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DATA SCIENCE HOLODECK

3D-VR Interaction Design Research and Recommendations

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COPENHAGEN BUSINESS ACADEMY

FOUNDATION

Based on our qualified knowledge and experience in the fields of *Human-Computer Interaction* and *User Experience*, the recent investigation on published information in the subject area *(*La Viola Jr. *et* al*, 2017),* our own experiments with the prototypes (Data Science Holodeck 3D-VR Interaction Design Inquiry, Data Science Holodeck Experimentation 2020-2023, Data Science Holodeck Demo Cases 2022-2023), as well as the feedback received (Data Science Holodeck Feedback Collection, 2023), we have limited our focus on researching the following components of the 3D and VR interaction:

Hardware

the headset and its operability by vision, audio, and controllers (VR), as well as a computer screen and a keyboard (3D)

Software

the software, visualising the VR environment and objects in it and the computing platform on which it is deployed: server, API, and client applications

Human Tasks

- observation – entering a virtual space with pre-defined boundaries
- exploration – including self-transportation and simple interaction
- data-related tasks, such as searching and classification
- interaction – including selection, manipulation, and feedback

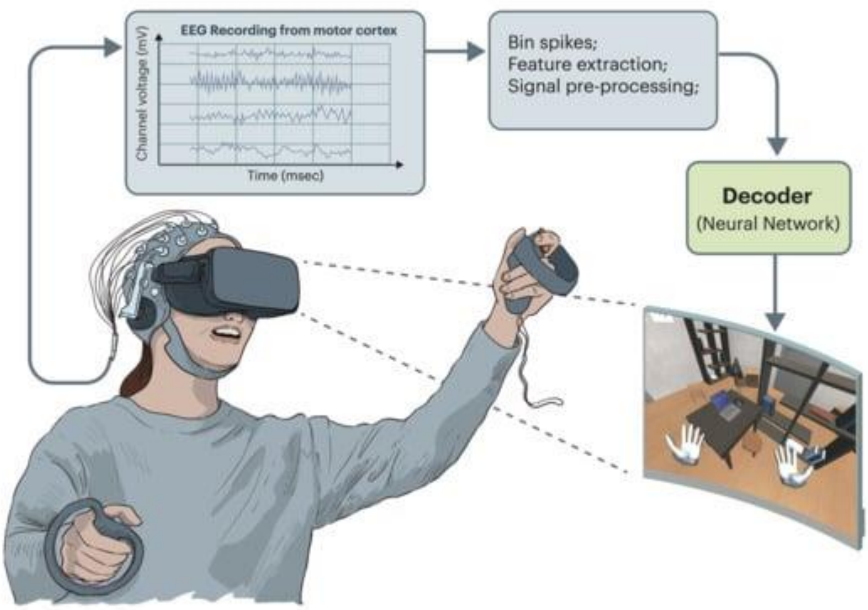

Figure 1 VR Environment, Source

INTERACTION

We have considered researching both isomorphic (realistic) and non-isomorphic (magic) interactions, related to the tasks listed above, and their dependency on various factors, such as:

The Virtual Environment

- space volume, its boundaries, and the visual objects proximity
- size and location of the objects in the space
- space furnishing and background metaphors
- use of floors
- use of display walls
- use of realistic scales, measures and measurement

The Quantity of The Visual Data Objects

- one object
- bulk of objects
- massive collection of objects
- high or low density of objects

The Type of The Operations, Constructing The Tasks

- pointing, addressing
- contacting – touching, grasping, kicking
- transforming – translating, rotating, and scaling
- progressive refinement or aggregating – drilling down or rolling up
- body motion – teleportation, way finding

Due to time and other resources restrictions, we have set aside for further investigation some interesting parameters, related to tactile and oral modalities, such as taking use of sound and speech, typing and handwriting, using different materials for different types of objects. We have experimented with voice conversation and lips reading to limited extend, insufficient for making conclusions.

We have also limited the research and the development, related to some aspects of visual menus (for example, on-hand vs on the virtual object vs in the space). We have experimented with the last two.

Another feature of interest that requires additional resources for further exploration is the simultaneous sharing of same virtual environment by multiple users.

VR INTERACTION TOOLS

In VR users interact with the environment and objects in it by the headset registering the body pose and eye movements, by free hands, or by controller devices.

The first two modes are helpful, but not sufficiently accurate on the average available devices we have used (Oculus and Oculus 2, shown on Figure 2), as the background technologies are still premature, not enabling the sufficient resolution.

Figure 2 Oculus and Oculus 2 Headsets, Source

Body pose determines the scale and scope of the VR environment. Eye movements are very important for the orientation inside the space, but there is a lag to the controlled action. Free hands movements are both fascinating and useful for range of action, but not precise in pointing.

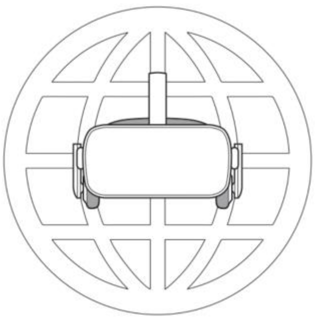

Figure 3 Oculus Head - Mounted Device and Movements, Source

We have focused our research on the use of controllers – the devices used by hands.

We have designed and run experiments, involving both students in a classroom and broader target group of colleagues and business partners using controllers.

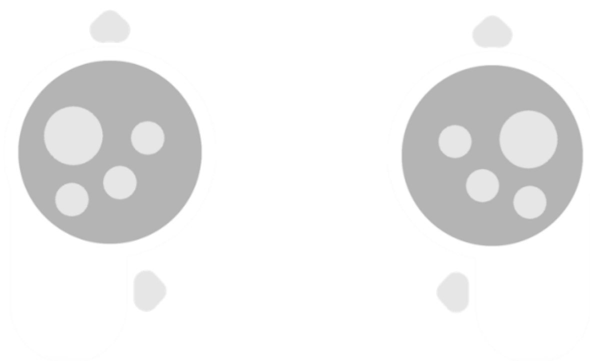

Figure 3 Left and Right Controllers and Their Interactors, Source

The left- and right-hand controllers offer six interaction instruments each: buttons, trackball, and trigger.

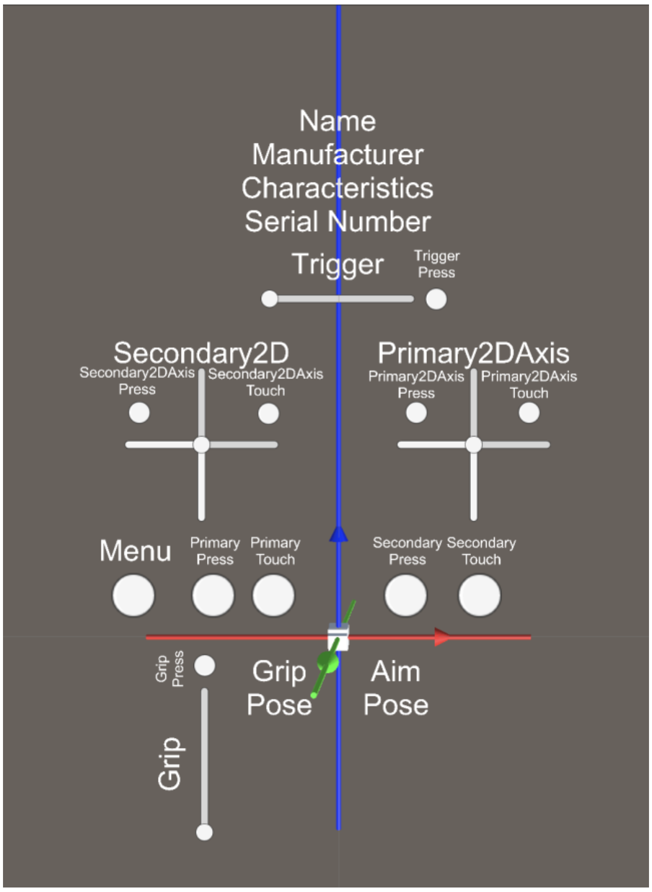

Figure 4 Oculus Predefined Use of Controllers, [Source]

Categories of Users

Our experiments with the use of controllers have identified three base categories of users, in regard to their professional and VR interaction experience:

a) individuals with previous experience in playing VR or console-controlled computer games
b) young people and tech-minded individuals
c) not so tech-minded adults

The differences come with the following specifics:

1. The experienced individuals (a) have pre-built skills in operating remote controls and expectations regarding the use of the various interacting components.

2. The second category users (b) can adopt to the stage quickly and easy. A brief introduction to the controls, either oral, written, or physical, is sufficient for them to get oriented and motional.

3. The third category of users (c) need more time to adopt to the not so intuitive control devices. They would gain from reading short instructions, self-focusing, and training before joining the VR.

Addressing the differences

To address the differences, we have done the following:

Identified the critical interactions

a) operating with the menu
b) moving and teleportation in all directions
c) activating a function

Collected and implemented advice from the first group of users (a).

Based on their extensive experience, we designed

a) moving by use of *thumbs*, and therefore assigning the moving interaction to the control keys, naturally located close to the thumbs

b) predominantly using the *right hand* for operating and activating menu options and *left hand* for motion

c) using the triggers for selecting

d) using grip as a right click

Prepared materials in support of the second and third groups of users (b, c)

In voice, text, and images

a) name conventions

b) a glossary of terms

c) minimal set of usable instructions

Find more in our Demo Case 1 here.

EXPERIMENTAL ENVIRONMENT

We have used Unity as a platform for development of prototypes of VR interactions. Unity offers a module in support of programming the VR Interactions, called *XR Interaction Toolkit* - a high-level, component-based, interaction system for creating VR and AR experiences (XR Interaction Toolkit, 2022).

The core of this system is a set of base Interactor and Interactable components.
Interactors are the instruments used by the user for creating interactions in the virtual world, such as the instruments located on the headset. The interactables are the virtual objects the user can interact with. Developers can associate each of the interactors with a set of actions – the human input, and to bind them to interactables (see Figure 5 bellow)

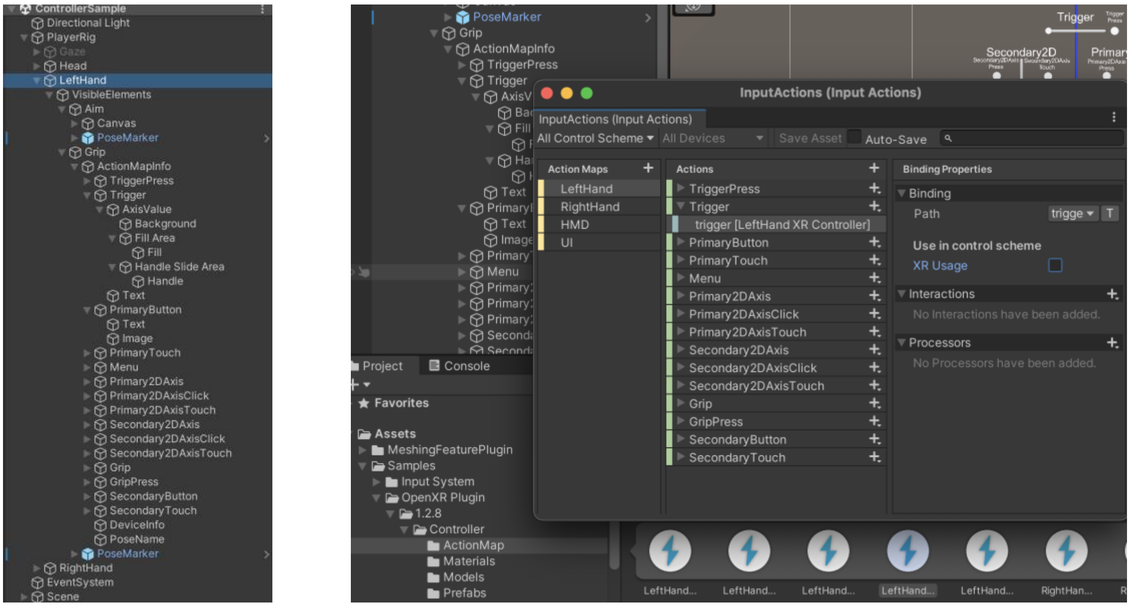

Figure 5 Using Unity XR Interaction Toolkit, Source

There are numerous of alternative combinations of components that can be used for programming one interaction element. We found out that keeping more than one way to perform intended interaction works well for the users.

RESULTS

Our main findings consist of the following:

1. VR set ups and demo cases show highly positive emotional acceptance of the idea and the perspectives of its implementation in real-life cases. Users value the unique non-trivial way of data presentation, as well as the intuitive visualisation.

2. VR creates benefits for users, especially for those involved in data and documents processing. It resolves complexity and promotes curiosity and engagement with the operations. Lack of previous VR experience is no an obstacle for achieving positive effect from the start. Experience in 2D diagramming helps as a familiar anchor.

3. The sense of presence in adventure space, the magic motion and interactions support the operating on well-defined tasks, but even just browsing the VR environment opens new horizon for vision and comprehension. Users do not feel isolated, but concentrated.

4. Applying art scenes, backgrounds and object metaphors are not distractive, but well accepted by the users. There is no reason to model and simulate office-like environment, as the expectations are for 'virtual' space - natural landscapes and sounds complement the positive perception and the excitement of the experience.

5. VR applications gain from personalisation and user profile adaptivity. The scale of comfort zones of user varies depending of many non-VR related factors, like previous experience, professional background, personality and interests.

6. Programming multiple alternative ways of implementing one human interaction with the VR in beneficial for the users, as it enables successful use of intuition, despite the individual differences mentioned above.

7. VR is not the best platform for reading long texts but displaying text instructions of behaviour inside the VR space is appreciated. Various menu types can help the navigation and operation with the virtual objects, but the number of menu option should be limited to three-four. Pop-up frames with labels and other informative properties of the virtual objects are needed, but they should contain only context dependent information, important for the task and limited is space (preferably transparent), so they do not disturb the bigger picture.

8. An appropriate separation of human vs automated operations is a must. Humans in VR environment should be only engaged in short specific operations, providing an extra value of the experience.

9. In general, VR of today creates physical and physiological discomfort. It is much confusing for users wearing glasses, the headsets do not fit well to the wider population regarding the anthropological measures, can create burning eyes, back and neck pain, headache or motion sickness, the controllers are not so intuitive, and last, but not least, is not quite hygienic, unless everyone has a personal device.

10. Applying traditional VR development tools, such as Unity is neither a trivial task, nor sufficiently productive for delivering of extended user experience. New, modern, and much popular and accessible environments, like the WWW, APIs and modern AI platforms provide enormous support for developers and operators of VR applications. Discovering the advantages of each technology, identifying the optimal compatibility and integration between the traditional and innovative tools is the recommended solution.

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