BGZ

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University of Applied Sciences

Assessment Report and Good Practice Catalogue on VR Applications

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bgi

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The assessment report documents possible and actual VR applications in the BSR, naming and describing the overall potentials and conditions of success that have been identified.

Editors

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Pictures

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1. Introduction

With the reappearance of Virtual Reality technology as a driving factor in creating digital worlds, the topic of immersive interactive worlds and their benefits has become increasingly important for many industries. While VR in its first consumer iteration in the 1990s was aimed at gamers, today's VR technology is widely considered to be an important asset for education, therapy, product presentation, and science.

Thereby going back to the initial idea of VR headsets being used to conduct specific experiments and training, much like the first VR Headset “Sword of Damocles” created in 1968 by scientist Ivan Sutherland, VR unfolds its full potential and a broad spectrum of use cases[1].

Parallel to VR, Augmented Reality technology is a growing medium, especially for non-gaming use cases. While VR provides a fully immersive, but encapsulated experience, Augmented Reality technology enriches the real world with digital content, without separating the user from it. Since both technologies influence each other, the term XR (Extended Reality) incorporates both, VR and AR, and therefore will be used throughout the report.

The main focus of this report is to provide an overview of the current state of Virtual- and Augmented Reality technology, to give information on current hardware and software and ultimately to display a wide spectrum of successful use cases of VR- and AR in the non-gaming sector, proving these technologies high potential.

[1] Sutherland, I. E. (1968). "A head-mounted three dimensional display". Proceedings of AFIPS 68, pp. 757-764.

2. Immersion, the Key Feature of VR/AR Technology

Per definition, immersion is the perception of being physically present in a non - physical world. In the context of VR/AR/XR applications, being able to create highly immersive worlds is the key advantage of this technology.

Programs and applications that are presented on a flat-screen offer a low level of immersion since the physical boundary of the monitor defines a clear separation between the digital content and the user.

In VR/AR/XR applications, the user is enveloped by the digital content which softens to the boundary of the digital- and the real world. The information that is presented in VR is therefore processed faster and the learning results can improve.

The increased immersion in VR/AR/XR Applications is remarkable because the users participate directly with their limbs and body, which is beneficial for practicing complex movement patterns as well as detailed hand interactions. Therefore, the amount of immersion created through the devices and apps is connected to the benefit of this technology[2].

[2] Adams, Ernest (July 9, 2004). "Postmodernism and the Three Types of Immersion". *Gamasutra*. Archived from the original on October 24, 2007. Retrieved 2007-12-26.

3. Overview of Current VR/AR/XR Technology

To understand the current devices, a general definition for the vocabulary of VR/AR/XR has to be established.

3.1 Virtual Reality Headsets

Virtual Reality headsets provide an experience where users are separated from the real-life environment. By using different methods to track the users' position in real-life, the position data will be delivered to the headset. Turning around or walking with a headset results in a similar movement in the digital world. While the enclosing nature of VR excludes most real-life stimuli, it provides a high degree of immersion.

A wide variety of companies provide the market with headsets for different purposes and budgets. The most noteworthy difference in VR technology is the separation between PC based headsets, which require a high-end Personal Computer and are connected via Cable, and wireless VR headsets, that are self-sufficient and don't require any cable connections, but provide less hardware power and are therefore not suitable for high-end visual content.

The most influential companies for high-end Headsets are HTC as well as Oculus/Facebook. HTC's Vive and Vive Pro provide a room wide tracking by using infrared sensor technology. The infrared sensors are attached to a wall or onto a tripod and cover an area of up to 10m x 10m. The sensors emit a signal that is processed by the headset to provide a highly accurate tracking inside the virtual environment.

Even the slightest movements are recognized, and the likelihood of losing the tracking signal is minimal. Thus, the HTC Vive is predestined for large scale VR environments. Similar headsets are the Valve Index, and the Pimax 8K, with the latter, even using the same infrared emitters as the HTC Vive[3].

Picture A: Oculus Rift S © 2019 Facebook Technologies

[3] https://www.vive.com/us/

The Oculus Rift S, on the other hand, uses inside-out tracking technology, which lets the headset track itself in the room, without requiring additional sensors or devices. The reduced amount of hardware required to run the headset makes it ideal to use in smaller spaces, for mobile presentations, especially with a laptop for a more agile use of VR applications. Microsoft's Mixed Reality Headsets use the same tracking technology and provide similar advantages[4].

All of the aforementioned devices require a PC to be used with but enables high-end visual applications to be run on those headsets.

In contrast, most mobile VR headsets do not require any other hardware than the device itself.

There are headsets like the google cardboard or Samsung Gear VR, that require a smartphone, but newer headsets are fully self-sufficient like the oculus go or oculus quest. The mobility results in technical limitations. The limited processing power of mobile headsets only allows applications with moderate graphics. The tracking methods of mobile headsets differ between individual devices. Older models like the Oculus Go or the Samsung Gear VR do not have room-scale tracking technology, which means that the user's physical movement will not be transferred into the virtual world. Only the movement of the head is transferred into the virtual world, which results in strong limitations for the size of the virtual world. Current mobile VR headsets like the Oculus Quest and the HTC Vive Focus use the same inside-out tracking as the aforementioned high-end VR devices so that the user's body movements are fully transferred to the virtual space.

Picture B: HTC Vive © 2019 HTC Corporation

Since mobile headsets do not require a high-end personal computer to operate, they are more economical and easier to use. By that, the hurdles for users are reduced, especially for those operating in the non-gaming sector and with a lesser affinity for technology.

[4] https://www.oculus.com/?locale=de_DE

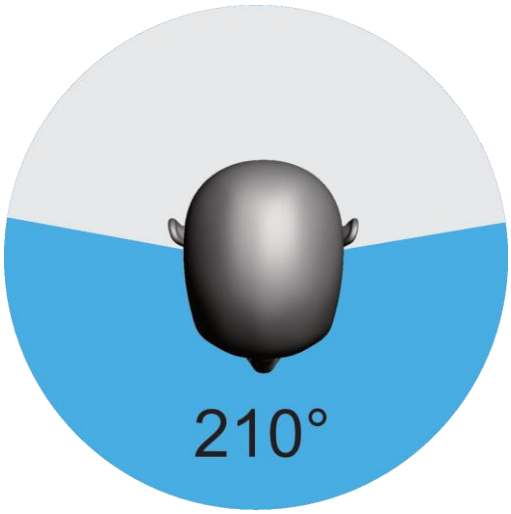
The overall controller tracking of current mobile devices is as precise as those of pc-dependent headsets, a usage for training, education or therapy applications is therefore possible. The lack of processing power only limits the visual quality of the applications.

3.1.1 Importance of the Field of View (FOV)

The field of view is a major factor in experiencing Virtual Reality environments.

With a range between 100 and 180 degrees, the FOV of current VR headsets cover between 50% and 70% of a human's native field of view, which is around 210 degrees wide.

A narrow field of view decreases the immersion that the users experience during VR sessions, so a wider FOV is considered an important advantage, especially when using VR for immersive learning and training. The decrease of immersion is not only caused by the limitation of the digital field of view, but also by the physical rim of the headset, that blocks the user's view on all sides[5].



Picture (C): Human Field of View © 2019 HTW Berlin

3.2 Augmented Reality Headsets/Devices

Contrary to the enclosing nature of VR, Augmented Reality devices create a digital overlay, expanding the user's perception with content and information, without separating them from reality.

The digital overlays will be presented as either flat images or can be applied to the geometry and structure of the surroundings, extending the real world's shape and form.

All AR headsets and devices are mobile, designed to incorporate the individual surroundings of each user.

The data of the surrounding's geometry is acquired through a camera in front of the AR device. The images are processed into a point cloud and a 3D map is created through stereo calculation. The

[5] https://vr-lens-lab.com/field-of-view-for-virtual-reality-headsets/

tracking can be further extended through the use of GPS data to place a specific digital model or information into a designated real-life location.

Since all AR devices are mobile, the full extent of technical restrictions of mobile VR headsets also applies to AR devices.

The hardware market is currently small, Microsoft HoloLens 2 and the Magic Leap one are devices with relatively high processing power, but are heavier than the Google Glasses Enterprise Edition that uses the same processor technology.

The most limiting factor of current AR technology is the small FOV (See 2.1.1). With a range of 40° to 45°, the FOV is significantly smaller in size compared to VR headsets. Covering only 20% of a human's FOV.

Combined with the effect that users are always aware of their real-life surroundings, AR applications offer a lower degree of immersion compared to VR applications.

However, AR technology should not be considered less potent tools for training and learning, however, they cover different needs, than VR headsets.

Picture(D): Microsoft Holo Lens © Microsoft Corporation 2019

A key factor for AR is that current smartphones may be used as AR devices. Therefore, AR technology is highly accessible, offering a flexible way to recall AR data, opening the market to a wider audience. Smartphones are more widespread and show a high operability, but have to be handheld, which is also a decreasing factor for the immersion. The viability for smartphones for AR training is thereby limited, but are a viable option to present AR-based data to a wide audience [6].

[6] https://uploadvr.com/hololens-2-field-of-view/

3.3 Mixed Reality Headsets

The term mixed reality can be considered inaccurate since different VR/AR companies use the term in different contexts Microsoft uses the term to refer to VR headsets. Mixed reality can also refer to the whole continuum of real reality augmented reality (AR) and virtual reality (VR). At the current state of technology, there are no headsets that combine VR and AR technology, therefore XR is not a term that refers to a combination of VR and AR, but acts as a preamble for both technologies.

3.4 Conclusion

Both VR and AR share many characteristics but also offer different advantages, resulting in different application types. Virtual Reality training is especially suited for all kinds oftraining and therapy situations where it is necessary thatparticipants are fully focused on the subject and are especially useful to create a uniform digital environment, even if participants are situated in different locations. It is useful to put participants is a normalized environment or situation. AR is especially useful if participants are required to recall additional information on real-life objects that they are going to interact with. However, it results in less comparable and more individual experiences, by not excluding the real-life environment from the overall experience.

4. Non-Gaming Use Cases of VR/AR

VR/AR devices and applications are used in a wide array of non-gaming fields. In this report, I will enclose those fields into three categories: Education, Skill Training and Therapy.

Education envelopes applications that provide information in vivid images and interactively provides them.

Training focuses on applications that train professional skills in work environments, especially in situations where training on the real reality subject is not always possible.

Therapy is dedicated to applications that promote a behavior that is beneficial for users to recover from physical and/or psychological diseases or limitations and to supplement traditional therapy and medication.

4.1 Meaning and Importance of Gamification

VR/AR technology in the above context leads to another key factor of software-based education, training, and therapy: the term „gamification“, a widespread principle in most VR/AR use cases.

Gamification is the use of core principles of games in a non-gaming context.

The most common principle of gamification is to give the users a feeling of gratification for using the software. Highscores and rankings provide transparent feedback to a person's progress in using the application and adapting the knowledge or skill that the application is aiming to provide. This heightens the user's motivation to execute recurring training sessions which leads to a significant increase in positive learning results.

The motivation of the user to improve the individual results is the main factor of why learning, training, and therapy benefit from game-related principles. Especially being in playful competition with others triggers an urge to pursue a certain goal or skill level. By taking the process that is trained out of a working context, users can establish a different neural connection to certain tasks, associating them with fun and excitement instead of pure necessity or a certain degree of stress[7].

[7] Sangkyun Kim, Kibong Song, Barbara Lockee, John Burton (2017) „What is Gamification in Learning and Education?“

4.2 Educational Use Cases

The broad field of education can benefit from the use of VR/AR technology because of its key feature, immersion.

VR makes information interactable and tangible which results in a highly motivating learning experience. Virtual- and augmented Reality also has the potential to visualize complex processes, context and connections and present virtual environments that exceed the physical boundaries of a lecture hall or classroom.

Combining the beneficial effects of immersion and gamification unfolds new possibilities in education and learning.

4.2.1 Example I: Nanome (Nanome Inc. 2019)

Picture(E): Nanome © Nanome Inc. 2019

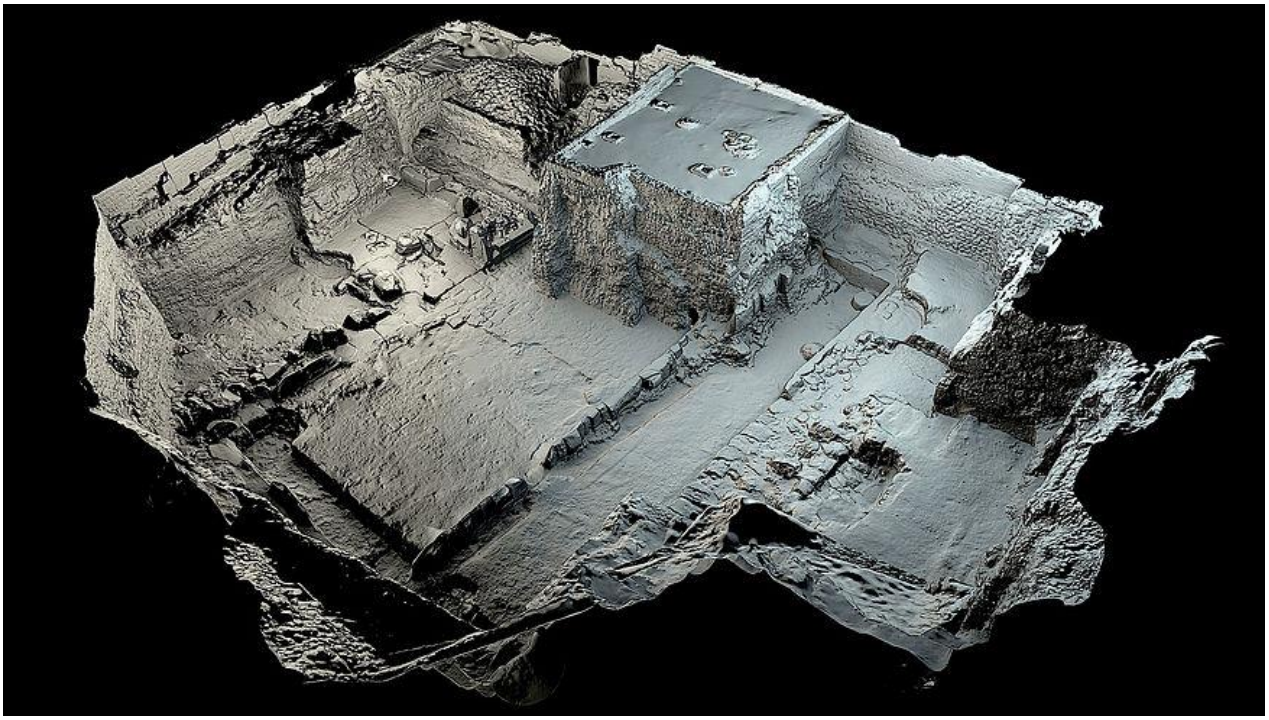
Nanome is an application to visualise nanolevel molecules and proteins in virtual reality.

Increasing the size of nanolevel objects and making them viewable and interactable surmounts the physical boundaries of real-life environments, allowing users to experience chemical and biological processes with a high degree of participation and involvement.

A major factor of this application is the opportunity to visualize and present chemical and biological processes to increase the comprehensibility by immersing users into a nanoscale virtual reality.

Nanomes target groups are highschool- and university students as well as researchers and tutors who can experience and explicate molecular compounds in VR[8].

4.2.2 Example II: Temple of the Weather God (HTW Berlin/DE:Hive)



Picture(F): Temple of the Weather God 3D Scan © 2019 DE:HIVE, HTW Berlin

Preserving cultural heritage sites and conserving knowledge and data for coming generations is the main goal of Prof. Dr. Karl Kohlmeyer who is a professor for excavation technology at the university of applied science Berlin (HTW- Berlin).

In collaboration with the DE:HIVE institute for games under the lead of Prof. Thomas Bremer, a team of archaeologists used high precision laser scanning technologies to fabricate a faithful recreation of the temple oft he weather god in Aleppo (Syria).

Preserving cultural sites that are situated in countries with ongoing conflicts makes these sites experienceable first hand for a broad audience and allows archaeologists to research these sites, especially if the architecture becomes damaged or destroyed due to the above-mentioned conflicts.

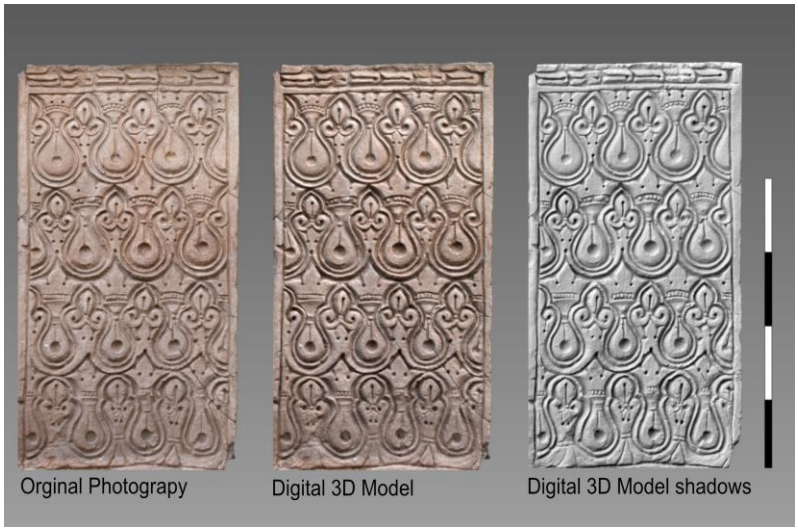
Since users can rescale the excavation site and to move freely through the architecture, it is possible to exceed physical boundaries and to conduct detailed research on the site.

[8] https://nanome.ai/

Picture(G): Temple of the Weather God – interaction in VR © DE:HIVE , HTW Berlin

The project is available in Virtual Reality as well as Augmented Reality and both apps are based on the same set of data[9].

Within the cultural heritage project, the HTW and the DE:HIVE institute created several other applications including the Samarra-discoverys of the Museum of Islamic Art Berlin.



Picture (H): Samarrah discoverys – 3D Model © 2019 DE:HIVE , HTW Berlin

[9] https://gamedesign.htw-berlin.de/forschung/virtual-archaeology/

4.3 Training Use Cases

The impact of VR/AR on professional training is comparable to that of VR/AR in the educational sector.

The core principles of immersion and gamification lead to training apps that help users to internalise complex processes and to practice situations that would otherwise be too expensive and/or dangerous or would require too specific circumstances to be experienced for an infinite number of times.

4.3.1 Example I: T.R.A.C.Y (HTW Berlin, DE:Hive Institute)

Picture (I): T.R.A.C.Y – Room © 2019 DE:HIVE , HTW Berlin

The VR training application T.R.A.C.Y is designed to train hospital staff in the use of a handheld fire extinguisher in case of a fire. A feature of this application is, that a virtual reality tracking device is attached to a real fire extinguisher so that users experience the actual weight and handling of a real-life fire extinguisher while fighting a virtual fire in a virtual environment.

With fires constantly breaking out and behaving like real fire by spreading through the room, users are continuously challenged to extinguish the fire by using the extinguisher in the intended way.

Since it is relatively expensive to empty a real-life fire extinguisher and to have it refilled, T.R.A.C.Y gives users the chance to repeatedly train a process that would otherwise be too expensive and time-consuming and would, therefore, be limited to a small number of possible repetitions.

The core principle of T.R.A.C.Y shows the potential of Virtual Training, providing immersive practicing sessions without endangering the users and without wasting resources, yet providing a realistic feeling oft he situation and the circumstances of a situation where the correct handling of a fire extinguisher is required[10].

Picture (J) T.R.A.C.Y – VR Interaction © 2019 DE:HIVE, HTW Berlin

4.3.2 Example II: Bosch Service Training (Bosch)

Bosch provides an augmented reality app to complement training sessions of mechatronics engineers. In a two-day workshop, participants can acquire the ability and authorisation to work on high voltage systems of different types of motors.

The AR application visualises differences in function and form of different types of motors, gives an insight into the high voltage components of those motors and provides strategies for troubleshooting, repairing and maintenance.

The information that is presented to the users is curated by a supervisor who controls the flow of information and who provides the digital content context-sensitive to the progress of the participants.[11]

[10] https://gamedesign.htw-berlin.de/forschung/tracyvr/
[11] http://www.bosch-training-solutions.com/de/

Picture (K): Bosch AR Training © 2019 Robert Bosch GmbH

4.4 Therapy Use Cases

Adapting new behaviors and strategies is an important factor in therapy and rehab.

The advantages of XR also apply for learning and adapting new behaviours and strategies or to unlearn detrimental behaviour.

Immersive applications help the users to focus on the task at hand and substantiate other treatment methods. XR Applications are already in use to treat different types of substance abuse, phobia or anxiety.

4.4.1 Example I: Acrophobia Treatment

Virtual Reality offers a way to train behavior in otherwise dangerous situations.

Treating fear of heights is a good example of the advantage of VR in confronting users with a certain, possibly dangerous situation.

Curing Acrophobia by leading users onto a digital roof instead of an actual one is also less timeconsuming and much more comfortable to recreate.

Because of the high degree of immersion, a user will face a similar amount of sensation and emotion when being faced with a specific phobia in VR, as if it was a real-life situation.

Since digital applications are highly customisable, researchers and therapists can adjust different parameters of such an application to individualize them towards the needs of each patient, without having to change the actual location of where the therapy session is conducted[12].

Picture(L): Richie's Plank Experience © 2017 ToastVR

[12] Tara Donker; Ilja Cornelisz; Chris van Klaveren; et alAnnemieke van Straten; Per Carlbring; Pim Cuijpers; Jean-Louis van Gelder: „Effectiveness of Self-guided App-Based Virtual Reality Cognitive Behavior Therapy for Acrophobia: A Randomized Clinical Trial", *JAMA Psychiatry*. 2019;76(7):682-690. doi:10.1001/jamapsychiatry.2019.0219.

4.4.2 Example II: Arachnophobia Treatment

Picture (M): Arachnophobia VR © 2016 IgnisVR

A classic method of behavior therapy to treat anxiety disorders like phobias is the so-called exposure therapy. In this method, a person who suffers from a phobia, for example, a fear of spiders (arachnophobia) experiences different levels of exposure to a Spider, developing habituation towards the animal.

Again, the different levels of exposure are easy to achieve for researchers and therapists by using an editable application framework.

Results have shown that the classic exposure therapy that uses a real animal can be accompanied with XR applications that also present the same animal to users and give positive results by decreasing the persons fear and anxiety when being confronted with certain creatures.

There are several applications focussing on arachnophobia treatment.

In VR one example is „Arachnophobia “, an application where users are in room with spiders on different levels of intensity, reaching from pictures of a spider, to spiders in a glass and ultimately spiders all around the user.

The above image shows an App oft he Virtual Reality Medical Center San Diego that is used to assist in the clinics therapy program for arachnophobia[13].

[13] https://vrphobia.com/clinical/fear-of-spiders/

5. Conclusion and Future of XR in the Non-Gaming Sector

Considering the many successful use cases of XR applications in the non gaming sector, XR is a promising medium to accompany training, therapy and education.

There are still boundaries tot he devices, Virtual Reality devices being limited to certain room conditions and places, especially those devices that requiere a high-end personal computer to be operated.

Virtual Realitys greatest advantage, the high amount of immersion can be considered the main factor of why non-gaming applications are well perceived and show positive results when used for education, training and therapy.

In the future, the technological limits of Augmented- and Virtual Reality will decrease, since most problems are caused by a limitation in processing power and the field of view, which is both negated by the ongoing technical advancement of computerprocessors and computer displays.

Content creators are requiered to understand the advantages and disadvantages of the given platforms for virtual content and have to decide which device is most beneficial fort he individual use case.

6. Picture Index

- A: Oculus Rift S, © 2019 Facebook Technologies Ireland, 4 Grand Canal Square, Dublin 2, Ireland, Oculus Press Kit (https://en.oculusbrand.com/assets/logos).
- B: HTC Vive © 2019 HTC Corporation, HTC Corporation, No. 23 Xinghua Road, Taoyuan Dist., Taoyuan City 330, Taiwan, (R.O.C) (https://www.vive.com/de/pr/newsroom-gallery/htcvive/).
- C: Human Field of View © 2019 HTW Berlin, 2019, Wilhelminenhofstraße 75A, 12459 Berlin.
- D: Microsoft Holo Lens © 2019 Microsoft Corporation, One Microsoft Way, Redmond, WA 98052-6399 USA (https://news.microsoft.com/presskits/windows-mixed-reality/).
- E: Nanome © 2019 Nanome Inc, San Diego California (Official Press Kit: https://nanome.ai/about/).
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- J: T.R.A.C.Y – VR Interaction © 2019 DE:HIVE HTW Berlin, Wilhelminenhofstraße 75A, 12459 Berlin.
- K: Bosch AR Training © 2019 Robert Bosch GmbH, Dr. Michael Schmidtke, Robert-Bosch-Platz 1, 70839 Gerlingen-Schillerhöhe (Bosch Press Kit: https://www.bosch-presse.de/pressportal/de/en/cart.html).
- L: Richie's Plank Experience © 2017 ToastVR, Fortitude Valley, Queensland (https://toast.gg/press/).
- M: Arachnophobia VR © 2016 IgnisVR (http://www.hypersomegames.comportfolio/arachnophobia-virtual-exposure-therapy).

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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