Human-machine interaction in virtual reality

Paul MacNeilage, Psychology
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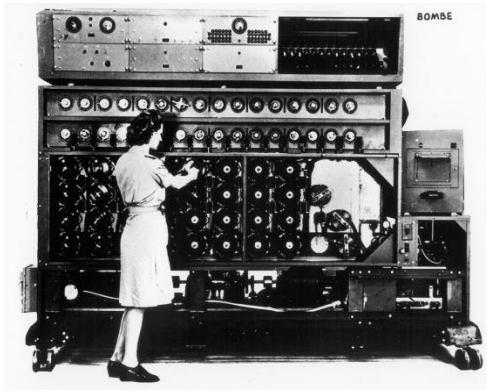
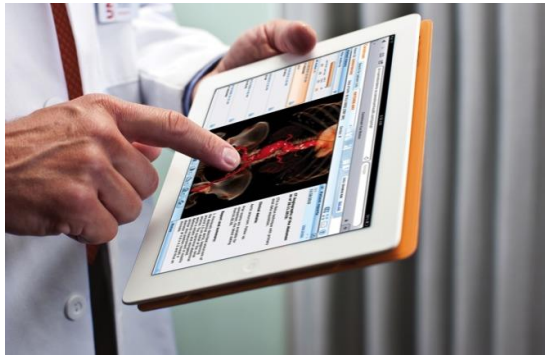
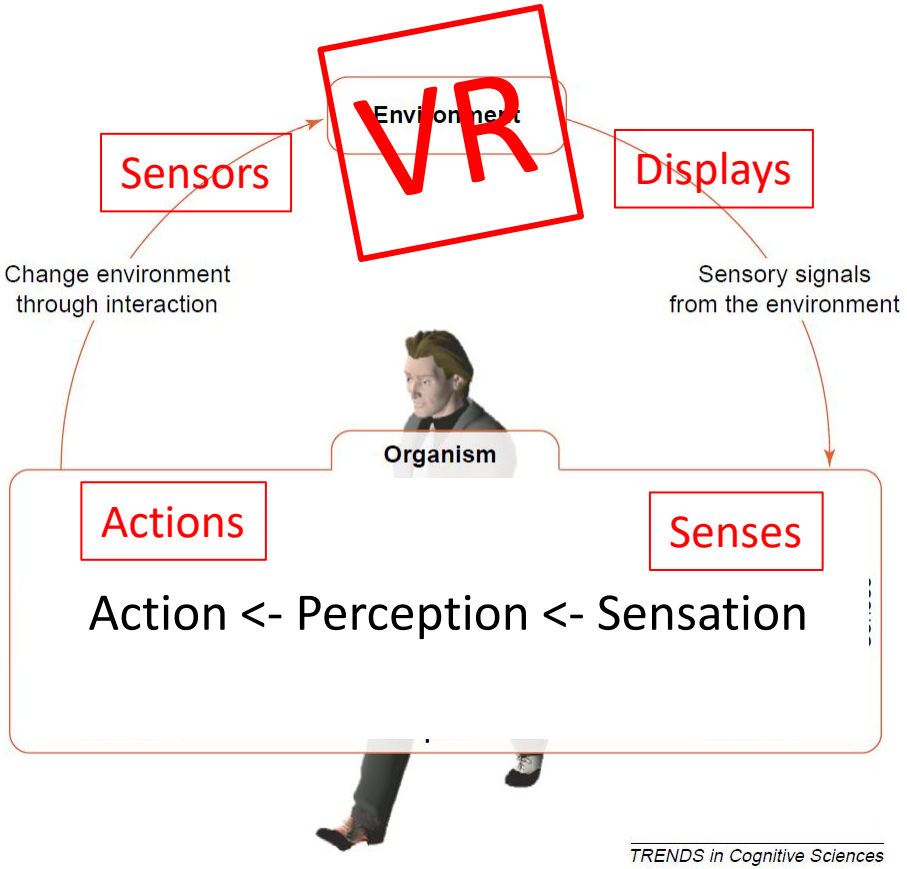
VR/AR as Next Gen Interaction





VR is Interactive



- Major strength of VR
- Interaction leads to presence

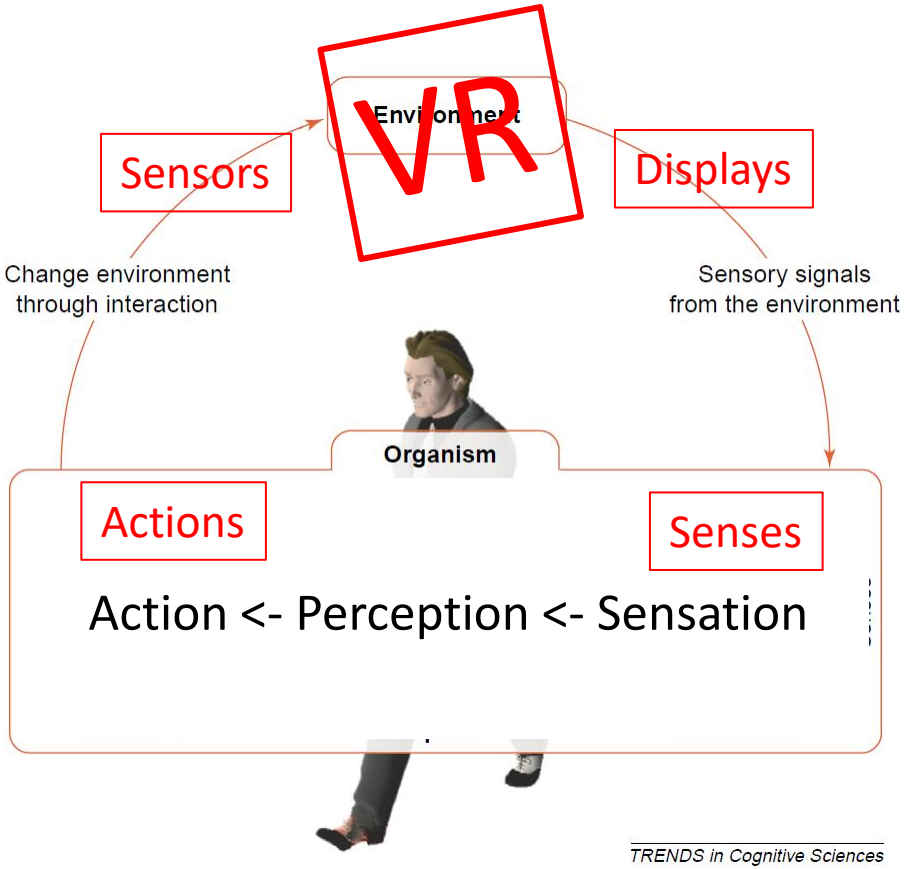
Universal Simulation Principle

- “Any interaction mechanism from the real world can be simulated in VR.”

Really?!

Anything?!

VR is Interactive



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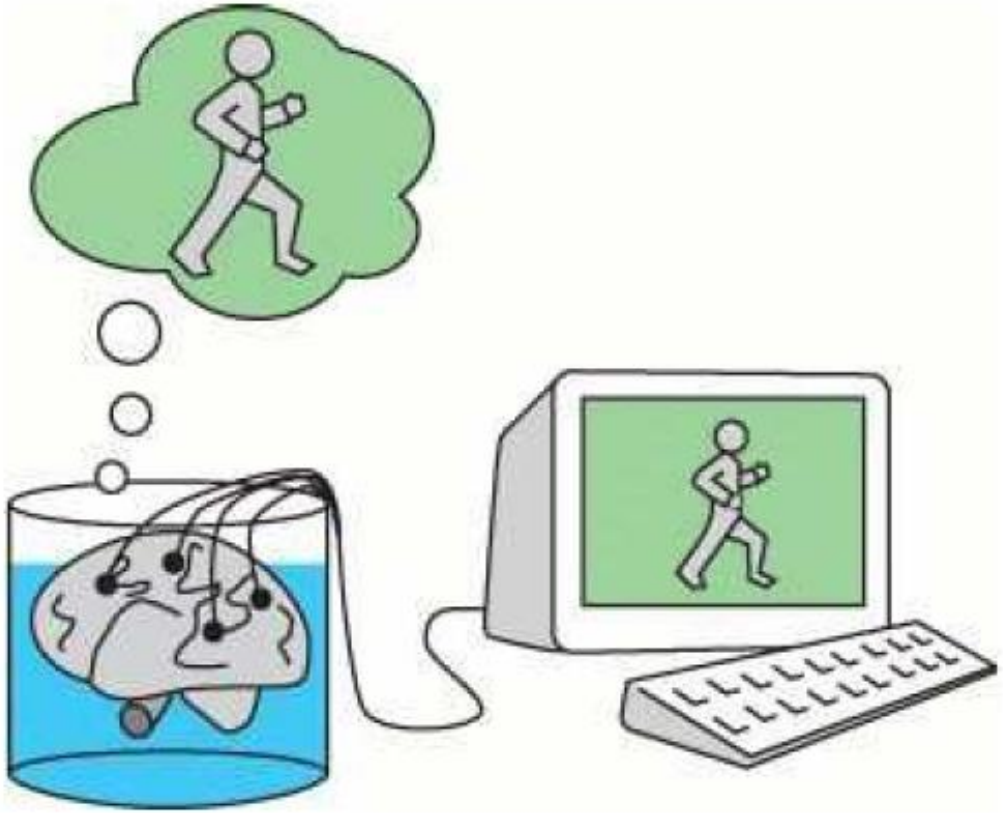
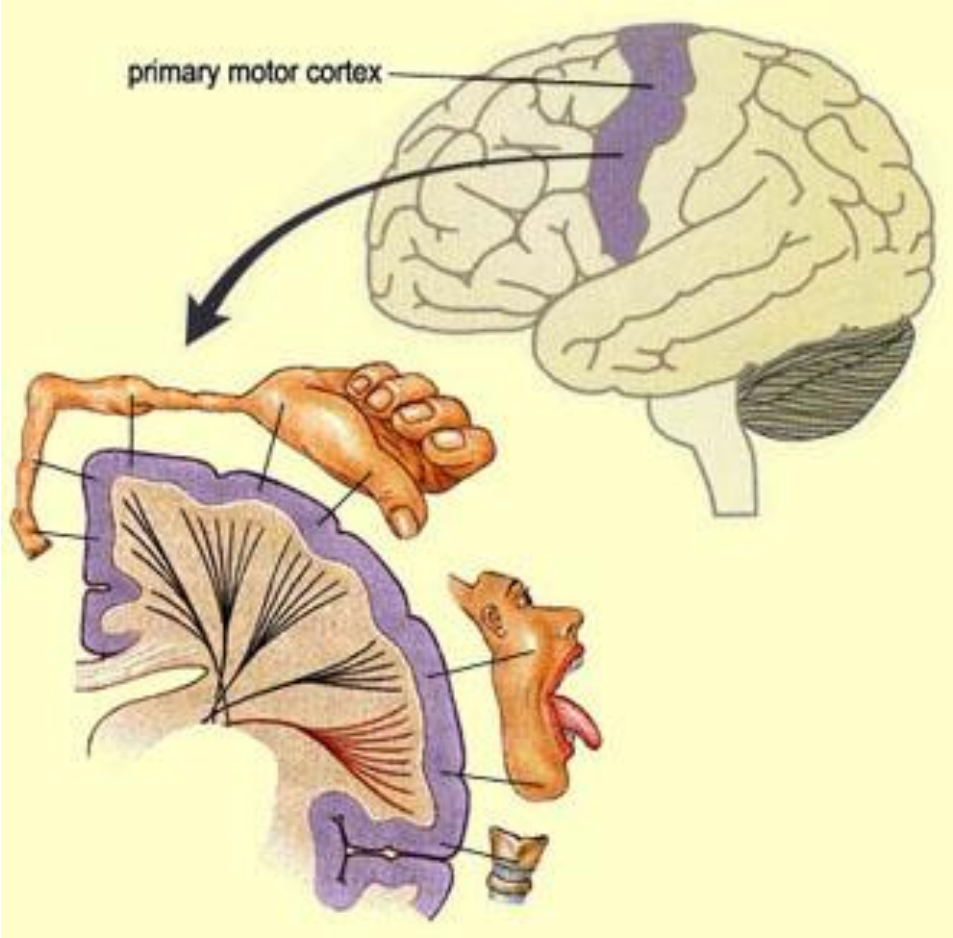
Interaction taken to logical extreme



- Brain-machine interaction or interface

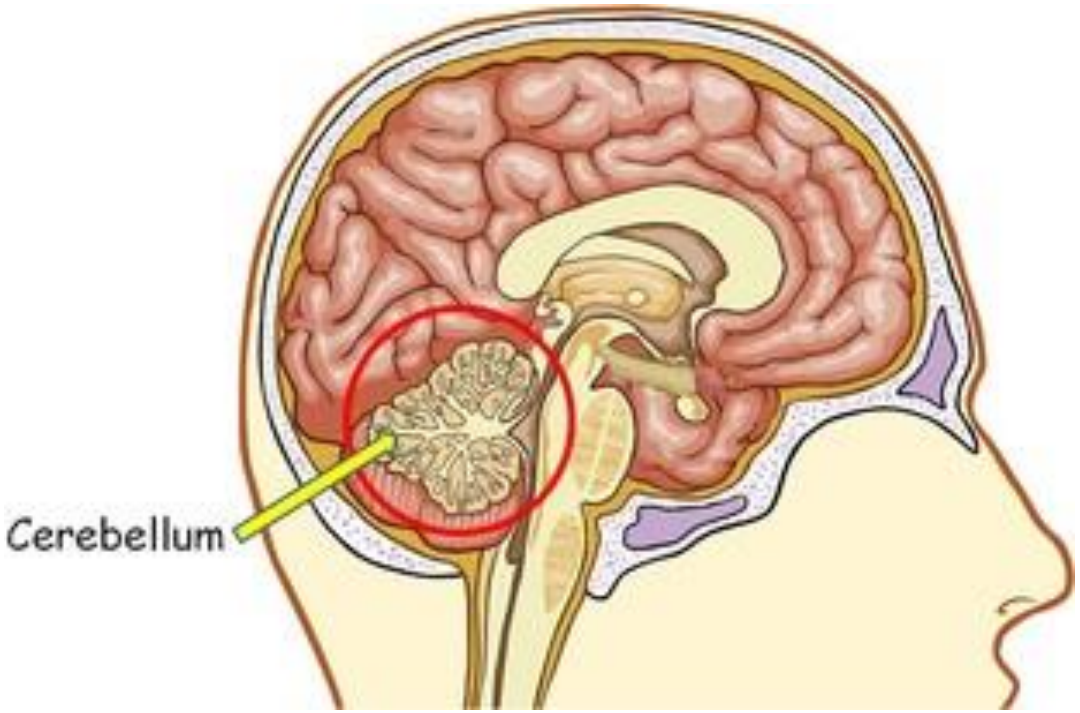
Primary Motor Cortex

- Interaction depends on Motor Actions
- These are generated by primary motor cortex*



*additional areas involved in eye movements!

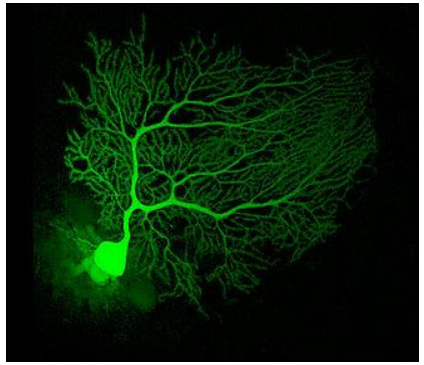
Cerebellum



- Plays an important role in motor learning and coordination

Cerebellum fun facts

- Cerebellum means?
  - "little brain"
- 3.6 times as many neurons as the cortex!!!
- Adaptation, precision, accuracy of movement
  - Cerebellar disease leads to loss of coordination
- Purkinje cells - most dendrites of any neuron
  - Good for integrating information



Other parts of the motor system?

- Spinal cord!
- Peripheral nervous system
  - Motor neurons
- Muscles themselves

Motor Programs

- Most motor actions repeated and thought to be based on execution of learned motor programs

- Motor programs are learned using sensory feedback

Examples of motor programs?

Motor Remapping

- VR often requires the user to adapt existing motor programs – i.e. requires motor learning

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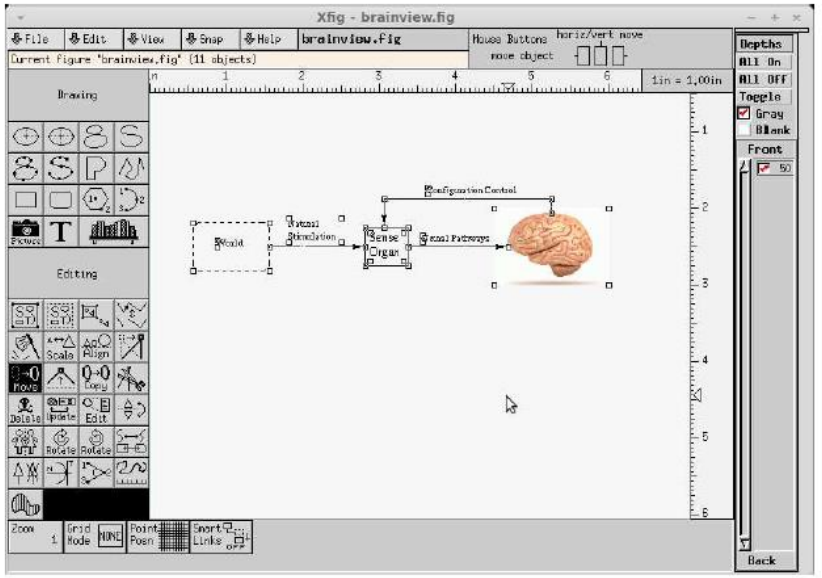


How can we interact in VR?

1) Button presses – existing devices
2) Tracking head movement
3) Tracking hand movement
4) Tracking eye movements

What else?

Components of Interaction

- Input method (hardware)
  - Registering user actions
  - E.g. computer mouse
- User interface (software)
  - How using the device changes the environment
  - E.g. using the mouse to point on the screen

Using existing controllers

Not ideal, not designed for VR

Pointing

- With the hand or with the head

- Like ‘mousing’ in VR

Pointing

- Good for interacting with menus, files, etc.

Bad technique for VR → “Gorilla Arms”

Design Considerations for VR Interaction?

- Effectiveness
- Difficulty of learning
- Ease of use
- Comfort

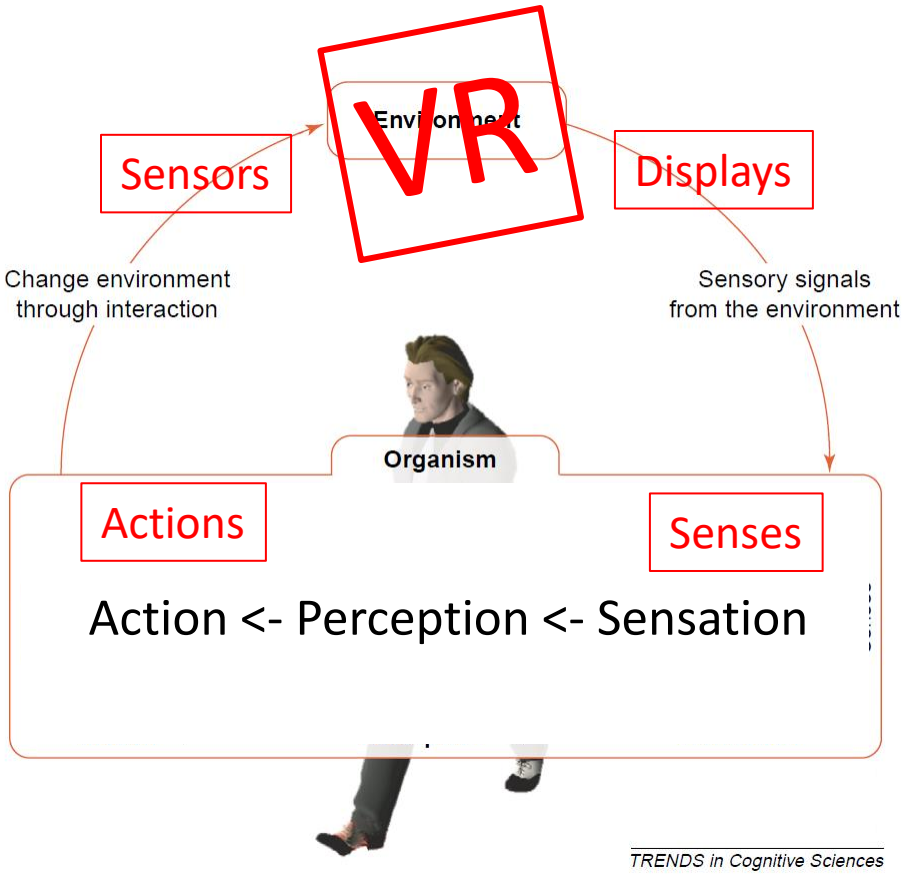
Use of Natural Motor Actions is Ideal

New interaction methods

- Great potential
  - Leads to immersion
- Great challenges
  - Technology does not exist
  - Best practices not established

Basic Types of Interaction

- Head movements
- Eye movements
- Manipulation
- Social Interaction
- Locomotion



Interaction via head turn

Spatial constancy -> Presence

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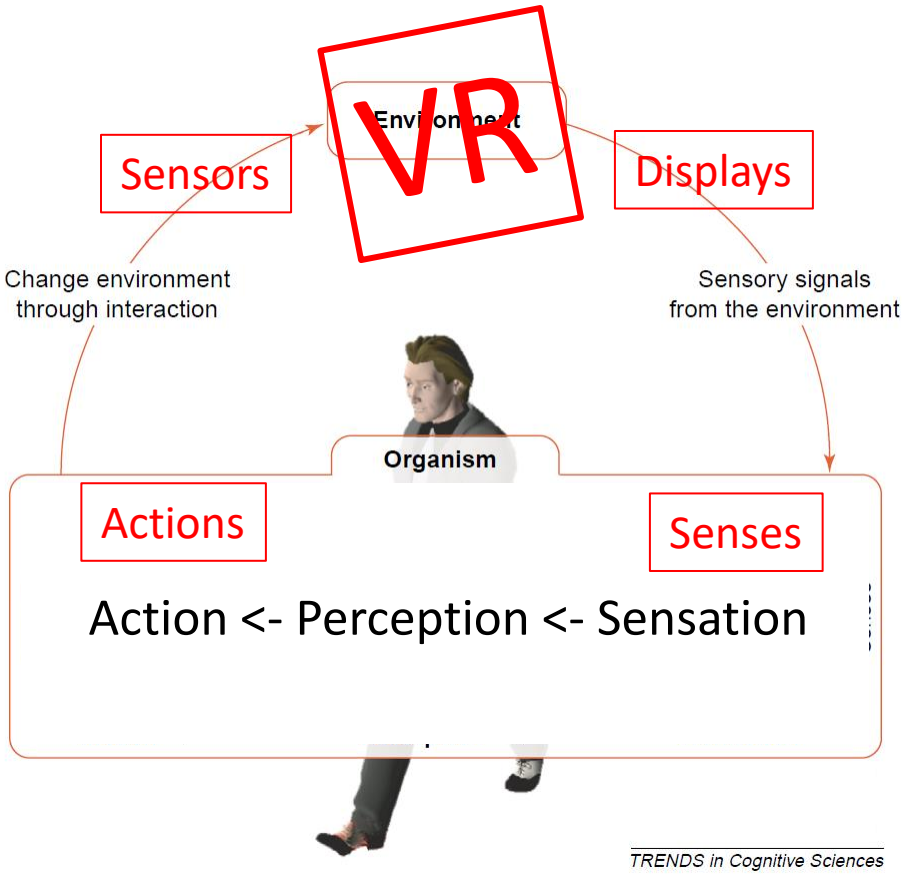

Interaction via eye movements

- Foveated rendering
- Track eye and render based on eye movements?
- Link to youtube

Interaction via eye movements

- Using eye movements for pointing and/or selection
- Dual-purpose problem:
  - Eye movements are not always under complete cognitive control
  - Overlap with natural visual exploration
  - Can lead to accidental pointing and/or selection, e.g. ‘Midas touch’

Virtual Reality
https://doi.org/10.1007/s10055-022-00738-z

ORIGINAL ARTICLE

Eye Tracking in Virtual Reality: a Broad Review of Applications and Challenges

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Abstract

Eye tracking is becoming increasingly available in head-mounted virtual reality displays with various headsets with integrated eye trackers already commercially available. The applications of eye tracking in virtual reality are highly diversified and span multiple disciplines. As a result, the number of peer-reviewed publications that study eye tracking applications has surged in recent years. We performed a broad review to comprehensively search academic literature databases with the aim of assessing the extent of published research dealing with applications of eye tracking in virtual reality, and highlighting challenges, limitations and areas for future research.

Keywords Eye tracking · Virtual reality

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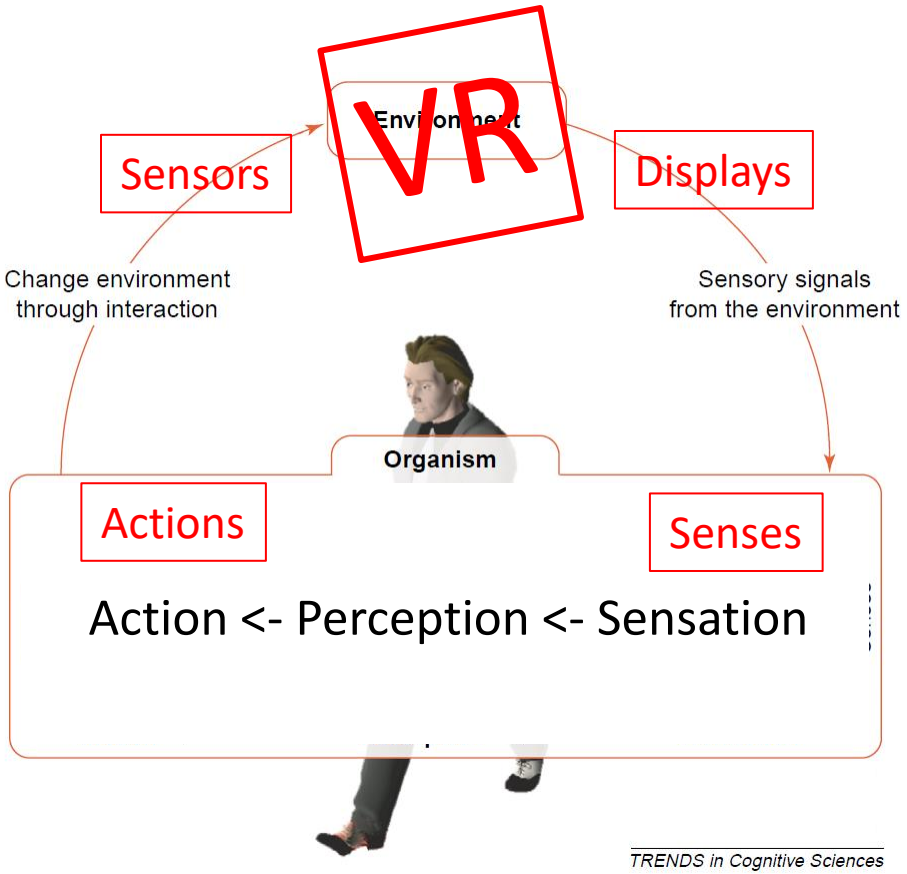

Manipulation

- One of the most important ways of interacting with the world around us… using our hands!

- Picking things up.
- Placing things.
- Throwing things.
- Pushing things.
- Using tools.

VR Controllers

- Separate controllers for each hand
- Optimized for tracking
- Optimized for ‘blind use’

VIVE

oculus

- But still relatively coarse

Natural Haptic Interaction

- Depends on control of fingers
  - Articulation/posture of fingers must be tracked
  - How can this be achieved?

Tracking grasping movements

- Hand tracking with computer vision
  - Leap controller
  - link
- Sensor-based tracking
  - Manus VR

Natural Haptic Interaction

- Depends on control of fingers
  - Articulation/posture of fingers must be tracked
- What sensory feedback?
  - **Proprioceptive** feedback when grasping
  - **Tactile** feedback when grasping
- Impossible with current technology…

Recording Natural Stimulation

- We do not have knowledge to simulate these complex experiences

- But research is going in that direction
  - Video here
  - “Haptography” – recoding haptic/tactile stimuli

Interaction with Tools

- Well-suited for VR – introduces some separation between user and environment

Sword simulation

- Easier to simulate, but still resembles everyday interaction

Future Devices

- These should allow more natural manual interaction… stay tuned.

Manus VR

Hybrid Reality

- In between VR and AR
- Virtual visual stimuli – real objects
- NASA example using Manus glove here.

Apple Vision Pro

- No controllers required
- Interaction via eye movements and hand gestures
- https://support.apple.com/guide/apple-vision-pro/basic-gestures-and-controls-tan1e2a29e00/visionos

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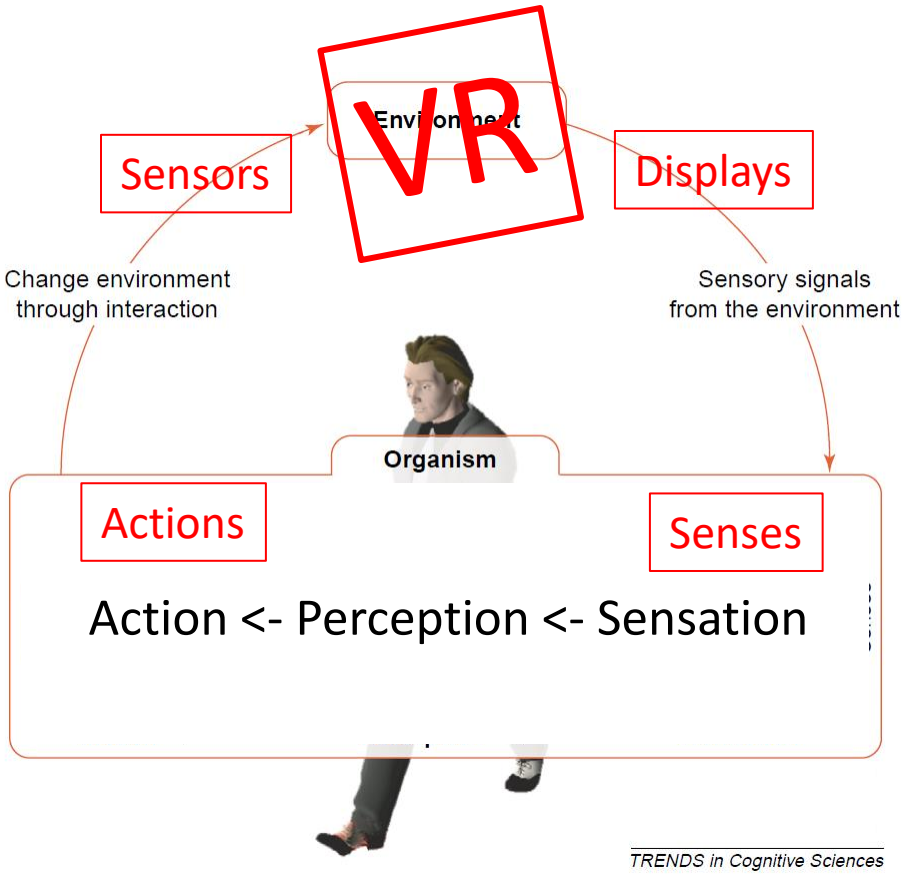


Social Interaction

- Watching a movie with friends

Figure 10.17: Oculus Social Alpha, which was an application for Samsung Gear VR. Multiple users could meet in a virtual world and socialize. In this case, they are watching a movie together in a theater. Their head movements are provided using head tracking data. They are also able to talk to each other with localized audio.

Social Interaction

- Beyond skype – feeling the presence of another person in the virtual environment

Figure 10.14: A collection of starter avatars offered by Second Life.

Avatars

How should they:
-look
-sound
-act

Social Interaction

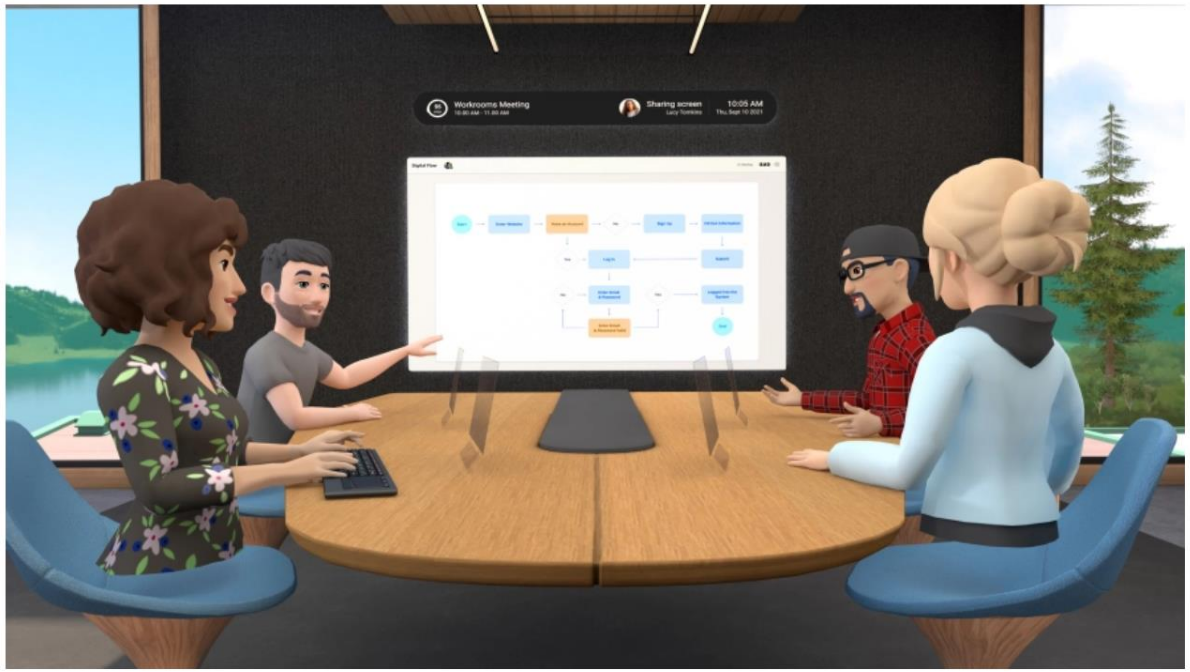
- Beyond skype – feeling the presence of another person in the virtual environment

Visual capture

Figure 10.15: Holographic communication research from Microsoft in 2016. A volumetric representation of a person is extracted in real time and superimposed in the world, as seen through augmented reality glasses (Hololens).

Social Interaction

- Meetings in VR using Meta Workrooms



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