UNIVERSITY OF TWENTE.

**Faculty of Electrical Engineering,
Mathematics & Computer Science**

Layout management on an interactive tabletop system

Mohamed Reda Benkhelifa

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Supervisors:
dr. M. Theune
dr. R. Damgrave
hdr. M. Serrano

Faculty of Electrical Engineering,
Mathematics and Computer Science
University of Twente
P.O. Box 217
7500 AE Enschede
The Netherlands

Abstract

Interactive tabletops are becoming increasingly popular. Their large screens allow a large amount of information to be displayed. This is why they can be found in work environments, such as universities, workplaces, laboratories, etc. Due to its size, a user can easily spread out the displayed content all over the virtual workspace. This can lead to the user being overwhelmed by the amount of content displayed and have difficulty in viewing it. The organisation of the content is therefore essential.

In this work, I developed a system to enhance the reading experience of research articles on an interactive tabletop. A user interacts with a tablet displaying the research paper and can retrieve its content to the tabletop. In order to address the issue of managing the virtual workspace on the tabletop, the system reorganizes semi-automatically the virtual workspace. To do so, I proposed three models for organising the extracted content displayed on the tabletop: a clock-model, a zone model, and a customisable model. These models, implemented as constraints, allow a semi-automatic reorganisation of the virtual workspace for the user.

Before arriving at this proposal, interviews were conducted in order to determine how scientists read a research article and to identify the content that is important to them. Next, co-design sessions were conducted to observe how participants would organise their workspace while reading a research article on a tabletop. From there, the different organisational models were implemented. I consider as future work to conduct high-fidelity experiments to compare the different organisation models and determine which one is the best.

Contents

Chapter 1

Introduction

1.1 Context

This thesis research was carried out at IRIT in Toulouse, France, in the Elipse team, as part of the French National Research Agency PERFIN project [1]. The project focuses on one of the most important topics of HCI (Human Computer Interaction), data visualisation. Which display format should be used to display the data and where should it be positioned on the display space? There is a recurring need to be able to visualise our data everywhere and make decisions quickly. This requires ubiquitous, dynamic and interactive displays. Projection-based displays can fulfill this vision. However, environmental constraints such as non-linear surfaces or the presence of objects can make the task more complicated.

Within the PERFIN project, Dynamic Decals [2] was developed. It is a projection display system in a 2D free layout environment, with content occlusion management by both physical and virtual objects, using a constraint-based approach. The system decomposes the interface into deformable graphical units called ”decals” and controls their position and behaviour with constraints. It dynamically deforms the components when needed while minimizing the impact on visibility which permits to enhance interface aesthetics and content visibility. However, the system was only demonstrated on basic layouts, not representative of more complex use cases. My goal in this internship is to extend the application of Dynamic Decals to a more complex layout system.

1.2 Goals

To extend the application of Dynamic Decals to a more complex layout system, I have conducted an HCI study of the following use case: **an application that augments the reading of a research paper on an interactive tabletop**. The idea is that the user places the paper on the interactive tabletop and can extract the content as decals on the tabletop's screen. The system will organise the layout semi-automatically within the constraints that will be implemented. Through my work, I will be able to answer the following research question:

RQ1: How do we organise the virtual content of a research paper on a tabletop screen, using a constraint-based approach?

Before developing this system, I had to answer some other questions in order to orientate my design. Since the concept of the application is to display content from a research-article, we may ask ourselves :

RQ2: How do researchers read articles?
RQ3: What content would researchers like to extract from the paper?

1.3 Approach

In order to best answer the established research questions, my approach in this project is based on the double-diamond design thinking process: Discover, Define, Develop, Deliver (Figure 1.1). The structure of this approach permits an understand-

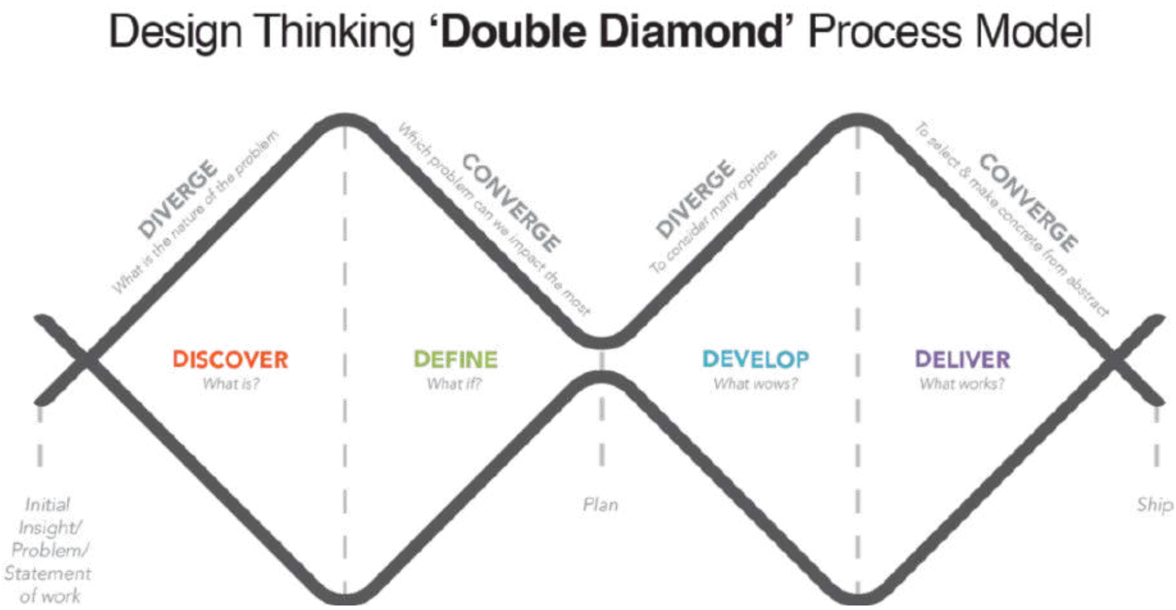


Figure 1.1: Double diamond design thinking process [3]

ing of the problems encountered by the users and to explore creative and innovative ways to solve them. It uses two different types of thinking. **Divergent thinking**: keep an open mind, consider anything and everything; and **Convergent thinking**: bring back focus and identify one or two key problems and solutions.

1.3.1 Discover

In the discover stage we practice *divergent* thinking. I have started by a literature review (Chapter 2) to have a more general knowledge of the different issues studied in the field. I have in parallel established a mind map in order to explore different design options regarding the interaction with the system, how to trigger menus, control the different objects, etc. It allowed me to regroup inspiration from the different works I have read for the literature review but also to identify the different interactions users may have with a system that enhances the reading experience of research article. To complete this stage, interviews were conducted with eight participants in order to gain a better understanding of how researchers read a research article, how to improve their reading experience and what problems they might encounter while reading a research article (Chapter 3).

1.3.2 Define

In the define stage we use *convergent* thinking. The interviews were not only useful in identifying to a large extent the different problems but also in refocusing the design choices and problems to solve in priority. The responses from the interviews allowed me to answer the research questions 2 and 3(Chapter 3).

1.3.3 Develop

The next stage, develop, also using *divergent* thinking, is the stage focusing on "How do we solve the problems?". To do so, I have conceived a low fidelity prototype of the system made of paper and conducted co-design sessions with 7 participants who handled the paper prototype. It has allowed me to identify the position of the content according to their type and identify different possible organisational models (Chapter 4).

1.3.4 Deliver

The final stage, deliver, I am practicing *convergent* thinking again, focusing on what I can actually implement according to skills and time restrictions and which solutions will solve users' needs. At the end of this stage, I was able to contribute to the code of Dynamic Decals (chapter 5). I managed to implement various constraints that allow to organise semi-automatically the content. I also discuss the limitations of my work during the thesis research and discuss future work possibilities (Chapter 6).

Chapter 2

Related works

This project take up Niyazov's work, Dynamic Decals [2], a projection display system in a 2D free layout environment, with content occlusion management by both physical and virtual objects, using a constraint-based approach. In this section I will start by explaining Niyazov's work. Then, since the aim of this project is to display information and organise virtual content semi-automatically so that it is always visible, it is interesting to look at the different techniques of occlusion management that allow the content to remain constantly visible. Finally, since my work consist in augmenting a physical paper in order to interact with it, I will develop about the different approaches of augmented paper systems.

2.1 Dynamic Decals

The problem that was highlighted and that pushed to develop Dynamic Decal is that with the development of display systems that integrate into our daily environment (e.g. tabletops or projected systems), how to avoid the occlusion of virtual content by physical objects such as books, plants, glasses...? and how to organise the content on non-regular display surfaces such as a circular table? This is why Niyazov et al. developed Dynamic Decal [2], a system that decomposes the interface into deformable graphical units and controls their position and behaviour by a constraint-based approach. The system dynamically deforms the components when needed while minimizing the impact on visibility.
To manage automatically their position, there is a solver integrated to the system. Cost functions are given to the solver who will try to minimise the cost by changing some variables. The solver library is private, so I can not give more details on how it works. Cost functions are implemented as constraints. A decal has to respect a constraint, if he does not, the cost increases with the degree of non-compliance. In Dynamic Decals, three constraints have been implemented (see Figure 2.1). The

Gamut constraint goal is to force the virtual content to stay on the display area. The *Distance constraints* role is to prevent the content to overlap to preserve the visibility and grouping content. The last one, the *Alignment constraint*, ensures that virtual objects stay on the same vertical or horizontal line even when they are moving. The point of the constraints is to maintain content visibility and layout simplicity. To prove the efficiency of their system, Niyazov et al. conducted multiple experiments (see Figure 2.2) where they simulated multiple object occlusion on rectangular and non rectangular display areas on four different interfaces (an image viewer, a mind map, a 3x3 grid of images and a 5x5 Grid of folders) and compared different sets of constraints activated. The conclusion that was reached was that the most efficient set of constraints was the one including a combination of the different constraints, mostly the Alignment constraint that increases the layout simplicity. The more occlusion there is, the more advantageous their approach is compared to other approaches. From the user perspective, the interface content is nice and visible whether on a rectangular interface or a non rectangular one.

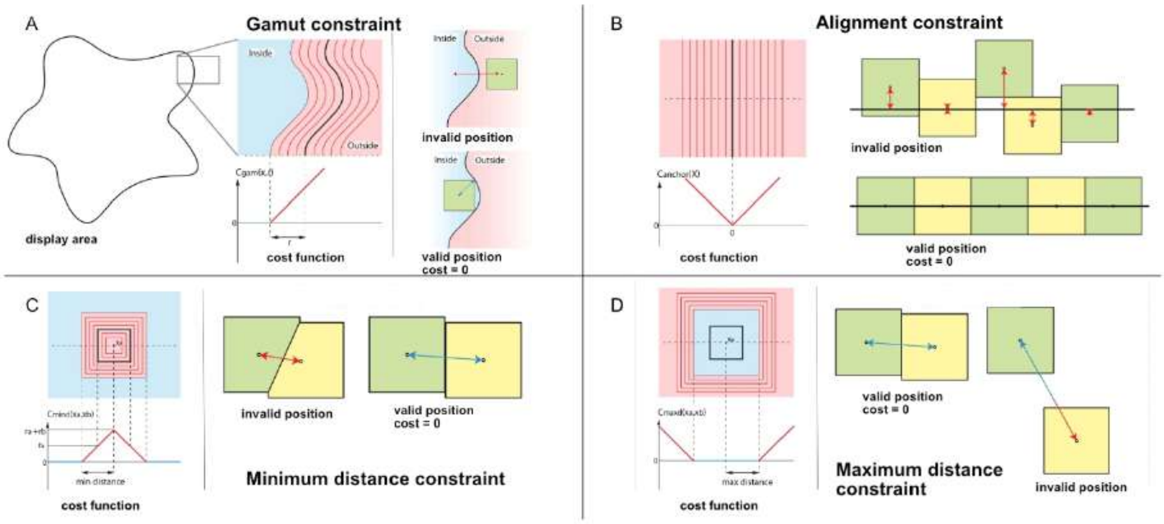


Figure 2.1: Dynamic Decals: constraint representation [2]

2.2 Occlusion awareness

One of the most recurrent problems in any type of display systems (computer, AR, tablets, tabletop...) is content occlusion. This is why it is interesting to look at techniques to ensure that content is always visible. It is called occlusion awareness. As Vogel and Balakrishnan [4] have defined it, occlusion-aware interfaces are interaction techniques which know what area of the display is currently occluded, and use this knowledge to counteract potential problems and/or utilize the hidden area. Over

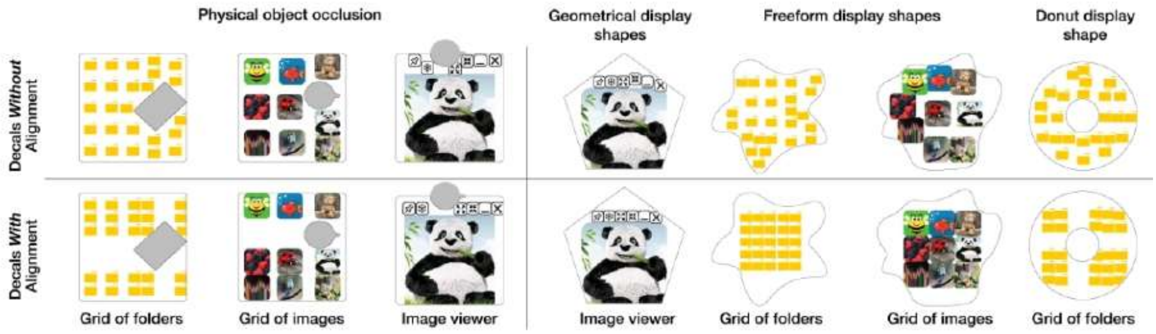


Figure 2.2: Dynamic Decals: experiments [2]

the past years, a set of techniques have been proposed to mitigate occlusion problems on touch devices such as tablets or tabletops. Occlusion is a recurrent problem that contributes to errors, fatigue and reduce performance [4]. This problem is encountered in all types of interfaces and in different forms such as user occlusion or also occlusion from objects .

2.2.1 User occlusion

User occlusion usually happens on touch interfaces. The user will tend to hide some information because of their hands or even with their arms on larger systems (huge screen tablets, tabletop, wall size display...). To enable occlusion awareness on pen based systems, Vogel et al. [4] developed a configurable real time geometric model capturing the general shape of the occluded area.

The user will set in the settings of the system the hand radius and the forearm angle and width (see Figure 2.3). The model will track the area occluded by user's hand and arm by tracking the position of the pen. The system considers objects that undergo changes to be important. It will display a preview on a non occluded area to let the user visualize the changes. For example when formatting text or changing parameters of an image. From the experiment, they were able to affirm that their system increases the speed and the

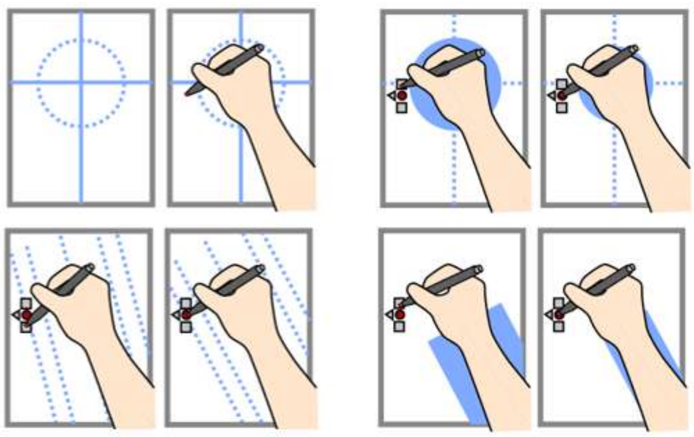


Figure 2.3: Occlusion awareness on pen based system: Hand and arm occlusion settings [4]

performance for a task, increases comfort and is user friendly.

While this system must be configured manually, it is also possible to consider a system that automatically detects the position and angle of the hand. That is the approach from Brandl et al. [5]. On the creation of circular menus, the tabs under the hand are not necessarily visible. The user needs to twist his hand to see the content. This is why they developed a way of detecting the angle of the hand according to its position on the touch surface to determine the occluded area and displaying a cut circular menu. The proposed solution worked properly and was more comfortable than usual for the user since he do not need to twist his hand anymore. But we can imagine in situations with circular menus with a lot of tabs, it will reduce the visibility of the content since the menu is smaller.

2.2.2 Object occlusion

With the development and increasing accessibility of large interaction surfaces such as tabletops, a user may want to place everyday objects on the surface. However, this adds new elements that may hide the virtual content. The usual approach to face this kind of occlusion is to display the hidden content around the physical object. For instance, SnapRail [6] resizes the content and places it on a circular widget around the object (see Figure 2.4). The interface elements are attached to the physical object and follow it if the user drags the object on the surface. The user can scroll the rail widget to view all the content fixed to it. Users from the experiment found the system very intuitive and easy to use.

Figure 2.4: SnapRail interface [6]

Khalilbeigi's et. al. [7] approach is a bit different than the previous one. When a virtual object is occluded, they display a light around the physical object and small picture that indicates the format of the virtual element. When the user grabs the proxy, the format changes and give him a more precise preview of the content (see Figure 2.5). In a previous work [8], Khalilbeigi et al. identified different areas in the working space of a tabletop. Such observation was also made by Tabard et al. [9] on their work about workspace and occlusion management on an interactive tabletop used in a chemistry lab. The three areas that were identified are the active area, the intermediate area and the storage area. Depending on the area in which the virtual object is, their idea was to propose different format of proxy that represent the occluded object but they observed during an experiment that the representation should be minimal. They have also observed that participants where using the occlusion to

Figure 2.5: Preview of occluded object when user grabs the proxy [8]

hide elements that they are no longer using.

2.3 Augmented paper

In the presentation of their system Illumipaper [10], Konstatin et al. identified from previous works two different categories of approaches that augment the paper with visual feedback (see Figure 2.6). The first one is the extended approach, i.e where the feedback is not on the paper but on a dedicated display. It can be mobile when using a secondary screen that can be placed beside or above the paper, or stationary when using a large screen next to the paper or placing a screen underneath. The second approach is the combine one. It is when there is a visual layer onto the paper itself. It can be done by attaching tokens to the paper, using a mobile projector attached to a digital pen that so it project content from the pen or a projected system that project the content directly on the paper.

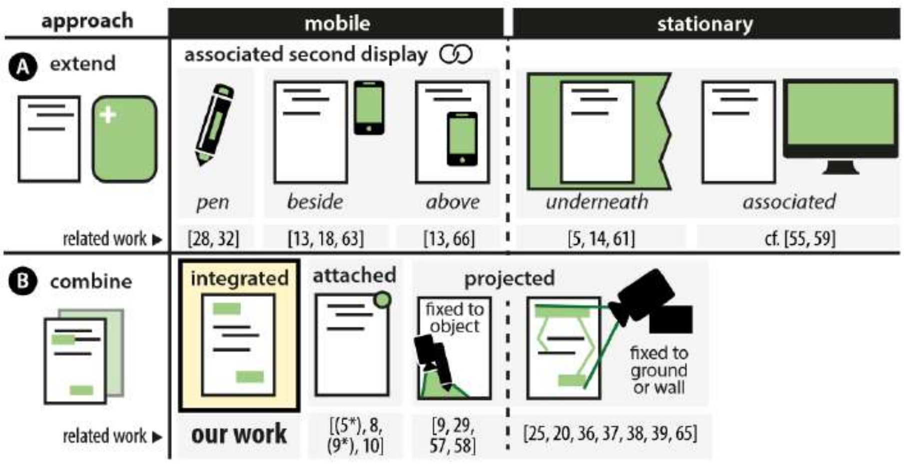


Figure 2.6: Different approaches of augmented paper system with visual feedback [10]

One of the first augmented paper system is based on this last approach. Contrary to what we may think, the idea of augmenting the paper is not new. Indeed, in 1991, Wellner present an approch opposed to the desktop metaphor. "Instead of making the worksation more like desktop, why not making the real desk more like a workstation?". That is how he presents the DigitalDesk [11], a projected tabletop system (see figure 2.7). It is equipped with a projector that projects the information on the desk, a camera that detects the movement of the hands, of the paper and its content. It is also equipped with microphones to detect the touch interactions with the physical or virtual content displayed on the desk. The system creates a link between the physical environment and the virtual one since you can interact with the physical paper to extract information and manipulate them in the virtual one, but it is also possible to project a virtual object on the physical paper and interact with it. A small user test session has been done with Wallner's co-workers. Their feedback was positive, the feeling of having more space was great and also the fact that it was more manual was pleasant. It is interesting to see that still thirty years later, despite technological progress, the research for this kind of system is still in progress.

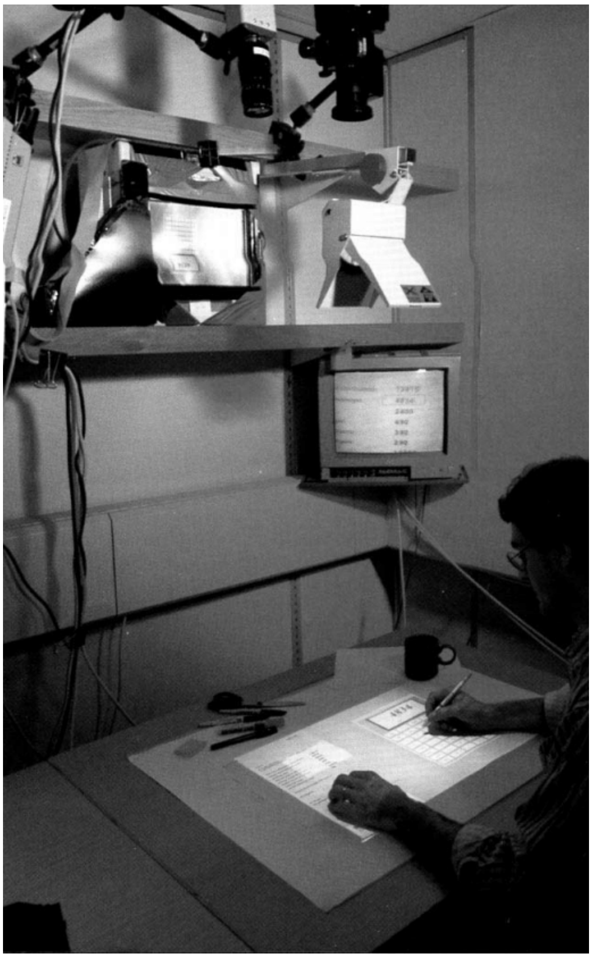


Figure 2.7: Digital desk from Pierre Wellner [11]

Despite the progress in technology, the disadvantage of projected systems is that they are not portable, are huge and can be expensive. Smaller systems have been developed such as augmented pen to capture user's writing. Augmented pen technology is not strictly speaking augmented paper but they are tools that augment the use of paper. Different approaches of augmented pen exist such as tracked based like the dodecapen [12] or camera based like the anotopen [13]. Tracking pens are pens equipped with marker(s). The movements and inputs of the pen are tracked by one or more cameras place around the user and can be used to digitize the writing. Camera based pens are pens equipped with a camera that will be able to read the

writing from the user and create a digital version. To be able to transcribe the writing, the pen must be used with a specific paper with a printed grid pattern to enable the pen to locate the writing on the paper. Most of augmented systems that use an augmented pen use the camera based approach. Similar systems are available in the market, with small differences between companies. For example RocketBook [14] drew logos at the bottom of pages as buttons to functionality in the tablet such as sharing the page by email, saving the page in the cloud etc.
Some researchers studied the approach of using buttons on the paper to call functions. Costa-Cunha et al. developed a system to augment a laboratory notebook [15]. In their paper they explain two interaction techniques: triggering of functions and the selection of areas to which the functions apply. In order to save more space on the page, the buttons associated to the functions are not on the pages of the notebook but on an additional sheet. The scientist will press on the buttons with the anotopen [13] to call a function that will help him organise his virtual laboratory notebook for example, create a title, highlight, create a paragraph... When the experiment was carried out in 2003, the anotopen technology was not able to give a real time feedback. The user needed to put the pen back in a dock connected to a computer to transfer all information stored by the pen to then observe the results of his work. New versions of digital pens have been developed with a Bluetooth connection to transfer in real time the data to a computer or a tablet but the inconvenience of such a system is to have a secondary device to get a preview of the digital version.

But despite the progress of the technology, the user will get the result of his actions only when he will look at the digital version of the document or will need to have an additional screen next to him to have a real time update. In order to compensate the lack of feedback, Konstatin et al. developed the illumipaper [10]: a system that integrates light feedback directly in the paper. They used paper-based electronics, paper and an Anotopen [13] to illuminate some elements on the paper to create a dynamic feedback on the paper. They designed 3 kinds of situation where their system can be used and improve the experience. In the first situation, they used it for a multiple choice questionnaire. The user can have direct feedback after ticking their answers to the questions and know whether they

Figure 2.8: Illumipaper multiple choice question example [10]

have answered correctly or not and what the correct answers are. In the second situation, they used their system to answer mathematical problems. With the anotopen [13] they were able to detect the user's handwriting and what number he wrote. From there, the system checks his answer and displays whether he got it right or not. In both situation, if the user is wrong it tells him with a red light that his answer is wrong and gives him the opportunity to see the right answer (see figure 2.8). If he is correct a green or white light will be displayed. The last situation they designed was for puzzle games such as crosswords. User can see if his answer is correct or not or provide him the solution. Using an anotopen makes it possible to locate the interaction on the paper as well as to recover what the user may have written. They tested their system with six experts from different fields: psychology, Human Computer Interaction, and education. The conclusion that was drawn was that the illumipaper reduces the risk of lost knowledge, that it is very intuitive and is recommended for use in an education. With this system they have overcome the problem of the Anoto paper by creating a direct feedback on the paper.

2.4 Conclusion

Regarding the methods to augment the paper, projected tabletop systems are a good way to add digital proprieties to paper. It is possible to extract the content from the paper, display virtual content on it, interact with it, transfer the annotation on the virtual version and have a good visual feedback, but the inconvenience of such systems are portability, costs and occlusion management from user's arms and hands. The inconveniences of systems using augmented pen were the method for calling functions in the system that usually require an additional sheet and mostly the lack of real time visual feedback.

This state of art allowed me to learn about the different techniques that have been developed and the reason of Niyazov's approach [2]. It has also revealed the identification of different areas on a tabletop system: the storage area, the intermediate area.

Chapter 3

Interviews

In order to better understand how people read research-articles, identify their methods and their motivations for reading, I have conducted eight interviews. The interview was designed to learn about the reading habits of a research article of the participants. It was also designed to identify the different motivations for reading a research article, to identify their methods of analysis and tools used during the reading sessions as well as the problems they may encounter. Research-papers reading is one of most time consuming activities in a researcher's carreer. This is why the participants are my co-workers from IRIT, all linked to the research. They were easy to recruit and it was easy to organise a session.

3.1 Interview structure and topics

The interviews were semi-structured (Appendix A.1). They were built around six topics:

- Participants' profile: Questions were asked to the participants about their age, experience in the research field, if they are right handed or left handed to observe whether there was a correlation between the participants' different answers.
- Participants motivation: Participants were asked about their motivation to read research articles and how many papers they read per week. The interest of knowing why they read a research article is to see whether their method of analysis differs according to their motivation. A reading for entertainment should not require a lot of focus from the reader who does not necessarily need to extract any information from the document. A reading in the context of work is expected to require more effort.
- Reading tools: This stage of the interview was focused on the different tools

participants may use while they are reading a research article. Do they read the article on paper or on a digital device? What kind of software/tools do they use? Are they taking notes physically or virtually?

- Reading method: this section was focused on identifying patterns in the reading of research articles. What are participants' methods to read a scientific article? What kind of information do they extract? Do they use the same method according to their motivation? Is there something that annoys them while reading a paper?

- Workspace management: the main interest of the project is about the content organisation. This is why participants were asked about the management of their virtual and physical workspaces. Do they consider themselves as organised or not? How do they arrange the different tools they use?

- Suggestions: In this last section, the participants had the idea of the project explained to them: a system on an interactive tabletop that enhances the reading experience of a research article and organises the content in a semi-automatic way. They were then free to suggest the different functions and tools they would want to see implemented in the system and how to interact with it.

3.2 Set-up

The interviews took place in an office at the IRIT. Due to security measures related to coronavirus, a distance of two meters was established between the participant and myself. The room was ventilated after each interview and participants were free to wear a mask or not. Participants had to sign a consent form (Appendix A.3) after being briefed on the interview (Appendix A.2), to allow me to record the session and use their answers in my research. The sessions were audio-recorded in order to complete the note-taking and not break the rhythm of the interview.

3.3 Results

During the interviews, I took notes of participants answers and audio-recorded them in order to complete the notes. I have then regrouped in a spreadsheet the key information to each question given by the participants, compared the different answers and synthesised them.

3.3.1 Participants' profile

Among the participants, there are 3 women and 5 men with an average age of 28 years old. Six of them are right handed, the others are left handed. There are different levels of experience in computer science research among the participants.The more experienced have been working more than 8 years in the field (2 out of 8), the others have less than 3 years (6 out of 8).

3.3.2 Participants' motivation

The purpose of this stage of the interview was to information about participants' reasons to read research articles. The amount of papers read per week varies. It depends mainly on the stage of the project they are working on. Most of the readings are done at the beginning of the project. 7 out of 8 participants read between 15 to 20 research articles per week. Most of the papers read are for a study of the state of the art but it also happens that they read articles for entertainment. For the participants who are the most experienced in the research field (2 ouf ot 8), they also do reviews for co-workers. They read in detail the paper written by their colleagues to give them feedback on what updates to do.

3.3.3 Reading Tools

The third stage of the interview was about identifying the different tools used during the reading of an article. Even if 3 of them prefer reading an article on a physical paper, all participants read papers virtually on a computer or on a tablet. When reading on a digital device, all participants need to zoom on the text to read it properly or to stay focused. Four of them are using huge screens to improve their comfort.

Reading an article involves doing research on internet to look for a definition or additional information. It also involves taking notes to write down important information or remarks. Each participant has his own preferences. Some of them prefer taking notes on a paper or a notebook and then transcribe the notes in a virtual document, but the problem that occurs for some of them is losing the notes. On the other hand other participants take their notes virtually. It can be on a separate text document or the notes can be taken directly on the PDF version of the research article.

3.3.4 Reading Method

Next stage of the interview was identifying analysis methods from participants. These are generally the same among participants. They start by reading the abstract and the introduction. If the paper seems to be relevant, they will continue by reading the conclusion or the results. Then, if they really are interested in the paper, they will read the content of the article multiple times and take notes. For people who read on tablet, they always do a short reading on the computer to determine whether the article should be read in depth or not. If they are reading for entertainment they will go less deeply in the analysis and do not necessarily read all parts of the article. They also do not necessarily take notes in this case.

Something recurrent that annoys participants while reading a research article is dealing with the references. When looking for a reference mentioned in the paper, they need to jump to the last page of the document in order to look at the reference details. This action breaks the rhythm of the reading since there is no fast way to quickly return where they stopped reading.

3.3.5 Workspace management

The penultimate stage of the interview was about workspace organisation. Five of them answered that both of their virtual and physical workspaces are organised but did not specify how. Three others answered that they have chaotic virtual and physical workspaces. This shows a preference of having an organised workspace since most participants prefer working in an organised environment.

3.3.6 Suggestions

The interview ended with a more open part where the participant was able to suggest features and methods of interaction with them. Most of the features that have been suggested are common tools that are available on different text editing applications (copy, paste, highlight, resize, keyword research...). Two suggestions were made about the position of the content. For the first one, people prefer to see appear the content on the side of their preferred hand. The other suggestion was to let the system manage it automatically but still give control to the user.

3.4 Discussions and conclusions

In this section we discuss how our results address the **RQ2: How do researchers read articles?** and **RQ3: What content would researchers like to extract from the paper?**. We could have imagined that there would be a difference between less and more experienced researchers regarding the reading medium but both read research articles virtually. This result is probably biased since all participants are from the computer-science field. We can imagine that scientists from other fields do not use the same devices and are more used to reading articles on physical-paper.

Despite the difference in experience between the participants, they have more or less the same analysis method of a research article. Starting by the abstract and introduction, looking for the results and conclusion, then focusing on the rest of the article if they are definitely interested in. What can be done with this information is to design shortcuts that create widgets containing the main parts of an article to be displayed on an interactive tabletop. A shortcut and widget for the references also needs to be designed in order to simplify the reference study.

The state of the art has highlighted that there is no ideal solution for augmenting the paper. Depending on the system, they can face: lacks of feedback for the user, content occlusion problems or high costs. The interviews revealed that researchers always read an article at least once on a digital device. Since everyone reads research articles on a digital device, the choice of using a tablet instead of physical paper to augment the article has been made. As a result, it simplifies the project and allows the focus to be on the layout issue rather than on a method that augment the paper.

Chapter 4

Co-Design session: Low-fidelity prototype

Based on the interviews, I was able to identify the most important sections of a research paper (Abstract, introduction, conclusion, results, references). Interviewees also shared their method of reading a researcher article, which is to read the most important sections first and then the rest of the article if it turns out to be relevant. However, the interviews did not provide any insight in the optimum way to organise extracted information from the document on the tabletop, all around the paper (**RQ1**). The next step in the project was therefore to respond to this problem. To do so, a low fidelity prototype was designed in order to conduct a co-design session. This experiment has the goal to determine where to place the extracted content according to needs and how the system can automatically organise the workspace for the user. The participants performed different scenarios that represent the different stages of reading a research article.

4.1 Low-fidelity prototype design

By being aware of the most important sections of a research paper, I started to imagine different types of widgets that could make up the system and grouped them in a table (Appendix B.1). Then for each widget I have conceived their design, imagined the different actions they could trigger, how they should behave in the system, e.g., do they behave like a decal [2] (a deformable graphical unit which position and behaviour is controlled by constraints) or not?, where they should appear, and how to create them. The number of possibilities being large, conducting a co-design session with a low-fidelity paper prototype seemed a good option to make design choices.
A paper prototype is a good way to explore different design possibilities and easy to

manipulate. It is quick and easy to design and build. In addition, it is easy to involve a participant in the co-design of the system since he only needs pen and paper to create a new element and add it to the prototype.

4.1.1 Material

Since the design choice was made from the interviews (Chapter 3) to use a tablet instead of physical paper to display a PDF version of a research-article, a PDF Reader application was developed for the prototype. To avoid influencing the participants' suggestions, this application limits the interactions from the user. It only allows the user to open a PDF and turn the pages. There are no other interactions implemented such as text selection or annotations. In order to simulate the conditions as close as possible to the final system, the handling surface of the prototype is a switched-off tabletop (Figure 4.1) to give a better overview of the system to the participants. For the paper components that make up the prototype, there are widgets that represent different elements extracted from the research-article, and there are menus that can trigger different actions possibly present in the final version.

Figure 4.1: Interactive tabletop used for the low fidelity prototype experiment.

Widgets

Regarding the widgets (Figure: 4.2), the design is similar to those grouped in the table at Appendix B.2. The content is taken from the research article that was chosen for the experiment. The text widgets that illustrate abstracts and introductions are represented in different formats and font sizes (Figures B.8, B.9, B.10, B.12, B.13, B.14). This was done in order to observe whether there is a format preference depending on the position of the object, on the use or not of the widget or on the overloading of content in the workspace.

- Paper widgets list (Figure 4.2)
  - Paper information
  - Author's information
  - Author's publication
  - Abstract
  - Introduction
  - Introduction's Figure
  - Reference list
  - Ref 8: Paper information
  - Ref 8: Abstract
  - Ref 8: Complete paper
  - Figure 10
  - Figure 11
  - Comments list
  - Video

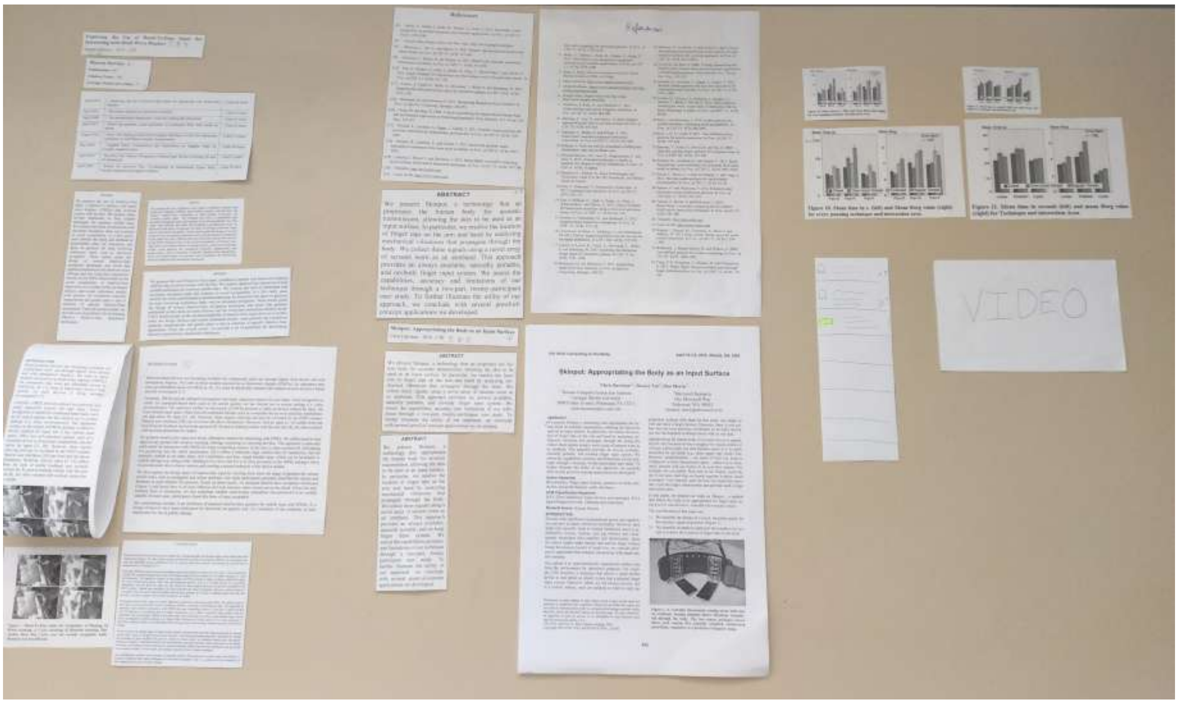


Figure 4.2: Paper widgets from the paper prototype. Appendix B.2 for more details.

Menus

The options presented in the menus are functionalities that can be implemented in the final system (Figure 4.3). As for some widgets, some menus have been designed in several shapes (column, horizontal, circular) to leave the choice to the participant and inspire them for eventually creating a new formats of menus. Empty menus with the various shapes have also been created in order for the user to suggest his own functionalities.

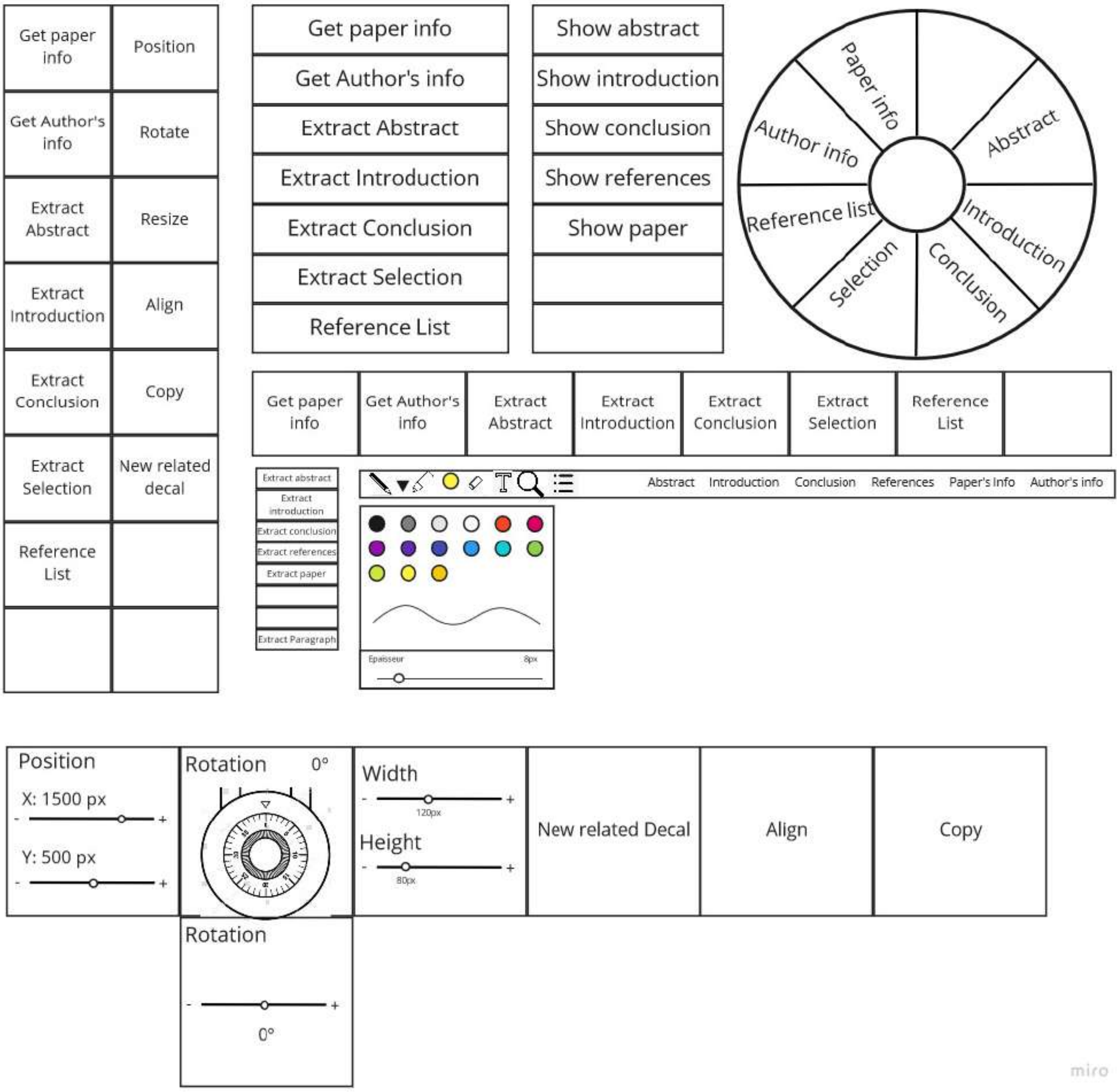


Figure 4.3: Paper menus from the paper prototype.

4.2 Experiment Design

The aim of the experiment was to observe how participants organise their workspace when reading a research-article on an interactive tabletop. From the results, I will determine different models of content organisation for a workspace on a tabletop. The experiment also made it possible to observe how widgets are created and how participants want the system to behave in order to adapt the design to their preferences. To do so the participants had to accomplish several tasks shared between five scenarios.

4.2.1 Set-up

The experiment took place in a laboratory at IRIT. With the signed agreement of the participants to take part in the experiment (Appendix B.4), each session was recorded in order to watch the video and note observations that may have been missed during the experiment. The participant's face did not appear on the recordings in order to preserve their anonymity. To respect coronavirus regulations, measures were taken for the safety of the participants. Participant also had access to pens, blank papers and scissors in order to create their own widgets and menus. The following participants could reuse previous participants widgets.

4.2.2 Course of the experiment

The participants were first briefed about the motivation for the experiment and explained on how the occlusion management from Dynamic Decals behaves (Appendix B.3) i.e. when there is contact between two widgets, they push each other to avoid overlapping. The explanations were followed by a few questions to establish participants' profiles. Those questions were about the age of the participant, their hand preference, their experience in the research field, if they were used to manipulate tactile surfaces other than smartphones and if they considered themselves organised.
The rest of the experiment consisted of accomplishing several tasks shared between five scenarios that represent different stages in the reading of a research article.

- Discovery of the article: this scenario consists of extracting and organising on the tabletop certain contents of the research article that the scientist is reading for the first time, such as information related to the article (Title, Author, date of publication...), the abstract, the introduction.

- References interest: this second scenario was oriented towards the interest in a reference. The participant was asked to create a widget that contains the reference's information (Title, Author, date of publication...), then to display the reference's abstract and finally display the referenced paper in its entirety. They also had to create the widget containing all the references from the scientific paper they were reading.

- Figure comparison: for the third scenario, the participant had to extract two charts from the research article to compare them. He was also asked about his method to annotate the observations made related to those figures.

- Annotations: the penultimate scenario focused on annotations. The participant was asked his preferences on the method to annotate the PDF, on how to see existing annotations and how would he proceed to type notes. Does he prefer using the tablet's virtual keyboard, typing on the tabletop? or using a physical keyboard?

- Workspace management: in this last scenario, the workspace was overloaded due to the previous scenarios. The participant was asked to move some widgets, to group and align them while respecting the system's occlusion management.

Questions were asked during the different scenarios to understand the choices made by the participants or to encourage them to further explain their thought process. The script of the scenarios can be found in the appendix B.5.

4.2.3 Participants profiles

The participants of this experiment were my co-workers. The amount of participants was 7, of which 5 participated in the interviews (see Table 4.1). According to Nielsen [16], user experience studies often report that the majority of findings are discovered within the first five participants. This is why the amount of participants for this experiment was seven.
All participants were right-handed, so it is impossible to observe whether there is a symmetry in the organisation of the workspace between right- and left-handed people. There were different levels of experience in computer science research among the participants. It ranged from 4 months of experience to 8 years of experience in the research field. If we consider that it takes at least 3 years of experience (the minimum time needed to obtain a PhD) to be considered experienced in research, then we have only one participant who is experienced (see Table 4.1). None of the participants were used to manipulate tactile devices other than smartphones.

Participant ID	Age	Gender	Experience in research	Hand preference	Organised
P1	40	M	8 years	Right	Yes
P2	22	F	4 months	Right	Yes
P3	24	M	11 months	Right	No
P4	26	F	1 year	Right	No
P5	22	M	4 months	Right	No
P6	22	F	4 months	Right	Yes
P7	25	F	1.5 year	Right	Yes

Table 4.1: Details on participants

4.3 Experiments Results

During the experiments, I took notes of participants' actions and remarks. I also watched the video recordings in order to complete the notes. Then, I regrouped in a spreadsheet the different meaningful observations for each task, and compared the different results to extract different observations. The results are divided into two sections. The first section focuses on content organisation on the tabletop screen: where the participants positioned the content at their creation, where they repositioned the widgets and what widgets format did they chose during the experiment. The second section is about the interaction. It details participants' methods to extract the content from the research article on the tablet, and how they want to see the occlusion management system behave.

4.3.1 Content organisation

P1, P3 and P6 mentioned during the experiment that they make a distinction between widgets that are directly related to the content of the paper and widgets that provide additional information (see Table 4.2). I asked the question to the other participants who did not make the remark and they replied that they also make the distinction. This is why this subsection is divided in three parts. First part concerns the placement of the content of the research paper. Second part focuses on the placement of the additional information about the paper and finally the last part is about the reorganisation of the workspace. I summarise in the first two parts the results obtained in each scenario concerned by the part.

Content related	Additional information
Abstract	Paper information
Introduction	Author's information
Introduction's Figure	Reference list
Video	Author's publications
Figure 10	Ref 8: Information
Figure 11	Ref 8: Abstract
Comments list	Ref 8: Full paper

Table 4.2: Widgets categories.

Research-paper content

- Discovery of the article: All organised participants (4 out of 7) and one non-organised participant positioned the two widgets related to the article content (Abstract and Introduction) on the same side (4.4a). However, only 1 out of 4 placed the widgets on the right of the tablet and in the back of the tabletop. Except him, all participants placed the text widgets next to the tablet. Regarding the format, 6 out of 7 participants preferred to use the large rectangular widgets instead of the column or small font ones (P1: "It is more comfortable for the reading").

- Figure comparison: All participants grouped the two related charts together (Figure 4.4c). 5 out of 7 placed them on top of each other, the two other placed them next to each other. 6 of the 7 participants placed the graphs next to the tablet, 4 of them placed them on the left, 3 of them on the right. If there was no place next to the tablet they re-positioned the content already there in order to give priority to the figures (P1: "Since I am going to analyse the charts, I want them close to my working area i.e. close to the tablet").

- Annotations: 2 out of 7 participants created a notes widget, like a notebook, with a fixed position next to the tablet on the right. They planned to take all their notes on it, even notes related to a widget (e.g. figures). The other participants preferred having a separate widget that contains the notes. However they preferred to have the widget notes hidden. They consider that it is not necessary to have them permanently displayed, they just need a shortcut somewhere to make the note visible again. Three of them preferred having access to the notes from a list widget that contains all the comments and highlights of the PDF, the others preferred having access to the notes from a button displayed on the concerned widget.

Additional information related to the research paper

- Discovery of the article: Whether they are organised or disorganised, all participants positioned widgets giving information related to the article on the top side of the tabletop ("P3: This is not important information. I can keep it in the back of the table where it doesn't bother me. If I ever need it, I can always grab it and bring it forward.").

- References interest: regarding the reference list, 6 out of 7 participants preferred the short version of the reference list i.e. the one containing only the references mentioned on the displayed page on the tablet. It is not something that they want to see displayed all the time since they do not always need it. Some of them suggested to remove the list, and to create instead widgets of the references they are interested in. When they were asked to position the widget containing the PDF of the reference, all participants placed it close to the edges of the tabletop. This was due to the size of the widget which was taking too much place and was not necessarily needed.

Workspace management

All participants had more or less the same behaviour regarding the organisation of their workspace. New widgets related to the research article were created close to the tablet. If there was no place next to the tablet, they moved the disturbing widgets further away and replaced them with the new ones. For informational content (references, paper's information) they preferred to place them further away but still within easy reach. However, some users had their own preferences for some types of widgets and wanted them to be fixed in a position. For example P1 kept the references list widget on the bottom right corner and did not reposition it in the following scenarios.

4.3.2 Interactions with the prototype

Content extraction

A first observation that was made related to the interaction was about content selection. For all participants, when they were asked to extract the abstract from the PDF, they all selected the text with a drag and drop gesture in order to call a menu that gives the option to extract the abstract or to move their selection on the tabletop surface with a second drag and drop gesture starting on the tablet and going to the chosen position.

Annotations

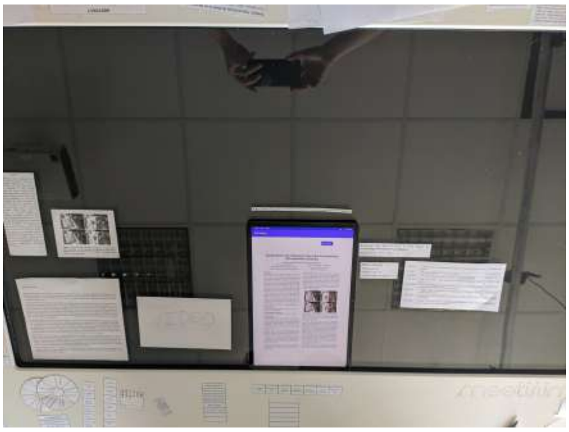
During the annotations scenario, 5 out of 7 participants said that they would take the notes by creating a post-it widget that would be attached to the concerned widget. However, those post-it would not always be visible. In the course of the scenario, P1 created a button that he positioned on the top-right corner of the figure 10 widget. “This button is to create new notes and for displaying or hiding the existing notes attached to the widget.”. This button were reused by four participants to trigger the same action. P2 and P6 opted for another solution. P2 stated that she wanted to use a physical notebook for her notes. She would place it on the right of the tablet, close to her. Conversely, P6 wanted a virtual notebook, also on the right of the tablet close to her. Both want to take their notes in the notebook.
Regarding the preference on how to take notes: P2 prefer using a pen, P6 would use a stylus to take the notes, and the others (5 parcitipants) would use a keyboard.

Occlusion management

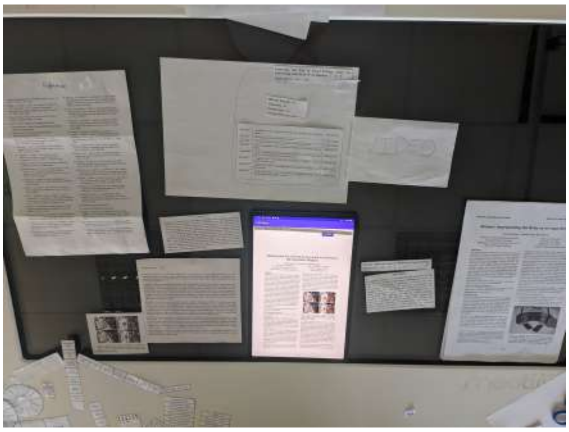
At the end of the experiment, the workspace was overloaded from the previous scenarios (Figures 4.4e, 4.4f). In the last scenario, I asked to the participants to reposition in front of them the widgets that are hard-to-reach. The goal was to force the user to interact with the content occlusion system from Dynamic Decals [2] and collect suggestions on how it should behave in my system. As a result, participants found frustrating to reposition the widgets without disturbing their workspace organisation. Indeed, because of the overloaded workspace, it was impossible for the user to move a widget positioned at the back to the front without colliding with other widgets. This resulted in these widgets being moved against the user’s wishes and disturbing his workspace.
A solution that was suggested was to distinguish between one-touch and two-touch input on a widget. With one-touch, the system’s occlusion management is disabled and the user can manipulate the widgets without thinking of a path to move the object without disturbing everything. With two-touch, the user has the illusion that he is putting more force and can push other objects. That is when the occlusion management is active. P3 mentioned that he does not want to see the system moving the objects constantly. For him it can be a source of distraction since he sees things moving in his peripheral vision. He proposed to disable the occlusion management when he is moving an object and to turn it on once he release the object he was moving. Other participants did not make any remarks regarding the occlusion management.

4.4 Conclusion

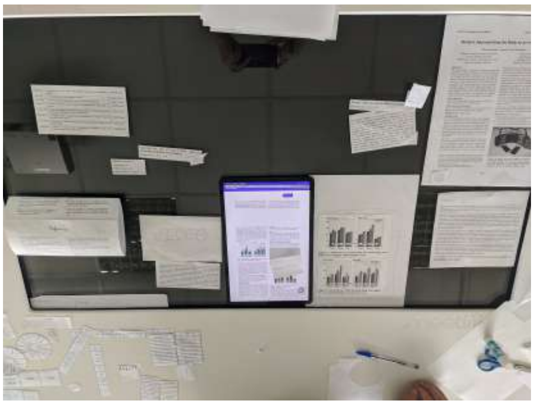
Working on distant content is not comfortable for the user. This is why objects of interest are positioned close to the tablet i.e. the working area. As the content becomes less important during the work session, it moves further and further away from the activity zone. During this experiment, participants were not allowed to delete widgets in order to fill the workspace and force them to organise it. As they said during the experiment, if the widget is no longer needed, they will remove it without repositioning it elsewhere else on the screen. Content that may be useful later tends to be positioned further away but with an easy access. Less important information is placed in the various corners of the tabletop, places that are more difficult to access and therefore where the least important content is displayed.
From this experience we can draw several requirements for a high-fidelity prototype. It is necessary to implement a method to disable the occlusion management. Depending on how overloaded the workspace is, this may be more of a handicap than a useful feature for the user. The presence of buttons on the widgets also seems to be necessary to have access to some of their own functionalities. The last requirement is to organise the content on the worksapce according to a template.



(a) Discovery of the article: P2 - Organised

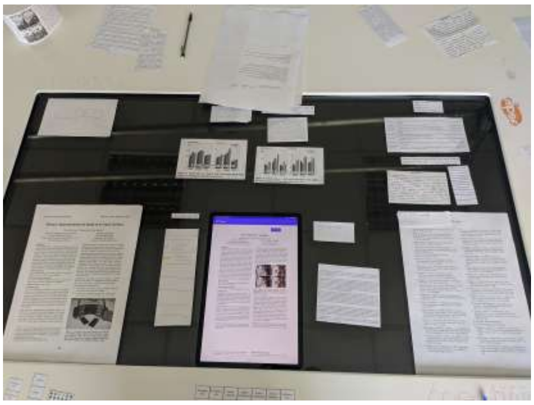


(b) References interest: P6 - Organised

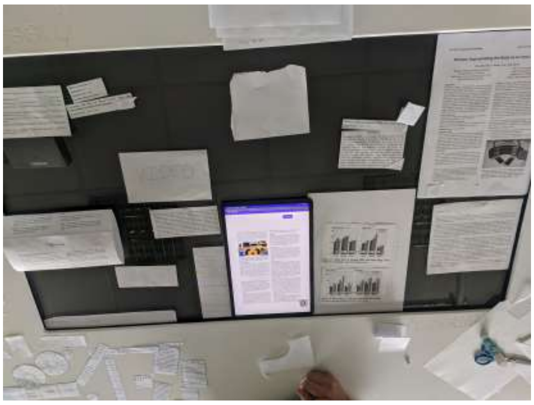


(c) Figure comparison: P5 - Non-organised

(d) Annotations: P4 - Non-organised



(e) Workspace management: P1 - Organised



(f) Workspace management: P5 - Non-organised

Figure 4.4: Status of the workspace at the end of each scenarios from different participants.

Chapter 5

Design and implementation of a high-fidelity prototype

5.1 Organisation models

The low-fidelity prototype experiments allowed me to observe the different ways in which participants organise their workspace. From these observations I have designed three models of content organisation:

Clock model

The first organisation model that was identified is the clock model (Figure 5.1). This was the organisation method from P2 during the low-fidelity experiment. It is a path that starts at the left of the tablet, goes left, then up to the edge of the screen and then right. It follows the direction of a clock. Since most of the time the new content extracted from the tablet by the user is used immediately, the new virtual objects will appear next to the tablet, on the left, directly on the path. As a new widgets appear, the older ones will be pushed away from the tablet, following the path, until they get removed. However, an empty space without path is kept on the right side of the tablet. It happens that user wants to keep some information to a fixed point until it is no longer needed. This empty space allow the user to store any widget close to the tablet without being repositioned. Thanks to the minimum distance constraint (Sec-

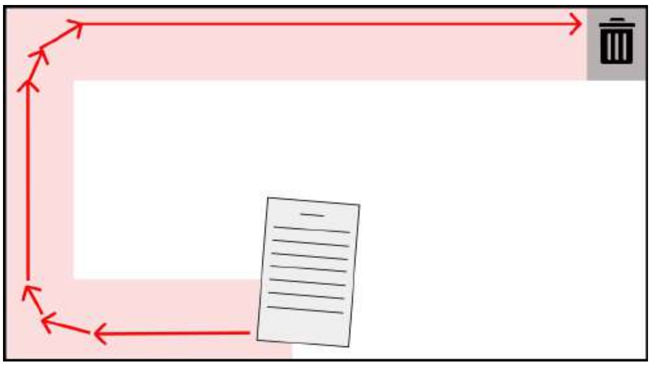


Figure 5.1: Clock model

tion 5.2.3), when new virtual objects are created, they will push the older ones along the path if they are colliding. The user is free to grab the object and move it else where on the screen. He can reposition it somewhere where there is no path to give to the widget a stationary position. He can also move virtual objects along the path. If the object arrives at the end of the path (top-right corner), the system considers that the user does not need the widget anymore and will delete it. This can also be used as a trash for the user to let him delete a widget when needed.
A path is composed of several lines. For each widget to which the constraint applies, the system will calculate for each line of the path the minimum distance between the orthogonal projection point and the widget. The widget will then be attached to the closest line and can only move along the path. In order to avoid the constraint being constantly active and to leave a space for free positioning, each line has a hit-box (see red area on Figure 5.1). If the widgets enter in the hit-box area, the constraint will be turned on and the widget will be re-positioned so that it is in contact with the line.

Rectangle model

The second organisation model is the rectangle model (Figure 5.4). During the experiment, participants instinctively positioned important widgets close to them and less important or no more used widgets further away from them. This behavior was already noted in the work of Khalilbeigi et al. [7] and Tabard et al. [9]. The rectangle model defines three areas with different storage criteria. Inside the green area, it is the **interaction** area. This is where the content that the user will interact with the most appears. The blue area is the **mid-area**. This is where the non-priority content, which the user still interacts with but not as much as the priority content, is stored. Then there is the storage area in red, the furthest from the tablet, where the less important content is stored waiting to be reused. For this model, the constraint limits the movements of widgets to the visible surface of the rectangles which are predefined. Each rectangle has a unique ID. The widgets have a parameter zoneID and are therefore bound to a rectangle. If the widget leaves the rectangle surface, they will be re-positioned at the closest edge of the rectangle. The

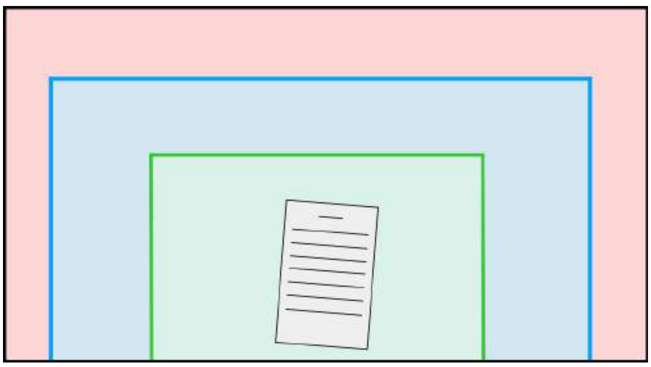


Figure 5.2: Rectangle model

user can use this constraint in order to organise his workspace and place the content by interest. The more important objects are attached to the closest rectangle and the less important objects will be attached to more distant rectangles.

Custom model

This last organisation model is the one that gives the most control to the user. As for the rectangle model, the widgets are limited to the rectangles to which they have been associated. The difference is that it is the user who creates his own rectangles of the size he wants, anywhere on the screen.
He can then associate the widgets to his custom areas. This model allows the user to customize his workspace according to his preferences rather than being forced to use the system's model. The user can activate an option from the tablet to enter in creation mode. In this mode, the user can draw a rectangle on the tabletop anywhere he wants on the screen with a single drag and drop gesture. Before validating he has to give to the new rectangle a unique ID and a color. The ID allows to link a widget to the rectangle, and the colors make it easier for the user to differentiate between the different zones. In a multi-user context, this model makes it possible to define a workspace for each user. This prevents overflow onto another user's workspace

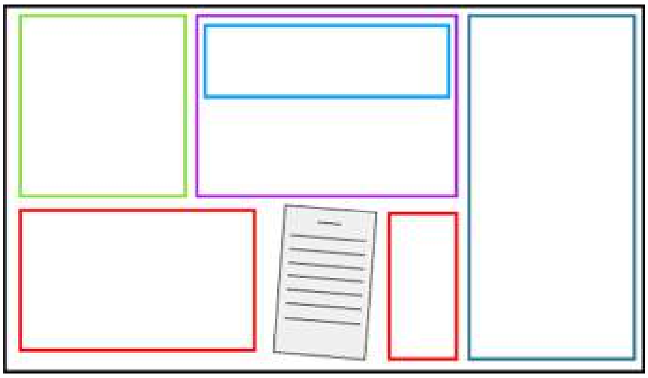


Figure 5.3: Rectangle model

5.2 Implementation

In this section I present an optimisation and extension of the Dynamic Decals system [2] with new widgets and new constraints.
As a reminder, the way dynamic decals works is as follows: rules, implemented as constraints, are applied to the different graphical elements of the system. Each constraint will calculate a cost. The more the graphical object does not respect the constraint, the higher the cost will be. If the graphical object respects the constraint, the cost will be 0. The cost is then sent to a solver which will test different values (in this project: the position) so that the cost is 0. Once the solution is found, it will apply the right value to the graphical object.

5.2.1 Optimisation

My first contribution in the code was to optimise it. Indeed, there was a lot of lag in the display which could have caused problems for future experiments and influenced the participants' opinion about the system. The way dynamic decals was implemented was very greedy in calculation. In order to perform the graphical deformation while preserving the content of the objects, the code managing the graphic display had to be written from scratch. In the context of my project, the graphical deformation was not necessary. This is why I got rid of this part of the code and used native library from Qt C++ to display the components. This allowed the program to be less computationally intensive and to have a smooth interface which will not influence the user's opinion on the system during an experiment.
During the low-fidelity prototype experiment, it came up that, depending on the situation, it can be annoying to have the constraints activated, especially the constraint preventing overlapping. The proposed solution was to distinguish between one-finger and two-finger input. This solution has been implemented. When one finger touches a widget, the solver is activated. When two finger touch a widget, the solver is disabled and when the user releases the widget, the solver is activated until all widget costs are reduced to 0.

5.2.2 Widgets

The original implementation of Dynamic Decals [2] allows only images to be used to create a widget. It is possible to display text but it must be converted to image format. In addition, these images were displayed as squares, with regular or rounded edges, or as circles. As a result, the type of content that can be displayed is limited. The rectangular images are distorted to become square and some texts widgets take up too much space. Since I decided to use Qt's graphical libraries to optimize the program, it was easy to create my own QTWidgets. I was able to give them a rectangular shape and it also gave me the possibility to create widgets with text. One of the additional advantages of text input is that you can easily change the content of the widget and change the settings (font type, font size, font color, etc).

5.2.3 Constraints

Minimum distance

The constraints of minimum and maximum distance between two widgets were already implemented in the previous version of Dynamic Decals [2]. I took up the method of calculation of Niyazov et al. [2], who compute the minimum distance from the widget's center (which is a square), and adapted it to rectangular shapes. In the original version, as the widgets are squares, whatever the direction of contact, the distance between the edges and the centre of the widget is the same. In my version, I had to adapt it. The calculation of the minimum distance depends on the side of the collision and therefore the height and width of the widget.

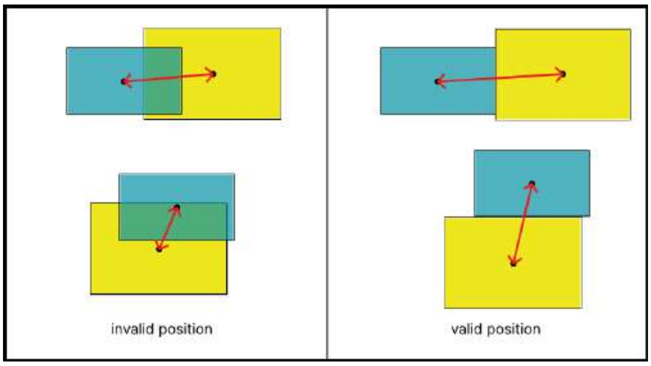


Figure 5.4: Rectangle model

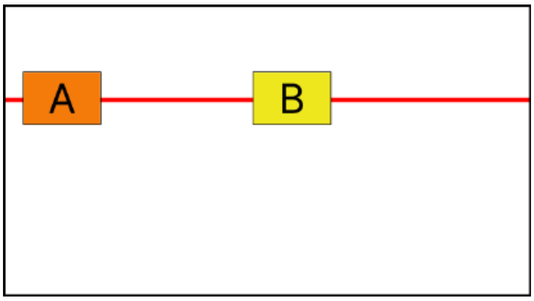
To calculate the cost, I first calculate the distance between the two widgets on the X axis and the Y axis. If there is an overlap, the highest on-axis distance between the two points is the value that will require the least system effort for repositioning. Then, to ensure that there is overlap, I calculate the minimum between 0 and the distance. If the distance is less than 0 then there is an overlap and the cost is equal to the distance.

Alignment

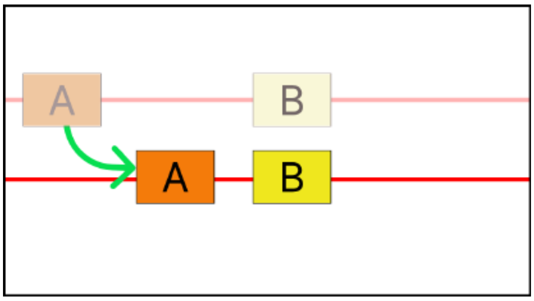
The alignment constraint makes it possible to limit the movements of a widget on only one axis. This constraint can be used in two different ways. The first way consists of establishing a fixed horizontal or vertical line (Figure 5.5). The widget is attached to the line and can only move along it. The other way is to align a widget to another (Figure 5.6a). When the widget A is moving, the widget B will move to stay on the same axis (Figure 5.6b). This has the effect of aligning two widgets with each other. The cost evaluated by the constraint is the distance between the center of the widget and the axis.

(a) Horizontal alignment *(b)* Vertical alignment

Figure 5.5: Alignment to an axis.



(a) Widget B aligned to widget A on the horizontal axis.



(b) Alignment axis depends on the widget A position

Figure 5.6: Alignment to a widget constraint.

Groups of constraints

In the original version of dynamic decals, it was only possible to apply the same list of constraints to all widgets. I have implemented a way to create different groups of widgets. Each group can then be assigned different constraints. This makes it possible to enrich the behaviours possible by the system. For example we can disable the resize constraint for a group containing important information in order to preserve the content.

5.2.4 Tablet

The android application has been implemented in Android Java. In order to retrieve the information contained in the pdf (Title, author, text...), a trial version of the PSPDFKIT SDK [17] was used. To transfer the data from the tablet to the tabletop, I have set up a TCP/IP connection between the two devices.
The user can select which organisation model he wants to use from the tablet. There is a menu with the different models proposed (Figure 5.7). In the case where the user chooses the **custom model**, a button that allows to create a new zone on the tabletop becomes clickable. Once clicked, a new window appears on the tablet and the user can set the ID and the color of the zone (Figure 5.8). The IDs allows the user to attach a widget to a zone and the colors facilitates recognition. While the new zone window is open, the user can draw the zone on the tabletop with a drag and drop gesture.

To create a text widget, the user needs to select text with a drag and drop gesture. A toolbar will then appear on top of the PDF with a button to create a text widget. A window will appear in order to create the widget. According to the organisation model selected, there are some differences in the content of the window. If the **clock model** is selected, the user can only give a title to the widget. For the two other models, the user can give a title to the widget and select the zone to which the widget will be associated (Figure 5.9).

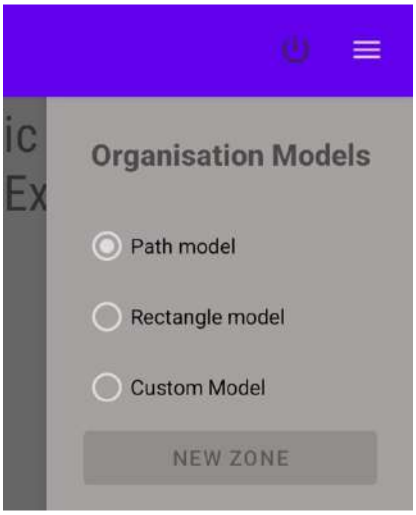


Figure 5.7: Zoom in on the organisation model selection menu.

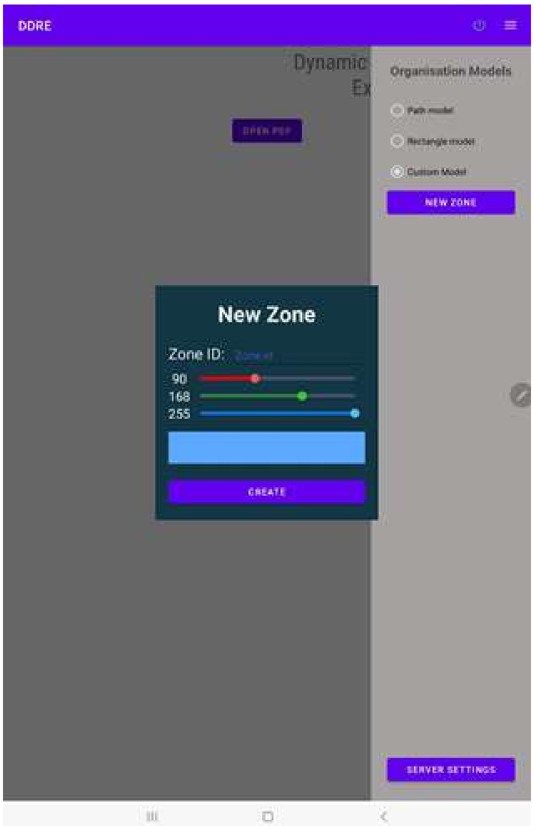


Figure 5.8: Tablet: New zone window

Figure 5.9: Tablet: New widget window

Chapter 6

Discussion and Future work

6.1 Discussion

6.1.1 Automatic vs semi-automatic layout

In this work the layout management was semi-automatic in order to give to the user control and adapt his workspace to his own way. The constraints are here to help the user to organise the content and not restrict the organisation in a certain way. However, it was quite possible to consider an automatic layout management where the user can not have any control on the position of the content and the system make the decisions for him.

In addition, it is quite possible to combine my work with AI. Fok et al. [18] worked on SCIM an AI that can automatically identify the content of a research paper and extract it by categories (Introduction, Objectives, Results...). It would be possible to create a fully automated system that can extract the content for the researcher and display it on his workspace, all with the minimum of effort.

6.1.2 Results

During the co-design session, participants said they preferred to use a keyboard to take notes. However, we may consider that there was a bias due to the material of the experiment. Indeed, the tabletop that was used has a large frame all around the screen, (see Figure 4.1), which makes it possible for a user to put objects on it, especially a keyboard. The question of the choice of material should be asked again in the case where there is no large frame around the table.

In the same experiment, participants were given a choice of different menus. The idea was to observe whether there was a preference via menu formats. However, the collected results were not used. The interest of menus is to group together the different functionalities available for an object or a system. However, no actions affecting the widgets were implemented. In the future, if more functionalities are added (text edition, constraints settings, etc), the participants' preferences regarding the format of the menus should be taken into account.

6.1.3 Limitations of the work

This study was limited to a modest number of participants. Further studies with a larger cohort should allow more detailed analysis. In addition, the number of experienced participants in the research field can be considered insufficient. With a larger number of participants, we could have observed different habits and collect even more precise feedback on their methodology for reading a research article and organise their workspace.
In the low-fidelity experiment, the participants were all right-handed. Experiments should be conducted with left-handed people to observe whether or not there is any symmetry with respect to right-handed people in the organisation of their workspace.
For this project the choice was made to display the research article on a tablet instead of paper. I have made this choice since all participants reads on a digital device. However, studies showed that people prefer to read on a paper and are more efficient [19]. However, one can imagine that today, due to the evolution of screen technology and the habit of using digital devices, the rate of preference and efficiency between reading on screen or on paper has changed.
I also considered the idea of displaying the PDF version of the research article on the tabletop, rather than using the tablet. However, there is a technological limitation that made this impossible. The screen resolution of the tabletop was too low (1920x1080p). It is impossible to display text with a small font size in a readable way. It is conceivable that this problem could be overcome with 4k or 8k screens.
Finally, my work is limited by the fact that no experiments have been conducted to validate the proposed organisational models. Therefore, it is not possible to know if these models have a real impact on the user experience or not.

6.2 Future experiment

Dynamic Decals [2] has already shown that a layout management with a constraint-based approach is more appreciated by participants than a classical interface. It has been also shown that the most appreciated configuration was the one with several constraints active. However, there were no constraints that organise the virtual content following a particular model. In order to establish which model is the more appreciated by users, it is necessary to conduct an experiment. The development of the system was much more time consuming than expected. This is why I have consider a high fidelity experiment, detailed below, as a future work.

Design of the high fidelity experiment

Three different models of organisation have been implemented: the clock model, the rectangle model and the custom model (Chapter 5.1). In order to determine which model is the best, in the case of a system that enhance the reading of a research article, a high fidelity experiment comparing the models to each other should be conducted. As with the low-fidelity prototype experiment (Chapter 4), the participants will perform different tasks through several scenarios in order to reproduce a reading session of a research article without going deeply. The scenarios are: discovery of the article, references interest, figure comparison, annotations and workspace management. They will perform the same tasks in the same order with the three different models. I aim to assess the user experience via Nasa-TLX [20], AttrakDiff [21], [22] or MeCue [23] surveys. Indeed they evaluate the following dimensions: usability, utility and efficiency.

To reduce the order effect bias, we consider to counterbalance the groups. It is necessary to create six different groups of participants. Each group will manipulate the different models in a different order, see Figure 6.1. Nielsen recommends to test with 20 users in quantitative studies requires [24]. This is why there should be at least 4 participants per group, making a total of 24 participants. The only requirement for the participants is that they come from a research background.

Material for the experiment

A tablet to display the PDF and an interactive tabletop will be used for this experiment. An application has been developed on the tablet in order to display PDF files and allow content to be extracted to the tabletop. The research paper selected for the experiment will be chosen in advance.

Analysis of the results

Qualitative and quantitative data will be collected regarding the models. First, participants will fill a user-experience survey (I will choose the most fitting one for the study). They will also be asked about their comments and preferences regarding the models. What did they liked about the models and what did they disliked?

To assess the efficiency of each model regarding its performance and not the preference of the participant, we consider collecting data about time and number of interactions. Indeed, the time of a task completion and the number of interactions

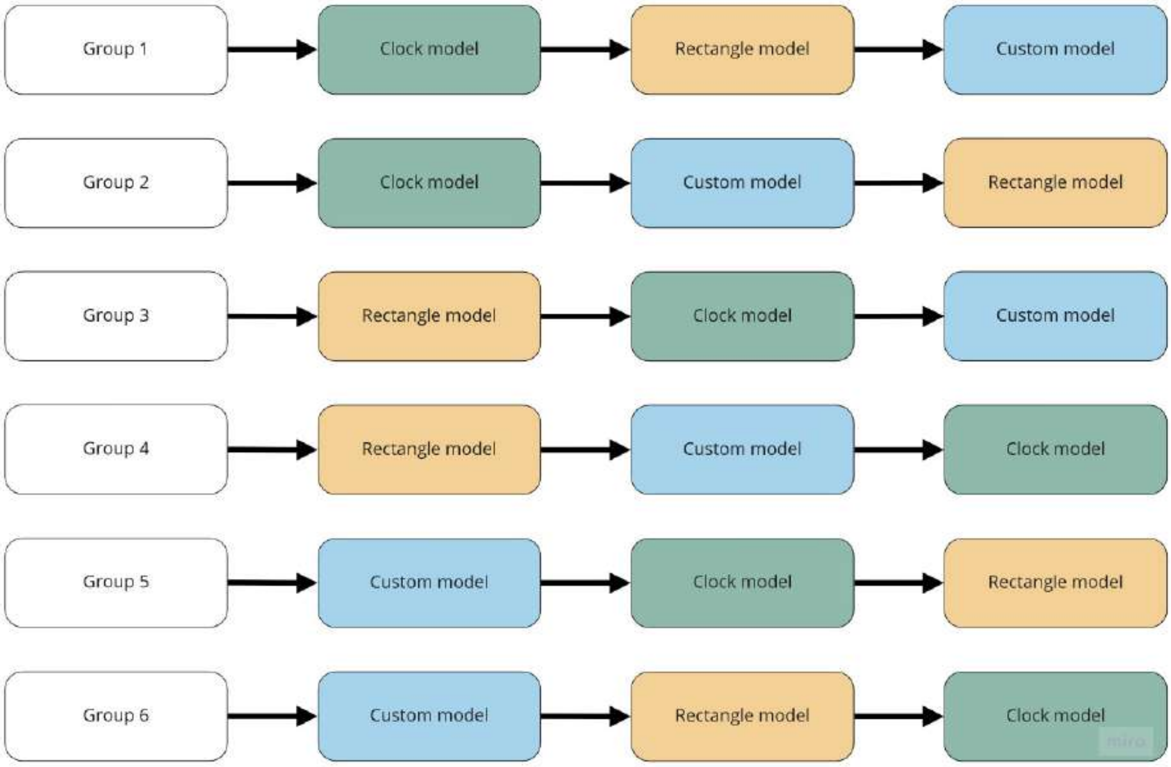


Figure 6.1: Counterbalancing groups

would indicate about the efficiency of the model. To complete a task, a participant must be satisfied by the organisation of his workspace and not need to make further adjustments.

6.3 Future work

One of the aspects studied in Niyazov et al. [2] works was the content occlusion caused by physical objects. We can consider as a future work to study how physical objects can influence the organisation of the workspace. Physical objects cannot be moved automatically and follow the organisation models rules. We could again compare the different organisational models implemented in this project and may observe different results.

Only three models of organisation have been implemented but there are other ways to organise your workspace. We can for example like SnapRail [6], imagine a model that organise the content all around gravity points. These gravity points can be physical or virtual objects. They would allow the user to group content together while highlighting the central object. We can also consider implementing a model based on a grid pattern. The content would be displayed in a grid. This would allow a regular and aligned display.

New constraints can also be implemented. For example a constraint that resizes the content according to the position of the object. Our study showed that the object in the back of the tabletop are less important and require less interaction. Thus, the constraint could be to reduce the size of the widget when it is positioned in the back. If the user bring it to the front, it get backs to its original size.
The implemented organisation models work independently. We can imagine for future work to merge these models together and give more control to the user on how to use the constraints. He would be able to select the spaces where the models are active or not, what constraint is prioritised over the other etc. For example we can imagine that the user uses the clock model on the left side of the tablet but using the custom model on the right side. Another possibility would be to use the clock model inside a rectangle from the rectangle or custom model. This would avoid overloading the rectangle and allow the new content to be displayed closer to the user.
In the context of this project, the models are applied to a rectangular display system. It would be interesting to lead a study on the efficiency of these models on non rectangular surfaces, if the approach is more efficient for a data visualisation task than usual approaches or not. In the case of a display surface with the presence of 'holes' where content can not be displayed, it is also less convenient for the user to interact and organise their content. Models that organise content for the user might be a solution to enhance his experience.
In a multi-user context, we can imagine using the constraint approach to establish a workspace for each user and limit the overlap conflict between different users. Then we might consider studying how a layout with a constraint based approach improves the workspace sharing and whether the workspace organisation models implemented for this project applicable in a multi-user context or not.

Chapter 7

Conclusion

In this study, we aimed to answer the following research questions: "How do we organise the virtual content of a research-paper on a tabletop screen, using a constraint-based approach?", "How do researchers read articles?" and "What content would researchers like to extract from the paper?". To do so I have conducted interviews and a co-design session with a low fidelity prototype.

Through the interviews, I have been able to highlight the methodology used by researchers to read a research paper. They start by reading the abstract followed by the introduction to then read the conclusion and the results. In case the article is relevant, they will pursue their reading by reading the rest of the paper. This reading order is equivalent to the more important parts of the article. The interviews also allowed us to highlight the fact that researchers mainly read the research papers on digital media instead of paper.

To answer the main research question, I proposed organisational models based on the participants' workspace organisation methods during the co-design session. The models organises the content on the tabletop semi-automatically for the user. The virtual objects are positioned on the screen by respecting predefined constraints. That allows the user to make less effort to arrange the content on his workspace. Three models were proposed and implemented, the <u>clock model</u>, the <u>rectangle model</u> and the <u>custom model</u>. The efficiency and appreciation of the implemented models could not be evaluated due to a lack of time but this can be done for a future work. These models have been implemented to be studied on a tabletop application but one can imagine studying the efficiency of these models on other interfaces such as augmented reality or on non-rectangular surfaces.

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Appendix A

Interviews

A.1 Questions

User profile:

- What is your name?
- How old are you?
- Are you right handed or left handed?
- What is your jobrole?
- How long have you been in the research field?
- How familiar are you with the new technologies?

User experience in reading paper:

- How many papers do you think you are reading per week or month (1-10, 10-20, 20+)?
- Why are you reading papers?
  - Entertainment?
  - Literature study for your current work?
  - To be up to date in your field?
  - Review for a co-worker?
  - Other? Which one?
- Do you read papers from a specific conference?

Tools for reading paper:

- Do you print the research articles you want to read or do you use a device for that?
- If you are doing both or using only a device, which one do you use? (Desktop, Laptop, Tablet, Paper tablet...)
- If you are reading on a screen, do you zoom on the paper or do you have a page fully displayed?
- If you are using multiple device and have different reasons to read a paper, do you assimilate a device to a reason or does it depend on your mood?
- Do you look for additional content related to the paper online?
- Do you extract information when you are reading? What kind of information?
- What kind tool are you using when you are doing it? A notebooktablet to take note? Post-it? Taking notes on a physical paper? Taking notes virtually on a computer? Other? (If taking notes on the PDF only) Why not taking notes on both? (physical and PDF)

Method to read paper:

- Do you take the paper in your hand when you are reading it or is it flat on the table?
- Can you explain your method of reading paper?
- (if not mentioning the video) Do you watch the video if there is one related to the paper? If yes when do you do it?
- Do you use the same method according to the reading of the reading?
- Do you have the same analysis according to the reason of the reading?
- Is there somethinga task that annoys you when reading a paper? Does it happen frequently?

Workspace management:

- Where do you usually read? At work? In the train? On a desk? On a comfortable chair?
- How do you organize your physical workspace?

- Would you say your workspace is organised or chaotic?
- Do you have a lot of object non-related to your reading on your desk? (other documents, books...)
- If you are combining devices or paper + device, what is your management? (Paper on left, Tablet on right?)

User's ideas (reexplain the idea of the project before):

- What kind of functions tools would you like to seeimagine on this kind of system?
  (ask for more details on some of the functionalities mentioned)
  Can you explain how you would interact with the system to get access to the functions you talked about?

Thank you!

Information Brochure

A.2 Briefing brochure

The objective of this interview is to know and understand the different behaviours that exist when reading and analysing a research article. I will ask you questions about your habits while reading, what kind of tools you are using and what is your method. It will take around 20 to 30 minutes.

This interview has been approved by the Ethics Committee Information and Computer Science from the University of Twente in the Netherlands.

We will collect your answers from the interview to design a system that will augment the reading of the paper. It will help the user to extract all wanted information and organise them all around the paper.

We inform you that your answers might be shared anonymously with the rest of the team working on this project.

To make sure we do not miss any information, we will record this interview and keep the data for the duration of the project. You are able to request access to your data or to ask us to erase them by sending an email to: mohamed.benkhelifa@irit.fr

Contact details:

- Student-Researcher: mohamed.benkhelifa@irit.fr
- UT Ethics Committee Computer and Information Science: ethicscommittee-cis@utwente.nl

(French)

L'objectif de cet entretien est de connaître et de comprendre les différents comportements qui existent lors de la lecture et de l'analyse d'un article de recherche. Je vous poserai des questions sur vos habitudes de lecture, le type d'outils que vous utilisez et votre méthode. Cela prendra environ 20 à 30minutes.

Cette interview a été approuvé par le comité d'éthique d'information et d'informatique de l'université de Twente se situant aux Pays-Bas.

Nous recueillerons vos réponses lors de l'entretien pour concevoir un système qui augmentera la lecture de l'article. Il aidera l'utilisateur à extraire toutes les informations souhaitées et à les organiser tout autour du document.

Nous vous informons que vos réponses peuvent être potentiellement partagé de façon anonyme avec le reste de l'équipe travaillant sur ce projet.

Afin de nous assurer que toutes vos réponses soient bien collectées, nous enregistrerons cette interview et conserverons les données jusqu'à la fin du projet. Vous avez la possibilité de demander l'accès à vos données ou de faire la demande de les supprimé en envoyant un courriel à mohamed.benkhelifa@irit.fr

Contact:

- Student-Researcher: mohamed.benkhelifa@irit.fr
- UT Ethics Committee Computer and Information Science: ethicscommittee-cis@utwente.nl

A.3 Consent form

Consent Form

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

ON VOUS REMETTRA UNE COPIE DE CE FORMULAIRE DE CONSENTEMENT

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated [15/05/2022], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction. J'ai lu et compris les informations sur l'étude datées du [15/05/2022], ou elles m'ont été lues. J'ai pu poser des questions sur l'étude et j'ai obtenu des réponses satisfaisantes à mes questions.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason. Je consens volontairement à participer à cette étude et je comprends que je peux refuser de répondre aux questions et que je peux me retirer de l'étude à tout moment, sans avoir à donner de raison.	○	○
I understand that taking part in the study involves an audio-record and written notes of my answers during the interview and the recording will be destroyed at the end of the project. Je comprends que ma participation à l'étude implique un enregistrement audio et des notes écrites de mes réponses pendant l'entretien et que l'enregistrement sera détruit à la fin du projet.	○	○
Use of the information in the study		
I understand that information I provide will be used for developing a system that enhance the experience of reading research articles and might be shared anonymously with other project members. Je comprends que les informations que je fournis seront utilisées pour développer un système permettant d'améliorer l'expérience de lecture des articles de recherche et qu'elles pourront être partagées de manière anonyme avec les autres membres du projet.	○	○
I understand that personal information collected about me that can identify me, such as [e.g. my age, my gender, audio record], will not be shared beyond the study team. Je comprends que les informations personnelles recueillies à mon sujet et permettant de m'identifier, telles que [par exemple, mon nom ou mon lieu de résidence], ne seront pas communiquées en dehors de l'équipe chargée de l'étude.	○	○
I agree that my information can be quoted in research outputs J'accepte que mes informations soient citées dans les résultats de la recherche.	○	○
Consent to be Audio Recorded		
I agree to be audio recorded. J'accepte de faire l'objet d'un enregistrement audio.	○	○

UNIVERSITY OF TWENTE.

I give the researchers permission to keep my contact information and to contact me for future research projects. ○ ○
J'autorise les chercheurs à conserver mes coordonnées et à me contacter pour de futurs projets de recherche.

Signatures

______________________ ______________________ ________
Name of participant Signature Date
Nom du participant

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.
J'ai lu avec précision la fiche d'information au participant potentiel et, dans la mesure de mes moyens, je me suis assuré que le participant comprenait ce à quoi il consentait librement.

Mohamed Reda BENKHELIFA ___________________ ________
Researcher name Signature Date

Study contact details for further information: Reda BENKHELIFA mohamed.benkhelifa@irit.fr
Coordonnées de l'étude pour plus d'informations

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

Si vous avez des questions sur vos droits en tant que participant à une recherche, ou si vous souhaitez obtenir des informations, poser des questions ou discuter de toute préoccupation concernant cette étude avec quelqu'un d'autre que le(s) chercheur(s), veuillez contacter le secrétaire du comité d'éthique Information et informatique : ethicscommittee-CIS@utwente.nl

Appendix B

Low-fidelity prototype

B.1 Widget design table

	Paper's Infos	Abstract/Intro/Conclusion
Content	• Title • Authors • Publication date • Conference • Link to Digital Library	• Abstract • Intro • Conclusion
How to create?	• Visible from the begining • Long press on title • Swipe from the title • Context menu from the paper • Dedicated button show/hide	• Visible from the begining • Long press on Abstract/... title • Swipe from Abstract/... title • Context menu from the paper • Dedicated button show/hide (menu on next to the title)
Where to place when created?	• Close to the paper • Top corner (left/right depend on user's hand prefrence) • Bubble like a tooltip	• Mid-distance • Left/Right side according to user's hand preference • Push elements if too many items
Behaviour	• Not as a decale • don't push other decales • (temporary displayed element)	• Decale
Actions	• Open in the web browser • Copy the ref to add in notes / doc • Show Abstract/Intro/Conclusion • Show refs	• Select text / copy • Jump to the paper (if tablet) • Resize
Visualization	Interacting with paper on the DigitalDesk Wellner, 1993, Communications of the ACM	Abstract

Figure B.1: First part of the widgets design table.

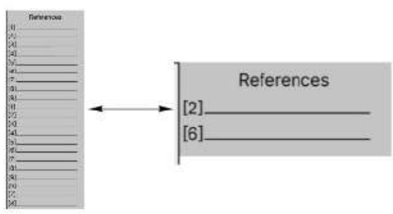
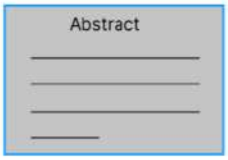
	References list	Reference
Content	A list with all references A list with only the references mentionned on the page	• Paper's info from the reference • Abstract?
How to create?	• Visible from the begining • Long press on Refs section title • Swipe from the Refs section title • Context menu from the paper • Dedicated button	• Long press on Ref in the text • Context menu from Ref in the text • Swipe from the ref in the text (maybe to small) • same but from the ref in the Refs section and Refs list widget • Preview of the infos if long press
Where to place when created?	• Mid-distance • Automatic position • Left/Right side according to user's hand preference • Push elements if too many items	• Mid-distance • Automatic position • Left/Right side according to user's hand prefrence • don't push other elements if preview
Behaviour	Decale attached to the paper	Decale
Actions	• Open reference • Jump to the paper (if tablet) • Add to a TO READ list	• Open reference • Jump to the paper
Visualization		

Figure B.2: Second part of the widgets design table.

	Table of content	Images/Videos/Graphs Figures
Content	Title of all parts of the paper	• Image • Video • Graphs
How to create?	• Dedicated button • Context menu from the paper / title • ~~Swipe to a specific position from a title (ex: left)~~	• ~~All figures visible from the begining~~ (too much infos) • Swipe gesture from the figure • Context menu from the picture
Where to place when created?	• Stick to the paper position (if physical) • Left side • Anchor position • Push items	• Mid-distance • Automatic position • Left/Right side according to user's hand preference • On top of the paper
Behaviour	Decale attached to the paper	Decale
Actions	• Jump to the paper	• Resize
Visualization		

miro

Figure B.3: Third part of the widgets design table.

	Paragraph/Selected text /Highligted text	Notes/Doc
Content	Paragraph	Notes support taken by the user
How to create?	• Swipe from the title of the section • Swipe from the selected area • Context menu from the paragraph/...	• Context menu from the canvas • Context menu from everywhere • Button from a toolbar • Double tap on the canvas
Where to place when created?	• Mid-distance • Automatic position • Left/Right side according to user's hand preference • Push items if no space available	• Where the user touched if position empty • Automatic position • Left/Right side according to user's hand preference
Behaviour	Decale	Decale
Actions	• Select text / copy • Jump to the paper (if tablet) • Resize	• Select text / copy / paste • Jump to the paper (if tablet) • Resize
Visualization		

miro

Figure B.4: Fourth part of the widgets design table.

B.2 Paper widgets

Exploring the Use of Hand-To-Face Input for Interacting with Head-Worn Displays

Serrano Marcos – 2014 – CHI

Figure B.5: Paper widget: Information about the research paper (Title, Author, Publication date, Conference).

Marcos Serrano

Publications : 60

Citation Count : 546

Average citation per article : 9

Figure B.6: Paper widget: Information about the author of the research paper.

April 2014	- Exploring the use of hand-to-face input for interacting with head-worn displays	- Cited 66 times
June 2012	- Movement qualities as interaction modality	- Cited 56 times
April 2008	- The openinterface framework: a tool for multimodal interaction	- Cited 53 times
April 2013	- Bezel-Tap gestures: quick activation of commands from sleep mode on tablets	- Cited 36 times
August 2015	- Gluey: Developing a Head-Worn Display Interface to Unify the Interaction experience in Distributed Display Enviornments	- Cited 33 times
May 2016	- Tangible Reels: Construction and Exploration of Tangible Maps by Visually Impared Users	- Cited 30 times
April 2015	- The Roly-Poly Mouse: Designing a Rolling Input Device Unifying 2D and 3D Interaction	- Cited 24 times
April 2020	- Robots for Inclusive Play: Co-designing an Educational Game With Visually Impaired and sighted Children	- Cited 20 times

Figure B.7: Paper widget: Table of the best publications from the author.

INTRODUCTION

Head-mounted devices are becoming available for widespread, daily use through lighter form factors and with transparent displays. We refer to these modern accessories as head-worn displays (HWDs). As consumers may soon get affordable access to HWDs [6, 30, 31], ways in which they interact with content on such devices is being actively investigated [17].

Currently, HWDs provide onboard microphones and small capacitive sensors for user input. Voice recognition is useful for command-based tasks such as for search queries but has limited use in certain settings (i.e. noisy environments). The capacitive surface on the temple of HWDs presents a viable on-device method for input, but it has limited input space. Other less self-contained options, such as a wearable device or an auxiliary smartphone, can also allow for input [21, 26]. However, these require carrying and may be occluded by the HWD content. Natural user interfaces [29] can overcome the above limitations. However, mid-air input [2, 14] suffers from the lack of tactile feedback and on-body gestures [8, 9] such as making contact with the arm skin [8], are often coupled with on-body projection for output.

We propose *hand-to-face input* as a novel, alternative method for interacting with HWDs. We define hand-to-face input as any gesture that involves touching, rubbing, scratching or caressing the face. This approach is especially well-suited for interaction with HWDs for many compelling reasons: (i) the face is often touched [18, 20] making it a promising area for subtle interactions; (ii) it offers a relatively large surface area for interaction, but not normally clothed as are other areas; (iii) it facilitates eyes-free, single-handed input, which can be invaluable in mobile settings (e.g. riding a bike, holding on in a bus); and (iv) is in close proximity to the HWD, making it likely to accommodate device-borne sensors and creating a natural extension of the device temple.

We first explore the design space of hand-to-face input by eliciting from users the range of gestures for various mobile tasks, such as navigation and action selection. Our study participants generally identified the cheeks and forehead as good surfaces for gestures. Based on these results, we designed hand-to-face navigation techniques (Figure 1) and found these to be most effective and least tiresome when carried out on the cheek. Given this non-ordinary form of interaction, we also examined whether hand-to-face interaction was perceived to be socially suitable. In most cases, participants found this form of input acceptable.

Our contributions include 1) an elicitation of potential hand-to-face gestures for mobile tasks with HWDs; 2) a design of hand-to-face input techniques for document navigation; and, 3) a validation of the suitability of such interactions for use in public settings.

Figure B.8: Paper widget: Introduction,square format, regular font size.

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Figure B.9: Paper widget: Introduction, square format, small font size.

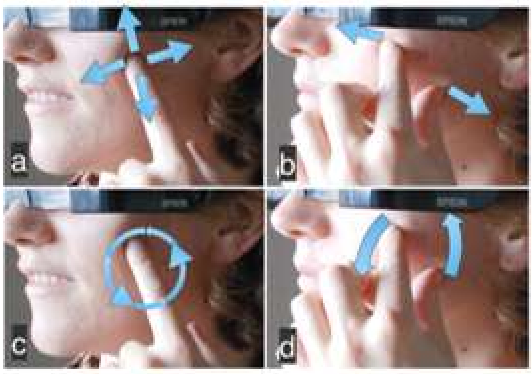

Figure 1. Hand-To-Face input for navigation. a) Panning, b) Pinch zooming, c) Cyclo zooming, d) Rotation zooming. Our studies show that Cyclo was not socially acceptable while Rotation was not efficient.

Figure B.10: Paper widget: figure in the introduction.

INTRODUCTION

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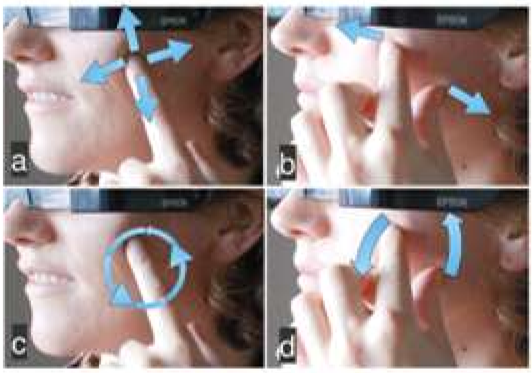

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Figure B.11: Paper widget: Introduction, column format, regular font size. This widget is used as a scrolling widget.

Abstract

We propose the use of *Hand-to-Face* input, a method to interact with head-worn displays (HWDs) that involves contact with the face. We explore Hand-to-Face interaction to find suitable techniques for common mobile tasks. We evaluate this form of interaction with document navigation tasks and examine its social acceptability. In a first study, users identify the cheek and forehead as predominant areas for interaction and agree on gestures for tasks involving continuous input, such as document navigation. These results guide the design of several Hand-to-Face navigation techniques and reveal that gestures performed on the cheek are more efficient and less tiring than interactions directly on the HWD. Initial results on the social acceptability of Hand-to-Face input allow us to further refine our design choices, and reveal unforeseen results: some gestures are considered culturally inappropriate and gender plays a role in selection of specific Hand-to-Face interactions. From our overall results, we provide a set of guidelines for developing effective Hand-to-Face interaction techniques.

Figure B.12: Paper widget: Abstract, linear format, regular font size.

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Figure B.13: Paper widget: Abstract, linear format, small font size.

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Figure B.14: Paper widget: Abstract, column format, regular font size.

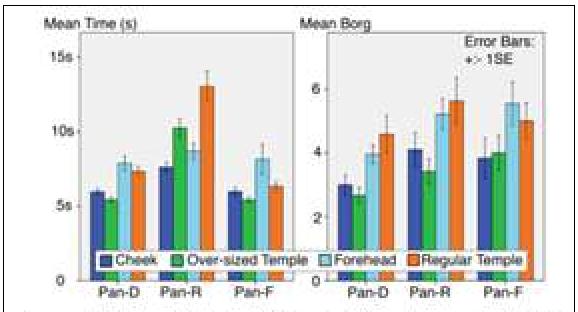

Figure 10. Mean time in s. (left) and Mean Borg value (right) for every panning technique and interaction area.

(a) Figure 10 small size

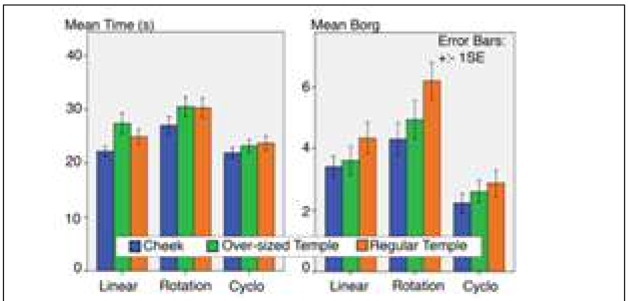

Figure 11. Mean time in seconds (left) and mean Borg value (right) for Technique and interaction Area.

(b) Figure 11 small size

Figure B.15: Paper widget: Figures 10 and 11 small size version.

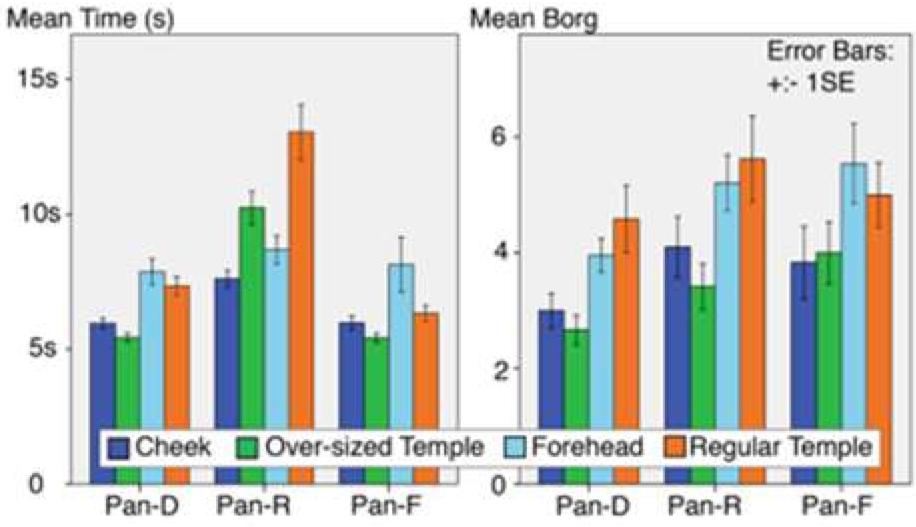

Figure 10. Mean time in s. (left) and Mean Borg value (right) for every panning technique and interaction area.

Figure B.16: Paper widget: Figure 10, big size.

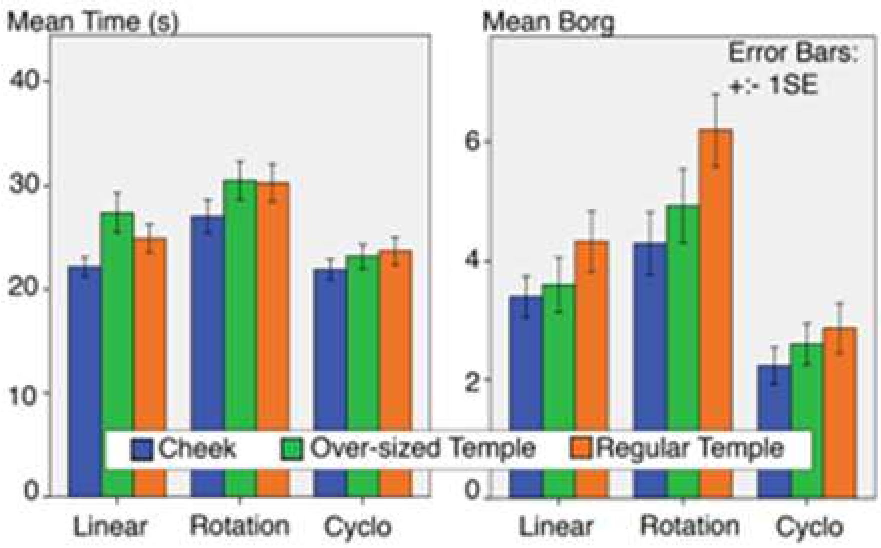

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Figure B.17: Paper widget: Figure 11, big size.

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Figure B.18: Paper widget: Short reference list, it regroups all the references mentioned on page 1.

Figure B.19: Paper widget: Long reference list, it regroups all the references mentioned in the paper.

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ABSTRACT

We present Skinput, a technology that ap propriates the human body for acoustic transmission, allowing the skin to be used as an input surface. In particular, we resolve the location of finger taps on the arm and hand by analyzing mechanical vibrations that propagate through the body. We collect these signals using a novel array of sensors worn as an armband. This approach provides an always available, naturally portable, and on-body finger input system. We assess the capabilities, accuracy and limitations of our technique through a two-part, twenty-participant user study. To further illustrate the utility of our approach, we conclude with several proof-of-concept applications we developed.

Figure B.20: Paper widget: Abstract from reference n° 8. Linear format, regular font size

ABSTRACT

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Figure B.21: Paper widget: Abstract from reference n° 8. Linear format, large font size

ABSTRACT

We present Skinput, a technology that appropriates the human body for acoustic transmission, allowing the skin to be used as an input surface. In particular, we resolve the location of finger taps on the arm and hand by analyzing mechanical vibrations that propagate through the body. We collect these signals using a novel array of sensors worn as an armband. This approach provides an always available, naturally portable, and on-body finger input system. We assess the capabilities, accuracy and limitations of our technique through a two-part, twenty participant user study. To further illustrate the utility of our approach, we conclude with several proof-of-concept applications we developed.

Figure B.22: Paper widget: Abstract from reference n° 8. Column format, regular font size

Skinput: Appropriating the Body as an Input Surface
Chris Harrison – 2010 – CHI

Figure B.23: Paper widget: Paper information from reference n° 8.

Information Brochure

B.3 Briefing brochure

The objective of this experience is to observe the organisation of your workspace when extracting information from a research article. We will try to identify if behaviours exist when analysing and organizing the content from the paper. You will handle a paper prototype and be asked to perform certain tasks. The tasks will be divided into 4 different scenarios that will illustrate different stages of the study of a research article where you will be asked to extract information and a fifth scenario focused on the workspace management where you will be asked to organise your workspace by using different functions. The experiment will take around 30 to 45 minutes.

This experience has been approved by the Ethics Committee Information and Computer Science from the University of Twente in the Netherlands.

We will collect your result from the experiment to design a system that will augment the reading of a research article and adapt the workspace in a semi-automatic way. The user will put his tablet on the tabletop screen and will be able to interact with the PDF in order to extract information on the tabletop and enhance his reading. It will help the user to extract all wanted information and organise them all around the article in an ergonomic way.

We inform you that your results might be shared anonymously with the rest of the team working on this project.

To make sure we do not miss any information, we will film this experience and keep the data for the duration of the project. Your face will not be visible. You are able to request access to your data or to ask us to erase them by sending an email to: mohamed.benkhelifa@irit.fr

Contact details:

- Student-Researcher: mohamed.benkhelifa@irit.fr
- Internship supervisor: marcos.serrano@irit.fr
- UTwente supervisor: m.theune@utwente.nl
- UT Ethics Committee Computer and Information Science: ethicscommittee-cis@utwente.nl

(French)

L'objectif de cette expérience est d'observer l'organisation de votre espace de travail lors de l'extraction d'informations d'un article de recherche. Nous tenterons d'identifier si des comportements existent lors de l'analyse et de l'organisation du contenu de l'article. Vous manipulerez un prototype de papier et serez invité à effectuer certaines tâches. Les tâches seront divisées en 4 scénarios différents qui illustreront différentes étapes de l'étude d'un article de recherche où il vous sera demandé d'extraire des informations et un cinquième scénario axé sur la gestion de l'espace de travail où il vous sera demandé d'organiser votre espace de travail en utilisant différentes fonctions. L'expérience durera environ 30 à 45 minutes.

Cette expérience a été approuvé par le comité d’éthique d’information et d’informatique de l’université de Twente se situant aux Pays-Bas.

Nous recueillerons les résultats de l'expérience pour concevoir un système qui augmentera la lecture d'un article de recherche et adaptera l'espace de travail de manière semi-automatique. L'utilisateur posera sa tablette sur l'écran de la Tabletop et pourra interagir avec le PDF afin d'extraire des informations sur la Tabletop et d'améliorer sa lecture. Il aidera l'utilisateur à extraire toutes les informations souhaitées et à les organiser autour de l'article de manière ergonomique.

Nous vous informons que vos réponses peuvent être potentiellement partagé de façon anonyme avec le reste de l’équipe travaillant sur ce projet.

Afin de nous assurer que toutes vos réponses soient bien collectées, nous filmerons cette interview et conserverons les données jusqu’à la fin du projet. Vous avez la possibilité de demander l’accès à vos données ou de faire la demande de les supprimer en envoyant un courriel à mohamed.benkhelifa@irit.fr

Contact:

- Etudiant-chercheur : mohamed.benkhelifa@irit.fr
- Encadrant de stage : marcos.serrano@irit.fr
- Encadrant de stage de l’université de Twente : m.theune@utwente.nl
- UT Ethics Committee Computer and Information Science: ethicscommittee-cis@utwente.nl

B.4 Consent form

Consent Form

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

ON VOUS REMETTRA UNE COPIE DE CE FORMULAIRE DE CONSENTEMENT

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated [09/06/2022], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction. J'ai lu et compris les informations sur l'étude datées du [09/06/2022], ou elles m'ont été lues. J'ai pu poser des questions sur l'étude et j'ai obtenu des réponses satisfaisantes à mes questions.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason. Je consens volontairement à participer à cette étude et je comprends que je peux refuser de répondre aux questions et que je peux me retirer de l'étude à tout moment, sans avoir à donner de raison.	○	○
I understand that taking part in the study involves a video-record, a transcription of the session and written notes of my answers during the experience and that the record will be destroyed at the end of the project. Je comprends que ma participation à l'étude implique un enregistrement vidéo, une transcription de la session et des notes écrites de mes réponses pendant l'expérience et que l'enregistrement sera détruit à la fin du projet.	○	○
Use of the information in the study		
I understand that information I provide will be used for developing a system that enhance the experience of reading research articles and might be shared anonymously with other project members. Je comprends que les informations que je fournis seront utilisées pour développer un système permettant d'améliorer l'expérience de lecture des articles de recherche et qu'elles pourront être partagées de manière anonyme avec les autres membres du projet.	○	○
I understand that personal information collected about me that can identify me, such as [e.g. my age, my gender, video record], will not be shared beyond the study team. Je comprends que les informations personnelles recueillies à mon sujet et permettant de m'identifier, telles que [par exemple mon âge, mon sexe, l'enregistrement vidéo], ne seront pas communiquées en dehors de l'équipe chargée de l'étude.	○	○
I agree that my information can be quoted in research outputs J'accepte que mes informations soient citées dans les résultats de la recherche.	○	○
Consent to be Video Recorded		
I agree to be filmed. J'accepte de faire l'objet d'un enregistrement vidéo.	○	○

UNIVERSITY OF TWENTE.

I give the researchers permission to keep my contact information and to contact me for future research projects. ○ ○
J'autorise les chercheurs à conserver mes coordonnées et à me contacter pour de futurs projets de recherche.

Signatures

______________________ ______________________ ________
Name of participant Signature Date
Nom du participant

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.
J'ai lu avec précision la fiche d'information au participant potentiel et, dans la mesure de mes moyens, je me suis assuré que le participant comprenait ce à quoi il consentait librement.

Mohamed Reda BENKHELIFA ___________________ ________
Researcher name Signature Date

Study contact details for further information: Reda BENKHELIFA mohamed.benkhelifa@irit.fr
Coordonnées de l'étude pour plus d'informations

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

Si vous avez des questions sur vos droits en tant que participant à une recherche, ou si vous souhaitez obtenir des informations, poser des questions ou discuter de toute préoccupation concernant cette étude avec quelqu'un d'autre que le(s) chercheur(s), veuillez contacter le secrétaire du comité d'éthique Information et informatique : ethicscommittee-CIS@utwente.nl

B.5 Experiment script

Profile questions:

- How old are you?
- How long have you been working in the research field?
- Are you right-handed or left-handed?
- Are you used to use tactile devices other than a smartphone?
- Are you used to read research papers on PDF?
- Do you usually take notes when you are reading a research paper?
- Do you think you extract a lot of information from a research paper?
- Regarding your work space, both physical and virtual, are you the organized or disorganized type?

Discovery of the article:

- Can you extract basic information as a widget? (Title, Author, date of publication, conference)
- Can you display more information related to the author of the article?
- Can you display the list of the best publication from the author?
- Can you extract the abstract as a widget? What version do you prefer?
- Can you extract the introduction as a widget?
- There is a video related to this article. Can you display it?

  Questions:

  – Are widgets related to information (paper, author) grouped together since they are in the same category (additional information)?

References interest:

- Can you display the paper's information related to the reference 8 mentioned in the introduction?
- Can you display the abstract from that reference?

- Can you display the full version of the reference 8 paper?
- Let's get back on the main paper, can you display the widget containing the list of all references from the paper? (present the small and full version)
- Can you show me how you would select the reference 8 but from the references list widget?

  Questions:

  - Should the abstract automatically be visible when looking at the paper information of a reference?
  - Imagine you want to read the introduction from the reference 8, should the abstract widget be replaced by the introduction? or would you like to have a new widget for the introduction?
  - In the case you are interested by the reference 8, are they more information that you would like to display?

Figure comparison:

- Can you extract the figure 10 and 11 from the research article?
- Can you position them so that you can compare them easily?
- Let's suppose you want to take some notes about your observations, how would you process?
  - Would you create a new empty widget?
  - Would you take the notes directly on the figures' widget?
  - Does the note widget appears automatically when you create the figure widget?

  Questions:

  - When extracting two figures or more in one time, are they grouped together?

Annotations:

- Let's suppose you have already read the article before and highlighted some content, how would you do to extract the highlighted passages? is it useful?

- Do you think that the annotation you took about the widgets (i.e. figures) should be registered in the PDF?

  Questions:

  - Are all highlights extracted? only the one on the displayed page?
  - Are all highlights extracted in one single widget? into separate widgets?
  - How would you take notes? With a physical keyboard? with a virtual keyboard on the tabletop screen? a virtual keyboard on the tablet? using a stylus on the tabletop? using a stylus on the tablet?

Workspace management:

- Can you bring from the back to the front a widget?
- Can you move this widget to the back?
- Can you align two widget together? (apply the constraint)
- Can you break the alignment? (remove the constraint)
- Can you group two widget together? (constraint)
- Can you break the group? (constraint)
- How would you delete a widget?

  Questions:

  - Do you consider the aligned widget in the same group?
  - How would you switch between a vertical and horizontal alignment?
  - Are the grouped widgets moving together?
  - What do you think about resizing widgets that have not been used for a while? (smaller)
  - How would you bring the inaccessible content in the background more easily to the front?
  - Do you identify different areas of information types? (Article content, data, information about the paper, ...)
  - What do you think about having a mini-map close to you that help you to reach the content that is at the back of the table?