Immersion and presence in virtual environments

CS 5754
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Terms: immersion vs. presence

✓ **Immersion**: the objective level of fidelity of the sensory stimuli produced by a technological system

✓ Theoretically measurable, controllable

✓ Different systems can be compared

Terms: immersion vs. presence

- **Presence**: the subjective response of a human indicating the feeling of “being there”
  - Not directly measurable, not controllable
  - The same system may produce different levels of presence in different people

Immersion and Presence

...lead to presence response

Components of immersion...
Presence

- Feeling of “being there”
- Virtual world replaces physical world - becomes “reality”
- Crucial for some applications?
  - training
  - phobia treatment
  - pain reduction
Open questions - presence

✓ Useful definition?
✓ What creates presence?
✓ Dependable measures?
✓ Applications/tasks:
  ✓ where presence improves performance or usability
  ✓ where presence is necessary
Sheridan (1992)

- Three measurable physical variables that determine presence:
  - extent of sensory information
  - control of sensors relative to environment
  - ability to modify environment

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Measuring presence

- 100-point rating scale
- Questionnaires
- Psychophysical measures
  - relate physical stimulus to perception
  - e.g. $R$ (rating) = $f(S)$ (stimulus magnitude)
Measuring presence (cont.)

✓ Objective measures

✓ physiological (heart rate, sweaty palms, breathing, etc.)
✓ behavior (real-world reactions)
✓ memory for object locations
✓ task performance when presence is a requirement
Witmer & Singer’s PQ & ITQ

- Validated questionnaire
- Measure both
  - level of presence
  - user tendency towards presence
- Effects on task performance, simulator sickness
Issues with using questionnaires to measure presence

- Assumes that a phenomenon called “presence” exists
- Assumes that people can describe their experience in terms of this phenomenon
- May put the idea of presence into the minds of the subjects
- Cannot provide evidence that presence actually played any role in subjects’ experience

Some components of immersion

- Visual: FOV, FOR, resolution, rendering quality, model detail, …
- Auditory: “field of hearing”, quality, …
- Haptic: “field of touching”, quality, …
- Kinesthetic: response to head/limb movements
- Vestibular: response to entire body movement
- Olfactory/gustatory: …
Motivation

- Immersive VEs have special characteristics.
- Intuitively, IVEs are different than 3D environments “on the desktop.”
- An understanding of the benefits of IVEs would transform research into commercial uses of VEs.
- BUT, it’s very hard to prove that IVEs are beneficial.
Examples of IVE benefits

✓ IVEs can distract users from the real world (presence?)
✓ IVEs can evoke real-world reactions in users (presence?)
Obvious benefit: “experience”

✓ Pain example: IVEs can “feel” different than non-immersive VEs.
✓ Phobia example: IVEs can “feel” similar to the real world.
✓ The IVE experience may be more “natural” or produce “presence.”
✓ These experience factors benefit certain applications (therapy, entertainment, training, design review)
  ✓ Note: These are the most successful applications of IVEs!
Obvious conclusion

✓ IVE research should focus on:
  ✓ Definitively proving the experiential benefits of IVEs
  ✓ Finding other applications for which these experiential benefits are useful

✓ Two problems with this conclusion:
  ✓ What technology really causes the experiential benefits? We need empirical, controlled studies.
  ✓ Is experience the only benefit of IVEs? We need to consider and study other potential benefits.
Other potential IVE benefits

- Increased spatial understanding (scale, shape, location, distance, direction)
  - Due to better 3D depth cues, head tracking, large FOR

- Increased peripheral awareness
  - Due to large FOV, head tracking

- Increased information bandwidth
  - Due to large FOV/FOR, multimodal output

- Decreased information “clutter”
  - Due to large FOR, unlimited virtual space

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Other potential IVE benefits

✓ Increased spatial understanding
  ✓ ...benefits visual data analysis
  ✓ ...benefits wayfinding
  ✓ ...benefits education
  ✓ ...benefits design

✓ Increased peripheral awareness
  ✓ ...benefits collaboration
  ✓ ...benefits multiple task situations
Other *potential* IVE benefits

- Increased information bandwidth
  - ...benefits attention-demanding tasks
  - ...benefits inherently multimodal tasks (e.g. architectural design)
- Decreased information “clutter”
  - ...benefits information visualization
  - ...benefits interface design
Our goals

- Empirically demonstrate the benefits of immersion on particular tasks and applications
- Explore the less-obvious potential benefits of immersion
- Give developers, designers, investors, etc. a solid reason to use (or not to use) IVEs
Existing approaches: practical comparison

QuickTime® and a TIFF (LZW) decompressor are needed to see this picture.
Existing approaches: HMD vs. desktop

Datey, A. MS Thesis, Virginia Tech
Existing approaches: Pausch et al. study

QuickTime® and a TIFF (LZW) decompressor are needed to see this picture.
Our approach

<table>
<thead>
<tr>
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<th>Small FOR</th>
<th>Large FOR</th>
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<tbody>
<tr>
<td>Static rendering</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>Head-based rendering</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

Raja, D. et al. IPT 2004
Bowman & Raja, Presence-Connect, 2004

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Preliminary study

✓ Investigate benefits of FOR and head-based rendering for abstract information visualization

✓ Possible benefits:
  ✓ Efficient identification of trends
  ✓ Greater understanding of entire data set
  ✓ Easier id of single data points
Encouraging results

✓ 3 of 4 tasks were faster in the high FOR condition
✓ All tasks considerably faster with head-based rendering
✓ Perceived disorientation and usefulness ratings were better with head tracking enabled
✓ The highest level of immersion produced the best performance and was also preferred
Potential future experiments

- More powerful experiment to show infoviz benefits statistically
- Investigate other components of immersion (stereo, FOV, resolution, rendering quality, etc.)
- Broaden the FOR condition to many different levels
- Investigate other application domains/tasks (education, design, therapy, etc.)
- A 6-sided CAVE is needed!