Chapter 20
Visualization of Big Data Sets Using Computer Graphics

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ABSTRACT

This chapter discusses some possible ways of how professionals, researchers and users representing various knowledge domains are collecting and visualizing big data sets. First it describes communication through senses as a basis for visualization techniques, computational solutions for enhancing senses and ways of enhancing senses by technology. The next part discusses ideas behind visualization of data sets and ponders what is and what not visualization is. Further discussion relates to data visualization through art as visual solutions of science and mathematics related problems, documentation objects and events, and a testimony to thoughts, knowledge and meaning. Learning and teaching through data visualization is the concluding theme of the chapter. Edoardo L'Astorina provides visual analysis of best practices in visualization: An overlay of Google Maps that showed all the arrival times - in real time - of all the buses in your area based on your location and visual representation of all the Tweets in the world about TfL (Transport for London) tube lines to predict disruptions.

INTRODUCTION

Data is often described by sets of numbers. However, exchange of data and information often goes through visual and other perceptual forms, which one can look upon as:

- **Two-Dimensional:** Drawings, Art works, graphs, infographics or typographic prints
- **Three-Dimensional Forms:** Architectural or sculptural
- **Four-Dimensional Time-Based Media:** Moving images
- **Interactive and Virtual Techniques**

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Visualization is a form of visual communication of information and knowledge. Communication may refer to the ancient (such as the quipu used in the Inca Empire, a system of knotted cords as a recording of numbers) (Ascher & Ascher, 1980, 1997) as well as contemporary (such as coding) ways of presenting data. Before the advent of computing communication have taken various forms with the use of senses. Codes used for communication often took visual forms. They may include nonverbal counting of numeral patterns (Gordon, 2004; Frank, Everett, Fedorenko, & Gibson, 2008). Actually, we often avoid using exact verbal number words when we say, some, less, a few, several, many, numerous, or a couple. A string of beads for keeping count in practicing devotion with a rosary, a calculating tool abacus, strings of worry beads komboloi used in Greece and other countries, and Hindu prayer beads can be seen as examples of numerical cognition processed without verbalizing.

Howard Gardner considered the perception of recurrent patterns, including numerical patterns to be the core of logical mathematical intelligence (Gardner, 1983/2011; 2006). For Rudolph Arnheim perceptual sensitivity to visual order of shapes seen as patterned forces may underlie our existence (Arnheim, 1969/2004, 1988, 1990). This notion may somehow correspond to the way computer scientists talk about the codes in terms of patterns. Programming languages such as HTML or Processing may also be seen as the information and communication tools, which draw from the numeral perception and serve for nonverbal communication between individuals and computers as well as for HCI. In contrast with the Arabic decimal system used today almost everywhere, the Mayans counted with fingers and toes creating a vigesimal system based on groups of twenty units (Maya Mathematical System, 2016). One may wonder whether the covering of toes with shoes might influence the developing of counting systems by limiting possibility to use this counting tool to ten. The same message can be conveyed and received in many ways: visually with the semaphore flags (signals made with hand-held flags, rods, disks, paddles or just hands), sonically (e.g., short versus long sounds), or through the international Morse code distress signal (· · · — — — · · ·).

Communication may be here seen as an exchange of sensory information in the form of different kinds of perception through the senses. Signals coming from the senses are often combined to convey a clear message. For example, we can receive information about numbers from various senses looking at patterns, listening to sounds, feeling vibrations or reading numbers.

The purpose of this chapter is to discuss a number of potential ways of using our senses to present data sets through visualization. This chapter is structured as follows: the next section describes ways we communicate, perceive the world and communicate using many senses. Perhaps, describing senses in separate groups may be seen improper because senses are interconnected in many ways. Senses used in data set visualizations especially delivered as interactive installations may involve several faculties acting in concert: hearing (including pitch or loudness referred to changes in data under inspection), touch and pressure receptors (when data quantities change product qualities such as its hardness), smell (especially in chemical processes' description), temperature (for example, in exothermic reactions controlled by its component agents), all allowing witnessing changes in specific data amount and its qualitative alterations. Sensory data presentations of these kinds are useful in both industrial and personal applications of information related to various production processes. The following section describes ways of presenting data with the use of our senses including ideas behind the visualization techniques and delineates several possible approaches to data visualization through art. Finally, the chapter concludes by discussing learning and teaching through data visualization.