Innovation and technological watch on Wall-Sized Displays

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ABSTRACT

Wall-sized displays are parts of many innovative systems and are the key to a large number of prototypes for future possible designs. Indeed, previous works show that wall-sized screens are useful tools that provide a large screen allowing great advantages for collaborative work, data visualization and novel forms of interactions. The non-commercialization of wall-sized displays to the general public makes it even more interesting to explore since there is no interaction anchored in the common spirit yet. Therefore, there is no standard way of interacting with Wall-sized displays which is an advantage for creating new interaction techniques but which can become a disadvantage for analyzing and classifying new techniques in terms of efficiency. Through previous works reviews, we discuss about different interactions possible on wall-sized displays and situations where the use of a wall-sized display can be beneficial for future designs.

1 INTRODUCTION

Wall-sized displays provide a wide range of application, thanks to their high resolution and size. They allow to visualize a large amount of data and to collaborate with other individuals in the same work space. Previous work have provided a large amount of interaction techniques and data visualization methods to improve the usability and efficiency of wall-sized displays.

However, creating efficient interactive techniques and information visualization remains a challenge that many researchers tries to solve with tailored solutions or by creating unified tool or framework to fit multiple problems. Previous work on data visualization on wall-sized displays have addressed challenges such as displaying data across multiple devices [7, 9], displaying data in an intuitive manner [4, 13, 18] and adapting the visualization according to the type of data displayed [8]. Research on collaborative systems focus on challenges of working with several users on the same wall-sized display [8, 13, 18] but also on two different wall-sized displays [1]. Studies shows that wall-sized displays can support different collaboration styles and fluid transitions in group work [10]. The collaboration of users across devices on a wall-sized display is also a common research question across previous works [7, 12, 13]. The biggest challenges remain in the interaction field. The focus points are on facilitating the manipulation of objects [13, 14, 18], drawing objects on a wall-sized display [20], performing basic and complex gestures such as zooming [16] or pointing [15], applying body gestures in order to navigate through data with the use of cameras or other devices [2, 6, 8, 12, 14] and using other devices to interact with the wall-sized display [7, 13]. Furthermore, researches were made on the impact of the physical properties of a wall-sized display and have shown that user performances improve with the size and the curvature of wall-sized displays while frustration decreases[19].

Moreover, wall-sized displays are still uncommon to the general public which represents an advantage and a disadvantage for responding to new challenges. Indeed, It can be an advantage for the elaboration of new designs since no system or interaction technique is anchored in the popular mindset. However, it can be a disadvantage for elaborating solutions to challenges without a 'standard' general opinion of what is efficient or preferable for the general public.

2 RELATED WORK

In this section, we present the three main challenges we identified in the several research articles we found which are data visualization, collaboration and interaction techniques.

2.1 Data visualization

Visualization of information and manipulation of data is one of the main challenges of wall-sized displays. Indeed, thanks to their resolution, these screens can display many information according to the type of data. Ways to display data may be different according to the situation, therefore, researchers try to solve this problem by finding creative solutions.

Several works use the size of wall-sized displays to their advantage to visualize a large amount of data. *ShapeCompare* [18] use the multiple screens of the display to show an object and its alternative representations allowing users to modify the characteristics by touching the desired design. Similarly, *CoReach*[13] takes advantage of the size of the display to show a large number of data on the wall-sized screen and animates it according to the different gestures performed by users. In *View and Space Management on Large Displays* [5], Bezerianos and Balakrishnan find a way to display and interact with data out of reach on the large screen. They created the *canvas portals* which are alternates views of display canvas areas where interacting with the portal's interior is equivalent to interacting with the depicted display area.

SpiderEyes[8] uses the location of the user to change the display of the data on the wall-sized projection. Different visualization can be also merged reducing the opacity of each and putting one above the other. A timeline can also be displayed by years and the data linked to specific years can be changed by the user's movements from left to right.

Studies on physical properties properties of wall-sized displays show their impact on efficiency and comfort. In their research, Shupp et al. [19] study curving displays and their effect on the user's performance time. They observed that physical navigation is less strenuous on curved conditions. Depending on the task, the larger viewport sizes also improve the performance time, and the user's frustration is significantly lowered with larger displays. Ball et al.[2] also present a study about specific relationships between large size displays, the amount of physical and virtual navigation, and user's task performance. Bezerianos and Isenberg [4] demonstrate that according to the position of the user, data should be displayed differently: if the user is conducting perception estimation tasks then he should take a few steps back and the system should be using the full size of the wall display to visualize data. However, if the user is close to the screen, data should be displayed in front or near is face.

Nishimoto [17] works on new way to work on data by mixing virtual reality and wall sized displays. By using an augmented reality headset, data can be displayed on the wall, but also above or bellow the wall. Users have just to move their head to see data which is not displayed directly on the wall. This system raises new challenges and shows the enhancing of data visualization using wall-sized displays.

2.2 Collaborative work

Wall-sized displays allow groups of people to work collaboratively by using different platforms and technologies. Researches shows that the high resolution, the size and the multi-touch management of wall-sized displays increase collaborative work conditions [10]. The collaborative techniques are not yet well adapted for all types of work and researchers' studies are focused on new ways to help people working together, on the same device or remotely[9].

Some collaborative systems are designed to be used by individuals on the same screen to interact with data. *ShapeCompare* [18] allows a group of people to work on a design CAD (Computer-aided design) even for non-CAD expert. It allows collaborative and interactive editing of CAD data adjustment. Likewise, *SpiderEyes* [8] provides collaboration on a same display by separating the screen according to the user's wanting and therefore offering a working space for the users. Users can then merged their work together according to their location in the space. The system also dissociates active users from passers-by. In addition, *CoReach* [13] is design to make several people manipulate data at the same time on a wall-sized display, individually or in group, making the process more cooperative and efficient.

On the other hand, some researches focus their study on the use of remote interactions or tools to collaborate such as tablets or multiples connected wall-sized displays. *Smarties* [7] is an input system for wall displays using puck to interact with data. It can be controlled by multiple mobile devices as the puck manipulating the information on screen can be storable and shareable amongst the users. *CoReach* [13] also allows the collaboration to be performed with gestures or on a tablet. Moreover, tablet-sized systems such as *Wallpad* [9] allow to have a quick and remote access to content on a wall-sized display while addressing legibility issues and supporting multi-touch interactions. Furthermore, *CamRay* [1] platform let two users working together on two different wall-sized displays to work together. It captures video of users as they move in front of wall displays using camera and presents this video on remote walls, for other users. With this device, the two users can manipulate data and collaborate together without working on the same wall-sized display. Those systems show the many capabilities of wall-sized displays for collaborative works.

2.3 Interaction techniques

The large size of wall-sized displays makes possible a large amount of different interaction styles. For a long time, interaction techniques were borrowed from smaller devices such as smartphones. Despite the popularity of these interactions types on small and medium-sized displays, these are not adapted for wall-sized displays. Several researchers from different laboratories have conducted studies to provide innovative and more efficient ways to interact with wall-sized displays.

2.3.1 *Direct interactions.*

The touch screen property of many wall-sized displays opens the door to a large range of interaction. Touch-based interaction is a classical interaction style for touch screens. Bi-manual and uni-manual touch-based interfaces were the most studied interaction techniques by HCI researchers. Okuya et al. have designed a touch-based interface with special finger placement to manipulate objects (move shape, rotate, update)[18]. In the same way, *CoReach* [13] allows data manipulation with gestures (and finger placement) that can be done directly on the wall size display. Some works also provide direct interactions and analysis of a sudden stop in the touch. *GlideCursor* [3] is a system modifying the behavior of the cursor in order to take advantage of the clutches. It makes the cursor glide when the user stop touching the screen making the control easier, faster and more comfortable on large displays. The touch-based interface of wall-sized displays can be also use for drawing object. *Sketchsliders* [20] let the users draw their own sliders to interact with data displayed on a wall-size display.

Less studied but also very important in the wall-sized displays field, 3D interactions were addressed to explore touch-based 3D interactions where users are immersed in 3D virtual environment. Users are able to manipulate and teleport 3D objects by a bi-manual touch-based techniques integrated on a large display[14]. Therefore, novel systems continue to be developed using direct interactions.

2.3.2 *Indirect interactions.*

As wall-sized displays can display a large amount of data and analysis, some researchers studied interactions allowing an overall view of the information by standing away from the screen using tailored or universal remote interactions and controllers.

The following research chose to either use remote devices such as tablets with an application manipulating the screen or a specific tangible object or controllers designed for large displays. For example, *Smarties* [7] is motivated by the will of creating a generic tool allowing users to interact and collaborate with others on data displayed on the screen. It can support many complex interactions according to the type of data thanks to a collection of shareable, storable and movable puck that can be easily attached to specific actions. It allows the users to be able to quickly interact with the

display. *ContHead* [15] helps users to point at very small targets on a large wall display. A small target, around four millimeters, can be difficult to reach on a large wall-sized display. By using a small handled device, such as a tablet, the user can move a pointer and point precisely a small target, around four millimeters. As said in the previous section, *CoReach* [13] allows data manipulation with to direct manipulation. However, it can also be manipulated on a separate device, for example a tablet like *Wallpad* [9]. Jansen et al. [11] decided to go another way and explored the use of customizable tangible remote controller to interact with wall-sized displays. In their study, they show that tangible interactions make interaction easier for users on wall-sized display using tangible controllers on a remote mobile device. Indeed, it allows the user to focus on the results rather than looking at the controller.

Several research try to get rid of controllers to manipulate data by using movement detection in order to recognize user's gestures, movement and location. Ball et al. [2] define physical navigation as bodily movement, such as walking, crouching or head rotation to control a virtual camera. In their paper, Koike et al. [12] present a new way to interact with wall-sized displays without touching the screen. With their platform, the user can manipulate data without touching the screen but only by pointing and moving the data with his hand or finger. Cameras detect the position of the user and allow him to manipulate the data. Moreover, by using a QR-Code displayed on the screen, the system allows the user to receive information on his mobile phone by scanning the bar code. Calandra et al.[6] worked on NUI (Natural User Interface), a non-intrusive technology, which do not require to use any devices such as mouse or even a virtual reality headset for example. This system allows the user to navigate into a 360° digital artwork using only his gaze. When the pupil's user move, the artwork displayed on the screen moves too and the user can visit it. *SpiderEyes* [8] allows user to move around an area and change the data displayed according to their body location in the space thanks to a tracking system. They can zoom and change the display by moving toward or away from the wall-sized screen or display a timeline year by year by moving from left to right.

Finally some systems use both controllers and gestures such as Nancel et al. [16] who search for techniques of interactions for Pan-Zoom on a wall-Sized display from a distance. The researchers developed 12 new techniques to execute panning and zooming; techniques that are based on their handiness(uni-manual or bi-manual), gestures (linear or circular) and their environment of use (devices or free hand). The experiment shows that two-handed gestures are faster than one handed techniques (consistently); 1Dpath is significantly faster than 2Dsurface and 3DFree and 2Dsurface is also significantly faster than 3DFree; linear gestures are faster than circular gestures. Novel systems continue to be developed on wall-sized displays through the use of many other devices enhancing the amount of possible interactions.

3 CONCLUSION

We have reviewed and analysed different problems and uses of wall-sized displays. We could identify three fields on which researchers focus their studies: the visualization of information, multi-users interactions and controls on large displays.

Wall-size displays are an advantage for data visualization. Indeed, their size allows the display of a large quantity of information on the same display. Researchers worked on several approach using the physical properties of those screens such as the curvature or the multiple screens composing the wall-sized display. Data visualization can be change by the location and movements of the user. Associated with Augmented reality, more data can be displayed even out of the boundaries of the screen. All these studies tends to work on making the data accessible and comprehensible for the users whether they are close or far away from the screen. Wall-sized displays represent an interesting tool for collaborative works. Indeed, they offer a large space allowing an easier division of space to collaborate in person. They also can be coupled with tracking cameras to provide a remote collaboration on separate wall-sized displays. We could identify many interactions possible on wall-sized displays. Their touch-based, connected and size properties make them good clients to create innovative ideas. Indeed, interactions can be done directly on screen or from a distance. Due to the precision of wall-sized displays, direct interactions represent a large range of techniques going from gestures and finger placement to 3D touched based techniques; going from uni-manual to bi-manual. Interactions can be also done from a distance using external devices and tangible objects. Tracking cameras are also a good way to interact with wall-sized displays using body movements and physical navigation.

While our work has explored many of the issues and solutions surrounding the use of a wall-size displays, one issue that remains unanswered is whether a "standard" way of using wall-sized displays is possible. As we have seen in this review that many problems could be countered by specific solutions, it could be interesting to elaborate on the efficiency and benefits that a general interaction solution could bring to the field. Moreover, the impact of the inclination of the wall-sized display on interaction techniques could be interesting to analyse.

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