Tool and Evaluation Method for Idea Creation Support

Ryo Takeshima and Katashi Nagao
Department of Media Science, Graduate School of Information Science, Nagoya University, Nagoya, Japan

Keywords: Idea Creation, Idea Evaluation, Digital Poster, Meeting Support, Collaboration, Machine Learning.

Abstract: We have developed a new idea creation support tool in which (1) each idea is represented by a tree structure, (2) the idea is automatically evaluated on the basis of the tree structure so that the relative advantages among several alternative ideas is found, (3) the ideas are presented in a poster format, and (4) the ideas are shared by multiple users so that the ideas can be quoted and expanded upon by individual users. In this work, we explain the mechanisms of this tool, including the evaluation and poster conversion of ideas and collaborative idea creation, and briefly discuss our plan for the future.

1 INTRODUCTION

Although it is well-known that idea creation and sharing are beneficial, and a variety of tools for this purpose have been developed, it is still very difficult to automatically evaluate the quality of an idea. Previous idea creation support tools have contributed to the creation, organization, and visualization of ideas, but they have not provided a function for evaluating the created ideas. We have therefore developed a method to relatively evaluate ideas by assessing the appropriateness of the data representing the ideas.

First, our developed tool helps users express the idea in a tree structure and then creates a presentation in a poster format on the basis of this structure. The tool accesses the database of the idea, called the "idea pool", to search and share ideas in the tree structures. The tree structure consists of a title to express the idea, its description, relevant keywords and their descriptions, images, Web pages, and videos as nodes and is defined by the hierarchical relationship between the nodes. Similar methods to express ideas by tree or graph structures have been proposed, a typical example of which is the Mind Map (Buzan, T., 1990) (Beel and Langer, 2011).

To clearly visualize the idea expressed in a tree structure, we developed a method of displaying the idea by a poster representation. This method arranges the contents of the nodes on the screen on the basis of the tree structure of the ideas. The created poster is interactive: any node (a block in the poster) can be displayed in more detail when the user selects and requests. This refinement does not merely enlarge the block—it also compensates for a convenient portion omitted by the area constraint and customizes the content to fit the larger area. We call this "semantic zooming."

Using poster representations enables an easier presentation of ideas, and hopefully additional ideas will be generated by the presentation and subsequent discussion. The poster can be shared by a group of users, along with its underlying tree structure. By reusing the shared poster, additional ideas of the community members can be integrated with the original idea.

Evaluating the ideas expressed in a tree structure makes it possible to prioritize the ideas. When additional resources are required to realize the idea, the priority can be a guide for optimally allocating the resources. Evaluation of the tree structure becomes more accurate if nodes with more abstract content are close to the root and nodes with more specific content are closer to the leaf of the tree structure. This enables a user who wants to know the outline to simply refer to the node of the parent and a user who wants to know specific examples and details to refer to the child nodes of the tree structure. This tree structure is considered suitable to describe well-organized ideas. While there is currently no guarantee that the excellence of the tree structure leads directly to the excellence of ideas, we feel it is obvious that more organized ideas can be found if the data is structured appropriately.

Evaluation of the tree is currently being carried out by analysis of the text in each node. First, the evaluation method performs a morphological analysis

Takeshima, R. and Nagao, K..
Tool and Evaluation Method for Idea Creation Support.
In *Proceedings of the 7th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2015) - Volume 1: KDIR*, pages 358-363
ISBN: 978-989-758-158-8

on the text in the node, then it segments the text into a word sequence, and finally it extracts its content words. Each content word is converted into a vector representation. This vectorization uses a machine learning algorithm called word2vec (Mikolov et al., 2013a) (Mikolov et al., 2013b). Wikipedia content was used for the learning of word2vec. Using the vectors of the word sequence, the method calculates the semantic distance between the tree nodes and the direction of abstraction based on the inner product of the vectors. Each tree node is vectored as a mean vector of the word vectors of its text content. If semantic distances between the parent node and several child nodes are closer, the tree structure is better balanced, and if the inner product of the difference vector of the parent node and its child node and the difference vector of its child node and its grandchild node is larger, the abstraction direction of the tree is more semantically coherent. On the basis of this vector calculation, we can determine the relative advantages of the ideas in the tree structures.

Our idea creation support tool always calculates the evaluation value of the idea and feeds the results back to the user, thus helping the user create a more sophisticated idea.

In this paper, first, we describe the support tool to express an idea in a tree structure and the mechanism to clearly visualize it by a poster. Next, as a means to compare the ideas expressed in a tree structure, a method of calculating the priority of the tree structure is presented. Finally, in order to facilitate idea creation in a group, we explain our meeting support system, which presents a poster at a meeting and enables the idea to be shared among all members. The system aggregates the ideas evolved by each member and integrates them into a larger tree structure.

2 IDEA CREATION SUPPORT TOOL

2.1 Problem of Idea Creation

Idea creation is a central part of activities such as research and product development. In idea creation, it is important to know the entire content of the theme being discussed, including peripherals such as background and potential applications of ideas.

If we do not have an overall picture of the idea, there is a danger of becoming too focused on the less essential issues, which sometimes causes delays in progress. If the idea creation is completed in a short period, grasping the overall picture is relatively easy. However, when idea creation requires a longer period of time, it becomes difficult. In this latter case, it is effective to hear the opinions of others in periodic presentations. However, in a presentation, the focus is often on the local problems of ideas, and it is generally quite difficult to evaluate such a discussion in a way that encompasses the orientation of overall ideas.

2.2 Related Work

So far, there have been a few tools and methodologies developed to support idea creation.

A typical example is the Mind Map (Buzan, T., 1990) (Beel and Langer, 2011), which represents an idea graphically by showing the relationship between the elements of ideas in a tree structure. However, the ability to create an intuitively understandable expression depends on the author: the tool does not automatically calculate the appropriateness of representation and does not give any advice to improve the content.

For collaborative idea creation, we typically conduct meetings in order to develop the idea. There are various systems in place to record the meeting content in chronological order and allow members to search and summarize the contents (Ishitoya, Ohira and Nagao, 2009). However, we feel it is not appropriate to use the time-series structure to represent the content created during idea creation activities because often several ideas are developed in parallel and we sometimes reconsider previous ideas. It is impossible to fully grasp the overall idea when information is presented in sequence.

2.3 How to Support Idea Creation

Structurally describing the contents of an idea may impose a large burden on the user, as it may entail not just the description of notes and sketches but also an awareness of the relationships between these. Moreover, with the concept of the description, it starts out as an abstract description and then the tree structure typically divides into more specific examples of the description. However, in the process of refinement, another abstract description may be derived, which may worsen the balance of the tree structure. This makes it difficult to grasp the overall picture. Therefore, in this work we focused on how the presentation should be performed in order to best explain the ideas to others.

In a typical presentation, visual aids such as slides and posters are required. Therefore, we developed a tool that can be used to create the tree structure of the idea easily and create a poster automatically. Figure 1 shows an example screen of the developed tool. Posters created by this tool are called "digital posters" and can include various contents such as text, images, videos, and slides. Moreover, interactive operation of the posters is possible, such as video playback and slideshows.

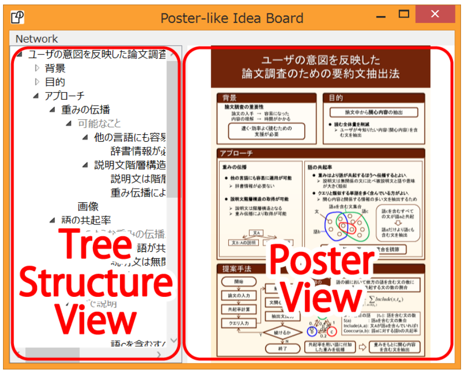

Figure 1: Example screen of the developed tool.

The user can easily estimate the appropriateness of the tree structure rather than simply creating the tree structure data because the tree structure is automatically converted into a poster by the system. Moreover, since the user can directly use the outcome of the idea creation in the presentation, the system helps suppress any decrease in motivation for idea creation.

2.4 Semantic Zooming

It is difficult to display the whole idea on one poster as the tree structure of ideas is expanded and the complexity of the idea increases. Therefore, the system calculates the score of each node by using the hierarchical relationships in the tree structure and the attributes added to each node by the user. Then, according to the score, the system presents the content in a simplified manner. When the user wants to view the nodes with the lower scores in more detail, he or she just selects them in the poster and requests their expansion. Expansion of the nodes does not just magnify them visually—they are also semantically refined in an operation called "semantic zooming". Semantic zooming displays the abbreviated content of the selected node according to the size of the usable area. An example of semantic zooming is shown in Figure 2.

It is possible to arbitrarily change the degree of omission according to the importance of the content of each node, and it is also possible to adjust the visibility of each node.

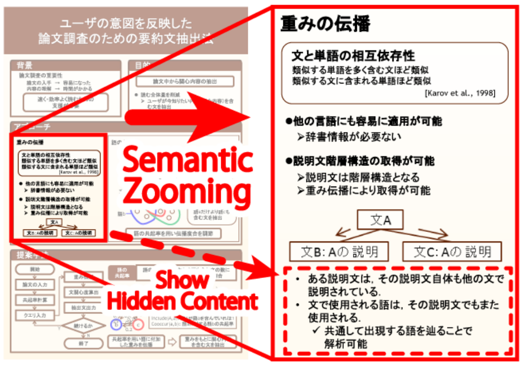

Figure 2: Semantic zooming.

Semantic zooming is available not only during a presentation but also whenever the users who are sharing a poster feel they want to.

3 IDEA EVALUATION METHOD

Sophisticated ideas can be expressed as a semantically good balanced tree structure. The semantically good balanced tree has parent and child nodes that constitute an abstract/concrete relationship. In other words, if the higher-level nodes of a tree include abstract descriptions and the lower-level nodes of the tree include concrete and detailed description of the contents of their parent nodes, the tree is semantically well-organized, i.e., the idea is deeply constructed. While it sometimes happens that interpretation of an abstract/concrete relationship between two nodes changes by the context, the meaning of that hierarchy will be well-defined if the parent node has multiple child nodes. Therefore, it is possible to calculate the semantic relevance of the tree on the basis of the appropriateness of an abstract/concrete relationship to a node having multiple child nodes. It is also possible to evaluate the quality of ideas on the basis of the evaluation of trees. In this case, we consider only the node containing the text and will find another mean for the nodes of the images and video.

3.1 Conversion of Tree Node to Vector

To calculate the appropriateness of the abstract/concrete relationship, our proposed method converts the node to a vector representation that enables numerical operation between nodes. For the vector of the node, we utilize the vector representation of the word, called "word2vec" (Mikolov et al., 2013a) (Mikolov et al., 2013b). word2vec uses a neural network called a "Skipgram" along with the result of the machine learning from text corpora.

First, using word2vec, the method obtains vectors of words contained in the node. We used Wikipedia text for the learning of word2vec. The number of dimensions of the vector to be learned was set to 200. For the input and output of the Skipgram neural network, we used the basic form of the noun and the verb, respectively. This is due to the fact that nouns and verbs represent the characteristics of the contents of the node. An intermediate layer of Skipgram is the word vectors of interest, and on the basis of this, the method calculates the vector of the node, as follows. The statements contained in the node are morphologically analysed to extract the basic form of the nouns and the verbs. Using word2vec, the method obtains a vector representation of the extracted word.

$$\overrightarrow{N_i} = \frac{\sum_{w \in N_i} Vector(w)}{Count(\mathrm{w} | \mathrm{w} \in N_i)} \qquad (1)$$

By formula (1), the method calculates a mean vector of words ($Vector(\mathrm{w})$) contained in the node(N_i) and treats it as a vector for the node. Regression analysis is performed using a set of average vectors of nodes in the multiple layers of the tree structure.

As a result, it discovers the axis of the concept of the word meaning that represents the abstract/concrete relationship of the tree structure. The distance between the vectors of the nodes represents the degree of the difference of meaning of the descriptions of the nodes. As shown in Figure 3 and Figure 4, when three nodes A, B and C are close to the axis of the abstract/concrete relationship, it can be said that A has a description that is an abstract or concrete version of the description of B and C. If node D is separated by a greater distance from the axis, it is considered that D has no strong abstract/concrete relationship with A, B and C.

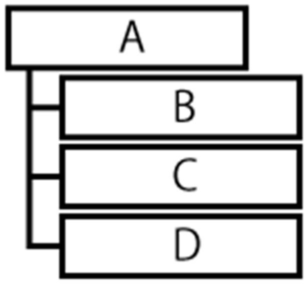

Figure 3: Tree structure of idea.

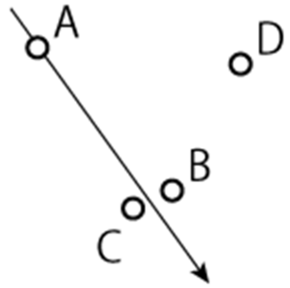

Figure 4: Abstract/concrete relationship.

3.2 Priority of Idea

To determine superiority or inferiority among ideas, it is judged whether the parent and child nodes of the tree structure have an appropriate abstract/concrete relationship. For a certain subtree, a preference in terms of how appropriate the abstract/concrete relationship is between the root node and its child nodes is determined on the basis of the following three evaluation values.

The preference of a subtree is higher if the average error of the distance between the root node and its child nodes is smaller. The distance between nodes represents a difference of their meanings. For parent-child relationship between nodes, when the distances between the parent node and multiple child nodes are equal, it indicates that the level of meaning between child nodes is similar. In a subtree, the root node A and its child nodes B, C, and D are like Figure 5, where nodes B and C have the same distance from node A. This means B and C are more appropriate as the child nodes of A. Meanwhile, node D is separated by a greater distance from node A in comparison with other child nodes. This suggests that there is some problem with connecting node D directly with node A.

- The preference of a subtree is higher if the sum of the distances of the child nodes from the axis of the abstract/concrete relationship of the subtree is smaller and the child nodes are close to the higher concreteness position of the axis. When the distances between the parent node and its child nodes are almost equal, if the child nodes are located on the axis representing the abstract/concrete relationship of the subtree, the content of the parent node is considered an abstraction of the content of all the child nodes. In Figure 4, the distance between the parent node A and the child nodes B, C, D are equal, and nodes B and C are close to the axes representing the abstract/concrete relationship, so the content of node A is an abstract of the contents of B and C. While the distance between A and D is the same as that of the other child nodes, it is located further away from the axis representing the abstract/concrete relationship. Therefore, we assume that node D has something wrong in its content or its position in the tree.

- The preference of a subtree is higher if the cosine similarity between the axis representing the abstract/concrete relationship of subtree A and the axis representing the abstract/concrete relationship of subtree B whose root node is a child node of A is larger. If the abstract/concrete relationship between parent and child nodes of the subtree and that between the child node and the grandchild nodes is similar, it is considered to have an appropriate abstract/concrete relationship between the root node and its grandchild nodes in the subtree.

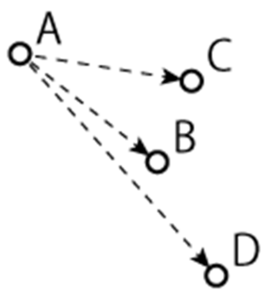

Figure 5: Distance between nodes.

An evaluation value of the tree structure is calculated for comprehensively evaluating the above three features. When several ideas are being considered, or when several alternatives are possible to embody a certain idea, the tree structure of the idea is evaluated to determine the relative advantages of the alternative ideas by using this formula.

4 COLLABORATIVE IDEA CREATION

4.1 Quotation of Ideas

Members of a group can share posters used at the presentation through a common server. When the poster is shared, its underlying tree structure of ideas is also automatically shared, and then it becomes quotable.

Each member has his or her own idea pool in which they can store the idea(s) they have created. The ideas that others have shared are stored in a separate pool.

A user can quote ideas by combining some of the ideas of the others with his or her own. In this operation, the entire or part of a tree structure is copied and pasted as a child of a node of the other tree structure as shown in Figure 6.

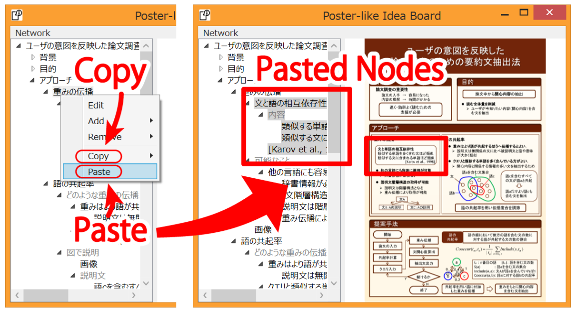

Figure 6: Copy and paste of subtree.

Two types of copy are possible: one, a quotation of the idea itself (hot copy), and two, a duplication of ideas that have been shared (cold copy).

With hot copy, when the original creator of the ideas that are shared edits them, the editing result is reflected in the copied nodes. However, a quoter cannot edit the content of the copied nodes. Moreover, the quoter is able to know when information has been edited by the original creator and can decide whether to reflect the result of that edit. After browsing the results of editing, the quoter can cancel the change and restore the content to that of before editing.

With cold copy, a quoter can edit the content of the idea that was copied and quoted. It is possible to notify the original creator when the quoter has edited it. Then, the original creator can refer to the results of editing and decide whether or not to modify the idea.

This mechanism of quoting ideas makes collaborative idea creation by a group more feasible.

4.2 Synergy of Idea Creation

Idea creation by a group proceeds by the group members sharing, quoting, and expanding ideas. However, in many cases, members get caught up on insignificant details, and the idea is likely to diverge. By integrating and evaluating ideas that have evolved separately, the proposed system attempts to converge several ideas to create a more sophisticated one.

For this purpose, first, a tree structure is integrated on the basis of quotation history. For hot copy, the quoted results are shared when they are used in the presentation. If the version of the quoted idea is not changed, it is possible to integrate the idea automatically. If the original idea has been edited, the system integrates the original and quoted ideas after some minor editing. In the case of cold copy, the original idea has been edited, so the system cannot perform a simple integration. The system splits the tree structure, or the original creator adopts a change, and then it is possible to integrate.

After ideas are integrated, the resulting tree structure can be very complex. The system therefore uses the tree structure evaluation mechanism to evaluate the tree and help users simplify the idea.

First, the system individually evaluates the branched subtrees and identifies their relative advantages. Also, during the presentation, the system prompts users to vote on parts of the poster content and assigns these additional evaluation values to the nodes of the tree.

The system selects and adjusts the idea on the basis of its evaluation of the tree structure and presentation.

Idea selection is done by choosing the subtree that has the highest value from among an assortment of subtrees. Idea adjustment is done by correcting the position or modifying the contents of the node as the evaluation value of the tree structure becomes higher.

Our proposed idea creation support tool is designed to help users perform these operations easily. The system can hide the less important subtrees by adding the attribute to their root nodes. The evaluation value is recalculated after editing the contents and relocating the nodes.

4.3 Task Management

Meetings for idea creation can include managing tasks and keeping task of the progress required to achieve the idea. In such cases, the tasks include research to refine the idea and prototyping to embody the idea.

The system inserts a node that represents the content and the progress of the task to the node of the corresponding idea. Each group member uses this meeting support function to keep track of the achievements and priority level of his/her tasks.

The degree of achievement depends on how much refinement and implementation of the idea have been achieved, and priority is quantified by whether the task contributes to any part of the tree structure of ideas (the node that is closer to the root node has a higher priority).

The productivity of meetings is greatly improved since the refinement of ideas and the task management are carried out at the same time.

5 FUTURE PLAN

The primary focus of our future work will be the operation and evaluation of the developed tool. On the basis of operational experience with other tools (Ishitoya, Ohira and Nagao, 2009), we will perform a three-month trial and refine the tool. After that, we will deploy the tool in a more ordinary situation for more than half a year.

In particular, we will evaluate the effectiveness of the evaluation of the idea by the tree structure. We will explore whether the evaluation of the abstract/concrete level in the hierarchy of the tree structure contributes to a reasonable indication of ideas that have been well-organized.

We innovate human creative activities by the practical application of the idea creation support tool that is the result of this study.

Detailed data on the various intellectual activities of human beings collected by our system can be made available by integrating an idea creation support tool such as the Mind Map, a presentation tool such as PowerPoint, or a task management tool such as groupware. The collected data is a good guide for considering the relationship between structures of ideas and ease of understanding presentation, for enabling idea integration by adjusting tree structures, and for optimizing design and management methods of tasks for the implementation of ideas.

In the near future, the accuracy of machine learning will improve, which will lead to even better support of idea creation and implementation.

REFERENCES

Buzan, T., 1990. *Use Both Sides of Your Brain*. Plume Books.

Beel, J. and Langer, S., 2011. An Exploratory Analysis of Mind Maps. In *Proceedings of the 11th ACM Symposium on Document Engineering*, pp. 81-84.

Mikolov, T., Chen, K., Corrado, G. and Dean, J., 2013. Efficient Estimation of Word Representations in Vector Space. *arXiv preprint*, arXiv:1301.3781.

Mikolov, T., Sutskever, I., Chen, K., Corrado, G. S. and Dean, J., 2013. Distributed Representations of Words and Phrases and their Compositionality. In Burges, C. J. C., Bottou, L., Welling, M., Ghahramani, Z. and Weinberger, K. Q. (eds), *Advances in Neural Information Processing Systems*, pp. 3111-3119.

Ishitoya, K., Ohira, S. and Nagao, K. 2009. TimeMachineBoard: A Casual Meeting System Capable of Reusing Previous Discussions. In *Proceedings of the Fifth International Conference on Collaboration Technologies*.