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LMMFE Laboratorij za multimedijo

VIRTUAL TECHNOLOGIES @western balkan universities

VR / AR / MR user experience guidelines

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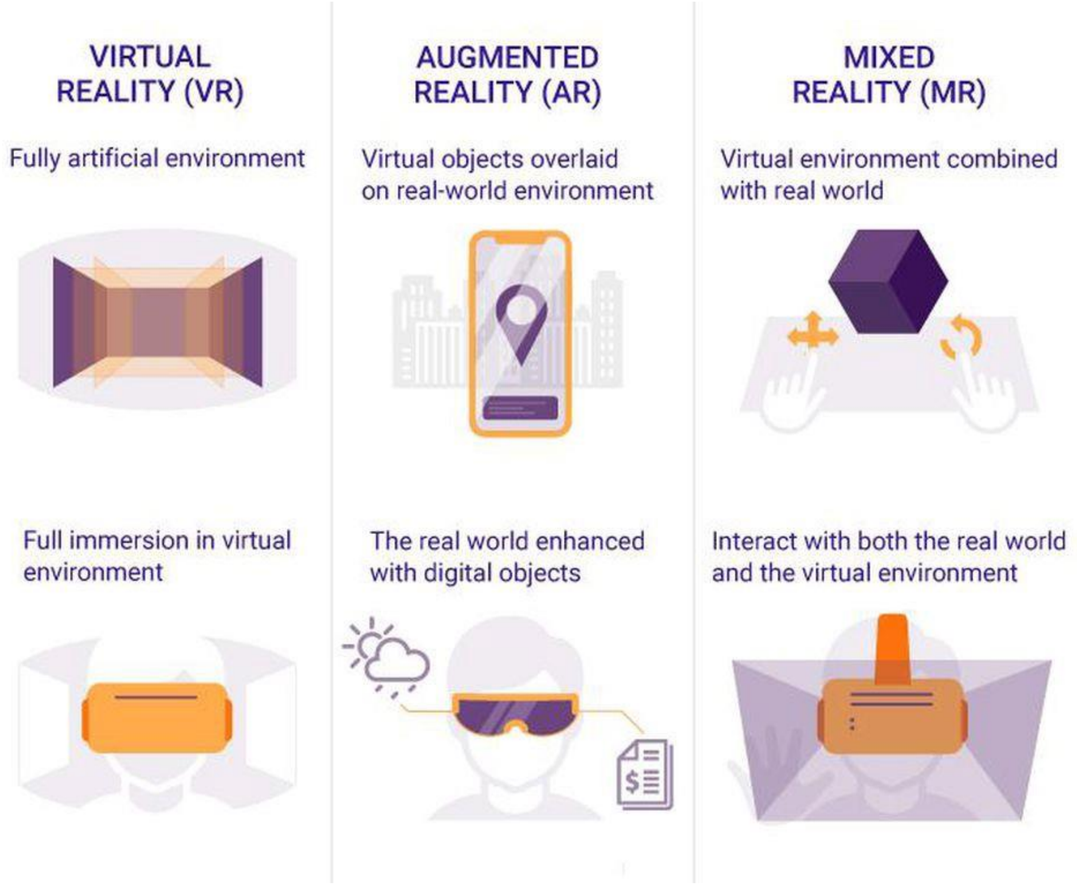
Content

- introduction – content and AR and VR technologies
- specifics of interactions and Ux
  - AR
  - VR
- 360° video
- trends
- demonstrations



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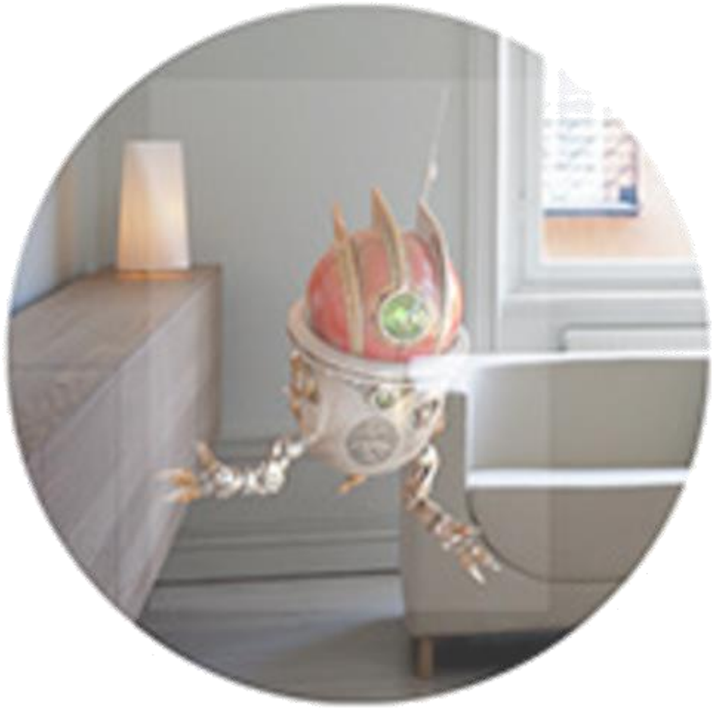
Types of reality - VR/AR/MR...RR?

VR



AR

MR

Content and applications of VR

- virtual reality
  - computer generated content (3D)
  - real content
    - multidirectional shots (360° video)
  - combination of both
- augmented / mixed reality
  - computer-generated content placed in the real world in real time

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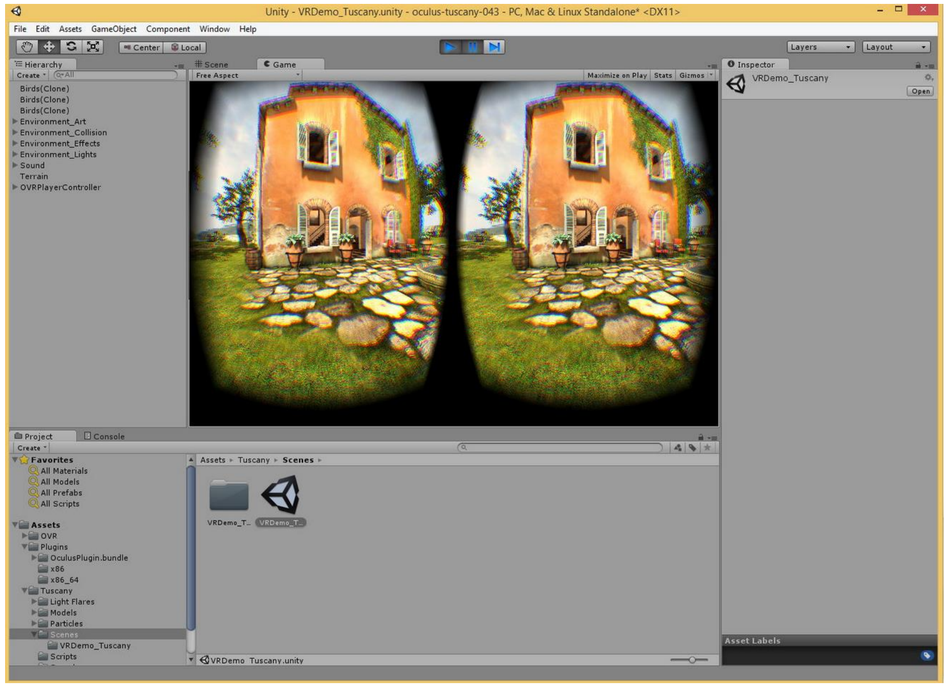
VR development technologies

- WEB XR (WEB GL) – web technologies
- Unity VR
- Unreal engine
- AppGameKit VR
- Torque3D



- support for various googles and their development on different platforms
  - Oculus Rift, GearVR, HTCVive/SteamVR, Google VR/Daydream

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Development technologies for AR

- native technologies
  - ARKit, ARCore, ARToolkit
  - Vuforia
- web technologies
  - WebXR
  - AR.js (Three.js, A-frame)
- web technologies are still under development and do not work on all platforms or browsers

Contents

- static/dynamic
  - responding to interactions
- animated
- 2D/3D
- procedural: generated according to algorithms
- tools for making and animating objects

https://medium.com/@goatsandbacon/a-quick-guide-to-designing-for-augmented-reality-on-mobile-part-1-c8ecaaf303d5

Interactions

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(HMD) Devices

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Ux aspects of VR - interactions

- different ways of operation
  - hands
  - view
  - controllers
  - voice control
- rules are not equally applicable to all

  management (operation)

  modes!

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A combination of modalities

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Blended reality

- mixing the real and the virtual world
- use of currently available technologies

https://thevoid.com/

User experience in AR

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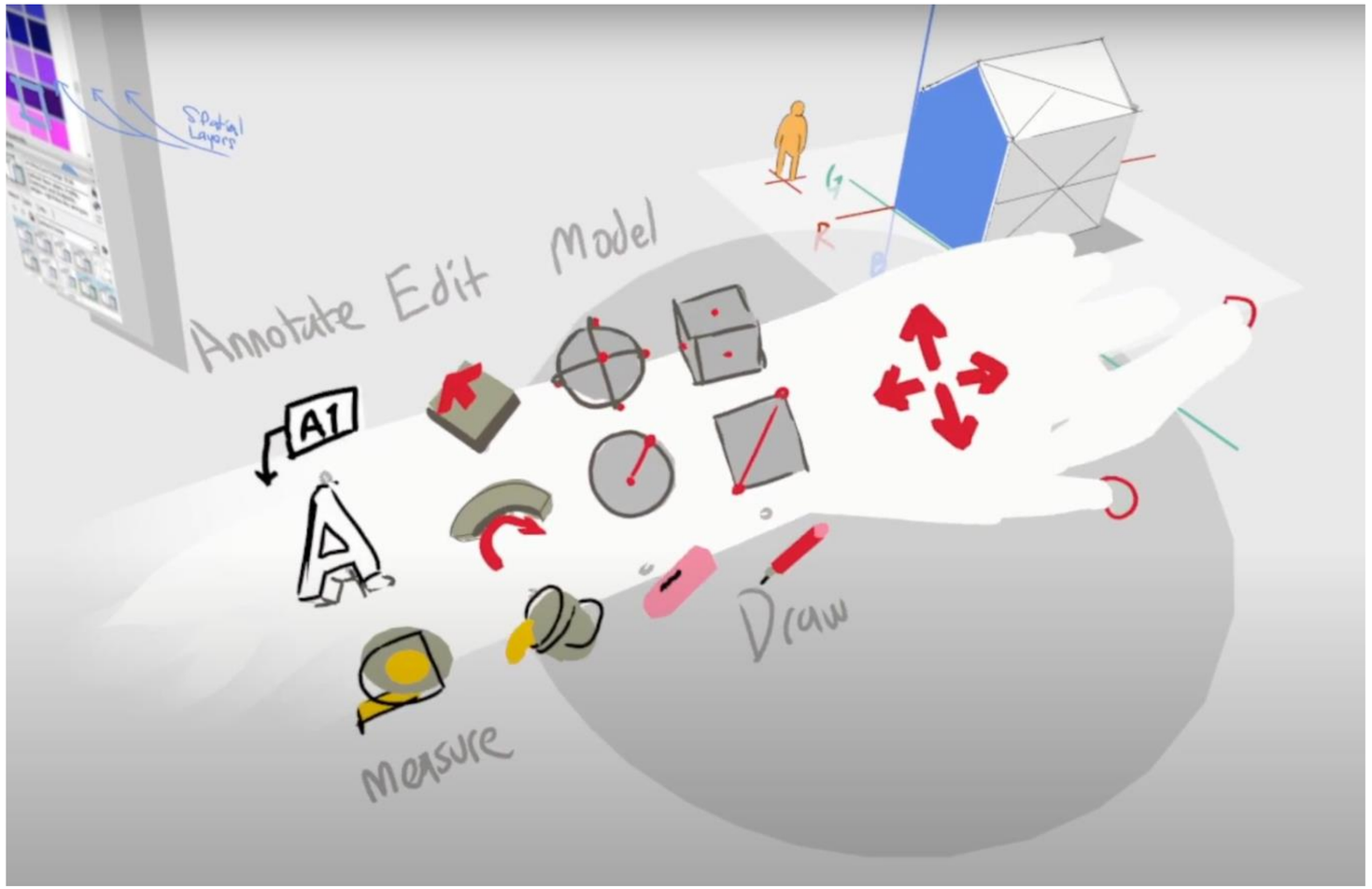
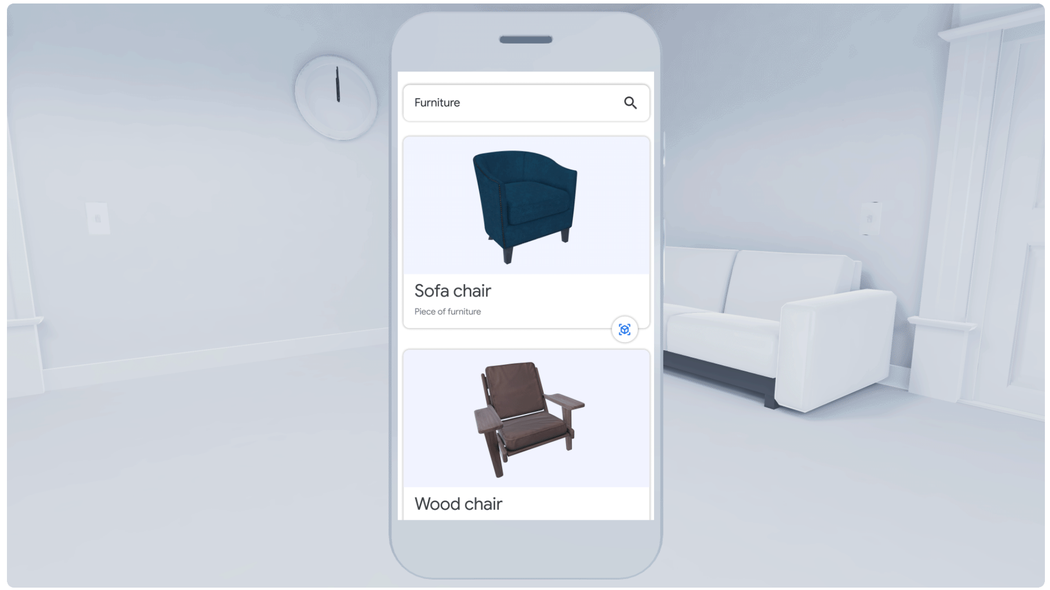
Ux aspects

- initialization
- indicators and feedback
- text, colors
- icon placement
- other



Ux aspects – initialization

- it must be clearly shown to users when they are entering AR mode of operation
  - transitions, “fade out”
  - at the user’s request/action



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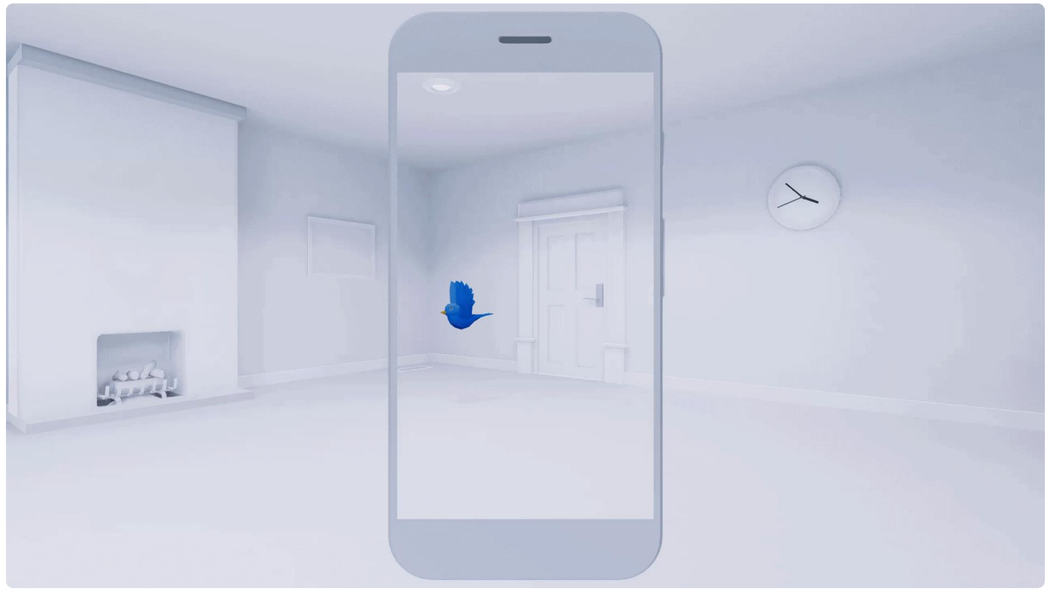
Ux aspects – indicators

- placing objects on the stage (screen)

- off-stage objects

- shadows



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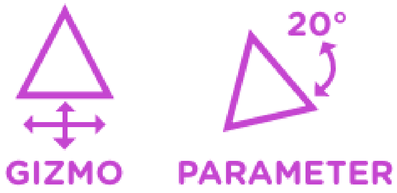
Ux aspects – indicators

- movements



- alignment

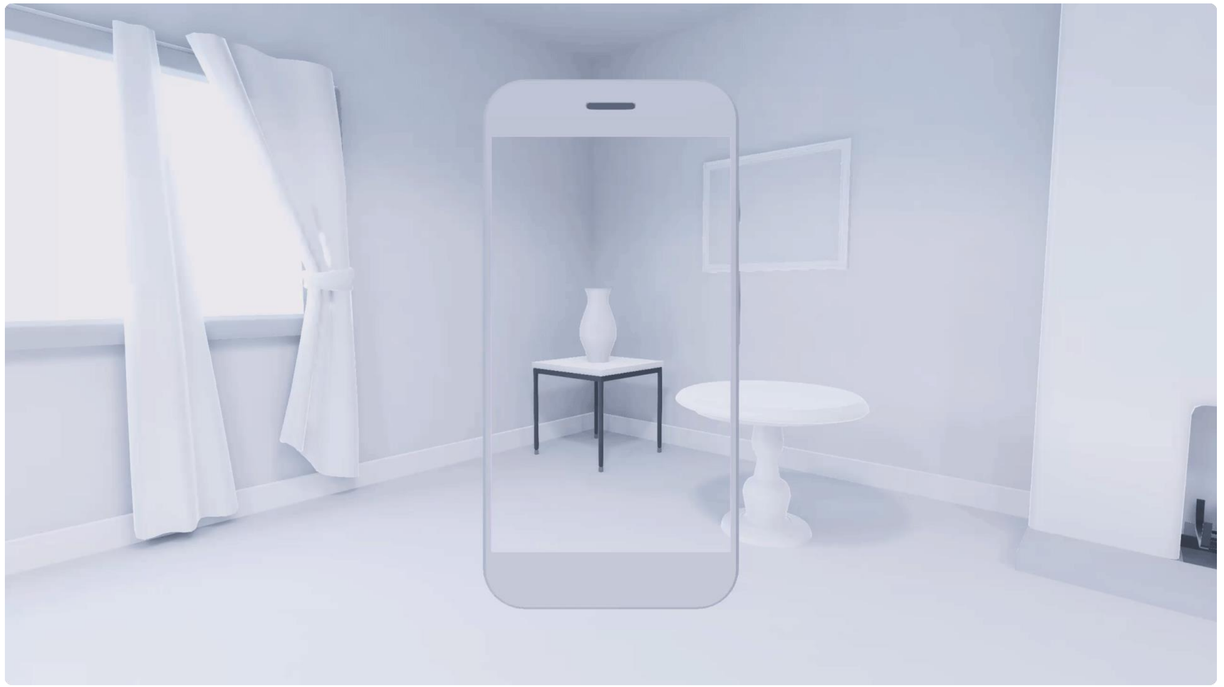
- indicators are fixed or animated

Ux aspects – indicators

- audio feedback
  - reduce the volume when the interaction is interrupted or moving the object out of sight
  - option to mute the sound (for individual objects)
  - avoid playing multiple sounds at the same time

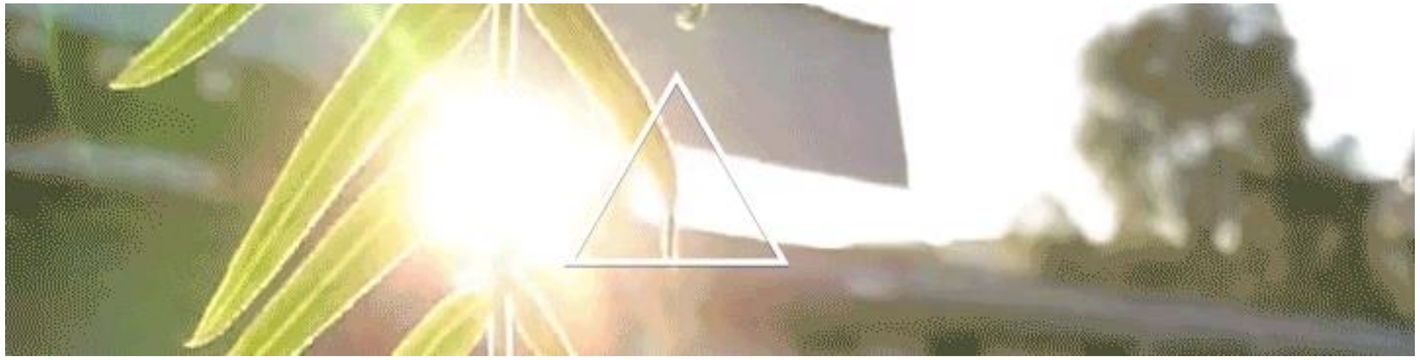
Ux aspects – indicators

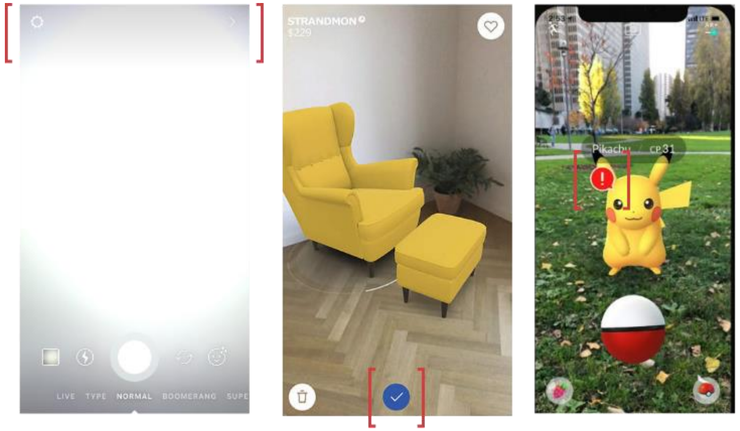
- haptic feedback is NOT welcome
  - differences between technologies on Android phones
  - device shaking is annoying when tracking objects



Ux aspects – text and colors

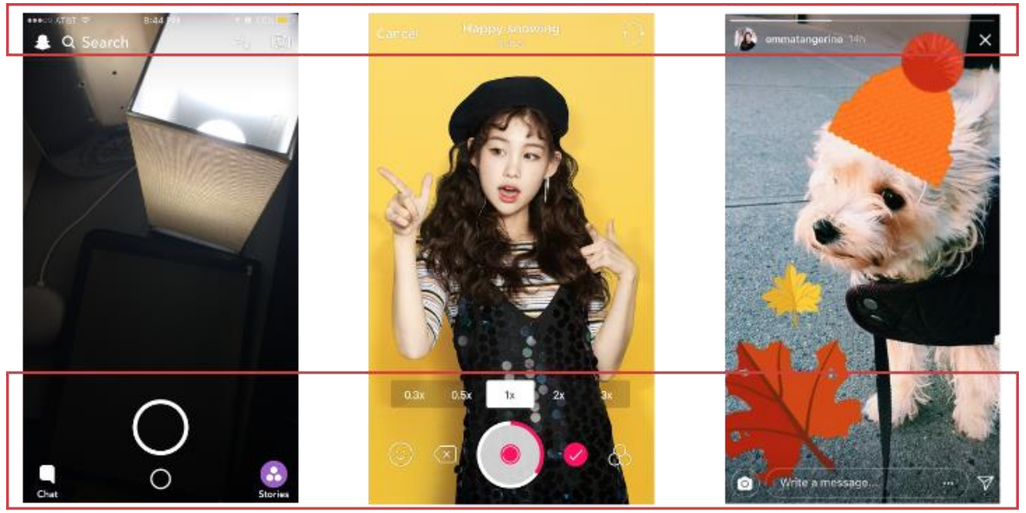
- the most common text color is white
  - added shadows, gradient… so that the elements are more readable in “strong” bright light conditions
- warnings in red color
- additional features / choices with opaque icons

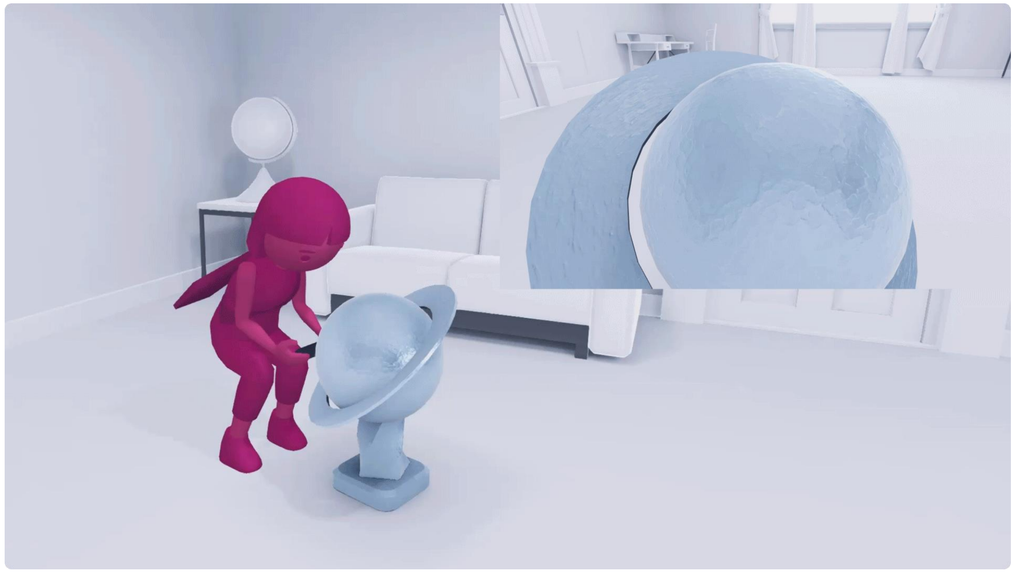




Ux aspects – placement

- fixed elements at the top or bottom
  - e.g. camera management, message writing fields
- (unwanted) transition into objects
  - blurring in case the user inadvertently enters the object by approaching it





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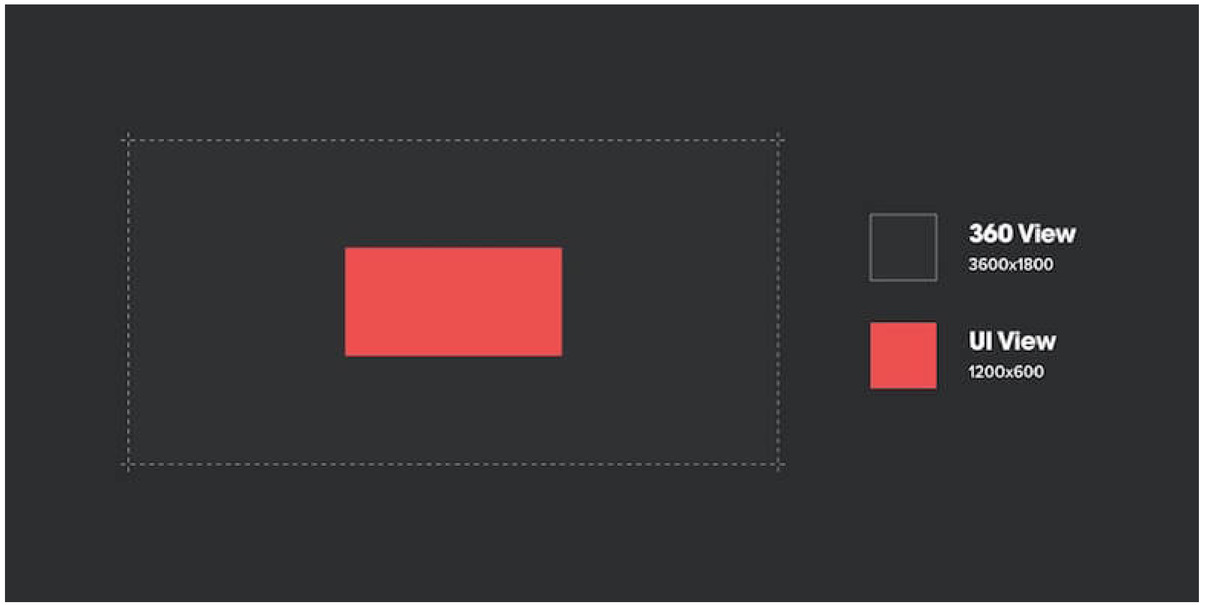
Ux aspects – other

- landscape and portrait
- errors - clear messages about what's wrong
  - the application does not see the marker / scene
  - moving too fast
  - …
- clear and short instructions
  - visual indicators (swipe, move,…)
  - standard uses

User experience in VR

„Scene“ size

- in VR scenes we see about 10% of 360^{o} scene at a time
- entire VR scene usually has a resolution of around 4K (3600 x 1800)
- visible part of the scene is planned in a resolution of approx. 1200 x 600



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picture	manufacturer - model	resolution	refresh rate	view width
	ASUS Windows Mixed Reality	1440 × 1440	90	95
	ANTVR	1080 × 1200	90	110
	ASUS Windows Mixed Reality	1440 × 1440	70	100
	Dell Visor	1440 × 1440	90	110
	FOVE	1280 × 1440	70	100
	GALAX VISION	960 × 1080	60	100
	GameFace	1280 × 1440	90	120

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picture	manufacturer - model	resolution	refresh rate	view width
	HP Reverb – Pro Edition	2160 × 2160	90	114
	HP Windows Mixed Reality	1440 × 1440	90	95
	HTC VIVE	1080 × 1200	90	110
	HTC VIVE Focus	1440 × 1600	75	110
	HTC VIVE Pro	1440 × 1600	90	110
	ImmersiON-VRelia PRO-DG1	1080 × 1920	60	123
	Lenovo Explorer Windows Mixed Reality	1440 × 1440	90	110

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picture	manufacturer - model	resolution	refresh rate	view width
	Oculus Go	1280 × 1440	60	101
	Oculus Quest	1440 × 1600	72	90
	Oculus Rift	1080 × 1200	90	110
	Oculus Rift S	1280 × 1440	80	110
	OSVR	1080 × 1200	90	110
	PIMAX 4K	1920 × 2160	60	110
	PIMAX 8K	3840 × 2160	120	200

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picture	manufacturer - model	resolution	refresh rate	view width
	Samsung Gear VR	1280 × 1440	60	101
	Samsung HDM Odyssey Windows Mixed Reality	1440 × 1600	90	110
	Sony PlayStation VR	960 × 1080	120	100
	StarVR	2560 × 1440	90	210
	Sulon Q	1280 × 1440	90	110
	Valve Index	1440 × 1600	144	130
	Vrvana Totem	1280 × 1440	75	120
	Varjo XR-3			

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Ux aspects of VR

- cyber sickness
  - conditioned by evolution - mismatch of what we see and feel (balance)
  - we can reduce it
    - depends on the scene dynamics


Exploring
cyber sickness

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Reducing the cyber sickness

- limiting alternations between light and dark scenes
- acceleration and braking limitation - steady movements
- constant tracking of head movements and scene adjustments
  - maximum 15ms – 25ms delay

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Reducing the cyber sickness

- usage of higher refresh rates
  - at least 50 fps
- static visual references
  - goggles
  - hat
- user has control over the **movement** at all times
  - exceptions?

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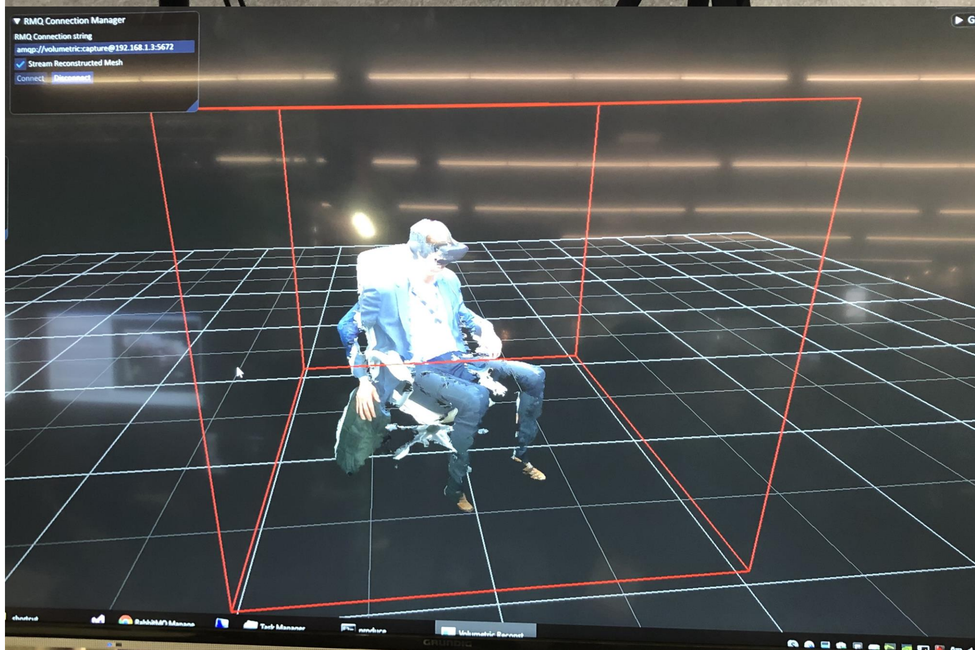
Reducing cyber sickness

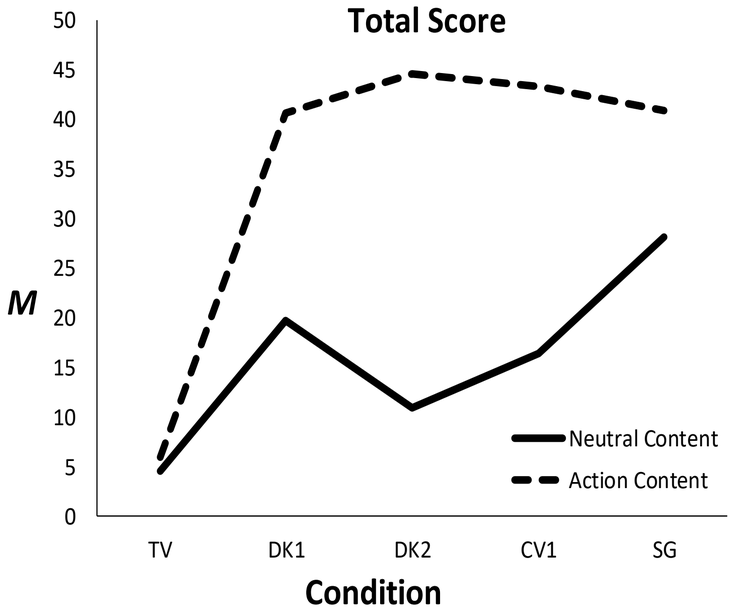
- the user is virtually seated in a

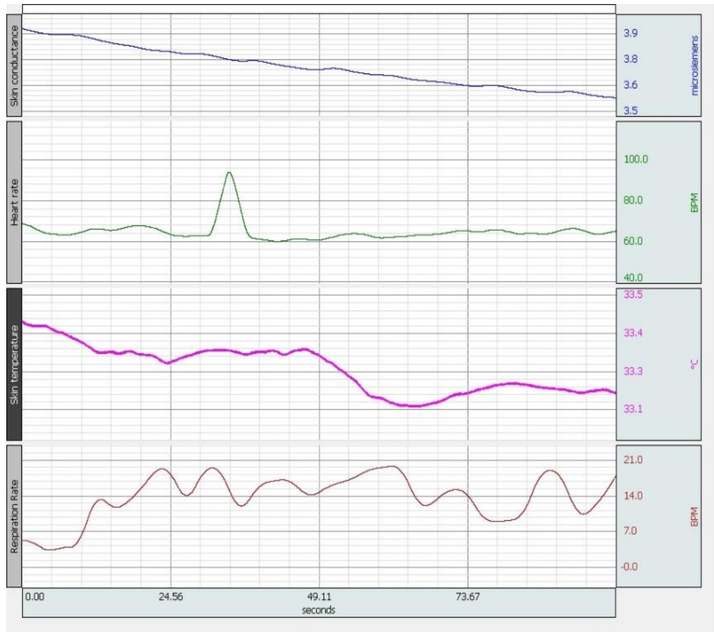
  chair / cockpit
  - showing the user’s body?
- fixed reference points in the given space
  - if large objects move past the user

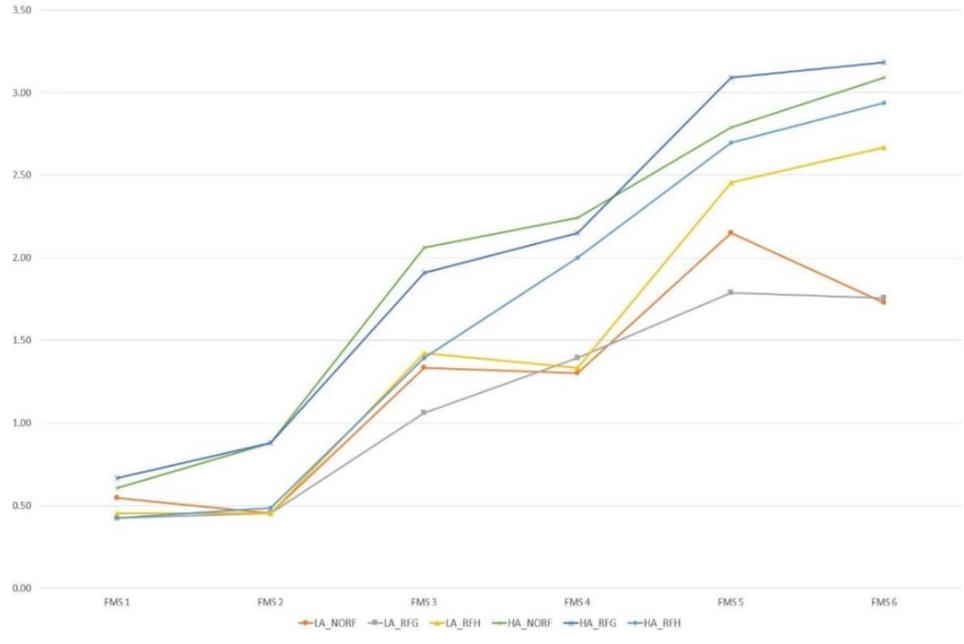


Evaluation of VR sickness

- another workshop/lecture ☺







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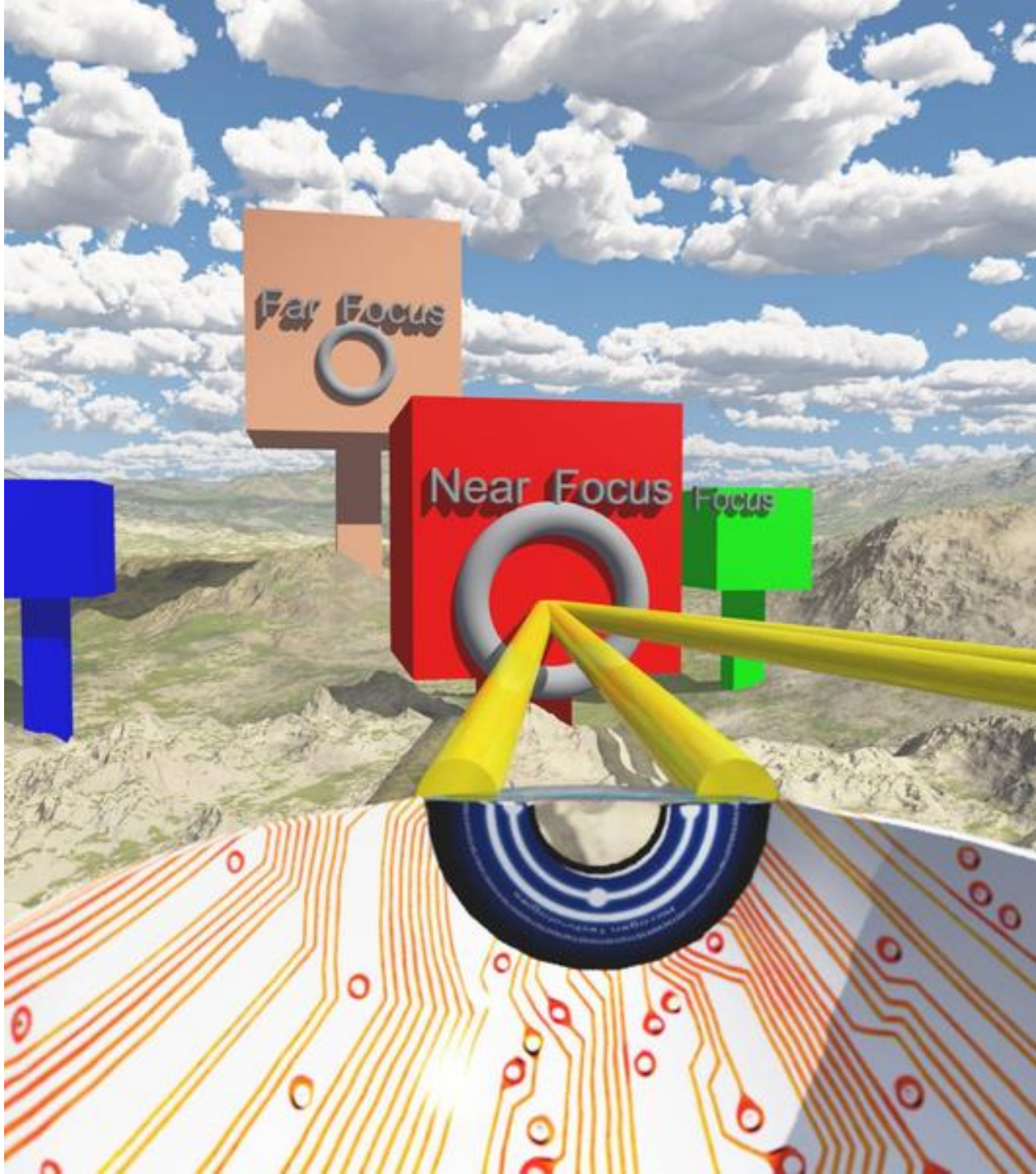
Ux aspects of VR

- in VR the image is in the “right place”– HMD goggles
- the start of the transition to VR mode should be triggered by the user – standard icon
- as natural interactions as possible
  - with hands – leap motion
  - less head targeting => more with controllers

Ux aspects of VR

- creating a sense of depth and space
  - occlusion, relative sizes
  - shadows, textures
  - spatial parallax
- surround sound



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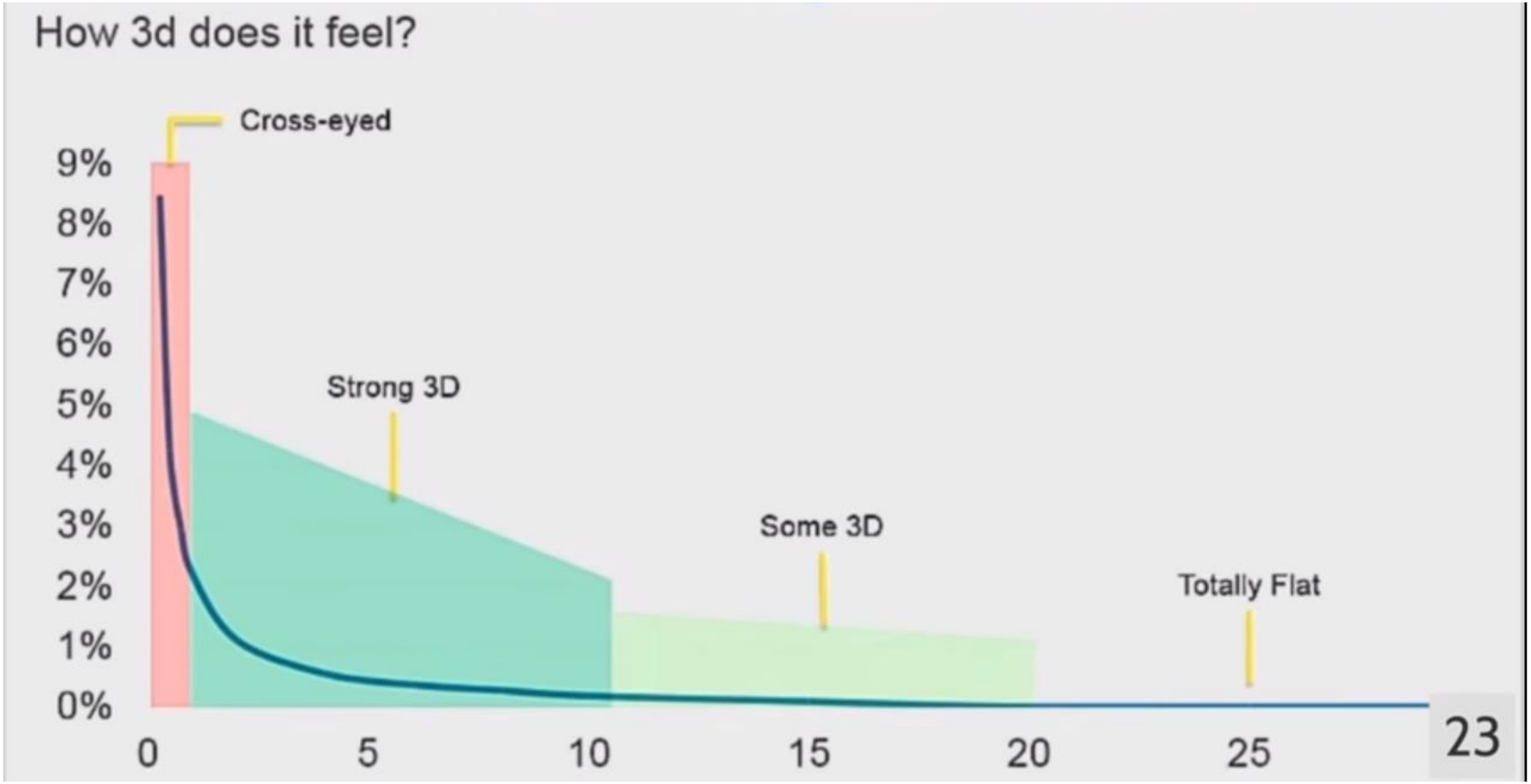
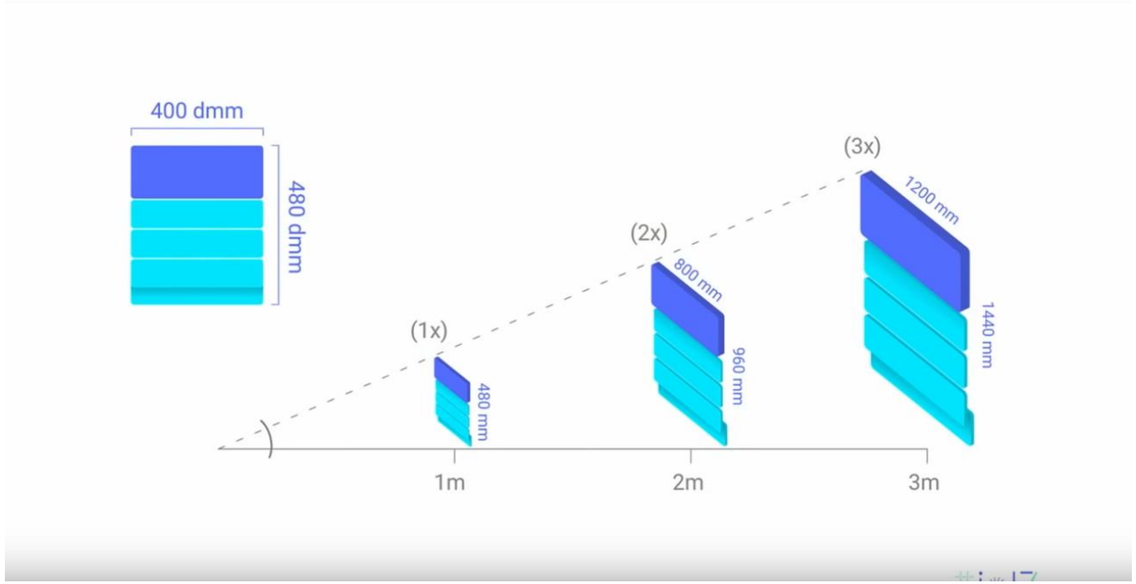
3D impression and distance

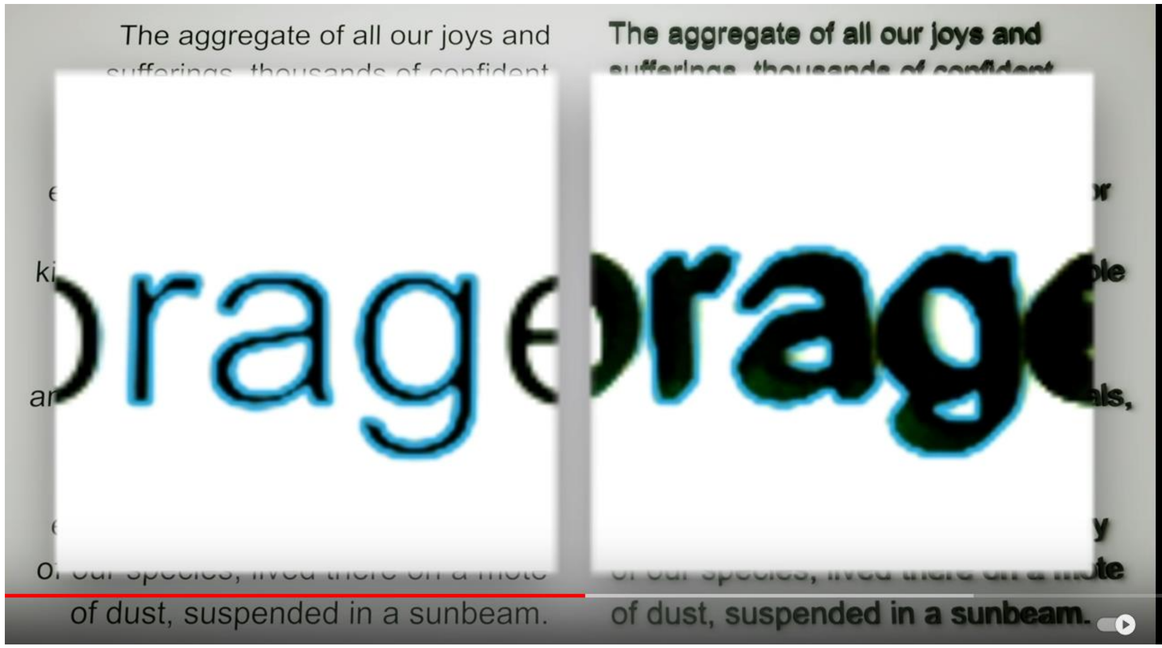


Sizes

- adapt size to distance
  - angular size adapts to distance
  - relative unit is dmm (1 mm per 1m of distance)



- reading text should be 2D and on a surface– people recognize silhuettes
  - 3D text only for decoration, logos,…



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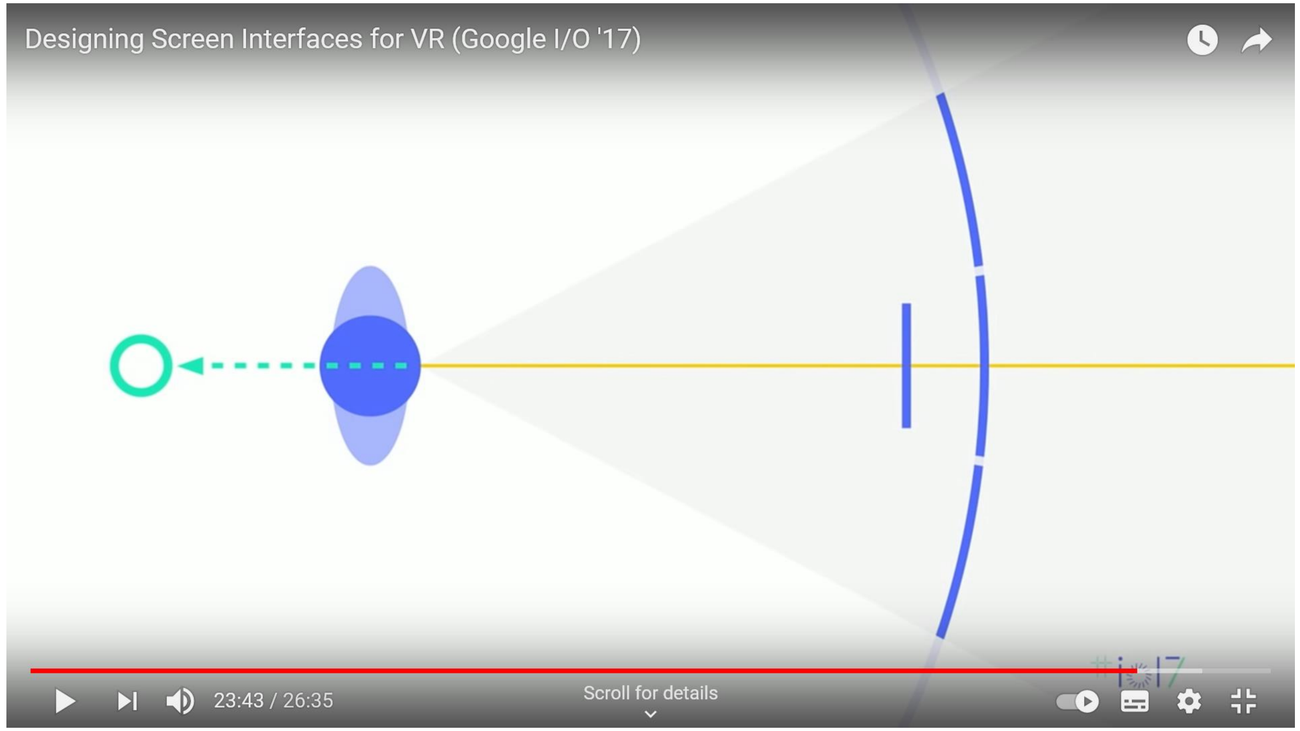
„Screens“ setup

- curved screens a must have
  - Cilinder center is behind the user
  - Smaller elements in the middle don‘t need to be curved

- better view from different positions



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User movement

- a survey on most suitable (fast) movement
  1. seven-league boots (no view scaling, only faster movement)
  2. ground level scaling (view scaling)
  3. eye level scaling (view scaling)

1 2 3

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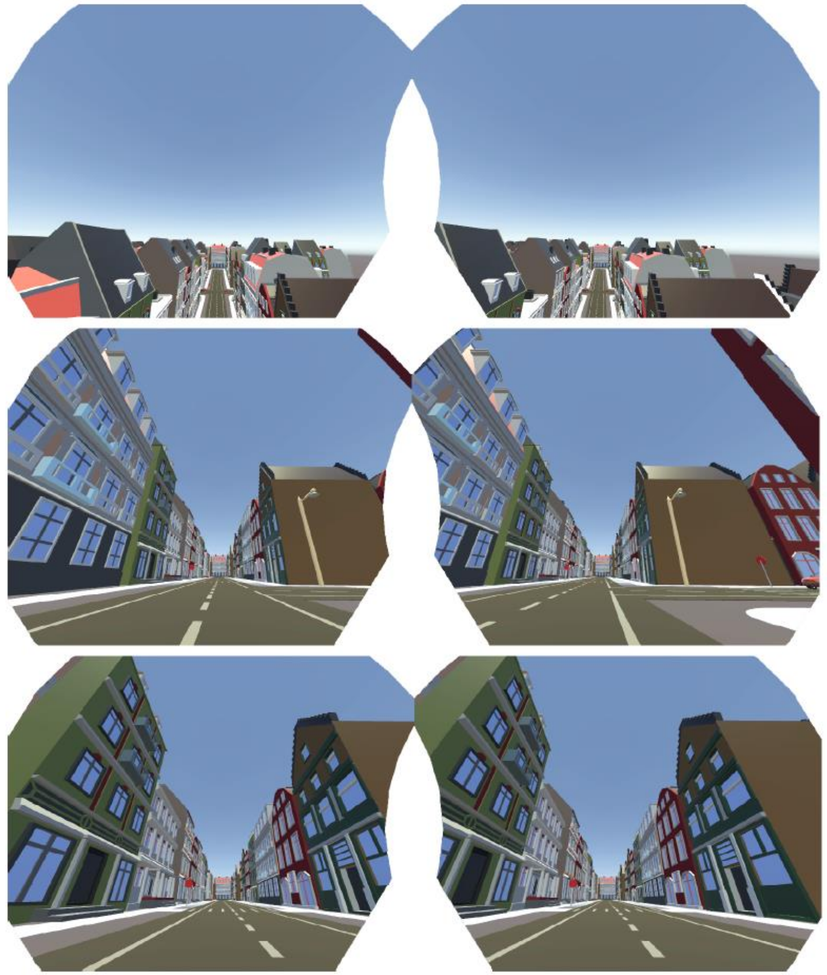
User movement

- scaling needs to be done instantaneously
- ground level scaling was preferred



Ground-Level Scaling

Speed Gain: 30x

Eye-Level Scaling

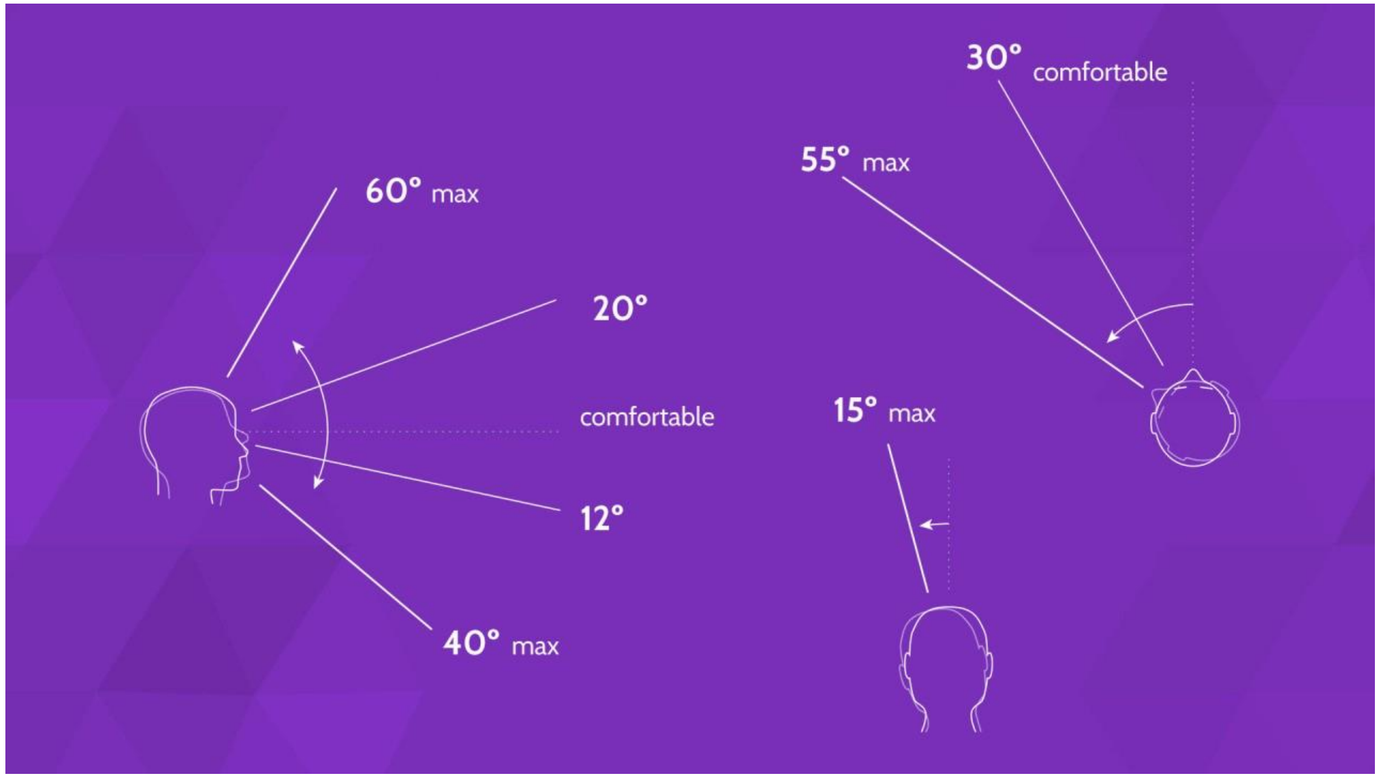
Speed Gain: 30x

Seven-League Boots

Speed Gain: 30x

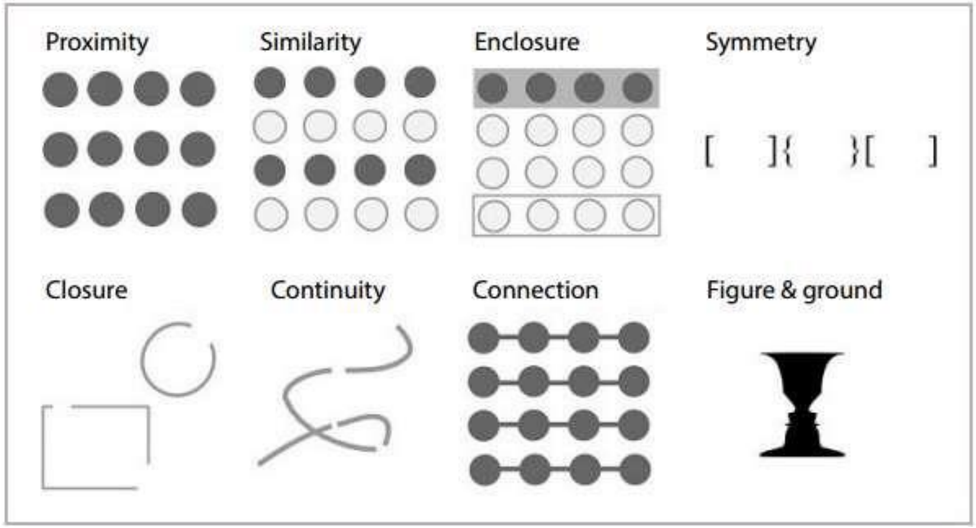
Comfortable and accessible interactions

- up
  - comfortable: 20º
  - maximum: 60º
- down
  - comfortable: 10º
  - maximum: 40º
- left/right
  - comfortable: 30º
  - maximum: 55º
- head tilt
  - maximum: 15º



Ux aspects of VR

- displaying objects
- not "closer than 0.5 m" from the user
- max 70^{o} left and right
- the peripheral zone is up to 105^{o} left and right from the axis of view, where we can still observe objects (interactions are not comfortable)
- the rest of the area is a curiosity zone, which is noticeable and accessible only if the user turns
- Gestalt principles still apply



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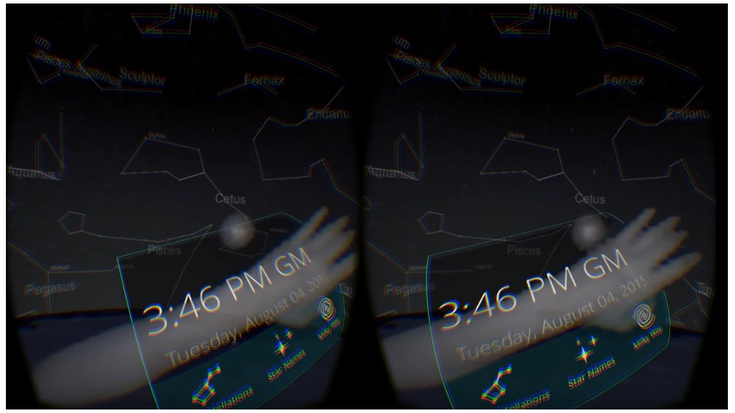
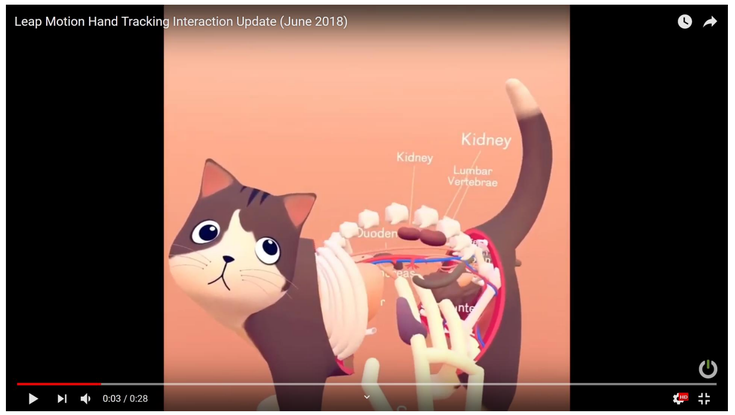
Ux aspects of VR – interactions

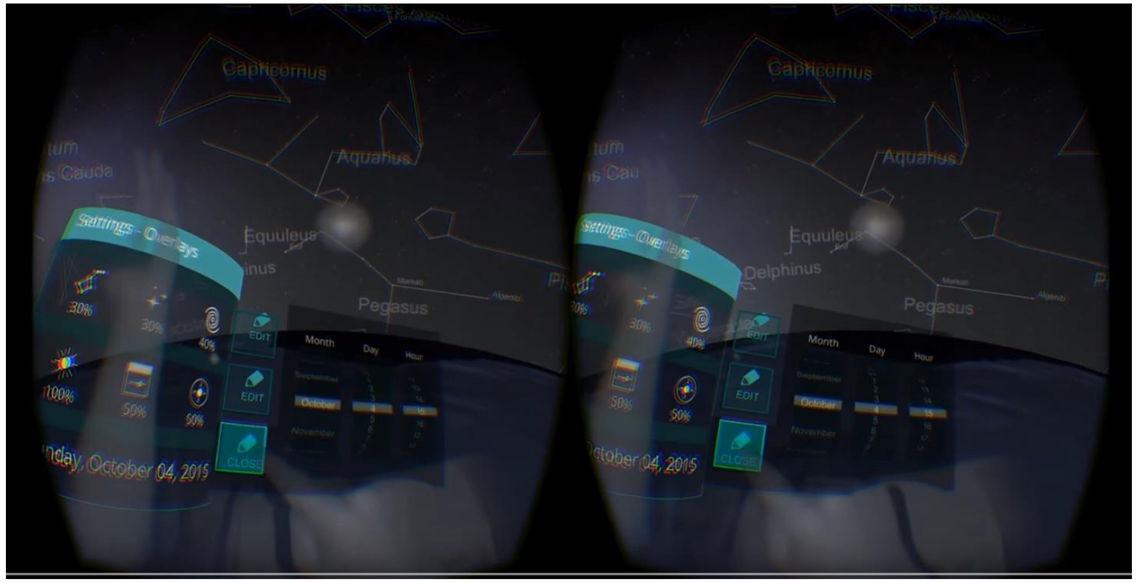
- the possibility of different use of the left and right hand (leap motion)
  - paint brush and color palette
- users expect to be able to interact with objects even though they are “drawn”
  - do not draw door handles if the user can’t grab and use them
  - do not draw a pan with a handle that is in reach
  - it’s important that you don’t demand the whole gesture but just symbolical one, otherwise it can become exhausting





Ux aspects of VR – interactions

- interactions should make sense
  - mixing a magic potion by tilting the bottle instead of “pressing A” to mix the potion
- the user needs to know=see which elements are interactive



Ux aspects of VR – interactions

- an additional dimension requires moving to the object before the interaction begins (6DoF)
  - teleport
  - stretching arms

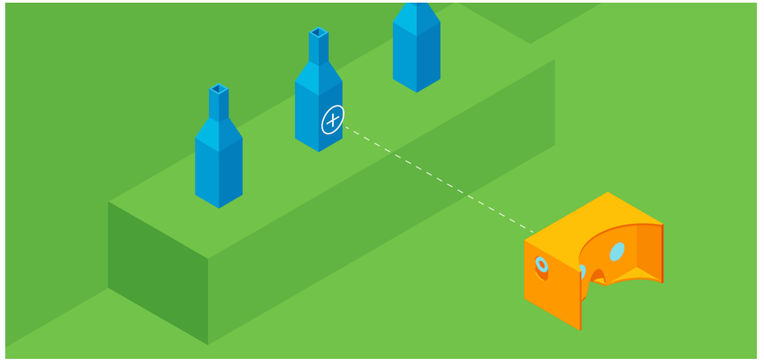
- Teleport – moving over an arc
  - More accurate positioning over long distances
  - Moving behind obstacles (e.g. hills, …)

Ux aspects of VR – interactions

- user load
  - simplified interactions
  - respect the limitations of the buttons on the controllers
    - only one button/move for one action (eg. Shifting gears)
  - drawing a ‚cross' for precise 'targeting' especially in directional guidance with gaze

Ux aspects of VR – feedback

- controllers
  - haptic feedback
    - short pulse / shaking of the controller when touching the target
  - useful for sensing friction, texture, elasticity
    - eg distance measuring, pulling the bowstring (pulse rate increases)
- view control
  - visual countdown timer
  - the size of the “sight” should be adjusted to the distance
  - change of color / light when it’s possible to interact with the object



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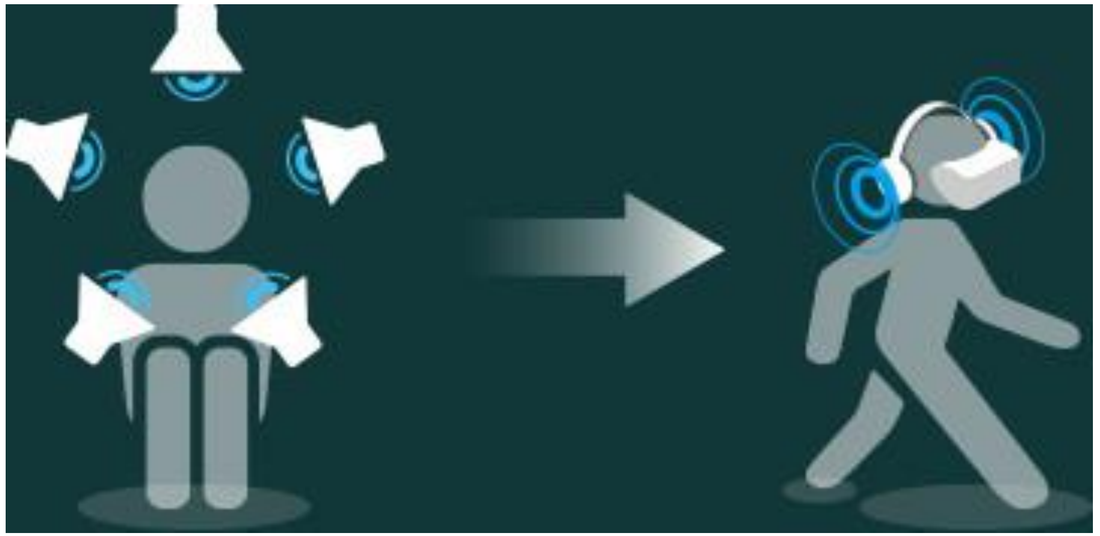
Ux aspects of VR – feedback

- audio
  - spatial audio to determine the direction of “activity”
  - instructions
- the ability for the user to change settings



Other

- inattentional blindness
  - unnoticed gorillas on the field while you're counting the red player's basketball hoop scores
  - it's important to be aware of this and keep important things in focus (unless the game is on the topic of measuring the player's attention ☺)
- when teleporting, it makes sense to indicate the direction and route of teleportation
  - https://youtu.be/_vQo0ApkAtI


360° video

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Why 360° video

- a useful approach to presenting educational content

- benefits:
  - real life examples
  - relatively easy to do
  - can be live
  - can be consumed on any device
- drawbacks:
  - not as interactive as simulations
  - high bandwidth for video

What is 360° video

- omnidirectional, spherical, immersive, 360-degree video, is a clip that captures views in all directions around the camera
- capture with multiple cameras or special cameras with multiple lenses
  - 2 cameras, 4, 6,…

What is 360° video

- possible capture of 3D content

  (separate images for each eye)

- 6DoF video
  - allows you to move around the room
  - usually combined with a 3D view

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Production of panoramic content

- a number of accesible camera models…

http://vuze.camera/

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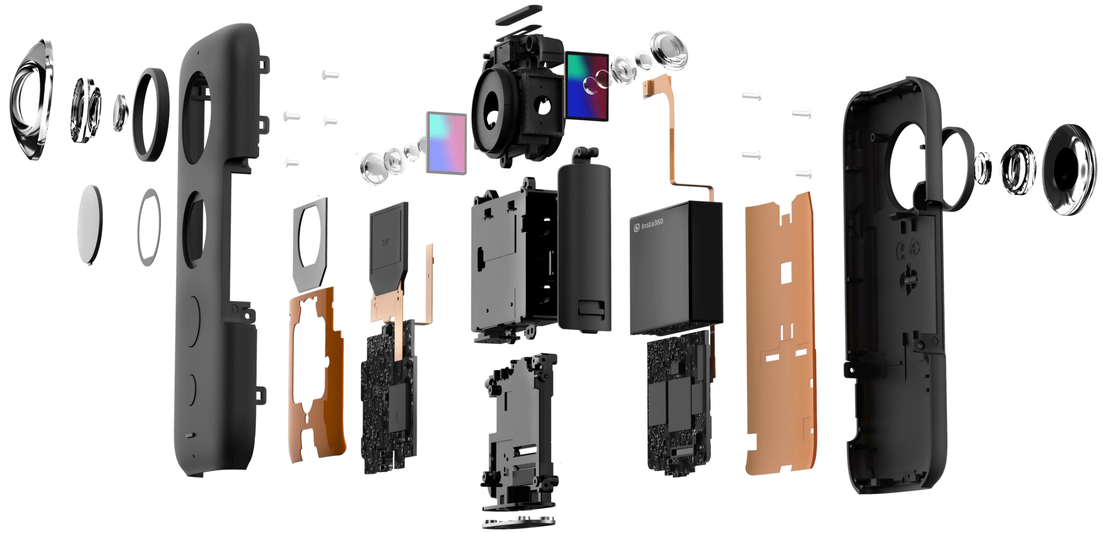
Insta360 One X

- capture
  - 2 lens, 2 microphones
- output
  - 5760*2880@30fps,,
    3840*1920@50fps,
    3008*1504@100fps
  - up to 120Mbit/s with H.264
- cca. 360 EUR (+accessories)



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Ricoh Theta V

- capture
  - 2 lens, 4 microphones
- output
  - 3840×1920@30fps
  - 1920×960@30fps
  - up to 32Mbit/s with H.265 and
  - up to 56Mbit/s with H.264
- cca. 360 EUR (+ accessories)

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HumanEyes Vuze XR

- capture
  - 2 lens, 4 microphones
- output
  - 5.7K@30 fps, 360º video
  - 4K@60fps, 360º video
  - recording in 3D mode(180)º
  - up to 120Mbit/s with H.264
- cca. 400 EUR (+ accessories)

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Insta360 One R

- capture
  - 2 lens, 2 microphones
- izhod
  - 5760x2880@30fps, 360º video
  - 3840x1920@50fps, 360º video
  - 3008x1504@100fps, 360º video
  - supports 3D mode (180 º)
- up to 100Mbit/s with H.265
- cca. 300 - 700 EUR

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GoPro Max

- capture
  - 2 lens, 6 microphones
- output
  - 5.7K@30fps 360º video
  - 1440p
  - up to 80Mbit/s
- cca. 500 EUR (+ accessories)

360° video formats

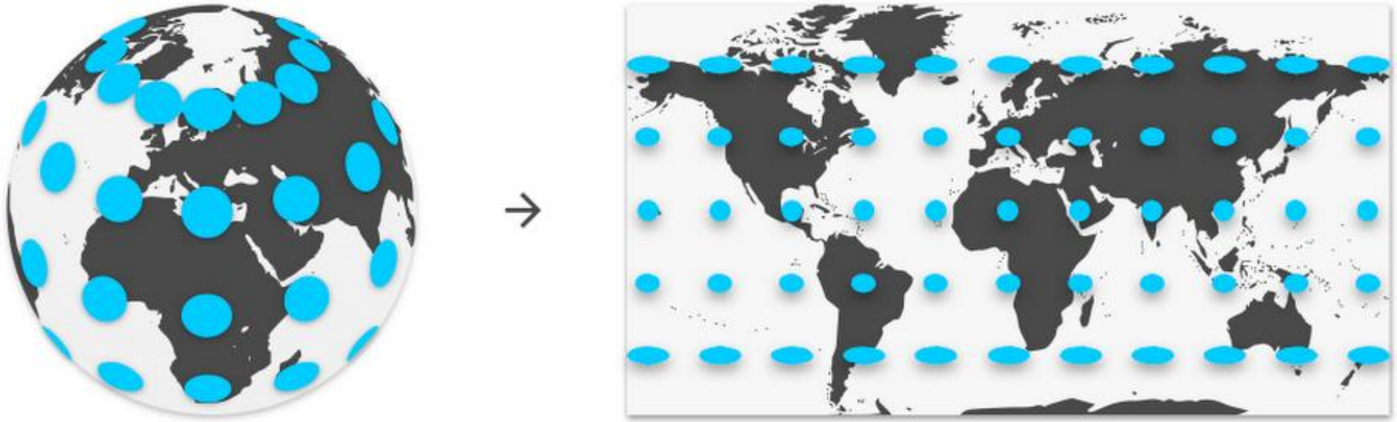
- monoscopic 360°

- stereoscopic (3D) 360°

- stereoscopic (3D) 180°

Problems of 360° video projection

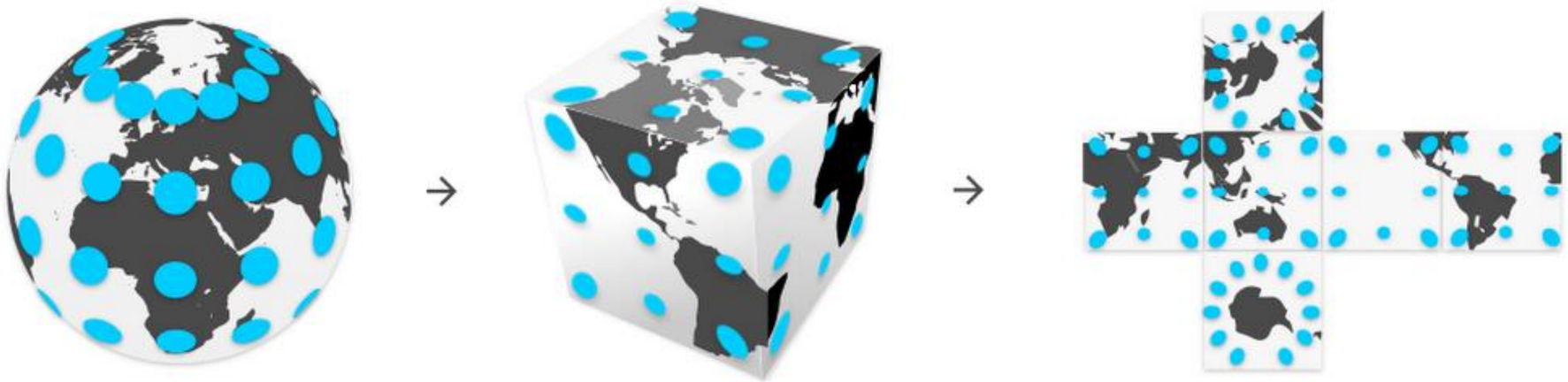
- camera captures the image in the form of a sphere, and then it is necessary to map it to a flat surface for the screen display
- geographical projection - equirectangular
  - the pixels in the ‘north’ and ‘south’ are too large



https://www.blog.google/products/google-ar-vr/bringing-pixels-front-and-center-vr-video/

Problems of 360° video projection

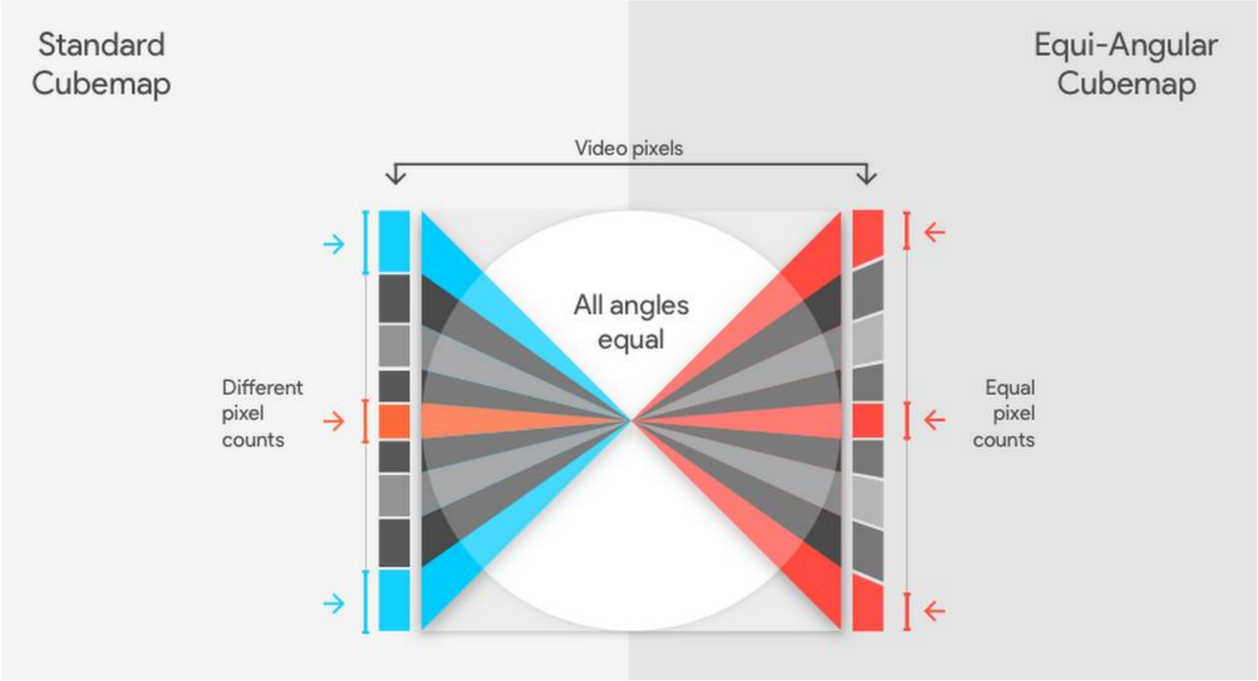
- cube map
  - projection of a sphere on 6 sides of a cube
  - improvement from the geographical projection but still uneven distribution of pixels



https://www.blog.google/products/google-ar-vr/bringing-pixels-front-and-center-vr-video/

Problems of 360° video projection

- equi-angular cube map
  - improvement in terms of reducing mappings numbers of pixels in the corners



https://www.blog.google/products/google-ar-vr/bringing-pixels-front-and-center-vr-video/

Example


Red Bull F1 VR / 360° Video Experience
0:28 / 2:51
Za več podrobnosti se premaknite navzdol
viemr

Different resolutions in practice

- typical Field of View FOV:
  - Oculus: 110°
  - HTC Vive: 110°
  - Samsung Gear: 95°
  - Playstation VR: 100°
- What if we want to see in 3D?

#	360° Video Resolution	Width of FOV Angle	FOV Video Resolution	Wasted data
1	4K : 4096x2048	120°	1280x720	90 %
2	4K : 4096x2048	90°	960x540	93.75 %
3	4K : 4096x2048	60°	640x360	97.22 %
4	16K: 16384x8192	120°	5120x2880	90 %
5	16K: 16384x8192	90°	3840x2160	93.75 %
6	16K: 16384x8192	60°	2560x1440	97.22 %
7	24K: 24576x12288	120°	7680x4320	90 %
8	24K: 24576x12288	90°	5760x3240	93.75 %
9	24K: 24576x12288	60°	3840x2160	97.22 %

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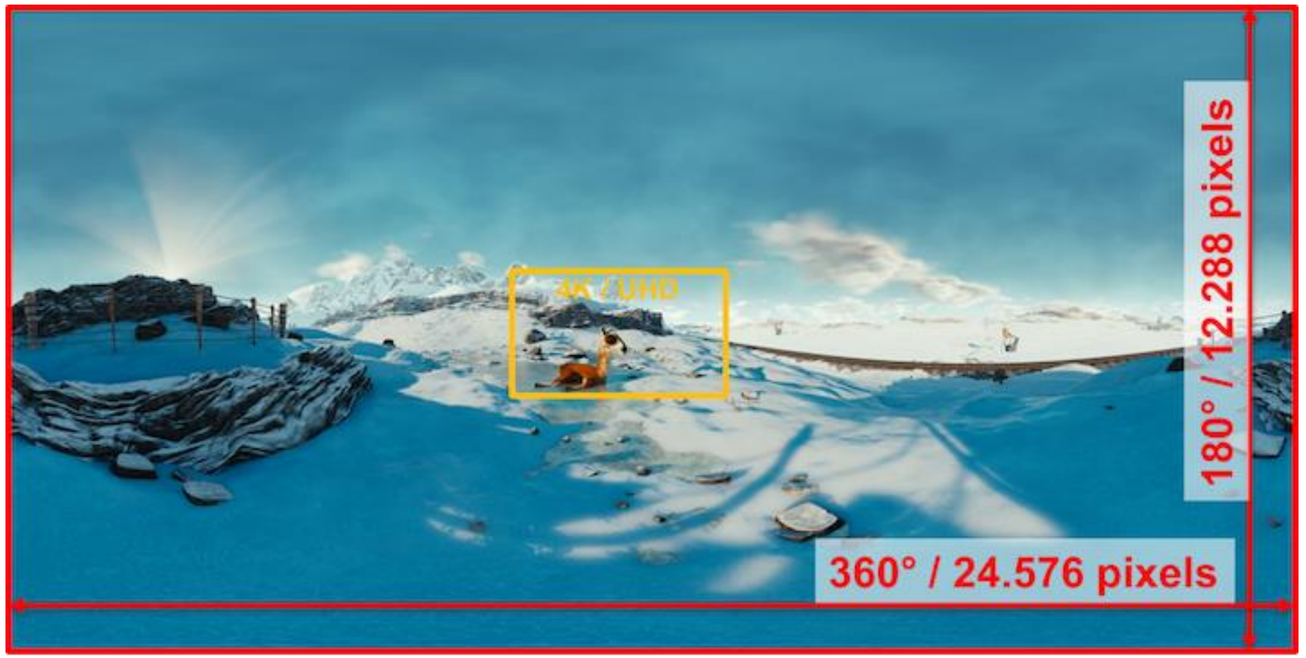
Optimal resolution?

- a human eye resolution is around 60 pixels per degree
- requirements for 360° video:
  - 360° horizontal and 180° vertical would take 21.600 x 10.800 pixels
  - closest video standard is 24K (24576 x 12288 pixels)
- HMD requirements:
  - 120° horizontal and 120° vertical would take 7.200 x 7.200 pixels
  - Varjo XR3?



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14° FOV with 2K resolution

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14° FOV with 4K resolution

14° FOV with 8K resolution

14° FOV with12K resolution

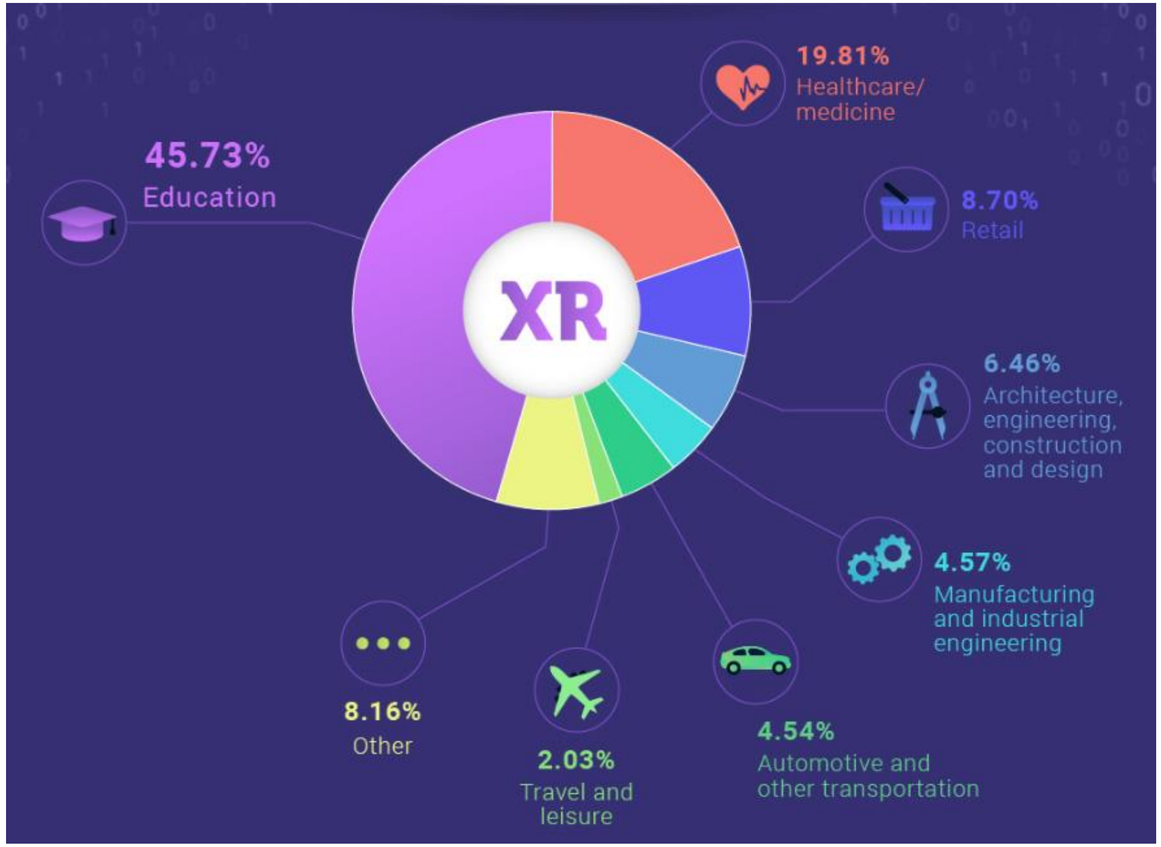
14° FOV with 24K resolution

Trends and challenges

Trends

- more of everything
  - resolution => 4k+, 8k+, 16k,…
  - temporal resolution => 60/90/120 Hz+
  - new display technologies
- no wires - wireless
- eye-tracking systems
- blending of VR and AR / MR worlds

  (space awareness)
- interactions and haptics



Challenges

- new technologies

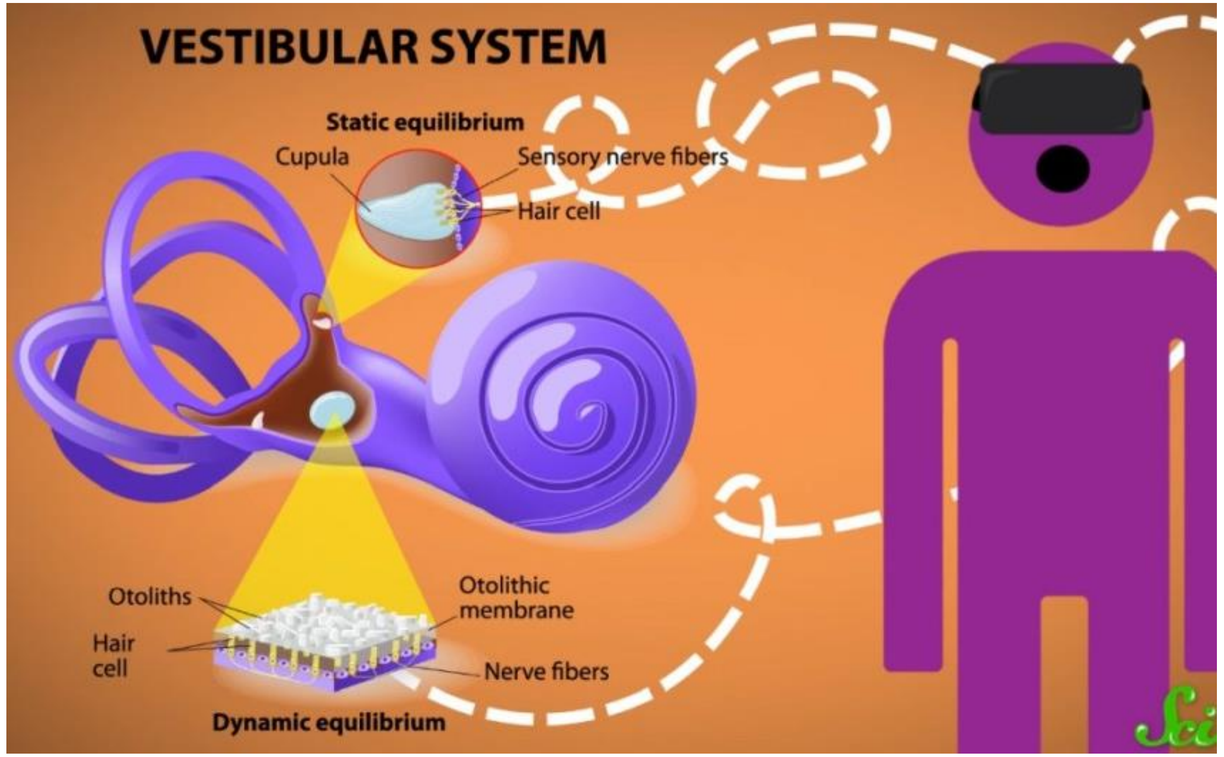
  (and problems)

- social influences / associativity

- eye fatigue

- cyber sickness

- Do we really need all this at all?



Discussion