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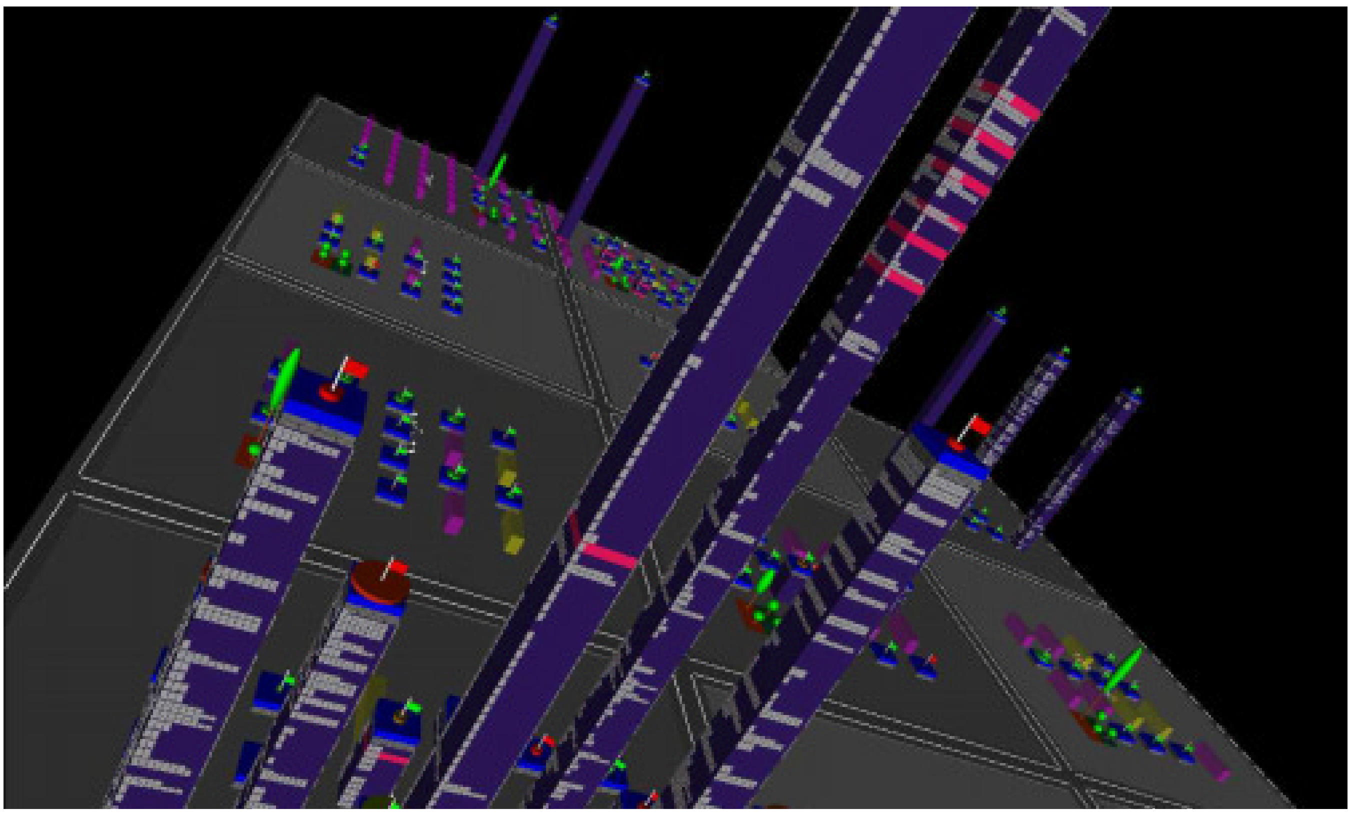
Visualizing Data Sets Issue 1 of 2



Multiple Views in 3D Metaphoric Information Visualiztion
C. Russo Dos Santos and P. Gros

formerly YLEM newsletter

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From the Editors
Anna Ursyn and Ebad Banissi

Visualizing Data Sets

The following materials consist of a thematic selection from the International Conference “Information Visualisation” IV-2002 and an the accompanying “Symposium and Online Gallery of Digital Art, IV-Dart,” London, England.
Information about current events can be found at:
http://www.graphicslink.demon.co.uk/IV03/.
http://www.graphicslink.demon.co.uk/IV03/GALLERY.htm.
Deadlines for the IV 2004 and IV-Dart 2004 and information how to submit papers and artwork will be posted at:
http://www.graphicslink.demon.co.uk/IV04/.
http://www.graphicslink.demon.co.uk/IV04/GALLERY.htm.
Conference papers and information can be found in the Proceedings, Sixth International Conference on Information Visualisation, Los Alamitos, CA: IEEE Computer Society, ISBN 0-7695-1656-4. Materials from previous IV Conferences, established and organized by Dr. Ebad Banissi and Programme & Organizing Committees in 1997, can be found in earlier Proceedings.

The leading theme of this series of articles is the progress in developing techniques for visualizing multidimensional data sets. As we can read in this issue, the analysis of Web server logs is a hot topic nowadays particularly because of the e-business explosion. Exploring large amounts of complex information on the web with the use of search engines means that we have to scroll through many results displayed in a single window and load multiple pages. From the Jonathan Roberts, Nadia Boukhelifa, and Peter Rodgers’ paper we can learn that there are currently over 2.5 billion pages available and this number is increasing by 7.3 million pages per day. The articles describe how traditional representations are replaced by visual exploratory techniques that go beyond charts and graphs, encourage the user interaction and the use of different tools and applications, especially in the area of web-search result visualization.

Issue # 1 contains articles about the Semantic web: the use of visualizations providing metaphors for web navigation and communication. For example, since people are familiar with the general concept of a parking lot or a skyscraper, this type of environment is being used to create associations for large web data organization. Data are structured toward metaphorical representation of a building. Floors, rooms, elevators, or corridors are being used as visual interpretations of subsets of a data set. Thus by imaginative tour of a skyscraper, one may create associations and connotations about each subset and its relationship to the whole set of data and its links. In this concept the same information can be looked at from various angles and the presence of the user has an impact on the future ways of personalized navigations and understanding the network topology and the hierarchy of the web site.

We are offering five exciting papers in this issue.

Cristina Russo Dos Santos and P. Gros describe 3D metaphoric information visualization. Their web server logs visualization tools represent the actual hierarchy of the web site – directories and pages. The network topology visualization tool developed by their group uses beautiful metaphors, creating geographic, temporal, or site views in the form of a “financial” district with tall buildings, a “residential” district with low houses, a world map, a landscape, a conetree, a solar system, a library, or a pyramid. One single visualization is not sufficient for grasping large volumes of information. Multiple views for the visualization of abstract information via metaphoric representations allow the user to explore large amounts of complex data sets more easily and rapidly. Multiple visualization requires implementing visualization tools ranging from network topology visualization, to file systems visualization, or to web server data analysis.

Nigel Robinson and Mary Shapcott describe Data Mining as the exploration and analysis of large amounts of complex information in order to recognize patterns or rules and build models which allow for making predictions about the domain. The proposed Virtual Environment as a Data Mining interface metaphor uses a filter flow model of ‘liquid’ data. The authors design the Virtual Data Mining application interface based on metaphoric visualization depicted as a ‘processing plant’ which ‘refines’ raw data into information.

Yasuhiko Saito presents three art works based on an information visualization technique for financial analysis. The visualization technique for analyzing the information has been applied as a tool for generating artistic images.

Andreas Loizides and M. Slater demonstrate a technique for holistic visualization of multidimensional data sets. In particular they consider a data set that resulted from a Virtual Reality (VR) experiment on social anxiety. With the EVA algorithm, they automatically map semantically important features of the data as emotionally or perceptually significant visuals (such as a human face). In other words a single glance at the face informs the observer of the global state of the data, since this visual structure has an emotional impact on the observer. In this example, the results for anxious people in the experiment were ultimately visualized by faces that looked anxious.

R. Brian Stone tells about the need for training the designers and design educators in the visual interface design enabling the interaction of the screen-based communication and entertainment devices. Understanding and teaching visual interface design for interactive multimedia experiences, such as CD-ROM-based learning tools, web sites, kiosks, and other information retrieval systems, require an integrative approach involving human-computer interaction, cognitive psychology, industrial design activity, and visual literacy. The author supplies several student designs from his “Interactive Visual Communication and Interface Design” course.

YLEM Forum: "Filmmakers Who Transgress the Boundaries"
Wednesday, November 12, 7:30 PM
McBean Theater, The Exploratorium
3601 Lyon St., San Francisco, CA 94123

Four filmmakers will show us the possibilities they have discovered for creating alternative cinematic experiences. Listen to how Lynn Marie Kirby probes the boundaries between time-based mediums. Hear how Ken Paul Rosenthal explores the presence and impermanence of human gesture in urban space and the natural world. Learn about hand-crafted ship-in-a-bottles re-figured as 16mm film-loop devices with Thad Povey and explore the relation between the document and the documented, fiction and fact, empathy and irony with Jeanne C. Finley.

P R O G R A M:
"When the Expectations of the Narrative Collides with its Form" by Jeanne C. Finley. Jeanne C. Finley is an artist /filmmaker who works with photography, video and media installation. Her work ranges from experimental to documentary forms. Finley's videotapes have been broadcast in the United States, Europe, Canada and Japan and her media work has been exhibited in festivals and museums throughout the world including the Museum of Modern Art in New York, the 1993 and 1995 Whitney Biennial, the George Pompidou Center, the Amsterdam Documentary Festival and the San Francisco Film Festival. She has been the recipient of several grants including a Guggenheim Fellowship, Cal Arts/Alpert Award, National Endowment for the Arts Fellowships and the Phelan Award in Video.

"Rhythms and the Architecture of Time" by Lynn Marie Kirby, For more than twenty-five years, San Francisco-based artist Lynn Marie Kirby has been locating her personal voice, and probing the boundaries, between virtually every time-based medium. Kirby has created a body of work that includes film, video, performance, installation and sound art. Kirby invests in all of her work a vibrant willingness to push the limits of each medium, and has maintained a remarkable sensitivity to new potentials for expression. An over-arching concern through all of her work is a fascination with the rhythms and architecture of time, exposing the openings, glitches and gaps between events and time or as she thinks of her recent work, with "time dilations."

"Ship-in-a-bottle re-figured as 16mm film-loop devices" by Thad Povey. Thad Povey works in film, both found, exposed, and made from scratch, as a means to explore the peculiarities of the human animal. He is recipient of a Phelan Award for California-born filmmakers and the founder of "The Scratch Film Junkies." As an installation artist, Povey is building a series of pieces based on the idea of hand-crafted ship-in-a-bottles re-figured as 16mm film-loop devices. "Wrapped Around The Screw" traps a Navy fleet in four whiskey bottles and "Escape Velocity" dangles an Apollo lift-off over the viewer's head. The pieces have been installed at The Exploratorium, The Ann Arbor Film Festival, and The Portland Documentary and Experimental Film Festival.

"The Presence and Impermanence of Human Gesture" by Ken Paul Rosenthal Ken Paul Rosenthal's films employ alternative photochemical and bacterial processes, re-photography and multiple projection set-ups to explore the presence and impermanence of human gesture in urban space and the natural world as reflected in the ephemeral nature of Creative Process and the moving image. He currently teaches at the Academy of Art College in San Francisco.

NOTE: At the Exploratorium follow the YLEM FORUM signs, enter by the side door.
FREE, open to the public, wheelchair accessible

Contact: Trudy Reagan, 650-856-9593, trudy.myrrh@stanfordalumni.org
Complete information listed at http://www.ylem.org/flash/forum/calendar.html
or http://www.ylem.org/text/forum/calendar.html for modem users.

From Hip Hop To Soulsville, Strippers To Stuntwomen…
19th Annual Film Arts Festival Of Independent Cinema
New Indie Films By Bay Area Filmmakers
October 30 – November 2 In San Francisco

The Film Arts Festival of Independent Cinema opens Thursday, October 30 and runs through Sunday, November 2 at the Roxie Cinema, 3117 16th Street; and at the Castro Theatre, 429 Castro Street in San Francisco. With more than 30 new films and videos by Bay Area artists, the Festival showcases the vision, passion and diversity of truly homegrown independent filmmaking.

This year's Festival features an exciting and inspiring mix of movies including a special Closing Night sneak preview of Amanda Micheli's new feature documentary DOUBLE DARE, a rollicking look at the daredevil Hollywood stuntwomen who doubled for Xena and Wonder Woman, Zoe Bell and Jeannie Epper. DOUBLE DARE screens Sunday, November 2 at 9PM at the Castro Theatre. At 7PM on November 2nd, the Festival presents the West Coast premiere of Adam Ballachey's AMERICAN DANCER, an intimate, darkly comedic portrait of a group of straight male strippers. Other Festival offerings include beautifully-crafted short films like 6 POSSIBILITIES, a modern dance film in spectacular 35mm, and cutting edge digital videos like the director's cut of SOUNDZ OF SPIRIT by Joslyn Rose–Lyons, a riveting exploration of the creative and spiritual power of hip-hop culture. SOUNDZ OF SPIRIT screens November 2 at 1PM at the Castro, along with special guest performances by local hip-hop poets and musicians. The festival will also include hard-hitting political documentaries like WAITING TO INHALE by Jed Riffe (Thursday, October 30 at the Roxie Theater, 7PM), a searing critique of the politics of medical marijuana. This year's Film Arts Festival also showcases dramatic short narratives by up-and-coming young di-

continued page 4

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rectors, experimental films by award-winning media artists, and the premiere of a collection of zany animated cartoons featuring space-age girlfriends PIKI AND POKO, the "Eternal Martial Arts Astrology Warriors from Another World." PIKI AND POKO screens on Sunday, November 2 at 11AM at the Castro Theatre.

Don't miss a special Halloween night commemorative screening of Curt McDowell's THUNDERCRACK, the rarely screened, underground sex epic, circa 1975. It's full of thunderbolts, spooky tree branches, an old mansion and more sex than you can shake your stick at. THUNDERCRACK screens on Friday, October 31 at 11PM at the Roxie Cinema.

The 19th Film Arts Festival of Independent Cinema brings local indie filmmakers together with artists from many disciplines to celebrate the renegade and abundant spirit of creative expression in the Bay Area. This year, look out for special performances by local musicians, dancers and spoken word artists at nearly every screening. Since 1976 Film Arts Foundation has served as supporter, educator, cheerleader, consultant, and community to thousands of independent filmmakers and enthusiasts. The comprehensive programs and services support all levels of filmmakers through every stage of production. Over the years, the Film Arts Festival of Independent Cinema has supported some of the best of Bay Areamade cinema, including THE WEATHER UNDERGROUND by Sam Green and Bill Siegel, HEART OF THE SEA by Charlotte Lagarde and Lisa Denker, Deborah Hoffman and Frances Reid's LONG NIGHT'S JOURNEY INTO DAY, STRAIGHT OUTTA HUNTERS POINT by Kevin Epps, Lourdes Portillo's SEÑORITA EXTRAVIADA, Jay Rosenblatt's HUMAN REMAINS and Arthur Dong's FAMILY FUNDAMENTALS, among hundreds of others.

The 19th Annual Film Arts Festival reflects the richness, passion and diversity of Bay Area filmmaking, the intelligence and probing spirit of local directors, and the incredible depth and breadth of Bay Area film art. This year's festival is packed with passionate, entertaining, dramatic and courageous work from one of the most dynamic independent film communities in the country.

Multiple Views in 3D Metaphoric Information Visualization

C. Russo Dos Santos and P. Gros
Eurécom Institute, 2229, Route des Crêtes, Sophia Antipolis, France. {russo,gros}@eurecom.fr

Abstract

Challenges regarding how we visualize information are being posed not only by the sheer quantity of data and the limited space for visualizing it, but also by the diversity of tasks the user wants to perform. The user then needs different visualizations, eventually simultaneously, to accomplish different goals.

Multiple visualizations allow the user to explore large amounts of complex information more easily and rapidly. We believe that one of the strengths of 3D metaphoric information visualization will emerge from the combined use of several interacting tools, each potentially depicting different views of the information.

This abstract presents work done on using multiple views for the visualization of abstract information via metaphoric representations. We use the concept of 'service' to define the data set to be visualized and 'visual metaphors' to depict the abstract information. We have developed several visualization tools that use three-dimensional metaphoric worlds to depict the information. Each visualization tool uses different visual metaphors according to the data set to be visualized and the user's task, thus providing multiple views of the information.

1. NFS visualization

We have developed a visualization tool to represent information regarding the Network File System (NFS) service. This service is characterized by an enormous amount of data. We have developed several views for the NFS service: one to visualize all the data set and other views that display only a subset of the NFS data. These other views, representing a reduced amount of data, allow for the emphasis to be put on the relevant data under scrutiny for that particular visualization. Furthermore, the visualization of smaller subsets reduces the risk of overwhelming the user with a large volume of complex data, some of it not relevant for the particular task in question.

For the NFS service visualization tool we have used a city metaphor. This metaphor revealed itself an appropriate choice due to the large number of mapping parameters available to map the NFS data, which has a high dimensionality. In the city metaphor, information is visualized using the structure of a real world city. In our implementation there are districts, residential blocks with low height houses and also financial blocks with tall office-resembling buildings. There are also roads and trees.

The metaphor is quite easy to grasp as the hierarchical relations are evident from their real world counterparts: cities contain districts, that contain blocks, that contain houses and buildings, and so on. The visual effect is quite impressive and provides lots of different elements and visual parameters to map information on.

1.1 Overview

Figure 1 (Fig. 1a is on the cover) shows two views for the whole data set describing the NFS service. This general overview allows for immediate knowledge regarding the NFS service. For instance, the user can easily identify servers and clients. A computer is mapped on a district and each disk is represented by a building; additionally, each client mounting that disk is a floor on the building. On the other hand, each imported disk is mapped on a house. In this way, "financial" districts, i.e., districts with tall buildings, identify unambiguously servers (Figure 1.a). Mutatis mutandis, "residential" districts, i.e., districts with low houses, clearly identify the clients (Figure 1.b). This is a powerful visual perception immediately evident upon first inspection.

1.2 Disk size view

Figure 2.a depicts a visualization of information regarding the NFS service. The data represented is a subset of the data repre-

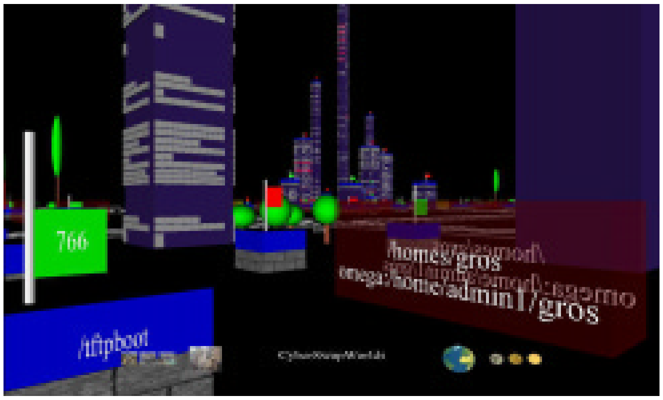


Figure 2a NFS visualization using a city metaphor.

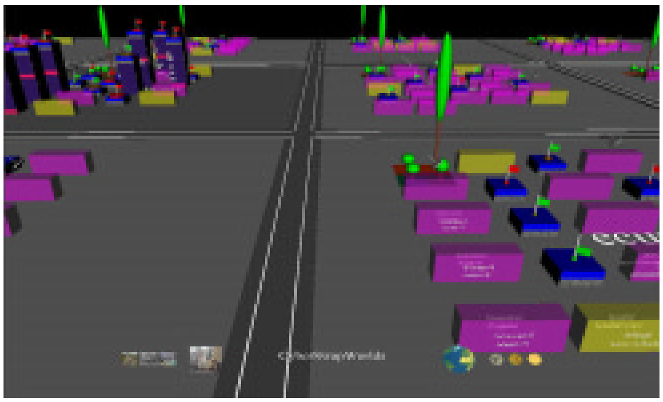


Figure 1b NFS visualization using a city metaphor.

sented in Figure 1. The emphasis is put on the size of the disks and on identifying disks that are system's partitions. In view of the foregoing, the size of the disks is mapped to the height of the buildings. For the houses representing the imported disks, the color hue maps whether the disk is a system disk or not. The user can thus easily identify large disks and which of their imported disks are non-system disks.

1.3 Disk status view

The data displayed in this view is a subset of the NFS set. The focus is on disk status: the number of users mounting the

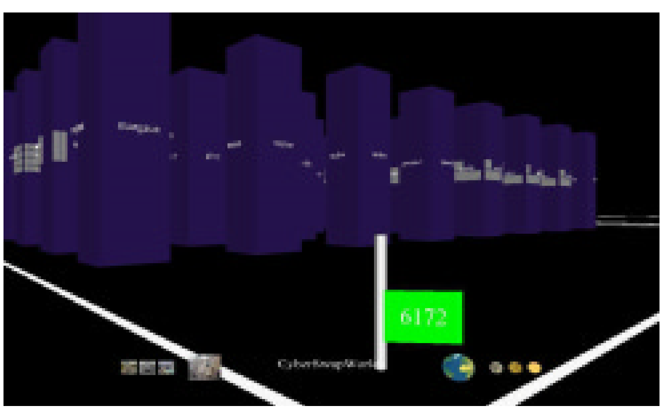


Figure 2b NFS visualization using a city metaphor.

disk and the number of open filehandles they have. The information regarding the users and the filehandles is immediately perceived as uncluttered by other non-relevant data. Figure 2.b shows a visualization of this information. In this view, each disk is represented by a district (square), and each client mounting that disk is represented by a building. The number of open filehandles is mapped on the number of windows present in each building.

2 Network data visualization

Regarding network data we have developed different visualization tools, each focusing on different aspects of the network, and using different visual metaphors. In the next sections we will give examples for the visualization of network topology, workstation data, and file systems information.

2.1 Network topology

We have developed a network topology visualization tool for depicting the topology of a computer's network. Due to the strong hierarchical characteristic of the network topology service and the fact that the number of different entities to be visualized was relatively small, the conetree metaphor was a manifest choice. This metaphor is generally associated with displaying hierarchical information due to the immediate visible hierarchy appearance. However, the number of different visual parameters available for mapping information is quite limited.

A conetree metaphor is thus used to display the network topology and some additional information regarding the network's performance, as is depicted in Figure 3.a. The hubs are cones with a blue box at the top and the switches are visualized as red boxes. The machines connected to a given hub are represented as spheres placed at the base of the corresponding cone. The connections between the different elements -- switches, hubs, and machines -- are depicted as cylinders. Additional data is mapped on the cylinders: the radius corresponds to the transmission bit-rate of the connection and the color saturation to the packets' loss rate. The hub's rate of lost packets is mapped on the color saturation of the cone.

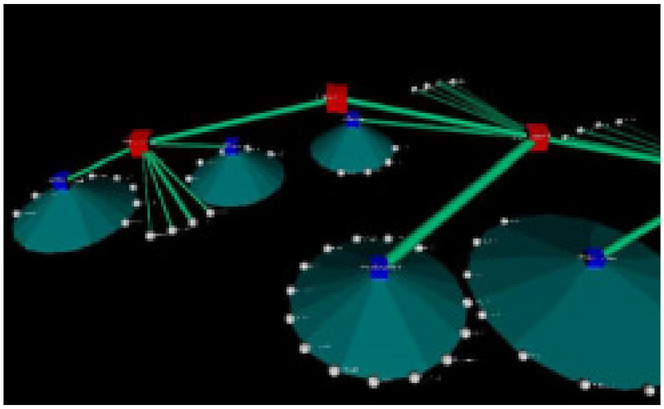
2.2 Workstation data

Figure 3.b shows information regarding networked workstations. The metaphor used is a solar system metaphor. The solar system metaphor, in our current implementation, is fairly simple. It uses stars, planets, and satellites to map information. The structure is given by the orbits of the various elements. The hierarchical organization is provided by the different orbital relationships: planets are attached to a star and satellites are attached to a planet.

In Figure 3.b workstations are depicted as stars (cubes) with planets, representing users, orbiting around. The users are mapped on spheres – color hue corresponds to the Unix group, size to memory usage, and color saturation to CPU time. Between the workstation and the users, satellites represent user processes that are mapped as cylinders. The mapping on the cylinders' visual parameters is coherent with that of the spheres: size maps memory and color saturation maps CPU time.

2.3 File system data

In order to visualize the contents of large file systems we have developed a file systems visualization tool. The visual metaphor that revealed itself more adequate to display large volumes of hierarchical information, as is the case with file systems, is the pyramid metaphor. Like the conetree, the pyra-



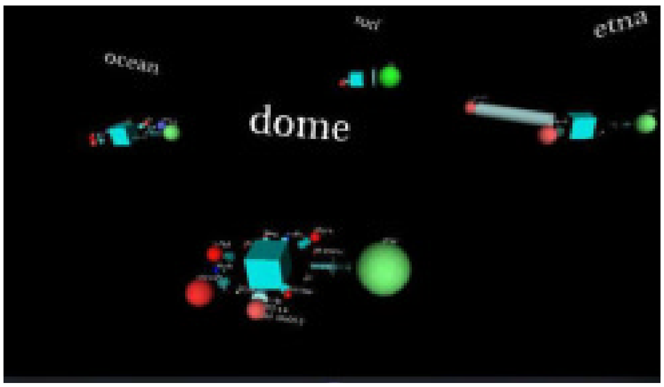


Figure 3a and b. Network data visualization using different visual metaphors.

mid metaphor is also recursive. It uses the concept of nested pyramids to display information. It is also usually associated with the visualization of large hierarchies of information.

Conceptually, the pyramid metaphor is similar to the conetree metaphor, using a hierarchy of pyramids instead of cones. Also the number of different elements and visual parameters it provides for information mapping is quite similar to the conetree metaphor. However, we feel that for very large hierarchies, the pyramid metaphor has a better performance than the conetree metaphor: the visual clutter is reduced in the former.

Multiple views have been developed to be able to exploit (visualize) the file system according to different parameters. Essentially, the file system's structure is always encoded in the same manner -- hierarchically with nested pyramids -- and the data under scrutiny is color coded (color hue). The color hue can thus encode the file type, the file owner, the file date, or the file security details, for instance. Figure 3.c shows an example of color hue encoding the file type.

3 Web server data visualization

The analysis of Web server logs is a hot topic nowadays particularly because of the e-business explosion. Our objective was to design a Web server logs visualization tool that uses 3D technology to present the information to the user. The information is displayed in different 3D metaphoric worlds, customized according to the needs (e.g., temporal, geographic representation), or the target audience (e.g., web master, sales personnel).

The implementation is fairly simple at present. There are three data types that we visualize: the number of hits, the traf-

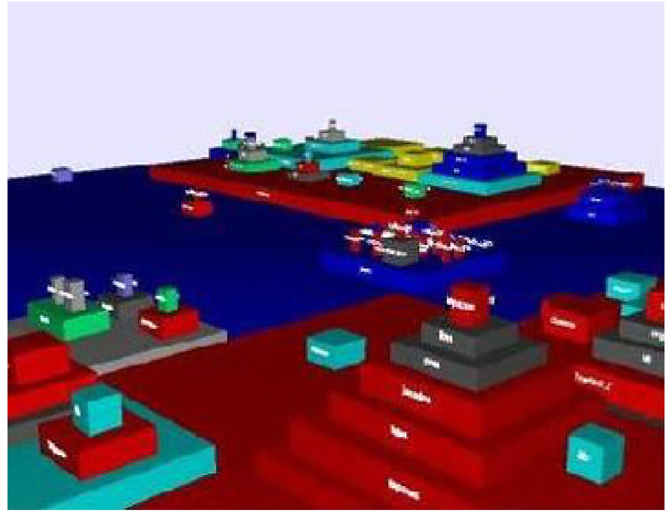


Figure 3c Network data visualization using different visual metaphors.

fic generated, and the number of hosts. This information is represented in three different views: geographic view, temporal view, and site view. Both the data and the view are selected from a selector interface.

3.1 Geographic view

The geographical diagram allows the user to situate and compare data from a geographic perspective. The metaphor used is a landscape metaphor. The information is placed in a virtual landscape, usually using the shape of a vertical bar or 3D spike.

In the geographic view (Figure 4.a) we have used an information landscape employing a world map to encode position. Details-on-demand are available by selection. Although there is basically only one element (the vertical bar) to map information on, this metaphor is interesting because position can be effectively used to encode information -- the position on the world map encodes country information.

3.2 Temporal view

The temporal view allows the user to compare data in a temporal manner. This view uses a library metaphor to display

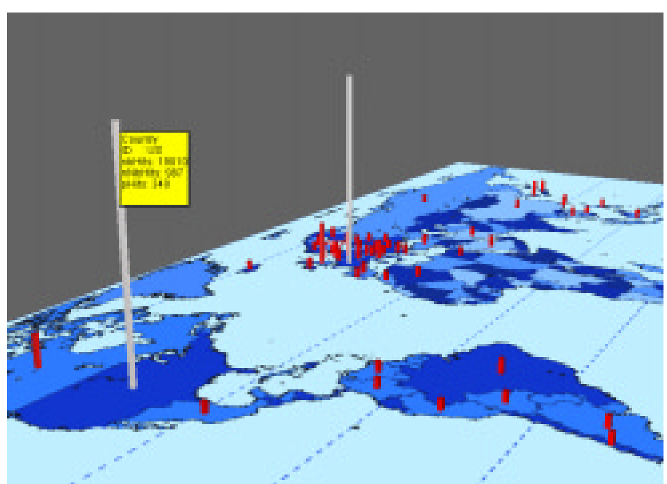


Figure 4a Web server logs visualization tool using different metaphors.

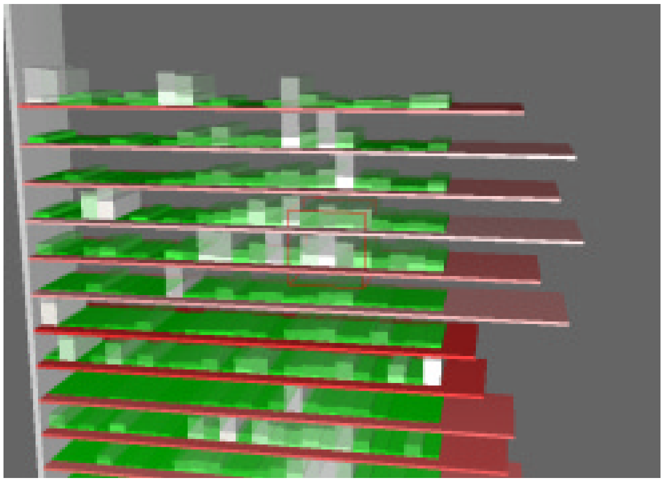


Figure 4b. Web server logs visualization tool using different metaphors.

the temporal data. The data is represented in a library containing several bookshelves; each bookshelf is subdivided into shelves upholding series of books.

There are three levels of segmentation: bookshelves, shelves and books -- where data is sorted respectively by week, by day, and by hour. The hierarchical structure is provided by the fact that bookshelves contain shelves and shelves contain books. Figure 4.b depicts the temporal view for the web server logs visualization tool.

3.3 Site view

The site view is a representation of the actual hierarchy of the web site -- directories and pages. This view allows for visualizing the most popular pages, for instance, or the files that are more frequently downloaded.

Figure 4.c shows an example of the site view. Again, as in the case of the file system visualization (Figure 3.c), the metaphor used to represent the hierarchical organization of the web site is a pyramid metaphor. The structure of the web site is mapped on the structure of the pyramid and the actual information regarding, for instance, the popularity of the pages, is color mapped.

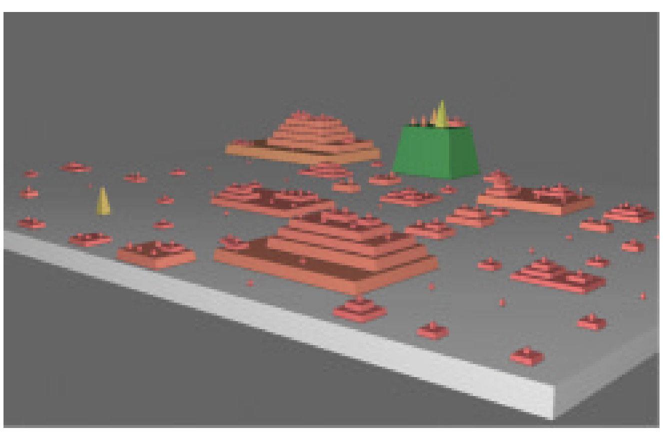


Figure 4c Web server logs visualization tool using different metaphors.

4 Conclusions

Multiple views per se are not a guarantee of a useful visualization tool. Their usage must be justified and they must bring some added value to the tool. The added value priority is to ease the user's task -- this entails a better user visual perception and comprehension of the data displayed.

In this abstract we present some of our work on multiple views, illustrated by examples taken from the visualization tools that we have implemented. In the examples that we gave, we tried to always present the motivation behind each different view. The multiple views have been validated in a number of different tools for different applications, ranging from network topology visualization, to file systems visualization, or to web server data analysis.

Data Mining Information Visualisation - Beyond Charts and Graphs

Nigel Robinson, Faculty of Informatics, University of Ulster Jordanstown
nigel.robinson@uk.thalesgroup.com
Mary Shapcott, Faculty of Informatics, University of Ulster Jordanstown. cm.shapcott@ulst.ac.uk

1. Introduction

Data Mining (or Knowledge Discovery in Databases) is defined as 'the exploration and analysis by automatic or semi-automatic means of large quantities of data in order to discover meaningful patterns or rules' [1]. In effect, Data Mining exploits the abundant supply of data accumulated in the day-to-day functioning of a domain in order to build models which can subsequently be utilised to make predictions about the domain. The use of mined information can improve business processes or identify new business opportunities, for example, assessing client risk when giving a bank loan.

2. Failure of Data Mining Applications in Mainstream IT.

Data Mining, having been a research field for some ten years, is now moving to application in mainstream information technology with in excess of one hundred commercial Data Mining software (Siftware) products in the market place.

Despite the general interest in Data Mining and the potential returns of a successful Data Mining strategy, Commercial Siftware products have not made a significant impact in the marketplace. In 1998, of the seventy companies producing Siftware, all but one or two were estimated to be losing money based on their Data Mining software alone [2].

There is a consensus of opinion, even among Siftware vendors, that Data Mining software have not reached sufficient maturity to be in general use. It is still influenced by academia with the focus being on the underlying algorithms. User considerations are secondary with many applications being a thin layer on the core technology [3] [4].

3. Data Mining HCI Challenges.

It can be argued that the failure of Data Mining applications can be traced to poor Human Computer Interaction (HCI) design which results in application interfaces which are difficult to use as commercial products.

In the hypothesis testing approach to Data Mining there are essentially six main phases [5]. The first involves identifying business problems and postulating potential solutions (generating hypotheses). The second phase is the extraction of the data set for mining from the source database. This is followed by data pre-processing, i.e. dealing with missing values or noisy data. In the fourth phase the required model is constucted using the data, this is then analysed against the hypotheses. Finally the model is actioned i.e. domain processes are reviewed based on the mined information.

Applications designed around the core Data Mining technology (e.g. a neural network) often focus only on the model building phase. It has been argued convincingly that the core algorithm should be as little as ten percent of the overall application [6]. Unless an application can support the user throughout the whole process it may fail.

The common definitions of Data Mining imply an automatic, machine-driven process. Consequently product designers attempt to automate the process. However, while the application of the algorithms may be automated, the other phases certainly imply a requirement for user involvement [7] and the addition of domain knowledge, e.g., assessing how to act on the information must be a man – rather than a machine – task.

If Data Mining is to incorporate domain knowledge, then application design must be more user (Data Miner) centred than function centred. The users with the pre-requisite domain knowledge obviously must come from within the domain where the Data Mining is being applied. Producing a Data Mining application for a target user population of domain based Data Miners presents a number of HCI challenges.

These stem from the fact that target users have no experience of the task domain (Data Mining) or knowledge of Data Mining tools. As with all interfaces, the user needs to be provided with a model of the application operation, however, the model cannot be based directly on elements of the task domain. Leaving the tool totally ‘Black Box’ precludes the Data Miner from being able to explain the logic behind the model. The problem is paradoxical in nature, the inner workings of the Data Mining tool must be made transparent to the user while at the same time an adequate model of how the tool derives results must be provided.

4. Addressing the Data Mining HCI Challenges

Improved visualisation facilities has been suggested as the means to address the Data Mining HCI issues but currently visualisations are reasonably conventional 2D or 3D charts embedded within a conventional Windows GUI [8],[9]. Visualisation, in the main, presents output at the end of the process. The failure of Data Mining applications suggests that current utilisation of visualisation is not the complete solution to the Data Mining HCI challenges. Could it also be the case that the employment of conventional charts within a Windows style GUI constrains the mental models of tool operation for the user? It is proposed that the Data Mining HCI challenges can be addressed with a more imaginative approach to interface design, an approach which takes advantage of modern graphics technology and goes beyond charts and graphs.

Extending visualisation to all phases of the process may provide context for the output in terms of a model of how it was derived. Ideally the boundaries between application interface and visualisation would be transparent.

Today’s game players are immersed in unfamiliar virtual environments often based on fantasy rather than reality. The players rapidly become familiar with these environments. Could such an approach work for domain based Data Miners placed in the unfamiliar surroundings of the Data Mining task domain?

Schneiderman [10] argues not, since application users sre too focused on their task. This may be true, say, when typing a letter on a word processor, but Data Mining is very much an exploratory process without the same clearly defined task start and end points.

Researchers in other fields employ metaphor-based virtual environments to provide interface models which make complex underlying functionality suitably accessible to users. Kahn’s ToonTalk uses an animated environment to map abstract programming concepts to concrete metaphors. Programs are constructed in what is essentially a video game [11]. Hutzler employs a Virtual Environment based on a garden metaphor for visualisation of complex systems. The evolution of the garden over time reflects changes in the underlying system [12].

5. Data Mining Interface Research

Research in progress is investigating the suitability of a metaphor-based Virtual Environment as a Data Mining interface through an appropriate implementation and subsequent experimental evaluation. The core metaphor for the interface design, inspired by Schneiderman’s filter flow model [10] is that of ‘liquid’ data. The proposed Virtual Environment is a ‘processing plant’ which ‘refines’ raw data into information. The domain database will be presented as a series of interconnected data storage tanks, which is effectively a visualisation of the database relations and the relational schema. The data set for mining is conventionally extracted through the execution of SQL queries. Access to this functionality is provided via ‘filter stations’ set in the interconnecting pipes. Inside a filter station are a number of tools which can be used to construct the necessary filter combinations needed to isolate the required data set. The filter combination illustrated in Figure 1 is derived almost directly from the Schneiderman concept with parallel pipes/filters for the OR component of a query and sequential filters for the AND component. Alternative filter station concepts are also being explored.

The pipe network from the source database connects to a data set tank into which ‘flows,’ the data set to be mined. Associated metaphors for pre-processing include a ‘fill level’ setting which allows a sample to be extracted from a large data set. Data with missing values could lie at different levels in the tanks from ‘clean data,’ affording the user the opportunity to drain off noisy or incomplete data.

Figure 1 Filter Combination (Humidity = Low OR Temperature = HIGH) AND (Outlook = Rain)

The underlying Data Mining tool for the application is an ID classification (decision tree) algorithm [13]. The constructed decision tree is presented as a series of filter stations (the deci-

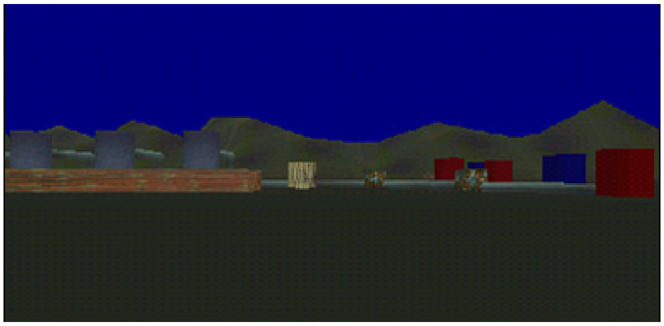


Figure 2 - Decision Tree as Tanks and Filter Stations

sion nodes) and data tanks (the leaf nodes) which contain the (ideally) 'pure' classified data, i.e., all the data 'in the tank' has the same value as the classification attribute (Figure 2).

The key feature to note is that the result visualisation is based on the same metaphor as the interface used in the earlier phases of the process. The user should be familiar with the visualisation of the output and its meaning as it is constructed in the context of the tools used initially to extract the source data set.

At a detailed level, the Data Miner could explore the internals various filter stations in the tree and at overview level the tree visualisation can be further enhanced by colour coding the leaf node data tanks and similarly coding the data flowing. The 'purity' of the data as it flows through each filter can be determined by observing how close it is to the colour coding of a classifier attribute. This may assist the Data Miner in pruning the tree and identifying attributes which significantly influence the classification.

6. Conclusion

A literature survey indicated that there is a significant challenge in making Data Mining accessible to Data Miners across a wide range of domains. While visualization has been suggested as a solution, the current employment of visualizations does not appear to be satisfactory. It is proposed that visualization has to go beyond charts and graphs and become an integral part of the interface in a manner consistent with the metaphor framework around which the interface has been designed.

It is proposed that a Virtual Data Mining Environment based on 'liquid' data which can be filtered and purified, could provide a suitable Data Mining application interface. Such an interface is currently under construction. While it may yet prove difficult to expand this environment to all data sets, benchmarking the usability of this environment against more conventional approaches would give an indication as to the correctness of the proposal.

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Using a Visualization Technique for Financial Analysis to Produce Artworks

Yasuhiko Saito

1. Introduction

I have produced a series of artworks using an information visualization technique for financial analysis. Some media artists use visualization techniques as tools for generating fantastic images. For these artists, the generated images are more important than the information from which the images are generated. On the contrary, the visualization technique used in my works is closely related to the information visualized in the works. These works, therefore, require the audience to understand the technique and to analyze the information visualized in the works. This note explains the visualization technique used in my works and presents three examples of works based on the technique.

2. A Technique for Visualizing Financial Data

In order to analyze financial data, I have developed a technique for visualizing outlines and features of a series of frequency distributions using portfolio textures. A portfolio texture represents a frequency distribution as a texture composed of numerous colored dots.

A frequency distribution is defined as a mapping f:CAT->FREQ, where CAT is a set of categories and FREQ is a set of frequencies. A frequency distribution can be represented as a pie chart. Each sector of the pie chart is colored. A color mapping is defined as h:CAT->HUE, where CAT is a set of catego-

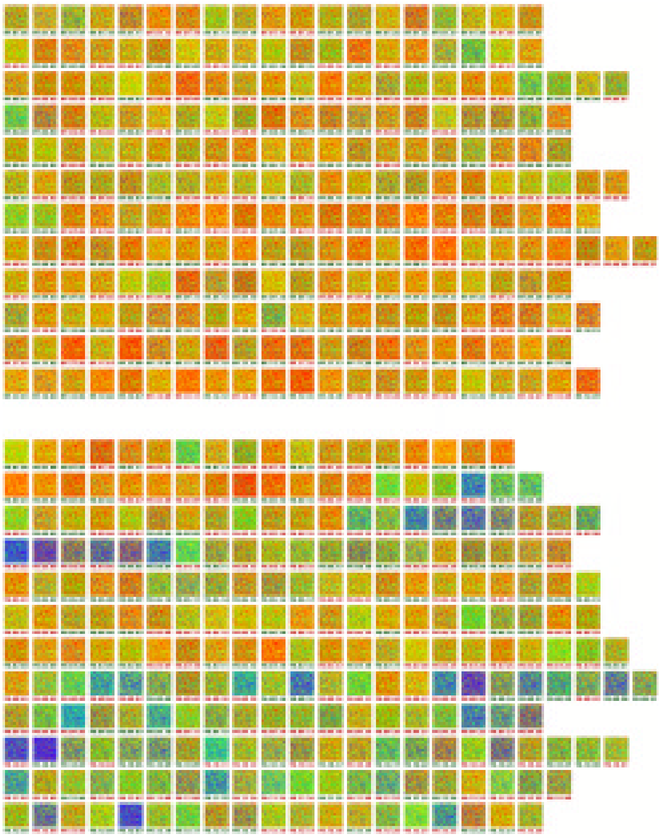

Figure 1

ries and HUE is a set of hues. Let h(C) be the hue of a sector corresponding to C, where C is a member of CAT.

Given a frequency distribution and a color mapping, a portfolio texture is generated as follows:

(1) A pie chart representing the frequency distribution is drawn using the color mapping.

(2) The pie chart is decomposed into numerous dots.

(3) These dots are mixed so that they are arranged on a plane randomly and densely.

A portfolio texture is defined as a rectangle area clipped from the plane on which the colored dots are arranged.

When we visualize a stock portfolio using a portfolio texture, it is necessary to prepare the following frequency distribution. Let p(T,S) be the price of a stock S included in the portfolio, where T indicates a trading day. Let r(T,S) be the price change rate of S. That is, r(T,S) is computed as $r(T,S)=|p(T,S)-p(T-1,S)|/p(T-1,S)$. We define CAT={0, 0.001, 0.002, ..., 0.065}. Each member of CAT is a price change rate. The maximum rate is 0.065. If the price change rate of a stock is greater than 0.065, it is regarded as 0.065. Let f(T,C) be the frequency of C in CAT. That is, $f(T,C)=n$, if $|\{S|r(T,S)=C\}|=n$.

For each C in CAT, $h(C)=4000C$. Thus, we obtain HUE={0, 4, 8, ..., 260}. Each member of HUE is a level on a color scale. Key colors on the scale are arranged as red<orange<yellow<green<blue<indigo<violet.

The portfolio texture indicates whether the portfolio is stable or not. If the texture contains more red, orange and yellow dots than green and blue dots, the portfolio is stable. This is because the stable portfolio includes many stocks of which price change rates are small. In contrast, if the texture contains more green and blue dots, the portfolio is unstable. This is be-

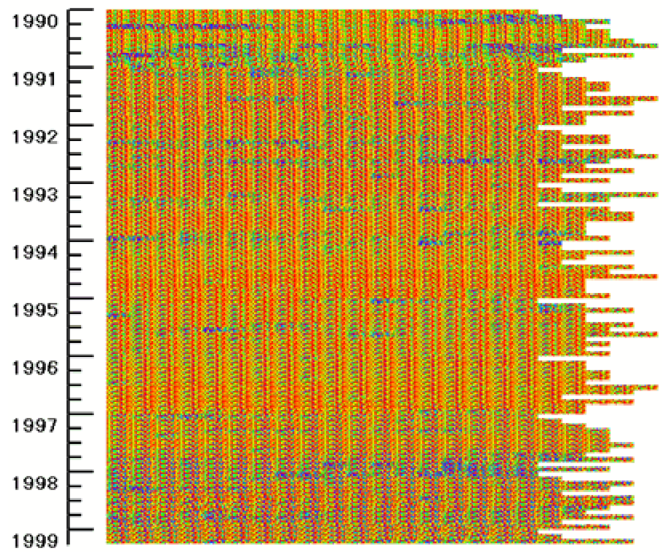

Figure 2

cause the unstable portfolio includes many stocks of which price change rates are large.

3. Examples of Artworks based on Portfolio Textures

In my artworks based on portfolio textures, I try to visualize dry financial data gracefully. In order to predict stock prices, investors draw various kinds of charts day by day. However, these charts are not graceful. If investors draw graceful charts, they can cover economic losses by aesthetic profits.

The work shown in Figure 1 consists of many portfolio textures, each of which is generated from stock price data of 23 Japanese automobile companies. The textures arranged in the upper part are generated from the data in 1989 and the textures arranged in the lower part are generated from the data in 1990. In 1989, most of textures contain more red, orange and yellow dots than green and blue dots. As a result, these warm textures make us feel comfortable. In 1990, however, we can find a number of cool textures containing more green and blue dots.

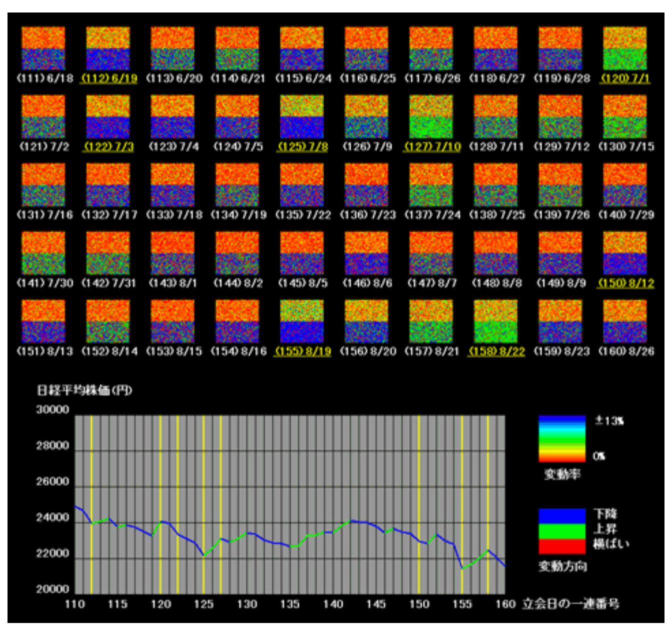

Figure 3

The difference between 1989 and 1990 implies a turn of the tide in the Japanese stock market. This work reminds us that the Japanese stock market bubble burst at the beginning of 1990.

The work shown in Figure 2 includes a large number of portfolio textures, each of which is generated from stock price data of about 2,500 Japanese companies. In this work, each texture is very small and there is no space around each texture. As a result, this work looks like a tapestry of an abstract painting.

The work shown in Figure 3 is a snapshot of a screen of the system for stock price analysis. Using this system, we can predict the trends of the Nikkei average, which is a major stock price index in Japan. In this system, we deal with two kinds of distributions derived from stock price data of about 2,500 Japanese companies. One is the distribution based on absolute values of the daily price change rates and the other is the distribution based on directions of the daily price changes. The former is visualized using portfolio textures explained in the previous section. The latter is visualized using portfolio textures, but there are only two categories, namely, price up and price down. Each square in the upper part of this work consists of two portfolio textures generated from these two kinds of distributions. The line graph below the squares represents the fluctuations of the Nikkei average. In order to predict the trends of the Nikkei average, analysts are required to discover relationships between the transitions of the portfolio textures and the line graph.

4. Summary

Useful visualization techniques allow engineers or analysts to produce artworks. Three artworks based on an information visualization technique have been presented. The technique used in the presented works is not only a tool for generating images. Since the technique is closely related to the information visualized in the works, the audience needs to understand the technique and then to analyze the information.

The Empathic Visualisation Algorithm (EVA) and its Application on Real Data

A. Loizides and M.Slater
Department of Computer Science, University College London (UCL), London, UK

Abstract

We demonstrate a technique for visualising multidimensional data sets holistically, and discuss an application in real data gathered from a Virtual Reality (VR) experiment. The EVA algorithm provides an automatic mapping from semantically important features of the data to emotionally or perceptually significant features of a corresponding visual structure (such as a face). In other words a single glance at the visual structure informs the observer of the global state of the data, since the visual structure has an emotional impact on the observer. The visualisation is designed to correspond to the impact that would have been generated had the observer been able to access the relevant semantics of the underlying data.

1. Introduction

The Empathic Visualisation Algorithm (EVA) [2],[4] is a fundamental extension of the type of multidimensional data visualisation [6],[8] first introduced by Chernoff 5. His idea capitalises on the fact that humans are hardwired to understand facial expressions and therefore can very quickly and efficiently interpret information encoded into facial features. More specifically, it is very easy to cluster the schematic faces, produced by Chernoff, into groups that represent similarities in the underlying data they originate from. Given an n £ k data matrix of n observations on k variables, the original Chernoff method mapped each variable to a particular facial feature such as shape of the nose, or shape of the eyes. The mapping from data to visual structure was arbitrary, and the resulting face had no correspondence to the underlying semantics of the data. Such faces are good for understanding patterns, but any individual face seen in isolation does not readily convey anything about the data without knowledge of the specific mapping used. The EVA algorithm provides an automatic mapping from semantically important features of the data to emotionally or perceptually significant features of the corresponding visual structure (such as a face). In other words, a single glance at the visual structure informs the observer of the global state of the data, since the visual structure has an emotional impact on the observer that is designed to correspond to the impact that would have been generated had the observer been able to analyse the underlying data itself. Finer details concerning interpretation of the visual structure are then available through knowledge of the relationships between semantically important features of the data and emotionally significant aspects of the visual structure.

The pictures of faces shown in Figures 1 and 2 represent the emotions of subjects giving talks to certain conditions in a Virtual Reality (VR) experiment [9],[10] that explored Fear of Public Speaking (FOPS). Prior to and during the experiment, data were gathered based on questionnaire and physical (e.g. heart rate) responses. The subjects were distinguished as phobic/confident and whether they gave their VR talk to an empty audience or to an audience of virtual people.

Here, it was of interest to us to see the difference in responses phobic and confident speakers have to both audience conditions. In particular, a large difference is expected in fear (anxiety) for phobic users giving talks to a virtual audience rather than an empty room, whereas the difference in fear for confident users should be relatively small with regards to the same two conditions. In general, it is also expected that the phobic users are more anxious than the confident ones, regardless of the condition the speech is given. In fact, by just looking at the results produced by EVA, it is easy to see that all our expectations described above are realised.

The top faces of Figure 1 represent confident users. Figure 2 shows more examples of faces produced by EVA giving their talk to an empty room whereas the bottom represent confident users giving their talk to a virtual audience.

On the other hand, the top faces of Figure 2 represent phobic users giving a talk to an empty room whereas the bottom represent phobic users giving a talk to a virtual audience. But how do we produce these faces that express holistically the emotions of the users when giving their talk? How does the mapping from multidimensional data sets (13 variables in this case) into human facial expressions occur? This is what EVA does as described below.

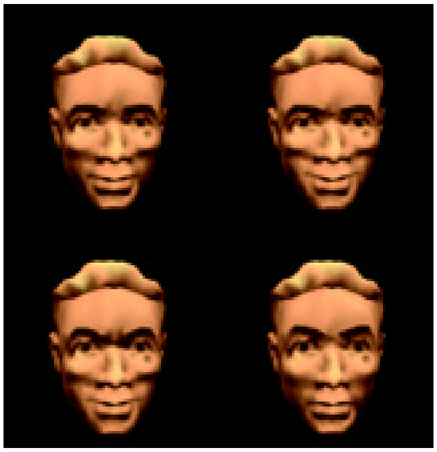

Figure 1. Examples of faces produced by EVA and FOPS experiment data.

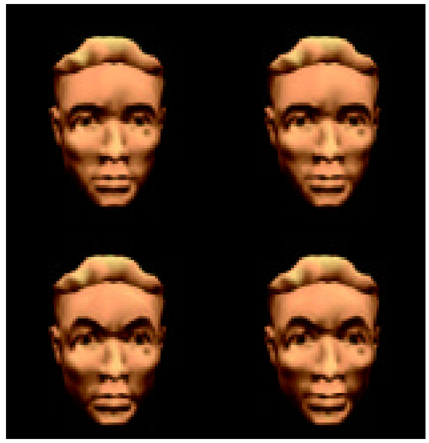

Figure 2. More examples of faces produced by EVA.

2. Method

Let's assume that we are considering the representation of multivariate data in an nxk data matrix X, consisting of n cases (people giving talks) on k quantifiable variables (data gathered from questionnaires and somatic responses, e.g. Personal Response of Confidence as a Speaker, heart rate etc.). Within the overall objective, which is to construct a visualisation – such as the salient features of the data can intuitively be recognised by an observer and representation gives an overall view of the data set – there are further objectives: The visual structure is naturalistic; something encountered in everyday life, something that does not require special knowledge for interpretation by a normal human observer. Hence the use of human faces. The mapping is automatic; such that semantically important features in the data are mapped to perceptually or emotionally important features of the visual structure. We call this kind of mapping a Visual Homomorphism. There are a number of global characteristics that can be used to describe the emotional expressions of a face, such as its degree of anxiety, sadness, anger etc. There are also a number of features of a face, such as muscle tensions, that have been used in the Park and Waters model [7] to determine the overall facial expression.

Correspondingly, there are a number of global characteristics that are of importance to the consumer of the data. In our FOPS experiment these are:

Somatic. This is the subjects own assessment of somatic responses during their talk (such as heart rate).

Modified Report of Confidence as a Speaker (MPRCS). This is a modification of a standard questionnaire that measures the degree of confidence of users after giving the talk.

Somatic x MPRCS. A combination of the measurements above to allow for an interactive effect between the responses above.

These global characteristics of the data correspond to the global characteristics of the visual structure. A somatic and MPRCS response of phobic subjects results in an anxious, sad and angry face. Finally, features of the data that is particular combinations of the variables determine the features of the visual structure, the muscle contractions. Therefore one set of them (in our case 18, one for each muscle used in our model) produces a single face. But, how do we choose these feature functions?

The overall method used is called Genetic Program (GP). Sets of 18 feature functions get generated. Applying each set into every row of the data produces n faces, one for each row. We can then measure (quantify) each face 3 for its emotional expressions. For example a face can be 75% anxious, 52% sad and 30% angry. On the other hand, each row in the data et has the corresponding quantifiable measurements for the characteristics of interest in the data set (Somatic, MPRCS, Somatic x MPRCS). Therefore by using a simple sum of square distances over all rows, error measure technique, we measure the fitness of an individual set of features functions. This fitness is used to determine probability of selection. Now we consider how to select these sets of feature functions.

2.1. Genetic Programming (GP)

We use a GP to select the set of features functions. Initially, a first generation of sets of feature functions is generated as random functions over the data variables. Next generations use probabilities based on fitness, to determine survival and hence selection for reproduction and mating. The same procedure is repeated for each new generation. The greater the fitness (of a set of feature functions) the greater the match between the global characteristics of the data and the characteristics of the visual structure (facial expressions). Figure 3, shows an overview of EVA.

3. Conclusions

We have introduced a method for constructing an automatic mapping from data to human faces, which enforces a homomorphism between important characteristics of the data and the emotional or perceptual impact of the visual structure. The type of visual structures (faces) produced by the method are informative 'at a glance', and can also reveal important detailed information. EVA is put forward as a method that provides a 'first-pass' visualisation that may, in particular applications, raise interesting features than can then be explored by more traditional (quantitative) visualisation techniques or indeed statistical analysis.

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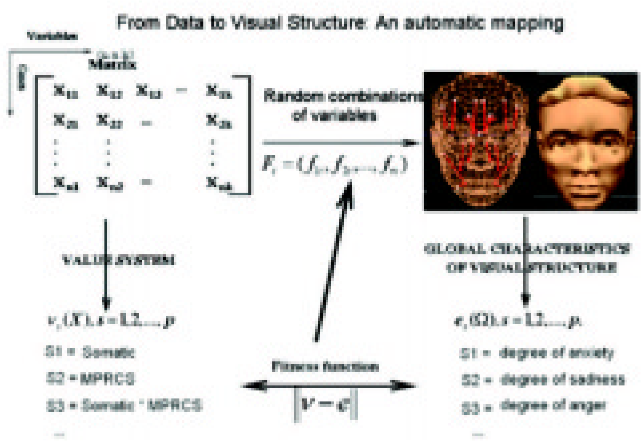

Figure 3. Overview of the method.

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Designing Visual Interfaces for Advanced Multimedia Functionality: A Convergence of Our Collective Expertise

R. Brian Stone, Assistant Professor
The Ohio State University

The field of design is going through a transformation. With the growing complexity and increased use of screen-based communication and entertainment devices, a key consideration for the designer is enabling the interaction of these devices. Designers enable this interaction and affect an experience through the interfaces they design. The way we use a product is as important as what that product can do, or what it looks like, thus the issue of what an object means or causes one to do with it has moved to the foreground [1].

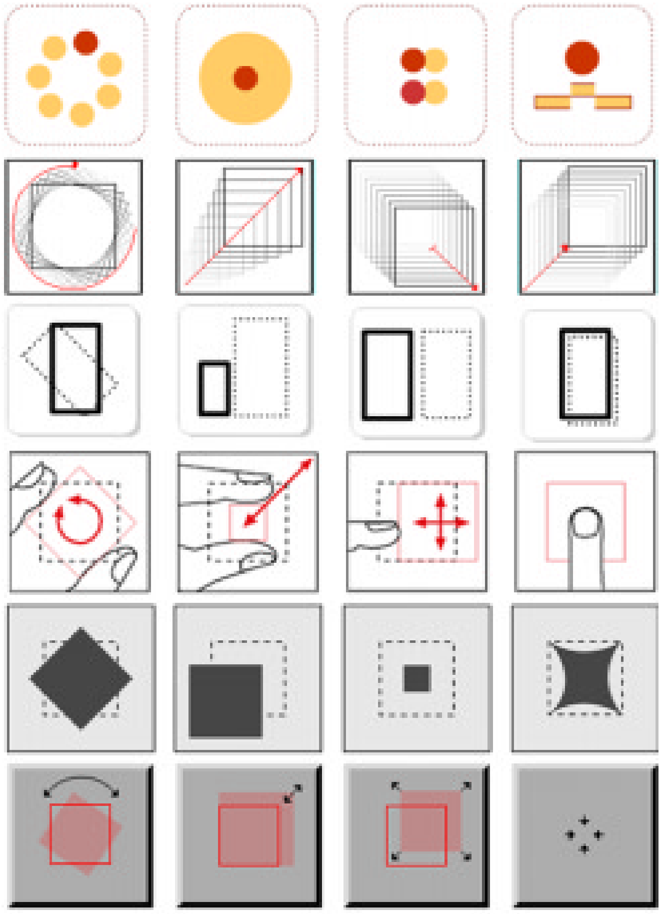
Screen-based interface design is the foundation of the activity of humans interacting with computer and communication systems. As the application of screen-based communication develops, designers and design educators involved in screen-based media must recognize the need for fundamental training in interface design, human-computer interaction, cognitive psychology, and visual literacy. To address the exponential growth of screen-based functionality, a primary concern for the multimedia designer is the broadening of an interface and interaction palette. Broadening this palette will empower multimedia designers to deliver interfaces that support user objectives and perceived functionality interpretations. By addressing the blurring of boundaries between the digital and physical interfaces of products, multimedia designers can yield interactive multimedia experiences that are more meaningful, allowing users to visualize and navigate a personal path to information.

As the body of knowledge and breadth of applications continue to expand for the visual communication and multimedia designer, how do we appropriately integrate the instruction of screen-based interface design for advanced multimedia functionality into current visual communication design curriculum? Our approach has been to apply appropriate structure, guidance, and principles from our companion disciplines. An examination of the relationships between cognitive psychology, human computer interaction, and industrial design activity has proven useful in structuring a process for understanding and teaching visual interface design for interactive multimedia experiences such as CD-ROM-based learning tools, web sites, kiosks, and other information retrieval systems. Several relevant concepts have been realized through an examination of the areas that define and distinguish visual interface design.

By gaining an understanding of these concepts, and then applying them at appropriate levels of the design process, multimedia designers can begin to yield visual interfaces that truly meet or exceed the expectations of users. In teaching interactive multimedia, our theoretical approach is based upon an exploration of the relationships between these interdisciplinary activities.

The similarities in design process between industrial and visual communication design have aided in structuring a means for understanding and teaching interactive multimedia and screen-based interface design. We embrace the syntactical ideas of physical product interfaces and tactile feedback, and translate these affordances and concepts into a visual screen-based solution. The disciplines of human computer interaction (HCI) and cognitive psychology have been integrated into our teaching in the Department of Design at The Ohio State University. It has afforded our design students a better understanding of how users interact with computer and communication systems from an HCI and cognitive psychology standpoint. Based on ergonomics, human factors, and cognitive psychology among others, HCI creates models and principles of performance to analyze user behavior while interacting with computer and communication system screens. These models and principles can help designers and design students better understand, predict, and even calculate human performance relevant to interaction with computer systems via screen-based visual interfaces. This is complemented with studies in cognitive psychology, which give us a clear picture of how users learn and perceive. By appropriately applying cognitive psychology models, multimedia designers will be better prepared to develop more efficient and meaningful interactive systems.

If screen-based interfaces are to achieve an effective func-



Figures 1 - 6. Student work: a family of interfaces supporting the actions of rotate, scale, drag, and push

tional result, the visual representation must attract the user's attention, enhance their emotional responses and evoke interaction. The visual language, or representation, must also be developed in a manner that users can encode the meaning of the interface, so that its function can be predictably interpreted. Visual communication designers through informed creativity, research, and design process are well equipped to deliver the visual manifestation of a multimedia interface.

By applying the previously-stated concepts in an advanced course setting, a variety of visual interface concepts worthy of discussion were developed. Student designers developed the following studies as a precursor to the development of a fully functional interactive multimedia program focused on the objective of teaching and learning. This intermediate stage forces the student to think specifically about the interaction and function their interfaces suggest. The objective was to develop a family of interfaces supporting the actions of rotate, scale, drag, and push (shown in figures 1-6). Interfaces were constrained to a square configuration, using pictorial images only. Although these interface studies are not placed in an actual context, it does challenge the student to integrate the previously discussed concepts in an effort to move beyond the overused, linear 'next' button.

The visual manifestations of these conceptual studies are intended to promote interaction and support specific tasks. Students are encouraged to consider interface semantics, feedback, and appropriate representation as a part of their design process. An overall thread is the establishment of clear boundaries, visual unity and a consistent display format. By establishing consistency over the different controls, some principles are recognized from one control to the other. This visual language standardization makes the interaction understandable, thus navigation is easier and more efficient as it circumvents additional learning time from one control to the other.

After reflecting on lessons from the interface studies, student designers then progress to the development of an interactive multimedia program. These programs are focused on the objective of teaching and learning. Each multimedia program in some way challenges current conventions in linear, static educational processes. They intend to use the medium as a means to 'explain.' These highly engaging programs incorporating semantic typography, sound, video, simulations and animation, offer multiple but logical paths of navigation. Student designers explore how complex information systems can be made more approachable and accessible by engaging the user through interactivity, with the intent of enhancing the experience of learning.

As educators, designers, and authors, we are all trying to fully understand the nature of visual interface design for interactive multimedia. A range of disciplines are defining where its strengths lie, its appropriate application, and how best to integrate it into design education curriculum. It appears that we have many different skill sets trying to claim ownership of the application. We need to keep in mind that there is a myriad of different skill sets, and they complement each other. As the complexity of interactive multimedia programs rise, users will have higher expectations of the visual interfaces they interact with. To satisfy the technical, functional, cognitive, and aesthetic demands of these interfaces, a convergence of our collective expertise will be necessary. With this, and keeping users in mind, we may be at the forefront of a new paradigm in the design of visual interfaces for advanced multimedia functionality.

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Credits

Project examples were developed as a part of course work in "Interactive Visual Communication and Interface Design" at The Ohio State University instructed by R. Brian Stone. Student work featured was designed by Weilum Chien, Phil Diol, Amy Detrick, Erin Corrigan, Brandon King, Daniel Landolt, Corinna Roedel, Eric Vivian, and Sophie Zumsteg.

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YLEM

n. pronounced eylum, 1. a Greek word for the exploding mass from which the universe emerged.

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YLEM
P.O. Box 2590
Alameda, CA
94501
USA

Contact Information

YLEM Main Contact
P.O. Box 2590
Alameda, CA 94501
http://www.ylem.org
ylem@ylem.org

YLEM Membership Issues
members@ylem.org

YLEM Journal Items
Loren Means
149 Evelyn Way
San Francisco, CA 94127 USA
lorenmea@pacbell.net