Exploring Shifting Densities through a Movement-based Cartographic Interface

Aline Menin, Sonia Chardonnel, Luciana Nedel, Paule-Annick Davoine

Exploring Shifting Densities through a Movement-based Cartographic Interface

Aline Menin
Univ. Grenoble Alpes, CNRS, Grenoble INP[1], LIG, 38000 Grenoble, France
aline.menin@univ-grenoble-alpes.fr

Sonia Chardonnel
Univ. Grenoble Alpes, CNRS, Science Po Grenoble[2], PACTE, 38000 Grenoble, France
sonia.chardonnel@univ-grenoble-alpes.fr

Paule-Annick Davoine
Univ. Grenoble Alpes, CNRS, Grenoble INP[1], LIG, 38000 Grenoble, France and Univ. Grenoble Alpes, CNRS, Science Po Grenoble[2], PACTE, 38000 Grenoble, France
paule-annick.davoine@univ-grenoble-alpes.fr

Luciana Nedel
Federal University of Rio Grande do Sul, Institute of Informatics, Porto Alegre, Brazil
nedel@inf.ufrgs.br

Abstract

Animated maps are widely used for representing shifting densities. Though there is evidence that animations can provide better memory recall than static charts, it could be a consequence of using better techniques for animation than for static representations. However, the lack of control makes them frustrating for users, while animated choropleth maps can cause change blindness. In this paper, we propose an interactive animation technique which employs the lenticular printing metaphor and benefits from the user's proprioceptive sense to explore density changes over time. We hypothesized that using a tangible interface based on the body movement would improve memory recall and, consequently, animated map reading.

2012 ACM Subject Classification Human-centered computing → User interface design, Human-centered computing → Visualization, Human-centered computing → Geographic visualization, Human-centered computing → Gestural input, Human-centered computing → Mobile computing

Keywords and phrases proprioceptive interaction, lenticular technique, shifting densities, tangible interfaces, mobility analysis

Digital Object Identifier 10.4230/LIPIcs.GIScience.2018.48

Category Short Paper

Acknowledgements We would like to acknowledge the Region Auvergne-Rhône-Alpes for funding this research.

1 Introduction

Shifting densities describe the density changes in different space areas over time. Studying them support the measurement of urban mobility while exploring indicators such as attractiveness changes and the space use frequency according to the activities performed [19].

[1] Institute of Engineering Univ. Grenoble Alpes
[2] School of Political Studies Univ. Grenoble Alpes

10th International Conference on Geographic Information Science (GIScience 2018).
Editors: Stephan Winter, Amy Griffin, and Monika Sester; Article No. 48; pp. 48:1–48:6
Leibniz International Proceedings in Informatics
LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

This indicator is often represented through animated choropleth maps. Even if there is evidence that animation can improve performance on memory-recall and map-reading if compared to static graphs [14], this representation has shown drawbacks like change blindness. Consequently, users regularly fail to detect basic changes within animated choropleth maps [13]. They can be frustrating while dealing with complex changing maps that are difficult to control [14].

Tversky et al. [21] found out that most of the so-called successful applications of animation turn out to be a consequence of a better visualization or study procedures such as interactivity or prediction that are known to improve learning independent of graphics. The same authors say that the drawback of animation may be perceptual and cognitive limitations in the processing of a changing visual situation. Animations are fleeting, they disappear, and when they can be reinspected, this is done in motion, where it may be difficult to perceive all the minute changes simultaneously.

Interactivity could be the key to overcome the drawbacks of animation while improving learning and giving the user the power of controlling speed, stop and start, zoom in and out, and so on. Therefore, we propose a motion-based interaction for map animation, which explores the lenticular printing metaphor combined with the user's proprioceptive sense to explore the use of the space in urban areas represented by animated choropleth maps. Our approach brings together the benefits of controlling the animation by using the lenticular foil technique, which allows the user to see spatial information separately, and to see relations and dependencies of phenomena by changing the view [11], and making use of their proprioceptive sense by tilting a mobile device.

2 Related Work

Previous studies have proposed visualization and interaction techniques to improve animation effectiveness for shifting densities exploration. André-Poyaud et al. [1] present the concept of territorial heartbeat, through which one could observe the density variation by sensing the city pulse: in the morning, the periphery people move towards the main agglomerations, which receive even more density, and then they leave gradually from the end of the afternoon to beginning of the evening. This technique has been explored in combination with the 3D view, by varying the z-axis height and color according to the density change on different map regions [15, 5]. Le Roux et al. [17] use animated timelines to represent the social segregation over time. Users can control time periods by pausing/playing or directly clicking on the timeline to choose periods.

In thematic cartography, researchers have explored the lenticular foil technique for improving map-reading and, especially, for displaying 3D effects without any specific device, e.g. glasses, which is called *true-3D*. Lenticular printing uses lenticular lenses to change or move the image as it is viewed from different angles. Cartography could benefit from the possibility of giving the user different information from the respective content layers since they can be visualized separately by auto-stereoscopic accentuation or sequential insertion. Moreover, it could reduce the drawbacks of graphic density and its associated bad legibility, as well as improving information communication [11].

The lenticular foil technique can display both 2D and 3D effects. Up to this date, it has been mostly applied to display information by using *true-3D*. Buchroithner et al. [7] employed this technique to create an interactive map of the Granatspitz Massif in the Eastern Alps aiming to exhibit the touristic places in the region. Similarly, Wagman [23] uses the same technique to support tourism in Manhattan city, in which the viewer has the impression of seeing several layers of information, almost like an hologram. The map can be seen from three different angles, showing the New York's subway system, the neighborhood, and the streets grid.

By using visualization environments composed of immersive and stereoscopic augmented reality combined with tangible input, Bach et al. [3] showed that direct manipulation with 3D holographic visualizations improves time and accuracy for tasks that require coordination between perception and interaction. In 3D visualizations employing spatial information with mobile devices, Buschel et al. [8] found that users perceived spatial interaction as more supportive, comfortable and preferable to touch input.

Besançon et al. [6] explore the possibility of using both tactile and tangible input for fluid dynamics data visualization using a portable, position-aware device. Their approach was better appreciated by the users than a traditional mouse-and-keyboard setup. Moreover, Arvola and Holm [2] showed that device-orientation based panning on hand-held devices is useful when engagement is considered important, and their results strengthen the idea that more intensive bodily interaction can be more engaging. In fact, the user's proprioceptive sense could help to retain information by using their body's position as a recall reference. This sense corresponds to user's feeling regarding the pose of their own body and the strength or effort being employed in the movement. It could assist interaction through tangible user interfaces, in which a person interacts with the digital information through the physical environment.

3 Space Use over Time

Studies on shifting density are of interest for areas as diverse as crisis and health management, social segregation, or mobility issues. Bañgate et al. [4] propose a multi-model of human behavior during seismic crisis based on the social attachment theory. During the simulation of the model, they consider where people are performing their activities at each hour of the day. Likewise, Davoine et al. [10] proposed a visualization tool to improve the study of social vulnerability considering spatio-temporal variations regarding visited places at personal and professional aspects.

The investigation of social segregation helps to dynamically consider place effects on individual behavior and to target areas to implement interventions more connected with the real rhythm of the city [17]. Moreover, the day course perspective may help to isolate some critical and sensitive periods in which changes in place attributes occur, as well as days and nights constitute an important timescale for humans as they impose a biological rhythm, which helps to understand the mobility impacts upon health [22].

In France, Household Travel Surveys (HTS) constitute a valued database on urban mobility. We explored the data from a large HTS regularly carried out in the Rhône-Alpes region since 1976, from which we recovered the 2010 edition [9]. This survey provides a large amount of information on the daily mobility of inhabitants aged five and older, as well as on the household and individual aspects. Displacements are described through origin-destination information, which contains information about departure/arrival sector and time.

In this study, we calculated presence density and migration rate varying along a 24-hour period. The first one refers to all people staying in the referred sector, while the second refers to the difference between present people and the sector population.

4 Lenticular Printing Metaphor

4.1 Design Rationale

Animations are appropriate when we need to use multiple maps to represent information changing over time. However, it should be interactive to properly replace static maps, which also facilitates analysis when allowing the user to choose viewpoints [12]. Dorling also points out the brain's poor visual memory as being a problem when animating time. Therefore, we believe the proprioceptive sense could assist the improvement of memory recall while using animation for the analysis of spatio-temporal information.

In virtual reality, proprioception aids users to orientate themselves spatially inside virtual environments [18], and improves object manipulation, which is also better performed when using a handheld object to guide the user from the physical space [20]. Additionally, the use of tangible user interfaces reduces the cognitive workload, while physical mobility may increase user creativity, which indicates that less constrained interaction styles are likely to help users to think and communicate. Tangible interfaces that engage the body can leverage body-centric experiential cognition [16].

Based on these assumptions, our animation technique uses a mobile device as visualization and interaction interface and grants interactivity through lenticular effects (see Figure 1). We implemented the morphing effect, which changes one image into another through a seamless transition and, thus, it is suitable to represent a series of spatial events gradually [11] along a 24-hour period. Since these transitions are activated by tilting the device, the user could use their wrists orientation as a physical reference to recall the information seen on the screen.

4.2 Implementation and preliminary results

In order to calculate presence density, individuals who reported staying at home all day were assigned to their residence sector during all observation time. Individuals that moved during the day can be considered either *visitors* (people that do not reside in the current sector they are staying) or *residents* (people whose displacements were performed inside their residence sector). Time periods have one-hour duration. Then, for each hour we calculated the number of people staying in each sector. Displacements were recorded from 4:00 AM to 3:59 AM, then we considered people were at their first origin sector from 4:00 AM to the departure time of their first displacement, and at their last destination sector from their last displacement arrival time to 3:59 AM. Following the approach of Le Roux et al. [17], we did not take people that were moving into account.

The density was calculated by dividing the number of persons present in the sector at each time period by the sector surface in square kilometers. The migration rate was determined by the difference between the current population and the number of inhabitants in the sector.

The map can display either the presence density or migration rate at the time. For the first one, we vary density from light to dark red, while for the second one, we vary migration rate from blue nuances (when the sector looses population) to red nuances (when the sector gains population). Time periods can be selected by cyclically tilting the mobile device, from which we recover accelerometer information. This data is mapped to a time period by computing the tilting angle and then matching it with the corresponding period. The indicators are dynamically updated according to the selected time. Finally, the user also disposes of a play/pause button (in the middle of the clock) and the velocity animation is determined by the user's movement speed while tilting the device. We used D3 Data-Driven Documents javascript library for developing our application, which holds a choropleth map and a 24-hour clock to select the time.

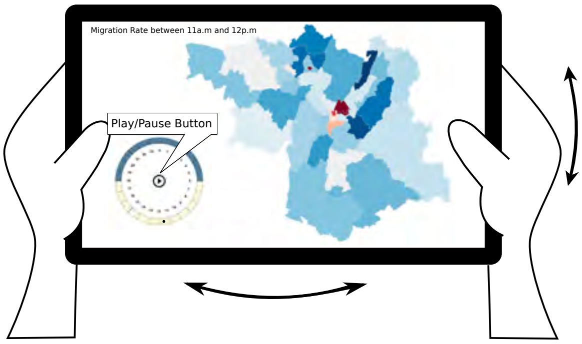

Figure 1 The desired time period is selected by tilting the tablet. During the movement, the clock (left) shows the current time period and the map is animated accordingly. Animation can be stopped by pressing the play/pause button and the movement speed is set by the tilting velocity.

5 Final Comments and On-going Work

In this paper, we introduced a technique for exploring animated maps based on a natural and tangible interface. We use the lenticular printing approach to visualize changes in mobility indicators along a 24-hour period by tilting a mobile device. By using a tangible interface we benefit from the user's proprioceptive sense, which aims to improve memory-recall and, consequently, map-reading.

This work is part of a greater project, in which we intend to develop a geovisualization tool for exploring individual mobility data by combining non-conventional interactions and successful visualization techniques for mobility analysis. Therefore, the next step consists of evaluating the proposed technique to test our hypothesis that it really improves animated map-reading.

References

1. Isabelle I. André-Poyaud, Sonia Chardonnel, Laure L. Charleux, and Kamila Tabaka. La mobilité au cœur des emplois du temps des citadins. In Florence Paulhiac Yves Chalas, editor, *La mobilité qui fait la ville*, Débats, pages 67–95. CERTU, 2008.
2. Mattias Arvola and Anna Holm. Device-orientation is more engaging than drag (at least in mobile computing). In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational*, pages 939–942. ACM, 2014.
3. Benjamin Bach, Ronell Sicat, Johanna Beyer, Maxime Cordeil, and Hanspeter Pfister. The hologram in my hand: How effective is interactive exploration of 3d visualizations in immersive tangible augmented reality? *IEEE transactions on visualization and computer graphics*, 24(1):457–467, 2018.
4. Julius Bañgate, Julie Dugdale, Elise Beck, and Carole Adam. Solace a multi-agent model of human behaviour driven by social attachment during seismic crisis. In *4th International Conference on Information and Communication Technologies for Disaster Management (ICT-DM)*, pages 1–9. IEEE, 2017.
5. Arnaud Banos and Thomas Thévenin. La carte animée pour révéler les rythmes urbains. *Revue Internationale de Géomatique*, 15(1):pp–11, 2005.
6. Lonni Besançon, Paul Issartel, Mehdi Ammi, and Tobias Isenberg. Hybrid tactile/tangible interaction for 3d data exploration. *IEEE transactions on visualization and computer graphics*, 23(1):881–890, 2017.

7 MF Buchroithner, Klaus Habermann, and Thomas Gruendemann. True 3d visualization of mountainous terrain by means of lenticular foil technology. In *4th ICA Mountain Cartography Workshop*, pages 125–135, 2010.

8 Wolfgang Büschel, Patrick Reipschläger, Ricardo Langner, and Raimund Dachselt. Investigating the use of spatial interaction for 3d data visualization on mobile devices. In *Proceedings of the 2017 ACM International Conference on Interactive Surfaces and Spaces*, pages 62–71. ACM, 2017.

9 CEREMA. *Enquête Ménages Déplacements (EMD), Grenoble, Grande région grenobloise.* Archives de Données Issues de la Statistique Publique, 2010.

10 Paule-Annick Davoine, Elise Beck, Isabelle André-Poyaud, Sonia Chardonnel, Céline Lutoff, and Anton Telechev. Géovisualisation pour la réduction de la vulnérabilité socio-spatiale en milieu urbain. *Comité Français de Cartographie*, 211:69–84, 2012.

11 Frank Dickmann. The potential of the lenticular foil technique for thematic cartography. *The Cartographic Journal*, 47(3):250–256, 2010.

12 Daniel Dorling. Stretching space and splicing time: from cartographic animation to interactive visualization. *Cartography and Geographic Information Systems*, 19(4):215–227, 1992.

13 Carolyn Fish, Kirk P Goldsberry, and Sarah Battersby. Change blindness in animated choropleth maps: an empirical study. *Cartography and Geographic Information Science*, 38(4):350–362, 2011.

14 Mark Harrower. Visualizing change: Using cartographic animation to explore remotely-sensed data. *Cartographic Perspectives*, 39:30–42, 2001.

15 Christophe Hurez. Localisation spatiale et temporelle des personnes et des voitures á partir des enquêtes ménages déplacements. `https://mappemonde-archive.mgm.fr/num27/fig10/fig10302.html`, 2010. Accessed: 2018-04-23.

16 Scott R Klemmer, Björn Hartmann, and Leila Takayama. How bodies matter: five themes for interaction design. In *Proceedings of the 6th conference on Designing Interactive systems*, pages 140–149. ACM, 2006.

17 Guillaume Le Roux, Julie Vallée, and Hadrien Commenges. Social segregation around the clock in the paris region (france). *Journal of Transport Geography*, 59:134–145, 2017.

18 Anderson Maciel, Luciana P Nedel, Vitor AM Jorge, Juan MT Ibiapina, and Luis FMS Silva. Reality cues-based interaction using whole-body awareness. In *Proceedings of the 2010 ACM Symposium on Applied Computing*, pages 1224–1228. ACM, 2010.

19 Matthieu Mille. Des densités habitantes aux densités mouvantes l'exemple de la métropole lilloise. *Cybergeo: European Journal of Geography*, 2000.

20 Mark R Mine, Frederick P Brooks Jr, and Carlo H Sequin. Moving objects in space: exploiting proprioception in virtual-environment interaction. In *Proceedings of the 24th annual conference on Computer graphics and interactive techniques*, pages 19–26. ACM Press/Addison-Wesley Publishing Co., 1997.

21 Barbara Tversky, Julie Bauer Morrison, and Mireille Betrancourt. Animation: can it facilitate? *International journal of human-computer studies*, 57(4):247–262, 2002.

22 Julie Vallée. The daycourse of place. *Social science & medicine*, 194:177–181, 2017.

23 David Wagman. Urban maps gives a vintage printing technique a high-tech revival. `https://www.directionsmag.com/article/3272`, 2009. Accessed: 2018-04-20.