

We aRe happy

**Virtual Reality – Yesterday, Today, Tomorrow, ~~Toyota~~**

David Kuťák, 27<sup>th</sup> of March 2024

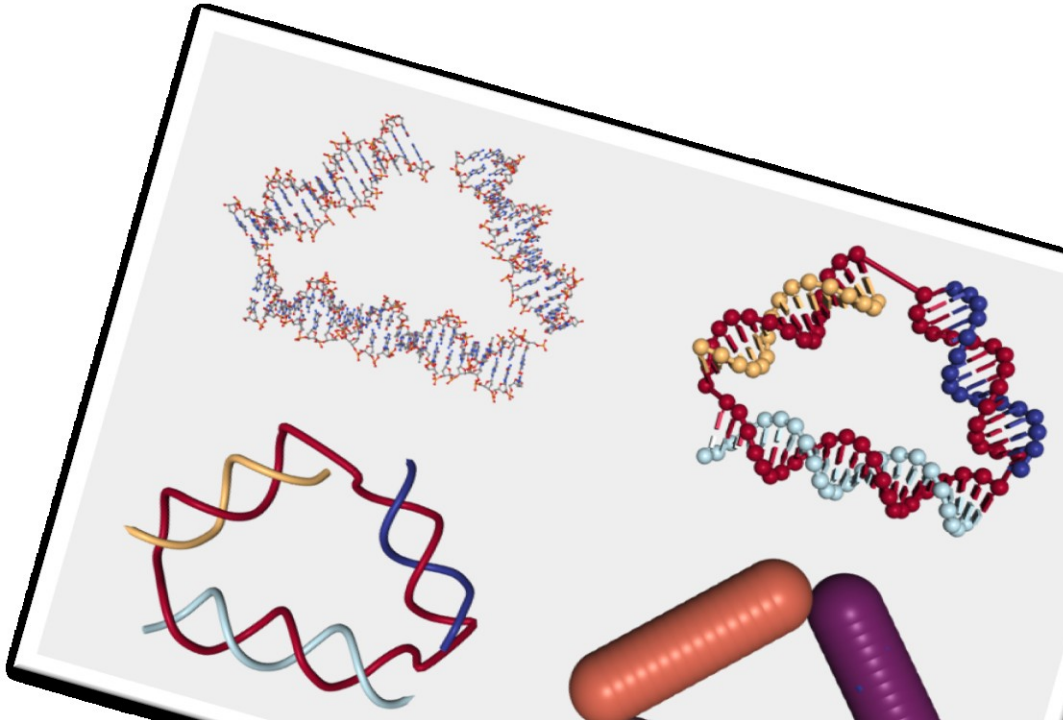
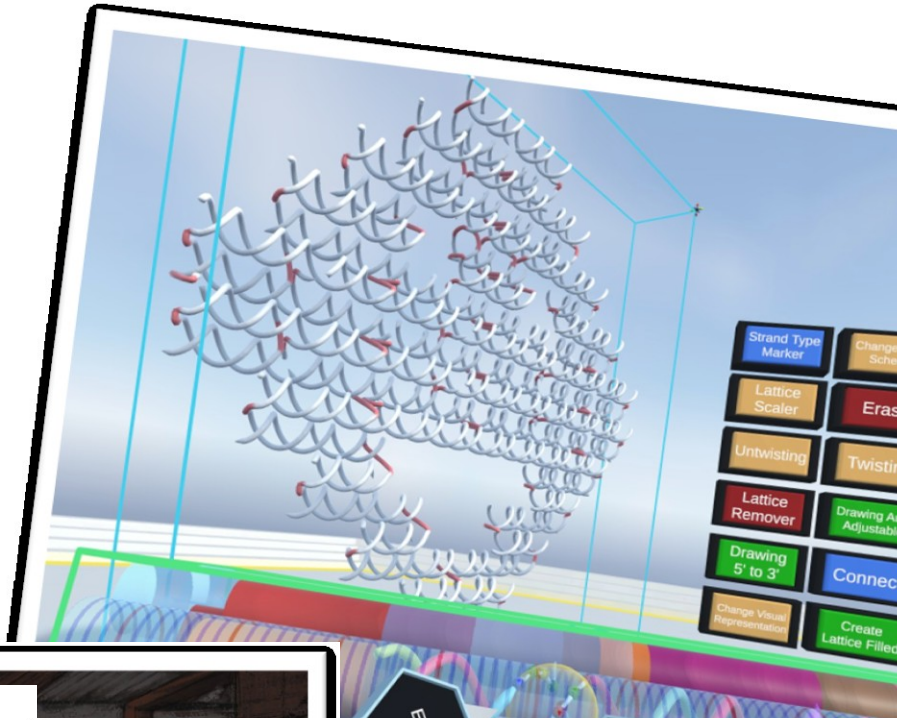
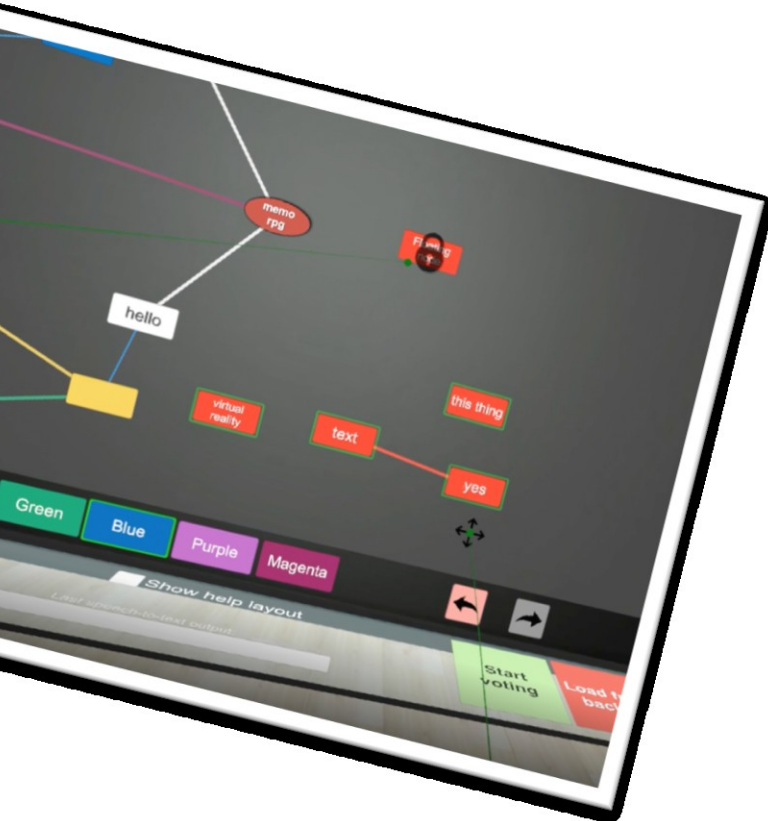


# Speaker Introduction

- PhD-in-progress-soon-to-be-finished
  - Here at FI MUNI
  - Virtual reality & molecular visualization
  - Especially DNA nanotechnology :)
- Three main areas of interest
  - Virtual reality
  - Molecular visualization & modeling
  - Games (development)



S



# Fun fact

- Two headsets owned now
  - PlayStation VR2
  - Meta Quest 3
- (1) One for games
- (2) Other for (game) development
- Point (2) did not yet happen :D



# Outline

Topic  
Introduction

History of  
VR

VR  
nowadays

VR in the  
future



*Images generated with [crayon.com](https://www.crayon.com)*

# Q&A

Raise your hand if you have experience with VR

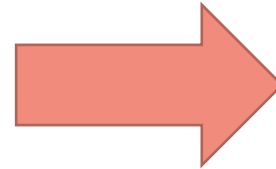
Feel free to share what you think about it





# Why to talk about VR?

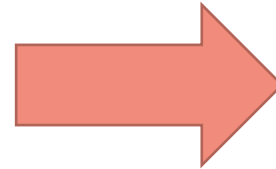
- It can help you or other people...





# Why to talk about VR?

- ... or it may not, as it is no magical formula.



# Why to talk about VR?

VR is a technology and we **believe** that **this technology** may **benefit us**.

*If this is not true, why to even bother?*





## What is a Virtual Reality?

# What is a Virtual Reality?

“Virtual reality is a **simulated experience** that employs pose tracking and 3D near-eye displays to give the user an **immersive feel** of a virtual world.” (Wikipedia)

“images and sounds **created by a computer** that **seem almost real to the user**, who can **interact** with them by using sensors” (Oxford Learner’s Dictionary)

“a **computer-generated** digital environment that can be experienced and **interacted** with as if that environment were **real**.” (The VR Book by Jerald)

“an **artificial** environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's **actions partially determine what happens** in the environment” (Merriam-Webster)

“vr is shit” (Pessoa Invisível, user of Facebook)

# What is a **Virtual Reality**?

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Digital experience **feeling like reality** both audiovisually and interaction-wise

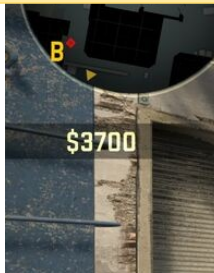
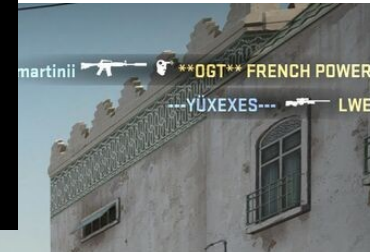
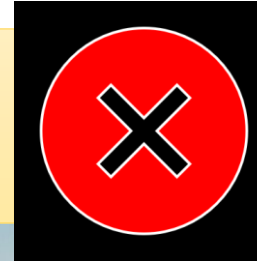
# What is **not** a Virtual Reality?



University lecture

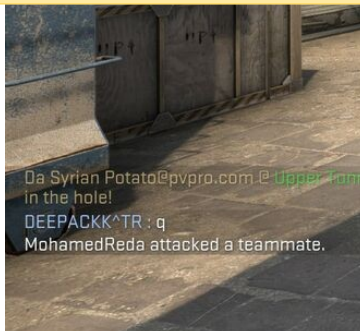
# What is **not** a Virtual Reality?

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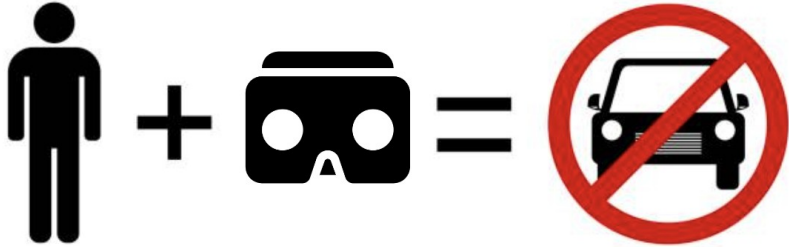


Counter Strike on a desktop PC. Or could it be?

# What is **not** a Virtual Reality?



This is dangerous.





# What is **not** a Virtual Reality?

- There are also other „realities“
- The definitions may differ
- **Augmented reality**
  - Augments digital data on top of real world data
- **Mixed reality**
  - Blends physical and digital worlds
  - Sometimes just used to refer to „both VR and AR“

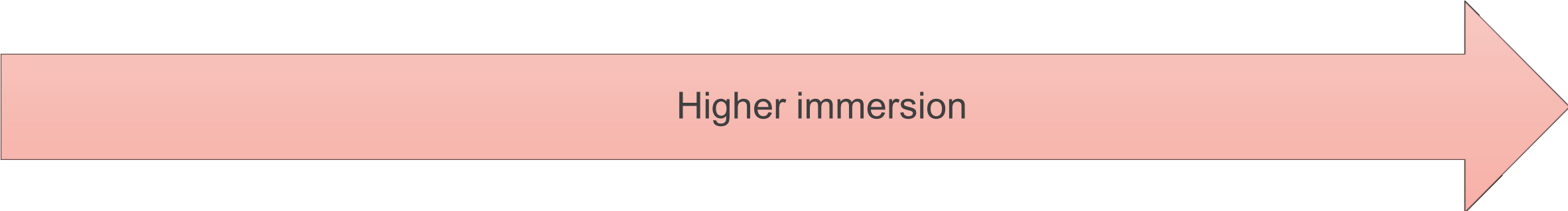


In this talk, we focus solely on **virtual reality**.

# Immersion x Presence

- Two common „VR terms“
  - Wikipedia definition of VR: „(...) **immersive feel** of a virtual world“
- Immersion
  - Technical aspect
  - The extent to which **the technology** makes you feel surrounded by the virtual world
  - Aids to achieve the „presence“
- Presence
  - Subjective aspect
  - The feeling of „being there“ at the given moment

# Immersion x Presence



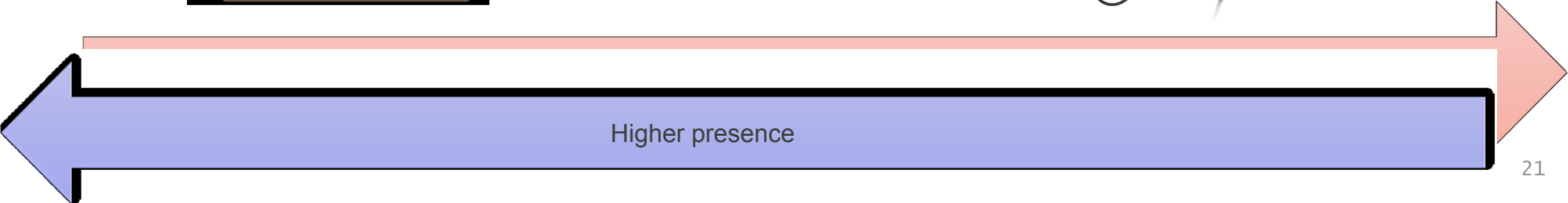
# Immersion x Presence



Higher immersion and also presence

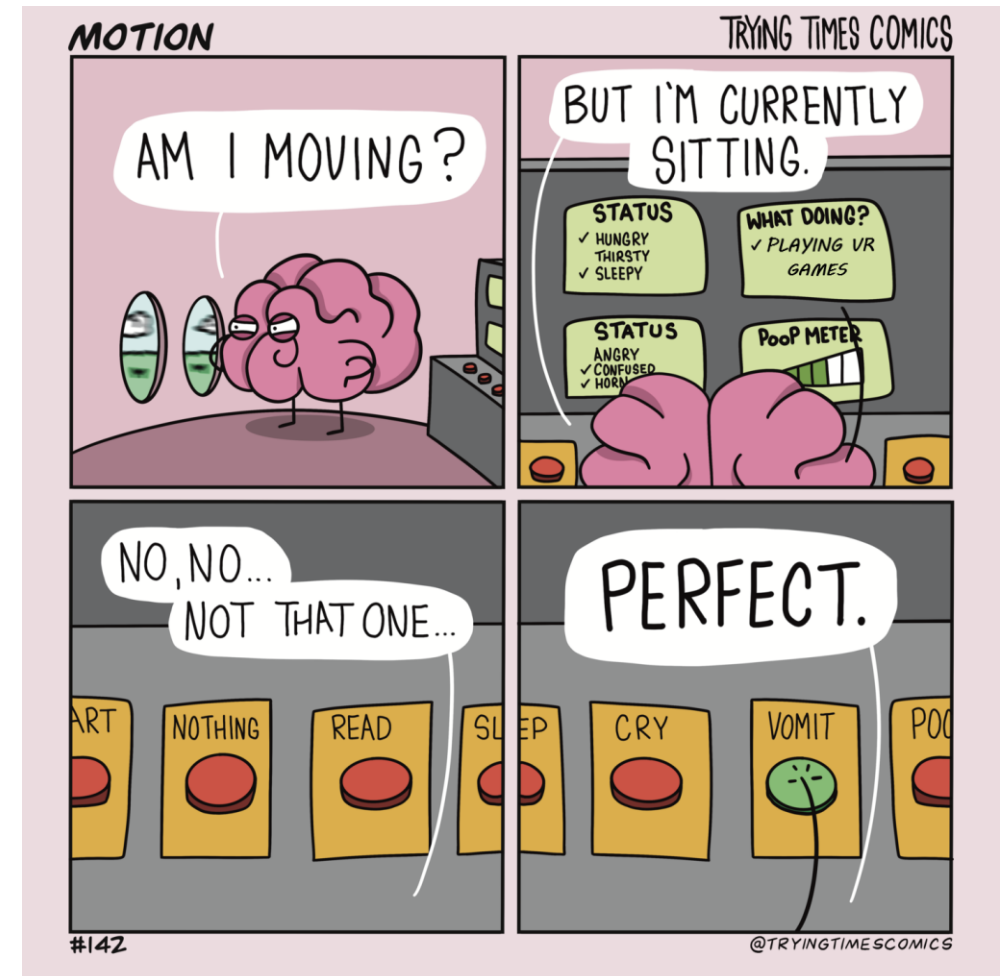
# Immersion x Presence

But what if...

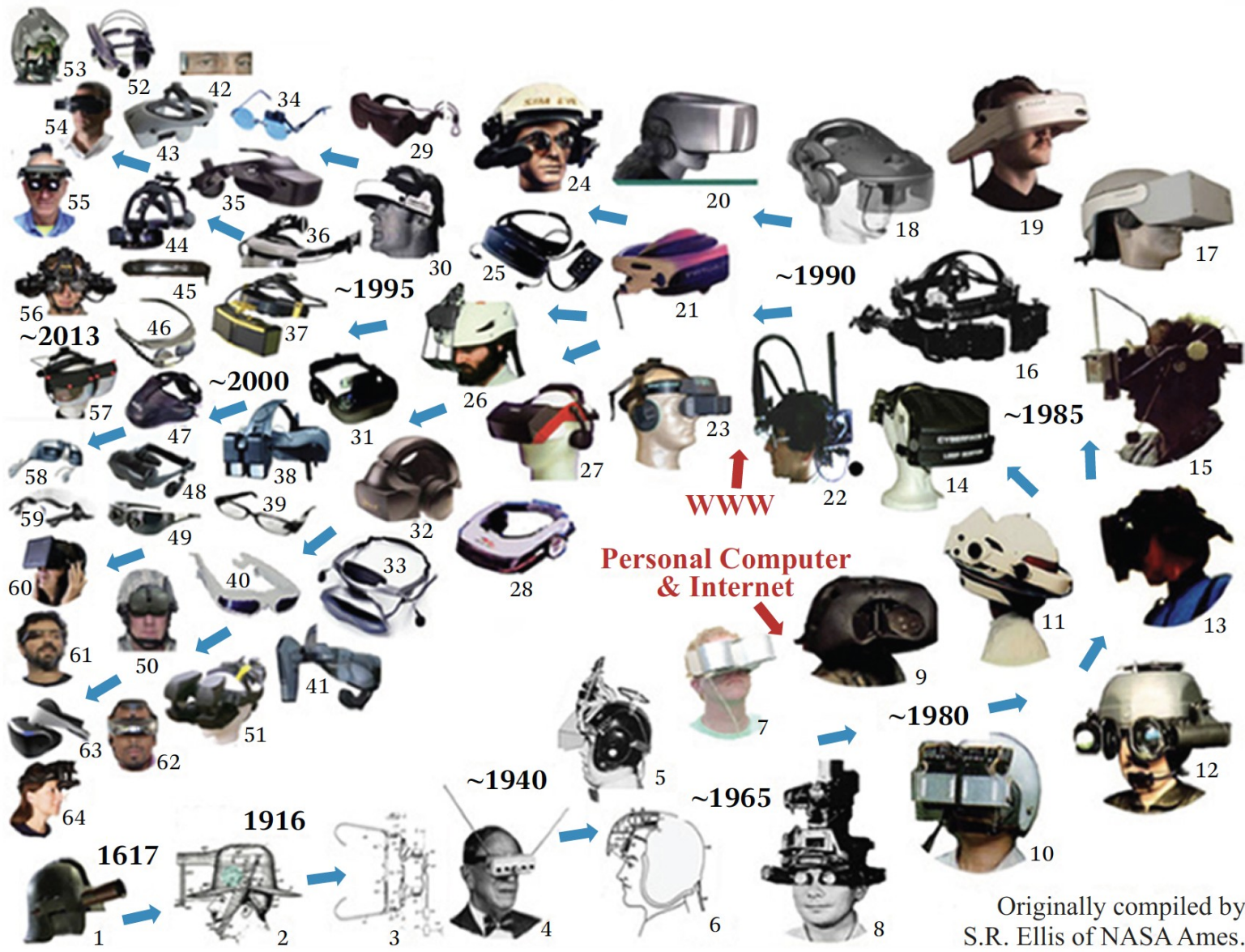


# Motion sickness

- You may feel sick or dizzy (or even vomit)
- Occurs when there is a conflict between senses
  - Eyes: “I am moving”
  - Body/inner ear: “I am sitting”
  - → problem
- You may experience when using VR
  - Depends on each individual,
  - and the application.



# Virtual Reality – Hardware through time



Head-mounted displays throughout the history

Originally compiled by S.R. Ellis of NASA Ames.

# Virtual Reality – Sword of Damocles

- 1968
- Attached to the ceiling
  - Head-tracking
  - Weight





# Virtual Reality – VIEW by NASA

- 1980s
- Stereoscopic display
  - Proper „HMD“
- Interaction gloves
- 3D sound
- Voice recognition



# Virtual Reality – Sega & Nintendo

- 1990s
- “Failures”
  - Sega → prototype
  - Nintendo → bad sales



# Virtual Reality – Nintendo Virtual Boy Commercial

1995 at its best :)

- I recommend to watch at home 😊



# Nintendo continued

- 2019
- Another „shot“ at VR with Nintendo Switch
- VR is part of „Labo“ cardboard kit
  - Very cheap, 3DOF
- Accepted more positively than Virtual Boy...
  - ... but no „major breakthrough“



# Virtual Reality – CAVE



# Virtual Reality – CAVE

Cave Automatic Virtual Environment

- 1990s
- Projections on walls
- Stereoscopic glasses
- Used to be popular
  - → natural collaboration
  - → being replaced by HMDs



# Virtual Reality Today

(for most people, as well as this lecture)

- VR „exploded“ in 2014 when Facebook (Meta) bought Oculus

Really  
exploded?



# Virtual Reality Today – Market

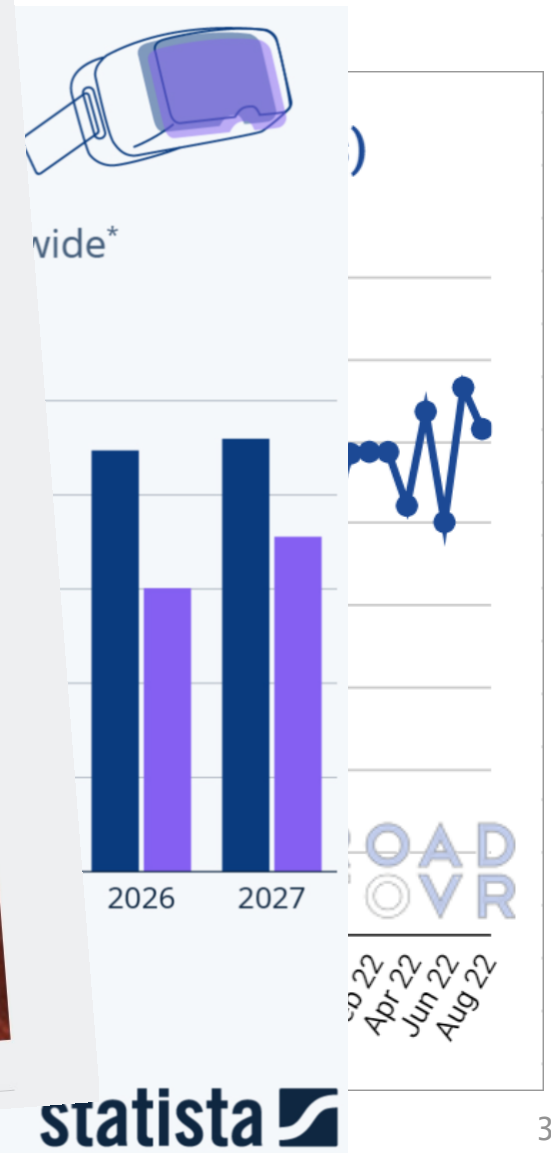
- Various data sources show that the number of actual users is questionable
- Right plot: estimated active users on Steam

**ars TECHNICA** BIZ & IT TECH SCIENCE POLICY CARS GAMING & CULTURE STORE FOR

*TOO MANY TOO LATE? —*  
**Report: Sony stops producing PSVR2 amid “surplus” of unsold units**  
Pricy tethered headset falters after the modest success of original PSVR.  
KYLE ORLAND - 3/18/2024, 8:37 PM



Enlarge / PSVR2 (left) next to the original PSVR.





# Virtua

 <p><b>DPVR P1</b>            1280x1440            Unknown            \$199            Oct. 2018</p>	 <p><b>Samsung Odyssey+</b>            1440x1600            101°            \$499            Oct. 2018</p>	 <p><b>Pimax 5K XR</b>            2560x1440            150°            \$1,449            Nov. 2018</p>	 <p><b>Helmet Vision</b>            3840x1200            120°            \$349            Jan. 2019</p>	 <p><b>Pimax Vision 8K+</b>            3840x2160            150°            \$1,449            Feb. 2019</p>	 <p><b>Varjo VR-1</b>            1440x1600            87°            \$6,000            Feb. 2019</p>
 <p><b>HP Reverb</b>            2160x2160            96°            \$599            April 2019</p>	 <p><b>HTC Vive Focus</b>            1440x1600            110°            \$599            April 2019</p>	 <p><b>Valve Index</b>            1440x1600            107°            \$999            April 2019</p>	 <p><b>3Glasses X1</b>            1200x1200            105°            \$550            May 2019</p>	 <p><b>Oculus Quest</b>            1440x1600            94°            \$399            May 2019</p>	 <p><b>Oculus Rift S</b>            1280x1440            88°            \$399            May 2019</p>
 <p><b>Pico G2 4K</b>            1920x2160            92°            \$399            May 2019</p>	 <p><b>HTC Vive Pro Eye</b>            1440x1600            98°            \$1,599            June 2019</p>	 <p><b>DPVR E3 4K</b>            1920x2160            110°            \$399            Aug. 2019</p>	 <p><b>Acer OJO 500</b>            1440x1440            95°            \$399            Oct. 2019</p>	 <p><b>HTC Vive Cosmos</b>            1440x1700            97°            \$699            Oct. 2019</p>	 <p><b>Varjo VR-2</b>            1440x1600            87°            \$4,995            Oct. 2019</p>

# Virtual Reality Today – Components

Audiovisuals

Interactions

Position  
tracking

Computations

# Virtual Reality Today – Components

Audiovisuals

Interactions

Position tracking

Computations

Display(s) – count, type, resolution, refresh rate



Lenses



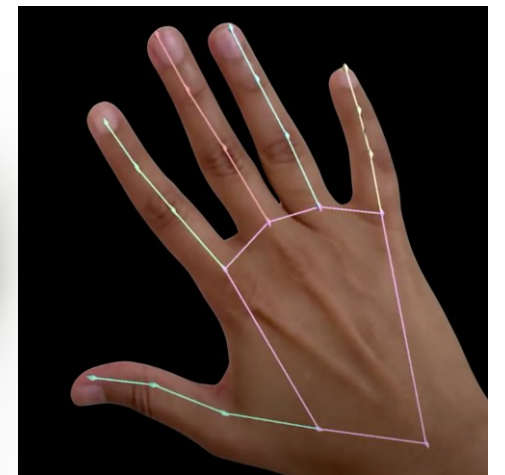
# Virtual Reality Today – Components

Audiovisuals

Interactions

Worth remembering: if you develop a VR application for users with different HMDs, you need to take into account their different interaction possibilities.

## Types of controll(er)s



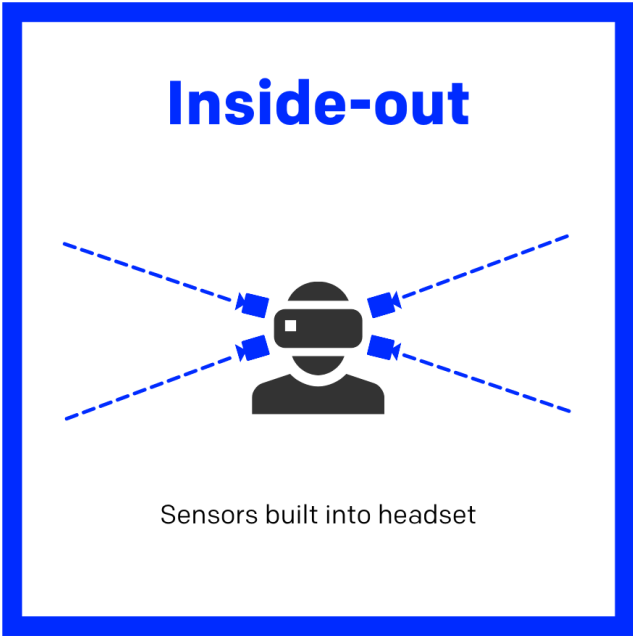
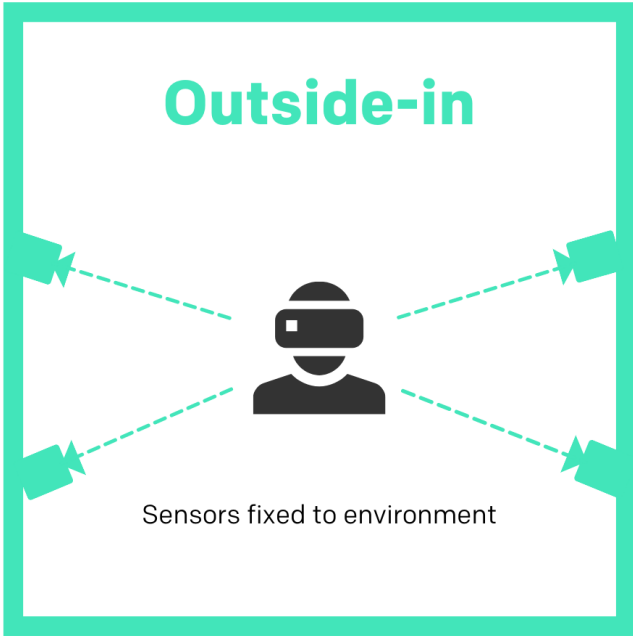
# Virtual Reality Today – Components

Audiovisuals

Interactions

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# Virtual Reality Today – Components

Audiovisuals

Interactions

Position tracking

Computations



3DoF



6DoF

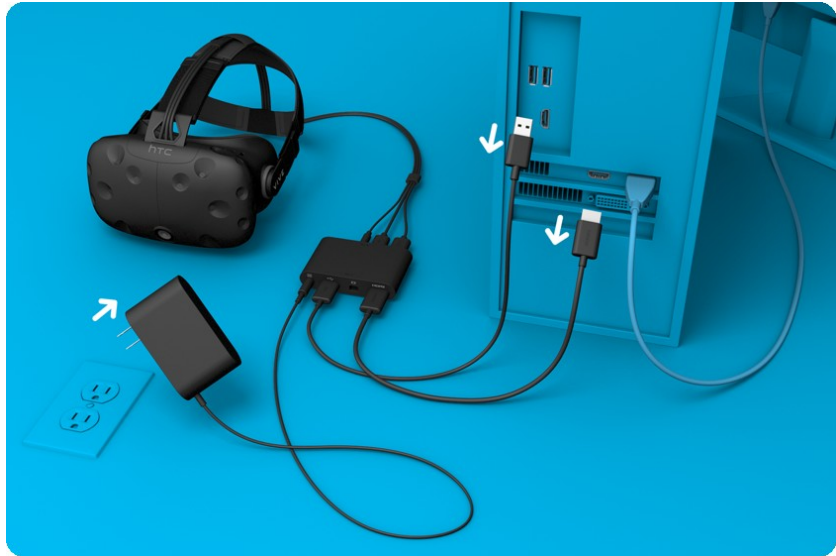
# Virtual Reality Today – Components

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# Outline

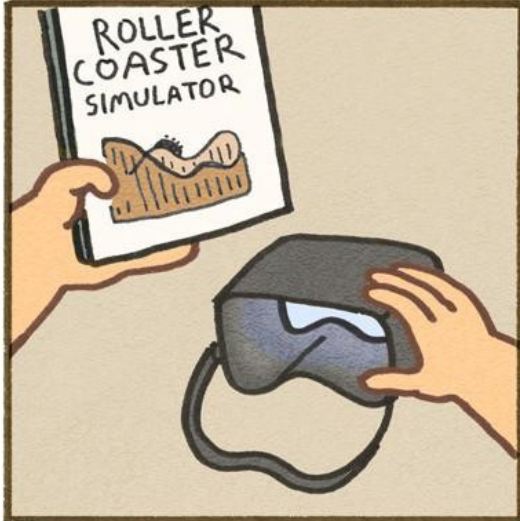


*Images generated with [crayon.com](https://www.crayon.com)*



# Joke Time

VIRTUAL REALITY



@SKELETON\_CLAW

SKELETONCLAW.COM

**VR ... what is it even good for?**

# VR in automotive industry

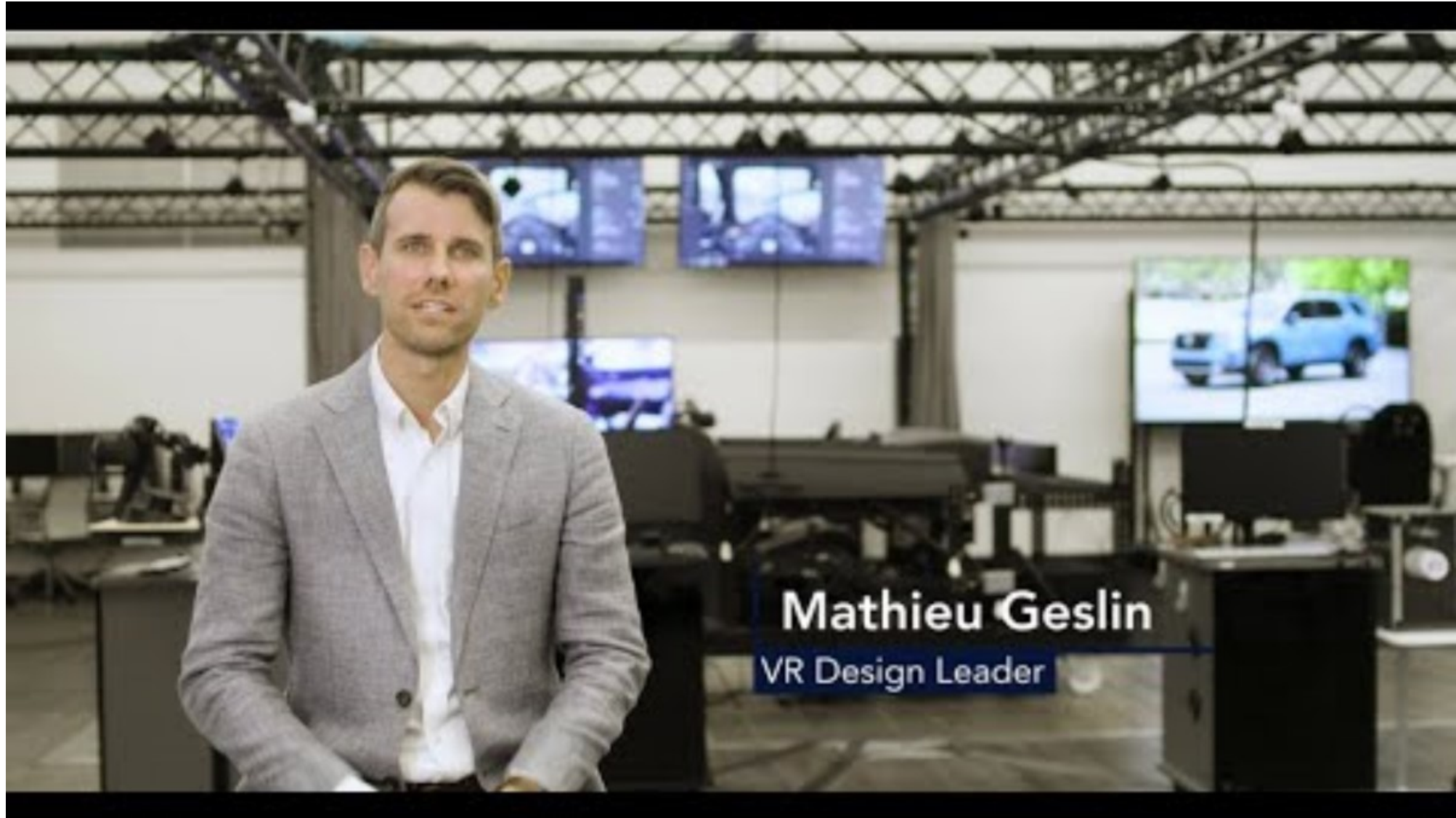
BMW use case

- VR since 1990s
- HTC Vive since 2015
- Combined with physical model of car's interior
- Faster iterations than with real cars
- Easy to simulate real driving experience



# VR in automotive industry

Honda



# Virtual Reality Exposure Therapy (VRET)

- Treatment of mental health issues
  - Phobias
  - Posttraumatic stress disorder (PTSD)
  - Social anxiety
  - Brain injuries
  - Etc.
- Landstuhl Regional Medical Center
  - VRET treatment of soldiers with PTSD
  - „(...) extremely effective treatment because it is a patient's personalized reality that they learn to process, control and regulate.“



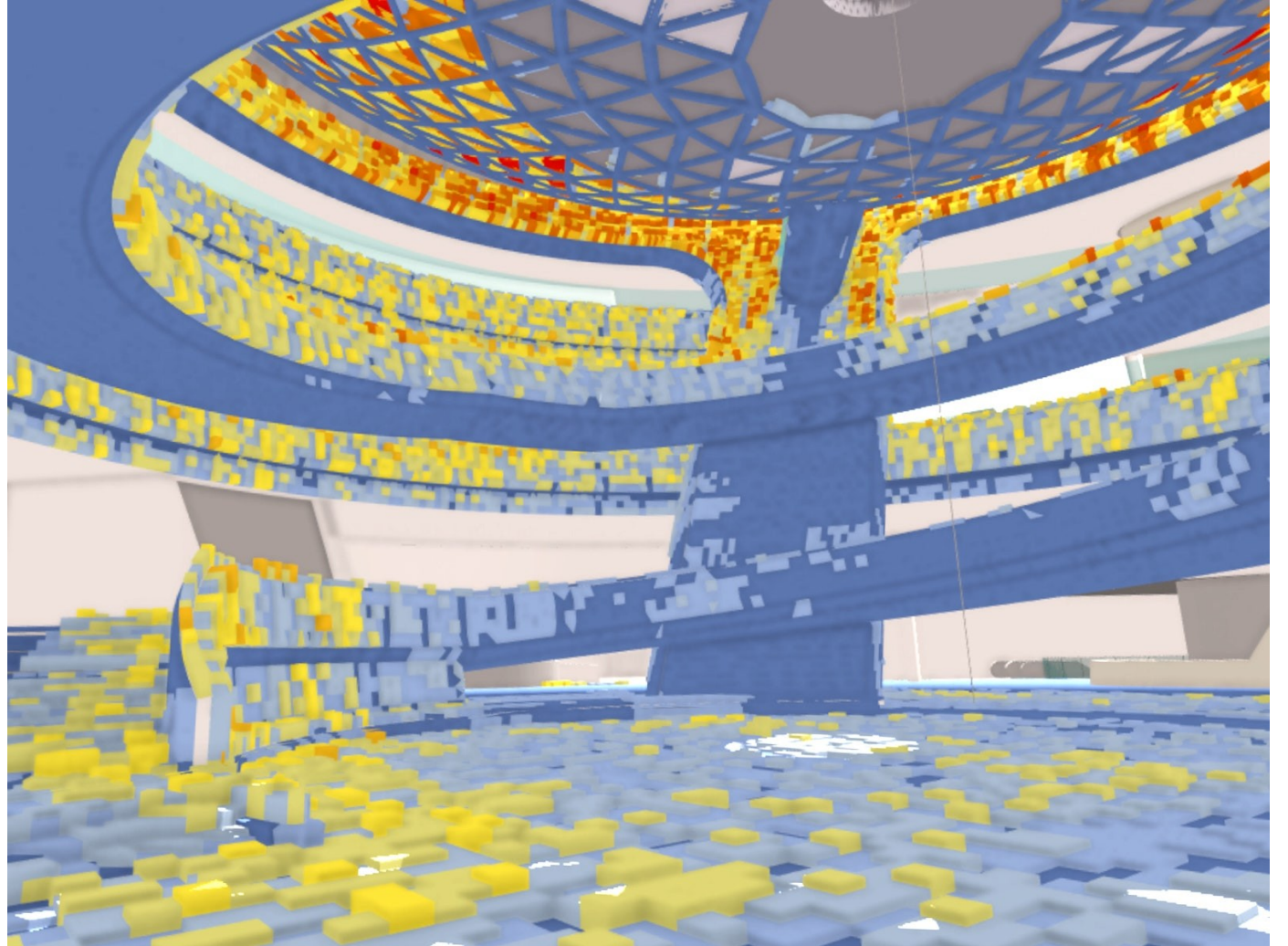
# Virtual Reality Exposure Therapy (VRET)

Targeting arachnophobia



# VR in architecture

- VR is popular in this area for visualization of buildings and their designs
- Ennead Architects company
  - Shanghai Planetarium visualization
  - Not just space itself but also most-lit locations



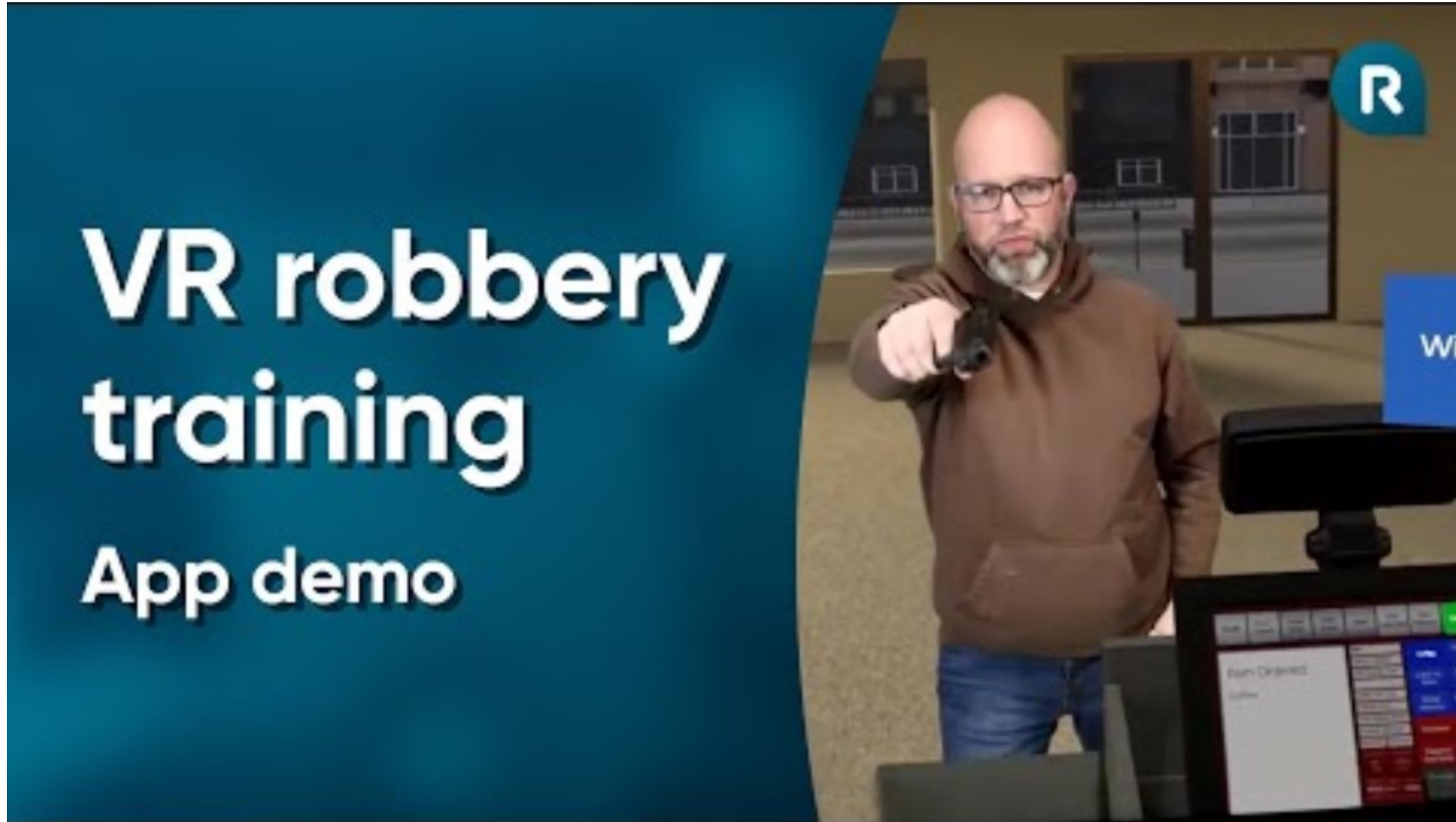
# VR in training

- Used by multiple companies to train their employees
- Bank of America
  - VR training for 50,000 employees
  - Five different VR simulations
    - Relationships with clients
    - Navigating difficult conversations
    - Responding with empathy





# VR in training



# VR in training

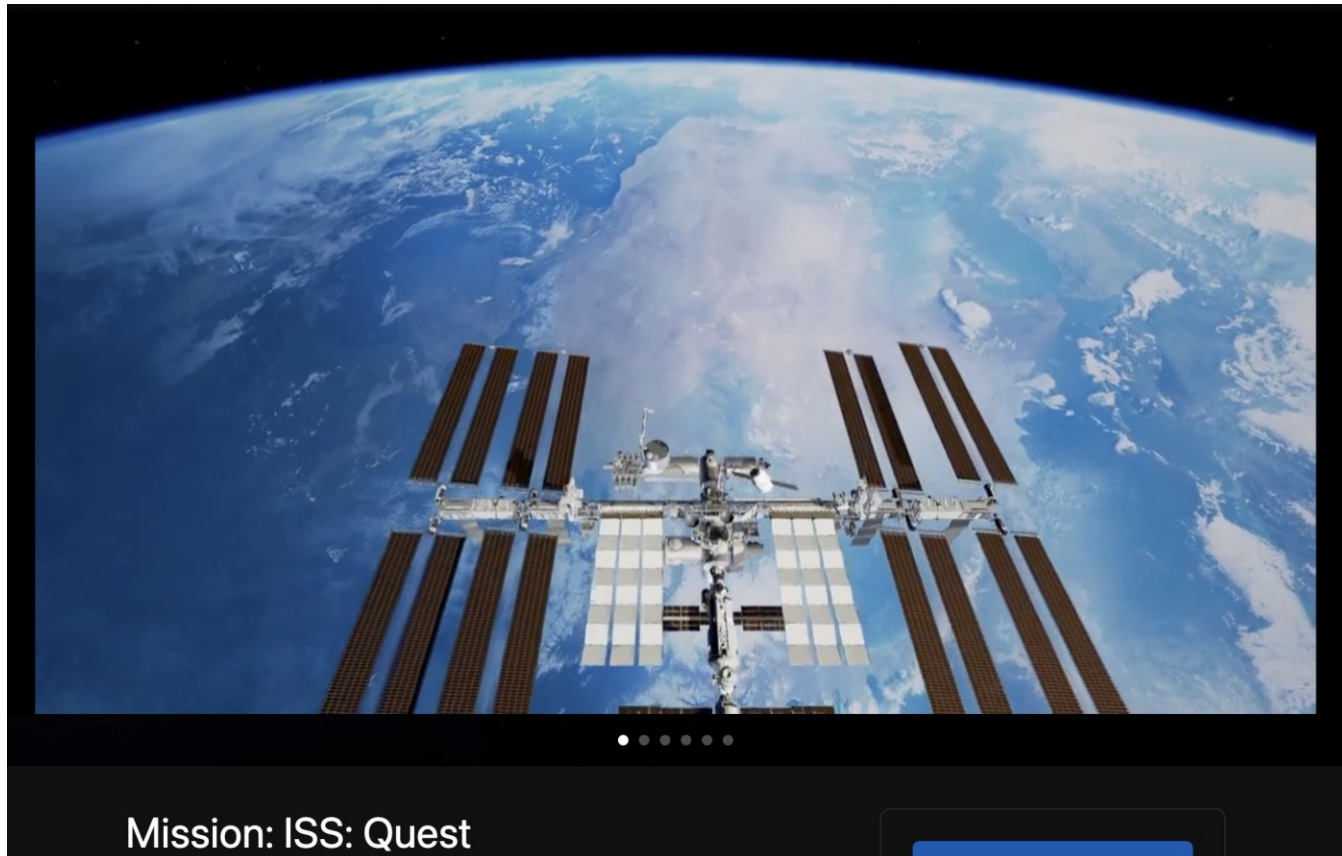
- Military or law enforcement training



# VR in entertainment

360° Movies

- YouTube, Disney, ...



Disney Movies VR

## Experience the wonderful world of Disney in VR

Disney Movies VR is your ticket to full immersion into the many Disney experiences optimized for virtual reality.

AVAILABLE NOW FOR HTC VIVE AND OCULUS

GET ON STEAM    GET ON OCULUS/RIFT

GET ON OCULUS/GEAR VR    GET ON OCULUS/GO

# VR in entertainment

Games

**The New York Times**

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***Virtual Reality Is a Disappointment?  
Not in the World of Video Gamers***

# VR in entertainment

## Games

- Large VR



# VR in entertainment

Games



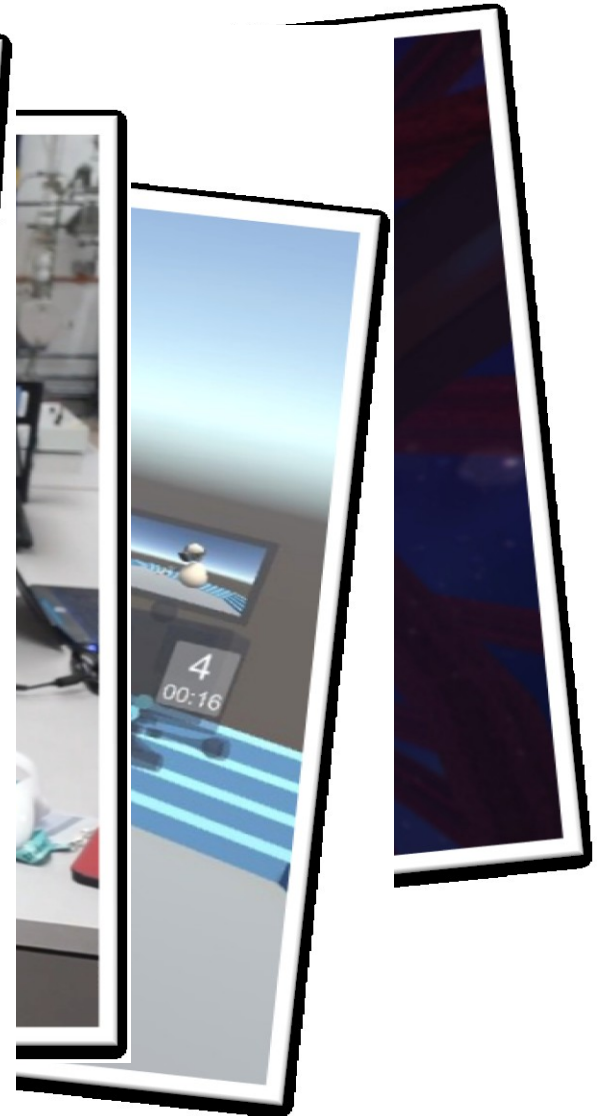
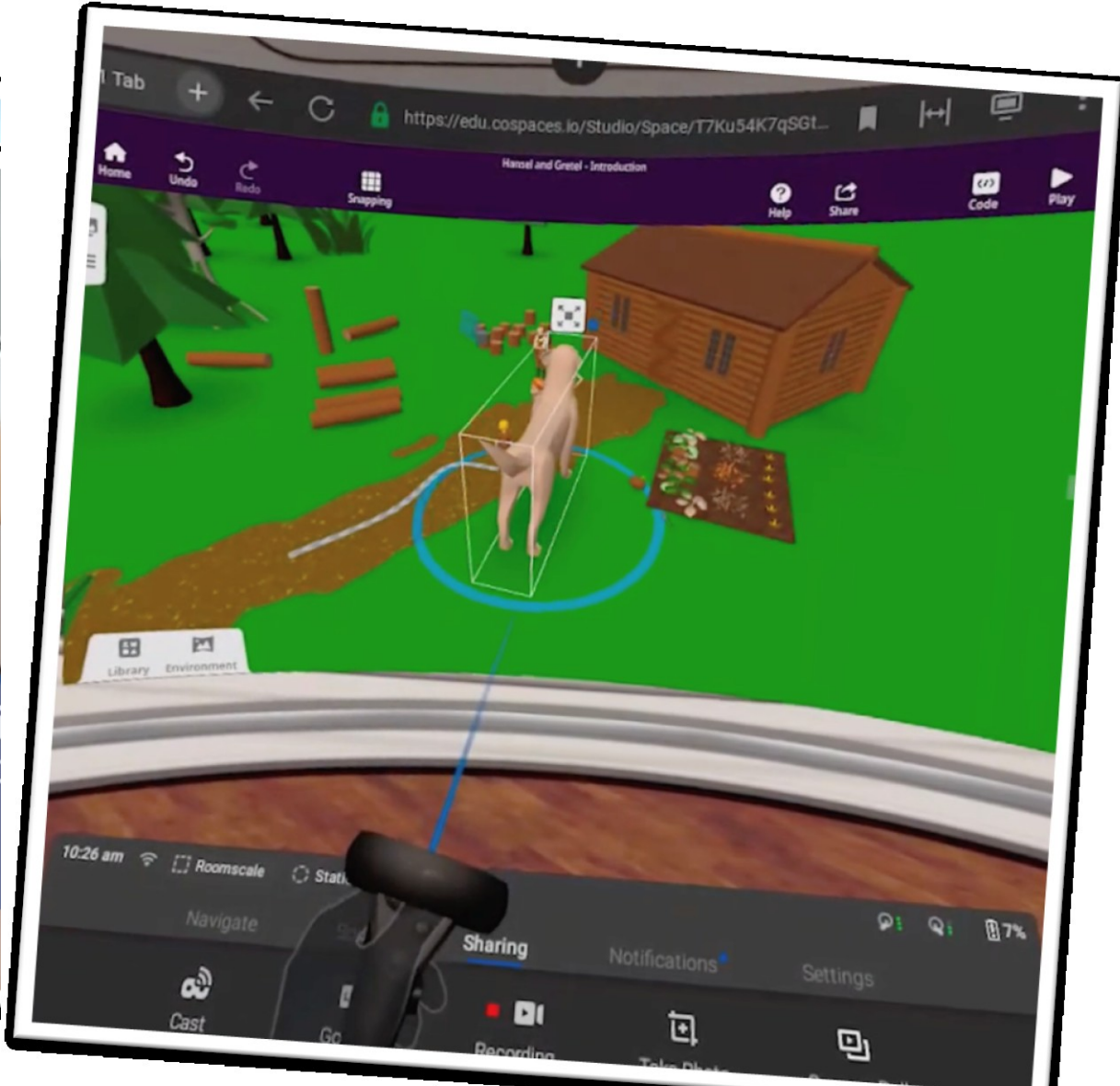
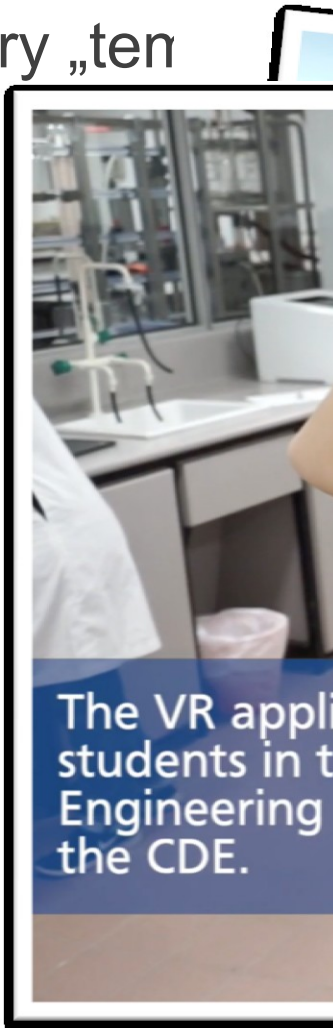
# VR in entertainment

Games



# VR in education

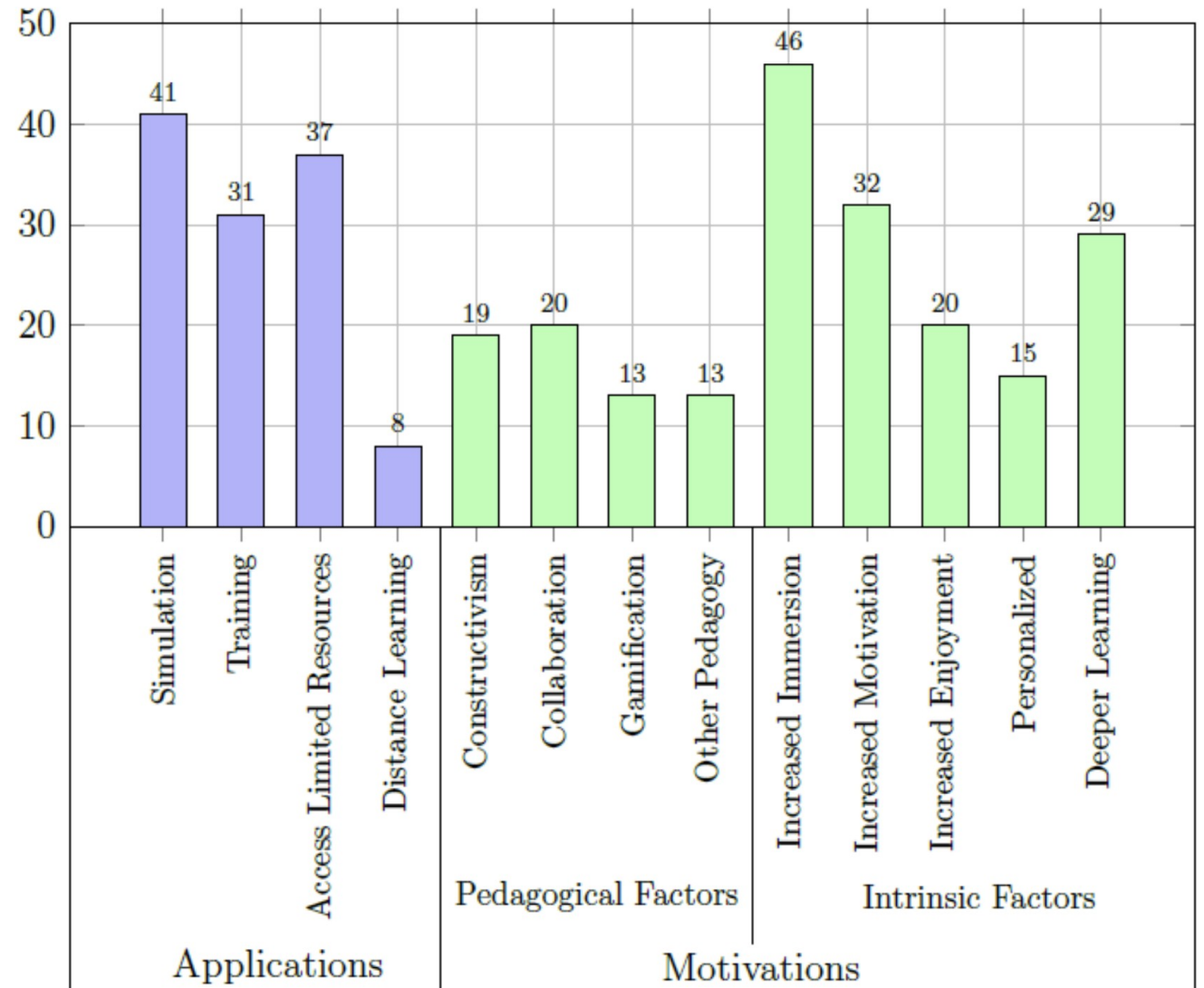
- Very „ten





# VR in education

- Reported applications and motivations of papers applying VR to education
  - Increased immersion
  - Increased motivation
  - Deeper learning
  - Increased enjoyment
  - Collaboration

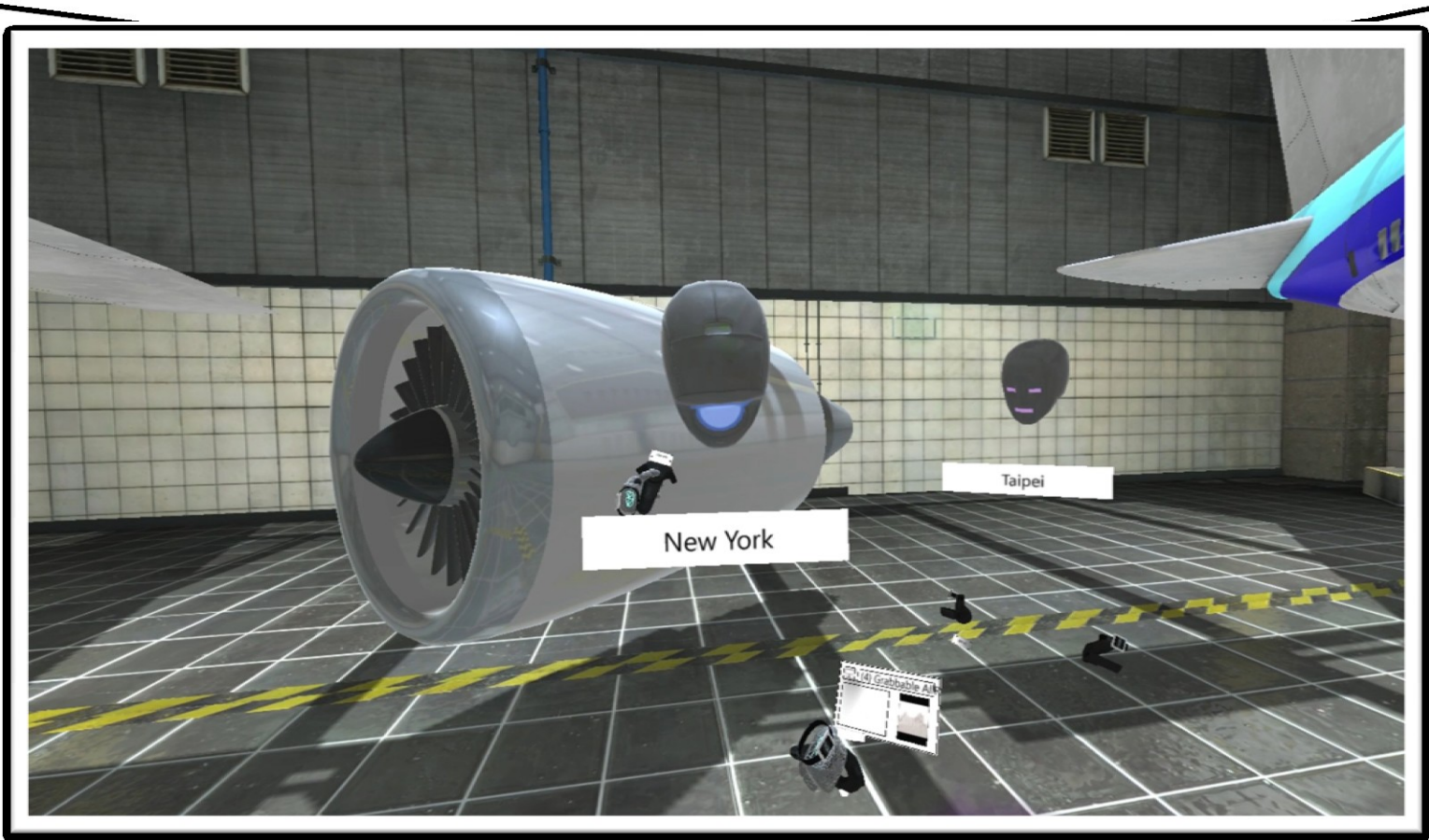
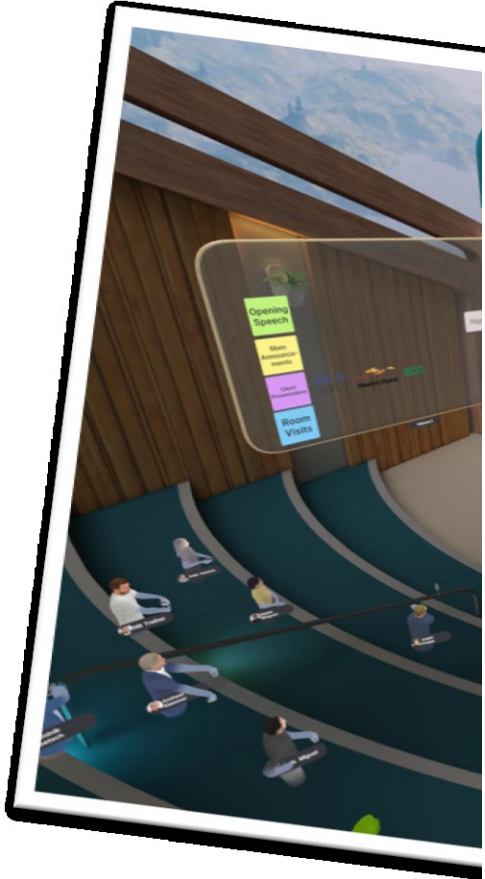
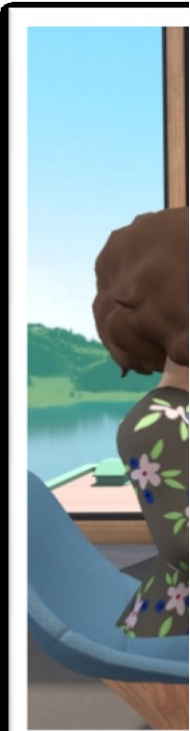


Kavanagah et al. (2017)

# VR for collaboration

Events, meetings, and conferences

- Higher
- Because
  - dis



# VR for animals aka „true creativity“

Because ... why not

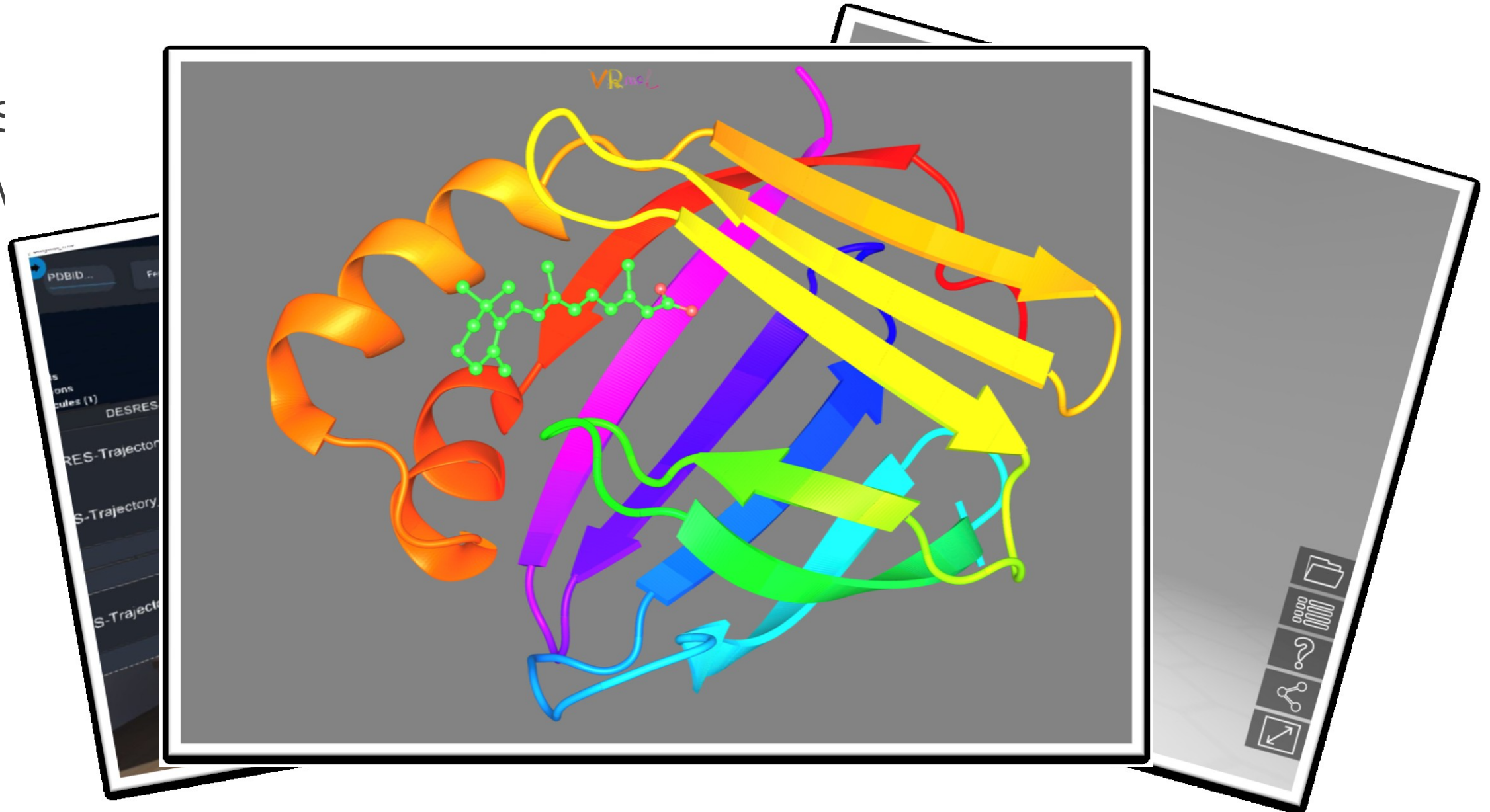
- Turkish farmer use(s|d) VR with his cows as it seemed (call it a „preliminary data“) to increase the amount of milk produced



# **Bio(Vis) and Med(Vis) examples**

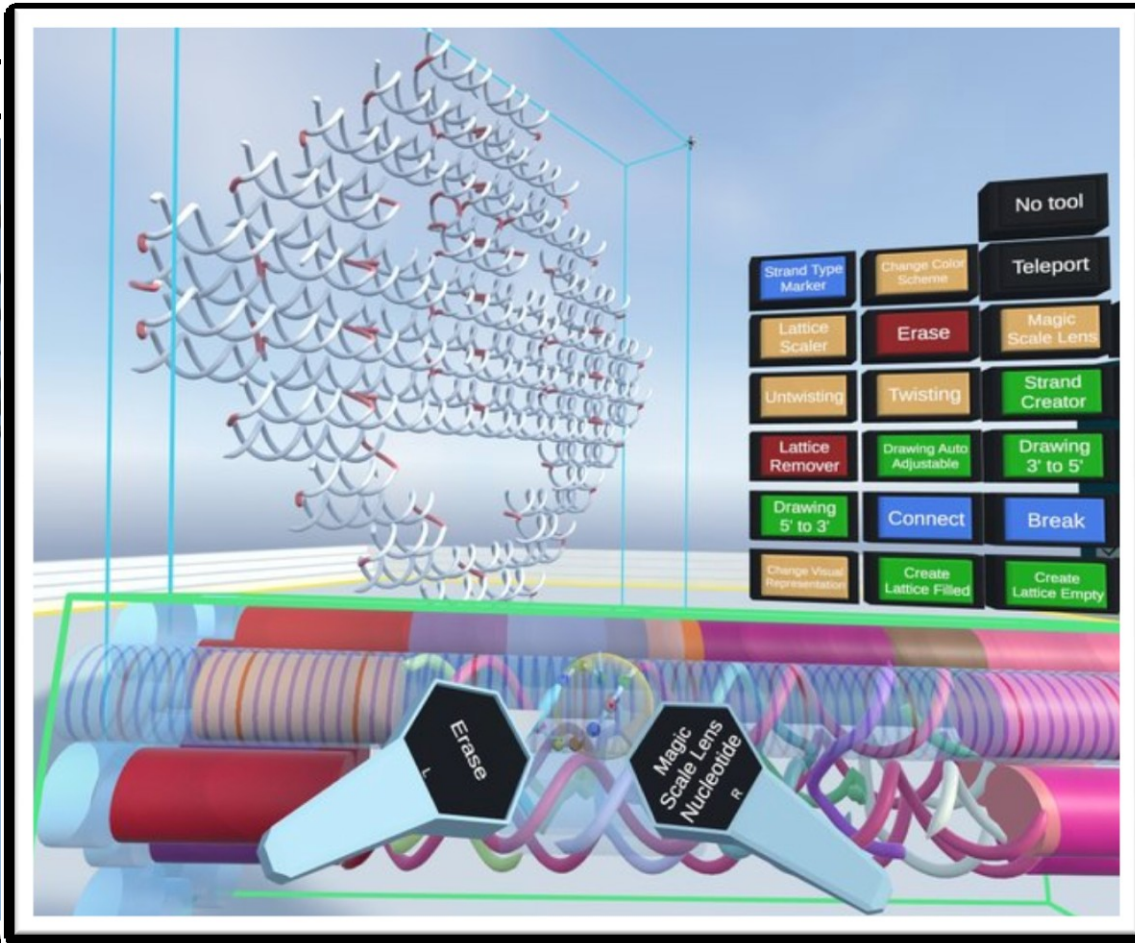
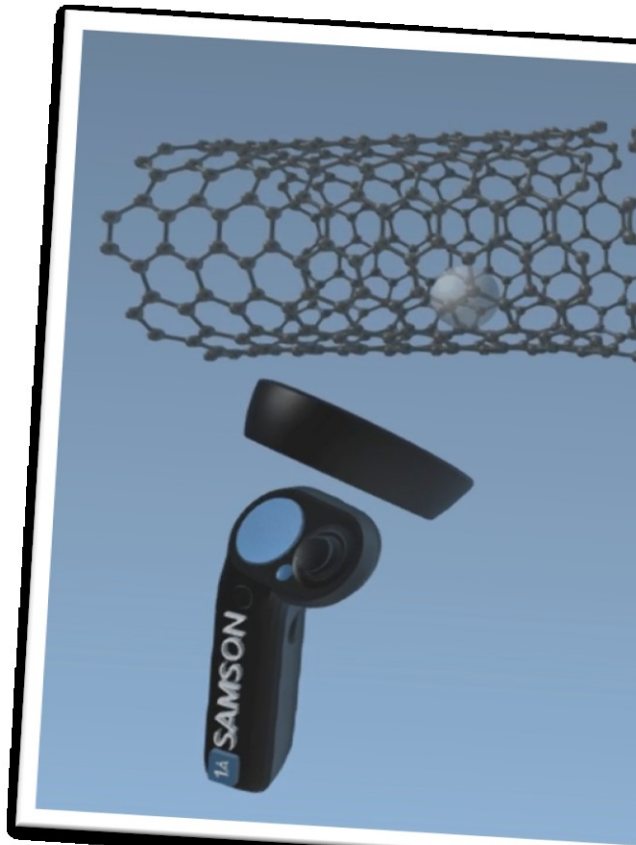
# Molecular Visualization in VR

- S
- M



# Molecular Modeling in VR

- Tries to combine VR visualization possibilities with its (potentially) more natural interactions

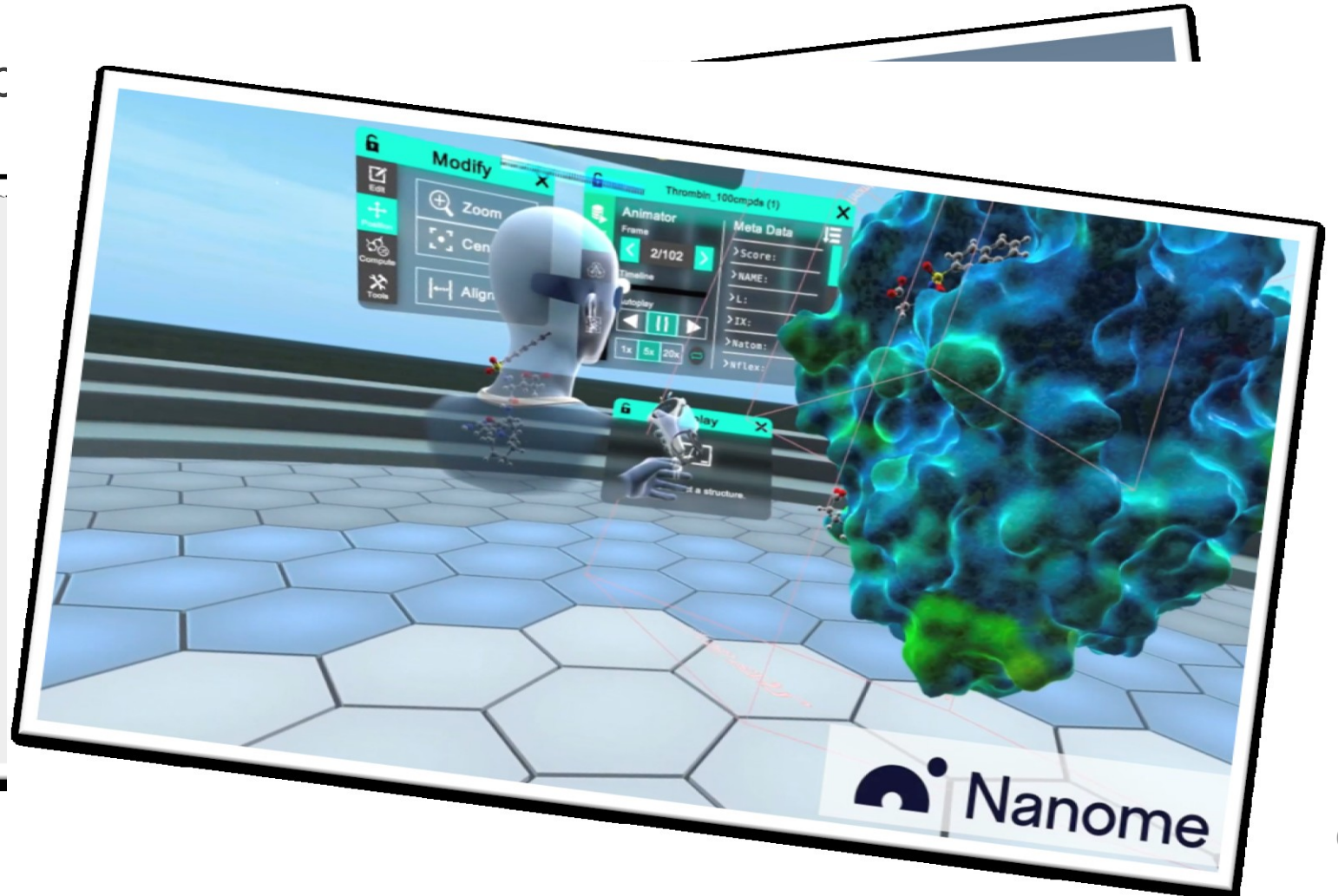


# Molecular Visualization & Modeling in VR



# Molecular Dynamics in VR

- Seeing how molecules behave
- Possibly also modeling sup





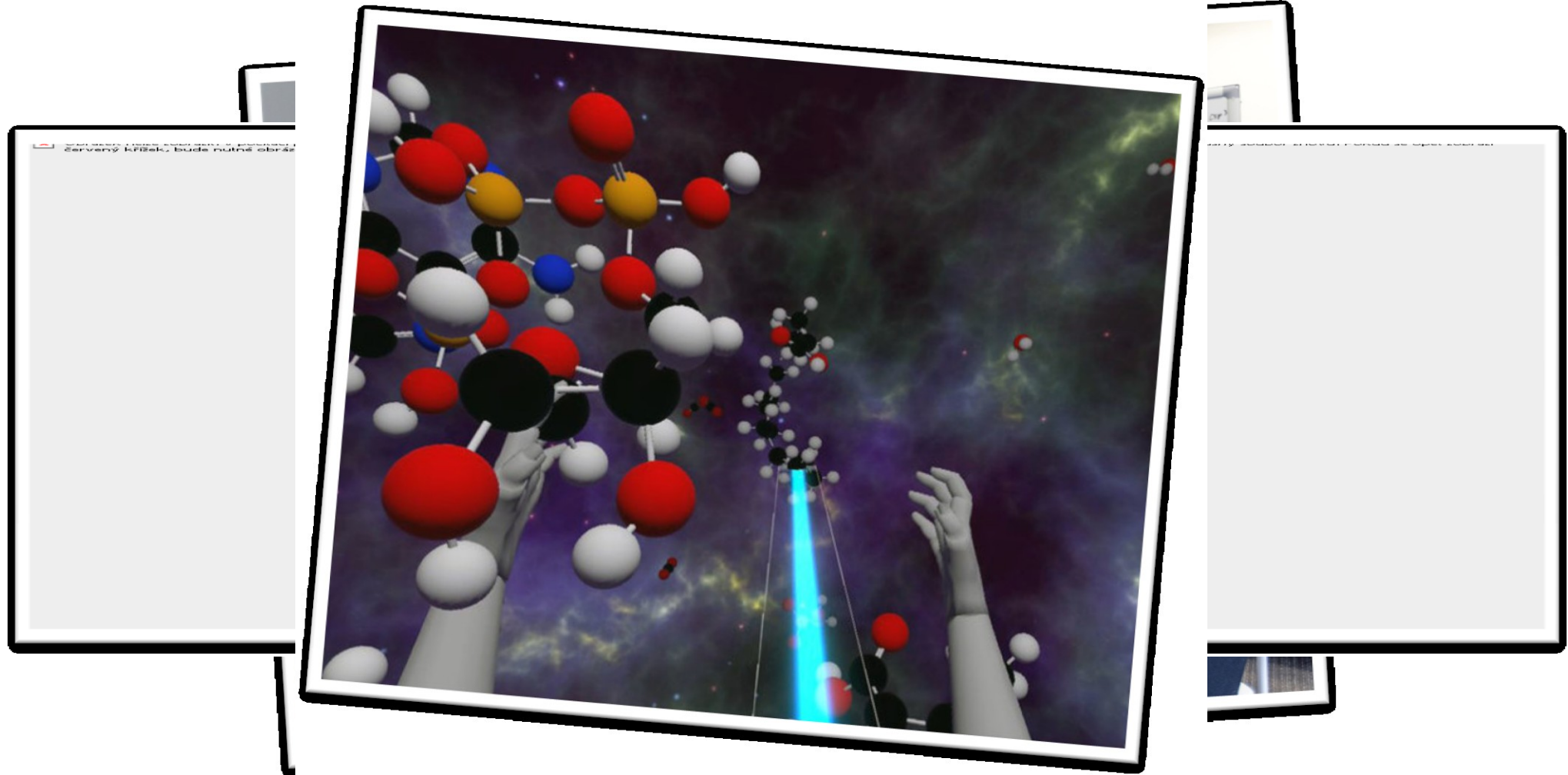
# Molecular Dynamics in VR

Interacting with MD & docking (in Narupa)



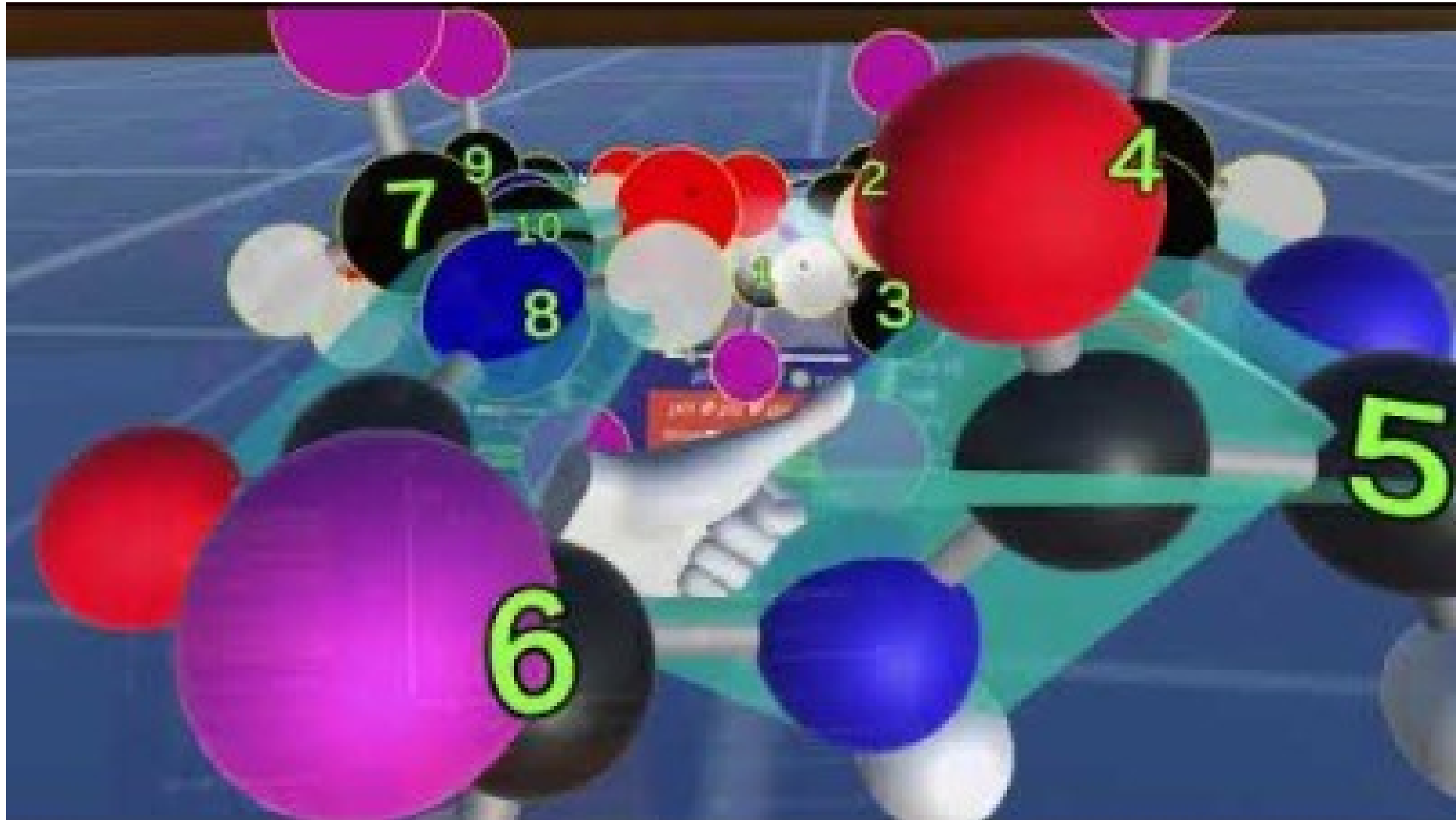
# Learning about molecules in VR

- Biology education is a large area in VR MolVis



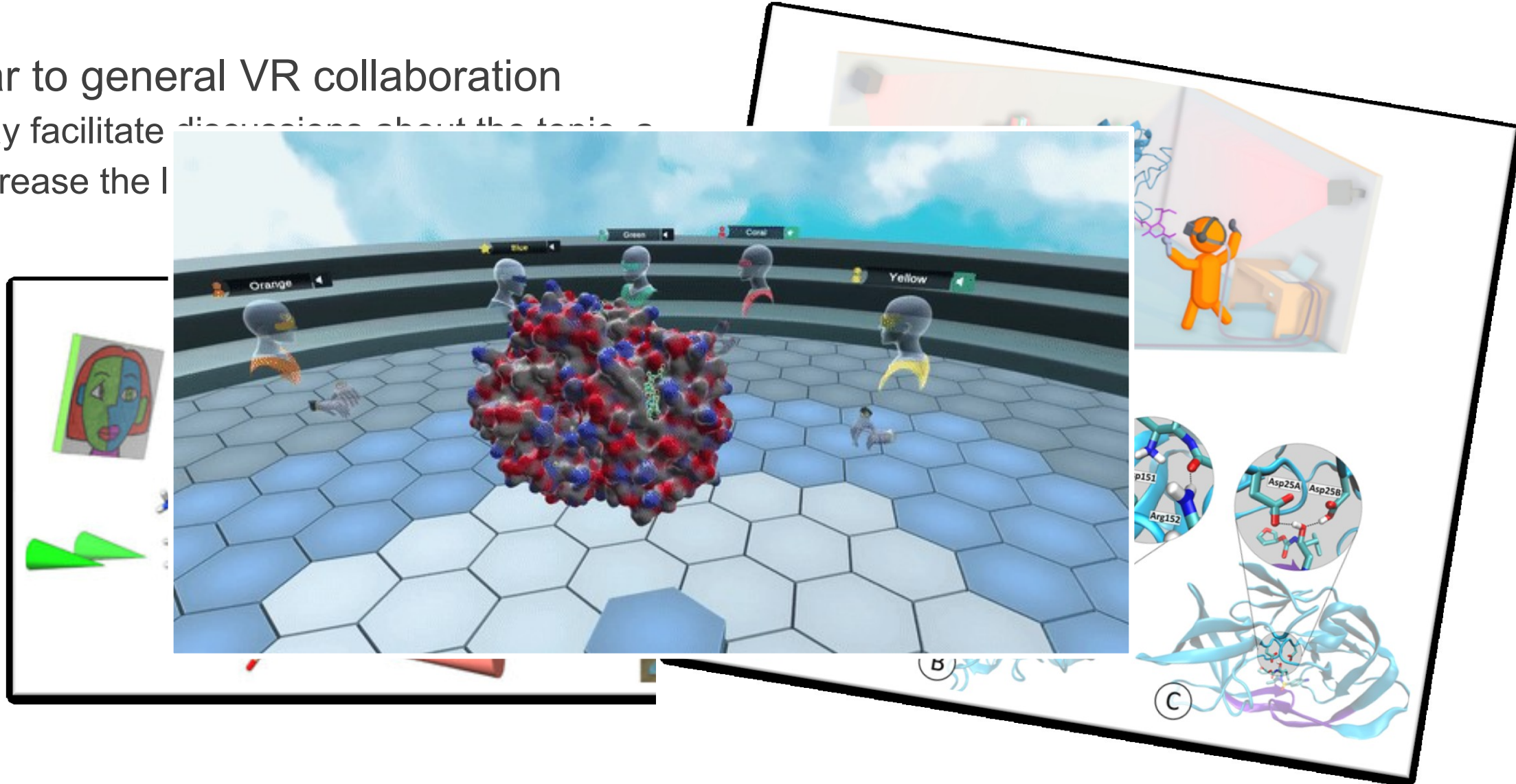
# Learning about molecules in VR

Nice feature of Peppy: works both with and without VR



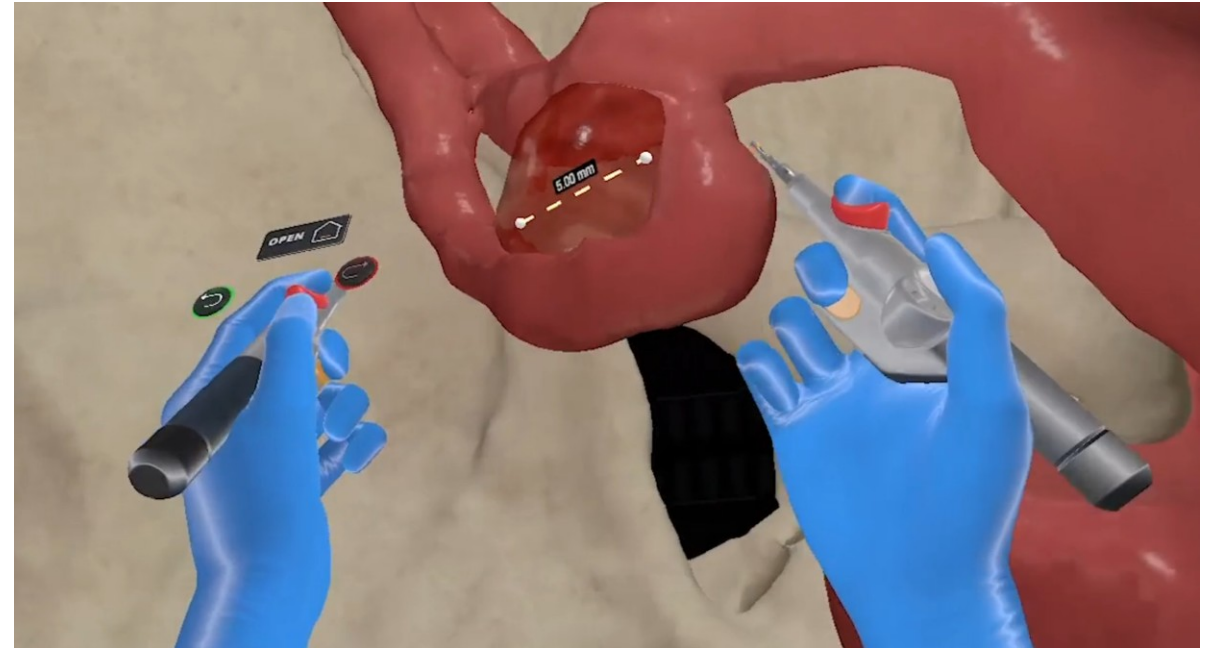
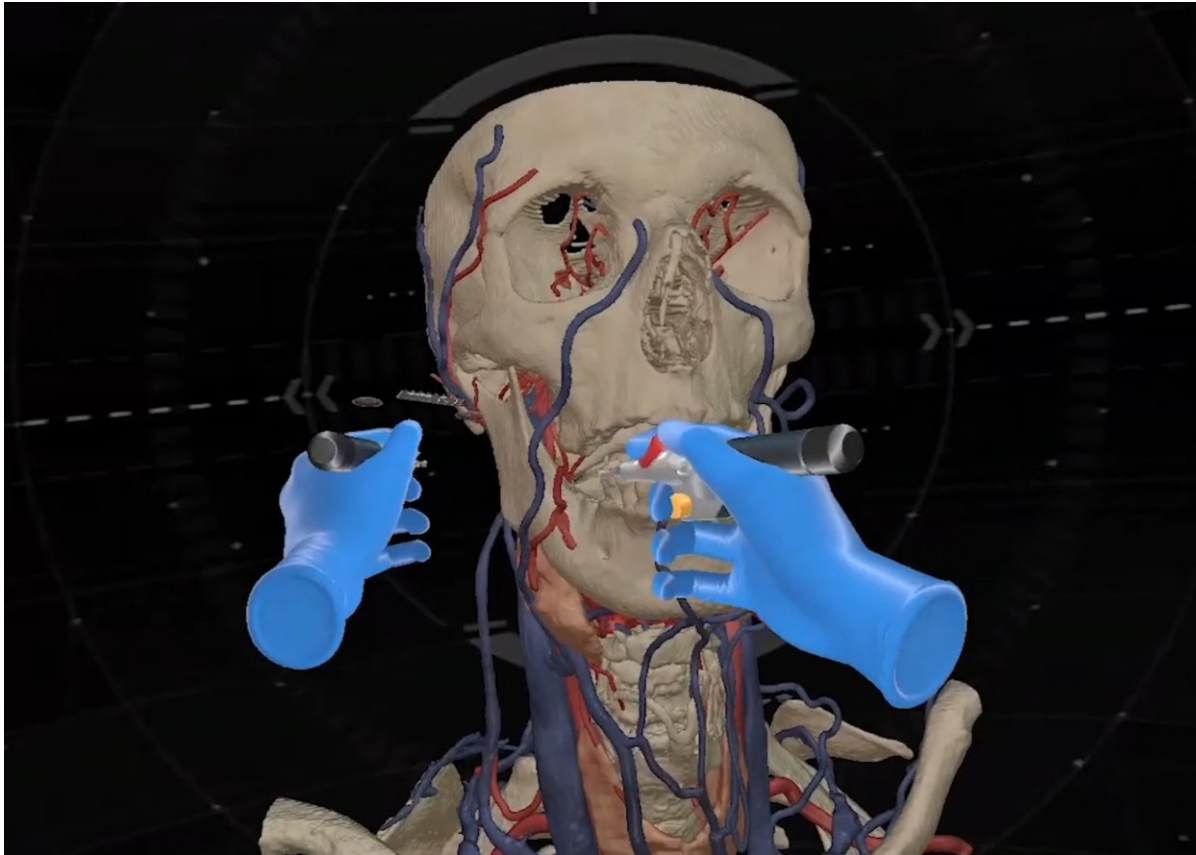
# Collaboration, molecules, and VR

- Similar to general VR collaboration
  - may facilitate discussions about the topic
  - increase the I



# Surgical planning

CT, MRI, ... scans visualized in VR (by ImmersiveView)

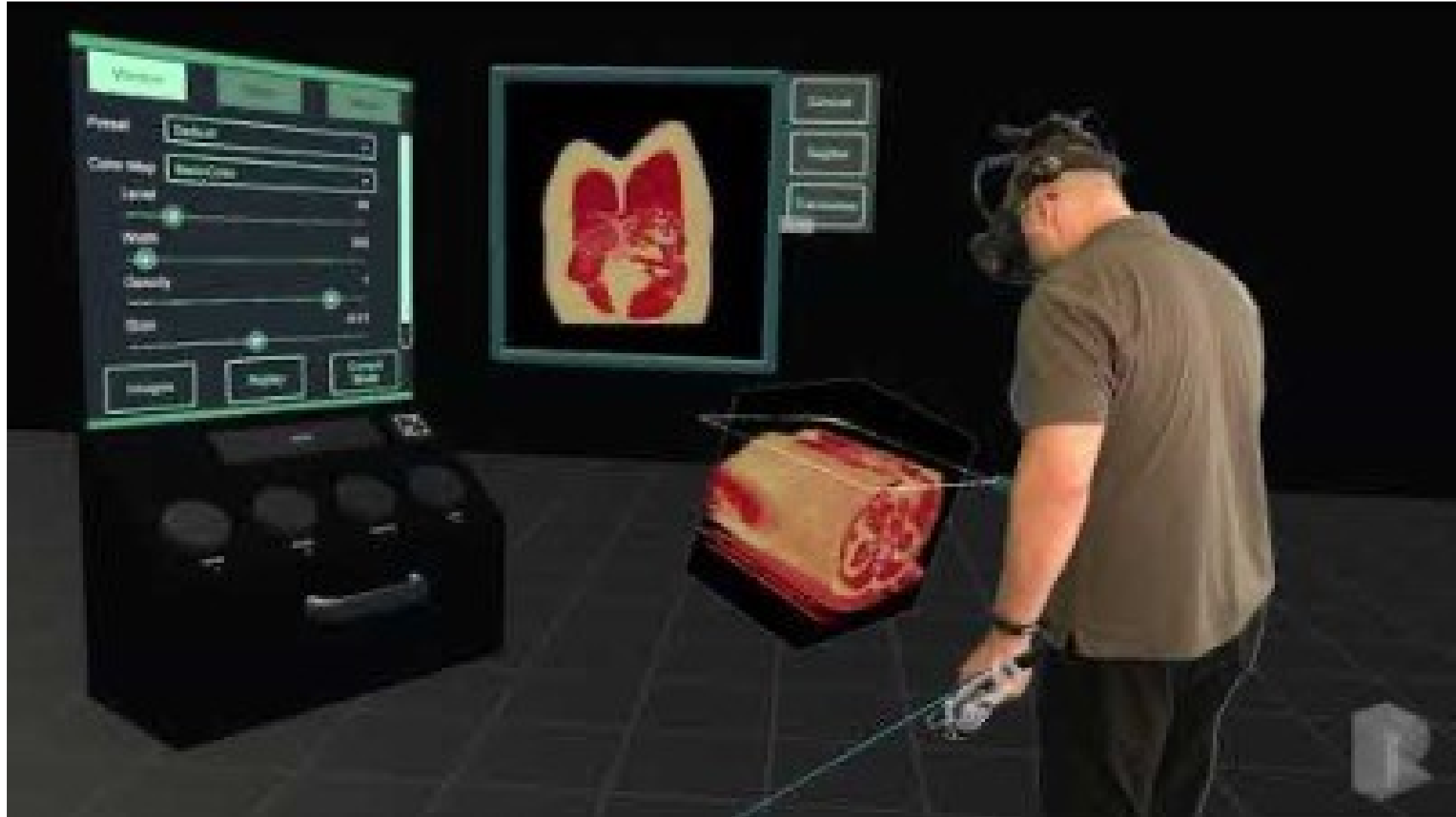


# Anatomy education

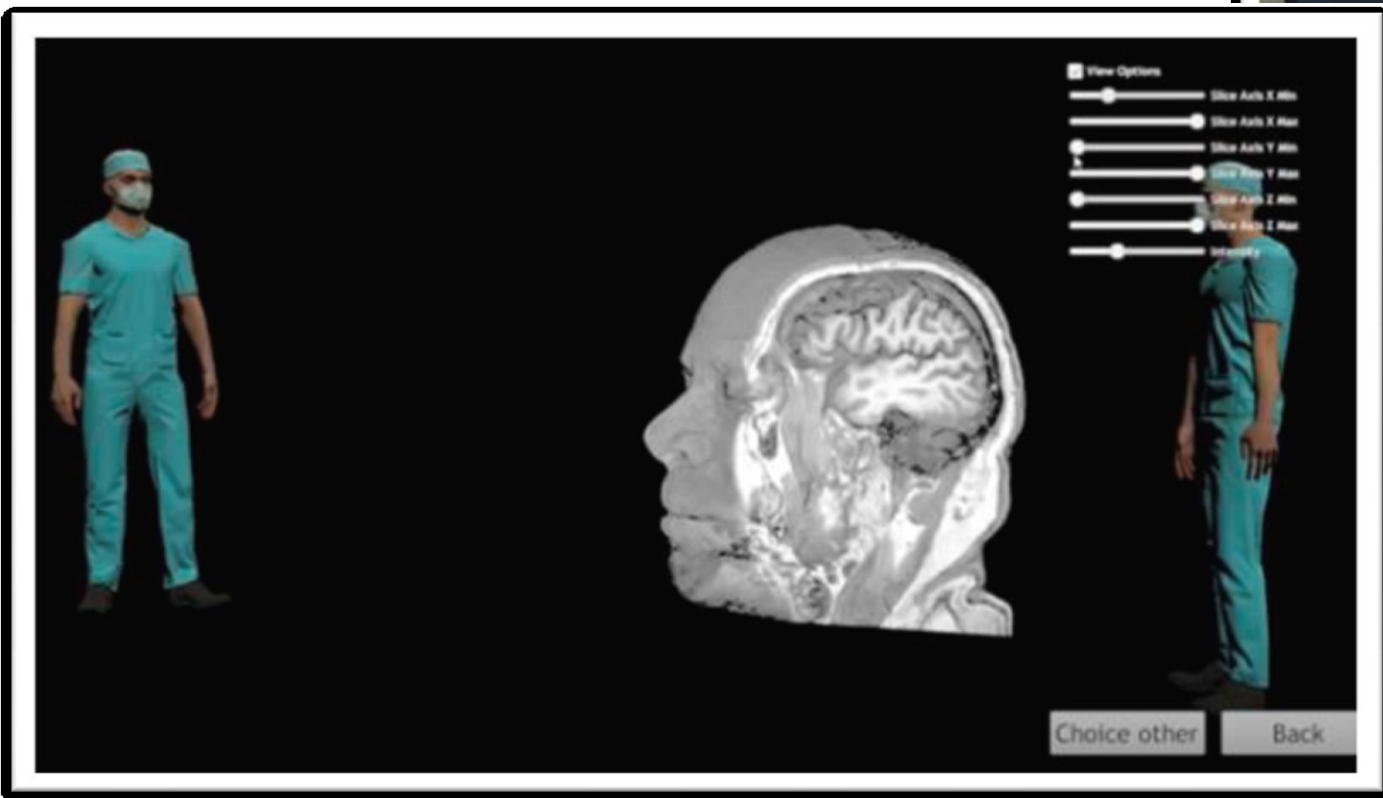
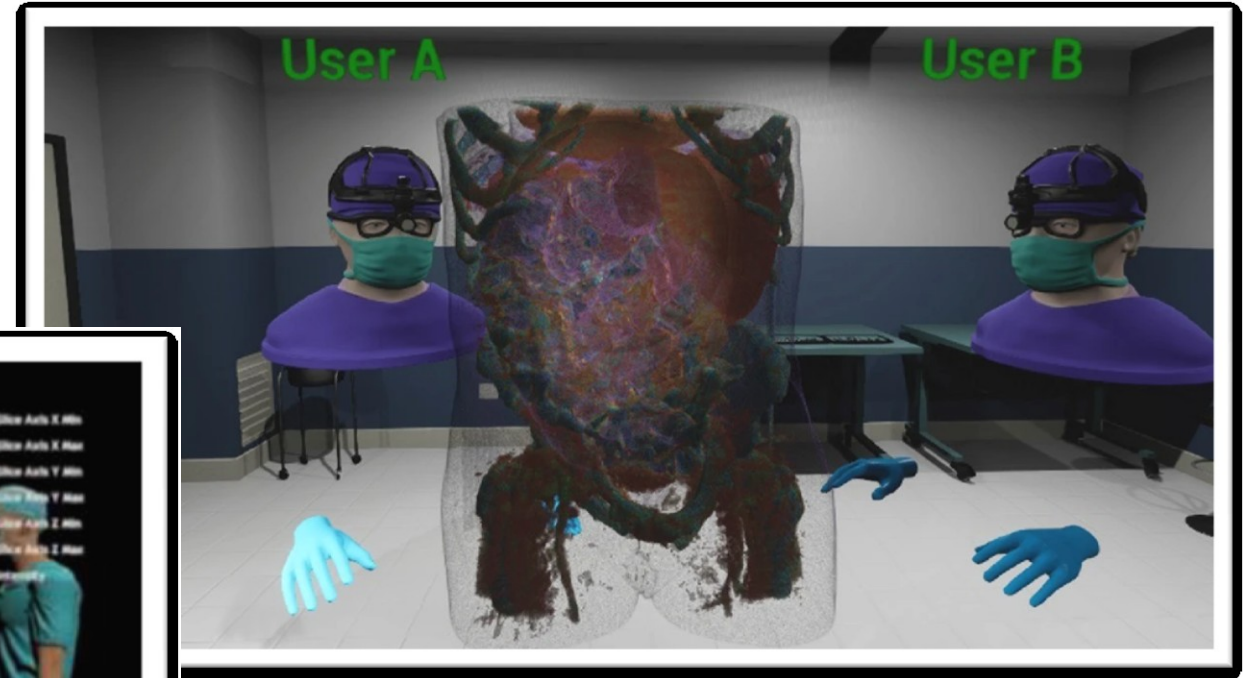


# Generic (volumetric) medical data visualization

Imaging Reality



# Collaborative medical data visualization





# Benefits and drawbacks of (HMD) VR

When compared to regular „desktop interface“



Higher immersion

Better spatial perception

More natural 3D interactions

Controlled environment

Less distractions

Hardware limitations / overhead

Fatigue

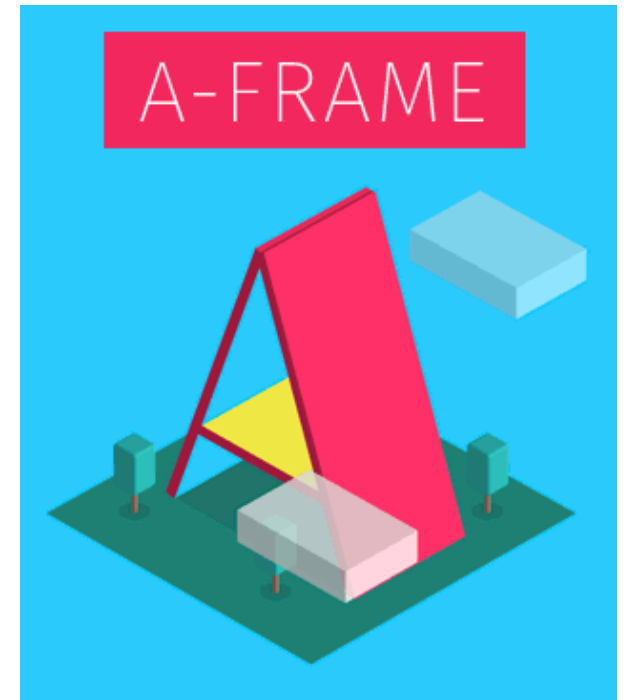
Difficult to input text and numbers

Some “classical” 2D interactions cumbersome

Q&A: Can you come up with additional benefits or disadvantages?

# How to develop for VR?

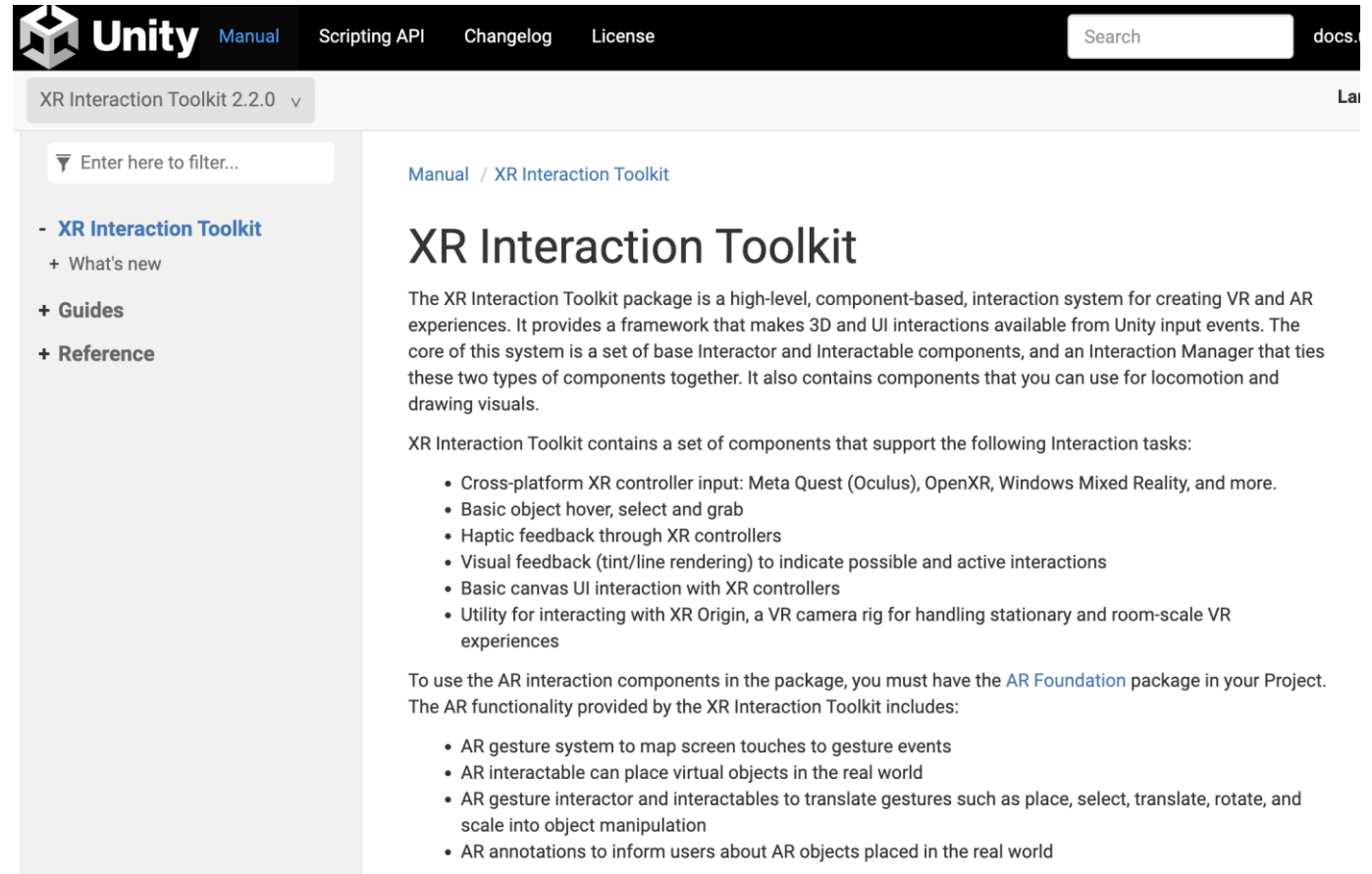
- I would suggest to consider any of these three ways:



# How to develop for VR?

## Unity

- Good support for majority of modern VR headsets
- Unity & C# are quite user friendly :)
- XR Interaction Toolkit
  - Developed by Unity
  - Good starting point



The screenshot shows the Unity documentation website for the XR Interaction Toolkit 2.2.0. The top navigation bar includes the Unity logo, links for Manual, Scripting API, Changelog, and License, a search bar, and a 'docs.' link. Below the navigation bar, the page title is 'XR Interaction Toolkit 2.2.0'. A left sidebar contains a search filter and a table of contents with sections for 'XR Interaction Toolkit', 'What's new', 'Guides', and 'Reference'. The main content area is titled 'XR Interaction Toolkit' and contains an introduction paragraph, a list of supported interaction tasks, and a section on using AR components.

Unity [Manual](#) [Scripting API](#) [Changelog](#) [License](#)  docs.

XR Interaction Toolkit 2.2.0 ▼ La

Enter here to filter...

- [XR Interaction Toolkit](#)
- + What's new
- + **Guides**
- + **Reference**

[Manual](#) / [XR Interaction Toolkit](#)

## XR Interaction Toolkit

The XR Interaction Toolkit package is a high-level, component-based, interaction system for creating VR and AR experiences. It provides a framework that makes 3D and UI interactions available from Unity input events. The core of this system is a set of base Interactor and Interactable components, and an Interaction Manager that ties these two types of components together. It also contains components that you can use for locomotion and drawing visuals.

XR Interaction Toolkit contains a set of components that support the following Interaction tasks:

- Cross-platform XR controller input: Meta Quest (Oculus), OpenXR, Windows Mixed Reality, and more.
- Basic object hover, select and grab
- Haptic feedback through XR controllers
- Visual feedback (tint/line rendering) to indicate possible and active interactions
- Basic canvas UI interaction with XR controllers
- Utility for interacting with XR Origin, a VR camera rig for handling stationary and room-scale VR experiences

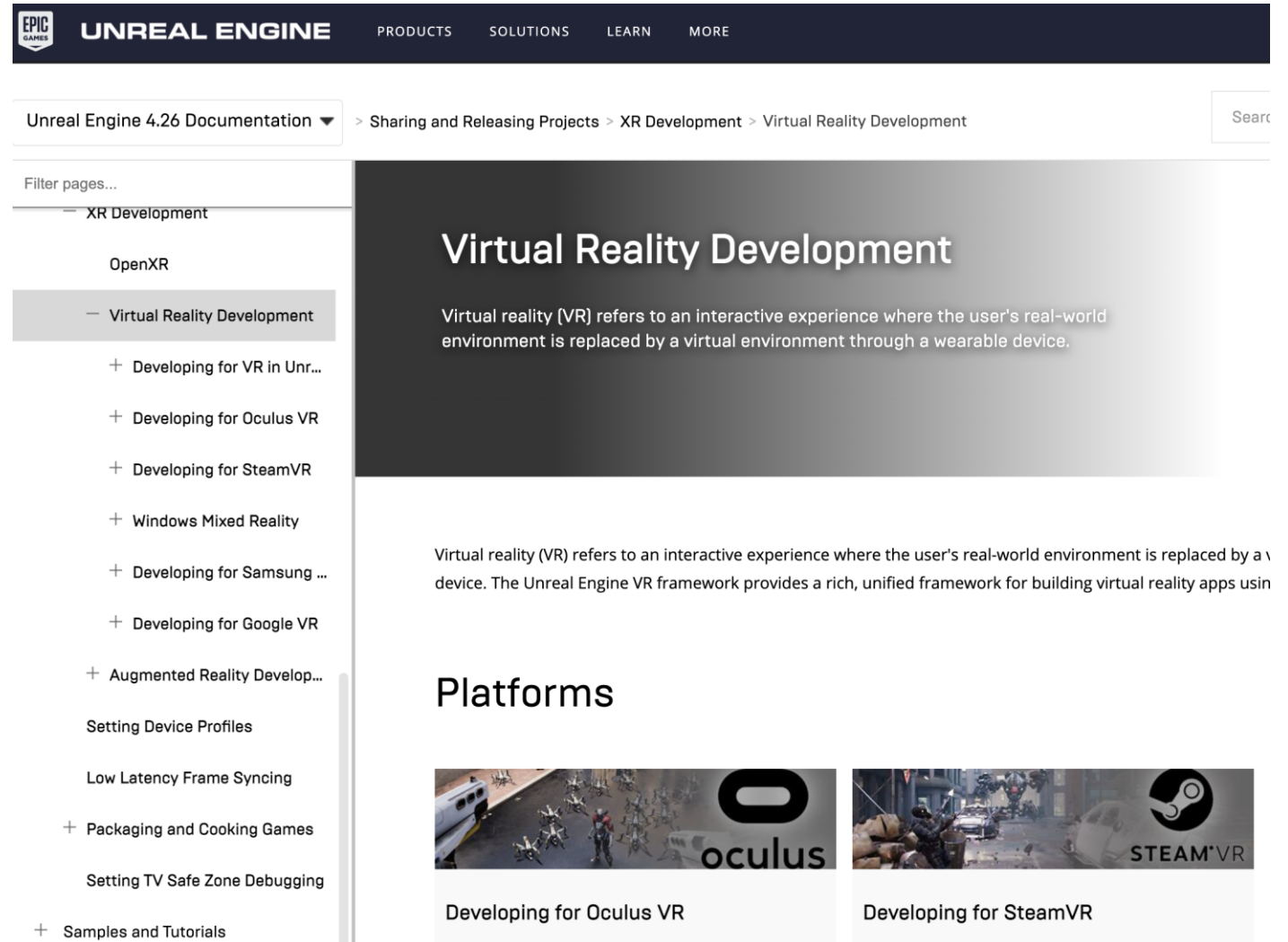
To use the AR interaction components in the package, you must have the [AR Foundation](#) package in your Project. The AR functionality provided by the XR Interaction Toolkit includes:

- AR gesture system to map screen touches to gesture events
- AR interactable can place virtual objects in the real world
- AR gesture interactor and interactables to translate gestures such as place, select, translate, rotate, and scale into object manipulation
- AR annotations to inform users about AR objects placed in the real world

# How to develop for VR?

## Unreal

- Also good support for majority of modern VR headsets
- Not as user friendly as Unity
- Unreal licensing is more „clear“



The screenshot shows the Unreal Engine 4.26 Documentation website. The navigation bar includes the Epic Games logo, 'UNREAL ENGINE', and links for 'PRODUCTS', 'SOLUTIONS', 'LEARN', and 'MORE'. The breadcrumb trail is 'Unreal Engine 4.26 Documentation > Sharing and Releasing Projects > XR Development > Virtual Reality Development'. A search bar is visible in the top right corner.

The left sidebar contains a 'Filter pages...' section with the following items:

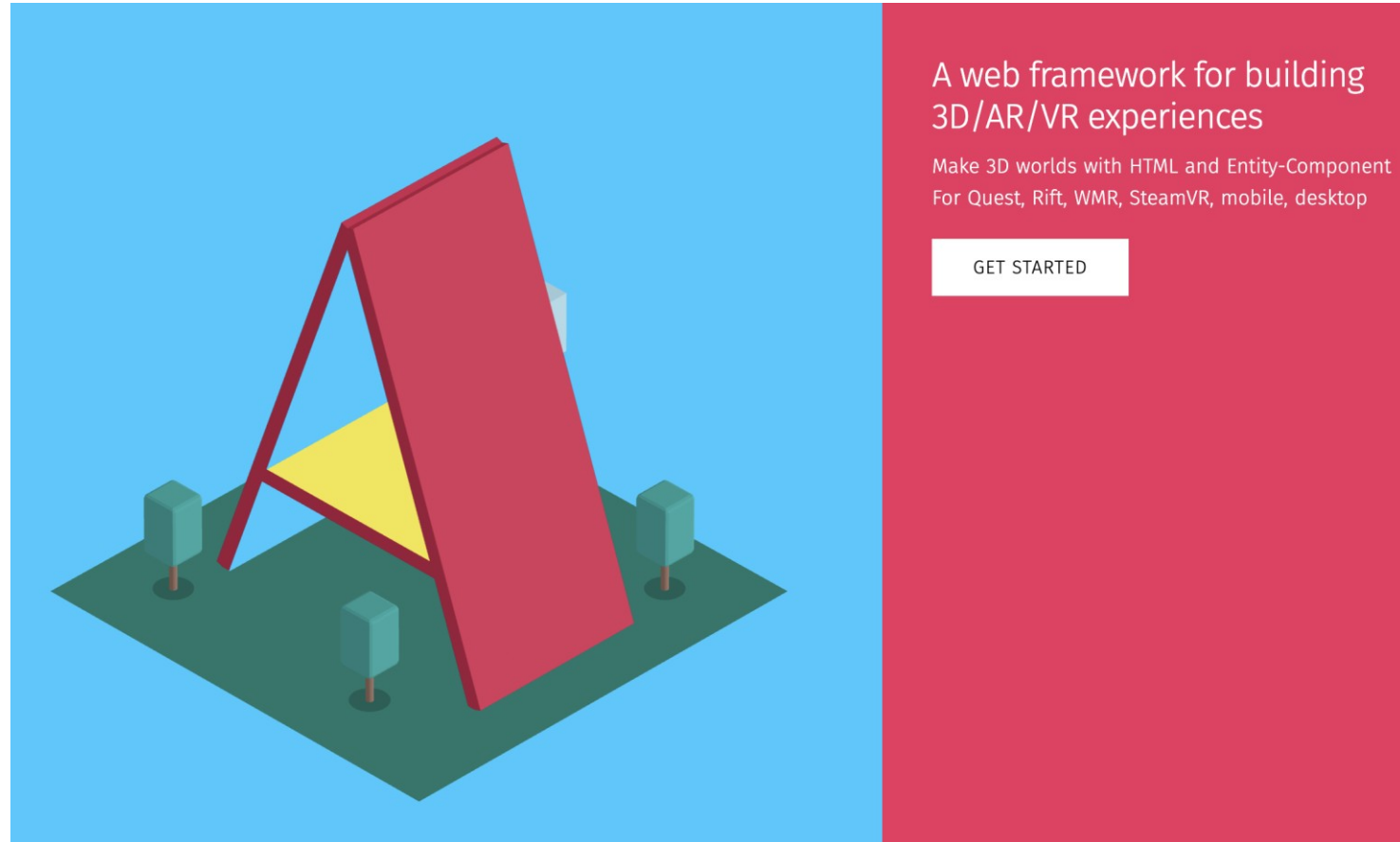
- XR Development
  - OpenXR
  - Virtual Reality Development**
    - + Developing for VR in Unr...
    - + Developing for Oculus VR
    - + Developing for SteamVR
    - + Windows Mixed Reality
    - + Developing for Samsung ...
    - + Developing for Google VR
  - + Augmented Reality Develop...
- Setting Device Profiles
- Low Latency Frame Syncing
- + Packaging and Cooking Games
- Setting TV Safe Zone Debugging
- + Samples and Tutorials

The main content area features a large heading 'Virtual Reality Development' with a sub-heading 'Virtual reality (VR) refers to an interactive experience where the user's real-world environment is replaced by a virtual environment through a wearable device.' Below this, a paragraph states: 'Virtual reality (VR) refers to an interactive experience where the user's real-world environment is replaced by a virtual environment through a wearable device. The Unreal Engine VR framework provides a rich, unified framework for building virtual reality apps using Unreal Engine.' The 'Platforms' section includes two cards: 'Developing for Oculus VR' with the Oculus logo and 'Developing for SteamVR' with the SteamVR logo.

# How to develop for VR?

## A-FRAME

- Web framework
- Built on WebXR and Three.js
- Web app → No installation of application needed
  - However, WebXR support depends on the user's browser
- Performance and some features might be limited



A NEW KIND OF "KILLER APP" —

# VR in the Oculus co-founder makes a VR headset that can literally kill you

Sword Art Online inspires Palmer Luckey to put explosive charges on a Quest Pro.

KYLE ORLAND - 11/7/2022, 10:28 PM

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Palmer Luckey

[Enlarge](#) / Looks comfortable...

VR viewer“?

# Concluding this section ...

- VR has advantages
- VR has disadvantages
- You should try it :)
  - But please do not try the explosive headset

Core thing to remember: **pros >> cons** to convince people to actually use it



**Thank you for your attention!**



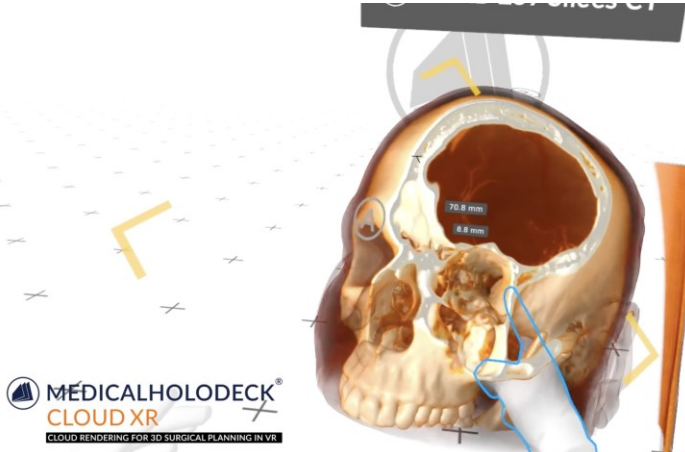
# References

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- <https://ieeexplore.ieee.org/document/9288058>

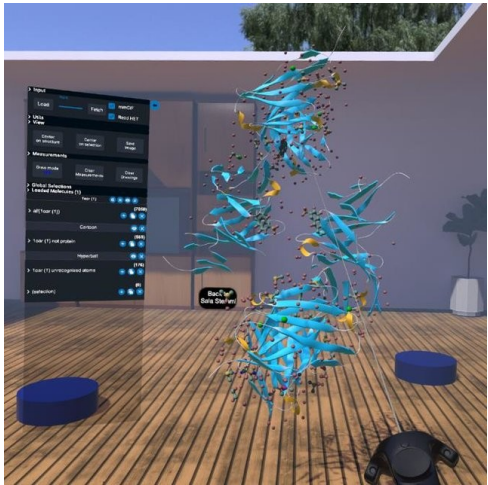
# Applications you may try ...



Nanome (molvis/molmod)



Medicalholodeck (medvis)  
*Alternatively: MedicalImagingVR*



UnityMol (molvis)



CellPaint VR (drawing of cell env.)



Blocks (creativity)



GORN (brutal game)