Cartography M.Sc.

Animated Transitions in Statistical Maps

1 Motivation and Problem Statement

Cartography has always been closely allying with statistics (Clark, 1937). They both aim to compress complex quantitative data into a shape understandable by human eyes and minds, and both try to reach design efficiency (Kruskal, 1975). As they are intertwined, statistical data is often communicated by both maps and graphics.

In cartography, statistical maps alone “tend to be inefficient and inaccurate sources of data” because they are “symbolized generalizations of the information contained in a table” (Jenks, 1976). For this reason, quantitative statistical maps are often supported by graphs. On the other hand, graphs hugely simplify the complexity of statistics and data and do not reveal spatial aspects when used alone (Dent et al., 2009). Thus, maps and graphs complement each other in the processes of exploration, visualization and analysis of statistical data by displaying different aspects when combined.

With the advent of animation, both statistical mapping and data graphics became motional, displaying variable changes in temporal and non-temporal contexts. Animation simplified detection of patterns, trends, and relationships (DiBiase et al., 1992; Dorling & Openshaw, 1992; Harrower, 2004; Kraak, 2007; MacEachren et al., 1998), and helped emptying a screen space by leaving fewer number of animated views instead of tens of multiple static maps (map series) or graphs (Griffin et al., 2006). However, even these “reduced” multi-component visualizations seem to be difficult to integrate into a clear cognitive image (Opach et al., 2014), and being animated they also leave questions on human ability to pay attention to two or more juxtaposed dynamic views (Blok et al., 1999; Javed & Elmqvist, 2012). Therefore, this research will focus on strategies to facilitate perception of changes when transiting between maps and data graphics with related statistical data. This may help to not split attention of the map reader (Opach et al., 2014), improve cognition (Bederson & Boltman, 1999) and decision-making (Gonzalez, 1996), and increase levels of engagement (Tversky et al., 2002).

As an animated map can be a viable alternative to multiple static maps (Dent et al., 2009; Griffin et al., 2006), animated transitioning between maps and graphs can also become an alternative to juxtaposed views. However, it is not clear what kind of animated transitions are possible in statistical maps and how they might affect user perception.

2 Research Identification

2.1 Research Objectives

The main objective of the current study is **to determine how animated transitions from statistical maps to graphs and vice versa change user perception**. Particularly, the study has the following sub-objectives:

1. To describe possible animated transitions between statistical maps and graphs;
2. To develop working examples of the suggested transition types;
3. To test and analyze if and how the animated transitions affect user perception.

The results of the suggested research can contribute to the area of data visualization, specifically quantitative thematic cartography and data graphics. This study will be valuable to cartographers, data graphics and user interface designers, statisticians, storytellers and journalists to find more efficient ways to explore, analyze and design representations of statistical data.

2.1.1 Animated Transitions

Animated transition is a particular class of animation or technique which realizes a movement within or between visual scenes without disordering the viewer (Chalbi, 2018; Segel & Heer, 2010). Therefore, the research scope narrows down to the search and analysis of animated transitions but not map animations as a whole.

The current research aims to describe possible ways to transit between maps and graphs but due to the high number of options, not all of them will be produced as working examples. There might be transitions directly from classical quantitative thematic maps to graphs (saving shapes of boundaries' geometries), and transitions with a use of other types of thematic maps (dorling, demers cartograms). The use of other thematic maps may help to achieve better aesthetics and higher perception level during animation.

It is important to mention that the design of animated transitions is not feasible between all the types of statistical maps and graphs. There will be examples when they are barely imaginable. Thus, the study aims to reveal where transitions are possible and where not.

There are two general types of animation. *Frame-based* animation simulates movement by displaying a sequence of static images in a rapid succession (Dent et al., 2009). Second type is a *cast-based* animation that simulates movement using foreground graphical objects independently moving against a background (Peterson, 1994). In implementing the animations in this research, it is planned to use D3 JavaScript library and, consequently, the SVG graphics language. Therefore, the current study works only with cast-based animations.

2.1.2 Statistical Maps and Data Graphics

It is important to highlight the meaning of the terms ”statistical map” and ”graph” in the context of the current research. *Statistical map* is a type of thematic map showing the

spatial attributes of quantitative geographic phenomena (Dent et al., 2009). *Graph* is a drawing that has a mathematical basis for its construction (Dent et al., 2009). Some examples of graphs are bar graphs, scatter plots, and donut graphs. In other words, charts, diagrams, pictograms, and other organization-based drawings, for which no mathematical relations exist between the elements of the drawing, are not examined here.

For instance, choropleth map is a good example of a map easily transforming into a graph and back to a map. Containing a quantitative variable that is aggregated by units and symbolized by graduated colors, it transforms into two-dimensional bar chart by displaying the quantitative variable on Y axis and units on X. However, it might be hard or even impossible to transit from some types of statistical maps such as Dot Densities, Isarithmic and Flow Maps, whose transition types will be different and have their own specific issues. Therefore, the suggested research will reveal and describe the difficulties of transition representations of statistical data from various types of maps into graphs and vice versa.

2.2 Research Questions

To meet the afore-mentioned objectives, the following research questions need to be addressed:

- Q1 What are the possible ways to transition between dimensions of statistical maps and graphs?
- Q2 How do animated transitions affect the map reader's perception?
- Q3 Does the change in perception improve the understanding of patterns, trends or relationships in statistical data?

2.3 Innovation Aimed At

There is a lot of research dedicated to animation, in particular, in thematic cartography and data graphics. Along with it, many studies work on how animation affects perception, cognition, and decision-making of users. However, there is no research working on finding and classifying possible transitions between maps and data graphics, and how they help exploring and analyzing statistical data. Therefore, the current research aims to fill the gap in theory of animated transitions between maps and graphs.

Moreover, due to relatively recent advent of simple and accessible tools for cast-based animation design, not many scientific studies in thematic cartography investigated this technique. Thus, the suggested research will serve as an addition to the limited number of studies using cast-based techniques.

2.4 Related Work

A literature review does not reveal any studies related to transitions between statistical maps and graphs specifically. Instead, there is a number of works primarily describing types, constituents, and methods of transitions in data graphics and user interface design (Chalbi, 2018; Heer & Robertson, 2007; Hudson & Stasko, 1993; Stasko, 1990).

Deeper studies examine those in more details working with timing aspects, trajectory investigations, transition duration and pacing (Dragicevic et al., 2011; Du et al., 2015; Shanmugasundaram et al., 2007). All of these studies can shape the basis for general description and classification of animated transitions in statistical maps.

Significant amount of studies is dedicated to the use of animation for facilitating comprehension, learning, memory, communication and inference. Therefore, there are many techniques to test perceptual aspects of users. Some use object tracking tests to reveal the effects of animated transitions at the syntactic level of analysis, other experiments focus on semantic analysis by estimating changing values during transition (Heer & Robertson, 2007). Fabrikant, Goldsberry, Opach, and some other authors propose eye movement studies to assess the effectiveness of dynamic map displays and attention allocation for learning and better understanding of user's visual behaviour. Tversky, Jones, and others compare animated graphics to informationally equivalent static graphics to reveal if animation is facilitatory and helps to knowledge construction (Jones & Scaife, 2000; Tversky et al., 2002). Within the current research, investigation of these techniques will help shaping the experiment for testing user perception change.

3 Project Setup

3.1 Methods Adopted

The primary research method for this work is a literature overview to find existing types, classifications and methods of animated transitions in data graphics, user interface design and other related studies. Identification and description of feasible transitions between different combinations of statistical maps and data graphics are the very first steps towards understanding of when and how they influence map reader's perception.

In the second stage, the vast majority of time will be dedicated to the development of experiments for measuring perception change. The test tasks will be prepared, and selected types of transitions from the first step will be designed using the D3 JavaScript library.

Finally, the testing will be conducted. After the results are analyzed, the study will discuss how different types of transitions affect user perception and which of them are the most and least helpful for perception.

3.2 Planned Schedule of the Project

The overall schedule of the project is presented in Table 1. The literature overview phase will shed light on the existing types of transitions and indicate the possible ways of transitions between maps and graphs. The experiment setup part will include user perception test preparation and describe the development procedure of animated transition examples. By conducting and analyzing the experiment, next two phases will reveal how animated transitions change map reader's perception and if this change improves understanding of statistical data. Conclusion and outlook part will summarize and discuss the results of the project.

Phase	Description	Month
Extended Proposal	Identifying research objectives and questions	April
Literature Overview	Overviewing background and related work Revealing possible animated transitions between maps and graphs Choosing methods for the user's perception testing	May
Experiment setup	Preparing a platform for the test/survey Structuring test questions Developing transition examples	June
Experiment conducting	Conducting the experiment Assessing and discussing the results	July
Conclusion and Outlook	Summarizing the work and finishing the chapters	August

Table 1: Master Thesis Schedule

Each phase of the project schedule is related to at least one chapter. Chapter drafts are planned to be submitted at the end of each month. Discussions with supervisors will take place once in every two weeks. In general, the research will be conducted between April and September 2020, and the submission date is preliminarily planned for the beginning of September.

3.3 Risks and Contingencies

Due to different issues, not all the animated transitions will be realized practically. Some of them might be difficult or impossible to produce, while others might require considerable amount of time for their design. Therefore, the examples of animated transitions will be developed only for the selected types of maps and graphs.

Additionally, there are difficulties related to the experiment setup. There are various techniques of perception change assessment, among which is an eye-tracking. In case of no access to the lab and equipment or not enough number of participants, the use of surveys on the web will serve as an alternative. Final decision on this choice is planned to be made three months before the submission date of the final Master thesis. Specifically, where one month is planned for experiment development, one for conducting and another one for the analysis of results.

4 Resources Required

For conducting the project, the work environment requires the following list of resources:

- **Data:** Any available spatial statistical data can meet the research needs. For the clarity of experiment, the set of data may represent totally different areas in case some participants are familiar with presented data;
- **People:** Depending on the testing methods, the experiment will need participants either in person at the lab or users in the web.

- **Software and hardware:** To create working examples of animated transitions, the research makes use of the JavaScript programming language and, particularly, the D3.js library. Therefore, it needs the following Hardware and Software requirements:

Processor:	486 dx4 or above	Operating System:	Windows / Linux
RAM:	16 MB	Text Editor:	text editor
VDU:	VGA or SVGA		
HDD:	1.2 GB or above		

  For the use of D3 Java Script library, the project also requires "modern" browsers, which excludes IE8 and older versions. D3 is tested against and works with Firefox, Chrome, Safari, Opera, and IE9+.

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