

Small Knowledge Canvas: Software for Managing Fragmental Knowledge

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Abstract— We propose a concept called “Small Knowledge” and a prototype system called “Small Knowledge Canvas” that enables users to collect and utilize fragmental knowledge, “Small Knowledge”. We find pieces of Small Knowledge in our daily life, such as a book that seems interesting, a phrase that might be used in ones writing, or a beautiful place to go. For the first step, though the concept is general, we limit the target for adopting this concept to the Web browsing environment. Small Knowledge can be regarded as an enhanced bookmark with personal context. We also propose a simple browsing model and context extraction algorithm for extracting personal context for Small Knowledge. Finally, we discuss the results of a user experiment of our prototype system.

Index Terms—personal knowledge management, bookmark, visualization, context

I. INTRODUCTION

We find many fragments of information in our daily life, such as a nice restaurant on a street, an interesting book recommended by a friend, a humorous phrase in a book, or a picture of a wonderful place to visit on a Web page. Without our effort, this kind of information is subjective and unorganized. In this situation, although fragments of information are important, we feel that we are drowning in a deluge of information or simply forget them and lose precious seeds of ideas. It is far from looking down at each phenomenon and getting ones insight.

As researchers recognize this problem, many knowledge management tools were proposed, but they are not used much because they are complicated to use. We simply try to manage fragments of information with daily knowledge management tools or communication tools, such as emails, chats, blogs and bookmarks. Since bookmarking systems are easy to use and do not require much input or time, they are widely used and play an important role in daily casual personal information management. Moreover, bookmarks and bookmarking activity are interesting topics of study because they are similar to finding and remembering objects in the real world.

The bookmark functions of Web browsers and social bookmarking services such as del.icio.us are popular ways to manage Web sites that seems interesting during Web browsing. Bookmarking function of browsers stores the titles and the URLs of pages. Social bookmarking services can also store tags and comments for each bookmark, not only for personal reuse but also for sharing with others.

However, our point of view, personal context corresponding to bookmarked information tends to be dropped. Only a pointer to a whole page that was edited by the author of the Web page is stored as a bookmark. So questions can arise when the user accesses the bookmarked pages. In what context did I reach the bookmarked page? What content on the page was of most interest? That is, what is the “personal context” of the content? Personal context, in other words, the personal story connected to the information makes the information special for a person, but it is not taken into consideration.

As conventional bookmarks do not include the user’s personal context, it is difficult to organize and reuse them appropriately. Even if the bookmarks are organized by general information, it will be hard for us to reuse the information by associative manner from our own context.

Given this situation, we carefully select which Web pages to bookmark while still worrying about making our bookmarking environment chaotic. We only bookmark Web pages when we are sure we will repeatedly use them. Except for the bookmarked information, other information, which we are just interested in, is buried in our memory and forgotten. For example, a Web page for local weather may be bookmarked, but a Web page for a book that seems interesting may not be. The hesitation to casually bookmark seems to occur from the lack of personal context to the information. What if the fragments of information have their own context? A large amount of fragments of information may be organized easier with their context. This allows us to casually bookmark what we are simply interested in without concern.

These problems, difficulties of reuse and organization of bookmarks, and our hesitation to bookmarking what attracted us, can be minimized by enhancing conventional bookmarks in two ways: (1) adding personal context to

each bookmark and enabling all the fragments of information to associate with each other using that context, (2) making portions of Web pages bookmarkable. These enhancements mirror what we unconsciously do in the real world. We store fragments of information from our point of view and recall them by association.

We named this enhanced bookmark “Small Knowledge”. The word “Small” means rudimentary. It is fragmental but important along with personal context. We use “Small Knowledge” like “A user clips Small Knowledge from Web pages”. In this concept, a person can create a bookmark that points to a particular portion of a Web page with a visual representation and personal context in addition to the two components of conventional bookmarks: the title and the URL of the original Web page. This visual representation is the part the user focused. The personal contexts are sets of URLs and keywords extracted from the user’s browsing behavior. We also propose a simple browsing model to formalize the context-extraction process. Context extraction is done on the basis of this model so that personal association is preserved. We then propose our prototype “Small Knowledge Canvas” that enables users to clip Small Knowledge along with their personal context, similar to taking photos in the real world. It also enables users to recall pieces of Small Knowledge clipped in the past by an associative manner. This recall process can be precious opportunities to rethink in what we were interested in the past from our current point of view and to abstract individual pieces of information. This process is expected to be a solution to our feelings of drowning in a deluge of information.

The remainder of this paper is organized as follows. In section II, we discuss related work. In section III, we introduce the concept of Small Knowledge and describe its structure. In sections IV and V, we introduce our browsing model and describe the algorithm used for context extraction. In section VI, we introduce our prototype system. In section VII we report an informal evaluation experiment and the results, and finally, we conclude in section VIII with a brief summary, a look at future work, and some remarks.

II. RELATED WORK

Since bookmarking and managing bookmarks are well established and essential, many studies have been made related to bookmarks such as “PowerBookmarks” proposed by Le et al. [1].

These studies have concentrated on two areas: how to enhance the functions of conventional bookmarks and how to make better use of bookmarks. Though many enhancements had been made to enrich the information provided by bookmarks, conventional bookmarks are preferred and still used due to their simplicity. From the aspect of making better use of bookmarks, automatic categorization and visualization that enable users to more easily identify connections between their bookmarks have also been extensively studied. In these studies, bookmarks are organized on the basis of page content.

Since Web pages do not represent the bookmarkers’ point of view, namely they are edited from the authors’ point of view, the results of the organization tend to be general, rather than personal. As social bookmarking services have caught on over the last few years, there have been several studies on organizing social bookmarks using social data. Although social data including tags added by individuals are used, such data are not as personal and differs from keywords related to an individual’s personal behavior to reach the information.

Nakajima et al. proposed “Context Dependent Web Bookmarks” and an application for search query [2]. In their approach, the effort made by a user to bookmark a page is calculated, and personal context represented by keywords is extracted. Personal context keywords are extracted by highlighting the differences between the bookmarked page and the other pages in the search results. In our approach we regard browsing as an associative process, and keywords are extracted from the user’s proactive behavior, namely moving from one page to another.

From the aspects of personal context in the physical world, Frohlich et al. proposed Audiophotography [3]. With their application, a user can take photos with peripheral sound. Sound is recorded a few seconds before the shutter clicks. This type of photography is a bookmark with personal context expressed by sound.

To search information a user stored, Susan Dumais et al. proposed “Stuff I’ve ever seen” [4]. Using their application, a user can search information in his/her computer from multiple aspects. Hino et al. proposed an environment “WebFarm” [5] in which searching and browsing are integrated. The users’ purpose is not searching but access to the data they need. In their application, an animal metaphor is adopted for bookmarks; each bookmark is represented by animal. They appear to the user’s environment and come across to content inside a Web page when the user browses the corresponding page.

Although many studies have been made, bookmarking an entire Web page has not been changed. We propose bookmarking portions of Web pages as Small Knowledge. Pieces of Small Knowledge hold visual and textual data representing the bookmarkers’ personal points of view as context. Moreover, our prototype enables users to clip Small Knowledge along with their personal context from Web pages, like taking photos in the real world.

III. CONCEPT OF SMALL KNOWLEDGE

In this section, we explain the concept of Small Knowledge both from its properties and its behavior as active data.

Properties of Small Knowledge

Small Knowledge can be thought as an enhanced bookmark. Small Knowledge and its properties, based on our prototype are shown in Figure 1.

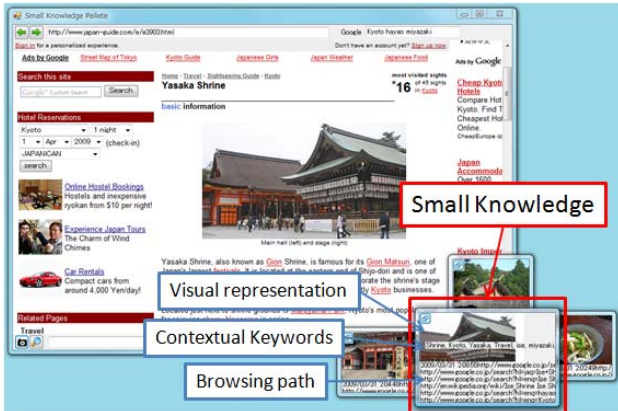


Figure 1: Small Knowledge and its properties

In our previous work, we proposed this concept as the pair of the URL, the title, visual representation, and a set of keywords that represents a user’s context. This time, we extend it to contain a set of addresses, namely URLs that represent context.

The property of Small Knowledge consists of the five elements noted by “-” in the list below:

- Components of conventional bookmarks
 - URL of the bookmarked Web page
 - Title of the bookmarked Web page
- Components of personal context
 - Visual representation
 - Browsing path (a set of URLs)
 - Contextual keywords

[Components of Conventional Bookmarks]

With Small Knowledge, users can point to portions of Web pages as bookmarks, which contain the title and the URL of the original Web page. Since Small Knowledge contains URL of the bookmarked pages, users can refer bookmarked Web pages as they do with conventional bookmarks.

[Visual Representation]

Visual representation is an image of the portion the user bookmarked in the Web page. It is shown in the red-boxed area in Figure 1.

These portions are generally unique to each person even though many people may view the same page. Therefore, in a broad sense, visual representation is a type of context. Context does not have to be described by text, but can be represented as an image.

Visual representation helps a user to intuitively recall what was bookmarked and in which content on the page he/she was interested. Text, such as bookmark comments or tags, can of course be used to describe this content. However, images are more effective as they instantly give an overview of the Small Knowledge. Moreover, in the organization of the Small Knowledge, visual representations help a user to recognize the various sets of information at a glance. The colorful outlook of the prototype may entertain users and allow them to be

creative with their knowledge; “Art with ones knowledge”.

[Browsing Path]

A browsing path is a set of URLs of Web pages. This is extracted from users’ browsing behavior based on the browsing model and context extraction algorithm we describe in the following chapters. With browsing context, users can recall what pages they saw and what they think when they bookmarked Web pages.

[Context Keywords]

Contextual keywords of Small Knowledge are represented as a set of keywords. Keywords are extracted from both the bookmarking process and the text surrounding the portion of interest on the bookmarked page, as illustrated in Figure 2.

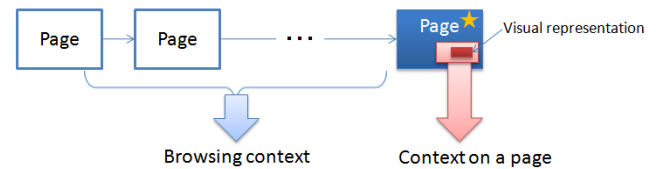


Figure 2: Context Keyword Extraction

Behavior of Small Knowledge

While conventional bookmarks are static information like most of data, Small Knowledge is active. Pieces of Small Knowledge appear users’ environment by themselves based on contextual keywords they have. This is our approach to the question; “Why we forget about the things previously we recognized?” Pieces of Small Knowledge appear in the users’ environment help users not only to recall in which they were interested in the past, but also to have second, third or more thoughts. This rethinking process helps users to compile their thoughts appropriately so that they can understand themselves and communicate these thoughts with others.

In our application, related pieces of Small Knowledge appear on the screen at the same time when users bookmark Small Knowledge. There are two types of relations; based on personal context and clipped time. This is described in Figure 3.

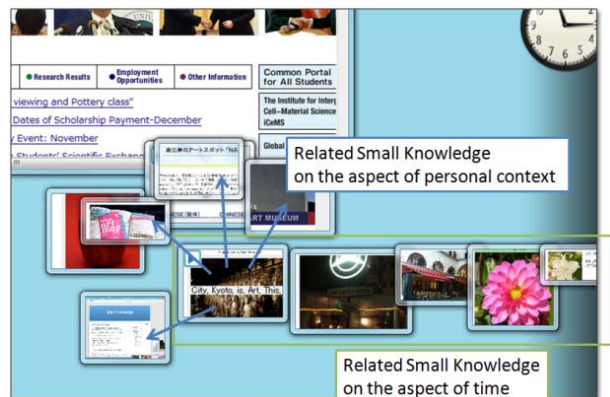


Figure 3: Behavior of Small Knowledge

Details of our prototype are described in Section VI.

IV. SIMPLE BROWSING MODEL

In this section, we will describe our simple browsing model for context extraction. The key features of our model are

- adopting multiple contexts
- categorizing page transfer in three categories to carefully preserve users' personal context.

First, we explain these two features and then present the entire model.

Two Key Features

[Multiple browsing contexts with one being active]

We assume that there are multiple browsing contexts and one of them is active.

Suggest that a user searches for information related to his/her work. Suddenly he/she hears the sound of rain and starts searching for information on local weather. Or he/she may feel hungry, recall that he/she has to book restaurant for a party, and then start searching for information on restaurants. In this way, users brows Web pages with multiple contexts. Each context consists of URLs and a set of keywords and their weights extracted from the user's browsing behavior. One context is active on a certain moment.

This is why we assume that there are multiple contexts and one of them is active.

[Types of page transfers]

While the pages that a user browsed are important for extracting personal context, the user's self-determined page transfers reflecting his/her personal context, i.e., personal association, are more important. Context can be detected from keywords related to page transfers. We thus focus on these keywords. Transferring between pages is categorized into three groups:

- Search: Move to the destination page using search engines.
- Link navigation: Move to the destination page by clicking a link inside the source page.
- Direct jump: Move to the destination page.

First, for the case of search, when a user encounters an unknown word, he/she may search for the definition of the word using a search engine, or suddenly remember a book and search for information using a search engine. In the first example, the user's context may continue but in the second one, it may not. We preserve the user's context if at least one of the search keywords is in the source page. If none of the search keywords is in the source page, we assume the current context is broken and determine which context to be activated. Second, for the case of link navigation, after a user reads a news article, the user may read a related article linked inside the source page. As a Web page may link to related Web pages, we

preserve the user's context for this case and use the anchor text to extract context keywords. Third, for the case of a direct jump, a user may suddenly move to a Web page not related to his/her current browsing context using his/her bookmarks or entering a URL. In this case, as the context is broken, we determine which context to be activated.

Entire Browsing Model

We formalize our browsing model in this section.

Based on the two features above, Figure 4 shows the outline of our browsing model.

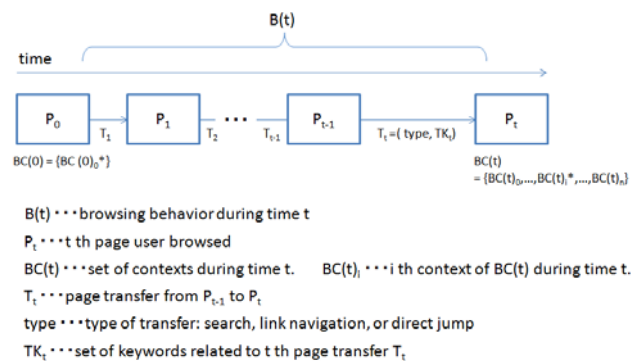


Figure 4: Browsing Model

Browsing behavior B(t) is the set of pages a user browsed during time t.

$$B(t) = \{P_0, P_1, \dots, P_t\}$$

Since we assumed that there are multiple browsing contexts, and there is always one active context, the browsing context BC(t) is described as a set of contexts during time t.

$$BC(t) = \{BC(t)_0, BC(t)_1, \dots, BC(t)_i^*, \dots, BC(t)_n\}$$

Context BC(t)_i is the i_{th} context during time t. "*" in the upper right of a context denotes that it is the active context. BC(t)_i^{*} is the current context in the expression above.

A context consists of URLs and a set of weighted keywords extracted from the user's browsing behavior. The weight for each keyword is calculated based on the occurrence of the keyword in the transfer and weaken along with the time.

$$BC(t)_i = (URLs, \{(bc_{k_{t_1}}, bc_{w_{t_1}}), \dots, (bc_{k_{t_n}}, bc_{w_{t_n}})\})$$

For simplicity, we define a set of keywords in the browsing context as

$$BC_K(t)_i = \{bc_{k_{t_1}}, \dots, bc_{k_{t_n}}\}.$$

Page transfer T_t during time t is a pair of transfer type “type” and a set of keywords T_K_t .

$$T_t = (\text{type}, TK_t)$$

The definition of type is

$$\text{type} \in \{\text{search}, \text{link}, \text{direct jump}\}.$$

TK_t is extracted according to the transfer types.

- (a) type = search
 $TK_t = \{\text{search keyword}_1, \dots, \text{search keyword}_n\}$
- (b) type = link navigation
 $TK_t = \{\text{keyword in anchor}_1, \dots, \text{keyword in anchor}_n\}$
- (c) type = direct jump
 $TK_t = \{\}$

An active context $BC(t)_i^*$ is selected as follows.

- (a) (type = search and $t_k_t \in P_{t-1}$) or (type = link)
 $BC(t)_i^* = BC(t-1)_i^*$
- (b) others except the case of max Sim is 0 for all j
 $BC(t)_i^* = BC(t-1)_j$
 such $j \max_{0 \leq j \leq n} \text{Sim}(BC(t-1)_j, P_t)$
- (c) max Sim is 0 for all j in case (b)
 $\{ \}$ form a new context

Similarity $\text{Sim}(BC(t-1)_i, P_t)$ is calculated as cosine similarity

$$\text{Sim}(BC(t-1)_i, P_t) = \frac{|bc \cdot p|}{|bc||p|},$$

where bc and p are vectors, elements of which are the weights of the keywords in $BC(t-1)_i$ or P_t . If $BC(t-1)_i$ or P_t does not have the pair of a keyword, the weight of the vector is 0.

$BC(t)_i$ is determined as follows.

- (a) $BC(t)_i$ is an active context
 $BC(t)_i = f(BC(t-1)_i, T_K_t)$
- (b) $BC(t)_i$ is not an active context
 $BC(t)_i = f(BC(t-1)_i, \phi)$

f is a function that determines $BC(t)_i$ from previous context $BC(t-1)_i$ and T_K_t . S in the expression below is a set that is T_K_t or \emptyset , depending on whether $BC(t)_i$ is the active context or not.

$$f(BC(t-1)_i, S) = (\text{URLs}, \{(\text{keyword}_1, \text{weight}_1), \dots, (\text{keyword}_n, \text{weight}_n)\})$$

$$\text{weight}_j = \begin{cases} bc_{w_{t-1}j} \times \alpha + \beta & \dots \text{keyword}_i \in S \text{ and } \text{keyword}_i \in BC_K(t-1)_i \\ bc_{w_{t-1}j} \times \alpha & \dots \text{keyword}_i \notin S \text{ and } bc_{k_{tj}} \in BC_K(t-1)_i \\ \beta & \dots \text{keyword}_i \in S \text{ and } \text{keyword}_i \notin BC_K(t-1)_i \end{cases}$$

$$0 \leq \alpha \leq 1, \quad 1 \leq \beta$$

α and β are constants: α weakens the effect of old keywords in the context; β strengthens the effect of new keywords in the context. In this way, all i , $BC(t)_i$ is calculated.

When Small Knowledge is clipped from a Web page, the current context is used as the personal context of the Small Knowledge.

The context is not reset when Small Knowledge is clipped. The context set is held until the user stops browsing.

Extraction of the browsing path and context keywords from page transfer are explained in the next section, “Context Extraction”.

V. CONTEXT EXTRACTION

In this section, we will describe how we extract a user’s personal context when he/she clips Small Knowledge.

Context of Small Knowledge is calculated from two types of contexts; (1) browsing context and (2) inside-page context.

Browsing context consists of URLs and weighted keywords as we described the previous section. When a user clips Small Knowledge, the active context is chosen to determine the personal context for that Small Knowledge.

Inside-page context is the context in the page the user is about to clip. For this context, the structure of the Web page needs to be considered in order to accurately extract the information. However, we approximately retrieve the title of the Web page and the text surrounding the place the user clipped. CI_t is the context extracted from the page during time t . It consists of weighted keywords. The weight is the number of occurrences of the word. The context during time t is expressed as

$$CI_t = \{(ci_{k_{t_1}}, ci_{w_{t_1}}), \dots, (ci_{k_{t_p}}, ci_{w_{t_p}})\}.$$

For simplicity, we define a set of keywords in the context as

$$CI_K_t = \{ci_{k_{t_1}}, \dots, ci_{k_{t_p}}\}.$$

Although we have not addressed the question of whether these two contexts should be distinguished or not, we nevertheless combine them.

The personal context C_t of Small Knowledge clipped during time t is expressed a set of weighted keywords.

$$C_t = \{ (k_{t_1}, w_{t_1}), \dots, (k_{t_q}, w_{t_q}) \}.$$

The weight of a keyword is calculated as follows, where $BC_K(t)_i$ is a set of keywords from $BC(t)_i$, and γ and δ are constants used to adjust the effects of the two contexts.

$$w_{tk} = \begin{cases} bc_{w_{t_1}} \times \gamma + ci_{w_{t_1}} \times \delta & \dots k_{t_i} \in BC_K(t)_i \text{ and } k_{t_i} \in CI_K_t \\ bc_{w_{t_1}} \times \gamma + 0 \times \delta & \dots k_{t_i} \in BC_K(t)_i \text{ and } k_{t_i} \notin CI_K_t \\ 0 \times \gamma + ci_{w_{t_1}} \times \delta & \dots k_{t_i} \notin BC_K(t)_i \text{ and } k_{t_i} \in CI_K_t \end{cases}$$

In this way, the personal context for Small Knowledge is calculated.

VI. PROTOTYPE: "SMALL KNOWLEDGE CANVAS"

We developed a prototype system, "Small Knowledge Canvas", based on the concept of Small Knowledge. Users can clip Small Knowledge and recall them on their context with it. In this chapter, we explain its implementation and how it works.

Implementation

Our prototype system is a client application written in C# and was implemented as an extended browser. For the part of organizing Small Knowledge, we use the Lucene .Net module to fetch semantically related pieces of Small Knowledge clipped in the past.

Clipping Small Knowledge: Camera Metaphor

A camera metaphor was adopted for creating Small Knowledge from Web pages. Users can clip Small Knowledge in the manner analogous to taking photographs in the physical world. Figure 5 shows how this is implemented in our prototype.

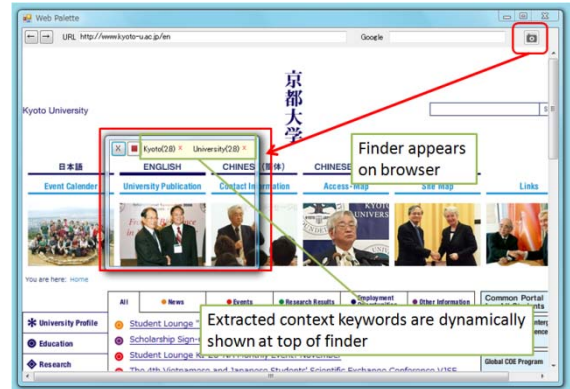


Figure 5: Camera Metaphor

When a user found an interesting fragment of information, he/she presses the camera button on top of the browser. A finder appears and the user can determine where to clip by adjusting and moving the finder. As personal context, weighted keywords are shown on top of the finder. The user can delete keywords by clicking "x" next to each keyword. After the user determines which place and with what context to clip, he/she clicks the record button on top of the finder to clip Small Knowledge.

Utilizing Small Knowledge: Visualize Semantic and Temporal Periphery

To enable users to have opportunities to recall and rethink their Small Knowledge clipped in the past, the prototype system presents related pieces of Small Knowledge on the timing that the user clipped Small Knowledge. Related pieces of Small Knowledge are selected based on temporal and semantic relativity. This is shown in Figure 6.

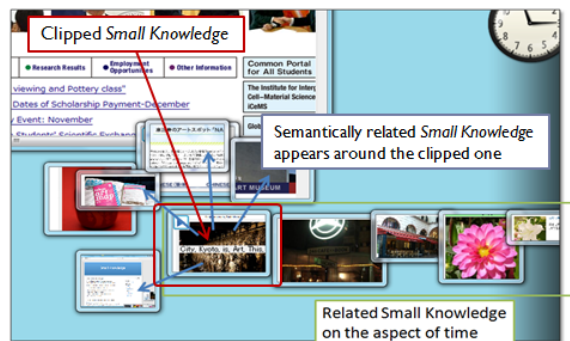


Figure 6: Semantic and Temporal Periphery

When a user clips Small Knowledge using the prototype system, semantically related pieces of Small Knowledge appear around the clipped Small Knowledge, as shown by the blue arrow in Figure 6. Semantic relativity is simply calculated as cosign similarity between context keywords of each Small Knowledge. The user can also refer pieces of Small Knowledge clipped in the temporal periphery of a Small Knowledge by double clicking that Small Knowledge. Then pieces of Small Knowledge in

temporal periphery appear in line, as shown in the green-boxed area in Figure 6.

In this way, we attempt to support users' association based on their context.

VII. INFORMAL EVALUATION EXPERIMENT

We set up our booth in Design Festa 2008, which was an international art event that took place at Tokyo Bigsight from 8th to 9th November 2008. The pictures below show the atmosphere of the event.



User Experiment at Design Festa 2008

At that time, there was a small difference in the prototype. The difference was the manner of clipping Small Knowledge. The latest prototype uses the camera metaphor, but the one used in the experiment did not. Users had to double click the upper left and lower right corner to clip Small Knowledge. Although there was a difference between the prototypes, we believe the results of this experiment are still important.

We asked people passing in front of our booth to use the prototype system and participate in our experiment. Throughout the two days, 21 people participated in the experiment. As knowledge management is a lifelong topic and cannot be examined in one or two days, we mainly asked questions about the interface of the prototype system. We did not set any fixed scenarios but simply asked the participants to use the prototype system and answer the questionnaire. If the participants were at a loss of what to do, we suggested clipping some information on design events in Tokyo. Our main interests were the following three points:

- Whether the prototype contributes to users' knowledge management, namely collecting and utilizing Small Knowledge.
- Whether the prototype system is easy to begin using or not.
- Whether the scattered pieces of Small Knowledge both from the system and users are annoying or not.

For the first point, over 80% of participants answered that it will contribute to their knowledge management. For the second one, while the knowledge management tools proposed in the research area tended to be complicated for daily use, over 70% of participants answered that the prototype is easy to begin using. For the last point, it is the question we always asked about, 13% of participants answered that it was annoying while 30% answered that it was not so annoying. Some of them answered that it was convenient or fun to use the feature.

One designer said that he sometimes hesitates to bookmark many pages in which he is intuitively interested. He just reluctantly opens web pages with tabs and finally closes them. He said our prototype system will be helpful for his work not only because it allows him to clip information casually but also because pieces of Small Knowledge have visual representation.

As the event was design-oriented, designers working in Web technologies were interested in our booth, they were possibility more favorable compared to non-designers or non-technical users.

For the first step to propose the concept of self organizing knowledge with users' personal context and an implementation to utilize this kind of knowledge with fun and artistic features, we conclude that the results were positive.

V. CONCLUSIONS

To think about what we are interested in deeply and repeatedly is important. This make us realize what we like, what thinking about from multiple points of view. However, this is quite difficult for us. We tend to see the surfaces of what we find in our daily life, knowledge fragments, and simply feel something at that moment and then usually forget about them soon after. Even if we record them, they usually become "dead storage". Our study started from this issue.

We started from defining these knowledge fragments as Small Knowledge. The concept of Small Knowledge is an enhanced bookmark that points to portions of Web pages along with personal context. To extract context of Small Knowledge, a simple browsing model and context extraction algorithm were proposed. Based on these, a prototype, "Small Knowledge Canvas", which enables users to clip Small Knowledge intuitively, analogous to taking pictures in the physical world, and utilize Small Knowledge clipped in the past in an associative manner. Pieces of Small Knowledge related to a Small Knowledge were discussed concerning temporal and semantic relativity. Finally the results of an experiment we conducted in Design Festa 2008 were discussed. Although we have not conducted a long-term experiment, we received favorable feedback on our prototype system.

Since the concept of Small Knowledge is general and may be adapted to fragments of knowledge we encounter in the real world, it has the potential to be extended to a form of knowledge management that works as a bridge between the Web and the real world.

We believe that this concept will bring significant changes to the way we manage daily fragmental information and lead us to a more information-rich life.

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