SI5 - Techniques d'Interaction et Multimodalité

VIRTUAL AND AUGMENTED REALITY: USER EXPERIENCE

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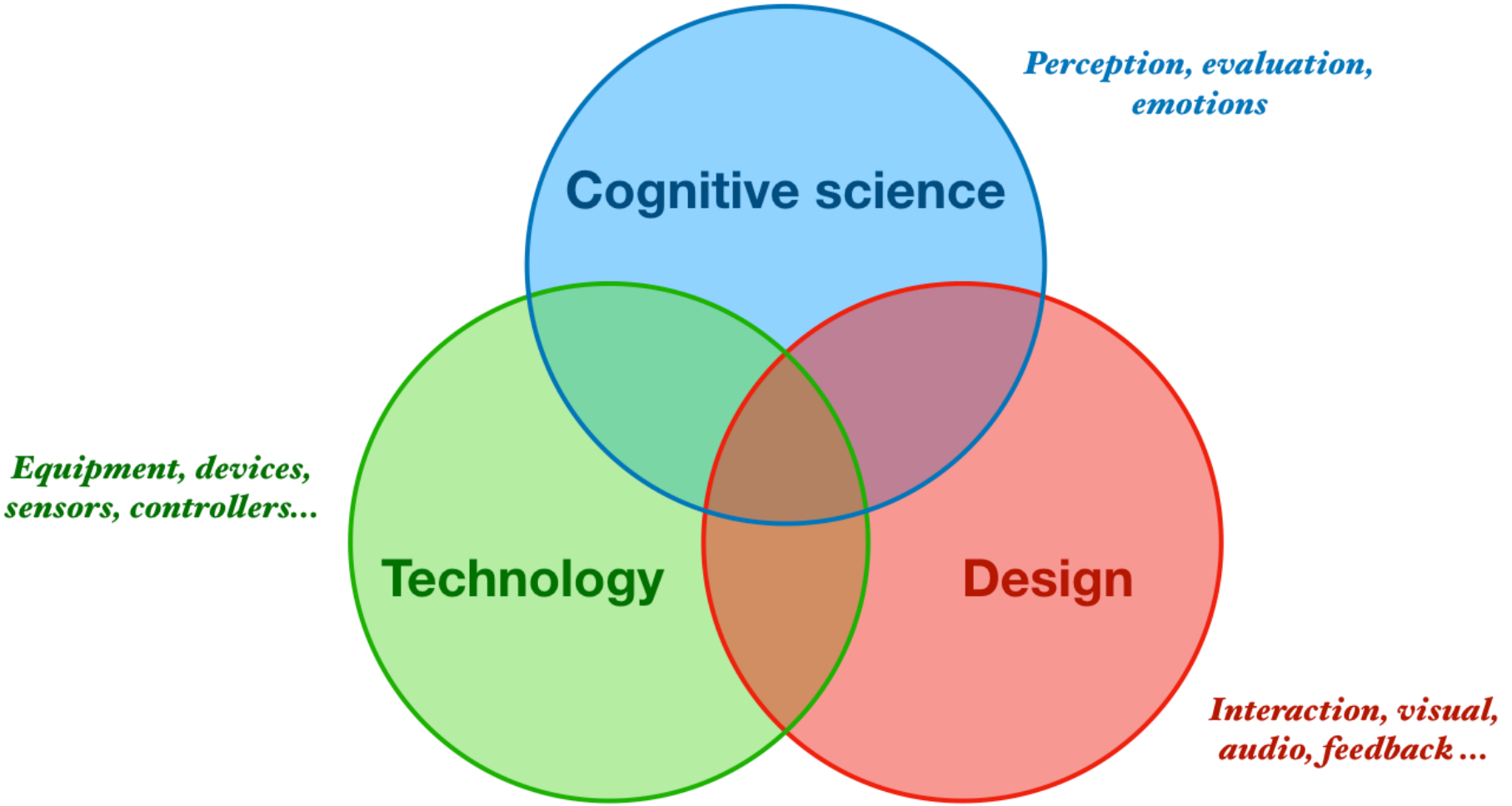
1. Introduction
2. Immersion and presence
3. Embodiment
4. Motion sickness

Where are we


Perception, evaluation, emotions
Cognitive science
Equipment, devices, sensors, controllers...
Technology
Design
Interaction, visual, audio, feedback ...

Important of User Experience

- **Telepresence**: for communication, accompagnement, health
- **Training**: for dangerous environments, professional training
- **Simulation**: realistic scenarios, overcoming psychological barriers (public speaking)
- **Entertainment**: personalised and engaging content
- **Research**: understanding human perception and behavior

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Immersion

Support for sensorimotor contingencies -- the actions that we know to carry out in order to perceive

Presence and Place Illusion

The strong illusion of being in a place in spite of the sure knowledge that you are not there

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1535), 3549-3557.

Immersion - Factors (2007)

- Field of view
- Field of regard
- Display size and resolution
- Stereoscopy
- Head-based rendering (light fields)
- Realistic lighting
- Frame and refresh rate

What's wrong with this list?

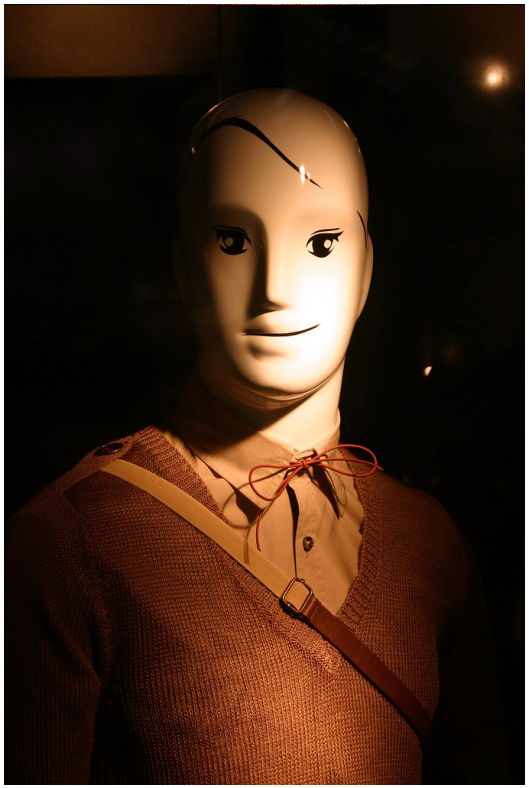
Bowman, D. A., & McMahan, R. P. (2007). Virtual reality: how much immersion is enough?. Computer, 40(7), 36-43.

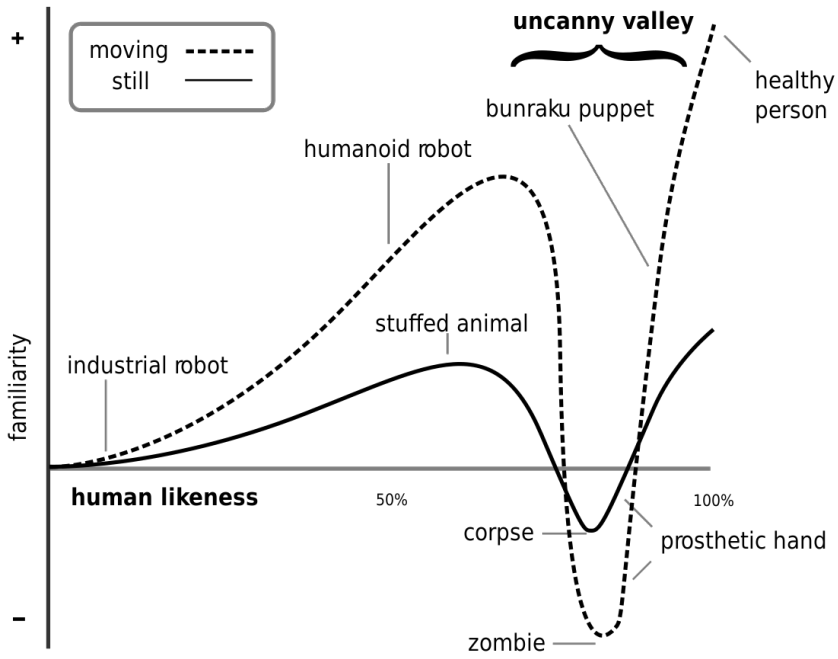
Immersion - Factors (1997)

- Extensiveness: range of sensory modalities
- Matching: congruence between modalities
- Surroundness: panoramic cues
- Vividness: quality of energy simulated
- Interactability: capacity of user to interact, for virtual entities to respond, and for the world to be influenced
- Plot: the story and world behavior

Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. Presence: Teleoperators & Virtual Environments, 6(6), 603-616.

Example: the uncanny valley





Ho, C. C., & MacDorman, K. F. (2010). Revisiting the uncanny valley theory: Developing and validating an alternative to the Godspeed indices. Computers in Human Behavior, 26(6), 1508-1518.

Plausiblity Illusion

For the virtual reality environment to provide correlations between external events not directly caused by the participant and his/her own sensations (both exteroceptive and interoceptive).

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1535), 3549-3557.

Immersion vs. Presence

Immersion provides the boundaries within which sense of Presence (Place Illusion) can occur.

- System and technologies vs. psychological
- VR systems will always have a limit where sensorimotor contingencies fail
- Presence and place illusion exists to the extent users probe the boundaries of sensorimotor contingencies

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1535), 3549-3557.

Examples of immersion, presence, and plausibility

- Natural movement and navigation: afforded through motion tracking, 6DoF HMDs, redirected walking
- Spatial cognition: afforded through high end graphics and surround sound equipment
- Realistic interactions and effects: afforded through haptic feedback and motion sensors
- Engaging events: afforded through plausible virtual events and interactions

Evaluations

- Questionnaires
- Physiological responses
- Behavioral responses

Questionnaires - ITQ (Immersive Tendency Questionnaire) subscales

1. Game: How often do you play arcade or video games?
2. Focus: How good are you at blocking out external distractions when you are involved in something?
3. Involvement: Have you ever gotten scared by something happening on a TV show or in a movie?

Full list

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. Presence: Teleoperators and virtual environments, 7(3), 225-240.

Questionnaires - other

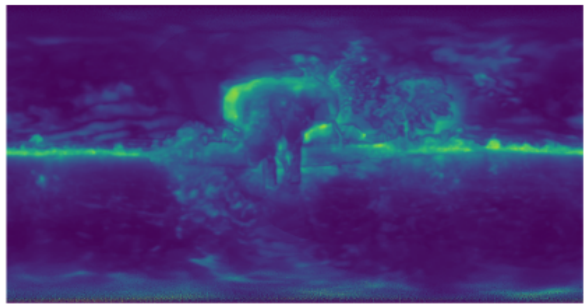
1. UTAUT2: technology adoption
2. NASA TLX: task load
3. SUS: system usability
4. SSQ: motion sickness (later)

Tcha-Tokey, K., Loup-Escande, E., Christmann, O., & Richir, S. (2016, March). A questionnaire to measure the user experience in immersive virtual environments. In Proceedings of the 2016 virtual reality international conference (pp. 1-5).

Hayotte, M., Thérouanne, P., Gray, L., Corrion, K., & d'Arripe-Longueville, F. (2020). The French eHealth acceptability scale using the unified theory of acceptance and use of technology 2 model: instrument validation study. Journal of medical Internet research, 22(4), e16520.

Physiological measures





We found that high-level salience (middle) is a better predictor of visual attention (gaze) than low-level saliency (right) under high arousal conditions

Guimard, Q., Robert, F., Bauce, C., Ducreux, A., Sassatelli, L., Wu, H. Y., ... & Gros, A. (2022, October). On The Link Between Emotion, Attention And Content In Virtual Immersive Environments. In 2022 IEEE International Conference on Image Processing (ICIP) (pp. 2521-2525). IEEE.

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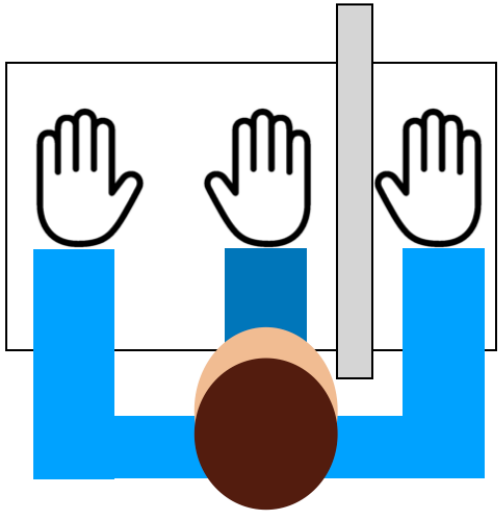
General idea

The extent to which one experiences the same sensations towards a virtual body inside an immersive virtual environment as toward the biological body.

Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. Presence: Teleoperators and Virtual Environments, 21(4), 373-387.

Example: The Rubber Hand Illusion

Multi-sensory information affects how we perceive our own body



Setup

- User sits at a table with arms on the table
- User is occluded from seeing one arm
- A rubber arm is placed in front of the user

Tsakiris, M., & Haggard, P. (2005). The rubber hand illusion revisited: visuotactile integration and self-attribution. Journal of Experimental Psychology: Human Perception and Performance, 31(1), 80.

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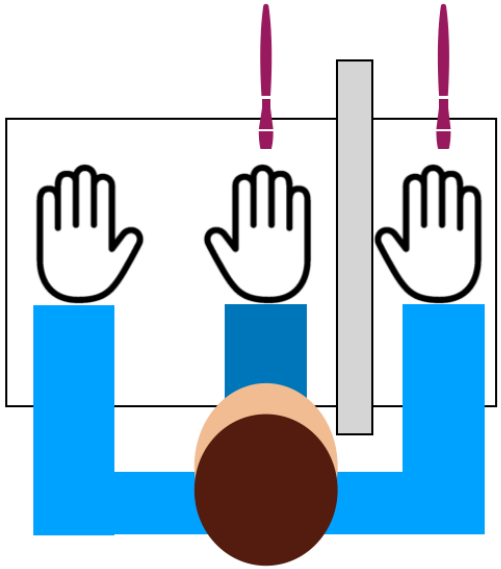

Experiment

- Multi-sensory stimulus is presented to user

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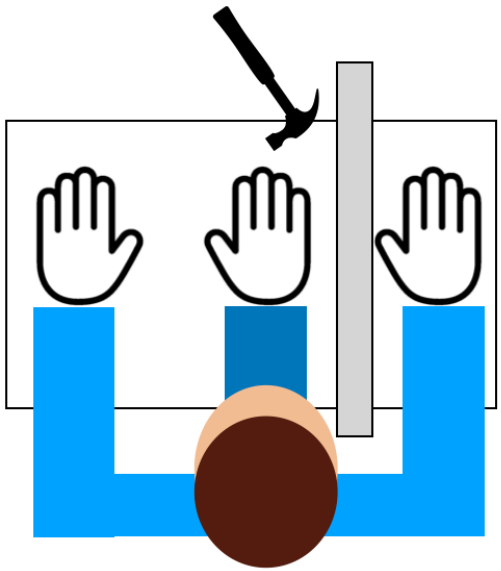

Experiment

- Multi-sensory stimulus is presented to user
- Threat is presented to the user

Tsakiris, M., & Haggard, P. (2005). The rubber hand illusion revisited: visuotactile integration and self-attribution. Journal of Experimental Psychology: Human Perception and Performance, 31(1), 80.

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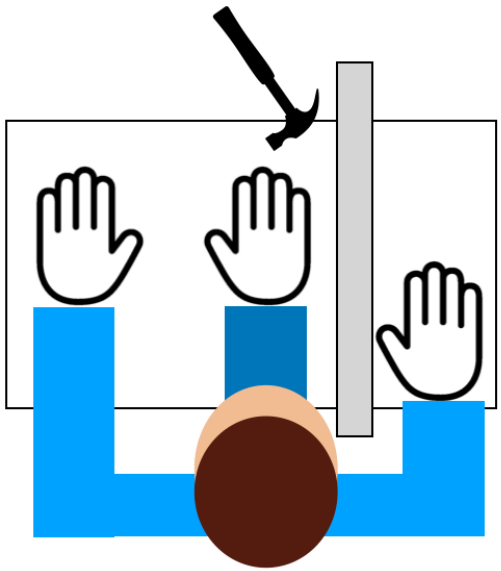


Experiment

- Multi-sensory stimulus is presented to user
- Threat is presented to the user
- Embodiment -- user feels the rubber hand is theirs

Tsakiris, M., & Haggard, P. (2005). The rubber hand illusion revisited: visuotactile integration and self-attribution. Journal of Experimental Psychology: Human Perception and Performance, 31(1), 80.

Sense of embodiment (SoE)

- **Sense of self-location**: one's spatial experience of being inside a body
- **Sense of agency**: having global motor control in active movements
- **Sense of body-ownership**: one's attribution of a body

Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. Presence: Teleoperators and Virtual Environments, 21(4), 373-387.

Evaluating Sense of embodiment (SoE)

- Binary vs continuous scale of evaluation

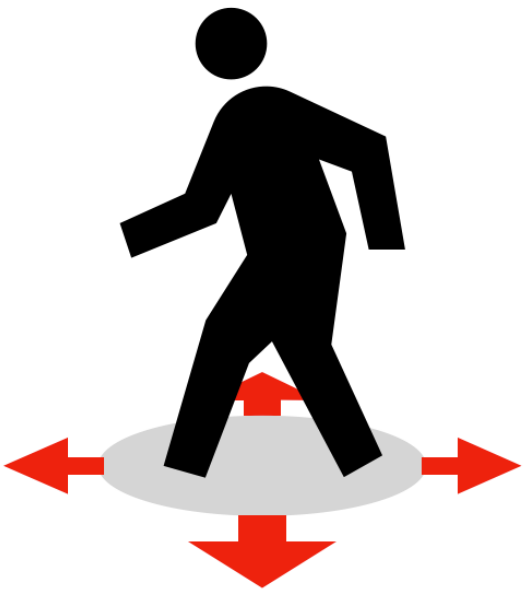
Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. Presence: Teleoperators and Virtual Environments, 21(4), 373-387.

Evaluating Sense of embodiment (SoE)

- Binary vs continuous scale of evaluation
- Intensity of subcomponents vary from none to maximum
- The biological body is fully embodied: all senses are experienced to the maximum degree

Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. Presence: Teleoperators and Virtual Environments, 21(4), 373-387.

Evaluating SoE -- Sense of Self-location



- Questionnaire: whether they felt in the place of the virtual avatar or viewing from outside
- Estimation of body position relative to movement or object placement
- Physiological response in view of threat

Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. Presence: Teleoperators and Virtual Environments, 21(4), 373-387.

Evaluating SoE -- Sense of Body Ownership

- Questionnaire: whether they felt the virtual object is a part of their body, or virtual body is their body
- Estimation of body part size
- Physiological response in view of threat or changes to physiological signals

Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. Presence: Teleoperators and Virtual Environments, 21(4), 373-387.

Evaluating SoE -- Sense of Agency

- Frequently measured as a part of body ownership
- Questionnaire: whether they felt fully in control of the virtual body

Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. Presence: Teleoperators and Virtual Environments, 21(4), 373-387.

Case studies

Imagine being placed in ...

- A child (Banakou et al. 2013) -- perception of size and voice pitch
- Someone of another race (Peck et al. 2013) -- implicit racial biases
- Someone of a different gender (Lopez et al. 2019) -- implicit gender bias
- ... and a non-human? (Gorisse et al. 2019) -- ownership and sense of threat

Banakou, D., Groten, R., & Slater, M. (2013). Illusory ownership of a virtual child body causes overestimation of object sizes and implicit attitude changes. Proceedings of the National Academy of Sciences, 110(31), 12846-12851.

Peck, T. C., Seinfeld, S., Aglioti, S. M., & Slater, M. (2013). Putting yourself in the skin of a black avatar reduces implicit racial bias. Consciousness and cognition, 22(3), 779-787.

Lopez, S., Yang, Y., Beltran, K., Kim, S. J., Cruz Hernandez, J., Simran, C., ... & Yuksel, B. F. (2019, May). Investigating implicit gender bias and embodiment of white males in virtual reality with full body visuomotor synchrony. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (pp. 1-12).

Gorisse, G., Christmann, O., Houzangbe, S., & Richir, S. (2019). From robot to virtual doppelganger: Impact of visual fidelity of avatars controlled in third-person perspective on embodiment and behavior in immersive virtual environments. Frontiers in Robotics and AI, 6, 8.

Lopez, S., Yang, Y., Beltran, K., Kim, S. J., Cruz Hernandez, J., Simran, C., ... & Yuksel, B. F. (2019, May). Investigating implicit gender bias and embodiment of white males in virtual reality with full body visuomotor synchrony. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (pp. 1-12).

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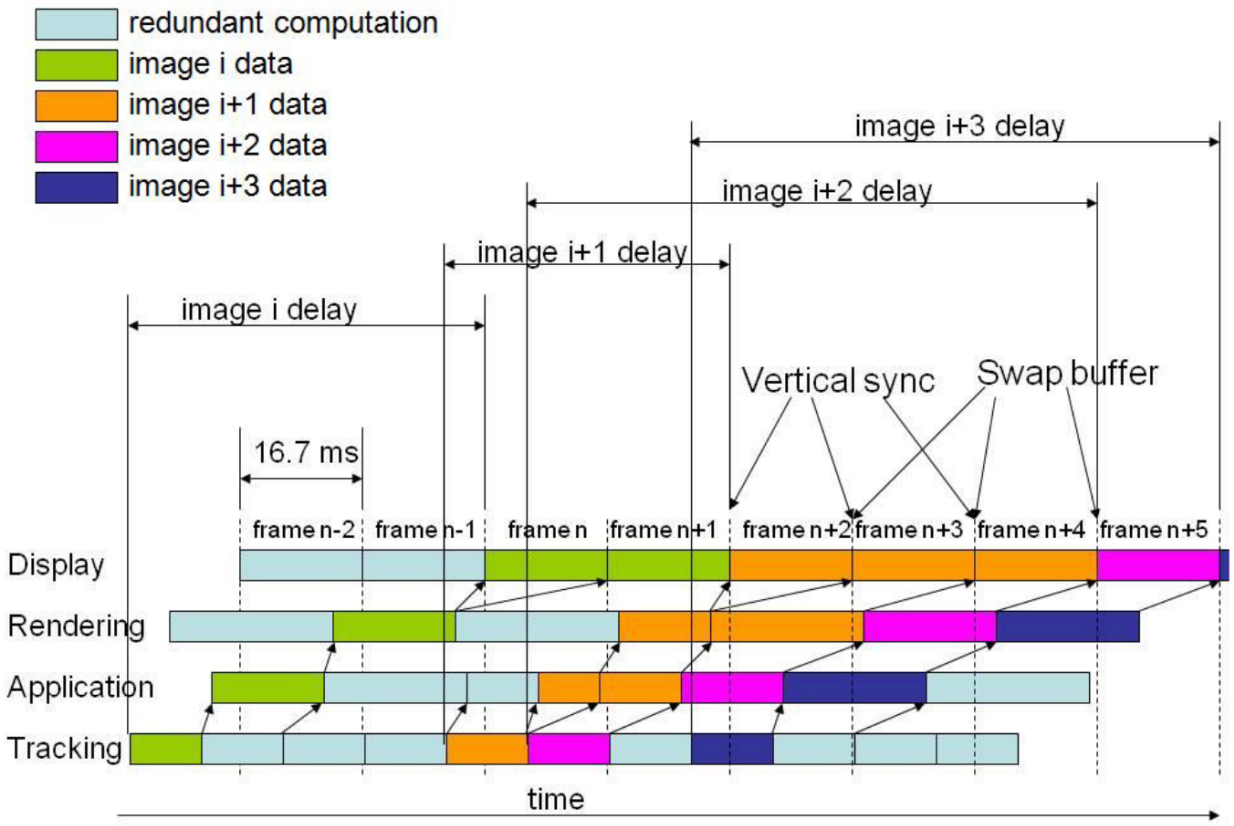
Motion sickness -- overview

- Experienced by a large portion of people: ~25%
- Resulting from sensory conflict between what we see and what we feel
- It is an unsolved problem (both for research and spread of VR)

Motion sickness -- causes

- Equipment: 3 DoF vs 6 DoF, controller type
- Latency: major reason of motion sickness
- Postural instability (due to visual movement)
- Biological factors: gender, age, health

Example: Latency



Jerald, J. J. (2009). Scene-motion-and latency-perception thresholds for head-mounted displays (Doctoral dissertation, The University of North Carolina at Chapel Hill).

Motion sickness -- evaluation (SSQ)

SSQ items	Nausea	Oculomotor	Disorientation
1. General discomfort	O	O	
2. Fatigue		O	
3. Headache		O	
4. Eyestrain		O	
5. Difficulty focusing		O	O
6. Increased salivation	O		
7. Sweating	O		
8. Nausea	O		O
9. Difficulty concentrating	O	O	
10. Fullness of head			O
11. Blurred vision		O	O
12. Dizzy (eyes open)			O
13. Dizzy (eyes closed)			O
14. Vertigo			O
15. Stomach awareness	O		
16. Burping	O		
Total	[1]	[2]	[3]

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. The international journal of aviation psychology, 3(3), 203-220.

Motion sickness -- evaluation

- **Postural stability**: one foot in front of the other, toe touching heel, weight evenly distributed, arms folded, chin up (Prothero and Parker 2003)
- **Physiological measures**: heart rate, blink rate, stomach upset, skin color, skin conductance (sweating) ...

Prothero, J. D., & Parker, D. E. (2003). A Unified Approach to Presence and Motion Sickness. Virtual and adaptive environments: Applications, implications, and human performance issues, 47.

Motion sickness -- solutions

Reducing field of view

Fernandes, A. S., & Feiner, S. K. (2016, March). Combating VR sickness through subtle dynamic field-of-view modification. In 2016 IEEE Symposium on 3D User Interfaces (3DUI) (pp. 201-210). IEEE.

Motion sickness -- solutions

Nasum Virtualis

Whittinghill, D. M., Ziegler, B., Case, T., & Moore, B. (2015, March). Nasum virtualis: A simple technique for reducing simulator sickness. In Games Developers Conference (GDC) (p. 74).

Motion sickness -- solutions

Other

- Reducing the amount of rotation movements
- Teleportation (instead of game pad)
- Increasing stability (sitting down)
- Devices: tethered headsets offer a smoother experience