Recommendations for Implementation of Virtual Reality Applications in Other Industries

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The VR Best Practice Catalogue plays a key role in opening up new business areas for game developers in the BSR. The stabilisation of existing and opening of new markets will enable the BSR to be a high potential actor in the rapidly growing VR sector and to develop into an international game industry hotspot.

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Content

1. Introduction

One of the many goals of the Baltic Game Industry project is the piloting of the implementation of Virtual Reality (VR) in a non-gaming context, in this case, for the health sector.

The DE:HIVE is a branch of the game design study programme of the HTW Berlin University of Applied Sciences, dedicated to creating virtual applications in cooperation with researchers and scientists. Working with a diverse team of artists, programmers, game designers and engineers under the leadership of Prof. Susanne Brandhorst and Prof. Thomas Bremer, our goal is to create and enrich digital applications for training, assessment, therapy, education, etc.

Using a method called "Game Thinking",[1] we work in close cooperation with researchers to find the best design solutions for the needs of a non-game application by transferring game design principles and best practices to a non-game context. When creating a new application for a specific sector, many factors have to be considered.

The following guide will provide insights and experience gained from creating a VR application for the health sector in close cooperation with Prof. Dr Simone Kühn of University Medical Center Hamburg-Eppendorf (UKE) who is in charge of the researchers that the application was created for. Aimed at designers and researchers, this guide will not only cover the technological and design considerations necessary but will also show the importance of clear communication between the different professions to ensure the best results.

Scientists and designers are experts in their respective fields but therefore misconceptions on both sides might occur during cooperation. This guide will cover common misconceptions to enhance the communication between the experts involved.

In addition, this guide will also give advice on the advantages or different VR devices and what to consider when planning a new XR application, based on the findings from developing also an Extended Reality (XR) application that DE:HIVE created during the Baltic Game Industry project.

[1] Explained e.g. here: https://gamethinking.io/.

2. Preparation & Planning

For the successful creation of a non-game application, this first phase of preparation and planning is indispensable.

In the planning phase, close dialogue between researchers and developers is crucial for the further course of the project. With a comprehensive knowledge of hardware, software and game design solutions, developers can provide impulses in the planning phase as to how the project can be optimally implemented both technically and conceptually.

For this purpose, the goal and target group of the application should be clearly defined. Designers should not assume that the participating experts from the medical sector already know about the development and use of XR applications and the associated hardware. Therefore, it is the responsibility of the developers to inform about the special features and possibilities in XR.

It is recommended that developers gather as much concrete information as possible about the objectives of the application during the planning phase to be able to advise the partners involved. The following questions will help in planning and implementing app development for the health sector.

2.1 What is the Goal of the application?

Assessment and training tasks might require a mindful, yet more playful approach to enhance motivation and reward the participants for taking part.

When working on a therapeutic application, either for physical or for psychological needs, a designer's approach needs to be even more attentive. A physiotherapy application should avoid the encouragement of body movement that will increase muscular tension. It should also not include hardware with bad ergonomics which will be discussed in detail in this guide.

The application's goal will have the most impact when the design is based on the following considerations. Engaging in a dialogue about these factors as early as possible is crucial for designers and researchers alike.

Designers and developers will be able to choose the game engine, the target device, the game mechanics and the user interface that best suits the application's needs.

2.2 Who is the Application Aimed at?

The target audience of an application in the health industry can be separated into two overarching categories.

2.2.1 Applications Aimed at Patients

The first category consists of patients who use the application to complement conventional therapy such as psychotherapy, physiotherapy, etc.

For researchers and developers, it is necessary to evaluate and consider the physical and mental capabilities of those patients. If the application is designed for a physically challenged audience, researchers and experts are advised to provide background information on what movement patterns and physical inputs the audience is capable of and more importantly, what movement patterns and audio-visual stimuli should be avoided.

When designing an application for the health sector it is also important to further evaluate the motor skills of the patients using the application. Traditional hardware interfaces such as gamepads, joysticks or virtual reality controllers might provide a challenge to patients who are either inexperienced in the usage of such control methods or physically incapable of using such hardware devices.

This will help developers to give advice on what hardware components potentially lead to the desired effect and what game patterns will work with the given hardware.

The mental condition of the target audience is an important factor when developing an application that will be used in a therapeutic context. Developers should be informed by experts about the amount of physical and mental stress that is reasonable to induce with the application. This helps to prevent the target audience from being overwhelmed with virtual stimuli. It can also enable the developers to induce a controlled and intended overload with certain stimuli.

2.2.2 Applications for Professional Training

The second category includes people who work, study or research in the medical field.XR applications are particularly suitable for training complex workflows in addition to working with real patients. It is especially important to clarify which input devices should be used. Controllers that are normally used for navigation in XR applications are not suitable for performing complex, fine motor actions that are normally performed by medical personnel.

Also, in the context of education and training, it must be clarified whether supervision of personnel should take place and which user data should be recorded. This could include data like eye tracking, blood pressure or skin resistance. In this case, an appropriate user interface for supervision and for controlling certain parameters of the application from the outside should be included in the panning.

2.2.3 Personnel Conducting and Supervising the Use of the Application

It should also be discussed if the personnel conducting the use of the application will have to be trained at preparing or operating the hardware which is especially important for Virtual- or Augmented Reality apps.

When creating applications for a professional context it should be assumed that most people operating the application and the user interface are unfamiliar with traditional video games, therefore developers have to make sure that the interface is as intuitive and accessible as possible. However, a minimum of experience in how to operate a computer should be assumed.

2.3 Special Hardware Requirements for Different User Groups

Due to the different motor and cognitive abilities as well as the necessity to learn certain movement and work patterns, it is important to choose the right hardware, especially in the medical field.

Users, who are supposed to take advantage of certain therapy or training offers in an XR environment, are composed of different demographics. A general affinity to input devices like controllers should not be assumed.

XR glasses usually use input devices that are very similar to controllers from the video game sector. These are not necessarily intuitive for people outside the gaming community. Due to the relatively high density of keys, joysticks, and buttons on a typical XR controller, it is advisable to make the keyboard layout as simple as possible.

A precise evaluation of the target group can help developers avoid overloading the input possibilities. This should be considered especially for applications in the field of therapy because overloading the hardware can lead to a falsification of measurement results.

2.3.1 Haptic Gloves

Haptic gloves are a suitable alternative to controllers. These facilitate the transfer of patient movement and interaction into the digital world since no keyboard layout has to be learned to use the application. It should be noted, however, that this means a considerable additional financial burden for institutions such as clinics if they make the application available to their patients on site.

In addition, the additional technical effort caused by the use of e.g. haptic gloves should be considered in the development. This also enables direct interaction with training devices, training dummies and other objects in the real world. A further advantage of haptic gloves is the possibility to simulate certain surface properties of digital objects and to make them tangible through the gloves.

2.3.2 Hand Tracking

In addition to various haptic gloves, various manufacturers offer a solution for direct tracking of the hands and transfer of the position data to the XR application. In addition to external products such as Leap Motion, the Oculus Quest and Oculus Quest 2, in particular, are capable of precisely tracking the hands of the user. This allows even more natural interaction with the environment. This also enables hybrid interaction with real objects while the patient is in XR.

2.3.3 Choosing an XR headset According to the Application's Goal

Due to a large number of manufacturers and product lines, it is necessary to weigh up the advantages and disadvantages of the various XR headsets. A decision should be made as early as possible in the planning phase, as clinics and other therapy centres, in particular, have long lead times and limited budgets for purchasing technology. In this process, designers can show the relevant possibilities of the individual headsets and give researchers and experts an insight into the technical possibilities.

In turn, developers should know the exact requirements of the application before choosing a headset in order to make a timely decision on the target platform. Due to the changing range of eyewear available, no individual manufacturers or specific products should be mentioned here.

The following list of features provides a complete overview of the capabilities of XR headsets and provides examples of how these features are used in the medical field. This can help you choose the right headset.

Field of View (FOV)

The field of view of XR headsets is critical to the wealth of visual stimuli that can be presented simultaneously. Humans have a natural field of view of approximately 210°.Headsets with a field of view that is nearly as large provide a higher level of immersion for users.

Outside-In Tracking

With this tracking method, the sensors for position determination must be distributed in the room. Since these sensors require a separate power supply, the requirements for the physical space in which the headset is to be used are higher than with Inside-Out Tracking.

In addition to a sufficient number of sockets, it must be ensured that there are as few reflective surfaces such as windows in the room as possible, as these can interfere with tracking. Due to the high coverage of the room with infrared rays, the tracking is very precise and allows a high degree of freedom of movement.

Inside-Out Tracking

With this tracking method, the position of the user is recorded by the glasses themselves, which means that less hardware needs to be installed in the room. This tracking form allows a high variance in the size of the room. In addition, the room does not have to be specially prepared for use, so that training or treatment in XR can take place anywhere.

It should be noted that the controllers are not tracked if they are behind the display, which can lead to a temporary loss of digital hands and thus possibly to confusion for inexperienced users. This should be considered in the selection.

Wired XR Headsets

It should be considered early that wired headsets require a powerful computer. First, it is crucial for institutions such as hospitals to calculate the cost of these computers when developing an application for clinical use. On the other hand, this limits the target group for home use of the application enormously.

The much higher graphic quality that can be achieved on a computer-bound headset is essential for a high degree of realism in the presentation.

Wireless XR Headsets

Wireless headsets offer high spatial flexibility. They are also less expensive to purchase because no computer is needed to operate them. Because they do not require a computer to operate them, they are more widely used and can potentially be given to patients for home use. In addition, no complex setup of the devices is necessary.

A decisive disadvantage is the relatively low computing power which limits the graphic quality of the applications. In addition, the choice of special hardware, such as haptic gloves, is much smaller than for wired headsets and the implementation is much more complex. This should be considered during development.

Eye-Tracking

Some XR headsets offer the ability to capture the eye movement and direction of gaze of users in the virtual environment. This can be helpful for certain surveys in the research and therapy sector. It can also be used in medical training to document and evaluate where users direct their gaze and to what extent certain optical stimuli can direct attention.

Although there are external attachments for certain headsets that do not have this feature themselves, the implementation is an additional effort that can be avoided if a headset with this feature is selected from the outset.

2.4 Ethics and Data Protection

A great responsibility lies in the protection of sensitive user data, especially when it comes to sensitive patient data. Developers should provide early warning of the risks and blatant gaps in data protection that currently exist in the area of XR headsets.

In the course of the development, the DE:HIVE team contacted all manufacturers to get a detailed statement about which data is collected by the operating software of the XR headsets and to what extent and if this can be deactivated. None of the manufacturer companies responded to this request, but the terms and conditions of the different platforms clearly indicate that user data is passed on to the manufacturers. Since it is not clear what kind of data is involved, it can be assumed that, among other things, the microphone of the headsets is also used for data collection.

Thus, especially in clinical applications, the input of personalised data should be avoided. Especially for nearly all headsets of the product line "Oculus" a Facebook account is required to operate them or will be required from 2022. This is a particular hurdle if an application is accompanied by an ethics committee, as is the case with medical applications by default.

One way to prevent uncontrollable data traffic to the manufacturers is to not connect the computers on which the application is used to the public internet. This eliminates all additional functions that explicitly require an Internet connection, such as online multi-user sessions.

3. Equipment for the Use of XR

The following describes the technical requirements that must be met in clinics or therapy facilities in order to use XR for medical purposes.

3.1 Room Set-up

First, a suitable room should be created or furnished. Requirements for the room is first of all a sufficient freedom of movement for the users of the application. Furthermore, the hardware requires sufficient power connections for a headset, a computer, and possibly existing tracking devices. Developers should also point out that cable management should be considered to avoid accidents in the treatment room.

3.2 High-End PC

Due to the high hardware requirements, wired XR headsets require a powerful computer. The minimum headset requirements are listed on the manufacturer's website, but a computer that exceeds the minimum requirements should be used.

3.3 XR-Specific Hygiene Products

Clinics can only provide a limited number of XR headsets, so XR-specific hygiene products should be considered when purchasing hardware. These include disposable masks that are placed between the users' face and the padding of the headsets to reduce skin contact with the glasses.

In addition, most headsets have foam face padding that absorbs perspiration and is difficult to clean. This should be replaced with a plastic, rubber, or leatherette padding.

4. Working With Recorded Data

4.1 Advanced Data Acquisition

In certain training scenarios and therapy fields, it can be helpful to collect additional data from the users in order to be able to evaluate them. For example, a measurement of blood pressure, skin resistance or heart rate can be measured. If this data is to be collected alongside with the use of an application, this must be considered early in the development of the application, because the devices for collecting this data may have to be purchased and implemented.

Alternatively, the XR application can be extended by microcomputers such as Arduino or Raspberry Pi to perform such measurements. The advantage, in this case, would be that the developers could develop their own hardware add-ons in coordination with medical experts which work specifically for the XR application.

4.2 Preparing Data From the XR application for Researchers

Unlike classic game applications, an important aspect of clinical applications is that certain data, such as patient reaction speed, movement patterns and sequences or the number of certain decisions or actions must be output very precisely in the virtual world. This is necessary to ensure that the data can be reused by physicians.

It is therefore important to output and prepare the data in such a way that it can be further processed in classic office programmes such as Excel. An interface to these formats should be planned at an early stage. During the planning phase, developers should agree with experts which data must be recorded in which format.

5. Development of the Application "ALCAVOID"

In the course of the Baltic Game Industry project, DE: HIVE has developed and implemented a therapeutic XR application in cooperation with Dr Simone Kühn from the University Medical Center Hamburg Eppendorf. The work was done in close cooperation between researchers and designers. The modified workflow will be described in the following.

5.1 Aim of the Application

The application serves to support classical behavioural therapy for people with alcohol addiction. Thereby, an avoidance behaviour should be learned and the ability to reject alcoholic beverages should be strengthened. Patients are presented with non-alcoholic and alcoholic beverages. These drinks must then be sorted. Non-alcoholic drinks have to be pulled towards the user, alcoholic drinks on the other hand should be pushed from the user away.

In addition to the number of correct and incorrect sorts, the reaction time of the patients is recorded, and it is also documented whether a decision is corrected at the last moment. This data is output in the form of a table. This table can be evaluated by doctors and therapists.

5.2 Technical Implementation

The basic structure of the application has already been developed and successfully tested by DE:HIVE as a tablet and desktop version.

For the XR application, two versions were created:

1. In version 1 the patients are in a white room with a square table. This allows for a focus on the action of sorting without using auditory or visual stimuli.
2. The second version is a 3D replica of a bar including the animated bar staff. In addition, this version includes a soundscape that is based on a real bar and feedback sounds during the sorting of the bottles.

Figure 1: Low Poly Botttles, DE:HIVE 2020

For the bottles themselves, several quality levels were also developed. Besides two-dimensional images, the bottles were first developed as abstract low-poly models. However, these were not recognis ed by patients without any doubt, which could lead to a falsification of the measurement results.

Therefore, high-poly models of the bottles were finally produced, which are clearly recognisable.

Figure 2: High-Poly bottles, DE:HIVE 2020

In addition to the shape of the bottles, the labels were also realistically represented by high-resolution scans.

For the creation of the bottles, the method of photogrammetry was used. A high-poly 3D model is generated with a multitude of photos of an object. This method accelerates the creation of models compared to classical modelling and allows a higher level of detail.

The bottle lables had to be translated into different languages which was another time consuming and complex task.

5.3 Lessons Learned

The workflow in the work with researchers differs from the classic game development in several points. Typical feedback systems such as sounds and visual effects have to be coordinated very closelfy and precisely with the experts to prevent falsification of the measurement results.

The recording of player performance is not done in the form of a classic high score. Rather, the performance of the players must be processed in a usable way so that experts can evaluate the data. Moreover, this data is not intended as feedback for patients and is therefore not made public.

A big problem with the use of XR headsets is insufficient data protection. Here, ALCAVOID also had to make sure that the computers in the clinics are used separately from a public network.

It is also important that the sessions can be individualised and can be clearly assigned to a patient number or an identification code. Therefore, it is important to create an input field for such an identification number.

In the implementation of such applications, it will be necessary to access “digital twins” in the future. This is a method that has been used in architecture and the furniture industry for quite some time. There is a digital counterpart to every real object from the respective product line. If this principle of digital twins is also used in other industries, applications of this kind will be easier and cheaper to produce in the future.

Future applications will drastically improve in visual quality due to the improvement of techniques for developing digital content aswell as the ever improving compuert and XR hardware.

The DE:HIVE of the HTW Berlin is looking forward for this developement.

THE PROJECT

The project 'Baltic Game Industry' (BGI) aims to foster the game industry in the Baltic Sea region - turning an ambitious game developer scene into a competitive and attractive business sector with sound innovation potential and thus making the region a game hotspot with worldwide competitiveness.

The partnership works together on framework condition improvements, on making business support services fit for the special needs of game start-ups and finally on new business opportunities for game developers in other industry sectors, such as health care. The core element is the installation of durable game incubators, programmes and schemes for game start-ups across the region.

BGI effectively combines policy and business development. Tailor-made game business support fosters a durable economic growth of this innovative industry in the whole region. The introduction of VR technologies in non-game industries contributes to boosting innovation beyond games. The common branding of the Baltic Sea region as game innovation hotspot will attract international clients, investors, creative entrepreneurs and qualified workforce.

Read more at www.baltic-games.eu

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