USING VISUALS TO CONVEY INFORMATION

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Abstract: This paper summarizes the literature on visualisation and information visualisation and provides a broad view of available systems and techniques. The paper also argues that the use of visuals can help conveying information, and that can be an advantage to the use of visualisation and information visualisation to support information management.

1 INTRODUCTION

As stated by Hamming, "The purpose of computing is insight, not numbers" (Hamming, 1962). Using visual representations of data to provide information is a well-established field. Abstract displays of information (such as graphs and plots) are a recent invention (around 1750-1800) (Tufte, 1983).

As considered by Card and others, visualisation is the use of computer-based, interactive visual representations of data to amplify cognition (Card et al., 1999). Wood and others assert that visualisation is a collaborative activity and propose the existence of a Computer Supported Collaborative Visualisation (CSCV) field (Wood et al., 1997).

Jern discusses the existence of a third-generation GUI paradigm: the Visual User Interface (VUI). The same author presents a number of characteristics that a VUI must have (Jern, 1997):

- picture-centric user interface;
- direct interaction – exploration and navigation;
- graphical object selection and data probing;
- close connection to data;
- object-oriented focused graphics;
- control of geometry resolution;
- direct engagement of the user.

Vision is the highest bandwidth human sense (Uselton, 1995). Humans are good at scanning, recognising, and recalling images. Visualisation takes advantage of human perceptual abilities (Johnson-Laird, 1993). If we consider the dictionary definition of the word "visual", we obtain several definitions relating to information gained through the human eye. However, an alternative dictionary definition suggests the conveyance of a mental image. If we now look at the dictionary definition of "visualisation", we see in one case that visualisation is "the power to process and forming a mental picture or vision of something not actually present to the sight". These definitions allow us to consider that a visualisation can result from input to any combination of the human senses, which is not restricted to "visible" images.

Visualisation can be seen as a process with six steps. The enumeration of the proposed steps is adapted from Uselton (Uselton, 1995). Uselton states that Visualisation extends the graphics paradigm by expanding the possible input. In particular, data analysis is a process of reducing large amounts of information to short summaries while remaining accurate in the description of the total data (Yu, 1995).

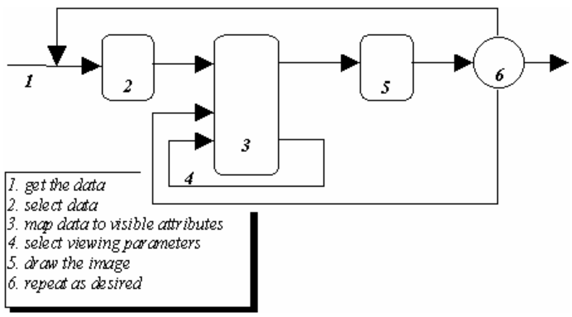

Figure 1: The visualisation process

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One particular graphical application use is in statistics. Yu proposes a framework for understanding graphics based on the idea of balancing summary with raw data, and analyses ten different visualisation methods for multivariate data (Yu, 1995). The author concludes that the use of colour in statistical graphics has long been neglected but this tends to change due to the availability of better hardware, changing the type of graphics that can be created and used. He also proposes the process of visualisation as an adjustment of noise and smooth (blocking understanding or facilitating it).

An extension of graphics is the concept of interactive displays of information. The Interactive Graphical Methods are defined as the class of techniques for exploring data that allow the user to manipulate a graphical representation of the data (Eick and Wills, 1995). The interactive graphics are also referred to as direct manipulation graphics or dynamic graphics.

Eick and Wills list a number of areas in which interactivity significantly improves static displays, such as: clarity; robustness; power; and possibility (Eick and Wills, 1995). The purpose of an interactive graphical display is to use graphical elements to encode the data in such a way as to make patterns apparent and invite exploration and understanding of the data by manipulating its appearance. Both Tufte (Tufte, 1997), and Eick and Wills present a general discussion of interactive graphics.

Making good visualisations requires consideration of characteristics of the user and the purpose of the visualisation. Knowledge about human perception and graphic design is also relevant (Uselton, 1995). According to Eick and Wills a good display must include the following three characteristics (Eick and Wills, 1995):

1. it should be obvious as to what is being displayed;
2. it should focus attention on the data;
3. it should indicate scale and location of the data

Cleveland gives an ordering of the difficulty of decoding visual cues, starting with the easiest ones: position along a common scale; position along identical, non-aligned scales; length; angle; area; volume; colour hue; colour saturation; and density (Cleveland, 1985).

In the DARPA's Intelligent Collaboration & Visualisation (IC&V) program, aimed at enhancing collaboration between teams through distributed information systems, one of the specified key challenges is to develop team-based visualisation software for sharing views, and in particular, visualising abstract spaces (IC&V, 1997). DARPA describes research challenges in mapping real objects to data about them; methods for augmenting real spaces with superimposed information that adds value, and the more difficult problems of developing techniques to support visualisation of abstract N-dimensional spaces, where there is a need to develop methods for representing abstract information spaces and for navigating such spaces (IC&V, 1997). Turner and others described a 4D symbology (3D symbols plus time-dependence) for battlefield visualisation where data come from real-time sensors and from simulations and are positioned in a high-fidelity 3D terrain (Turner et al., 1996).

2 INFORMATION VISUALISATION

Andrews defines Information Visualisation as the visual presentation of information spaces and structures to facilitate their rapid assimilation and understanding (Andrews, 1997). In the same document, the author provides details of a collection of Information Visualisation related Web resources. Young reports on three-dimensional Information Visualisation (Young, 1996). This report provides an enumeration of visualisation techniques and a survey of research visualisation systems.

McCormick and DeFanti define Information Visualisation as the transformation of the symbolic into the geometric (McCornick and DeFanti, 1987). Bertin proposes Information Visualisation as an augmentation to intelligence in helping find the artificial memory that best supports our natural means of perception (Bertin, 1967). The main goals of Information Visualisation are related to aiding the human in analysis, explanation, decision-making, exploration, communication, and reasoning about information (Card et al., 1999).

Visualisation offers a support structure (such as spatial or graphical representations), for pattern finding, change detection, or visual cues to help reasoning about large datasets and multiple and heterogeneous information sources. These factors are also reasons for the need to develop cognition artefacts that use information visualisation techniques (Norman, 1998). More specifically, it is possible to summarise that visualisation should make large datasets coherent and present huge amounts of information compactly; present information from various viewpoints; present information at various levels of detail (from the more general overviews to fine structure); support visual comparisons; make visible the data gaps; and tell stories about the data (Hearst, 1998).

Three main perspectives can be considered for visualise information in 3D (Buscher et al., 1999):

- using the properties of information objects and defining rules for their distribution in space – VIBE (Olsen et al., 1993), BEAD (Chalmers and Chitson, 1992) and Q-PIT (Colebourne, 1996);
- visualisations of hypermerdia-link based systems – (Card et al., 1991);
- human-centred tools, allowing people to structure and display information in electronic spaces – (Benford et al., 1997).

An example of an information visualisation system is the Populated Information Terrains (PIT). The PIT concept aims to provide a useful database or information system visualisation by taking key ideas from CSCW, VR and database technology. A PIT is defined as a virtual data space that may be inhabited by multiple users. One particular characteristic is that users work co-operatively within data (Benford and Mariani, 1994). Moreover, VR-VIBE was designed to support the co-operative browsing and filtering of large document stores (Benford et al., 1995).

Computers facilitate access to large datasets, interaction, animation, range of scales, precision, elimination of tedious work, and new methods of display (Hearst, 1998).

An overview of graphical visualisation is made by Ware, where the main issues with visualisation techniques are listed as: space; time; stability; and navigation, based on the hierarchy notion (Ware, 2000). A paper collection presenting an overview of classical visualisation techniques (pan and zoom, multiple windows, and map view strategy), and focus+context techniques (fish-eye, hyperbolic browser, cone-trees, intelligent zoom, treemaps, and magic lens) is given by Card and others (Card et al., 1999). Beaudoin and others introduce a novel approach – Cheops –, and a discussion of strengths and limitations of focus+context techniques (to which the Cheops approach belongs) (Beaudoin et al., 1996).

One of the application areas for Information Visualisation is Scientific Visualisation, where applied computational science methods produce output that could not be used without visualisation. This happens because huge amounts of produced data require the high bandwidth of the human visual system (both its speed and sophisticated pattern recognition), and interactivity adds the power (Uselton, 1995). Visualisation systems provide a single context for all the activities involved from debugging the simulations, to exploring the data, and communicating the results.

Other information visualisation application area is the Software Visualisation, defined as the use of “the crafts of typography, graphic design, animation, and cinematography with modern human-computer interaction technology to facilitate both the human understanding and effective use of computer software” (Price et al., 1994). By computer software, Price, Baecker, and Small intend to include all the software design process from planning to implementation. These authors present taxonomy for systems involved in the visualisation of computer software.

Chen discusses the use of information visualisation and virtual environments, presenting the StarWalker virtual environment (Chen, 1999). For research opportunities, Uselton points out, among others, the need for new interaction tools and techniques; new mappings of data to visual attributes; new kinds of visuals, and automatic selection of data or mappings (Uselton, 1995). Hearst reports that a lot of the new information visualisation methods have not been evaluated (Hearst, 1998).

3 FINAL REMARKS

Information management has been recognized as a fundamental activity by large organizations, including some governments. In the US, the federal administration pioneered the management of information resources in the 70s, and gives high priority to information management in general. Not incidentally, these organizations show a level of readiness for doing electronic business that other information-unaware organizations lack.

Since the 80s, some authors have proposed frameworks for information management, and for its integration with information systems and technology management. Some of the proposals were inspired in Library and Information Science views, some in the Database and Systems design views. M. Earl, at the London Business School, proposed the information triangle, and defined the three management activities, with clear roles and responsibilities (Earl, 1988):

- Information Systems strategy: is demand driven, has a business emphasis, can be considered as doing business with IT; basically answers the “what” we need question;
- Information Technology strategy: is offer driven, has a technology emphasis, can be considered as doing IT with business; basically answers the “how” we do it question;

- Information Management strategy: is management driven, has a management emphasis, can be considered as doing IT and business; basically answers the “who” does it question;

As a result, such activities can be seen as highly dependent from human understanding. For such issues regarding information management, both visualization and information visualization can become an important tool to support the individual and its relation with information within organisations.

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