Information Visualization and Smart Cities – Practices and Cultural Perspectives.

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Abstract

This paper aims to draw up a panorama on Information Visualization (InfoVis) and how its techniques can be used to visualize data generated in the context of cities in order to reflect part of the complex network of activities that constitute cities. To do so, it reflects on the ways in which InfoVis dialogues with the concept of smart cities, not only for their concrete manifestation, but also for the complex interconnection of data that can reflect, expand or restrict social, artistic and cultural practices.

Keywords

smart-cities, artistic visualization, big data, urban media art

Introduction

In September 1854, Dr. John Snow drew a map of central London (Figure 1) and plotted the location of cholera deaths (marked with dots), as well as the sites of water sources used by the population (marked with "X"). By examining the arrangement of dots in contrast to the map he was able to see that most of the deaths were close to the water sources, suggesting that the causes of the deaths were related to the water consumed by the population at these sites. The hypothesis was confirmed by a drastic reduction of cholera deaths when the water source with the highest number of deaths around was interdicted.

According to Tufte [1], this example is one of the most valuable uses of maps for recording disease-spreading patterns in geographic spaces. Dr. Snow´s map is a classic example that demonstrates the power of mapping quantitative data into visual elements to broaden our understanding of a given set of data. What Dr. Snow has done can today be defined as "Information Visualization" (or simply InfoVis).

Lev Manovich [2] proposes an initial definition that considers information visualization the mapping of discrete data in the form of visual representation. This mapping seeks, as pointed out by Robert Spencer [3], to form a mental model or mental image of something. To Spencer [3] the principal task of information mental model or mental image of something. To Spencer [3] the principal task of information visualization is allowing information to be derived from data. A classic definition used by computer scientists is one proposed by Card et al [4] that defines the term visualization as "the use of computer-supported interactive, visual representations of abstract data to amplify cognition". In general, we can divide visualizations into two main types: information visualization (or its synonym data visualization) and scientific visualization.

Spence [3] says that the visual result of a scientific visualization is usually associated with the physical "thing", whereas information visualization focuses on the visual representation of abstract data. Another way is to say that scientific visualizations tend to incorporate spatial contents such as meteorological, topographical, medical and biological data. While information visualizations typically represent non-spatial, abstract data such as dates, names and values.

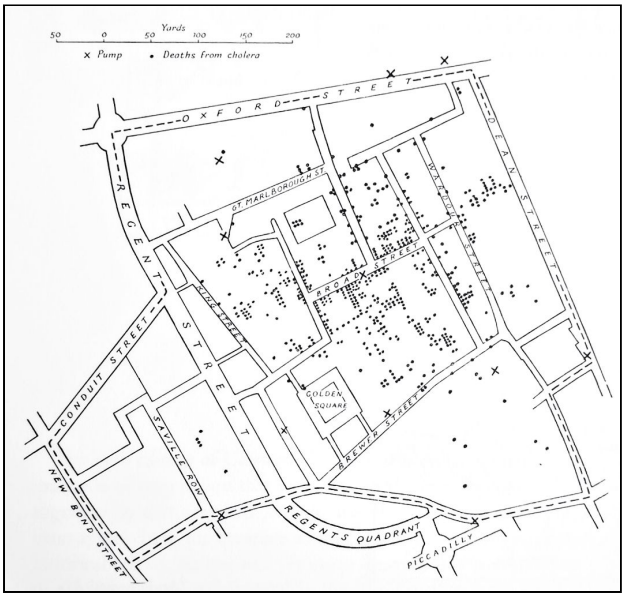

Figure 1. Map of central London showing cholera death (dots) and water sources (x). Source: (TUFTE, 1983)

City and Big Data

According to Kitchin, Maalsen, McArdle [5] it is through the long history of cities that data is generated on their ways and activities in order to provide information and knowledge to control operations and to serve as a guide to the implementation of public policies. More and more cities are dependent on the collection, processing, analysis and interpretation of large volumes of data for their management. By incorporating computing into the fabric of infrastructure, operations, and governance of urban systems, there has been a shift in the pace at which urban data are generated [5]. This change of pace has led to an exponential growth in the amount of data that can be summed up in the term big data. According to an IBM study [6], we currently create about 2.5 quintillion bytes of data every day. These data come from everywhere: sensors to generate information about the climate, publications in social networks, photos, and videos, transaction records, cellular data, GPS, among others.

Smart City

Despite the popularization of the term "smart city" there is still no clear and consistent consensus regarding the use of the term among researchers in the area [7]. Hollands [8] does not fail to punctuate the self-promotional inclination of some cities that use the term "smart" without necessarily knowing what that means. It escapes the scope of this paper to exhaust this discussion. Thus, we use the definitions of smart city proposed by Norbert Streitz [9] for understanding that there are no big differences among the concepts already based on the theme. Streitz brings two notions about the term smart city:

> The first notion is based on the general deployment of ICT for its realization. This includes pervasive computing and ambient intelligence infrastructure and transforming urban environments into interactive spaces that are meant to be adaptive, responsive and smart. Combining information and experience spaces with ubiquitous and pervasive computing in urban contexts results in what I would call a "Smart City". (Streitz, 2016, p.276)

The second notion highlighted by Streitz [9] says that: "'smartness of a city' can also be characterized by how much the city knows about itself (enabling self-awareness) and how this is communicated to its citizens".

In the first notion, he highlights the important role that the expansion of ICTs and the use of pervasive computing in infrastructure and urban environments have in the construction of spaces that respond and adapt to the context of their use. The second notion, however, points out that the intelligence of a city is directly related to how much the city knows about itself and how this type of information is communicated to its citizens. It is in this context that data visualization plays a key role.

Visualization and Smart Cities

Undoubtedly maps are the most recurring artifacts in the visual representation of geographic spaces. In its most detailed form, the maps can bring indication of terrain, river courses, streets, railway lines, architectural landmarks, local business and a whole myriad of information related to a certain place. Maps can be static, like paper maps, or dynamic and interactive like digital maps such as Google Maps and OpenStreetMap. Although maps are very important for the visual representation of cities, their model is not enough to represent satisfactorily the various types of data generated in real-time by cities. An example of use that requires a visualization model besides the geographic map can be found at the Centro de Operações Rio (COR) – Rio Operations Center – in the city of Rio de Janeiro in Brazil. Inaugurated in 2010, COR [10] is a project developed in partnership with IBM that integrates data generated by 30 city agencies, public transportation companies, information services, and the video feed from 560 cameras installed throughout the city for monitoring and prevention of events and 24-hour traffic control. According to COR [10], all data gathered are interconnected for viewing, monitoring and analysing in the control room on an 80 square meter screen (Figure 2).

Figure 2. 80 meters screen with dashboard visualization at Centro de Operaçõe Rio (COR). Source: (simi.org.br)

According to Kitchin, Maalsen and McArdle [5] the use of large screens for data visualization is a key resource in urban control rooms such as that used by COR. Such data are usually presented in a dashboard-like interface, panels that provide visual means for organizing and interacting with data, allowing users to drill down into a given set of data, filter out uninteresting data, select an item or group of data and retrieve details, view relationship among items, enabling an overview and detail in a single visualization system [5]. In this way, we can see the relationships between

items, extract sub-collections, overlap and interconnect different data, allowing an overview and detail in a single visualization system. In addition to COR, where access is restricted, various visualization projects, from official demands to popular initiatives, use dashboards to provide a global view of activities in cities, like those developed for the cities of London[1] and Dublin[2].

The use of real-time data visualizations in a dashboard-like interface to generate information and insights about the city may be the most recurrent use of InfoVis in the context of smart cities. However, other types of visualizations, especially those produced by designers and artists, also make use of the data generated by cities to broaden our understanding of the nature of activities in urban spaces. According to Manovich [11] from the early 2000s, there was an explosion of interest in the area of information visualization. With the popularization of softwares like Processing, designers, artists and researchers started using InfoVis techniques as a creative and expressive medium.

A good example of that is Aaron Koblin's visualization for the Current City project (Figure 3), promoted by MIT's Senseable City Lab and the Dutch government, which depicts usage patterns and geolocation of SMS messages sent in Amsterdam during the New Year's Eve of 2007. In the visualization, each point represents an SMS sending. The pace of SMS usage between day and night is clearly visible, as is the sudden increase in the number of messages sent at midnight on December 31.

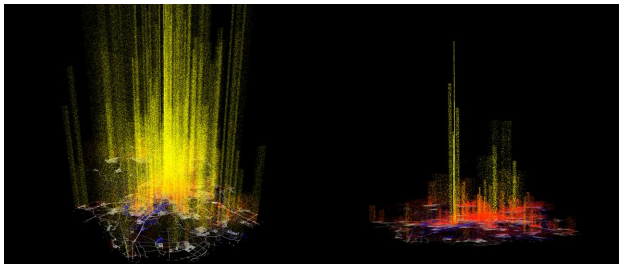

Figure 3. Visualization of mobile SMS activity during the New Year's Eve of the year 2007 in the city of Amsterdam, The Netherlands. Source: (aaronkoblin.com)

Urban spaces, smart cities and culture

Zygmunt Bauman [12] uses the concept of entropy - the universal tendency of isolated systems to pass from more to a less organized state - as an analogy to explain the complex system of relations present in culture. According to him, culture has anti-entropic capabilities, that is, it tends to organize the systems within a more or less predictable structure. This concept seems very useful to explain how culture is articulated within the phenomenon of smart cities. In essence, the goal of a smart city is to generate useful information from a large amount of data generated by cities.

The data generated by the traffic of vehicles in the city show patterns of temporal and spatial displacement related to the spatial movement of the inhabitants of a certain region. Such information, far beyond simple flow or traffic control, together with other kinds of data, can tell us much about the cultural life of a particular location. Beyond information, data can also bring narratives about how people interact with cities.

In commenting on the constitutive complexity of cities, Manuel Lima [13] says that "Cities happen to be problems in organized complexity, like the life sciences. They present situations where a half-dozen or even several dozen quantities are all varying simultaneously and in subtly interconnected ways". When comparing cities with natural sciences, the author seeks to highlight the complex network of relationships that aim to organize interests, with all their contradictions and idiosyncrasies, in the constitution of cities.

Hollands [8] says that the mere use of ICTs in a city does not make them "smart". In order for the desired transformation of cities into intelligent, sustainable and connected organizations to take place satisfactorily, the city must be understood as an ever-changing organism; a highly complex network with a large number of variables [13]. Culture is undoubtedly an important variable to indicate the quality of life in a city. Cranshaw et al. [14] say that cultural perceptions shape and limit the texture and character of the local urban life.

An example of using technology and data available in urban spaces for cultural purposes is the SelfieSãoPaulo project (Figure 4). Carried out in 2014, at the SP Urban Digital Festival, by Moritz Stefaner, Jay Chow and Lev Manovich using the visual patterns of about 20,000 selfies shared with the Instagram application in a 5 square kilometers range in the central region of São Paulo. The visual result was presented in a large LED panel located on the facade of the FIESP building on Avenida Paulista. Selfies were presented sequentially using three types of animations that viewed data overlapping the photos with an estimate of the age, genre and smile level.

Such kinds of projects raise a number of questions about the use of communication technologies by city dwellers. Pop et al. [15] say that this project reminds us that our participation in online activities, eg. share an image on Instagram, becomes sources of behavior and cognitive data that are used for commercial and surveillance purposes. The cultural and artistic use of the available technological structure in cities serve, in addition to their immediate purposes, as vectors for a broad reflection on the impact of these technologies on the cultural life of cities.

[1] http://citydashboard.org/london/
[2] http://www.dublindashboard.ie/

Figure 4. Selfies displayed on the facade of FIESP with information on the level of smile, age and gender. Source: (manovich.net)

Conclusion

Information visualizations have been used since the 19th century as a strategic resource in the analyses of urban phenomena. At the beginning of the 20th century, the first concepts of smart cities emerged as the materialization in urban spaces of the rapid development of computer processing capacity and Information and Communications Technologies (ICTs). Cities are becoming intelligent not only in terms of using ICTs in the automation of city functions but also as a way to efficiently monitor, understand, analyze and plan the quality of life of its inhabitants in real time. Indeed, these changes are also reflected in cultural and artistic manifestations in cities.

With the rapid technical advancement in connectivity and the popularization of what used to be hard-to-reach hardware, like computers with great processing and graphic power, artists and researchers are increasingly interested in visualizing data generated in urban contexts as a way of investigating, commenting and proposing artistic reflections on the impact of such technologies on our routine and private lives in cities. Shannon Mattern [16] says we need interfaces that make us engage critically in the ocean of date generated by our cities. In this sense, we believe that information visualizations have much to contribute to widening our perception about the city when it proposes visual metaphors to critically perceive aspects that are not evident in our daily routine.

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