Teaching Information Visualization: A Playground for Classroom Response Systems and Declarative Programming Projects

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ABSTRACT

Information visualization is a subject that has attracted growing interest in recent years, both in academic and general public literature such as newspapers. We reflect our experience with visualization courses at Master's level and find that the subject provides a playground for innovative teaching methods. It is shown that typical visualization (and human computer interaction) topics such as perception and cognition offer particular potential for using classroom response systems (CRS). Besides using ConcepTests for testing the understanding of fundamental concepts taught in the lecture, we employ CRS to demonstrate certain perception phenomena and to evaluate the effectivity of visualization solutions with regard to the students. Laboratory projects allowing the application of visualization methods are generally enjoyed by students, who can bring their own data and get immediate visual feedback. In our laboratory projects the JavaScript library D3.js is used, which builds upon a declarative programming paradigm. This lets students experience several new concepts in computer science, such as web-based programming, declarative programming, and web services for access to data sources.

Keywords: Information visualization; visual perception; teaching methods; classroom response systems; laboratory projects.

Index Terms: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Graphical User Interfaces (GUI); K.3.2 [Computers and Education]: Computer and Information Science Education—Computer Science Education.

1 INTRODUCTION

Having been an academic subject for many years, visualization—in particular information visualization—has attracted growing interest recently, with newspapers now publishing complex visualizations of, e. g., political or commercial networks, thus no longer restricting themselves to common bar and pie charts. Interactive visualizations abound in online news and business portals, and even information visualization blogs have been established [3, 4]. In view of this it is not astonishing that a growing number of (information) visualization courses exist in computer science programs at various universities [6, 7].

Both scientific and information visualization aim at the visual perception of its users. An introduction to visual perception and cognition thus forms a fundamental part of a typical visualization course [9, 11], which also holds for human computer interaction (HCI) [5]. Human perception boasts a number of interesting and partly surprising phenomena, with optical illusions as widely known examples. Instead of merely explaining these phenomena to the students, it is more effective to let the students experience them in an active learning setting. We show how classroom response systems (CRS) can be employed for this end as well as for the evaluation of visualization solutions.

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In Poster Abstracts of IEEE VIS 2015,
25–30 Oct 2015, Chicago, IL, USA.

Teaching visualization usually involves letting the students create visualizations of example data in laboratory projects. As more and more visualization libraries are web-based, this offers an opportunity to teach web technologies such as JavaScript and web services for data access by means of interesting applications with visual and interactive results. D3.js is a widely-used visualization library that has the additional benefit of confronting the students with a declarative programming paradigm [1].

2 COURSE SCHEDULE

The course *Visualization Techniques* has been a mandatory module of our M. Sc. program in Applied Computer Science since 2007. Its syllabus comprises both scientific and information visualization, roughly following the textbooks [9, 11] and similar to courses at other institutions [6, 7]. Recently (2013) our course has been extended to cover fundamental aspects of human computer interaction as introduced in [5], which is reflected in the new course title *Visualization and HCI*. After a brief introduction to visualization and a review of classic charts the course can be divided into three parts:

1. Concepts common to information and scientific visualization like visual perception, data representation, interpolation, color mapping, and contouring.
2. Information visualization techniques like focus+context, tree and graph drawing, glyphs, as well as fundamentals of human computer interaction.
3. Scientific visualization techniques like volume rendering and flow visualization.

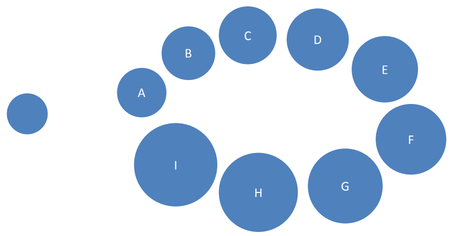
3 TEACHING METHODS

3.1 Classroom Response Systems

The most common use of CRS are ConcepTests, i. e., tests of the understanding of concepts taught in the lecture [8]. Besides this, we use Turning Technologies CRS [10] to let the students experience visual perception phenomena. While optical illusions often have the problem that students know what they are expected to see (or not to see), other phenomena give more rewarding results.

As an example a question concerning Steven's law is shown in Fig. 1. Steven's law relates the perceived scale of measurements to the actual scale, stating that areas are underestimated by most people by an exponent between 0.6 and 0.9 [11]. In Fig. 1 the correct answer (double area) would be C. The classroom response shows that six out of twelve students underestimate the area of the larger circles D, E, and F, while two students voting for H and I obviously interpret "twice as large attribute value" as double radius (which is sometimes used in naive visualizations, but not understood that way by most people).

Similar questions can be posed to test color perception, the validity of Gestalt laws, or the efficiency of visualization solutions: is the intended effect achieved by the visualization? The poster presents further uses of CRS with exemplary results. More advanced approaches going beyond this are sketched in section 4.



Answer option	A	B	C	D	E	F	G	H	I
Frequency ($N = 12$)	0	0	4	2	3	1	0	1	1

Figure 1: "Which circle corresponds to an attribute value twice as large as the circle on the left?" CRS question demonstrating Steven's law and classroom response of a small group of students.

3.2 Declarative Programming Projects

Laboratory projects in teams of two to three students form an integral part of our visualization courses, first to put the concepts and techniques taught in the lecture into practice, but not least to let the students get a feeling for good visualizations and for the benefit of interactivity. We reserve the exercises of the second half of the semester (about seven weeks) entirely for working on the project, with a mandatory discussion of the project concept with the lecturer after three weeks and a final presentation in front of the class at the end of the semester. In the semester following the lecture larger visualization projects may be offered, sometimes resulting in publications as in the case of a collaboration with Hannover Medical School [2].

Since 2012 we encourage the students to use the JavaScript library D3.js [1], with support for different data formats including JSON, CSV, and REST such that students can bring their own data from a field of personal interest. The code snippet shown in Fig. 2 exhibits the declarative programming model, with nodes being created and configured based on the data instances `d` by means of lambda functions. The radius of the larger circles is scaled with the square root of the number of referenced pages, as indicated by Steven's law (without correction for the underestimation of areas). The poster contains further project examples from the current instantiation of the lecture as well as student evaluation results.

4 Work in Progress

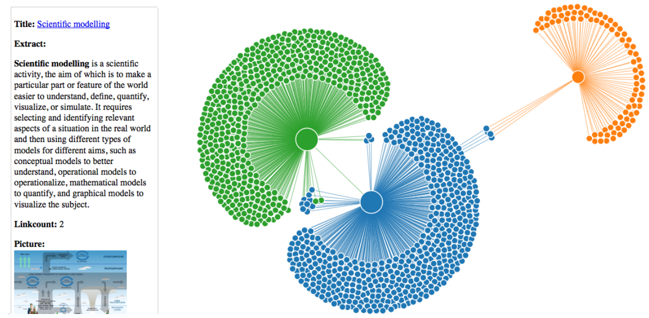
Our current work concentrates on making use of the personalization functionality of CRS senders, which allows to study connections between the answers of each student to different questions. In our visualization course we intend to use this for the creation of multivariate data which can then be visualized by, e. g., parallel coordinates or scatter plots.

A further application of personalized CRS senders could be the interactive creation of networks (or graphs) in a classroom setting, which could be visualized using force-directed graph drawing methods with continuous updating. It is expected that seeing the immediate effect a self-created edge or node has on the overall graph layout will help the students understand the function and the limitations of graph drawing methods.

5 Results and Conclusion

We observe that the students, when working on their projects, take particular care for visualization concepts and perception phenomena that have been taught using CRS. An example is given in figures 1 and 2 by the scaling of the radius of circles (or bubbles) with the attribute size. The same holds for principles of color mapping.

In conclusion we have shown (and further explore) how classroom response systems (CRS) can be used in innovative ways to enhance the undestanding of perception phenomena and visualization concepts. Laboratory projects play a key role in most visualization courses. We find that using D3 generally motivates our students due to its JavaScript foundation and its declarative programming model, the latter of which is new to most of them.




```
node.filter(function(d) {
      return d.level == loadLevel - 1; })
  .append("svg:circle")
  .attr("r", function(d) {
      return rScale(d.weight); })
  .style("fill", function(d) {
      return nodeColors(d.level); });
```

Figure 2: Student project example with D3.js code snippet visualizing links between Wikipedia articles; the large circles represent articles on computer science (blue), education (green), and visualization (orange), the smaller circles their first neighbors in the interaction graph, respectively (by Simon Beckstein, Julian Scheichel, and Dominik Schöner).

Acknowledgements

The author gratefully acknowledges valuable feedback of numerous paticipants of his visualization courses, with special thanks to the students contributing the project of Fig. 2.

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