Information Visualization (iV):

Notes about the 9th IV ’05 International Conference, London, England

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## Abstract

This review tells about the International Conference on Information Visualization that is held annually in London, England. Themes selected from the Conference Proceedings are focused on theoretical concepts, semantic approach to visualization, digital art, and involve 2D, 3D, interactive and virtual reality tools and applications. The focal point of the iV 05 Conference was the progress in information and knowledge visualization, visual data mining, multimodal interfaces, multimedia, web graphics, graph theory application, augmented and virtual reality, semantic web visualization, HCI, digital art, among many other areas such as information visualization in geology, medicine, industry and education.

## Notes from the iV 05, Information Visualization Conference, D-Art Symposium and Digital Art Gallery, London, England, 6-8 July 2005

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# 1. **Introduction**

The focal point of the iV 05 Conference was visualization, information visualization, and knowledge visualization. The theoretical concepts (such as cognition, constructivist approach to language and culture, spatial abilities), basic framework (such as human-computer interaction, graph theory, geometric modeling, visual data mining) and applications (such as geo-visualization, building-visualization, web visualization or knowledge visualization in organizations) were equally discussed at the iV Conference. D-Art Symposium and Digital Art Gallery complemented the Conference. Some art works presented at the Gallery illustrate the Notes.

Visualization can be defined as the creation of graphic images directly from data, and outcomes form algorithmic manipulation of these data (Slocum and al., 2004, after Lobben, 2005: 764-769). Data types are 1D linear, 3D world, and multidimensional (Graham, 2005: 599-603). Much attention is given to visualization through non-visual modalities, as information can be presented by sound, touch, or in multisensory ways. Non-visual and multimodal sessions include interactive multimodal data presentation (such as user interfaces that can be realized in visual, auditory, or tactile domains), sonification (such as sonification of polyrhythms, or human motion), and haptic/touch interfaces (for example, pressure sensitive interfaces).

"Information visualization (IV) can be defined as the use of interactive visual representations of *abstract* data to amplify cognition" (Bederson and Shneiderman, 2003), in contrast with scientific visualization. Interactive visualization is an essential issue in organizational communication or knowledge media design (Klein, 2005: 70-75).

Knowledge visualization stresses the transfer of knowledge and concentrates on the recipients, other types of knowledge (know-why, know-how), and on the process of communicating different visual formats (Burkhard et al., 2005: 76-81). Knowledge maps is a subset of knowledge visualization.

Notes from the iV 05 Conference refers to a small part of material provided by the Conference contributors. Selected themes involve information visualization, knowledge visualization, spatial abilities, virtual environment and virtual reality, design, art, applications, and learning.

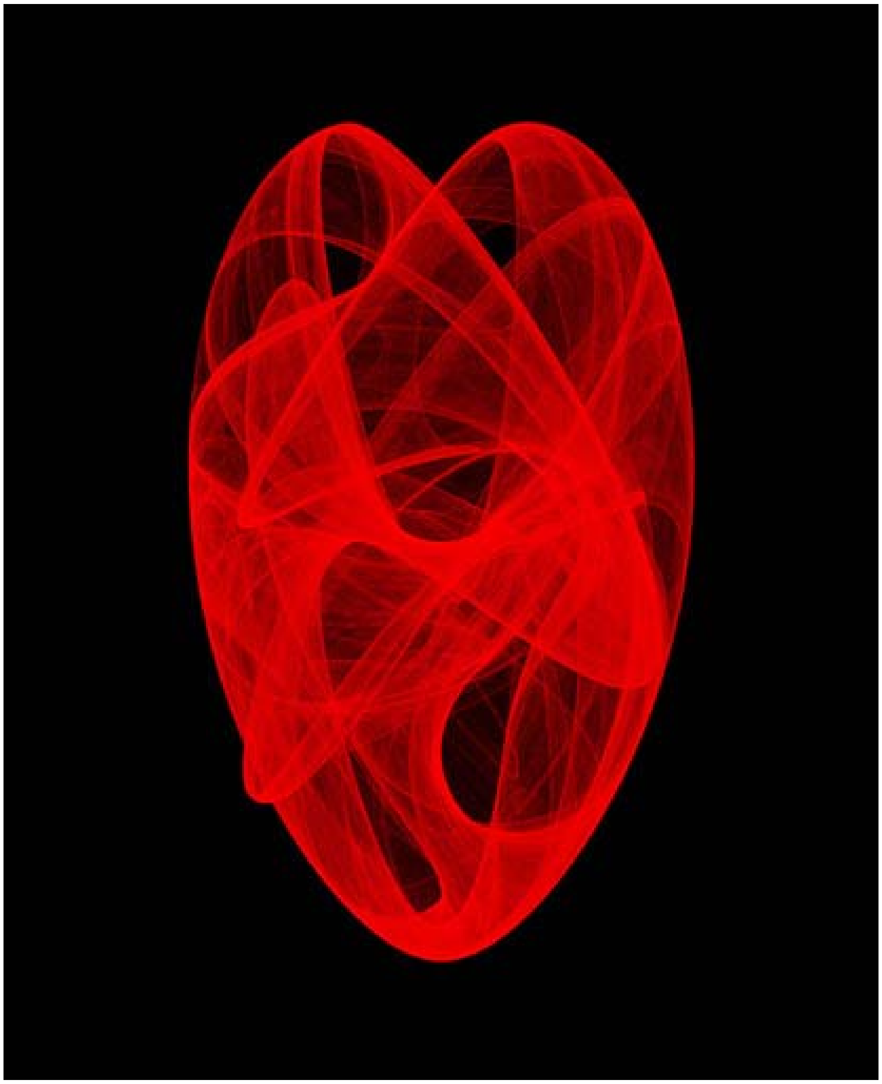

Fig. 1. Robert Krawczyk, Bends Unraveling III.

## 2. Information visualization

According to Hartman and Bertoline (2005: 992-997), computer graphics learning environment takes advantage of a learner's ability to quickly process and remember visual information. But "normally, the graphic disciplines are scattered throughout the university." Technological world uses graphics "to plan, produce, market, and maintain goods and services", because about 80% of sensory input comes from our visual system (Hartman and Bertoline 2005: 992-997). Great amount of information associated with producing good graphics include color theory, projection theory, cognitive visualization, and geometry. It is used to communicate and store information, solve problems, and affect through the senses the human experience. Hartman and Bertoline postulate that a body of knowledge called Visual Science should be studied, practiced, and scientifically verified as a discipline. Visual science is defined as the study of the processes that produce real images or images in the mind. Visual science has at least three major categories: geometry, spatial perception, and imaging. It will have its own knowledge base, research base, history, and public perception.

Sophisticated graphics on slides or PowerPoint presentation do not communicate effectively (Tufte, 2003). Interactive visualization is a medium, as it mediates between the user and the physical world. While changing figures in the simulation do not change the production line, real world figures and interrelations go into the simulation, so a model leads to actions in real world (Klein, 2005: 70-75).

By definition, the GUI is an interface between languages of a code and a usable visible language. It facilitates our interaction between the abstract world of zeros and ones and a human centered symbolic interpretation of this information Gwilt (2005: 931-936).

Shneiderman (1996) described the task taxonomies: information visualization application should support seven high level tasks:

– overview of the entire collection: for the file system, the size of files, for the newspaper, the number and size of articles.
– zoom on items of interest. Zooming involves two cognitive tasks. Zooming-in enlarges smaller data. Zooming-out reveals hidden, often contextual information and integrates the close inspection into a larger understanding.
– filter out uninteresting items. Filtering diminishes complexity in the display but it disturbs the general context. The adjustment of widgets in the interface allows for control of which data points are visible, so that information can be simplified to aid cognition. The dynamic filters allow users quickly see how the changed variable affects the data representation.
– details-on-demand on a selected item, with the level-of-detail design (a simple action such as a mouse-over or selection)
– relate - view relationships among items, with hierarchical parent-child relationships of data, so the user can separate nodes from leaves.
– history of actions, to support undo, replay, and progressive refinement, to allow the user to delete, create, and move files and directories.
– extract sub-collections and query parameters, to save the current state of visualization.

As stated by Craft and Cairns (2005: 110-118), Shneiderman's Visual Information Seeking Mantra serves as a methodological guidance to practitioners who seek to design novel systems and many authors reference to Mantra as a holistic approach to visualization design. However, he described his ideas as descriptive and explanatory but not prescriptive. His recommendations were not validated and assessed as guidelines, but there are few methodologies to choose from. In 2004 there were at least 52 citations of the Shneiderman's Mantra in different kinds of publications that describe implementations (such as novel information visualization systems, a document analysis visualization tool a software visualization tool, or design implementations), methodologies, evaluations, taxonomies, and general discussion of the paper.

According to Graham (2005: pp. 599-603), challenges for IV and tools development for IV are identified with respect to: import data; combining visual representations with textual labels; seeing related information; viewing large volumes of data; integrating data mining; collaboration with others, and; achieving universal. It became a norm that large projects with several partners should provide a website publicizing their project. The Matrix has been created to facilitate IV of the EU project. A prototype for website was developed using DreamWeaver. Later it was rewritten in html to make it easier for incompetent partners.

## 3. Knowledge visualization

While information is explicit, knowledge has to be reconstructed by individuals through communication and verbal or visual interaction with information. Our innate visual system can be exploited using insights coming from the Gestalt School and neuroscience of vision. Visual representations help to address emotions, illustrate relations, discover trends, patterns and outliers, keep the attention of recipients, support remembrance and recall, present overview and detail, facilitate learning, coordinate individuals, motivate people to establish a mutual story, or to energize people to initiate actions by illustrating options to act (Burkhard et al., 2005: 76-81).

Types of visualization include sketches, diagrams, images, maps, objects, interactive visualizations, and stories. Frameworks for knowledge maps involve questions about their function type (what?), recipient type (whom?), and map type (how?) that may include a heuristic, diagrammatic, metaphoric, geographic, 3D, interactive, or mental map (Burkhard et al., 2005: 76-81).

Knowledge maps. Mental maps are formed through direct exploration and stored as environmental point features (home, work, store), line features (route, river), and area features (neighborhood clusters) (Lobben, 2005: 764). Knowledge maps do not only need to be seen as graphic depictions of explicit information but as catalysts for change processes and the implementation of strategies. For building a framework for the transfer of knowledge, several issues must be solved, that are related to information depth, reduction, users' background, and relevance. Knowledge maps use cartographic conventions to visually reference knowledge showing overview and/or details, and interrelationships among details (Burkhard et al., 2005: 76-81).

Constructivist approach. Bertschi and Bubenhofer (2005: 383-389) analyzed metaphorical face of knowledge visualization by examining interrelation of metaphor, linguistic learning, and mediation of knowledge through visualization.

Language and culture shape metaphors applied in visualization. Phraseologisms, multi-word units belong to the specific text-types (such as 'passed into eternity' belongs to an obituary and 'with kind regards belongs to a private letter). Such patterns in communication depend on the social behavior of speakers and leads to normative structures in language. Such linguistic structuring of figure-like expression units was called idiomatic coinage, people being semantically coined in everyday communication. Levels of language structure include phonemes, morphemes, syntactic phrases (collocations, idioms, phraseologisms, etc.), sentences and phrases, and textual patterns in whole texts. They all, being linguistic forms and patterns, reflect social structures (culture) (Bertschi and Bubenhofer, 2005: 383-389).

Knowledge visualization techniques aim at portraying the reconstruction of patterns, facilitating transfer and creation of knowledge by giving people richer means of expressing what they know, augmenting communication. Graphic means that convey insights, experiences, methods, and skills mediate knowledge through visual metaphors. But visualization is efficient only if it follows basic semantic figures in discourse and is compatible with existing linguistic patterns. Also, visualization means representing what is not visible beforehand, converting tacit knowledge into explicit knowledge (with a risk of oversimplification and falsification).

Communication calls for language, imaginary or articulated: pictures need a caption. Because language is metaphorical, there is no non-metaphorical thought. Thus visualization is pictorial and linguistic at the same time, both kinds being complementary parts of communication. Also, social conditionality of there patterns is significant. Every visualization is based on frequently used linguistic pattern (with social or cultural discourse). For example, a 'pie chart' metaphor of market shares uses metaphors about cutting a pie; a 'starry night' metaphor can show it in 3D, etc. Thus, according to Bertschi and Bubenhofer (2005: 383-389), metaphor is a tool of conceptual economy but also a tool of discovery of structures within novel or unfamiliar situations.

People think in pictures, so knowledge must be recreated in the mind of the receiver. Modes of thought can be adequately understood if their social origins are familiar and the pictures are defined by language used in a specific culture at a specific time. Visual metaphors combine the creative leap of sketches with the analytic rationality of conceptual diagrams and organize information meaningfully. They can either be natural objects or phenomena (e. g., mountains, tornados) or artificial, man-made objects (e. g., a bridge, a temple), activities (climbing), or concepts (war, family). They fulfill a dual function: organize and structure information, but also convey an implicit insight through the key characteristics or associations of the metaphor (Eppler and Burkhard, 2005, http://www.knowledge-communication.org). The viewers can relate what is new (the expert's insights) to what they already understand (the metaphor's main characteristics). According to the Wittgenstein's constructivist concept of learning, viewers give meaning to the concept through the way they use it. They gain the first-order knowledge as an awareness of object, and then metaknowledge as knowledge about things, meanings, associations, and possible improvements. Third-order knowledge involves comprehension or conclusion about meaning: how it is and why it is that way. Such mental processes are always socially or culturally mediated and context-specific. Internal constructions evolve, as culture enters our personal understanding. A source of mediation can be an artifact, a system of symbols, behavior of others, but mostly language (signs and symbols). Meaning-making results from people's active participation in social and cultural contexts and settings. Knowledge visualization has to be impressive and has to work identically in all recipient heads. It has to be conformable to all existing linguistic patterns. Knowledge visualization acts as a mirror of linguistic (or idiomatic) coinage, which in turn is a mirror image of culture and context (Bertschi and Bubenhofer, 2005: 383-389).

Burmeister (2005: 89-96) examined the use of visual means of speech, especially the iconic character of gestures in sign language that may also be useful for the search of metaphors in information visualization. The use of metaphors in information visualization may be useful to express ideas with sign language. As described by Burmeister (2005: 89-96), the Piaget's description of mental operations includes the senso-motoric level, the semiotic level (mental representations of the environment), and the level of formal operations (implication, inversion, negation, or reciprocity). Conceptual systems, everyday actions, and speech derive their content from cognitive metaphors. Metaphors transfer content of the origin to the target. Semantic may be defined in three ways. The intensional approach traces the sense of a word (a definition works that way). The extensional approach tries to refer to real objects as content for a word. The third approach relies on the use of concepts. A metaphor is an invitation to use the semantics of a symbol like another symbol that is better known (mapping the abstract word to the use of the metaphorical word). Information retrieval software provides different ways of accessing information by various user groups. A demonstrator program for a knowledge editor is based on cognitive metaphors and may be used for analyzing metaphors. In this framework, metaphors are the background for the semantic of symbol systems, no longer visual substitutions for data cluster. They can represent a type of prelingual thinking. Knowledge given by prelingual thinking is important for understanding the relation between data and their representation. Evaluation of metaphors broadens IV technologies for other domains, such as humanities (Burmeister, 2005: 89-96).

Cognitive approach, memory. According to a cognitive load theory on multimedia learning, students learned better when several principles were fulfilled: multimedia, split-attention, modality, spatial contiguity, temporal, coherence, and redundancy principles (Manton et al., 2005: 966-971).

While working on new possibilities of enhancing the 3D file search with the TerraSearch+ system, Faiola and Groth (2005: 613-618) reviewed existing information about memory. Finding a file, often hidden in folders, is difficult because of a breakdown in memory of events over time. Human memory has declarative and nondeclarative categories. Declarative memory includes episodic memory that receives and stores information about temporary dated episodes and events, recent or distant. Declarative memory also includes semantic memory, which is repository for words, concepts, rules, and abstract ideas, and is necessary for language. It is critical for organizing knowledge about words and verbal symbols, their meaning, referents, and their interrelationships. With semantic memory, we name, locate, and hierarchically organize files but we retrieve them with episodic memory. Nondeclarative, procedural memory helps take the routine actions, such as driving to work or taking the action Ctrl S (save) multiple times.

Cognitive maps allow us to recall visual and spatial knowledge. We can store and recall rout and spatial knowledge. Rout knowledge is related to the specific pathways used to get from one place to another, and survey knowledge deals with more global relationships between environmental cues employed during navigation. With visual and declarative memory working together, the mind associates imagery with events in time. Both 2D and 3D imagery is likely to be used in fact retrieval. Interactions in space are explicit (when we move here and there in time) or implicit (we know where we are and what surrounds us). Visual cues support spatial movement or navigation. Memory records landmarks, paths, links, and nodes. Spatial navigation is a mental construction that is schematized based on reasoning about space (for example, estimating distances and direction). Graphic representations, preserved in memory, act as historical records, off-load working memory, process and promote inference and discovery. The traditional file management systems depend on declarative memory for naming and organizing files hierarchically. If users could organize files geographically, visual memory and spatial condition would play a greater role in file acquisition. As opposed to declarative memory (that depends on internal representations), visual memory and spatial memory interact with external representations. Visualizations that represent semantic and symbolic information on a computer display could provide users with other forms of file management. Visual memory has an outstanding storage capacity for geographic information and the potential to quickly access files from locations in visualized space.

According to Faiola and Groth (2005: 613-618), today's operating systems use a folder metaphor for organizing files. Users have one choice of placement of individual files (it is a burden to decide where to place a file) and can create references to files located elsewhere. Users group related files into a common folder structure. The first-order properties of files determined by users are content, file name, and file location. They are the typical targets of search functions available to users. Properties implicitly set (automatically set by the system) are date created, last modification date, and number of pages.

Faiola and Groth (2005: 613-618) focused on relationships between first-order properties as searchable information. Files accessed near each other in time can be graphically represented visually to the user to improve their recognition ability to recall and retrieval of documents. TerraSearch+ utilizes a 3D terrain-based landscape for file management that is augmented with the second-order information that graphically depicts the relationship between first-order properties. Episodic and semantic memories are limited in their ability to support user's recall of the location of files from past events. Recalling the location of documents based on declarative and visual memories provides a model for file management in 3D space. Recreating the historical conditions of past interactions with the document is a very frustrating task and users do not document each of these interactions (e. g., creating, modifying, and saving). TerraSearch+, a 3D visualization system, may support a memory trace to bridge time and events of file management with a geographic visualization. Users, especially those oriented toward 3D cognitive processes of discovery, can manipulate thumbnails (linkable shortcut icons) or allow direct application launch.

Fig. 2. Joohyun Pyune, Monotony.

## 4. Spatial abilities

Every single entity of spatial data is described by several variables, location along the x-, y-, and z-axes and, in geographic research, also temporal data on a fourth axis. A map is a product of positioning attributes on x- and y-axes. Humans perceive environmental phenomenon by classifying spatial data by form (point, line, area). Their topological relationships can be expressed through geometric elements (such as polygons) with topological spaces: inside, left, right, above, below, outside; objects can be touching, not touching, or connected (Lobben, 2005: 764-769).

Wyeld (2005: 593-598) provided a historical perspective on depiction of 3D information. The 3D visualization of digital information relies on user's ability to interpret the 3D perspective depictions (3D objects and depth relationships on 2D surface). This kind of perspective dominated Western visual culture since Renaissance. Renaissance aesthetic measures to compensate for perspective distortions included multiple vanishing points, curvilinear perspective and anamorphism. It is open to debate at what age the psycho-physiological space develops and allows to adopt a 'viewpoint' and the Euclidian spaces (Euclid proposed that if certain axioms could be accepted on faith, such as that the shortest distance between two points is a straight line, then theorems should hold. Descartes organized this schema into an arbitrary 3D axial system). It is also debatable whether the ability to image 3D objects in the mind's eye is universal regardless of race, gender, or culture. Non-Western perceptions about how to represent multi-dimensional world include Asian isometry, African and South-American iconographics, and Australian Aboriginal dot painting, among others.

According to Wyeld (2005: 593-598), the 3D computer graphics representations are perceived within Euclidean space. In the 3D information visualization the images displayed have no physical world counterparts except abstract metaphors and 3D tends to be used as an interface. Scientific reductionism (the idea that nature can be described scientifically and there are no unknowable facts) poses that there are the negative implications for the perspective IV. They may be seen in the fact that the 3D perspective depictions often need one locus – one correct view with a correct center of projection, and there is inability for 3D representation media to show the relationship between data which we know exist but are obscured. If we spin the object around we have to 'remember' what we saw first. Thus, as Wyeld (2005: 593-598) puts it, the 3D computer graphics image is not an arbiter of the truth, we read a predictable convention we rely on and accept it as the truth. Restructuring of information is always framed by the methods we use. The 3D computer graphics perspective is a method for separating a code from its content (e.g., legend from a map or diagram) to communicate a particular kind of information. The perspective though grammar and encodings often hide more that they reveal, they ignore our organizational structure, values, desires the political, social, and economic factors. Extensions to the perspective paradigm are animation, real-time navigable spaces, database-linked dynamically-updated displays, parameterized displays with multiple manual or automated input sources, and so on. Sometimes it is difficult to enhance in 3D information that have been presented in 2D format. For example, Minard's graphical depiction of Napoleon's march into Russia in 1812 shows at least six dimensions of information; it traces the movement of troops across time, distance, geographical location, number of soldiers, direction, and temperature. The 3D space as a visual medium for organizing information has often been pursued at the expense of possible alternate methods.  This has a potential to obscure information both literary and metaphorically.

Spatial ability research (Hartman, Bertoline, 2005: 992-999) began in the 1920s. The interest about the 'spatial factor' related to what it is, how it relates to human intellect and how it interacts with other factors, is it learnable, etc. E. L. Thorndike in 1921 wrote 'On the Organization of Intellect' and defined mechanical intelligence as an ability to visualize relationships among objects. Thurstone's theory of Multiple Factors identified associative memory, number facility, perceptual speed, reasoning, spatial visualization (with three factors defined), verbal comprehension, and word fluency. Spatial visualization included three factors and many sub-factors that remain disputable till now: biological, cultural, and educational. Evidence about factors like gender, age, environment (biological, cultural, social, educational), learning style, hemispheric specialization, and speed and efficiency has been perceived non conclusive. Success in many fields is considered predictive on the basis of spatial abilities tests. Thurstone's concepts about factors evolved into (1) Mental Rotations, (2) Spatial Visualization, and (3) Spatial Perception. It is possible to improve these abilities. Research involved methods of improvement, assessing abilities and predicting success in many fields. Computer graphics educators perceived the improvement of spatial abilities as a means to facilitate understanding of representation techniques and methods, especially 3D geometry projection on 2D planes, and of the use of computer graphics tools in an artificial 3D space (Hartman and Bertoline, 2005: 992-999).

## 5. Virtual Environment, Virtual Reality

Immersive environment and the link to education. Virtual Reality (VR) technology provides visual, aural and tactile stimuli of a 3-dimensional virtual world that is generated and updated in real time as the user moves through the environment (Hartman and Bertoline, 2005: 992-997). VR can be applied to learning so learners become immersed in a computer generated (barely distinguished) virtual world, redefining the human-computer interface. In educational context, VR is a mode of interaction between the user and the computer generated environment, where the learner is able to (1) both view and manipulate virtual objects and (2) heighten use of multi-sensory, multi-perceptual, and multi-dimensional capabilities to increase understanding in learning and problem solving skills. The similarity in psychological processes in virtual and real environment aids transfer of learning. VR is usually used when experiments are expensive and concepts difficult (Hartman and Bertoline, 2005: 992-997).

Data format may affect the user exploration patterns of spatial data visualized as tables and maps through Geographic Information System (GIS) (Lobben, p. 764). Data enter into a GIS as data tables, maps or statistical models and are then converted and analyzed. Scale models represent real-world features such as atmosphere, transportation networks, or hydrology. Conceptual models represent ideas, hypotheses, or spatial theories such as landscape formation, population flows, or urban development. Mathematical models represent statistical spatial relationships such as geographically weighted regression. GIS software may be custom programmed for specific data analysis or visualization through maps or models.

The extent to which people rely on the three forms of spatial data (point, line, or area) is not known. Also, it is not known how the framework theories of mental map formation apply to spatial learning in GIS environment. The experiments were conducted with upper-level GIS students, aimed to assess the usability of customized GIS interface Arc-View (Lobben, p. 764).

Global Positioning System (GPS) is useful as a tool for data gathering. According to Molenaar (1998), it is considered as a collection of components including the earth, earth-circling satellites (approximately 24 solar-powered radio transmitters orbiting about 20,000 kilometers above the earth surface), ground-based stations, receivers (gathering satellite signals and often recording data, often including elevation), and the users. The receivers can calculate position along an x,y plane to an accuracy of millimeters; most units also record elevation (Lobben, 2005: 764-769).

Navigation is essential task for any Virtual Environment (VE) applications, especially large VE where navigator viewpoint does not encompass the whole environment (Lazem and Sheta, (2005: 752-756). Way finding is a cognitive component of navigation, aimed to acquire spatial knowledge and build an effective cognitive map. Users may acquire three types of spatial knowledge: landmark knowledge (about visual details of an object in VE), procedural knowledge (about a sequence of actions required to follow a definite path traverse), and survey knowledge (about spatial relationships among places and knowledge of geographical patterns). Identified local and global landmarks (objects with distinct features that function as reference points) are used to enrich landmark knowledge to help the users with maintaining knowledge of their location and orientation.

Data mining is the process of discovering implicit, non-trivial, previously unknown, and potentially useful information from data. Spatial data mining is the process of discovering patterns from large spatial data that may have spatial attributes (such as location, shape, geometric and topological properties) and non-spatial attributes (building age, activity). A spatial outlier, inconsistent with the remainder of the data set, differs from other objects, often in non-spatial attributes (e.g., a new house in old neighborhood). Lazem and Sheta (2005: 752-756) developed automatic landmark identification in large virtual environment, and transformation of data into useful knowledge. With a spatial data mining approach, spatial outlier detection algorithm has been developed based on the models used in real environment of Egyptian cities. A model has been created for defining attractiveness of landmarks in a VE. Governmental buildings, camps, university institution, factories, and gardens were identified as landmarks that can be used to enrich landmark knowledge.

There is a need for available interactive visualization tools. O'Connor et al. (2005: 758-763) developed a model for 3D visualization of spatial information and environmental process. This visualization tool is aimed at collaborative data exploration, to improve understanding of environmental models by experts and non-experts. SIEVE, the Spatial Information Exploration and Visualization Environment integrates Geographic Information System (GIS), 3D CAD models, a Geodatabase, and a game engine. SIEVE will use the 2D outputs from environmental process model to create a virtual environment where the objects and terrain show realistic or abstract effects of the model. Subsurface objects (like the water table or geological features) may also be created under the terrain surface. Keystroke options allow for choosing realistic or abstract visualization, turning the terrain on and off to view the subsurface, or viewing satellite imagery or thematic textures.

Interactive and cooperative virtual environments can be based on videogame 3D engines. Andreoli et al. (2005: 515-520) developed interactive 3D environments by using videogame engines. Designing VE involves coordinating various skills, e.g., in architecture or scenography to produce highly immersive 3D environments. A commercial videogame engine can be used to create an integrative and enjoyable visit to an archeological site. The authors use a Quake 3D game engine to create a 3D library where the user can browse books by looking at a 3D library with book shelves and so on. A laser pointer replaced the weapon of the user.

Fig.3. Jen Zen, Final Spin.

## 6. Design

Brath et al. (2005: 724-729) stress the importance of aesthetic sizzle in visualization for communication. Sizzle, aesthetic details such as highlights, 3D display, animation, simplification, use of color and other visual effects may enhance potential to communicate, improve the design's appeal, intuitiveness and memorability. However, used without care, 'sizzle' can reduce the effectiveness of the visualization by obscuring the intended message. If poorly designed, 'sizzle' adds the 'chart junk', moiré patterns, and clutter, so many follow a mantra introduced by Mies van der Rohe, 'less is more.' The primary signifiers of data values are spatial and color dimensions. A complex dataset requires the designer to couple the techniques of information visualization, such as scale, contrast, and proportion, with those of interaction design, such as affordances, representation, and structure. 3D bars are more visible than a 2D grid. A 3D display seen from an angle helps to compare relative heights of bars. Yet, the gestalt grouping principles apply both to location and color, so common aspects such as glyph and label sizes, color, and placement may give an implied meaning and cause the observer to assume unintended relationship. Connotative associations are essential, for example when used for correlating color with temperature (warm and cold colors). Linear perspective projection can both add and detract from the design. Sometimes, an isometric viewpoint is used. Fixed-size labels that do not obey rules of linear perspective scaling cause confusion when gauging depth. The use of transparency is also essential in complex visualizations. Other sizzle factors to be used with caution are highlights, simultaneous views, color-coding, labels (minimal labeling reduces clatter), and fonts (clean sans-serif are preferable) (Brath et al., 2005: 724-729).

Conceptual organization of information supports accessing and operating spatially organized information (Bujalska, 2005: 713-723). Spatial perception is important in cognitive processing abstract data. It is important to organize spatial design guidelines for information visualization, as it improves memory. Spatial manipulation is a subconscious activity with low cognitive load. A framework for spatial visual design of abstract information developed by Bujalska includes factors, such as object (a graphic representing concepts), context (a graphic space representing relations between elements), and order (spatial arrangement in the graphic space). These are groups that are connecting on different levels, as well as the user task group (a cluster of tasks depicted by Shneiderman (1996) and the designer goals group. On the user level, a mental model is important component of the user interface. On the community level, social space of the multi-user environment includes such representations as digital portrait (the user's presence within environment), digital conversation (in newsgroups, chatrooms, wikis, and mailing lists), digital crowd, visiting environments of online documents or websites), and social networks (netvis.org, patterns of relations). The framework proposes a holistic approach in sharing expertise among visual design, computer science, and social fields of study.

A framework for visualizing large graphs reduces data complexity using the clustered graph model, so users can navigate by browsing the clustered graphs (Li et al., 2005: 528-535). The semantic fisheye view approach to a clustered graph, a filtering strategy to form an appropriate abstraction representing the whole structure, keeps its visual complexity on a constant level. A large graph is visualized as a tree with a set of nodes; a special node is singled out as a clustered graph. Clusters can be opened or closed depending on the user's degree of interest, how it is related to the focus. User's processing task is mainly handled by short-term memory that has capacity limited to about 7 items at a time and decays within 200 ms. Logical abstractions of a clustered graph are designed to avoid visual complexity and ease user's cognitive overload.

According to Li et al. (2005: 528-535), the general visualization model, adjustable mapping from data to visual form (data>data table>visual structure>view) shows human interaction as adjustments, first through data transformation, then visual mapping of the transformed data, and finally viewing the visual structures. The graph visualization model visualizes relational structures, where the component of graph is used to model relational structures. During communication flow some techniques are required, first, the graph drawing algorithms to create visual structure, then the visualization techniques to secure a view. Interaction techniques involve human processes.

The large graphs visualization involves graphs, clustering the graphs, abridgement of clustered graphs as their logical abstraction, and finally their representation as a view. Human cognition processes result in interaction by sending a request to the component of clustered graph, which responds the request by updating the abridgement. The semantic fisheye view of a clustered graph (which can be enlarged or compressed by increasing or decreasing the number of clusters contained in it) can be used as an abstraction strategy in this framework. Multiple foci fisheye view can be generated by combining several individual fisheye views that have a single focus. It allows user to see details of several super-clusters at the same time. Case studies that compare visual complexity of incremental drawings with the fisheye views with views done without filtering clusters included a case of navigating the architecture of a compiler and navigating a citation graph. Both experiments “demonstrate that the first-order fisheye view of a clustered graph conserves a constant level of visual complexity.” (Li et al., 2005: 535)

Siirtola (2005: 869-876) investigated the effect of data relatedness in interactive graphics. Visualization techniques often include small multiple designs that represent the sets of data with miniature pictures or glyphs, to reveal repetition, change, pattern, and facilitate comparisons. While icons are generally static pictograms, glyphs can change their shape. Hermann Chernoff proposed in 1973 the idea of using the cartoon faces. Loizides and Slater introduced facial expressions instead of facial features, so they may produce emotional response for the observer. Thus a positive state in the visualized data should be reflected as a smiling face and vice versa.

Siirtola experimented with two kinds of glyphs, the Chernoff faces and the cars that were data-related glyphs to their car related visualization. He constructed a prototype program called Glyph Explorer. Subjects selected for the experiment were tested on car data after they performed observations of the car data sets. To answer each question, they had to assign data variables (or combinations of variables) to both kinds of glyphs. Data-related glyphs provided slightly better results and were more favored by the users.

Techniques for visualizing multivariate data sets include pixel oriented techniques (a single pixel represents each data value), geometric projection techniques (that map n-dimensional information space to subspaces), icon-based techniques (small icons represent the attribute values of the data records), and hierarchical or graph-based techniques (information space is displayed as a hierarchy or a graph) (Nocke et al., 2005: 103-109).

According to Nocke et al., icon-based visualization techniques “map data variables onto geometric (e.g., shape, size, orientation) and non-geometric (e.g., color and texture) visual attributes” (p. 103), using icons or icon-based textures. Metaphor based icons are rather uncommon, with the exception of Chernoff faces. An image mosaic, created from smaller images that together portray a larger subject, include two levels of detail in a single image.

Nocke et al. (2005: 103-109) developed an icon-based visualization using mosaic metaphors to enhance visualizations of multivariate data sets on maps. Image metaphors closely relate to the application domain. Image mosaic techniques include image layouts, image selection, and color correction. The graphical user interface (GUI) consists of a visualization window and an area showing legends and parameters. The maize icon has been applied to visualize the risk of a drought for maize cultivation in a given year and area based on local observation stations' climate models.

Mala et al. (2005: 587-592) developed visualization of biological ecosystem patterns in event detection and tracking. Users can distinguish and assimilate positions, colors, textures, and relationships that can be shown by proximity, containment, connected lines, color-coding, etc., after scanning the points in the data for clusters, outliers, trends, and gaps. Temporal document visualizations follow time sequence animations that show the overall change in topics. Time may be viewed as a point (when did this happen first?), line (how long has this been going on?), and a plane (how much of this has been happening during some time interval?).

As stated by Mala, biological interactions show the relationship that exists between species: interspecific competition (between two or more different species for food, space or other resources), predation (predator feed directly on all or parts of a prey and destroy it), parasitism (a parasite feeds on a part of the host that is harmed but not destroyed), mutualism (two species are involved in a relationship in a way that they benefit both), and commensalism (an association between two organisms in which one benefits and the other derives neither benefit nor harm). Biological ecosystem model can be matched to the relationships of stories to events. Competition exists among the events to capture the story. Predation happens when an incoming story can destroy or replace the existing event.  Parasitism can be seen when a multi topic story discusses two events but is assigned to only one event depending on the maximum score of its strength. Mutualism exists when both the strong story and the event benefit. Commensalism is present when the event is benefited but the story is neither benefited nor harmed.

The event detection and tracking task in visualization of biological ecosystem patterns detects events within streams of broadcast news stories. A model based on biological species interaction visualizes a structure of the incoming stories and the growth of the events in time. News articles related to specific topics are sifted and sorted out from online news. Temporal visual structure helps to identify the amount of information added by a story to the event. Interaction of biological species serves as a model of relationship of a story to the event. The first story about the event forms a new event; next stories are plotted in a visual structure of events. A biological species interaction approach has been applied, to calculate the strength of the event (the fitness score of the story to the event), identify and learn new classes of events, temporal relationship in the data, and the interaction between the story and the event. With this model, temporal visualization gives an idea about the importance of an event, importance of a story within an event, the time span the event has been active, and the worthiness of the story (Mala et al., 2005: 587-592).

Lind and Kjellin (2005: 896-900) carried out research into the optimal speed of animated visualizations for decision makers. Animation may serve as a visualization technique for time-dependent events. In order to control dynamic processes (such as traffic flow, emergency operations, or military command and control), decision makers (DM) must discover complex patterns in animations. To have a grasp of the spatio-temporal relationships, the DM needs to have a grasp of the nature of events leading up to present state and make predictions of the future states. Speed was understood as the mean absolute speed in degrees of visual angle per second of the object shown. For example, the speed of the hour hand of a watch is too slow to see its movement, while the smeared lines show moving objects that are too fast.

The authors explored how different animation speeds affect the performance of human decision makers, especially the ease of learning a complex relationship defined between two (low difficulty) or three (higher difficulty) moving objects. There was no effect of speed in the conditions with low difficulty, but in the conditions with the higher difficulty the performance in the highest speed was significantly better than in the lowest speed. The authors discussed possible actions how to employ animations as decision support tools (Lind and Kjellin, 2005: 896-900).

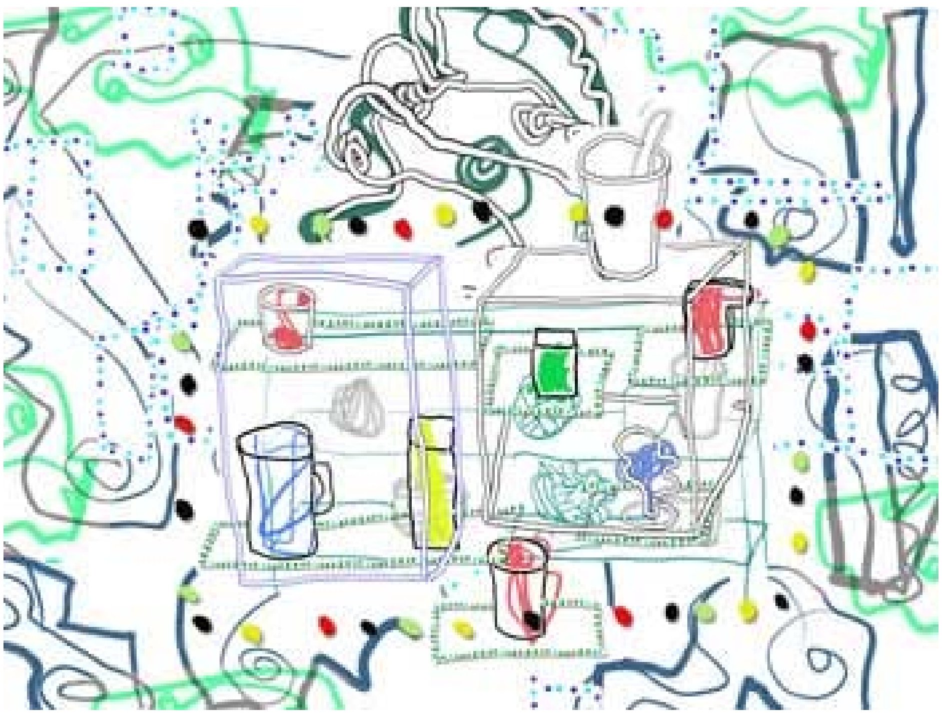

Fig. 4. James Faure Walker, BRQTHGTS, Digital Painting.

Interface metaphors. Edsall (2005: 642-647) has been challenging conventions for geovisualization interface design and made some implications for exploratory data analysis. The use of interface metaphors and cartographic guidelines may limit the power of the system or the representation, Socially and culturally determined factors are important, as well as adjusting design according to the targeted users (their experience, knowledge, and background) or the targeted task (for example, data exploration tasks).

Visualization depends on cognitive processes specific to the user (in terms of socio-cultural factors) and the use (in terms of task-specific factors). In HCI practice interface metaphors facilitate the understanding of a complex and abstract system. Users employ their previous knowledge of the system and the metaphor (such as a desktop, a typewriter or a book) to refine their mental models of the system through the association of familiar real-world concepts to unfamiliar abstract concepts. Thus interface metaphors activate cognitive schemata, especially when the learning material (a map interface, visualization) is similar in structure to the existing schemata. Some patterns in thought enable the perceiver (such as a sight-reader of music, a chess master) to anticipate a certain conclusion. Metaphors can be designed to guide the user by activating such anticipatory schemata.

According to Edsall (2005: 642-647), the interface metaphors for data exploration tasks in geovisualization encourage creative and unconventional thinking, but the use of conventional interface metaphors without consideration of socio-cultural factors may constrain the interpretation of mapped phenomena lead to incorrect conclusions or missed discoveries. Socio-cultural factors may be related to the orientation of the society to individual or group (collective) achievements, the acceptance of social power hierarchies, and the culture's tolerance for uncertainty. Culturally specific conventions in interface design may include the use of color (for example, in China white is indicative of death and red is the color of happiness, both contrary to Western conventions). In cartographic conventions, north is on the top, 'higher' corresponds to 'more' (3D density maps and 2D bar graphs), darker colors corresponds to greater qualities (chloropleth maps), and temporal progress in animation is indicated by a rightward movement of a temporal indicator. A color scheme for GIS packages and American maps, with green at the sea level through olive, yellow, beige, brown and white with increasing elevation, might lead a user to believe that arid and hot Yuma, Arizona, close to sea level, is lush with vegetation. This misconception reflects a semiotic mismatch between referent and interpretants, such school children or naïve map users. Edsall (2005: 642-647) conducted experiments that challenged temporal legends on animated maps and the north-up convention. Experiments that used proxies of animation, map pattern recognition and understanding, and feature comparison confirmed that longstanding cartographic conventions and established interface metaphors might serve to suppress creative thinking and inhibit rather than encourage out-of-the-box approaches to data visualization.

## 7. Art

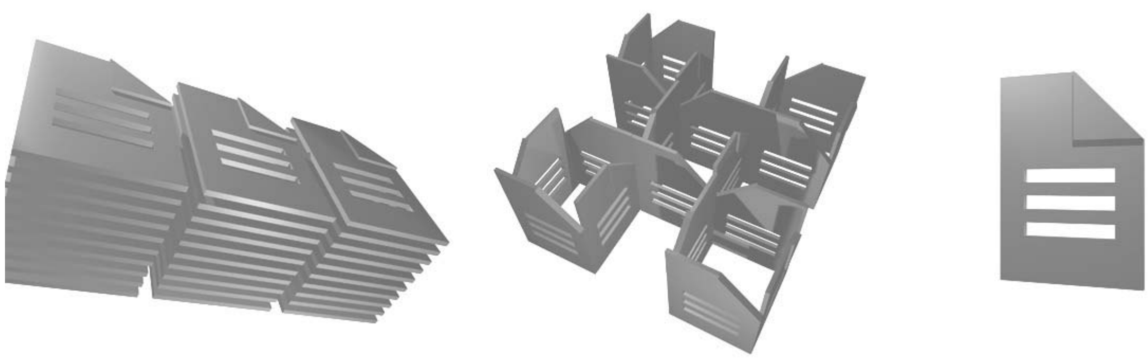

Fig. 5. Ian Gwilt, Files

Gwilt (2005: 931-936) gives an historical account of the graphical user interface (GUI) in digital art practice in the period of 1994-2004. He states that the GUI image became a discernable artistic and cultural phenomenon as the GUI has been incorporated as part of the image content and picture plane. Many artists enlisted the visual qualities of the GUI in their artwork, thus computer interface aesthetic became a source material. The author discusses the formal, social, and speculative aspects of this event.

In 2004 the Google Company bought a painting "A web page" depicting the Google home page conceived by Exonemo and painted by Masayuki Inagaki (3.33 m x 2.58 m). It was a part of an installation called the "Natural Process." It stirred a discussion about which of the Google homepage manifestations is most real, the painting in the museum, the image on the Internet of the painting, the video projection of the webpage in the gallery, or the source code and graphics of the 'original' Google homepage referenced in the work and realized on millions of individual computer web browsers?

The author discusses several works of artists, such as Miltos Manetas who creates paintings of the very hardware of technology (cables, monitors, joysticks, along with their users), Carlo Zanni (NY/Milan, Italy) who paints oil on canvas images of icons (e.g., PhotoShop jpeg icon and Napster logo), Russian artist George Pusenkoff who exploits and transforms such icons like Mona Lisa as products of digital environment and then paints them again. Some artists see Internet as a database not a medium. Akexei Shulgin and Mark Napier give some self-reflection about the net-based artwork. The author sees some parallels and similarities between early web works (with its use of the HTML language, hypertext and text-based links) and Conceptual art with its main categories defined as readymades, interventions, documentations, and words. Turbulence.org is the Net art initiative curated by Patrick Lichty. The computer game interface is another form of popular culture imagery. The author discusses also works of Manetas and a Chinese artist Feng Mengbo (Gwilt, 2005: 931-936).

Turner et al. (2005: 912-919) describe supportive transdisciplinary environments for interactive art. The programmers can play several social and technical roles in art-technology collaborations, both supportive and obstructive, when they help artists to learn programming. Attuning between the actors (artists) and artifacts (computers) involved is most important. Interactive art can be defined as an art system (that embraces all participants including a viewer) that changes from the presence of or actions by the audience-participant. Programming is the articulation of statements in a programming language which can include a style that involves writing and compiling ASCII code, uses visual programming languages (VPLs), and end-user programming (EUP) environments, many of them are indistinguishable from other forms of the graphical user interface (GUI) manipulations. There is no ontological distinction between programming a computer and using it, so all uses of a computer are forms of 'programming' – popular programming (e.g., developing spreadsheet formulae, hacking another's JavaScript), or deep programming, expert usage of a general-purpose language C or assembly language, in combination with an expert knowledge of computer architecture.

As Turner et al. (2005: 912-919) describe, computers allow us to think thoughts that are impossible to think with any other tool. Four technological strengths of computing are speed (ability to do things quicker or in real time), slavery (cheapness and obedience of computation), synaesthesia (computer performs operations on 1s and 0s, video is same stuff as texts, and as time, so it is possible to combine and convert between them, which is exploited in interactive art), and structure (a power of computing that is mental operation with no analogue in physical world, so one can abstract situations into structures).

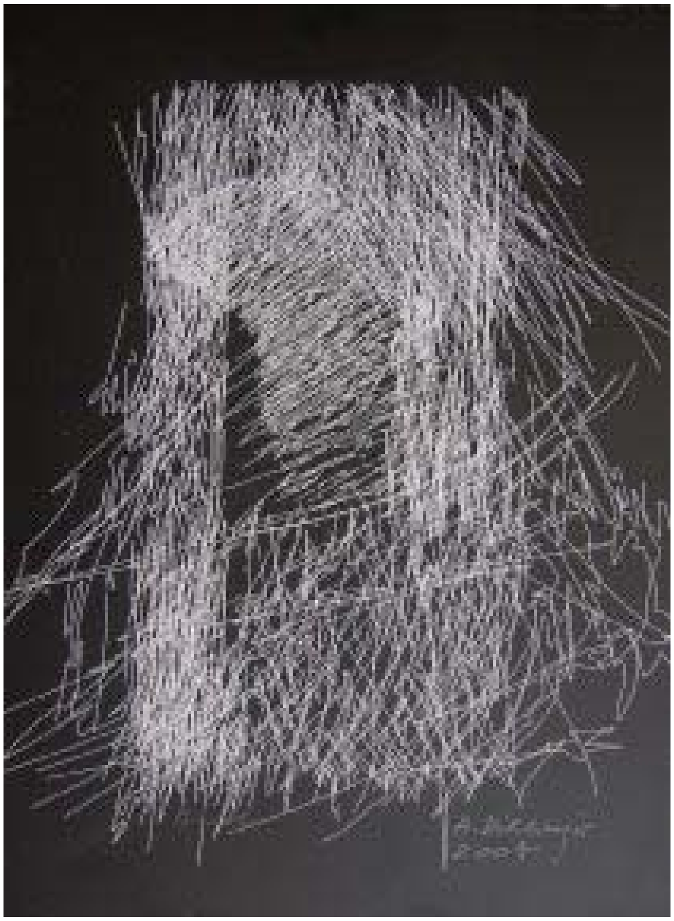

Fig. 6. Hans Dehlinger, Bird.

As stated by Turner et al. (2005: 912-919), the supportive role of technology includes the expressivity support. Popular programming languages allow us to achieve impressive things with no much effort but at the expense of flexibility. Deep programming provides learning, exploratory, and expressivity advantages and creativity support. Shneiderman lists 8 operations that help more people be more creative more of the time:  searching (for knowledge and inspiration), visualizing, consulting, thinking, exploring, composing, reviewing, disseminating (Communications of the ACM, 45, 116-120, 2002). Also, it includes methodological support, social support – communication and collaboration. The COSTART (Compute SupporT for ARTists) residencies provide tools to support communication and research on the supportive role of a programmer. Based on grounded theory analysis (an approach where the theory emerges from the data itself), recordings, diaries, quantitative interviews with artists and programmers, and then the open coding procedure were done. The main finding was that the process of attuning between humans and between artist and programmer-attuned computer are of fundamental importance. The programmer’s role is to attune the computer to the artist, that the artist no longer needs the programmer. Collaboration context, approaches to problem solving and developing subsystems as well as intimate iteration vs. play and language learning were further analyzed as possible implications for designers of programming support environments.

Kasao and Miyata (2005: 903-911) present the enhanced SIC (Synergistic Image Creator) for artistic use. Non-photorealistic rendering (NPR) technique is an image expression tool for a 2D static art. The authors simulate typical painting styles by creating brushstrokes. The technique is based on knowledge about human optical illusions. It allows the artist to select several areas of extreme expression and choose many types of brushstroke for a single artwork that is created algorithmically without a mouse or a pen-tablet. Synergistic Image Creator (SIC) is a framework for this tool, so it inherited vector-based processing from the original SIC. The SIC consists of several processes in sequence: color space transformation, directionality extraction (texture), image segmentation, calculation of vector segment data, brushstroke creation, and coloring of brushstrokes. Then, image merging, to identify dark and bright areas, was made in consideration of optical illusion. It gave the expression tool the ability to compensate for optical illusion, to modify positions of brushstrokes, and to combine many types of brushstrokes in one artwork.

## 8. Application, learning

Manton, Maple, Callard, and Baker (2005: 966-971) investigate the use of multimedia and web based materials for teaching and learning. They developed the Sitecam, a multimedia tool for the exploration of construction environments. The building sites present safety and access difficulties for visits, so they are suitable for virtual exploration using interactive software. The paper describes a tool to be used in the teaching of construction, that provides multiple cross-linked digital media of a construction site. This project enhances the learning experience and employability by bringing the reality of construction processes and procedures to the lecture room. The visualization in construction included a record made with time lapse photography, multimedia used to create virtual exploration experience, and a software consisting of a user interface (made with Macromedia Director) to navigate between media showing a construction: time lapse photos, animation, 3dMax, AVI digital video, real time footage, and video interviews. Also, still images taken by a webcam (1500 images edited in Adobe Premiere and exported as AVI digital video). Different variants were produced: CD-ROM lecturer version, DVD lecturer version, DVD student version (using QuickTime format), and an online version.

Paley (2005: 1007) investigates how visual mnemonics add meaning to perceived patterns, just engaging human sensory and perceptual mechanisms. ”Knowledge Acquisition Pipeline” examines the human visual system, from photons to contextualized ideas. It sorts and connects data to the appropriate perceptual mechanisms, explores finals stages of knowledge acquisition when patterns exposed by visualization tools get integrated into the individual ideas and shared metaphors of knowledge domain. It can streamline interpretation and memory embellishment that anchors ideas, when domain experts define the goals of a view and their metaphors inform the structure of the view space and shapes of the glyphs. Thus, designers can sort out which data to present to what perceptual/cognitive process. They can also evaluate designs whether they are missing expressive opportunities (ignore human input channels). This approach seems well suited to tying the tool to the representation experts have in their minds, makes each tool more of a toy, work more like intellectual play, and adds the depth of human meaning to our pretty patterns.

Heimonen and Jhaveri (2005: 877-882) visualized query occurrence in search result lists. The authors incorporated visualization into the conventional search result interface of the web search engines, in addition to a title, a brief summary, and an URL (Uniform Resource Locator). For each resulting document, occurrences of the query were depicted as a small document-shaped icon. Such visualization indicated the distribution and frequency of the entire query in the context of the retrieved document.

The authors carried out a user study, to assess the utility of this indicator, find out how the visualization affected the user performance in information seeking tasks, and collect subjective observations of the users. There was no significant effect in terms of accuracy or task completion time. The participants found the visualization unobtrusive, easy to understand and useful in spotting irrelevant results in the search result list.

Kienreich and Granitzer (2005: 213-218) developed a 3D visualization system for knowledge maps consisting of encyclopedia articles. A turning, multi segment table serves as a metaphor to depict a result set as a whole, and 3D objects of various shapes placed on the top of the table represent individual encyclopedia articles (e.g., 240,000 articles and 350,000 mentioned keywords). A typical encyclopedia article features some metadata categories that describe its content: technical metadata (size, date, etc.), content metadata (topics and summaries), and relational metadata (ontological links to other articles). A turntable metaphor employs visual attributes (like object size, color, and shape) to encode object metadata. Objects are rendered as solid geometry. Article close-up, pop-up menu and dynamic label layout algorithms are provided, with interactivity secured with areas sensitive to mouse operations. Depth-dependent label transparency has been used to create a consistent display of textual object information. One-second lasting animation sequences provide transitions between discrete points of view within the visualization. Thematic background images matching the topics of segments complement the groups of articles. A backing ontology help to connect articles via directed, annotated edges. Java 1.5 was used for developing environment and JOGL, Java OpenGL bindings were used as a graphical interface.

According to Wesson (2005: 619-625), visualization requirements for some completely different areas, such as genealogical information systems and network application management are very similar. The interactive visualization tools developed can be used to explore and analyze these kinds of information.

Hu and al. (2005: 503-508) applied a real 3D digital method for large-scale cultural heritage sites. The 3D laser scanners and CCD cameras served for registration into a common coordinate system, after removing noise and filling the holes. A volumetric-based algorithm served for the construction of a 3D mesh that enclosed all range scans. Real 3D geometric and real texture models of buildings and grottos were obtained through texture mapping.

Klein (2005: 70-75) describes knowledge visualization in practice: how corporate communication in Daimler-Chrysler AG has been improved with introduction of interactive visualization. Interactive visualization developed for the Daimler-Chrysler AG is a platform for direct experience with the model of a highly abstract domain. The issue is complex in many dimensions because of technical complexity of a product based on many logistics. Several parallel timelines refer to the production dates, product usage, and budget effects. Quality issues relate to many levels within the organization. Interactive visualization included to the charts an additional time dimension, an interactive timeline. The interactive time slider helps to understand interrelations between various key figures, their development, cause and effect relationship, and temporal effects, all in specific periods of time. Thus, the mapping of different time perspective is made possible.

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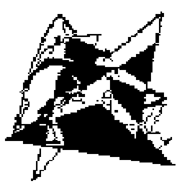

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