# Augmenting Creative Design Thinking using Networks of Concepts

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**ABSTRACT**

Here we propose an interactive system to augment creative design thinking using networks of concepts in a virtual reality environment. We discuss how to augment the human capacity to be creative through dynamic suggestions providing new and original ideas, based on specific semantic network characteristics. We outline directions to explore the structures of the concept network and their connection to creative concept generation. It is expected that augmented creative thinking will allow the user to have more original ideas and thus be more innovative.

**Keywords**: Creativity, concept generation, creative thinking, augmented thinking, design thinking, concept network.

**Index Terms**: H.5.1 [Information Interfaces and Presentation (e.g., HCI)]: Multimedia Information Systems—Artificial, augmented, and virtual realities

## 1 REPRESENTATION OF CREATIVE DESIGN THINKING PROCESS

Creative design thinking remains a vague notion. It is still not clear how it can be systematically enhanced and augmented. Previous research investigated creative concept generation at an early stage of design [5, 7], thereby suggesting that it can be facilitated by using "semantic network" aids with certain structures. Semantic networks comprise words and semantic relationships between them; these networks are generated using a concept dictionary (e.g., WordNet, [2]), based on the user's verbalizations. Previous research described the network structure of the concept generation process [7], identifying certain structural characteristics in this thinking process that can lead to a highly creative design idea.

To augment and enhance creative design thinking, the idea proposed in this research agenda is to visualize and investigate the intricate structure of a semantic network of concepts in virtual reality. In our planned prototype, we have the option to utilize two types of virtual reality systems, i.e. HMDs such as the Oculus Rift or HTC Vive, as well as a CAVE system, with a panoramic stereoscopic rendering as virtual reality environment (Figure 1).

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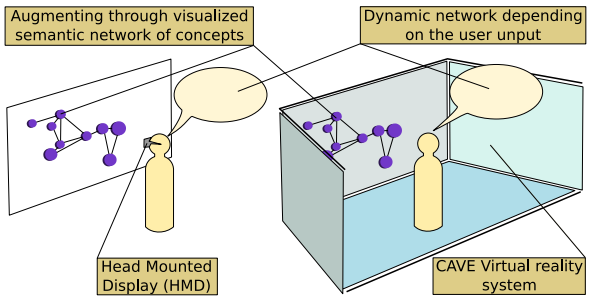


Figure 1: The proposed system concept (utilizing HMDs or CAVE).

We are interested in the structure of knowledge itself during concept generation or design thinking which results in an idea (whether it is an industrial, product, software, or any other kind of design) of high originality. To represent this structure, we propose a method in which a semantic network is a framework of the concept space (space of concepts in which the design thinking is performed). In particular, we are interested in the possibility of walking through a semantic network by using an immersive virtual reality system. The motivation to use virtual reality is based on: (1) Immersive characteristics of virtual reality can support inherent characteristics of creative thinking; (2) interaction characteristics of the virtual reality representation can contribute to the persuasiveness of concept generation as an activity, such as the concept of presence [6]; (3) high levels of presence in virtual reality have a positive impact on performance [1]; (4) exploration of the structural characteristics of the concept network can contribute to 'a-ha' or insight moments; and (5) dynamic interaction with network is expected to contribute to real-time feel in conjunction with the actual thinking process. Experimentation and supporting playfulness in tools have value that support creative thinking [4]. When people concentrate too much effort on how to use the tools themselves, they will have less cognitive resources left for use in finding creative solutions to their tasks [4]. Early virtual reality studies had concluded that immersive virtual reality systems increased user performance in tasks demanding spatial perception [6]. In addition, task performance will also increase due to increased attentional resources users allocated, if they experience high levels of presence [1].

## 2 METHOD AND EXPLORATIVE CASE

The method relies on the principle of a semantic network comprising the semantic relationship between words, such as hypernym–hyponym (hierarchical superordinate–subordinate) and other relationships. We use WordNet [2] as a tool to create a semantic network. WordNet is a large-scale database containing

information about the manner in which humans process language and concepts. We propose a 3D visualization for the network, where the nodes (words) and connections (relationships between words) would be visualized in a virtual reality. Such visualization would allow interactive examination of the network by walking through different network paths and examining the details, words, and their connections. The possible directions to explore and augment are outlined in Table 1. The particular plan for future experimentation with this visualization will request the participants to walkthrough the network (e.g., in a case with reference to a particular idea or product). Semantic networks have measurable network parameters, such as *path* and *density* [7]. By using such parameters, the semantic network structures for idea generation process perceived as one with higher creativity can be replicated in new idea generation processes.

Table 1: The directions to explore in creative concept generation.

| **Structures to explore in semantic networks** | **Connection to creative concept generation** |
|---|---|
| Exploration of related but divergent concepts | *Divergence* of concepts |
| Exploration of network of higher hierarchy concepts | *Abstraction* of concepts [8] |
| Exploration of distant concepts | *Longer paths* relate to originality [7] |
| Connection between two concepts through a part of the network with lower density | *Lower density* relates to originality [7] |
| Exploration of neighborhood of a concept with high number of links | *High number of links* to concepts relates to originality [7] |


Figure 2: Examples of base network and low density network.

Here, we discuss an explorative case of visualization of semantic networks as a preliminary investigation. In the proposed system, the 3D representation will aid the systematic walkthrough representations in accordance with the directions identified in Table 1. The benefits of 3D visualization over 2D will be a better understanding the networks, inter-connections, and structures, offering an additional degree of freedom. Furthermore, stereoscopic viewing could make graphs more readable, as overlapping and non-orthogonal nodes easily make graphs unreadable. The benefits over non-virtual and less immersive visualization will be in terms of immersiveness, interaction, exploration, and dynamics. In an example of implementation, we take the network between the concepts 'bird' and 'glass' as a base network (Figure 2), visualized in a CAVE environment. Example of low density network from the base network can be seen in Figures 2 (see Table 1) [3], visualized with Fruchterman Reingold 3D layout.

The following outcomes can be expected from interactions with such visualization: (1) Exploration of the relations and paths of design thinking, providing structure, and also associative clues; (2) realization or surprise regarding the characteristics of the design thinking process, externalizing inexplicit concepts that can lead to unexpectedness; and (3) reflections on design thinking and knowledge creation concerning the design thinking process.

## 3 Challenges to Address and Further Steps

Specific challenges and design issues to address in future implementation of working prototype are: (A) Dynamic construction of networks and visualization on the basis of searches in WordNet [2], (B) mode of user input and user's way to interact with the data, and (C) implementation of divergence and convergence activities in concept generation (the way the semantic networks change). Challenge (A) requires the implementation of searches in WordNet, construction of multiple networks and visualization of one network at a time (corresponding to a direction in Table 1). For challenge (B), we plan to use verbal user input (new words) and gesture-based interactivity/operation with the graph (selection of connections/views). Verbal input and gesture-based operation will allow natural interaction, blending virtual environment with the non-augmented thinking mode. Interactivity is a very important element in almost any information visualization system [9]. Challenge (C) will require limiting the number of network nodes visualized based on the time of visualization and user operation.

Further research will include the use of such network visualizations in an experiment, comparing unaided and aided idea generation on exposure to stimuli (in accordance with Table 1). We expect CAVE to be a better environment for augmenting design thinking, being closer to existing modes of design thinking. We expect that augmented design thinking will result in ideas that exhibit greater originality and overall creativity.

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## References

[1] Karl-Erik Bystrom, Woodrow Barfield, and Claudia Hendrix, "A Conceptual Model of the Sense of Presence in Virtual Environments", *Presence: Teleoperators and Virtual Environments*, 8(2), pages 241–244, 1999.

[2] Christiane Fellbaum, *WordNet: An Electronic Lexical Database*. Cambridge, MA, MIT Press, 1998.

[3] Ivan Herman, Guy Melançon, and M. Scott Marshall, "Graph visualization and navigation in information visualization: A survey", *IEEE Transactions on Visualization and Computer Graphics*, 6(1), pages 24–43, 2000.

[4] Mitchel Resnick, Brad Myers, Kumiyo Nakakoji, Ben Shneiderman, Randy Pausch, Ted Selker, and Mike Eisenberg. *Design principles for tools to support creative thinking*, working paper, 2005.

[5] Nicole M. Segers, "*Computational representations of words and associations in architectural design*", Doctoral dissertation, Technische Universiteit Eindhoven, 2004.

[6] Mel Slater, and Sylvia Wilbur, "A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments", *Presence: Teleoperators and Virtual Environments* 6(6), pages 603–616, 1997.

[7] Toshiharu Taura, Eiko Yamamoto, Mohd Y. N. Fasiha, Masanori Goka, Futoshi Mukai, Yukari Nagai, and Hideyuki Nakashima, "Constructive simulation of creative concept generation process in design: a research method for difficult-to-observe design-thinking processes", *Journal of Engineering Design*, 23(4), 297–321, 2012.

[8] Thomas B. Ward, Merryl J. Patterson, and Cynthia M. Sifonis, "The role of specificity and abstraction in creative idea generation", *Creativity Research Journal*, 16(1), pages 1–9, 2004.

[9] Ji Soo Yi, Youn ah Kang, John T. Stasko, and Julie A. Jacko, "Toward a Deeper Understanding of the Role of Interaction in Information Visualization", *IEEE Transactions on Visualization and Computer Graphics*, 13(6), pages 1224–1231, 2007.