Time-series and images could be any one of these]
6. Design Principles for Visualizing Trees, Time-Series, and Images
   1. Client View, Nested View contains superimposed detail on demand views
   2. Each of these composite visualizations has its strengths and weaknesses. Juxtaposing all three views together creates a system that can tackle a wide range of analyses. Linked and brushing ties the data elements together across these views.
   3. Note Horizon Charts – Visualize large trees and show multiple time-series
7. Aardvark Design
8. Implementation
9. Case Studies
10. Discussion and Limitations
    1. A major theme throughout this work is that understanding this data holistically requires understanding how these three pieces of information fit together.
       1. Scalability issues when it comes to large trees with over a few hundred nodes
       2. Work is generalizable
11. Conclusion and Future Work
    1. In conclusion, this work examines three distinct data types (trees, time-
    2. series, and images) that are interwoven to create a complex multimodal
    3. dataset. We describe our design principles for combining these com-
    4. plex, disparate data types into intuitive composite visualizations. We
    5. use these principles to implement an open-source visualization tool,
    6. Aardvark. We demonstrate the utility of Aardvark to perform quality
    7. control, data analysis, and communication tasks with three case studies.

**Cartogram Visualization for Bivariate Geo-Statistical Data**

**Here 2 variables(Mcdonalds and Starbucks numbers) are being compared(3rd variable would be radius of circle indicating the total number of Mcdonalds or Starbucks and the 4th variable is position of each state).**

A close-up of a diagram

Description automatically generated

**While we could compare our 2 variables(aggregate vs sample) in a similar way and also give various sizes of circle dependent on indicator weight(3rd variable) *similar to the bivariate cartogram*, we’d need a way to differentiate which indicator is low or high(here everything is defined as a state) and we also don’t have the luxury of determining positions of each indicator(here, even casual geography people know where states lie) and finally, there are 6 levels of the hierarchy which any indicator can belong to.**

**In conclusion, we have SIX variables compared to the above FOUR that they are doing.**

**We could certainly use these colors to separate our two variables. Can certainly use this to “separate” two variables, aka each radial bar shows one variable, basically small multiples.**

1. Abstract
   1. We describe bivariate cartograms, a technique specifically designed to allow for the simultaneous comparison of two geo-statistical variables. Traditional cartograms are designed to show only a single statistical variable, but in practice, it is often useful to show two variables (e.g., the total sales for two competing companies) simultaneously.
2. Introduction
   1. The main appeal of cartograms is that they combine statistical and geographical information in the same visualization.
3. Background
4. Related Work
5. Our approach
   1. Automatically determining the best threshold value would be an interesting problem for future work.[related to the comparison of 2 variables]
6. Extensions and Generalizations
7. Experiment and Evaluation
8. Results and Data Analysis
9. Limitations
   1. Our approach encodes the difference between the two statistics in the boundary of the regions of a map. This makes it difficult to generalize the approach to more than two variables and also limits the scalability of the approach (e.g., when there are many regions, most of the area will be white space).
10. Conclusions

**CerebroVis: Designing an Abstract yet Spatially Contextualized Cerebral Artery Network Visualization**

1. Abstract
   1. To assist neuroradiologists in identifying cerebral artery abnormalities, we designed CerebroVis, a novel abstract—yet spatially contextualized—cerebral artery network visualization. In this design study, we contribute a novel framing and definition of the cerebral artery system in terms of network theory and characterize neuroradiologist domain goals as abstract visualization and network analysis tasks.
2. Introduction
3. Domain Background
4. Network Model of the cerebral artery system
5. Related Work
   1. Network Visualization concerning node-link viz
   2. **Check out treevis.net**
6. Domain Goals and Task Abstraction
7. Cerebrovis design process
   1. Design Requirements
      1. 2D visualization should preserve the expert mental model of the artery structure of the brain(which is 3D)[**abstracting this to my project, once someone has seen the hierarchy, an indicator in the multivariate radial bar should show where the indicator is in the hierarchy**]
      2. Highlight abnormalities in the 2D visualization
      3. Check whether the abnormality is present in the 2D viz is present in the 3D rendering
8. Cerebrovis
   1. 2D projection links with 3D visualization by way of interaction
9. Data and Implementation Robustness
10. Comparative Evaluation
11. Discussion
12. Limitations and Future Work
13. Conclusion

**Visual Analysis and Dissemination of Scientific Literature Collections with SurVis**

1. Abstract
   1. Bibliographic data such as collections of scientific articles and citation networks have been studied extensively in information visualization and visual analytics research. Powerful systems have been built to support various types of bibliographic analysis, but they require some training and cannot be used to disseminate the insights gained. In contrast, we focused on developing a moreaccessible visual analytics system, called SurVis, that is ready to disseminate a carefully surveyed literature collection.
2. Introduction
   1. We argue that the list of references, which had been carefully collected and curated by the authors of the survey, would be an even more valuable source of information if presented in an interactively explorable way and augmented with additional data, so that: (i) publications that address similar research challenges can be retrieved, (ii) historical developments and recent progress in the research area can be analyzed, and (iii) experts in the field and highly influential publications can be identified.
3. Related Work
4. Requirement Analysis
   1. Usage scenarios for
      1. Curator: collect, structure, and analyze the literature
      2. Researcher[**Reader**]: deep analysis of the presented literature
      3. Practitioner[**Reader**]: find relevant information quickly to use it in practical application.
   2. For the Curator and Researcher, the system needs to be powerful enough to gain relevant insights. However, at the same time, the solution has to be easy to use and self-explaining because the Practitioner should be able to quickly retrieve desired information.
   3. A close-up of a research paper

      Description automatically generated
   4. Functional requirements:
      1. Here, existing systems(similar to Survis) are evaluated on 4 Requirements Publications, Structure, History and Relationship
      2. All the given systems do not fulfill all the 4 requirements fully, hence the need for this paper
5. Survis system
   1. Design Principles/Objectives[which help fulfill given requirements]:
      1. Since the system should be usable by Readers of a survey article without much explanation and training, we tried to design the system as simple as possible; in doubt, we favored usability over adding more features.
      2. Survey authors usually invest great effort in structuring a literature collection; we assume that approaches extracting information automatically cannot compete with this manual curation regarding data quality.
      3. To not limit users of the system in exploring the data, every presented piece of information should be interactively selectable to filter the data and find related entities.
   2. Literature Data on which Survis is based on
   3. User Interface has elements that fulfill given requirements.
   4. Usage of **sparkline visualization**(word sized viz that encodes a variable)
   5. Data Curation
   6. System Architecture and Implementation
   7. Formative Development and Impact
6. Expert Feedback(Visual Analytic Experts) based on Linkert-type scale
7. Conclusion

**Lineage: Visualizing Multivariate Clinical Data in Genealogy Graphs**

1. Abstract
   1. The majority of diseases that are a significant challenge for public and individual heath are caused by a combination of hereditary and environmental factors. In this paper we introduce Lineage, a novel visual analysis tool designed to support domain experts who study such multifactorial diseases in the context of genealogies. Incorporating familial relationships between cases with other data can provide insights into shared genomic variants and shared environmental exposures that may be implicated in such diseases. We introduce a data and task abstraction, and argue that the problem of analyzing such diseases based on genealogical, clinical, and genetic data can be mapped to a multivariate graph visualization problem.
2. Introduction
   1. Current medical or historical genealogy visualization tools are ill equipped to help researchers find patterns in these large, highly multivariate graphs of families and their rich medical histories. In this paper, we present a novel genealogy visualization tool that we have developed in collaboration with psychiatrists and geneticists studying the genetic underpinnings and the environmental factors of suicide and autism.
3. Domain Background and Data
   1. In this paper, we will focus on suicide, yet our methods are easily transferable to other complex, multifactorial conditions and diseases.
   2. To summarize, each of our many graphs describes a family, with individuals as nodes and family relationships as edges. Since the graphs are constructed by tracing ancestry to a founder, they are predominantly tree-like, but they do include cycles, for example, when two cousins have offspring. In addition, we have attributes on the individuals/ nodes in the graphs of various data types, including numerical, categorical, temporal, geographic, and textual data.
4. Domain Goals and Tasks
   1. The overarching goal of our collaborators is to gain a better understanding of the determining or associated factors of suicide. Below are tasks:
      1. **Select families of interest.** The analysts want to select a family by browsing, by selecting a specific family based on prior knowledge, or in a data driven way. An example of the data-driven approach is to find families with high rates of suicide or with individuals for which suicide co-occurs with bipolar disorder.
      2. **Analyze individual case.** Our collaborators need to investigate the context of a case. For example, a potential genetic component contributing to suicide is judged differently if the person had many psychiatric comorbidities and committed suicide at a young age, compared to a late-life suicide of a person with a terminal disease.
      3. **Compare cases.** This task encompasses comparing individuals and identifying shared attributes to characterize a potentially meaningful shared phenotype.
      4. **Judge prevalence and clusters of phenotype.** The number of suicide cases and the prevalence of comorbidities vary greatly between families and between branches of a single family
      5. **Compare families.** Once an interesting observation has been made in one family, our collaborators want to be able to investigate whether similar cases also appear in other families.
      6. **Quality Control**
5. Related Work
   1. Multivariate Networks
   2. Tree Visualization
   3. Genealogy Visualization(**consider fan charts**)
6. Visualizing a multivariate graph
   1. Linearization Approach
      1. De-cycling and Linearization
   2. Aggregation
7. Lineage Design
   1. Genealogy graph
   2. Table Visualization
   3. Viewing Multiple Families
8. Implementation and Preprocessing
9. Case Studies
   1. We present two forms of validation for Lineage: case studies, a method employed widely to demonstrate the fitness for use of visualization design studies [10], [67], and informal usability testing and analyst feedback, which is described in the next section
   2. Tasks were fulfilled
   3. Expert and Analysts Feedback
10. Discussion
    1. Although details of our design study and our implementation, such as how we display parents and family grids, are specific to genealogies, we argue that our linearization and attribute-driven aggregation approach can be applied broadly when analyzing multivariate trees or tree-like graphs, such as phylogenies or file directories.
11. Conclusion
    1. Using Lineage, our collaborators are now able to efficiently explore the structure of large families and even multiple families at the same time, in addition to analyzing dozens of attributes for the individuals in these families. They can use Lineage to identify phenotypes of interest that appear in multiple families, and then use this knowledge to inform and narrow down their search for genetic variants.

**Visualizing Historical Book Trade Data: An Iterative Design Study with Close Collaboration with Domain Experts**

1. Abstract
   1. The circulation of historical books has always been an area of interest for historians. However, the data used to represent the journey of a book across different places and times can be difficult for domain experts to digest due to buried geographical and chronological features within text-based presentations. This situation provides an opportunity for collaboration between visualization researchers and historians. This paper describes a design study where a variant of the Nine-Stage Framework [46] was employed to develop a Visual Analytics (VA) tool called DanteExploreVis. This tool was designed to aid domain experts in exploring, explaining, and presenting book trade data from multiple perspectives.
   2. The main contributions of this paper include: 1) the development of a VA tool to support domain experts in exploring, explaining, and presenting book trade data; 2) a comprehensive documentation of the iterative design, development, and evaluation process following the variant Nine-Stage Framework; 3) a summary of the insights gained and lessons learned from this design study in the context of the humanities field; and 4) reflections on how our approach could be applied in a more generalizable way.
2. Introduction
   1. The BookTracker platform was established to develop visualization tools to address various domain needs. Our previous design study is detailed in [55], while this paper focuses on the development of DanteExploreVis. Building on our previous experience, we adapt the core phase of the Nine-Stage Framework [46] to better suit the iterative nature and prioritize the continuous refinement of domain problems and tasks.
   2. Contributions:
      1. Completing a six-month iterative design process with the leading domain expert, resulting in the development of DanteExploreVis.
      2. Evaluating the usability and usefulness of DanteExploreVis through surveys and expert interviews with a group of domain experts.
      3. Adapting the Nine-Stage Framework with a more explicit prominence of its iterative essence.
      4. Documenting and visualizing the design study process, sharing insights and lessons learned from collaboration with humanities scholars, and discussing the scalability of our approach to wider domains.
3. Domain background and data
   1. Hierarchical Data
4. Related Work
   1. **Core to visualization design studies is a collaboration between researchers and domain experts to address real-world problems using visualization techniques.**
5. Design Study Overview(variant of nine-stage framework)
   1. Discover
      1. refine domain problems,
      2. increase DEs’ interaction and
      3. expand information collection channels beyond the conversation.
   2. Design
      1. DEs often have specific design expectations (e.g., our LDE desired a 2D geopolitical map with all elements); we recommend first summarizing their anticipated visualizations and then adjusting or proposing alternatives from visualization experts’ perspectives. Presenting them with multiple design options using real data to test and then implement the highest-rated design in the final tool.
   3. Implement
      1. In the adapted framework, we suggest using rapid prototyping with real data to explore the design and refine the early versions of the tools.
   4. Validate and Evaluation
      1. The former, termed validate, is incorporated within the iteration cycle to assess the usefulness of features in early versions. We asked questions such as “Do the current visualizations address domain requirements?” and “Which design alternatives are most effective?” during validation. Usability feedback is collected but not prioritized. The latter, labeled evaluation, occurs after the final iteration, outside the iteration cycle, and before the tool deployment.
6. Domain Problems and Tasks
   1. Requirements:
      1. Visualize the trajectory of a single copy.
      2. Visualize the circulation of a group of copies.
      3. Present the distribution and circulation of all copies on a geopolitical map
      4. Static visualization of **provenance**-related(origin/record of ownership) information.
      5. Animate book movement.
      6. Gain insights from features extracted from provenance-related information.
   2. Data Abstraction
      1. We outline five manipulations made during the iterations, which can be regarded as milestones propelling the progress of the design study:
         1. Addition of Geographical Coordinates
         2. Alternative Presentation of Chronology
         3. Addressing Data Uncertainty
         4. Flatting Provenance Blocks
         5. Bundled Path Coordinates
   3. Task Abstraction(which fulfill requirements)
      1. Browse & Explore
      2. Elaborate & Explain
      3. Lookup & Locate
      4. Identify & Compare
      5. Present & Enjoy
7. Iterative Design Process
   1. This explains what the researchers did at each iteration(**there are 7**), complete with dates.
   2. Throughout the iterative process, the researchers expanded on the 6 given requirements
8. DanteexploreVis
9. Evaluation
   1. User Survey
   2. Expert Interview
10. Reflection and Discussion
    1. Our experience underscores the importance of adapting design study frameworks according to the target domain. Experts from different fields possess distinct habits, including information processing, data perception, thinking styles, collaboration methods, etc. Adapting to these habits and customizing the framework for design research implementation can enhance the process’s efficiency.
    2. For instance, they(humanities researchers) favor textual information and may display lower sensitivity to visual and numerical data. Although they may establish goals and problems to solve at a project’s outset, their strong divergent, and creative minds can generate needs unrelated to the current design mid-project.
    3. When examining data from qualitative evaluations, it is essential to prioritize feedback regarding the tool’s functionality and overall usefulness. Be discerning about whether praise from domain experts may be affected by the wow effect.
    4. [**Questioning domain expert assumptions**]For instance, in our case, despite initial skepticism from domain experts about the usefulness of a heatmap, as the project evolved, they discovered its value in interpreting large datasets and as a source of inspiration for their research.
    5. Overcoming Interdisciplinary Collaboration Challenges: The framework variant emphasizes iterative design cycles and deep collaboration with domain experts, cultivating a more context-sensitive and user-centered design perspective.
11. Limitations and Future Work
    1. Data Uncertainty and Ambiguity
    2. Scalability
    3. Scalable Data Visualization
12. Conclusion

**Towards Visualization Thumbnail Designs that Entice Reading Data-driven Articles**

1. Abstract
   1. However, little research exists on the design rationale for visualization thumbnails, such as resizing, cropping, simplifying, and embellishing charts that appear within the body of the associated article. Therefore, in this paper we aim to understand these design choices and determine what makes a visualization thumbnail inviting and interpretable.
   2. Based on the survey and discussion results, we then define a design space for visualization thumbnails and conduct a user study with four types of visualization thumbnails derived from the design space. The study results indicate that different chart components play different roles in attracting reader attention and enhancing reader understandability of the visualization thumbnails.
   3. Ultimately, we distill our findings into design implications that allow effective visualization thumbnail designs for data-rich news articles. Our work can thus be seen as a first step toward providing structured guidance on how to design compelling thumbnails for data stories.
2. Introduction
   1. However, it is unclear which factors influence both interpretability—helping readers understand the article from the thumbnail alone—and appeal—inducing the reader to click to read the article. In this research, we aim to investigate visualization thumbnail designs that support both of these affordances.
   2. The main contributions of this work are as follows:
      1. Extracting the key components of visualization thumbnail designs by surveying in-the-wild visualization thumbnails
      2. identifying reader preferences for visualization thumbnail designs and their rationale for their preferences via a crowdsourced user study
      3. reporting lessons, design implications, and open research areas for visualization thumbnails.
3. Related Work
   1. In this study, we investigate the role thumbnails play as people browse online news articles in the context of data journalism.
4. Visualization Thumbnail Design Practice
   1. A survey of visualization thumbnails
   2. Interviews with visualization designers
      1. Intentions for designing thumbnails
      2. Challenges of incorporating visualization into article thumbnails
      3. Broad set of goals for thumbnails
   3. Visualization thumbnail definition and goals
      1. In this paper, we seek to understand how to design visualization thumbnails to merge both of these perspectives. More specifically, we are looking for a middle ground where visualization thumbnails are both visually appealing—thus inviting more clicks—as well as representative of the underlying article—thus ensuring that readers do not feel misled.
      2. We believe our work to be the first investigation of this topic. Due to the limitations in the existing methods and scopes of the study, the proposed definition should be considered as a working definition and could evolve or be replaced with the results of follow-up experiments and studies.
5. User Study
   1. Research Goals
      1. (RQ1) what design types readers would most likely click to read and why?
      2. RQ2) what do readers think of the components in visualization thumbnails?
   2. Visualization Thumbnail Design
      1. Since we limit our discussion to the line chart thumbnails, there remains a research question on extending the design space for charts with different visualization components, such as bar, bubble, or scatterplot, and maps.
      2. 4 types of thumbnails: Resized, GNRD(graphics not related to thumbnail), Highlight, HRO(Human recognizable objects)
   3. Workshop with Practitioners
      1. As the workshop began, we described the four types of visualization thumbnails and showed the 16 thumbnails (Figure 3) produced with associated news articles. We asked them to evaluate the quality of the thumbnails and their personal preferences for the thumbnail types. We also requested that they report any possible issues that make a thumbnail ineffective for use.
      2. To sum up, we found that the thumbnails we produced are similar to what the practitioners create. We also confirmed that the thumbnails could be used in the user study after revising them based on the collected design suggestions (e.g., increasing font sizes, rounding line edges).
   4. Study procedure held for 161 participants to see which of the 16 thumbnails they prefer
6. Results and Analysis
   1. We performed statistical tests to determine the most popular thumbnail type and the reasons stated by participants for their choice (RQ1). Then we conducted a qualitative analysis that investigated the readers’ opinions on the components of the visualization thumbnails (RQ2).
   2. Reader’s choice for thumbnail type(RQ1)
      1. Most chosen thumbnail type(Highlight and HRO)
      2. Thumbnail selection reasons
   3. Reader Opinions on Chart Components (RQ2)
7. Discussion
   1. We have shown that readers want visualization thumbnails that not only keep their eyes focused on the thumbnail (i.e., inviting), but also convey the article’s main point (informative). Our findings indicate that thumbnail design can be aided by understanding chart component roles.
   2. Lessons
      1. Lesson 1: Readers want easy-to-understand visualization thumbnails.
         1. Suggestion 1: Including descriptive text with a summarized visualization can make a thumbnail more understandable.
      2. Lesson 2: Readers want attractive visualization thumbnails.
         1. Suggestion 2: Including highlights or visual embellishments can make a visualization thumbnail engaging.
   3. Limitations and Open Research Areas
8. Conclusion
   1. We began this project by asking what makes thumbnails for data stories inviting and interpretable. We surveyed visualization thumbnails and had a series of interviews with practitioners about the design of thumbnails for data-driven stories. Based on our survey, we defined the design types of visualization thumbnails and conducted a user study to determine the most appealing thumbnail design. Our study results reveal a design space for thumbnails: a set of thumbnail design guidelines that can be leveraged to attract readers and help them understand the context of articles associated with thumbnails

**VISGRADER : Automatic Grading of D3 Visualizations**

1. Abstract
   1. We present VISGRADER , a first-of-its kind automatic grading method for D3 visualizations that scalably and precisely evaluates the data bindings, visual encodings, interactions, and design specifications used in a visualization. Our method enhances students’ learning experience, enabling them to submit their code frequently and receive rapid feedback to better inform iteration and improvement to their code and visualization design. We have successfully deployed our method and auto-graded D3 submissions from more than 4000 students in a visualization course at Georgia Tech, and received positive feedback for expanding its adoption.
2. Introduction
   1. Contributions
      1. **VISGRADER, the first-of-its-kind automatic grading approach for D3 visualizations** that scalably and precisely evaluates the data bindings, visual encodings, interactions, and design specifications used in a visualization (Fig. 1). Our method avoids a rigid “one-size-fits-all” approach to grading, by offering a novel flexible way that provides students with tailored feedback while supporting their design freedom in developing visualizations.
      2. **Large Scale D3 Auto-Grading.** VISGRADER has been used tograde more than 72,000 submissions from more than 4,000 students for four semesters 2 in Georgia Tech’s CSE 6242 Data and Visual Analytics course
3. Background and Related Work
   1. Auto-grading student programs
   2. Auto-grading complex visualization
4. Design Challenges
   1. Increased Iterations of Detailed Feedback.
   2. Scaling to Large Class Sizes.
   3. Accepting Variations in Visualization Designs.
   4. Grading Interactivity.
5. VISGRADER : AUTOMATIC D3 GRADING
   1. Design Goals based on challenges
      1. Rapid and frequent feedback interface
      2. Distributed auto-grading for thousands of students.
      3. Logic that preserves design flexibility.
      4. Evaluation of interactive visualizations.
6. Auto-grading method
   1. We outline the implementation and function of VISGRADER and demonstrate how it meets the four design goals. A subsection is provided for each design goal and how VISGRADER accomplishes it.
7. L ARGE SCALE D3 AUTO -GRADING DEPLOYMENT
   1. Scale and Student Experience
      1. To date, more than 4,000 students have used VISGRADER.
   2. Visualization Categories and Interaction
   3. Visualization Course Assignment Requirements
8. IMPACT, LESSONS LEARNED , AND LIMITATIONS
   1. Student impact
      1. After releasing VISGRADER for the assignment described in (Sec. 6.2), we observed that the number of questions decreased from 1,965 posts to 1,356 posts (-31.0%) for a nearly equivalent enrollment size: 920 in Fall 2020 and 926 in Spring 2023 (online sections), leading us to conclude that there is some reduction in confusion and improved learning experience.
      2. We observed students completing more error discovery on their own and then helping others, allowing students to get answers at scale.
      3. Our approach has dramatically reduced configuration errors that students may experience, such as incorrectly referenced libraries or data files; before using auto-grader, such errors would prevent the visualization from being rendered or graded, and graders would need to manually resolved them.
      4. After implementing and deploying the auto-grader for more than 1,100 student in Fall 2021, the re-grade requests amount dropped 98%, from more than 500 in the semester before to less than 10.
   2. Instructor Impact
      1. The auto-grader deployment resulted in a reduction of 400 TA hours (a conservative estimate) spent on grading effort every semester.
      2. The reduction in re-grade requests (Sec. 7.1.4) also resulted in a drastic reduction in the required TA hours needed to re-grade these assignments.
      3. Increased Time for Qualitative Feedback
   3. Lessons Learned
      1. Balancing Focus Between structure and Design Choices
      2. Helping Students Learn Better Coding Practices
      3. Designing Informative Test Cases
   4. Limitations
      1. Focus on Test Case and Score
      2. Grading Design of a Visualization
      3. Allowing Open-Ended Design(using bar chart vs line chart)
9. DISCUSSION AND FUTURE WORK
   1. Generalized Visualization Auto-Grading(not just D3)
   2. Incorporating Design Suggestions
   3. ML Methods for Visualization Interpretation and Design
10. CONCLUSION
    1. In this work, we present VISGRADER, an auto-grading method that enables scalable grading for the static and interactive components of a D3 visualization. We discussed the key-features of our method and how it can be flexibly adapted to other visualization assignments.

**Action-Evaluator: A Visualization Approach for Player Action Evaluation in Soccer**

1. Abstract
   1. Based on the design, we introduce a visual analytics system, Action-Evaluator, to facilitate a comprehensive player action evaluation through player navigation, action investigation, and action explanation. With the system, analysts can find players to be analyzed efficiently, learn how they performed under various match situations, and obtain valuable insights to improve their action choices. The usefulness and effectiveness of this work are demonstrated by two case studies on a real-world dataset and an expert interview.
2. Introduction:
   1. The first challenge is to integrate essential match situations into the visualization of soccer actions and their scores. To address the first challenge, we design a pitch-based visualization for soccer actions that places the action choices with the match situations in the same view. The visualization presents the action choice, the team tactic it belongs to, and the player locations in the same pitch to facilitate comprehension of the tactical intention of the action choice.
   2. The second challenge is to design visualization tools for effective action score comparison and explanation. To evaluate the strengths and weaknesses of a player, analysts need to compare how the player performed with different action choices under various match situations. To address the second challenge, we design a visual analytics system, Action-Evaluator, for a comprehensive soccer player action evaluation. Users can navigate players of interest through the player view. The action view supports the exploration of essential match situations and multiple comparisons of player action scores.
   3. Main contributions:
      1. A characterization of domain problems that summarizes the description of match situations and the criteria of player action evaluation from soccer experts.
      2. A tailored visualization to integrate complicated soccer match situations into soccer actions and their scores.
      3. A visual analytics system to support the comprehensive evaluation of player actions in soccer matches.
3. Related Work
   1. Soccer Player Performance Evaluation
   2. Soccer Data Visualization
4. Background and System Overview
   1. Term Definitions
   2. **Requirement Analysis**: We collaborated with three soccer experts for one year to develop a visual analytics system for soccer player action evaluation and improvement.
      1. Navigate important players for evaluation and improvement.
      2. Identify similar players on decision styles for comparison.
      3. Explore player action scores by match situations.
      4. Investigate player action scores of different action choices.
      5. Compare action choices and their scores from different players under similar match situations.
      6. Display the individual action and the results of its alternative actions.
   3. Data Processing
   4. System Overview
5. Framework for Action Evaluation
   1. Task Definition
   2. The Probabilistic Classification Model Architecture
   3. The Calculation of Action Score
   4. Model Evaluation
6. Visual Design
   1. Overview of Visual Design and User Interface
      1. In Action-Evaluator, we design a player view for player navigation (R1, R2), an action view for action investigation (R3, R4), and an explanation view for action explanation (R5, R6).
7. System Evaluation
   1. We invited two experts who did not participate in the requirement analysis to conduct the case study, including a senior sports analyst (E1) and a professional soccer coach (E2).
   2. Expert Interview after case studies
      1. Usability
      2. Suggestion
8. Discussion
   1. Significance
      1. With our approach, analysts can evaluate player actions by match situations and gain insights for improving player performance on action choices in future matches.
   2. Generalizability
      1. Our approach can be extended to other team sports where the match structure is similar to soccer.
   3. Design lessons
   4. Limitations: Scalability to more than 5 players
9. Conclusion

**PMU Tracker: A Visualization Platform for Epicentric Event Propagation Analysis in the Power Grid**

1. Abstract
   1. As a result, we have developed PMU Tracker, an event localization tool that supports **power grid operators** in visually analyzing and identifying power grid events and tracking their propagation through the power grid’s network
2. Introduction
   1. As a solution, in this paper, we implement PMU Tracker, an end-to-end visual analysis and event localization tool that affords streamlined, flexible, and scalable analysis of PMU data. The high-level workflow supported by the system is as follows: based on an encountered (or identified) grid event, users can apply spectral analysis for anomaly detection across a set of coordinated visualizations. In particular, the “event epicenter” (the PMU(s) at or near the center of the event) can be identified and highlighted for further analysis, and nearby PMUs can be selected, clustered, and tracked to understand how the event propagates out from the source into the surrounding network.
   2. Contributions:
      1. understand industry challenges and practices for handling and visualizing PMU data to formulate design requirements.
      2. Based on requirements, implementation of PMU tracker.
      3. Novel epicentric cluster dendogram view
      4. Based on evaluating PMU Tracker, we demonstrate and discuss how visual analytics can be used to analyze power grid event anomalies.
3. Related Work
4. Domain Survey and Task Analysis
   1. To help motivate our software development efforts, we surveyed three power system engineers that we have previously collaborated with to understand current challenges for visualizing and analyzing PMU-based power grid data.
   2. Task Analysis based on challenges that domain experts have identified:
      1. Flexible and interactive data retrieval.
      2. Link events to PMUs.
      3. Support temporal analysis.
      4. Provide multiple perspectives for analyzing events.
5. PMU dataset storage and retrieval
6. SOURCE LOCALIZATION VIA FFT
7. Interface and Usage Scenario
   1. Supports the 4 tasks
8. Evaluation via expert reviews
   1. 12 power domain experts
   2. Qualitative, not quantitative feedback
9. Discussion
   1. Generalizability to domains/relevant networks with similar epicentric event and data considerations.
10. Conclusion

**ECoalVis: Visual Analysis of Control Strategies in Coal-fired Power Plants**

1. Abstract
   1. Three challenges were identified: a) interactive extraction of control strategies from large-scale dynamic sensor data, b) intuitive visual representation of cascading impact among the sensors in a complex power plant system, and c) time-lag-aware analysis of the impact of control strategies on electricity generation efficiency. By collaborating with energy domain experts, we addressed these challenges with ECoalVis, a novel interactive system for experts to visually analyze the control strategies of coal-fired power plants extracted from historical sensor data. The effectiveness of the proposed system is evaluated with two usage scenarios on a real-world historical dataset and received positive feedback from experts.
2. Introduction
   1. Identification of Challenges
   2. Contributions
3. Related Work
4. Data and Task Abstraction
   1. To characterize the workflow of analyzing control strategies of coal-fired power plants, we collaborated closely with four domain experts, EA, EB, EC, and ED, in the past year. EA and EB are researchers from an intelligent city research team, and they have decades of experience in developing data-driven approaches for the energy sector. EC has worked as a senior engineer at a coal-fired power plant for more than three years and is extremely knowledgeable about power plant operation. We also invited ED, a Ph.D. candidate in energy science, to join the collaboration, such that we could leverage her expertise to better understand the rationales behind the diverse control strategies.
   2. Requirements analysis:
      1. We followed the nine-stage design study methodology framework to iteratively discover the user requirements by reviewing the related literature, obtain domain insights from expert interviews, and discussing the design ideas with the experts. Finally, we conclude five user requirements as follows.
      2. R1: Extract the impact of control strategies with time series queries.
      3. R2: Identify responsible control strategies for anomalies in important sensors.
      4. R3: Explore the spatial propagation of control strategy impact.
      5. R4: Obtain the temporal cascading of control strategy impact.
      6. R5: Inspect the details of the sensor time series.
5. ECoalVis
   1. To meet the user requirements summarized in Sect. 3.3, we proposed ECoalVis, a novel interactive system for experts to visually analyze the control strategies of coal-fired power plants. During the design procedure of ECoalVis, all the domain experts were also tightly integrated in the discussion of design alternatives.
6. Implementation
7. Evaluation
   1. 2 Use case scenarios explored by the authors and evaluated by the experts using ECoalVis on real-world historical datasets.
   2. Expert Interview where the experts reproduces the use case scenarios and followed the think-aloud protocol [21] and analyzed the control strategies of interest with ECoalVis. Finally, we collected qualitative feedback from the experts. Feedback on
      1. Effectiveness
      2. Designs and Interactions
      3. Improvement
8. Discussion
   1. Implications – Analytical framework can be applied to other domains.
   2. Lessons Learned – Usability and Flexibility
   3. Limitations and Future Work
9. Conclusion