

A Research for the Classification of Knowledge Visualization

Zhou Yan

College of Science
Yanshan University
Qinhuangdao, China
zhouyan1958@163.com

Yin Liqun

Dean's Office
Hebei Normal University of Science & Technology
Qinhuangdao, China
liqunyin@163.com

Wang Lei

Haerbin HuaWen High School
Haerbin, China
dazhong878@yahoo.com.cn

Abstract—Knowledge visualization is a method which is increasingly used widely for representing, conveying, and accessing knowledge with all kinds of visual elements in recently years. This paper sets forth the definitions of knowledge visualization and related at first, and then elaborates the three categories of knowledge visualization, finally analysis and compares various classification methods of knowledge.

Keywords—knowledge visualization; knowledge visualization; Classification;

I. INTRODUCTION

With continuous development of human society, human knowledge is growing rapidly, according to UNESCO statistics: nearly three decades of human scientific knowledge accumulated has accounted for 90% of the total accumulated of the history by 1980. Prior to this, scientific knowledge accumulated thousands of years before accounted in only 10%. Knowledge of this explosive growth makes faster updates of knowledge and also presents challenges to acquire knowledge. As solely traditional methods of education and learn is far from meeting this challenge, efficiency of knowledge acquisition must be improved, faster and more new ways to acquire knowledge be seek.

Based on scientific visualization, information visualization and data visualization, Knowledge Visualization developed to be emerging research field, through visual means, knowledge can be used to access, discussion, assessment and daily management for people, which provide strong support for fast access to and mastery of knowledge in response to challenges of information age. Dr. Lin Xia who works in Drexel University, Philadelphia, PA USA proposed that: knowledge visualization is "visualization easy to understand", "visualization could transfer tacit knowledge into explicit knowledge", "visualization able to create new knowledge", and also is visualization that "can help people learn, cognitive and cooperation".

II. SOME CONCEPTS

A. Visualization

Visualization means visible, pictorial, clearly present and so on. Visualization as a professional term began in February 1987, when the United States National Science Foundation (NSF) convened a special seminar, gave it definition, covering areas and the recent & long-term development of scientific computing visualization, which marks the scientific visualization as a discipline has matured in an international context.

B. Information visualization

Information visualization is a rapidly growing field of study, Card (1999) defined it as: "visual representation of computer supported, interactive, used to performance abstract data and to expand the cognitive." [1] Information visualization can help people to explore information and visual information search, information explore is interactive data browsing and analysis in the visual interface which allows provisions of the direction or point, once very little information and the target is not clear, this can become a useful supplement for database queries and information retrieval; visual information search combines information expression and dynamic user control technologies, which help to explore data and on the basis of these ideas to explore the visual patterns on the reconstruction target continuously.

C. Knowledge Visualization

Knowledge Visualization developed to be a new study field on the basis of Scientific Computing Visualization, Data Visualization and Information Visualization. Fig. 1 is the process of its development.

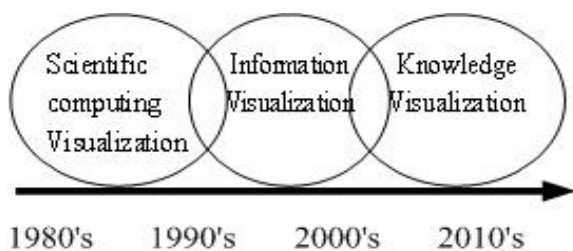


Figure 1. Visualization development process

Martin J. Eppler and Remo A. Burkhard (2004) presented a widely accepted definition of knowledge visualization: knowledge visualization is a field of examining the use of visual representations to improve the creation and transfer of knowledge between at least two people, thus it can be defined all graphic means that can be used to construct and convey complex insights[2]. Zhao Guoqing(2009) proposed revised definition of knowledge visualization: knowledge visualization is the subject that study on how to improve complex knowledge creation and transmission between two or more applying visual representation. [3]

D. knowledge visualization vs. information visualization

Although both of knowledge visualization and information visualization develop our own capabilities to promote visual expression effectively, it is very different that the application ways of this capability in these two areas:

Zhao Guo-qing etc., compared of data visualization, information visualization and knowledge visualization from four respects such as visualization objects, visualization purpose, visualization ways and interactive types, as shown in Table I :

TABLE I. COMPARISON OF DATA VISUALIZATION, INFORMATION VISUALIZATION AND KNOWLEDGE VISUALIZATION

	Data Visualization	Information Visualization	Knowledge Visualization
visualization objects	Spatial Data	Non-spatial data	Human knowledge
visualization purpose	representation abstract data in intuitive way	find new information from abstract data	promote dissemination and innovation of group knowledge
visualization ways	computer graphics, image	computer graphics, image	drawing sketches、knowledge chart、visual metaphors etc.,
Interactive types	human-machine interaction	human-machine interaction	human-human interaction

From above comparison, we can find the goals of information visualization are to discovery new ideas from a large number of abstract data (digital form usually) or just to make data be stored more accessible. Information visualization is not only used to display non-spatial data of multidimensional images, so as to enhance users understanding data, but also used to guide the search process, speed up the retrieval speed

with visual images. Current research of information visualization focuses on designing and choosing which kind of display way to facilitate users understanding of large multi-dimensional data and their relationship, which involves psychology, human-computer interaction technology and other issues.

Goal of knowledge visualization is to increase the generation and delivery speed of knowledge between people by giving people rich ways to express what they know. In addition to conveying factual information, the knowledge visualization aims to transfer insights, experiences, attitudes, values, expectations, views, opinions and prediction, and in that way to help others reconstruct correctly, remember and application this knowledge.

III. THE CLASSIFICATIONS OF KNOWLEDGE VISUALIZATION METHODS

To the classification of knowledge visualization methods, many scholars from different angles for different division, three categories are widely used, as follows:

A. The Classification of Martin J. Eppler etc.

Martin J. Eppler etc. divided knowledge visualization tools into six categories from perspective of visual ways:

- **Heuristic Sketches:** as Fig. 2 shows, they are figures that can make the knowledge externalization to support group reflection and exchange of thinking and then generate new insights. They also give the team sufficient room for individual expression, promote the development of individual and team creativity, explain and draw changes at the same time, which not only contribute to expression thoughts rapidly and let other people access to new content quickly, but also play a role in attracting the attention of communicators in the process of using the pen to draw. This approach is able to express personal views, the drawer's thinking process in addition. With heuristic sketch, team members can form a comprehensive understanding of the drawler views and help thinking communication and generation of new ideas.

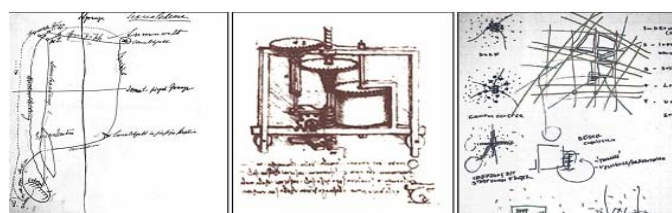


Figure 2. Heuristic Sketches

- **Conceptual Diagrams:** they are visual representation ways using standardized graphics (such as arrows, circles, cones or matrix) to describe the outline view of abstract views so as to structural information and clarify the relationship. For the transmission and generation of knowledge, they can help to make abstract concepts easier to understand, reduce understanding complexity of key issues, and expand

relationship of awareness and discussion. Specifically they can be divided into 18 kinds as shown in Fig. 3.

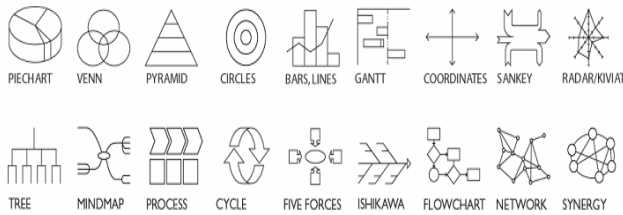


Figure 3. Conceptual Diagrams[4]

- **Visual Metaphors:** They are knowledge visualization ways that provide some familiarity things to new things through migrating understanding elements from the master subject to new areas. They can be natural objects or phenomena and can also be artificial, man-made things; the main function is that they will organize information meaningfully in order to achieve two functions: first, visual metaphors realize information organized actively and structured; second, visual metaphors express a grasp on the information characterized by way of analogy as the main feature. Fig. 4 is an example of visual metaphor which describes the ingredients of a brand.

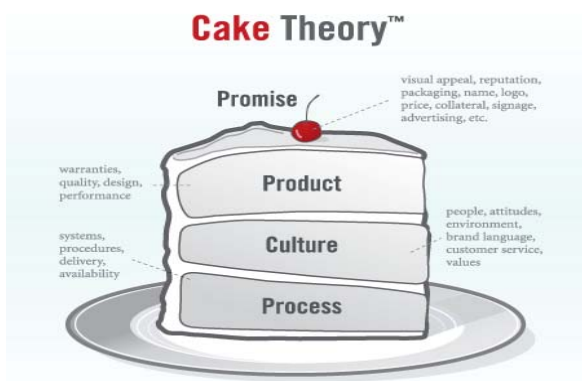


Figure 4. Cake Theory of brand

- **Knowledge Animations:** They are supported with computer, dynamic and interactive visualization, which allow users to control, interactive and manipulation of different types of information skillfully to promote knowledge generation and transmission.
- **Knowledge Maps:** They are visualization format that follow the drawing rules and reflect the relationship of knowledge. A knowledge map consists of two parts: the underlying scope usually concludes common background understood and contacted by all members maps, and individual components casted light upon this range. This background may be a visualization of the company's business model, actual products, field of a company's ability, a company's value chain, or a simple map; may be also elements reflected in this shared background from the experts, project team or

drill team to more clearly and coding knowledge, such as white papers or articles, patents, lessons learned (for example, after review or project work report), event (i.e. conference draft), database or similar forms, such as expert systems or simulations. Knowledge maps combine all of these elements to represent their relationship, location and characteristics.

- **Scientific Diagrams:** conclude visual interface of knowledge fields and digital libraries. The former concerns the identification and visualization representation news of scientific frontiers in multi-disciplinary background, and new ways of access to knowledge resources (authors, institutions, papers, journals, etc.) through visual link scientific fields; based on visualization, the latter applies existing or new visual means to provide new ways for digital libraries so as to better develop the existing information repository.

B. The Classification of Burkhard & Meier etc.

Burkhard & Meier divided 7 visualization methods from the ways of delivery and creation knowledge by architects [5]:

- **Heuristic Sketches:** used to express main ideas, create atmosphere and help to visualize an opinion quickly. Heuristic sketches often make knowledge explicit and query so as to assist group expression and communication.
- **Diagrams:** relatively abstract, diagrams used to explore the structural relationship among parts.
- **Maps:** consisting of map range and elements in this range, maps are visualization format that follow drawing rules reflecting the relationship of knowledge
- **Images:** impressive, rich expression or symbolic of reality, identification emotion and they are inspiring, attractive, incentives and strengthen. Therefore, they are used in advertising as key means.
- **Object:** object use three-dimensional and physical experience allowed material, object in the physical space as information point, knowledge exposition or exhibition help to supplement nature ,digital visualization, and display content from different view point.
- **Interactive Visualizations:** Interactive visualization allows different types of information access, query and understanding which is the interaction design and information visualization application areas.
- **Stories:** This is a imagine visualization type that convey and dissemination of knowledge efficiently through time and space. Use of story i.e. tells story, allows pass descriptive spirit image via oral or written language and can be used in tissue practice.

C. The Classification of Jonassen etc.

Jonassen etc. put forward five visualization ways commonly used as cognitive tools [6].

- Concept Map: as an important class of knowledge visualization tools, which is proposed by professor Novak of Cornell University in 1960s. In concept maps, concepts are connected by arrows and lines as nodes, hierarchy relationship between concepts is expressed by conjunction in order to represent and organize structure knowledge.
- Mind Map: mind map also known as mind mapping which is a visualization tool expressing divergent thinking effectively formed by summary study of famous British educator Tony Buzan in 1971. Mind Map combines images and text, performance relationship of themes at all levels with level map of level chart, establish memory links among keywords, image and color, make full use of left and right brain function, use the rule of memory, reading and thinking to help people develop balance in the science and art, logic and imagination, thus open the unlimited potential of human brain.
- Cognitive Maps: Cognitive map which are used to help people plan work and promote group's decision-making, also known as cause and effect diagram, based on individual constructive theory it was put forward by Ackerman & Eden in 2001, put "ideas" as nodes and connect them together to show "causality" or "cause", which is no level restrictions.
- Semantic Networks: relative to the production rules, they are mainly used to describe the main causal knowledge, and also can be used to express more complex concepts and their relationship, then form an semantic network figure. by the nodes and arc. Nodes connect by directed arc in the semantic network figure indicate things, and labels on the arc indicate the relationship between nodes. They can represent factual knowledge, and also relationship between them. Mainly reflect in the following aspects: fact, connection between things and more complex knowledge.
- Thinking Maps: thinking maps are proposed as visualization tools that used to help students create links between what they learn, and promote the development of cognitive construct by Dr. David Hyerle in 1988. Rather, thinking maps are visualization tools that used to construct knowledge, divergent thinking, improve the learning ability[7], which conclude 8 forms such as thinking maps, a total of parentheses maps, bridge plans, bubble diagram, circle diagram, double-bubble diagrams, flowcharts, flow charts and tree [8].

IV. THE COMPARISON OF THREE KNOWLEDGE VISUALIZATION CLASSIFICATION

Analysis of these three classification methods, it can be known that Eppler etc., pays attention to the visual way, so there are 18 species in Conceptual Diagrams; from the view point of emphasize the role of knowledge visualization played

to knowledge transfer, accumulation and concentrated, Burkhard etc., pay much attention to representation of different visual ways for different types of knowledge in the knowledge exchange process; however, from the view point of tools, Jonassen etc. focus on assistance to promote cognitive and then separate mind map into individual methods. Some of specific form of concept map (such as flow charts, circle graph, tree, etc.) in the classification of Eppler etc., are included in the range of thinking maps in the classification of Jonassen, etc., but from the perspective of abstract expressionism they are concluded to be general type of chart, meanwhile added a number of different forms with the other two (such as images, objects and stories, etc.) to other species in the classification of Burkhard. Compare with the above three knowledge visualization categories, it can be seen that there are cross-section among these categories of visualization methods formed from different angles or applications area, and also they focused on different according to different application areas.

V. CONCLUSIONS

In summary: knowledge visualization will not only help presentation and delivery of information, also to reconstruct it; can not only realize transmission of explicit knowledge, but also allows transmission of tacit knowledge; can not only create knowledge but also help understanding and collaboration. Therefore, knowledge visualization can play a significant role to improve knowledge expression, promote communication and improve people's learning performance. With gradual deepening of relevant theories and rapid development of technology supported, various applications of knowledge visualization will be gradually maturing, be in-depth application and popularization in education and other areas, so as to promote information transmission efficiency and improve quality.

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