# Interactive Keyword Map Equipped with Focus+Edit Function


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**Abstract:** Information visualization systems based on graph drawing have been used in various fields such as creative thinking support and knowledge management. However those systems have focused on how to visualize the data space, and have not paid enough attention to interactive facilities. In this paper, the interactive keyword Map system that enables users to edit keyword arrangement is proposed. Experimental results show the system can provide users with useful functions according to their purposes.


## I. Introduction

Automatic drawing methods of graphs have been widely studied in the field of informational visualization[1]. Various techniques have been proposed aiming at beautiful drawings[2]. Among them, the Keyword Map system that employs graph expression is effective for users to intuitively grasp various structures formed by keywords. However, the functions to edit a graph structure by users is restricted, and its interactive nature is inadequate.

In this paper, an interactive Keyword Map system is proposed, which enables users to dynamically edit keyword arrangement. In order to help users to focus on and edit interesting part of the map, several Focus+Edit functions are proposed, each of which is realized based on the spring model.

An interactive Keyword Map is developed with Java, which is evaluated through experiments with test subjects.

## II. Spring model with Force-directed method

A Keyword Map is a system that arranges keywords in a 2D plane, so that users can grasp easily the relationship among keywords.

In this paper, a spring model, which is one of the force-directed graph drawing methods, is employed for arranging keywords dynamically.

The imaginary elastic force energies arise in graph is defined by Eq.(1).

$$E = \sum_i \sum_j \frac{1}{2} k_{ij} \left(d_{ij} - l_{ij}\right)^2 , \quad (1)$$

$$d_{ij} = \sqrt{\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2} . \quad (2)$$

The $k_{ij}$ is a spring constant between keywords $i$ and $j$, $d_{ij}$ defined by Eq.(2) is a distance between the keywords $i$ and $j$ on a drawing plane. The $l_{ij}$ is the spring length between the keywords $i$ and $j$.

Since the total energy of all keywords represents the degree of graph distortion, the optimal arrangement that faithfully reflects the structure of the original data can be obtained when $E$ has the minimum value.

The moving distance of keyword $i$ in each step is expressed with the following partial differentiation of $E$.

$$\Delta x_i = c \frac{\partial E}{\partial x_i} \ , \ \Delta y_i = c \frac{\partial E}{\partial x_i} . \quad (3)$$

The $c$ is arbitrary positive constants, and enlarging this value makes $E$ converge quickly.

The $l_{ij}$ is defined based on their relevance $R_{ij}$ ($\in$ [-1,1]) in the original data(Eq.(4)).

$$l_{ij} = m\left(1 - R_{ij}\right). \quad (4)$$

By repeating this calculation and updating coordinates, a keyword arrangement are closing to one of local optimal arrangements. That is, the keywords with the high $R_{ij}$ will be arranged close to each other, while those with low or negative $R_{ij}$ will be arranged far away from each other.

## III. Focus+Edit functions

Although Keyword Map visualizes the relationship among keywords in the data, users sometimes feel that the arrangement is different from what they expected. In such a case, they want to edit the arrangement as they like. The capability of editing keyword arrangement is also important for supporting divergent thinking process.

When a user edits the keyword arrangement on a map, he focuses on the interesting keyword and modifies its relationship (i.e. distance) with other keywords. Therefore, an interactive Keyword Map should support users' focusing and editing operations. In this paper, those functions that support users' focusing and editing operations are called Focus+Edit functions.

Since the spring used for keyword arrangement is a virtual one, not only a spring length but a spring constant is also variable. This section proposes several Focus+Edit functions, each of which is realized based on spring model.

### A. Rivet Function

When a user is focusing on a keyword, he might want to fix its position. The rivet function is used to put any keyword on arbitrary position in the map. Users can use this function by simply dragging a keyword to where they like with mouse operation. The keyword in the fixed position with rivet function is said to be in focused state.

Since the positions of other keywords are rearranged automatically with Eq.(3), the map is redrawed dynamically. Moreover, if focus setting of a keyword (the focused state of a keyword is toggled by a left click) is canceled, it gets to be automatically arranged again.

### B. Change of focus level

When a user wants to focus on the relationship between the focused keyword and others, he can increase the spring constants of those connected with focused keyword. A user can specify arbitrarily the value of those spring constants and a keyword with high focus level can form a cluster with related keywords.

### C. Total enlargement and reduction

All spring lengths on a map can be adjusted at the same time, according to the size of a drawing plane.

On the other hand, there is a function to magnify only the partial area around a focused keyword. This function is realized by lengthening only those springs connected to the focused keyword[3].

## IV. Interactive Keyword Map system

The Keyword Map system equipped with the Focus+Edit functions proposed in sec.III is developed with Java. This system reads the data which consists of keyword pairs with their spring lengths, and generates a keyword map on a 2D plane(Fig.1). A user can click any keywords in which he gets interested and can move them as he likes. Moreover, one of slider bars below the map can adjust the focus level of the selected keyword in the map(Fig.2). A user can use these Focus+Edit functions for editing the structure of a map arbitrarily. Appearance of rearranging keywords is shown as smooth animation, which will give a user the feelings of "having his own structure", which will contribute to promote creative thinking[4].

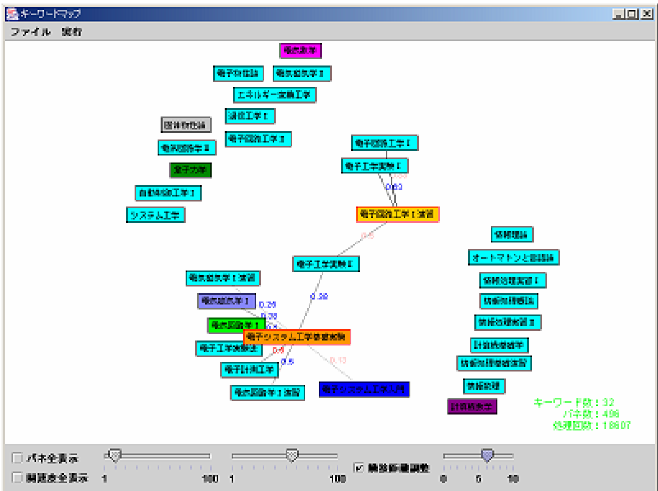

Fig.1 Developed Keyword Map system

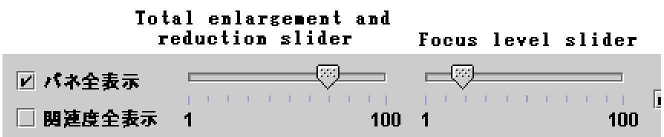


Fig.2 Slider bars

## V. Experiments

Five subjects (A-E) used the Keyword Map system. While each subject is using the system, the change of elastic force energy is measured. After the experiments, the questionnaire are performed for evaluating Focus+Edit functions. Data sets for Keyword Map are prepared for each subject with the topic in which he is interested.

### A. Change of elastic force energy

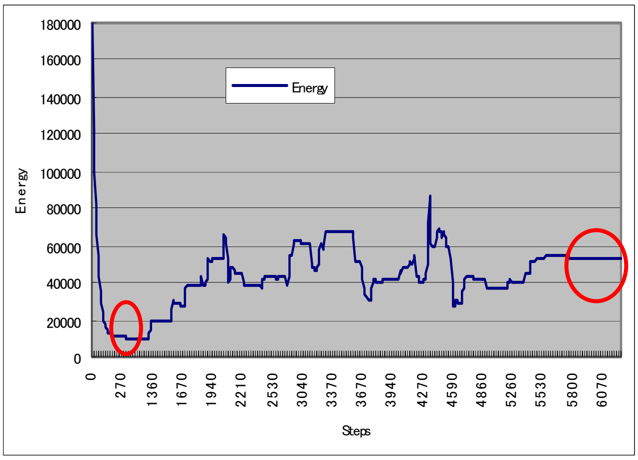


Fig.3 Energy change in time series

Fig. 3 shows the change of energy(Eq.(1)) during the experiment by one subject, from when automatic arrangement starts to when he finishes editing. In Fig.3, there is two stable states enclosed with a circle, first one(around 300 steps) corresponds to initial arrangement, and second one(5800-6230 steps) corresponds to the final arrangement. Energy in the final arrangement is higher than that of initial arrangement. This shows Keyword Map has been distorted from ideal arrangement by user's editing operations.

Moreover, there are many spikes in Fig.3, which occurs when the subject edits keyword arrangement. That is, as a result of making several trials and errors, he obtains the final arrangement. These characteristics are observed for all subjects.

### B. The Evaluation of Focus+Edit functions

Each subject is asked to evaluate each Focus+Edit function on a scale of 1 to 4. Furthermore, subjects are asked to give as many comments as possible.

Table1 briefly shows each subject's task, and Table2 summarizes the evaluation scores of Focus+Edit functions by each subject. In Table2, the "Displaying all springs" function displays all springs between keywords. The "Displaying all $R_{ij}$s" function displays $R_{ij}$s for all keywords. The "Contiguity Adjustment" function avoids the overlapping of keywords on a map. Table2 shows that the functions for editing operations obtain a high score, and all subjects give high score to the "Total enlargement and reduction" function.

Table1 Subject's tasks

| | Task |
|---|---|
| A | Classify medical terms. |
| B | See the information available on the Web regarding local sightseeing spot and related events. |
| C | Look for hub sites[5]. |
| D | Explore relationship between interesting terms about art. |
| E | Find other news articles from the term that is contained in the news article about a certain accident. |

Table2 Evaluation of Focus+Edit functions

| | A | B | C | D | E |
|---|---|---|---|---|---|
| Rivet function | 4 | 4 | 1 | 4 | 4 |
| Focus only (auto arrangement) | 4 | 2 | 4 | 1 | 3 |
| Displaying all springs | 1 | 2 | 4 | 2 | 1 |
| Displaying all $R_{ij}$s | 1 | 1 | 4 | 3 | 1 |
| Total enlargement and reduction | 4 | 4 | 4 | 3 | 4 |
| Change of focus level | 1 | 2 | 4 | 3 | 4 |
| Contiguity adjustment | 2 | 4 | 2 | 2 | 4 |

It is found that the subject C evaluates rivet function with low score, and gave a comment that it is unnecessary. Because he is interested in only the connection between keywords, he did not have to move any keyword. Instead, he highly evaluate "Focus only" function. That is, it can be seen from Table2 that subject C's evaluation is opposite to other subjects' evaluation.

When the purposes and the attentions of the subjects during the experiments are investigated in terms of their tasks, it turns out that subjects are separated into two groups (C and others) as shown in

Table3. The table shows that required function is different in each group. Therefore, it can be said that the proposed system is equipped with the functions that satisfies users' various requirements.

Table3 Purpose and required functions for each group

| | Purpose of use | Focused objects | Required function |
|---|---|---|---|
| Type1. A,B,D,E | Looking for interesting keywords. | Keyword itself. | Rivet function. |
| Type2. C only | Looking for keywords related with many keywords. | Graph structure. | Displaying all springs. |

## VI. Conclusion

The interactive Keyword Map system is proposed, which has various Focus+Edit functions based on spring model. The experiments with test subjects are performed, of which the results are examined in terms of their tasks and purposes. It is shown clearly that there is a strong relation between the purpose of use and required functions. Future work will include the improvement of Focus+Edit functions aiming to give the system with more flexibility, and also the application of developed system to Web Information Retrieval[6].

## References


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