Regular Paper

A Spiral-type Idea Generation Method Support System for Sharing and Reusing Knowledge and Information Among a Group

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We have developed an idea generation support system, called GUNGEN-Spiral. GUNGEN-Spiral supports collecting ideas, saving ideas, sharing ideas, shaping ideas and reusing ideas. The system consists of GMemo running on a Personal Digital Assistant (IBM WorkPad), Wadaman (Whole mediA DAta MANagement system), WWWW (World Wide Web Wadaman, W4) and GUNGEN (GroUpware for a New idea GENeration consistent support system). Users can collect and input ideas in free handwriting using GMemo immediately anytime and anywhere, and the ideas are saved in Wadaman and shared all together using W4 on the Internet. Moreover, participants use those ideas directly as data for GUNGEN. We can reuse the results of GUNGEN as topics for further ideas, and others' ideas sometimes give rise to new ideas. We have applied this system on a trial basis.

1. Introduction

Ideas may be flashed anytime and anywhere. Ideas should be stored immediately, because they will disappear immediately. We have developed an idea generation support system, called GUNGEN-Spiral. GUNGEN-Spiral supports collecting ideas, saving ideas, sharing ideas, shaping ideas and reusing ideas. The system consists of GMemo running on a Personal Digital Assistant (IBM WorkPad)[1),2)], Wadaman (Whole mediA DAta MANagement system)[3)], WWWW (World Wide Web Wadaman, W4) and GUNGEN (GroUpware for a New idea GENeration consistent support system)[4),5)]. Users can collect and input ideas in free handwriting using GMemo immediately instead of paper media (e.g., Post-It notes) anytime and anywhere. The ideas are saved in Wadaman and are all shared together using W4 on the Internet. Wadaman is a multimedia database system based on Umesao's card system. Moreover users can also use ideas, which were written in free hand, as data for GUNGEN directly. GUNGEN is a system that supports the KJ method on computers connected to a network. The KJ method is one of the most well known idea generation methods in Japan. GUNGEN has a shared window, multimedia communication functions (text-based chat, video and voice). We can reuse the results of the KJ method, performed by GUNGEN, as topics for further ideas, and others' ideas sometimes give rise to new ideas.

This paper describes the design policy of GUNGEN-Spiral, the features and the application results of GUNGEN-Spiral to idea generation support. We evaluate the effectiveness of GUNGEN-Spiral for idea generation in this paper.

2. A Concept of a Spiral-type Idea Generation Method

Our system is partly influenced by Umesao's card system. It is important to give an overview of Umesao's card system and the KJ method before describing the spiral-type idea generation method.

2.1 Umesao's Card System

Umesao's card system was developed in the 1950's[6)]. The card system was originally developed for the field of anthropology. The card system consists of cards and card boxes. The card size used is B6. Users must write one memorandum on one card, because cards are categorized after being saved. Time, recording person, place recorded, and information source must be recorded together. A card is copied for a personal use card and a shared use card. Persons share their cards and use them for idea generation for intellectual work. The elaborated process of Umesao's card system was said to be a KJ method.

2.2 The KJ Method

The KJ method is known as a method for establishing an orderly system from a chaotic

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mass of information[7),8)]. The KJ method was developed by Jiro Kawakita. This method is called KJ method after his initials. This method was originally developed for anthropological fieldwork to extract the relation that leads to findings from gathered and stored data. The KJ method as applied to technical innovations is the systematization of brainstorming and its focusing. The feature of the KJ method is cooperative work toward innovation. The KJ method has been used for software requirement analysis in Japan[9)]. The KJ method is a text-based idea generation support method.

There are three kinds of KJ methods corresponding to the managing range: the narrow sense KJ method, the broad sense KJ method and the cumulative KJ method. The so-called KJ method seems to be the narrow sense KJ method. The narrow sense KJ method can be divided into the A type KJ method, by which the relation between proposals is visually illustrated, and the B type KJ method, by which a conclusive composition is written to summarize a discussion. The narrow sense KJ method consist of four steps:

(1) Proposing ideas

In the first step, participants propose their ideas on to a theme, and they write down each idea on a tag (a small piece of paper) and put them on a table. Participants must propose their ideas without hesitation. This step corresponds to brainstorming. It is also important for participants to be inspired to come up with new ideas based on others' ideas.

(2) Grouping ideas into islands

In the second step, the participants examine these tags and classify them into groups through discussion. The criterion for this grouping is not the category of ideas but their similarity. Each group is called an island and given a representative title.

(3) Illustrating relations between islands

In the third step, the participants look for an arrangement that expressed mutual relation of the representative titles spatially. Then the participants connect the related representative titles together in a certain kind of line.

(4) Writing a conclusion

In the last step, the participants write a conclusive composition. They should not express their opinions but should write the conclusive composition based on the data itself.

The broad sense KJ method starts from the idea collection process in the field and other steps are the same as that of the narrow sense KJ method.

The cumulative KJ method uses both the A type and the B type KJ method normally, but our system uses only the B type KJ method. The cumulative KJ method is used to reiterate the broad sense KJ method. Kawakita stated that the cumulative KJ method was useful to solve difficult problems[8)].

A spiral-type idea generation method means the cumulative KJ method. The name 'spiral-type' comes from the contents of Kawakita's book[10)]. We believe that it needed to support the cumulative KJ method (repetition of the broad sense KJ method) as an idea generation support system. Generally, many ideas are required in order to obtain good results by the KJ method. The number of ideas produced in the narrow sense KJ method is limited. This is because time and space are restricted. Therefore, it is hard to obtain many ideas within a limited time. Then, we thought that it could obtain a better result of KJ method by supporting from data collection so that many ideas can be used when of the KJ method is carried out.

3. A spiral-type Idea Generation Method Support System

3.1 Design Policy

We sometimes get ideas suddenly while walking, though often not while in front of a PC. Furthermore others' ideas sometimes give rise to new related ideas or completely new ideas. We believe that sharing individual ideas all together can extract a wide range and large number of ideas. That is, others' ideas may encourage flashing a new idea as an intelligent trigger. The design policy of the whole system is supporting from data collection to data reuse. That is, if a user inputs data once by free handwriting, the data can be used as ideas of the KJ method. The data is used seamlessly. The results of the KJ method can be used as input data again. The load of data input can be minimal. The integrated system is expected to have high efficiency. We aim to apply this system to business improvement, for example, QC activity for efficiency of businesses or rationalization of businesses. The concrete goal is that all participants collect ideas using this system actively.

Figure 1 shows a supporting flowchart made by the spiral-type idea generation method support system. **Figure 2** shows a correspondence

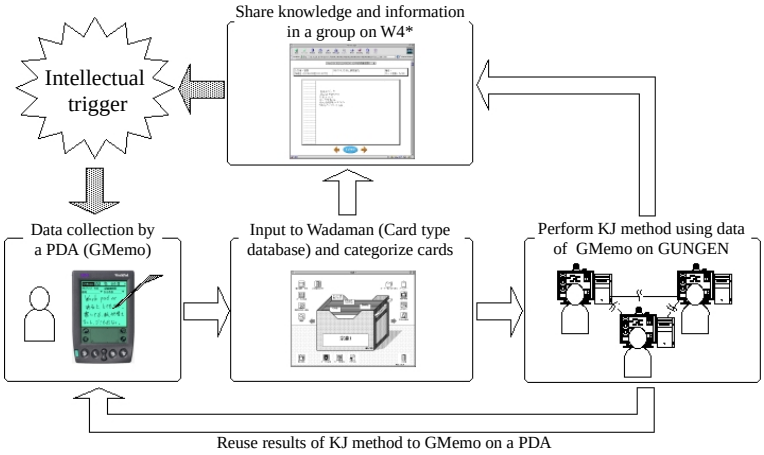

Fig. 1 A supporting flowchart made by a spiral-type idea generation method support system. * W4 was developed after collecting data by GMemo.

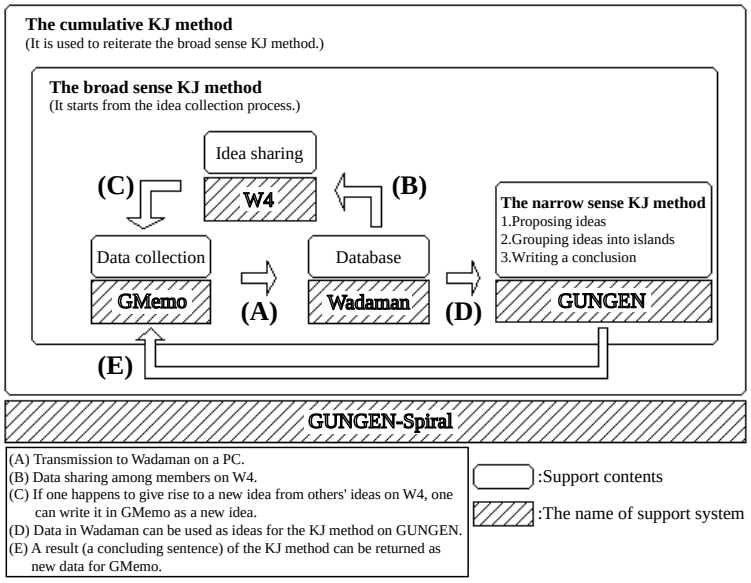

Fig. 2 A correspondence between a spiral-type idea generation method support system and the KJ methods.

between this system and the KJ methods. This system consists of the following four parts.

- Idea collecting software on PDA (GMemo)
- A multimedia database system for storing and categorizing (Wadaman)
- Stored data, such as knowledge and information, sharing system on the Internet (W4)
- A KJ method supporting system on computers connected to a network (GUNGEN)

From our experiments using a conventional PDA[3] and the results of our application of the KJ method, the design policy of each subsystem is summarized as follows.

(1) GMemo

Users can collect and input ideas in free handwriting using GMemo. The advantage of free handwriting is that one can express one's thinking most easily using a pen trace. Thinking is not interrupted by the actions of writing. The handwriting input is easy to learn compared with the kana-kanji conversion input. The disadvantages of the input method are that simple text searching with a handwritten character is difficult and that the amount of data for preservation is large compared with that of text data. Although the method of handwritten character recognition and the input by Japanese kana-

Table 1 Specifications of GMemo.

Functions	Explanation
Pencil	Draw the locus of the pen
Eraser	Delete the locus of the pen
Create page	Create a page
Delete page	Delete a page
Turn over pages	Show pages in front and behind
Automatic input of date and time	Automatic input of date and time when a new card is created
Automatic input of recorder	Automatic input of the recorder when a new card is created
Automatic input of place recorded	Automatic input of place recorded for data inputted just before a new card is created
Automatic input of information source	Information source for data inputted just before a new card is created
Selection of place recorded	Select place recorded from a pop up menu
Selection of information source	Select information source from a pop up menu

kanji conversion is easy for text searching, the problem of incorrect conversion still remains. Nakagawa[11] has also adopted the free handwriting input, in order not to interrupt thinking (They, however, use 'Lazy recognition' which performs character recognition later). Then, we used free handwriting input.

We used handwritten characters which are saved in a PDA for GUNGEN. We used WorkPad (IBM) as the PDA. The size of WorkPad is $120 \times 80 \times 15$ mm, and the weight is 160 g. This size is small enough for most breast pockets and can be carried by users at all times.

(2) Wadaman and W4

- Public provision of collected data
  Collected data by each person is stored on a Wadaman. The data is categorized after being stored and keywords can be added to a Wadaman card. In order to provide the data to the public, a user sends data to the W4 server. A user can look over the provided data using a Web browser on a computer.
- Edition control of publicly provided data
  Publicly provided data can also be revised by anyone using Wadaman. Moreover, the revised data can be provided to the public again. At this time this system does not replace the old data with the revised data. This system deals with former data as an old revision. In other words, this system leaves in both former data and new data, and a user can always view both.
- Multiple servers
  Each place of use, separated by a long distance, has a W4 server. This is because each server shortens the time for viewing and adding written data. All data of each server is synchronized automatically. When a user writes in a nearby server, the server synchronizes automatically to other servers.

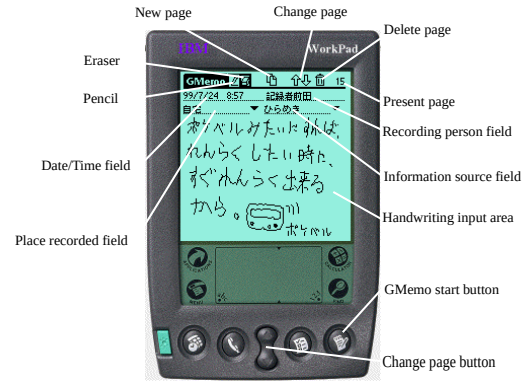

Fig. 3 WorkPad and an example of the GMemo screen.

(3) GUNGEN

GUNGEN deals with an image-type idea as well as a text-type idea for GMemo data. Results of the KJ method can be returned as new data of GMemo.

3.2 System Configuration

3.2.1 GMemo

Figure 3 shows an example of the screen of the GMemo and WorkPad in operation. The functions of GMemo are shown in **Table 1**. The main display of the WorkPad is a 160×160 pixel LCD panel (55×55 mm). We have used Post-It notes as the media of conventional data collection. The size is 75×50 mm. The same input ability is required of the PDA. Date, time, recording person, place recorded and information source are displayed on the upper part of the screen. These were determined from items commonly needed for recording data in anthropological field work shown in Section 2.

Date and time are input automatically. Other items are input beforehand. Place recorded and information source can be easily changed with the pop-up menu shown in **Fig. 4**. Items not shown in a pop up menu can also be entered directly.

Table 2 Specifications of W4.

Functions	Explanation
Reading PDA data	Reads PDA data (GMemo data) to cards.
Data receiving from W4 server	Receives data from W4 server to local PC.
Data sending to W4 server	Sends data from local PC to W4 server.
Data synchronizing	Synchronizes data from local PC to W4 server.
Data revision management	W4 server manages data revision at data changing.
Selection of data revision	A user can view another revision of a card using a pop-up menu.
Convert to HTML form	W4 server converts data to HTML form automatically.
Data synchronizing between W4 servers.	W4 server automatically synchronizes all data between W4 servers.

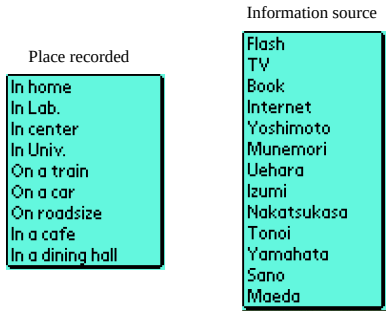

Fig. 4 Pop-up menu of place recorded and information source.

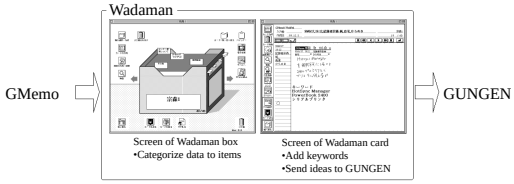

Fig. 5 An example of Wadaman screens.

The amount of data required by a GMemo screen is 3.3 kbytes. When other software is not being used, about 1200 data items can be saved (4 Mbytes). GMemo was developed on a Macintosh using CodeWarrior for the Palm OS Release 5 (Metrowerks)[12]. Now, the number of program lines is about 1000 lines.

3.2.2 Wadaman and W4

Wadaman is a multimedia database system based on Umesao's card system shown in Section 2. A feature of Wadaman is an interface of boxes and cards (**Fig. 5**). A user can edit pictures and characters on a card screen directly. A user can make pictures and characters as idea labels in the KJ method.

W4 is a data sharing system for Wadaman on the Internet. The specifications of W4 are shown in **Table 2**. **Figure 6** shows an example of the screen of W4. The left part of Fig. 6 is a screen of Wadaman, and the right part of Fig. 6 is a screen of a Web browser. The data shown is the same. A user can carry out writing and viewing on a W4 server using a Web browser. Transmitted data is changed into HTML form,

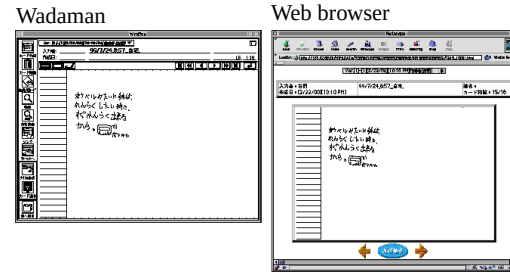

Fig. 6 An example of W4 screens.

and is also viewable by a Web browser. When a user writes in a server, the server synchronizes automatically to other servers. All servers hold the same data.

One feature of W4 is edition control. Publicly provided data can also be revised by anyone using a Web browser. Moreover, the revised data can be displayed to the public again. This system does not replace the old data with the revised data. That is, a new card (data) is produced. Edition information consists of a main-version, a sub-version, a transmitted date, a transmitted time and a creator. A user can view all editions of a card by a pop-up menu on a Wadaman and a Web browser.

3.2.3 GUNGEN

The specifications of GUNGEN are shown in **Table 3**. GUNGEN basically supports the narrow sense KJ method (three steps: brainstorming, grouping ideas and writing a conclusion). GUNGEN can display and handle about 100 ideas (labels) at a time on its screen.

3.3 A Spiral-type Idea Generation Method Support System

A spiral-type idea generation method is supported by each component of GUNGEN-Spiral. The arrows of Fig. 2 show the relation of each component:

(A) Data stored in GMemo are transmitted to Wadaman on a PC. One can classify data on Wadaman, and add keywords.

(B) Data of GMemo is shared among members on W4 via Wadaman. Members can read the data freely using a Web browser.

Table 3 Specifications of GUNGEN.

Specifications		Explanation
Fundamental functions	Number of computers	Three or four computers.
	Screen size	20 inches.
	Screen size reduction	A quarter or one-half reduction.
	Control right	Control right allows access to shared window, while putting an idea on the screen freely.
	Communication	Video and sound, text could be used to communicate anytime.
	Log data	Shared events are automatically recorded.
KJ method support functions	Ideas	Characters may always be entered into input window. Picture ideas, e.g. GMemo data, can be entered via Wadaman.
	Chat	Always possible. Chat menu is provided.
	Island	If a participant moves an island, ideas in an island are moved together.
	Composition	Participants can compose sentences with three or four computers.

(C) If one happens to come up with a new idea from others' ideas on W4, one can write in GMemo as a new idea.
(D) Data in Wadaman can be used as ideas for the KJ method on GUNGEN. Participants can use data collected by GMemo via Wadaman, or input ideas by Keyboard.
(E) A result (a conclusion sentence) of the KJ method can be returned as a new data of GMemo after using the KJ method. Members can refer and examine the result of the KJ method anytime and anywhere.

4. Experiments and Discussion

The Wakayama University Information Science Center began operation in a new building from the Heisei 11 fiscal year. At that time, thought was given to what its daily business would be. Therefore, it was considered that recording each member's ideas and examining them by others was needed.

We applied GUNGEN-Spiral to the following schedule. Data collection using GMemo was carried out over about 5 months from June to November in 1999. The KJ method was carried out twice using the collected data in December. In order to feed back the results of the KJ method to the users, the data was saved in the users' GMemo in March 2000. At about the same time, the collected data were shared within the group using W4. In this section, we describe the above applications and their evaluations. In addition, the second application of this system has begun and data collecting has been performed under the data share using W4 from the beginning.

4.1 Application of GMemo

We requested members of the Wakayama University Information Science Center to use GMemo regularly. Nine persons used GMemo for about five months. Four people were teachers and five were office workers. Two of the teachers had been using a PDA regularly before this experiment. All members normally use a personal computer in their work. In order to encourage data collection, we commended those who had inputted much data at the end of the year. We carried out the KJ method using handwritten data collected by GMemo.

A total of 290 pieces of data were collected. **Table 4** shows the number of data collected by each person. 'User F' collected the maximum number of data. 'User B' followed 'User F.' 'User F' had used a PDA before this application, and he was also in the habit of note-taking. The 'User B' had not previously used a PDA, nor was he in the habit of note-taking. We investigated time, places and sources of GMemo data. The results of the data show that most of the data were saved within office hours (from 9 a.m. to 6 p.m.), either at home or at the Center. As for the source of ideas, most were original. That is, this shows that most users collected their data alone, and that the users were not influenced by other users in data collection. The mean value of characters in one idea was about 26, which was nearly the same as the conventional method of collecting ideas by paper media (Post-It notes, 75×50 mm) in our former experiment 4). **Table 5** shows the content of data except for characters. There were many arrows and underlines in GMemo screens. There were a few pictures. The legibility of the saved data was about 55% to 95% depending on the individual.

The results and discussion of GMemo use are as follows.

(1) The numbers of input data fluctuated

Table 4 The number of collection data items by each person.

Collector	Number of data
A	9
B	70
C	6
D	16
E	5
F	160
G	8
H	3
I	13
Total	290
Average Value	32.2
Standard Deviation	49.2

Table 5 Pictures and signs that were saved into GMemo.

Pictures and signs	Number of cases
Arrow	52
Underline	17
Picture	11
+	7
Circle which surrounds characters	3
Handmade sign of omission	3
{	3
Insert mark	2
Sweat mark	1
☆	1
◎	1
×	1
=	1
#	1

sharply depending on the individual. People who have a habit of taking notes can input data into GMemo easily. But it is difficult for most of the others to input data daily. The motivation of data input seems to be important.

(2) Ideas were flashed anytime and anywhere. But most saved ideas were inputted to GMemo in the Center or at home. Because the PDA was somewhat large and users could not always carry it in their pocket. Mainly they put the PDA in a bag or in a desk.

(3) The merit of GMemo is to input ideas easily without a keyboard.

(4) The demerit of GMemo is that the size of the input area was somewhat small. Users could not input many large characters for legibility.

4.2 Application of W4

W4 was developed after collecting data by GMemo. After data was collected and the KJ method performed, we requested members of the Wakayama University Information Science Center to look at W4 using a Web browser. The questionnaire results are shown in **Fig. 7**. The total number of answers for the questionnaire is 6. In Q3–Q7 of Fig. 7, the star marks show entry and the round marks show the average. We mention some items of interest regarding the results of the questionnaire. When we asked users about their impressions of others' ideas, some users were interested in others' ideas (the number of ideas or the contents of ideas) and it seems that they are influenced by others' ideas (Fig. 7, Q2 and Q7). Some data is hard to read, however, users could understand most data (Fig. 7, Q2 and Q4). Some people wanted to use W4 when they entered data; others did not feel the necessity for the function of sharing ideas (Fig. 7, Q5). The deviation of Q5 is comparatively large. We found that most users wanted to write in some ideas using W4 on a web browser very much (Fig. 7, Q6). We also found that some others' ideas gave users hints (Fig. 7, Q7).

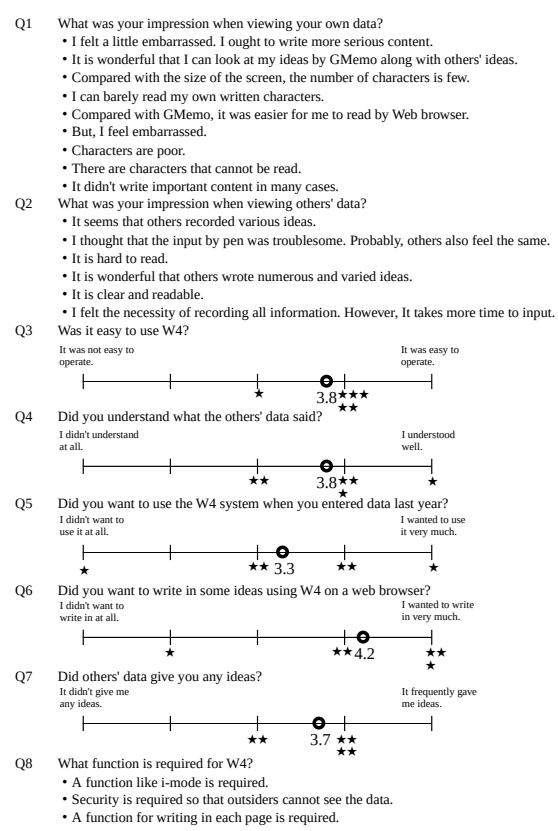

Fig. 7 Results of Questionnaire. In Q3∼Q7, the star marks show entry and the round marks show the average.

4.3 Application of GUNGEN

We performed the KJ method twice by GUNGEN using data saved into GMemo. **Figure 8** shows the screen of a computer while performing the KJ method. The subject of the KJ method was the improvement of GMemo. The

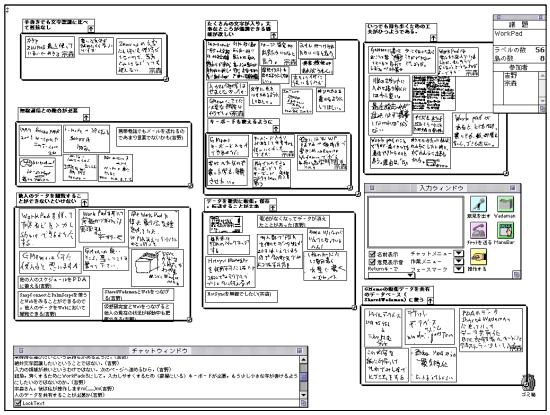

Fig. 8 A GUNGEN screen. All opinions displayed with rectangles were input by GMemo.

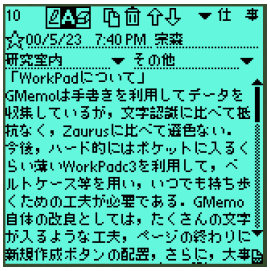

Fig. 9 A GMemo screen in which the result of the KJ method was written.

number of the ideas used for the KJ method was 56. Two persons used the data saved into GMemo in advance. No particular problems occurred.

The results and discussion of using GUNGEN are as follows.

(1) Some characters were very difficult to read. The persons who had written them had to be asked about their meaning. According to our experiments, we believe that the difficulty of reading characters is dependent on the individual who wrote them. The writers of most opinions are distinguishable by their handwriting.

(2) The results of KJ method were similar to those of the conventional KJ method on paper[4].

(3) When the number of opinions increases or the number of opinions containing many figures increases, the area of the screen is insufficient.

4.4 Application of the Results of the KJ Method to GMemo

We evaluated a feedback portion of an idea spawned by a result of the KJ method as a new data of GMemo. **Figure 9** shows an example of a GMemo screen in which the result of the KJ method was written. The questionnaire was conducted and replies were obtained from 5 users. They are summarized as follows.

- It is fortunate that the conclusion of the ideas over 1 year can be seen by GMemo.
- In order to give rise to an idea, an itemized sentence seems to be better than a sentence.
- As for reading the results of the KJ method, W4 is better than GMemo.

We found that GMemo was suitable for viewing a memorandum and was unsuitable for reading a long sentence.

4.5 Discussion of the System Mainly Equipped with Handwritten Input

The basic concept of GUNGEN-Spiral is to support 'handwritten input.' We discuss the merits and the demerits of handwritten input.

(1) Data collection

The handwriting input is easy to learn compared with the kana-kanji conversion input. One can express one's thinking most easily using a pen trace. Thinking is not interrupted by the action of writing. We can draw a picture easily by handwriting compared with voice input. The method of handwritten character recognition and the input by Japanese kana-kanji conversion have merits in the reuse and the easy reference after the input.

(2) Database

Wadaman is equipped with visual retrieval (card turning over), and it is suitable for the handling of handwritten data. When using the database of handwriting data, keywords input by a keyboard have to be added. The amount of data for preservation is large compared with that of text data. Text searching in handwritten data is difficult.

(3) Data sharing

The writer of an opinion is distinguishable by handwriting. Some data were very difficult to read, but it depends on the individual.

(4) Idea generation

It is very useful to include a picture with an idea (label) by the handwriting input. The area of the handwriting data needs to be larger than that of text data. Input of a new idea on a PC can be done conveniently with a keyboard.

(5) Returning ideas

The result of the KJ method can be returned to GMemo as text data. Text data is readable with small-size characters in GMemo.

Combining each merit of handwritten input

and text input can raise the effectiveness of the whole system. The integrated system is expected to have high efficiency.

4.6 The Entire GUNGEN-Spiral

We found the following results from applications of GUNGEN-Spiral.

(1) GUNGEN-Spiral has the following merits: collection of a wide range of ideas, collection over a long period, collection by dozens of people and storing and sharing the collected ideas. GUNGEN can handle about 100 ideas at a time. The number of ideas was less than 100 in the two experiments. It will easily exceed 100. We need to take steps to deal with many ideas.

(2) Users mainly use a PDA daily in GUNGEN-Spiral. Users cannot always be aware of the situation of others. Therefore, GUNGEN-Spiral was required to share a number of others' ideas and their contents. We found that GUNGEN-Spiral needs to strengthen 'awareness.' We believe that W4 can serve users as a stimulus. As a result, users can produce ideas further.

5. Related work

There are two idea generation (KJ method) support systems, which have a PDA for an input device other than GUNGEN. Sugiyama, et al.[13] have developed a system that combines D-ABDUCTOR as an idea generation support system, Keyword Associator as a presentation tool of related ideas, and Idea Base as a database. They use ZAURUS (SHARP) as an input device (PDA). ZAURUS has a handwritten character recognition function and they use text format data. Nakagawa, et al.[11),14] developed IdeaPad which uses POSSIBLE (HITACHI) or AMiTY (MITSUBISHI ELECTRIC) as an input device. They use handwritten data or handwritten character recognition data as vector format data. These systems do not provide functions for long-term use such as place recorded and information source.

6. Conclusion

We have developed an idea generation support system, called GUNGEN-Spiral. We applied this system to collecting ideas, saving ideas, sharing ideas, shaping ideas and reusing ideas. The second application of this system has begun. Data collecting has been performed under data share using W4 from the beginning. We found the following results from these applications.

(1) GUNGEN-Spiral has the following merits: collection of a wide range of ideas, collection over a long period, collection by dozens of people, and storing and sharing the collected ideas. We need to take steps to deal with many ideas.

(2) Users mainly use a PDA daily in GUNGEN-Spiral. Users can not always be aware of the situation of others. Therefore, GUNGEN-Spiral was required to share a number of others' ideas and their contents. Furthermore, we found that GUNGEN-Spiral needs to strengthen 'awareness.'

(3) We collected 290 pieces of data, and we performed the KJ method twice using the data. Two among nine users took an active part in data collection.

Our next aim is that more than half of the users participate actively. Users have already been using W4 from the beginning of data collection in the second year. We believe that many more ideas will be collected than in the first year. In the future, We will improve and evaluate GUNGEN-Spiral through further application over a long period.

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