A Tool for Creating and Editing Dashboards in VR Spaces Based on a Canonical Set of Operations

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***Abstract*—VR spaces are increasingly used for purposes other than entertainment, to help communicate ideas in more memorable and effective ways. This paper focuses on the problem of how 2D panel layouts – i.e. information dashboards – can be effectively created and edited in 3D spaces. We propose a set of canonical operations to support such layout design. We also introduce a pilot implementation that enables the use of these operations to help configure 2D content within spaces running on the MaxWhere VR platform.**

***Index Terms*—Virtual reality, 3D spaces, Cognitive artifacts**

I. Introduction

Despite its common association with 3D gaming and entertainment, virtual reality (VR) technology is increasingly viewed first and foremost as a communication tool, and is finding applications in a broadening range of fields and vertical markets. Today, VR is showing strong potential in areas as diverse as modeling / design [1, 2, 3], off-site training [4, 5, 6], rehabilitation and capability enhancement [7, 8, 9] and all stages of education in general [10, 11, 12, 13].

The definition of VR formulated by Kizza in [14] aptly describes the groundbreaking potential of this technology: "*Virtual reality (VR) is a type of virtualization technology that employs computer-controlled multisensory communication capabilities that allow more intuitive interactions with data and involve human senses in new ways. Virtual reality is also a computer-created environment immersing users and allowing them to handle information more easily*". Kizza also highlights the fact that a "sense of presence" or "immersion" is a necessary component of VR, regardless of whether it is categorized as immersive, desktop, projection or simulation VR [14]. From the perspective of cognitive infocommunications, both of these aspects are crucial, as they make it clear that VR is primarily a communication technology that appeals to the natural 3D capabilities of the human brain [15, 16, 17].

In this paper, we focus on the problem of how 2D dashboards – i.e., spatialized layouts of 2D displays – can be configured and edited in 3D spaces. Though seemingly trivial, this task is actually very important and far from easy to accomplish.

It is an important task because 3D spaces, apart from integrating 3D animations and visualizations, are also often expected to provide 2D information (through e.g. 2D visuals, text, video or web content) and would be much less useful as tools of infocommunication without this capability. It should also be noted that, as demonstrated in earlier research, VR spaces can be most effective if the arrangement of the 2D content integrated inside them in some sense follows the logical structure of the content itself [17, 18, 19, 20] – making it doubly important that VR designers and users be able to quickly reconfigure the 2D layouts they are using.

However, achieving this is far from trivial because no clear interaction metaphors (i.e., cognitive models for interaction [21]) exist for the arrangement of such layouts, based on which users could quickly and intuitively position, orient, and scale 2D displays in a 3D space. As VR technology gains increasing adoption, the difficulty of this task is a hindrance to the success of many applications.

In this paper, we propose a set of operations which are general, yet holistic and intuitive enough to enable the quick reconfiguration of 2D layouts in 3D. Although our work was implemented in a desktop virtual reality, the tool we developed can be used in the design of a variety of different kinds of VR spaces integrating 2D content.

The paper is structured as follows. In Section II, a brief overview is provided of the MaxWhere desktop VR platform, which will serve as a basis for the practical parts of the work described in the paper. In section III, a brief overview is provided on how 2D layouts are generally created in structured in the MaxWhere VR platform. In section IV, our aim is to propose a canonical set of operations that can be used to create and manipulate 2D display arrangements. This set of operations is canonical in the sense that we aspire to minimize their number and variety as much as possible. Section V provides implementation details, and some discussions based on preliminary feedback from users are provided in Section VI. Finally, Section VII concludes the paper.

II. The MaxWhere Desktop VR Platform

The Széchenyi István University established the VR Learning Research Centre to help further its goals of facilitating online learning. The VR Learning Research Centre introduced the MaxWhere desktop VR platform to the university as a platform for transitioning from web-based e-learning approaches to VR learning.

Besides functioning as a desktop VR system, MaxWhere can be conceived of as a '3D Web Browser' in the sense that it provides a cloud backend with a large collection of 3D spaces (at the time of this writing, over 150 public spaces), allowing users to navigate between them. The space - webpage analogy is viable in this conceptual framework because MaxWhere

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spaces enable the integration of 2D web content laid out in spatially arranged panels (so-called smartboards), while also function as a 3D document, with hierarchically represented nodes for various interactive 2D and 3D components (meshes, light sources, camera, canvases, webviews).

It has been investigated in several previous works to what extent the use of virtual reality in general, and MaxWhere in particular can bring benefits to education [18, 19, 11, 20, 13] and industry / management [22]. The primary claim often made in these works is that the ability of students to view multiple related sources of information at the same time, to have the content thematically laid out in front of them without the need to search for them or open them as separate files not only speeds up information access but also helps to create learned associations more effectively. Further, the ability of 3D spaces to integrate interactive 3D models which users can animate and experiment with can be highly valuable when explaining concepts that are spatial and / or dynamic in nature. The net effect of accessing all of these different content types in 3D space is that the areas of the brain responsible for 3D processing are stimulated to a higher degree, leading to a much more natural experience and as a result of all of the above, more effective learning with better recall [22, 20, 19].

III. 2D LAYOUTS IN THE MAXWHERE VR PLATFORM

2D layouts, or dashboards can be implemented in MaxWhere using so-called smarboards. Each smartboard consists of a webview (a display with a web engine running behind it) and a status bar for entering urls and configuring the behavior of the smartboard content. Within the 3D space, each smartboard has a position, orientation, as well as a size (width / height) in units of centimeters. For the past few generations, MaxWhere has implemented an auto-resolution technology, such that the resolution of each smartboard is calculated automatically based on information on how many pixels the webview would take up on the given hardware display (the laptop or monitor screen) when zoomed in. Of course, the decision to display the webview in the sharpest form possible when viewed at a close distance represents a trade-off, given that in 3D, the same webview can be viewed from any distance.

In the current workflow, the layouts applied in the different spaces are specified by the graphics team working on the given space. Once a layout is defined, users have no way to change it (apart from a few interactive options which allow users, in some spaces, to toggle between a small number of pre-defined arrangements). Several users in the past have remarked that it would be useful if they could have the ability to add or remove smartboards, or to rearrange existing layouts more freely in the spaces. The difficulty in allowing this is that the precise positioning of the smartboards can be difficult (especially when specifying their orientation) as no universally accepted interaction metaphors exist for this task which would also be intuitive to end users.

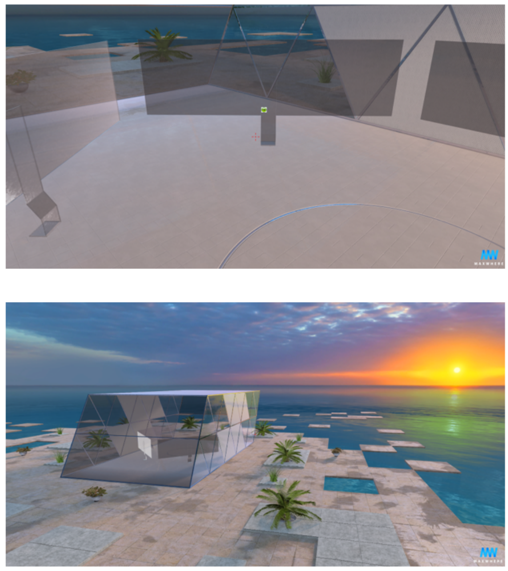

Fig. 1. Tarek Setti Lab from inside and outside the building

IV. CANONICAL OPERATIONS FOR LAYOUT ARRANGEMENT

The key challenge in defining interactive tools for layout creation is to provide a set of operations that are in some sense minimal (or at least relatively few in number) but still allow users to create any variety of layouts in a way that is intuitive and fast. In a more mathematically oriented formulation, the goal is to develop a minimal set of operators that still allow users to explore the full dimensionality of the problem of positioning and scaling smartboards in 3D.

In this work, we hypothesize that a sufficient set of operator types would include:

- Placement operators (i.e. cursor placement), which help specify where in the 3D space (in terms of x,y,z coordinates) the smartboard should be added and in what orientation.
- Addition operators, which enable users to add one or more smartboards (according to a certain arrangement) to the place previously specified using a placement operator.
- Selection operators, which enable users to select 1 or more previously added smartboards for further manipulation.
- Manipulation operators, including
  - Movement operators, allowing users to translate the selected smartboards left, right, up and down in its own plane.
  - Rotation operators, allowing users to rotate selected smartboards along their horizontal and vertical axes.
  - Aspect ratio operators, allowing the aspect ratios of selected smartboards to be toggled (key aspect ratios in MaxWhere are 4:3, 9:16 and A4 sized aspect ratios.

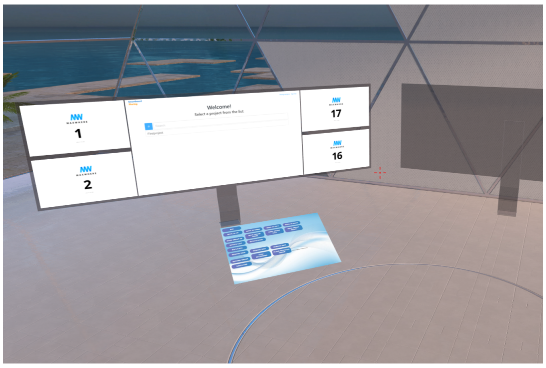

Fig. 2. Billboard version of our UI.

– Scaling operators, allowing users to scale the smartboards

Defining a suitable placement operator is not without challenges because if the cursor can be moved simultaneously in the 3 coordinates of the space, it can become difficult for users to understand the depth at which the cursor is located at any given time. One possible solution is to allow users to 'snap' the cursor onto existing surfaces in the space. This has the added benefit of also implicitly specifying the orientation of the smartboard to be added (i.e. matching the orientation of the surface).

Defining movement, rotation and scaling operators is challenging because of the continuous range of positions, orientations and scales at which smartboards can be defined. Therefore, operators are necessary that can be used to quickly and precisely set the desired values.

V. Implementation of Editor Tool in MaxWhere

To test the ideas detailed in the previous section, we created a test space in MaxWhere, nicknamed "Tarek Setti Lab", with the goal of developing a first version of our layout tool within this space. The space was initially created as an empty version of another space called "Seascape" (see Figure 1). The main research question was whether users could use the tool we develop to design a dashboard layout in this space similar to the original one, or at least in a way that follows the logical structure of the grey panels in the space.

To test our ideas, we developed two versions of our editor tool. In one case, the user interface was placed on a billboard in the middle of the space (Figure 2). In the second case, the interface was placed on an overlay display, which appeared only when the user 'froze' the 3D navigation in MaxWhere by opening the 2D (pebbles) menu (Figure 3).

Below we summarize the key features of our implementation.

A. Placement operators

The implementation features a placement operator, which allows users to attach a green selection cursor to the camera, and to paste it onto a surface by double-clicking on the surface. In case there is no surface within the view of the camera, the cursor is dropped at a fixed distance from the camera, in the same orientation as the camera's (Figure 4).

Fig. 3. Overlay version of our UI.

Fig. 4. Addition of smartboards around the location of the green cursor

B. Addition operators

Currently our implementation has 2 addition operators: one for adding a single smartboard, and another for adding a 2-by-2 grid of smartboards at a fixed distance from the location of the cursor (Figure 4).

C. Selection operators

To allow users to select groups of smartboards to manipulate, we developed a separate "group selection mode" which can be toggled via a button on the user interface. Whenever the group selection mode is on, existing smartboards in the space can be selected / deselected to be part of (or removed from) the group by moving the 3D mouse over the smartboards. Every second time the mouse enters a given smartboard, it will be selected / deselected. Whenever a smartboard is selected, a special image with the text "Selected" is displayed on it (Figure 5).

D. Manipulation operators

Whenever one or more smartboards are selected, they can be moved (left, right, up, down), rotated (forward / back and left / right), scaled (made larger or smaller) and even duplicated.

The aspect ratios of the selected smartboards can also be modified using the user interface (aspect ratios of 4:3, 16:9

Fig. 5. Selected Group of Smartboards

Fig. 6. Moving smartboards to the left

and A4 size can be selected). Whenever the aspect ratio of a smartboard is modified, the width of the given smartboard is kept at its existing value and its height is modified accordingly.

Figures 6, 7 , 8 and 9 demonstrate the use of the manipulation operators. It should be noted that whenever a new smartboard is added, a unique integer is chosen as an ID for

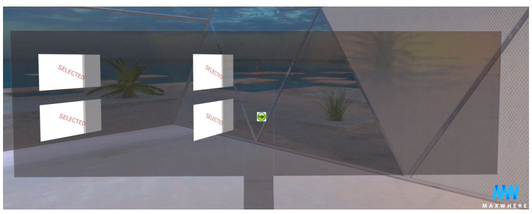

Fig. 7. Rotation to the left

Fig. 8. Setting the aspect ratio of smartboards

Fig. 9. Duplicated group. When a group is duplicated, the duplicate smartboards are in a slightly translated position so that all smartboards are visible

the smartboard (ensuring that no two smartboards in the space have the same ID).

E. Exporting and importing layouts

Finally, the tool we developed includes facilities for saving the layout in a given space into a JSON file at a location specified by the user. Similarly, JSON files can be imported to continue working on a given layout.

VI. Discussions based on feedback from users

When testing our layout tool with users, the space was empty at first. In the 'billboard version', the user interface was visible at the center of the building, so users had to turn back to the billboard whenever they needed to activate a feature or manipulate the layout in some way. In the 'overlay version', the users simply had to click on the right mouse button to enter the pebble menu and the user interface for our tool would then also be available at the bottom of the screen.

To evaluate the effectiveness of our tool, we prepared a questionnaire that contained a set of questions related to our work as shown in Table I. The purpose of this questionnaire was to evaluate how well users understood the operations and how well they were received.

5 users (students from different majors at Széchenyi István University) filled out the questionnaire. 3 of the students were between ages 18 and 25, while 1 student was below 30, and 1 student was above 30 years of age. In all cases, the questionnaire was filled out by the users after we explained to them the features of MaxWhere and of this particular layout tool, and after they tried using both versions of the layout tool.

All users agreed that VR technology is useful for education, and all users were able to learn and proficiently use the navigation tools inside MaxWhere after a few minutes. When asked which version of the layout tool they preferred, 1 student indicated that the 'overlay version' was better, while the other 4 indicated that they were able to use both versions equally well. In follow-up conversations, uses indicated that the overlay version of the user interface was easier to use, as the UI was better structured, and also because it was more tedious to have to always turn back to the display panel in the billboard version.

The distribution of answers to some of the other questions are shown in Figures 10, 11 and 12. It is interesting that the

Questions
Do you think that by using VR technology, education and learning can be improved?
What 3D space would you choose, the billboard version (version 1), overlay version (version 2) or both?
How do you find the 3D space that you have chosen?
What are some things that would make a 3D space useful in your opinion?
How do evaluate the differences between the editor panels in version 1 and version 2?
What are operations that you feel are important and why?
What are operations that you feel are not necessary and why?
Do you have any other suggestion that we can add as an operation?

TABLE I
LIST OF QUESTIONS

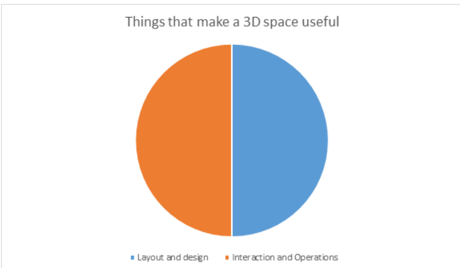

Fig. 10. Things that can make a 3D space useful

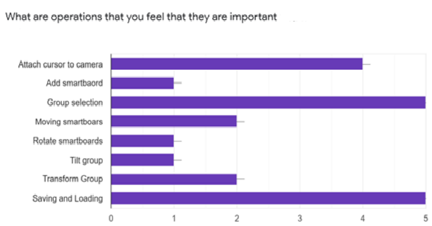

Fig. 11. The operations that users feel are most important

operators of group selection, cursor placement and saving / loading were evaluated to be the most useful by the users. Without these operators, users felt that they would be unable to work effectively. The cursor placement operator can help users choose where to place the smartboards in a free and unconstrained way. The ability to select groups also enables users to work much faster, without having to repeat the same manipulations on multiple smartboards. Conversely, two users (a relative minority) felt that the rotation operation was unnecessary, given that the location of the cursor already linked the orientation of the smartboard to the orientation of the given surface.

When it came to suggestions, one user brought up the idea of converting the button-based UI into a voice (text-

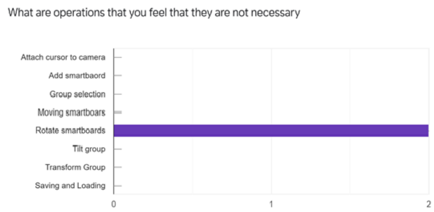

Fig. 12. The operations that users feel are not necessary

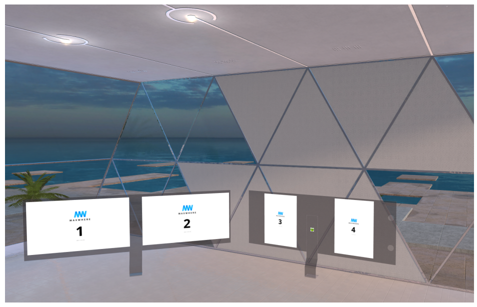

Fig. 13. Sample layout created using the proposed layout editor tool

to-command) UI, which would solve the billboard-overlay conundrum and help users complete the task faster. Another suggestion was to add an artificial agent (a virtual person) to the space using AI methods to support users who are new to the MaxWhere platform.

Figure 13 shows an example of a layout created using our tool. Although the layout was created successfully in less than 2 minutes, some imprecisions can still be found in the result. For example, the left and right margins of smartboard 1 and 2 are not perfectly the same – smartboard 1 should be moved slightly to the left, but the discrete step taken using the movement operators are too large. A somewhat similar situation can be seen at the top margin of smartboards 3 and 4. This suggests that it may be useful to allow users to specify a step size with which the manipulation operators update the layout, or to make the step size dynamic depending on the rate at which the given manipulation occurs. Further lessons could perhaps be gleaned by using various forms of bio-feedback – including eye-gaze tracking, which has been shown to provide good measures for cognitive load [23, 24, 25].

VII. CONCLUSIONS

Using virtual reality provides useful benefits for many application domains. The results of this research work revealed that 3D spaces can be more convenient when users can configure 2D layouts freely. The paper introduced a set of manipulation operators for configuring such layouts using a set of operators that are meant to be canonical and in some sense minimal. A pilot implementation was developed within the MaxWhere VR platform. Future work is needed to fully evaluate and refine the solution.

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