

An Interface for Visual Information-Gathering During Web Browsing Sessions: BrainDump - A Versatile Visual Workspace for Memorizing and Organizing Information

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Abstract— We propose a new method for visualizing the strength of associations based on a fluid metaphor and cell structure. This enables users to place gathered information visually in relation, while solving complex information tasks. Both, vague and precise relations can be visualized. We applied our approach to a scenario of information retrieval during web browsing sessions. In this paper we describe our novel visual information-gathering system called *BrainDump*. To support the user’s sensemaking process, this system provides the possibility to change the initial associations, follow links back to the source of information, annotate content and hierarchically group collected items. A preliminary user test was designed and conducted.

Keywords-graphical user interface; visual information gathering; visual sensemaking; personal web information system

I. INTRODUCTION

Complex web information tasks involving answers to more than one question to satisfy a user’s goal are called *information-gathering tasks*. Users executing this kind of task are called knowledge workers and are defined by Sellen et al. as people “whose paid work involves significant time: gathering, finding, analyzing, creating, producing or archiving information” [36].

Working on complex information-gathering tasks, knowledge workers have to understand unfamiliar contexts – a process which has been coined *sensemaking* [12][35]. This complicated, iterative process occurs in everyday life and requires a high cognitive load. For instance, when a researcher faces an unfamiliar field of research, he or she has

to gather information from an unfamiliar field and make sense of that information.

Considerable research has investigated how people organize information making use of spatial memory [24][27][31]. Spatial layouts are often used to manage transient or temporary information in current visual interfaces. Examples include web bookmarks [34], spatial hypertexts [38] and desktop icons [2]. In most systems, a cluster represented by a spatial aggregation of elements, exists only in the user’s mind. However, internal mental representations perform poorly on making sense of complex and rich object relations or associations. In contrast, well designed external representations can support this sensemaking process [35].

Especially at the beginning of this process, the user anticipates associations and potential relationships. While making sense, there are a lot of changes in the user’s mind, concerning the structure of collected information. Organizing information with the help of spatial layouts is far more flexible and lightweight than using explicit grouping mechanisms such as bookmark-folders [1][3]. This makes spatial layouts an excellent technique to organize information in the transient, temporary states of a sensemaking process.

To understand the relations between the contents found in a complex web information-gathering task, knowledge workers use bookmarks, tabs, browsing history, different browser-windows, virtual documents, folders, offline documents, and sketches. The challenge is to keep in mind where specific information is located. This problem has been called *information fragmentation* [22][34]. Users might lose the *big picture* of their task or the context of the currently

pursued question, during a long session on the web. Since most information-gathering tasks require multiple web sessions to satisfy a goal [24], annoyance and frustration with current systems is increased [28]. Loss of context happens when users are getting sidetracked, forgetting their original questions involved in the information-gathering task or when the title of a bookmark cannot be remembered. The results of a study by Kaasten et al. [37] show that thumbnails of visited websites support the recognition considerably. In this study, color, distinctive images, layout, and pieces of text on the webpage are features helping the user to recognize the exact page. Plain use of titles, like in browser-tabs and browser-windows cannot take this into account, and therefore may not be enough to remember the websites behind them. Hence, a part of the task already achieved has to be repeated in order to reacquire the lost information.

We are addressing the problems discussed above with our new approach. A knowledge worker can use a highly flexible visual map to represent and refine his current understanding of a task using the human strength in spatial memory. A metaphor based on fluids and cell structure allows the user to visually memorize anticipations about relations with the option of using textual annotations. We assume that resuming an interrupted task, or continue an earlier finished research is highly accelerated by utilizing a map that helps the user in information retrieval and to remember his last status of understanding. The concept aims towards offering the user a high degree of recognition for collected elements.

This paper consists of four parts: the first part shows related work, the second part explains our design decisions while the third part describes the interface of our prototype named BrainDump from a user's perspective. The fourth part briefly describes our first short preliminary user study.

II. RELATED WORK

In this section, related work of different fields concerning the BrainDump approach is presented.

A. Spatial Layout and Aggregation

Spatial layout has been a basic feature in window based systems, like the early Macintosh. It has long been used for document management. There are several extensions to this 2D layout, for example ZUIs (Zoomable User Interfaces). ZUIs aim on solving the problem of having more information, than fits on the screen by providing panning and zooming operations. The first system to explore this approach was Pad [33]. Bederson defines ZUIs as "systems that support the spatial organization of and navigation among multiple documents or visual objects [4]."

Spatial aggregation plays an important role in management of information using spatial layout. As a part of an original experimental workshop [9][10] we collected ideas how to visualize relations between objects based on the properties of fluids. For example, a person can drag parts of fluid substances over a surface and form them to bigger or smaller groups (see Figure 1).



Figure 1. Snapshot of our experiments with fluids [9]

An interface for manipulating spatial aggregations of objects is Bubble Clusters [41]. A spatially efficient bubble shape is drawn around objects, leveraging the natural expectation of users concerning the behavior of bubbles.

This approach in line with a visual gimmick named Realtime Blobs, found on the website of the designer Ivanov [20], inspired us to use rotund shapes in our system.

B. Techniques for Mapping the Mind

Several techniques to create different kinds of external representations exist [14]. One of the most commonly used is the mind mapping technique. Eppler defines a mind map as "a multicolored and imagecentred, radial diagram that represents semantic or other connections between portions of learned material hierarchically" [14]. The typical application context is personal note taking and reviewing. In addition to Concept Maps, Conceptual Diagrams, Semantic Maps [18], and Topic Maps [32], the major advantage is that these techniques mostly provide a concise overview. Inspired by these approaches, our vision is to give the user a permanent and reliable overview of the context of his information-gathering tasks while working on them.

C. Systems Supporting Web Tasks

An example for the 3D arrangement of Bookmarks is Data Mountain [34]. In this approach the user can place documents on an inclined plane textured with landmarks. It follows an interesting approach that takes advantage of human spatial memory skills.

For sensemaking and manual collection via drag and drop of web-scrapes like pieces of text, pictures, and URLs, Scratch Pad [7] is a conceptual approach. The simple way to collect items from websites via drag and drop is extended in our approach by displaying a visual metaphor for the collected items.

III. DESIGN DECISIONS

Our contribution is a system, where the user defines a visual map of his or her comprehension of relations between content, established while working on web information-gathering tasks. Manually collected information can be spatially arranged, visually related, and annotated.

A. Visual Metaphor

For displaying associations and relationships between collected objects, we use a visual metaphor. As described in Section II, it is based on the idea of fluids, Bubble Clusters, and Realtime Blobs. The authors of Bubble Clusters proved that users can quickly create, merge, and split groups by moving objects on the screen. In addition to the existing approaches, we display visual real-time feedback of the strength of relations, while a user drags two objects next to each other. Thus, different intensities of a relationship can be defined as shown in Figure 2: objects labeled 1, 2 and 3 are dragged at a position, where they have a visually loose connection (left) or a rather visually strong connection (right). Due to the real-time visual feedback while dragging objects next to others, it seems as if the user is dealing with a fluid substance.

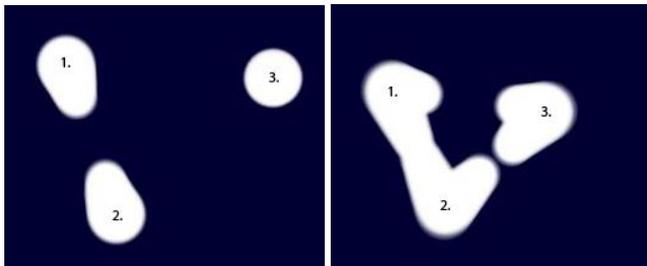


Figure 2. Metaphor for displaying relationships of different intensities. Left: weakly related objects. Right: strongly related objects

B. Visualization Algorithm

Objects are represented as white filled circles. The visual relation depending on the distance between two objects is represented by several white filled circles, drawn on a non-visible straight line between the center points of these objects (see Figure 3). This visual relation is displayed by an algorithm based on our observation of Realtime Blobs [20].

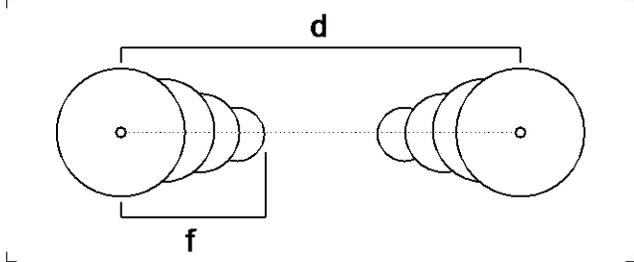


Figure 3. Schema of the drawing-algorithm: distance d between two objects and the circles expansion distance f

If the distance d between two objects falls below a prior defined limit, the particular circles for the relation are drawn by the system. They become linear smaller until one third of the original objects diameter is reached. If the user drags an object half the distance of the prior defined limit of d the circles reach the center of the other object. Until this point the circle expansion distance f increases - and therefore the number of circles drawn. As one object is dragged closer to another object, f decreases again, until it reaches zero. The

objects appear to attract each other (see Figure 2). This algorithm achieves a reasonable balance between aesthetics and performance.

C. Hierarchical data structure

With our current concept we are combining the flexibility of spatial layouts with the benefits of hierarchical grouping. An object in our system can be an *item* or a *topic*. Items are manually collected parts from websites (see Table 1) with a white circle in the background - imitating a cell with a core (see Figure 4). They are created by the user to represent a hyperlink to that specific website. The users' collected items can be grouped into topics. These topics are slightly bigger than items, with a colored background (see Figure 4) and can be put into other topics to build a hierarchy. The data structure provided by the BrainDump system is a tree structure with one single root node. Every node is a topic and every leaf is an item. The user can decide to work in the root topic alone or to create other topics for hierarchical grouping.

For navigation and organization in our system, we are using the technique of a ZUI with animated transitions and a multi-level layout [5][15]. By accessing the different hierarchical structured topics the predefined zoom levels are helping the user in navigation tasks. Studies on how people learned from zoomable spaces imply that users working with ZUIs may be more engaged and may remember the spatial structure of the content better [8][16].

D. Representation and Handling of Gathered Items

One of the design guidelines for ZUIs by Bederson is only to use ZUIs, if there is a small visual representation of the data available [4]. Thus, our concept lets the user choose his or her personal small representation for a collected website displayed in the center of an item. In addition, the title of the website is displayed under the representation and can be edited by the user (see Figure 4).

Table 1 shows which parts of a website can be manually collected using what kind of interaction.

TABLE I. ADDING OBJECTS TO THE SYSTEM

Web browser source	Representation in the system	Interaction	
		for selection	for collecting
URL	Thumbnail of the actual entire website	Drag	Drop
Picture	Picture	Drag	Drop
Video ^a	Video (playing while hovering cursor)	Drag	Drop
Pieces of text	Thumbnail of user selected text with direct surroundings	Marking, dragging	Drop
User-defined clipping of a website ^a	Thumbnail showing the respective part	Lasso/rectangle selecting, drag	Drop
search queries	outline around object, with favicon of the search engine used before finding the respective object	added automatically	added automatically

a. not included in the current implementation of the prototype

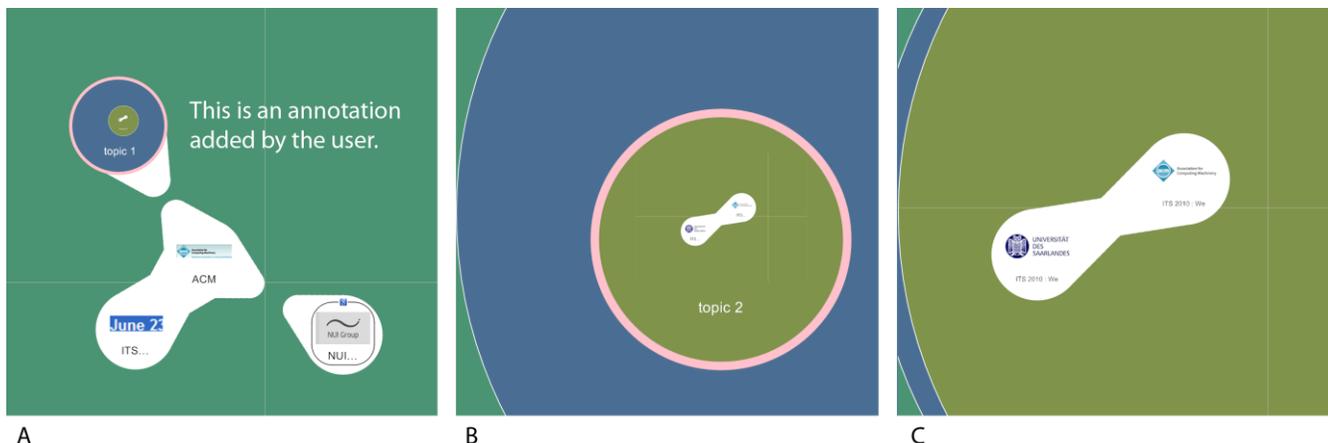


Figure 4. Look and feel of BrainDump prototype interface with hierarchically clustered topics (colored) and items (white). *A*: Screen-capture of the green main topic with three items and one blue topic. *B*: Screen-capture of the zoomed-in view on the blue *topic 1* with no items and one topic. *C*: Zoomed-in view on the chartreuse *topic 2* with two items. The rings on the left side of the screens *B* and *C* can be clicked to zoom-out and get up the hierarchy.

The only element which is added automatically to the system is a search query the user submitted to find a collected item. This query will appear at the respective website representation in the system (see Figure 4, *A* and Figure 7 - black outline), making it easy to recall successful queries later. The website's favicon - a small graphic that is associated with a website - is displayed on top of the outline.

To recognize a collected website later, we are expecting, that choosing his or her own representative for this site helps the user, since learning techniques rely on associations between easy-to-remember constructs and the data that has to be remembered [14]. Despite being carefully chosen, the items in a user's collection are sorted and their relevance is questioned by the user. Since any changes in the layout are only made by the user himself, a consistent layout is provided. This can help the user to build up an internal map over time and make it easy to recognize objects. Using a consistent layout is another design guideline by Bederson [4] which is fulfilled by our concept.

In addition to gathering items, the user can include annotations in his collection (see Figure 4, *A* - white text on green background). This is achieved by a right-click of the mouse on the background at the position where text should be inserted. The font-size is always constant in relation to the pixel dimensions of the display. Thus, the user can place different sizes of annotations into the system by changing the actual zoom-level before adding an annotation.

E. Summary of Design Decisions

To give an overview of our design decisions, we list them in form of requirements for Information-Gathering Systems:

- manual visual definition of relations with optional textual description
- definable strength of relations between objects
- free spatial sorting and arranging of objects
- hierarchical structuring of items with topics
- automatic saving of item related search queries

- manually collected representations of websites, according to interesting content for the user (e.g., pictures, text, videos)
- making annotations to the collection
- local saving of websites related to collected items to prevent the loss of outdated websites
- local saving of links (URLs) referring to the respective website

F. Implementation of the prototype

As proof of concept, we implemented a first prototype, a windows application, running on Windows XP and higher versions. The current version is based on the .NET-Framework and uses OLE (Object Linking and Embedding) for embedding and linking to documents and other objects. Therefore, the prototype can be used in combination with Microsoft Internet Explorer 7 or higher. The collected data is stored in an XML-file. For realizing the ZUI, we used the Piccolo.NET framework [6].

IV. THE BRAINDUMP INTERFACE

The BrainDump interface consists of two parts: The *Dropping Area* and the *Management Mode*. We will describe them in the first two subsections. The third subsection describes navigation in BrainDump.

A. Dropping Area

This part of the interface appears at the right side of the browser in a separate window (see Figure 5). The dropping area can be equipped with links referring to topics existing in the user's collection. We call these links *Topic Portals* (see Figure 5, right column). The user can drag pictures, pieces of text, and URLs onto these links. While hovering over a Topic Portal its size increases (see Figure 5, B). The user can place his dragged content and define the strength of the visual relationship to other gathered items. He can also put items into topics existing in the Topic Portal. These portals are shortcuts for the user to optimize his conduct of information-gathering tasks. Portals avoid changing the

application window for placing or moving an object. Moreover, the user can have multiple topics easily accessible while browsing.

B. Management Mode

The Management Mode offers a fullscreen view of the user's collection. Here he can manage and organize all collected items and topics (see Figure 6) - labeling of topics included (see labels in Figure 4. A and B). Furthermore, the user can manage the Dropping Area and utilize Topic Portals as shortcuts for moving objects to topics in different hierarchies. He can create a Topic Portal by dragging a chosen topic from the canvas onto the Dropping Area. Topic Portals can be deleted without any consequences for the actual topic inside the system. As a result, the user can optimize his dropping area for the context of his current information-gathering tasks.

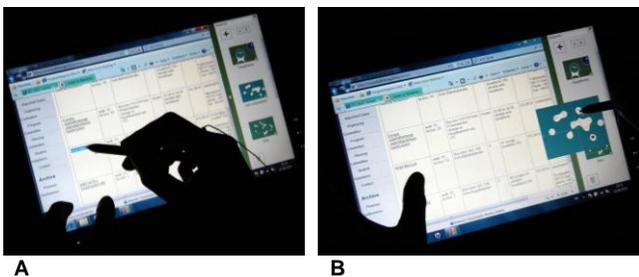


Figure 5. Dropping area on the right side of the browser, A: Marking a piece of text and B: Dragging the piece of text into a topic portal

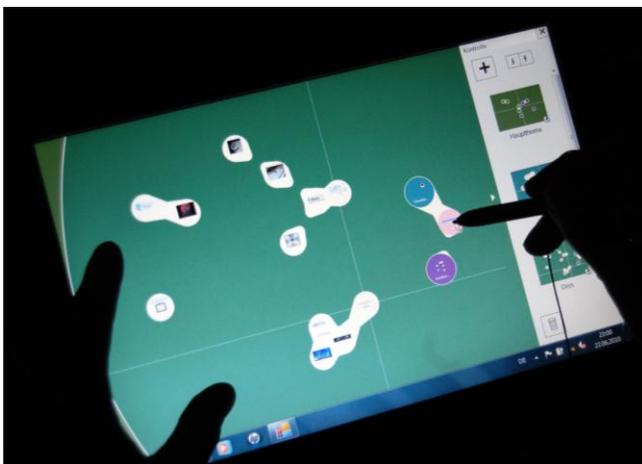


Figure 6. The Management Mode with the Dropping Area on the right

To create a new empty topic the user can press the “+” button in the upper left of the dropping area. To create a new topic with an object already in it, an item or topic can be dropped on this button. This instantly creates a new topic in the one currently viewed. Thus, a new node is inserted into the internal tree of the systems data hierarchy, as described in Section III.C.

C. Navigation in BrainDump

The user can zoom in on a chosen topic by double clicking it. By doing so an interactive ring on the left side of the screen appears (see Figure 4, B). More rings appear if the user navigates deeper into the hierarchy (see Figure 4, C). These rings enable zooming out of a topic and thus navigating up in the hierarchy. Additionally, these rings provide an overview at which hierarchy level the currently viewed topic is located. Backtracking can be done step by step up the hierarchy or directly jumping to an upper topic. The transitions are animated to support user orientation. An example is shown in Figure 4: First the user views the green main topic with three items and one topic in it (A). Then he navigates inside the blue topic named *topic 1* (B). Being inside this topic, a green ring for backtracking to the main topic appears on the left side of the screen (B). Similarly, an additional blue ring appears when the user navigates into the chartreuse colored *topic 2* (C).

Depending on the zoom scale, the text in an item may not be legible. To address this problem, an alternative, summarized representation is chosen by the system. When a text line is small on the screen the user may only want to see its beginning. As the item is magnified, this may be augmented by a short summary or outline. At some point, the entire text line is revealed. This technique is called semantic zooming [33]. As shown in Figure 7, we have implemented semantic zooming for displaying a reduced (A) and full (B) display of search queries and titles of items.



Figure 7. A: minimum and B: maximum of displayed information. Items consist of: representation of the respective website (here a picture), title of the website and search query displayed through favicon and black outline.

In doing so, we follow the suggestions by Kaasten et al. [23], who found out that right truncation of website titles allows for best recognition.

V. PRELIMINARY USER TEST

Since our prototype is in an early development stage, we chose to conduct a formative evaluation, a process of ongoing feedback to improve and optimize our concept. Thus we conducted a preliminary user test with nine participants to elicit first directions concerning three questions:

1. Do users get lost while navigating in the ZUI?
2. How is the acceptance of the used metaphor?
3. Can users recognize collected visual information?

The average age of the test persons was 29, two of the nine participants were female, no one used the Internet Explorer during their work before.

A. Design

In order to obtain valid results, we made a checklist for ensuring exactly the same course of actions for each test user. A task was designed including a scenario, where the users had to plan a trip to an exhibition. The participants should imagine they want to attend the conference *games convention*. To prepare for the visit, they should get an overview through saving related information using BrainDump. The scenario was described in detail with three subtasks: getting started, getting information about exhibitors and getting information about the conference. For each subtask the participants were given detailed information, what they have to look for, e.g. "Because you are interested in browser games you want to meet the company gamigo AG".

This scenario consisted of two stages: training and evaluation. The training stage aimed at providing some practice in the use of information-gathering functions of the prototype and to support the test persons in understanding the purpose of BrainDump. The target of the evaluation stage was to identify usability problems referring to the three questions mentioned above. We provided precise subtasks for the test persons in the given scenario.

To get impartial results, we observed the participants during the evaluation and recorded their sessions, including mouse clicks, keystrokes and voice using the software *Morae 3* from *Techsmith* [30]. Apart from that, we wrote down comments and reactions of the participants (think aloud protocols).

A questionnaire was given to the test persons to investigate their subjective attitude towards the usage of the prototype. This questionnaire was divided into ten sections with 75 questions in total: the first section covered feedback about the evaluation itself, and if the scenario including subtasks was comprehensible. The second section served to estimate general usability problems by means of the System-Usability-Scale. Detailed usability questions were asked within sections three to seven, using a standardized heuristic. Section eight investigated aspects of visualization, interaction, and user satisfaction. In the ninth section, participants were asked to state missing features. Demographic questions together with earlier used software were asked in the last section. Throughout the questionnaire, a five point Likert scale was used to examine the participants' level of agreement to each statement.

B. Procedure

In total, the evaluation took about 35 minutes per test person. At first, the purpose of BrainDump was explained briefly. In order to not affect the results, no further aims of the evaluation and software were revealed. Exactly three features of BrainDump were shown to all participants to

create equal starting knowledge: 1. How to collect and put items into a Topic Portal in the Dragging Area. 2. Making annotations in the system. 3. Creating a new topic.

With handing out the scenario descriptions, the recording started. The practical part took about 25 minutes to complete. Afterwards the questionnaire was given to the test persons.

C. Results

The purpose of BrainDump was understood completely. All of the participants would like to use the application more often in their daily work. They especially liked the fast way to visually change relations and associations between information.

Some shortcomings of the current implementation were identified: Four of the nine test users thought that the software does not provide sufficient information about which actions are currently permitted. An equal number of the participants found the font size used for the labels too small. Six persons were irritated by the automatically drawn relation between objects. Four persons expected the possibility of manipulating the drawn relations. Three participants expected by mistake that some of their topics were empty, because the content was not visible. Two of them deleted such a topic that was not empty. Five test persons expected to be able to select multiple objects at once. Four users were irritated by topic portals or rather did not recognize them as links referring to topics.

Further additional features were requested: A solution to cut off unwanted relations with a gesture, manipulation of relations between items and scaling of objects to highlight importance.

D. Discussion

The results can be interpreted by taking the three initial questions into account. Since the number of nine participants is hardly representative, no generalized conclusion can be drawn at this point. The results have to be treated carefully. Further, the participants had no possibility to get used to the system which increases irritation, especially when not being used to a ZUI. In addition, the performance of the prototype was slowed down by the capturing software *Morae*. This made dragging of items from websites into the system extremely slow - thus further irritating users.

1) Do the users get lost while navigating in the ZUI?

The deletion of non empty topics may be a result of the fact that users got lost while navigating. Bederson discovered that when objects are placed at many different levels - and therefore very small sizes - users won't remember that they exist [4]. To solve this problem, the concepts' spatial layout can be designed to indicate hidden objects to the user. Another possibility is to minimize the depth of the hierarchy to circumvent undersized objects. As observed, some people had problems understanding and using Topic Portals. A study by Hornbæk showed that an integration of overview and detail windows requires mental and motor effort [19] - since Topic Portals are very similar, this might indicate that this problem does not necessarily depend on being used to it. In a following study, it has to be investigated whether this

problem stems from graphical representation or the concept itself.

A solution for these problems might be to use a hybrid system - a combination of a ZUI with traditional approaches like facets or folders.

2) How is the acceptance of the used metaphor ?

Despite liking the visually changeable relations and being engaged with the systems use, some participants were irritated by the automatically drawn relations and missed direct manipulation of these.

One possible explanation for this irritation might be that the relation depends solely on distance - which was not expected by the user and might be a less critical factor when participants are used to the system. To minimize these irritations, the metaphor could be refined to a more natural, expected behavior and with regard to connecting items independently from distance. Direct manipulation of the relations has already been part of our concept, but not yet included in the current prototype.

3) Can users recognize collected visual information?

Despite observing the problems with font size, the duration of the evaluation was too short to simulate an interruption long enough for the users to be a handicap. Therefore, a study taking several days with a long break in between will be necessary.

VI. CONCLUSION AND FUTURE WORK

This paper presents a new approach to ease the process of memorizing and organizing information during complex tasks using the internet. This is achieved by a visual approach to connect objects to unique shaped groups and the possibility to relate objects in different visual intensities. The user can choose what part of a website he wants to be the representation of his bookmark. Manifold associations can be mapped on one simple and powerful metaphor. Since the user places objects in space and no one else is moving them except himself, he can build up a personal internal map over time. Indicated by considerable research [4], a consistent layout can help the user to recover objects.

As proof of concept, we implemented a prototype and conducted a first preliminary user test, showing that participants enjoy using such a system, but also indicating that several parts of the prototype and concept have to be refined. Based on the results, we will improve the presentation of items in the next version of our prototype to improve legibility. The approach of Strobelt et al. uses interesting algorithms and heuristics which we want to take into account for a refined concept [40]. Apart from displaying well designed representations, Klemmers' work on Design History [25] suggests that also the history of creation may be important to reconstruct meaning. We plan to integrate this idea in the current concept.

Since zooming in and out repeatedly is typically straining [4], this should be minimized. Therefore, we will consider using a hybrid system - a combination of a ZUI with traditional approaches to minimize depth of zoom levels. A

further improvement in orientation could be to use landmarks, as seen in Data Mountain [34]. Inspired by this idea, we will enhance our concept with structured background pictures.

To minimize user irritation, the visual metaphor will be refined to a more natural behavior, possibly enhancing it to enable visual relation apart from using distance. We already made first experiments with new algorithms (see Figure 8) derived from experimental observations [9][10].

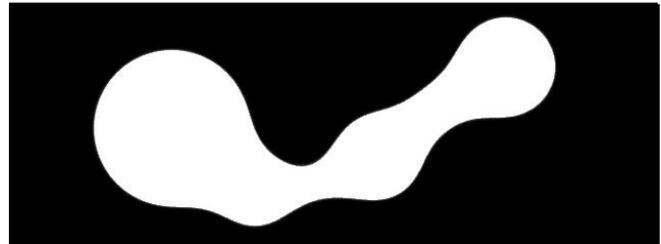


Figure 8. First Experiments with new algorithms

Besides, we plan to enable the use of documents other than websites. For example contact files, office files, e-mails, and information from the file system or social networks. Thereby, we are addressing the problem that users lose track of their project documents and relations, studied by Bergman et al. [7], the authors called this *project fragmentation*. Furthermore, we plan to conduct a qualified user study and compare other systems to our system.

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