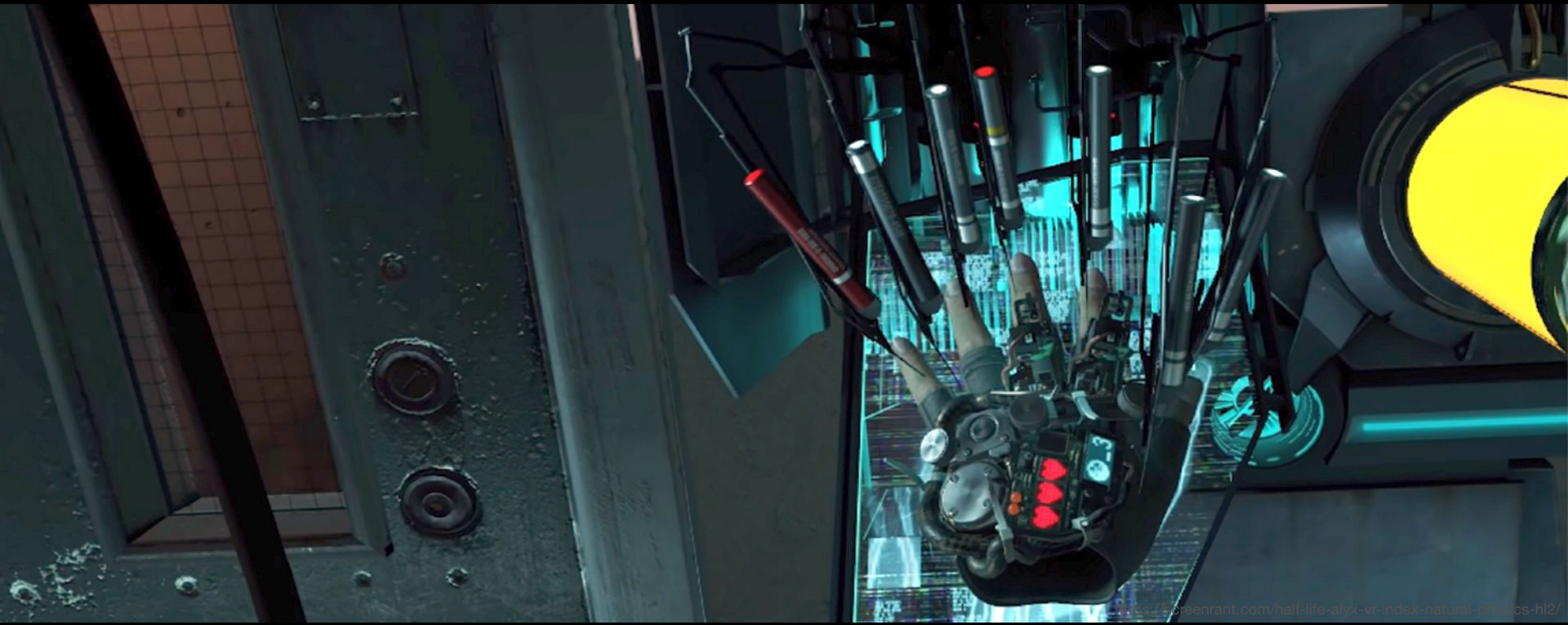
Virtual & Augmented Reality

WS 2025



VR Locomotion

BHT

OVERVIEW

- Was ist Locomotion
- Locomotion in VR
- Locomotion Inputs
- Teleport
- Other Movements
- Locomotion Tricks

LOCOMOTION

- Locomotion: „*movement*“ or „*the ability to move from one place to another*“

- Necessary to reach other areas in a game
- Type of locomotion often depends on camera view in the game
  - sidescroller: x,y movement
  - 3D: x,y,z movement
- Movement in classic computer games mostly with buttons (left, right, up, down) or joystick (vector 2 / float 2)

LOCOMOTION IN VR

- One of the big research topics of VR
- Because of immersion we want to interact with the world
- Biggest challenge:
  - Intuitive
  - Mismatching locomotion can trigger motion sickness

Beispiel Railshooter: wie Motion Sickness vermeiden, wenn man beschleunigt/bremst?

“CLASSIC” INPUT

keine/schlechte Lösung:

- First VR games and some non-exclusive-VR Games use more classic input
- Keyboad or Game Controller
- Often not intuitive or comfortable
- Inputs:
  - Joystick for Walking
  - Buttons for Rotation

HARDWARE BASED LOCOMOTION

hardwareabhängige Lösung:

STANDING VR / SEATED VR

designabhängige Lösung:

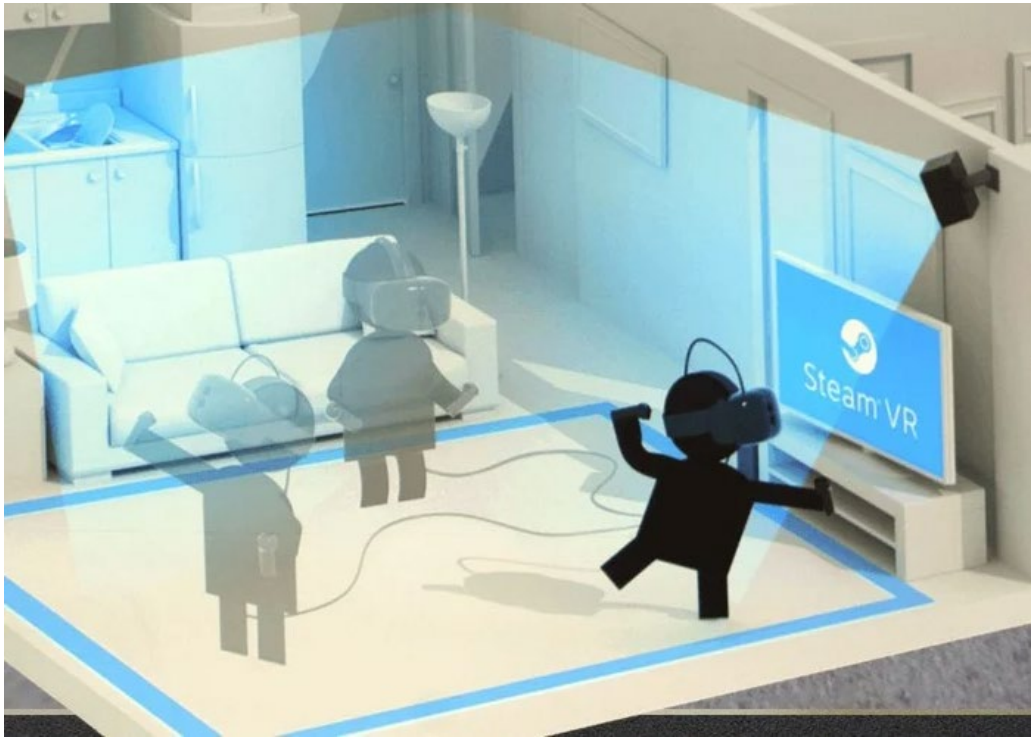
- Applications were the user only needs to stay at one place to experience the VR application
- Movement not necessary or more indirectly available (forced motion, teleport, other techniques)

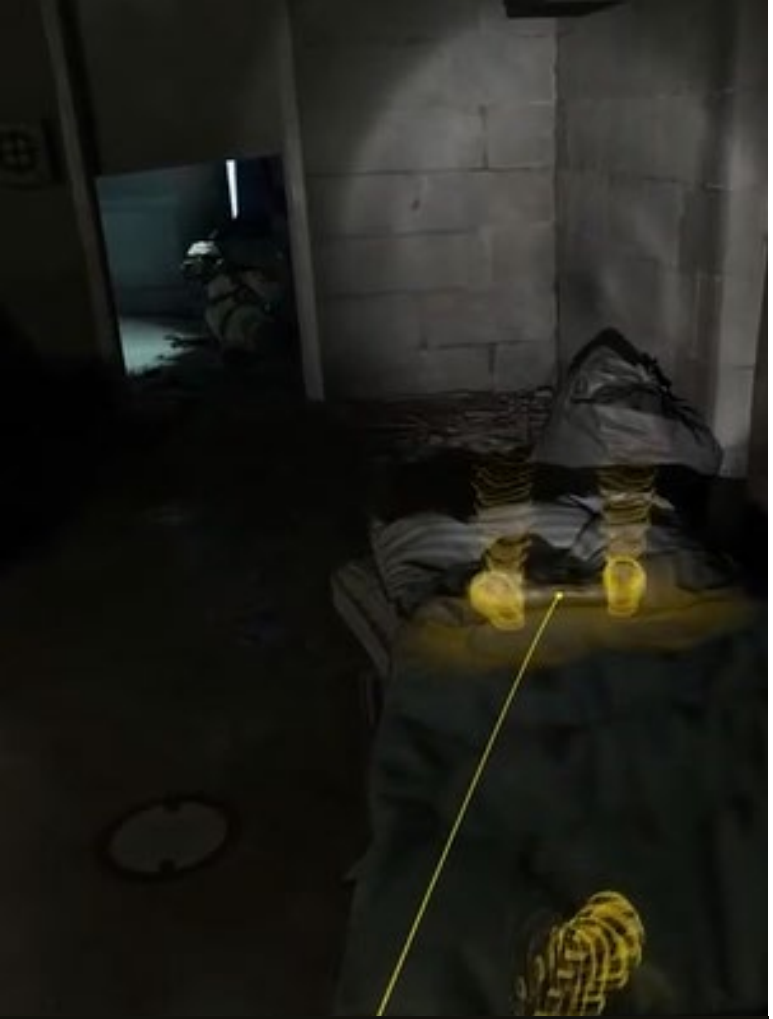
Star Trek Bridge Crew

NATURAL WALKING

realsynchrone Lösung:

- Natural walking allows walking in a defined tracking space
- Tracking of Headset translated into a 1-on-1 movement in VR
- Very comfortable and intuitive
- Constrained by borders → in hectic situations borders could be ignored





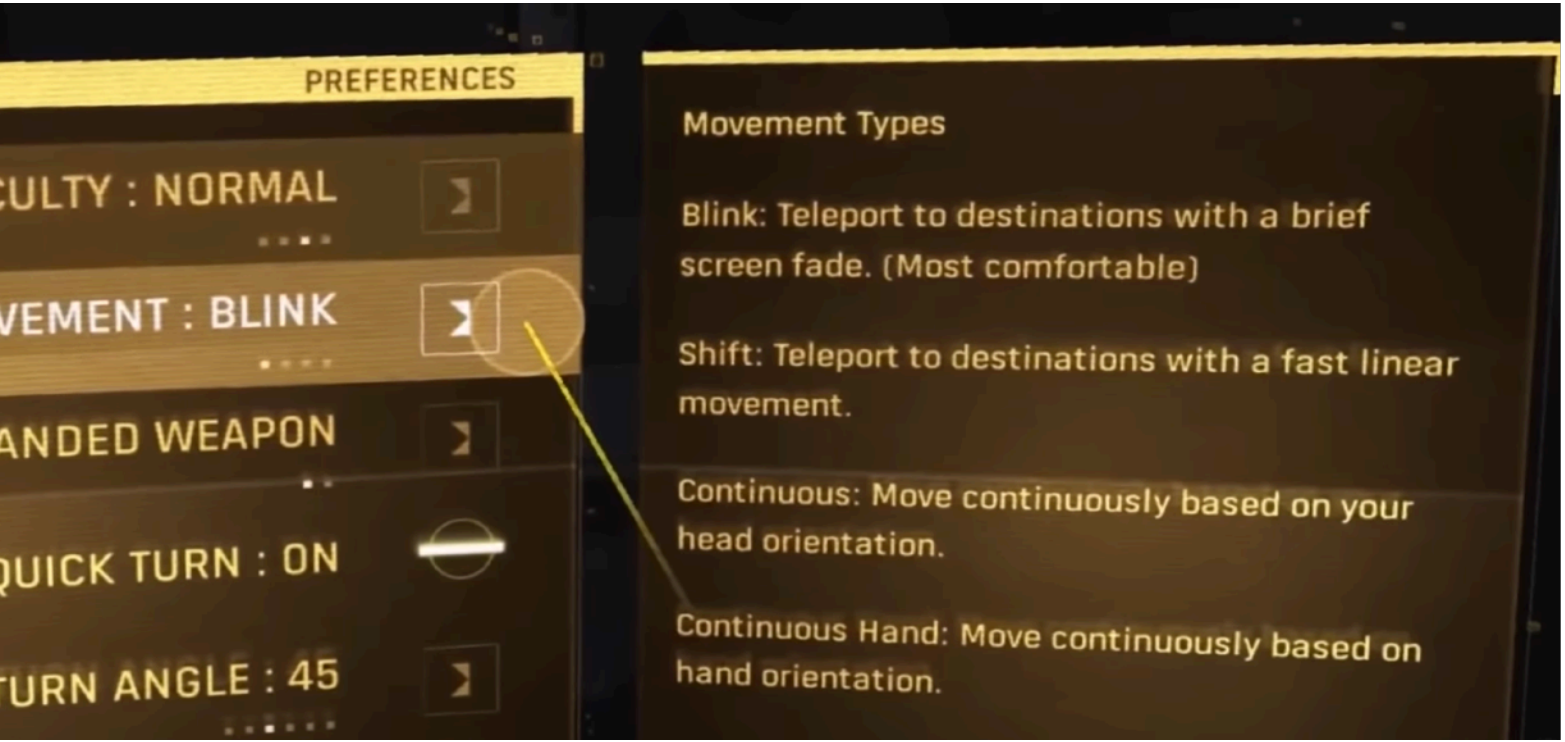
TELEPORTATION

- One of the most common locomotion techniques currently in VR applications
- Still allows for natural walking in the tracking space
- Pointing to a destination, where the player will be teleported
- Blink teleportation: screen gets black for a frame and the player is moved there
- Shift teleportation: player is shifted to the position in high speed

INTELLIGENT TELEPORT

- Half Life Alyx introduced a very intelligent teleport, which supported the level and interaction design:
  - Showing feet at the destination to help the player image where he/she will end up
    - Showing of virtual footsteps helped to understand, why not all destinations could be reached
  - Calculating the destination height to evaluate if the player could reach it – sometimes a player would need to crouch to be able to reach am area with a low ceiling
  - Distance and means to reach the spot – like reaching a higher spot only after “climbing” onto a box
  - Floor prioritization: to avoid climbing onto objects accidentally in stressful situations – matching people's expectation rather than explicit input

INTELLIGENT TELEPORT



https://www.youtube.com/watch?v=u9Nj1lYyQml

TELEPORT DASH VS TELEPORT BLINK

- Different Implementations for teleport:
  - Dash: Very quick animated forced movement to the target location
  - Blink: teleport to the target location while fading the screen quickly to black and back

TELEPORT + ENABLED NATURAL WALKING

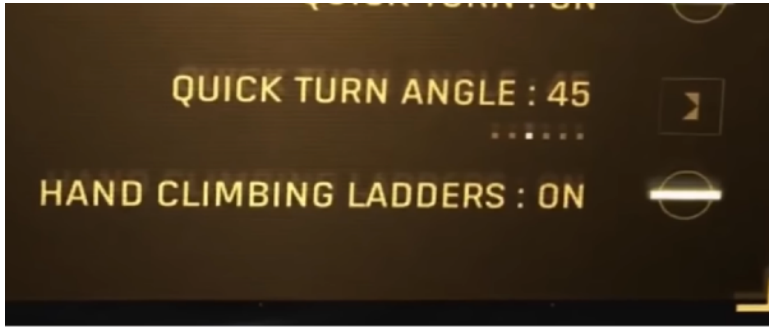
- If teleport is available, players tend to use it a lot instead of natural walking, even if the space is available
- Too often tracking space is not used
- By designing specific teleport locations and designing the level around it, players are forced to explore the rest by walking, crouching etc.

ROOMSCALE

CONTINUOUS

CLIMBING

- Special case ladder mechanic:
- climb instantly (teleport blink/dash) after a hold-to-complete interaction
- climb with your hands
  can even hold with one hand and shoot freely with other



CLIMBING

- The Climb – Crytek
- Locomotion by climbing
- Whole level is designed for grabbing and dragging

- People actually fell on the ground, when falling in the game

ARMSWING

- Humans tend to move their arms while walking (Walk Cycle)
- Leverage the arm swings of the walk cycle for motion instead of feet motion
- Intention of walking vs. other interactions movements

OTHER EXAMPLES

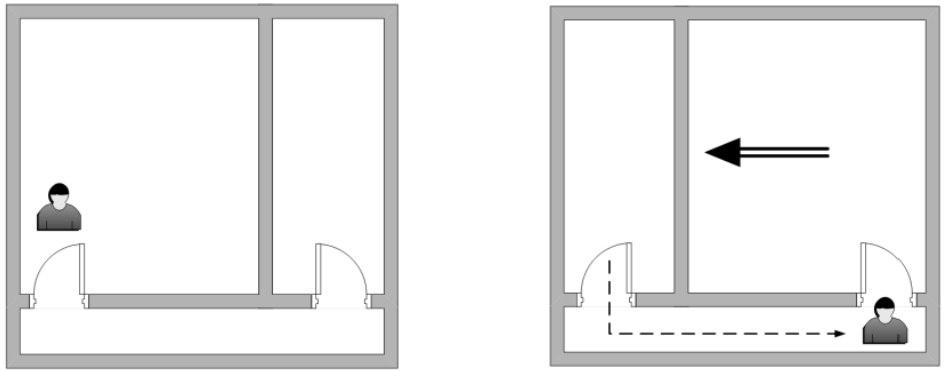
„dank“ VR viele Möglichkeiten zum Erforschen:

- Jet Island → steer a hoverboard by using both controller for
- Walking with tracked feet → putting controllers onto the feet
  - Interact and walking (For example being a giant in a city)
- Dribbling a ball while moving
- Swimming motion under water
- Steering a vehicle with controller motions (steering wheel, wheelchair, spaceship)
- And more….

LOCOMOTION TRICKS

IMPOSSIBLE SPACES – ALMOST LOCOMOTION

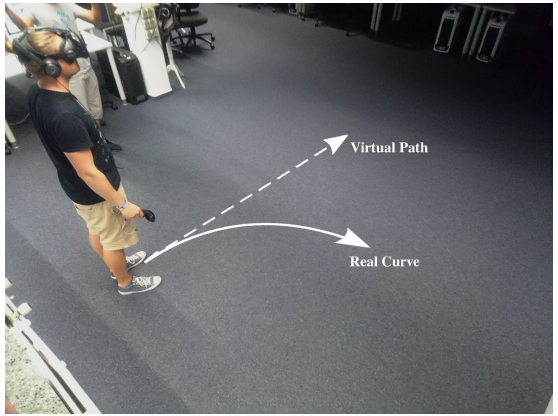
- Using the tracking space more effectively
- Not possible in reality, but in VR based on the user's viewpoint rooms can take up the same space in the tracking space



REDIRECTED WALKING

- Human perception doesn‘t register small induced changes
- subconciously the player will compensate the changes
- these imperfection can be utiziled to rotate or translate the player in the virtual world

- Lack of usage in real applications because of the development overhead



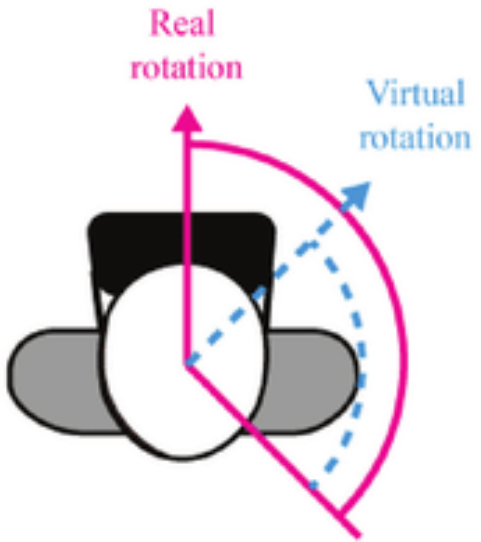
Langbehn et al. 2018

When and how much can we introduce changes?

ROTATION GAIN

- Continuous added rotations
- Increase or decrease real rotation

- added up to 49% or reduced 20% to be unnoticeable

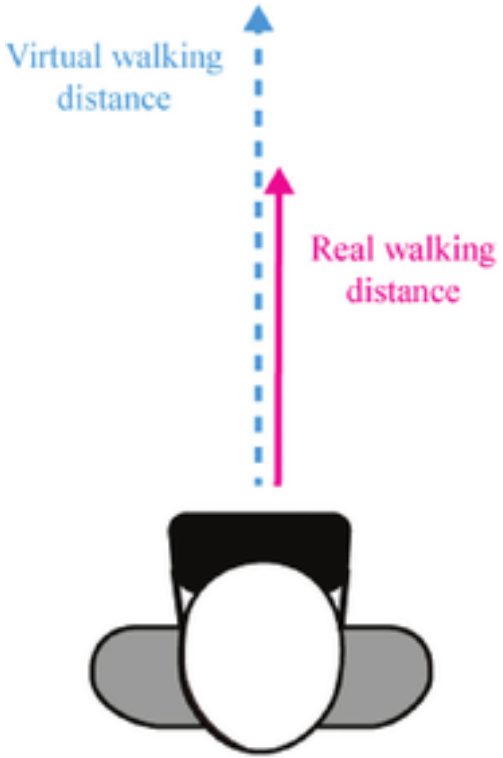


Nilsson, Niels & Serafin, Stefania & Steinicke, Frank & Nordahl, Rolf. (2018). Natural Walking in Virtual Reality: A Review. Computers in Entertainment. 16. 1-22. 10.1145/3180658.

TRANSLATION GAIN

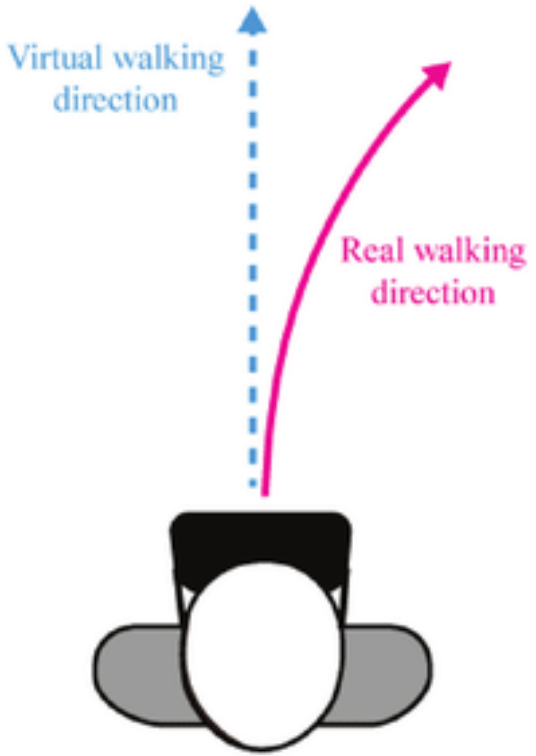
- Translation = movement
- Increase or decrease translation

- Can be 26% or down-scaled by 14%



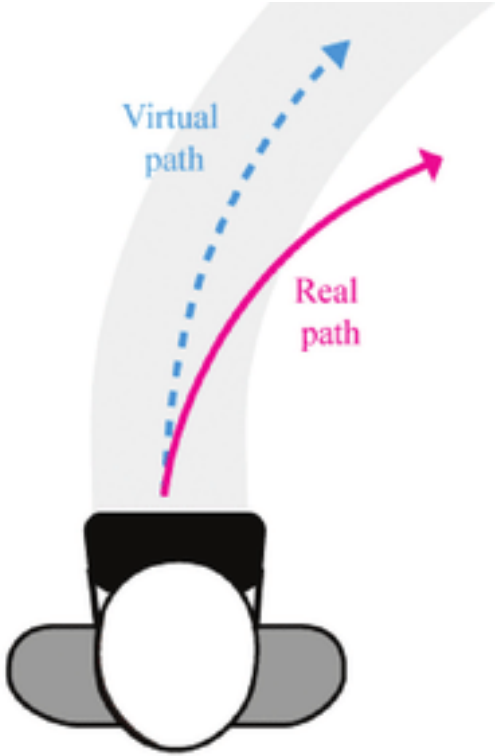
CURVATION GAIN

- Rotate the walking direction while walking down a path
- If the tracking space is large enough a person can be walking endless in a circle while thinking they walk a straight line



BENDING GAIN

- locally warps the virtual scene geometry so straight paths appear curved (or vice versa)
- bending the virtual environment around the user so their real walking direction maps to a different virtual heading
- can redirect users more strongly in short spaces.



INTERACTIONS

- Focus of interactions can be leveraged for Redirected Walking
- Change Blindness: We often won't notice big changes, while our focus is shifted onto something else
  - Very famous experiment: People playing Basketball, while a Gorilla (someone in a costume) walks/dances through
  - A lot of people fail to perceive the Gorilla, because on their focus on the Basketball (Of course of you know, it is easy to see)
- Different interactions can get the focus

Gorillas in our midst: sustained inattentional blindness for dynamic events

https://www.drjoebio.com/uploads/1/8/1/3/1813500/gorrila_in_our_midst.pdf

Figure 3. A single frame from an additional experimental condition in which the gorilla stopped in the middle of the display, turned to face the camera, thumped its chest, and then continued walking across the field of view. Subjects performed the Easy monitoring task while attending to the White team, and the noticing rate was similar to that in the corresponding condition with the standard (shorter) Opaque/Gorilla event.

BLINKING AND SACCADIC EYE MOVEMENT

- Add rotations during blinking
- Temporarily blind, small shifts of the scene can go unnoticed

- rotation during saccadic eye movement
- During fast eye movements between two focus points, the brain does not update the image and small changes can be introduced

REDIRECTED WALKING ALGORITHM

- Goal orientated algorithms:
  - Always has goal, where the user is steered towards
  - Rotation based on goal and current position in tracking space
- Generalized Algorithm:
  - Level design unspecific
  - Example: Steer-To-Center, Steer-To-Target (of the tracking space), other variations

- research area to get RDW consumer ready

DONE!

The Climb: https://www.youtube.com/watch?v=0ICNrzeA1Q8

Gorilla Tag: https://www.youtube.com/watch?v=HV1O9TaK_qg