Visual Indicators of Real-Timeness in City Dashboards

Samuel Stehle*, Rob Kitchin†

National Centre for Geocomputation
National University of Ireland, Maynooth

March 20, 2018

Summary

This paper surveys numerous publicly available, online city dashboards to describe the multiple ways that the real-time properties of urban data are visually presented to public viewers and viewers from city authorities. It identifies eleven strategies used to present real-time data, especially indicating the ways that it is ingested into the visual representation. This survey informs city dashboard design by considering the facilitation of specific spatio-temporal displays and the ability to detect patterns among both time series and real-time data.

KEYWORDS: city dashboards, spatio-temporal representation, visual analytics, real-time data

1. Introduction

City dashboards are public-facing collections of front-end visualisations connecting to open, but often authoritative, urban data. Dashboards compile indicators of city progress toward milestones, updated traffic and weather reports at fine spatial scales, and facilitate historical comparison to patterns and prior events. Thus, temporality is a critical part of taking the pulse of and regulating the social function of cities. In particular, real-time information and communication of the real-time variability of city networks and conditions is critical for both decision-makers (Coletta and Kitchin 2017) and for citizen observers.

This paper examines the display and communication of real-time data through visual strategies and indicators. Real-time displays in dashboards include various strategies for representing spatial and temporal properties including various timescales, update frequencies, and historical or archived data. Here, the methods used to represent and make sense of real-time data are surveyed for their utility for dashboard viewers.

2. Real-time visualisation issues

While visual methods present real-time data in attractive ways, particularly to attract casual users, the design must not detract from the ability of viewers to use the presentation to their advantage. These visual approaches must balance facilitating visual pattern detection and impressive dynamic displays with seamless integration of new data directly from networked sensors. Studies have described these trade-offs and the strategies that visual analytic interfaces utilise to address them.

Dynamic or animated displays make pattern detection difficult for viewers due to limited visual perception and attention. Changes to a display which are small in magnitude, brief, or dispersed through the display reduce the perception of individual changes and larger patterns, and thus dynamic maps and

* Sam.Stehle@mu.ie
† Rob.Kitchin@mu.ie

other animated representations introduce many potential instances where change blindness may occur (Goldsberry and Battersby 2009). Similarly, excessive animation or visual data overwriting can detract from the attention necessary to recognize a salient pattern, and in the case of visual updating, removes the display of data from previous time periods, removing the ability to observe patterns in time series.

Spatio-temporal visualisation is a frequent component of city dashboards, particularly of transportation network dynamics and other stationary and mobile sensors (see the Dublin Dashboard in Figure 1). Although strategies have been successfully implemented to represent dynamic spatial data, such as interactive linked displays and time-series glyphs (Thakur and Hanson 2006), the usability of such strategies are complicated by real-time updates and the need to communicate the nature of those updates to the viewer.

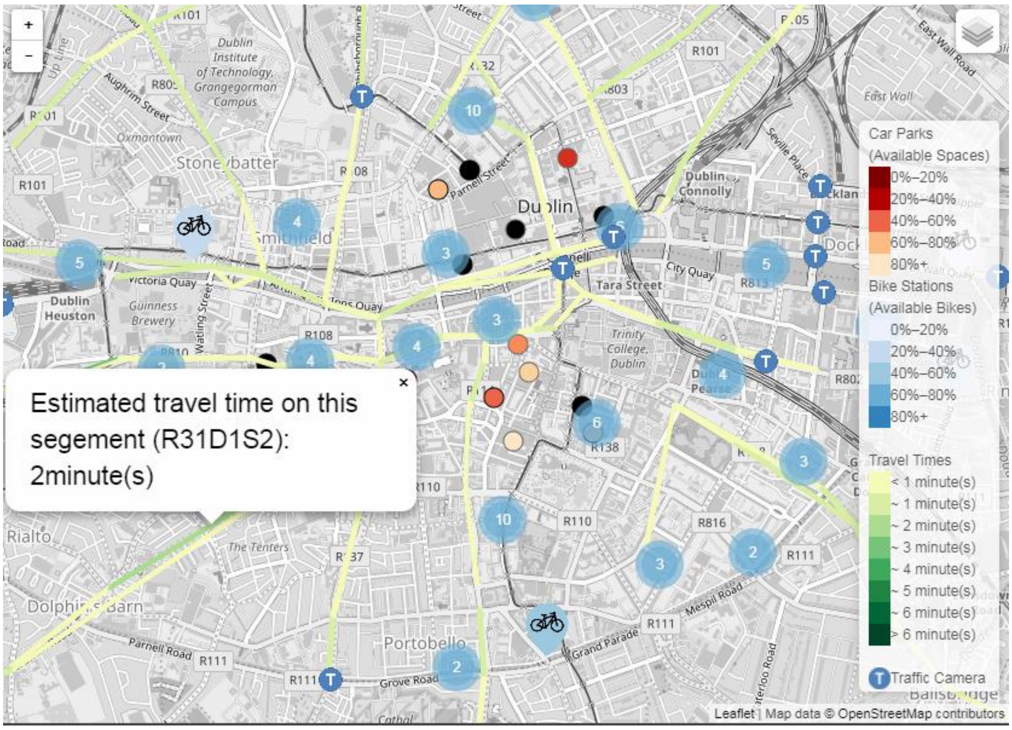

Figure 1 Screen capture (January 12, 2018, 15:25 GMT) of the Dublin Dashboard's real-time module (http://dublindashboard.ie/pages/DublinTravel)

3. Real-time visual indicators

One primary question this paper considers with respect to visual methods is whether the methods introduce an interruption to the viewer's process of visual pattern detection and interpretation. This survey identifies several visual strategies used to communicate the real-time dynamic nature of visual displays among city dashboards and similar urban data-visualisation tools. These indicators provide information about how often the display updates, when to expect the display to change, how much interactivity is necessary to create a display change, and whether multiple sensors can be compared in real-time.

First, the question of *manual vs. automatic refresh* is considered, referring to the incorporation of new real-time data into the display. Typically, real-time dashboards automatically refresh when new data is available, maintaining the aesthetic of real-timeness to tool viewers. In the automatic case, an *indicator of refresh rate* is necessary. However, in at least one example, new data is compiled external to the visual presentation, and updates are only made on demand (see the dashboard built for the city of Seattle by Best et al in Figure 2). Tools must also present an *indicator of refresh style* with either a button indicating the display will refresh, or a notification of an upcoming automatic update.

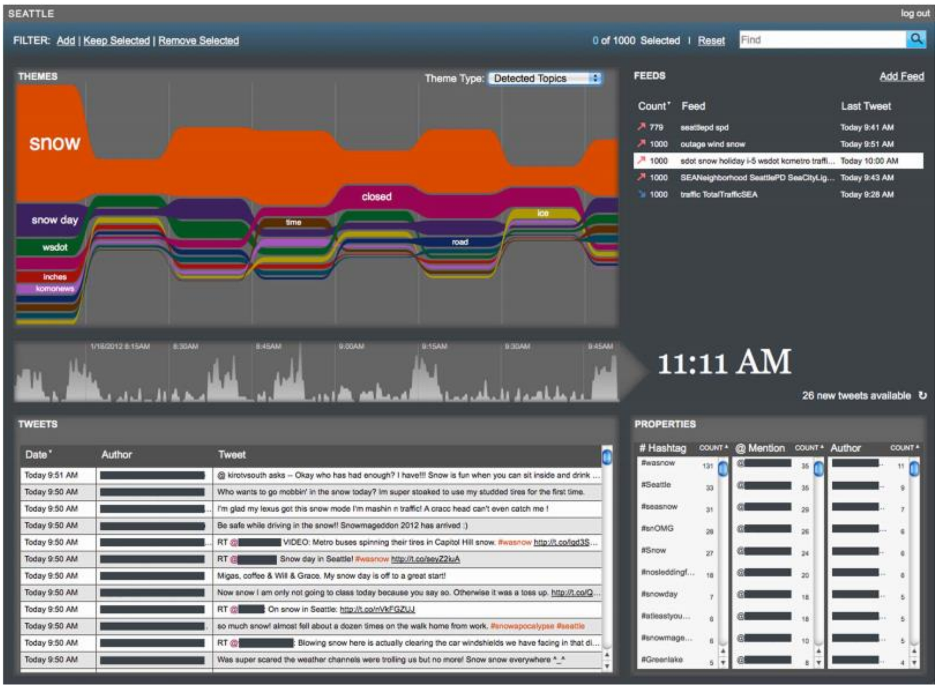

Figure 2 Best et al's real-time dashboard with manual update via a clickable link next to the digital time display (Best et al 2012)

Viewers should be able to compare subsequent states of the display by comprehending the interval between new updates. City dashboards use either a *time since last update* or a *time until next update* strategy to alert viewers to the dynamic nature of the display. Data, though dynamic and at times variable in an urban context (in such measurable contexts as vehicle counts, for example), is represented in ways where change may not be apparent, even when anticipated. Consider the colour-designated assignment of numerical data to bins in a choropleth map. Time since last update indicates the age of the data on display, while time until next update measures the time remaining before the current data is replaced. Regardless of which indication is given – though not exclusive strategies, no approach to dashboard design explored here incorporated both – another indicator to consider is whether *update notifications are in clock time or accumulated time*. A clock time indication operates independently of the last time the tool was operated on by an automatic update or user intervention.

Some dashboard designs *provide for comparison among individual sensors* which carry their own temporal information. Spatial views accomplish comparison using symbology, although map symbols and choropleth maps, in an overwhelming number of cases, may display only a single time period. Interactive displays may require a selection to display data contained in a selected sensor, making comparison (defined here as simultaneous viewing) impossible.

4. Comparison with archival temporal information

Real-time information display is valuable in isolation, but the ability to compare newly updated information with archival data, once itself collected in real-time, facilitates an important analysis of changing urban dynamics. The ability to *compare a real-time value against archival data* is critical to a city dashboard for providing perspective on current observations. When comparison to archival data is available, the ability to *control the timing and scale* of the archive is important to further understand periodic and seasonal patterns in the measured phenomena. Most dashboards implement archival controls via a single time series display with the real-time data at one end of the series. A more rare temporal analysis tool in dashboards is presented with a complete series from the previous cycle in an archival comparison that enables *benchmarking* between multiple time series (See the Oberlin, Ohio city dashboard in Figure 3). Benchmarking improves upon the trend analysis possible with archival control by comparing established trends, and allows direct comparison between specific points in time. Finally, although several interactions are normally necessary to access a historical record of observations, few dashboards provide the capability to *compare multiple sensors' archived data*. Spatial views rarely allow for this time series comparison, but linear time-oriented views appear frequently among the publically accessible city dashboards.

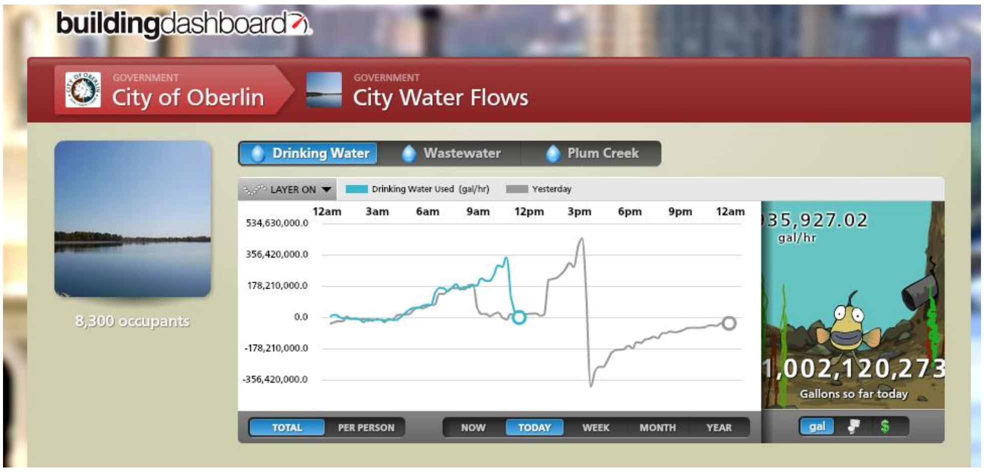

Figure 3 Screen capture (January 12, 2018, 17:35 GMT) from Oberlin, Ohio, USA's dashboard with controllable archival comparison (http://buildingdashboard.net/oberlincity/#/oberlincity/citywateruse)

5. Significance

This paper evaluates the visual factors influencing a sense of real-time presence within city dashboards. The criteria described here arise from observation of many dashboards and serve as initial step toward creating dashboards which attempt to portray data accurately and in interpretable ways. City dashboards are both a public resource and a system for local government to make informed decisions. Presentation of actionable information is thus critical to the effective design of city dashboards. This paper explores the various methods employed by existing dashboards for presenting real-time information and collating them with their purposes and visual analytic strengths, generates best practices for temporal data representation and design.

6. Acknowledgements

The authors would like to acknowledge the support of Science Foundation Ireland (Award No. 15/IA/3090) and the contribution from our data partners and providers.

7. Biographies

Sam Stehle is a postdoctoral researcher on the Building City Dashboards project at the National University of Ireland, Maynooth. Sam's research interests are in time series analysis and visualisation, smart cities, and machine learning applications and evaluation.

Rob Kitchin is professor and ERC Advanced Investigator at the National University of Ireland Maynooth. He is (co)principal investigator of the Programmable City project and the Building City Dashboards project. His research interests focus on smart cities and data-driven urbanism.

References

Best, Daniel M., Joe Bruce, Scott Dowson, Oriana Love, Liam McGrath (2012) Web-Based Visual Analytics for Social Media. *Association for the Advancement of Artificial Intelligence Technical Report* (no. WS-12-03).

Coletta, Claudio and Rob Kitchin (2017) Algorhythmic governance: Regulating the 'heartbeat' of a city using the Internet of Things. *Big Data and Society*. 4 (2)

Goldsberry, Kirk and Sarah Battersby (2009) Issues of change detection in animated choropleth maps. *Cartographica*. 44 (3) 201-215

Thakur, Sidharth and Andrew J. Hanson (2010) A 3D Visualization of Multiple Time Series on Maps. *14th International Conference on Information Visualisation.*26-29 July 2010, London, UK