Training Simulations, Expertise & Virtual Reality

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Simulation Hub

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Contents

10 years of VR @ MQ
Visor Research Themes
Characteristics of VR and AR
Training in VR
VISOR Training Simulations
Experiment on Immersion
Experiment on Expertise
Future Projects and AR

Human Performance Simulation: A Meeting of Minds WORKSHOP
VR Lab, 2005
VISOR @ VR Lab

- 6 Postdocs
- 12 PhD students graduated
- 6 current PhD students
- 7 Honours students
- 21 MIT students
- 9 MEng interns
- 6 Programmers
- 67 in total
ARC Grants

- 2005-2008  Australian Research Council Discovery Grant, DP0558852 (Richards, Kavakli, Dras) Risk Management Using Agent Based Systems, Macquarie University ($362K)
- 2005-2006  Australian Research Council Linkage International Fellowship, LX0560117 (Kavakli, Pelachaud, Szilas) Interactive Drama Engine in Virtual Reality, Macquarie University ($71K)
- 2002-2005  Australian Research Council Linkage Grant, LP0216837 (Kavakli, Bossomaier, Tien, Cooper), Cognitive Modeling of Computer Games Pidgins ($75K)
VISOR Publications

- 8 book chapters, 18 journal, 68 conference p., 6 abstracts
- 100 papers since 2003

- 2014 Best Paper Award, CENTRIC 2014, The Seventh International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services, IARIA International Academy, Research, and Industry Association
- 2012 Best Paper Award, MMEDIA 2012, International Conferences on Advances in Multimedia, IARIA International Academy, Research and Industry Association
VISOR: Virtual and Interactive Simulations of Reality

- HCI
  - VR/Graphics Programming
  - Simulation Design
  - Motion Tracking

- Learning/Training
  - Scene Complexity
  - Simulator Sickness

- Expertise
  - Novices and Experts
  - Cognitive Processing

- Performance
  - Cognitive Load
  - Human Information Processing
  - Joint performance of Human Computer/Machine Interfaces
Our Interest: Expertise

- VISOR (Virtual and Interactive Simulations of Reality)
- CEPET (Centre for Elite Performance, Expertise, and Training)

Understanding expertise is important for the design of training programs.

Principles and mechanisms proposed to underlie expertise can be used to evaluate the theories about basic cognitive processes and capacities, and thus explain human performance more generally (Loft et al, 2009).
VR

Jaron Lanier (1989)

- a medium composed of interactive computer simulations
  - sense the participant's position
  - replace or augment the feedback to senses
  - giving the feeling of
    - being immersed or
    - being present in the simulation.

- Immersion / Visualization:
  - The computer generates visual, auditory or other sensual outputs to the user of a world within the computer.

- Interaction:
  - The user can interact with this virtual world, directly manipulating objects in it.
VR & AR

※ http://www.youtube.com/watch?v=bBjvqnKQsTl&list=PLDF1BBECCE066EE5E
※ https://www.youtube.com/watch?v=V34gCw4fyLs
Tracking motions
Biopack:
EEG, ECG, EGG, EMG
Emotiv Headset
Training in VR

- A professional’s confidence can be strengthened through VR exposures that provide the opportunity:
  - To experience mastery and
  - Control under high-stress conditions.

- VR Scenarios are designed to allow trainees:
  - To work through fear and
  - Successfully translate it into effective performance.

- Through repeated exposure, trainees develop a skill set to achieve high-demand tasks under mission critical and high-stress operations.
5

Border Security Sim

Welcome to Melbourne Airport...

VisoR: Virtual and Interactive Simulation of Reality Research Group 2008
Speech & Gesture Recognition
Fire fighting Simulation
Scene Complexity
Simulator Sickness
Augmented Reality

A view of a physical, real-world environment whose elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data.
Future project: iDesign
A Multimodal Augmented Reality System for Spatial Design

- Using the **GPS** location, accelerometer and gyroscope of the smart tablet, and Google glasses, we will generate a mobile AR system.
- The AR system (I-DeSIGN) will facilitate design communication by
  - using **3D architectural objects** such as walls and windows
  - to push and pull to shape and create a virtual built environment,
Coucke (2013) examined multimodal computer interfaces with a particular attention to the area of **speech and co-verbal gestures**.

- Krauss defines a lexical affiliate as
- "The word whose retrieval the gesture is hypothesized to enhance".

Experiment on Immersion

Is Information Processing in VR different from Non-VR?
Finding 1: Task times were longer in the 3D VR environment especially for some participants, compared to the non-3D environment.
Information richness in 3D

※ Finding 2: More words were spoken in the 3D experiments than in the non-3D experiments.
※ Finding 3: No significant difference in either keyword or gesture counts were observed between the 3D and non-3D experiments.
Keywords

**Finding 4:** The 3D environment produced some unique **keywords** which reflected differences between the 2D and 3D objects, these include **details**.

**Finding 5:** **Keywords and iconic gestures are correlated in both** 3D and non-3D environments.

**Finding 6:** **Nouns dominated keywords in both** 3D and non-3D environments.
**Finding 7:** There is an increased delay in 3D VR environment between gesture stroke onset and lexical affiliate observed. 

70% of the 3D experiments had an increased delay.

The average delay in the 3D environment being 1.29 seconds as compared to .92 seconds in the non 3D experiments.

Gestures precede the words whose retrieval they facilitate.

We can see a correlation between our mean of .92 seconds for the non-3d environment and the mean of .99 that Krauss found.

---

**Temporal difference between Gesture and Keyword onset**

<table>
<thead>
<tr>
<th></th>
<th>2a heart</th>
<th>2a Traditional</th>
<th>2b heart</th>
<th>2b Traditional</th>
<th>2c heart</th>
<th>2c Traditional</th>
<th>2d heart</th>
<th>2d Traditional</th>
<th>2e heart</th>
<th>2e Traditional</th>
<th>2e Traditional</th>
<th>non 3d</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>non 3d</strong></td>
<td>1.04</td>
<td>1.80</td>
<td>1.04</td>
<td>1.10</td>
<td>0.67</td>
<td>0.25</td>
<td>0.65</td>
<td>1.22</td>
<td>0.38</td>
<td>1.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3D</strong></td>
<td>1.61</td>
<td>1.60</td>
<td>0.79</td>
<td>1.45</td>
<td>1.13</td>
<td>0.20</td>
<td>2.31</td>
<td>1.61</td>
<td>0.91</td>
<td>1.27</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Ubiquitous System Development: DeSIGN in VR

2009-2012

Australian Research Council
Discovery Grant, DP0988088 (Kavakli)
A Gesture-Based Interface for Designing in Virtual Reality

Research questions:

“How do we generate 3D models of real objects by sketching using VR in real-time?” and
“How can we support the design process using VR, design cognition, and gesture recognition?”
Postdoctoral fellowship: Sketchpad Development

- **NATO Science Fellowship** (1996, UK)
- An AI Application for the Transformation of a 2D Sketch to a 3D Geometric Model

**Project Report:**

- The NATO Science Fellowship Program for Post Doctoral Studies, NATO area code: 4301, NATO list code: 51/B96/TU
Gesture Recognition

※ HCI
※ VR Programming
※ Motion Tracking
Gesture Recognition

- 52 individual piezzo resistive sensor strips
- located from wrist to shoulders on the right and left side of the t-shirt.
- The data is acquired by the National Instrument Data Acquisition Unit.
Findings

- Sparse Representation-based Classification (SRC).
  - allows signals to be recovered with a few number of samples

- Using SRC and Compressed Sensing
  - we obtained a gesture recognition rate of
    - 100% for both sensor jacket and wii-mote based user-dependent tracking for 3D and 2D gesture sets
    - 99.33% for user-independent 2D gesture sets
    - 97.5% for user&time-independent 2D gesture sets
  - The adapted SRC algorithm outperforms other methods
    - SRC recognition rate in face recognition: 92.7 ile 94.7
    - Naïve Bayes recognition rate in sensor jacket apps: 65-97%
    - HMM recognition rate 71.50-99.54%
Recognising Gehry’s sketches

This means that explaining the 3D versions of these phenomena would require postulating a different mechanism and a different form of representation—one that itself could not take the form of a neural display since there are no known 3D neural displays that map a design space.
Experiment on Expertise
Is an Expert’s Information Processing different from a Novice?

- Analysis of design protocols of novice and expert designers, although based on a limited number of designers, have shown that there are differences in the balance of cognitive actions between the novice and the expert designers (Kavakli et al., 1999).

- The hypothesis:
  - the reason for the imbalance in cognitive activity between the novice and the expert designers in the conceptual design process is the rate of information processing driven by their relative experience in drawing production and sketch recognition.
What are the cognitive actions corresponding to each design action?

An expert can be viewed as having developed the level of skill required to control emotions during high stress operations, over time and through experience.
so I am going to have to segment this a little bit. Something has to be here and something back here. And I am not going to bisect the main space.

<table>
<thead>
<tr>
<th>Action type</th>
<th>index</th>
<th>class</th>
<th>Description (where, of what, among what?)</th>
<th>Dependency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawing</td>
<td>Dc</td>
<td>new</td>
<td>Circle 3</td>
<td>index</td>
</tr>
<tr>
<td>Looking</td>
<td>L1</td>
<td>old</td>
<td>Line 67</td>
<td>On what</td>
</tr>
<tr>
<td>Perceptual</td>
<td>Psg</td>
<td>New</td>
<td>New/old</td>
<td>Dc, Psg</td>
</tr>
<tr>
<td></td>
<td>Prn1</td>
<td>new</td>
<td>i-space relation g-relation</td>
<td>Prn2</td>
</tr>
</tbody>
</table>
|             |       |       | The rest space spatial rel (separate): the two spaces spatial rel (included): the new space is on the side of the building | New/ne new
|             |       |       |                                          | Prn1, Prn2 |

<table>
<thead>
<tr>
<th>Functional</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>type</th>
<th>content</th>
<th>Source</th>
<th>Trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 2</td>
<td>I am not going to bisect the main space of the building</td>
<td>Seg/typ</td>
<td>what?</td>
</tr>
<tr>
<td>Type 1.3</td>
<td>I am splitting the building on the side, not in the center</td>
<td>256</td>
<td>Prn1, Prn2</td>
</tr>
</tbody>
</table>
Table A Correlation coefficients of cognitive actions across design depictions (Dc)

<table>
<thead>
<tr>
<th></th>
<th>Expert</th>
<th>Novice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drf</td>
<td>0.03</td>
<td>0.34</td>
</tr>
<tr>
<td>Dts</td>
<td>0.58</td>
<td>0.98</td>
</tr>
<tr>
<td>Dtd</td>
<td>0.25</td>
<td>-0.75</td>
</tr>
<tr>
<td>Dsy</td>
<td>0.35</td>
<td>0.74</td>
</tr>
<tr>
<td>Dwo</td>
<td>0.32</td>
<td>0.75</td>
</tr>
<tr>
<td>L</td>
<td>0.81</td>
<td>0.91</td>
</tr>
<tr>
<td>Psg</td>
<td>-0.17</td>
<td>0.71</td>
</tr>
<tr>
<td>Posg</td>
<td>0.27</td>
<td>0.64</td>
</tr>
<tr>
<td>Pfn</td>
<td>0.45</td>
<td>0.66</td>
</tr>
<tr>
<td>Pfp</td>
<td>0.15</td>
<td>0.90</td>
</tr>
<tr>
<td>Pof</td>
<td>0.53</td>
<td>-0.27</td>
</tr>
<tr>
<td>Prp</td>
<td>0.74</td>
<td>0.98</td>
</tr>
<tr>
<td>Prn</td>
<td>0.70</td>
<td>0.28</td>
</tr>
<tr>
<td>Por</td>
<td>0.57</td>
<td>0.92</td>
</tr>
<tr>
<td>Fnp</td>
<td>0.31</td>
<td>0.60</td>
</tr>
<tr>
<td>Fop</td>
<td>0.68</td>
<td>0.21</td>
</tr>
<tr>
<td>Fi</td>
<td>0.24</td>
<td>0.26</td>
</tr>
<tr>
<td>G1-1</td>
<td>0.45</td>
<td>-0.29</td>
</tr>
<tr>
<td>G1-2</td>
<td>0.67</td>
<td>0.73</td>
</tr>
<tr>
<td>G1-3</td>
<td>0.44</td>
<td>0.21</td>
</tr>
<tr>
<td>G1-4</td>
<td>0.14</td>
<td>0.85</td>
</tr>
<tr>
<td>G2</td>
<td>0.34</td>
<td>0.38</td>
</tr>
<tr>
<td>G3</td>
<td>0.21</td>
<td>0.71</td>
</tr>
<tr>
<td>G4</td>
<td>0.19</td>
<td>0.58</td>
</tr>
<tr>
<td>Ma</td>
<td>0.31</td>
<td>-0.29</td>
</tr>
<tr>
<td>Mod</td>
<td>0.07</td>
<td>0.60</td>
</tr>
<tr>
<td>Moa</td>
<td>0.69</td>
<td>0.89</td>
</tr>
</tbody>
</table>
We are all looking for an answer but in fact what drives us is the question.
Future isn’t written. It is designed.

Welcome to our Sci-Fi World!

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Design protocols

**Differences in Cognitive activity:**
- the expert: 2,916 actions and 348 segments,
- the novice: 1,027 actions and 122 segments.

The expert's design protocol is 2.84 times as rich as the novice's in terms of actions.

There were 2.85 times as many segments in the expert designer's session as in the novice's.

**Differences in Productivity: (~3.25-3.5 times)**
- the expert: 13 pages and 7 design alternatives
- the novice: 4 pages and 2 design alternatives.

The statistical results (chi squared test, $\chi^2>c$, at 0.5% significance level):
- there are differences between the expert's and the novice's cognitive actions.
- The strongest differences statistically are in perceptual actions and goals.
Sketches II
Table 5. Correlation coefficients of cognitive actions in pages

<table>
<thead>
<tr>
<th>expert-page</th>
<th>Drawing</th>
<th>Looking</th>
<th>Perceptual</th>
<th>Functional</th>
<th>Goals</th>
<th>Moves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawing</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Looking</td>
<td>0.864</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceptual</td>
<td>0.998</td>
<td>0.909</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional</td>
<td>0.998</td>
<td>0.951</td>
<td>0.998</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goals</td>
<td>0.995</td>
<td>0.829</td>
<td>0.996</td>
<td>0.996</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Moves</td>
<td>0.975</td>
<td>0.635</td>
<td>0.968</td>
<td>0.978</td>
<td>0.975</td>
<td>1.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>novice-page</th>
<th>Drawing</th>
<th>Looking</th>
<th>Perceptual</th>
<th>Functional</th>
<th>Goals</th>
<th>Moves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawing</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Looking</td>
<td>0.968</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceptual</td>
<td>0.786</td>
<td>0.898</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional</td>
<td>0.744</td>
<td>0.828</td>
<td>0.670</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goals</td>
<td>0.655</td>
<td>0.806</td>
<td>0.981</td>
<td>0.617</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Moves</td>
<td>0.951</td>
<td>0.862</td>
<td>0.680</td>
<td>0.504</td>
<td>0.529</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Imagery and perception share many of the same types of neural mechanisms (Farah, 1988, Finke, 1980, 1989) and all characterizations of imagery rest on its resemblance to perception (Kosslyn, 1995).

Given the apparent parallels between the uses of imagery and those of like-modality perception (Osherson, 1995), it is not surprising that imagery apparently shares some of the same processing mechanisms used in recognition (Finke and Shepard, 1986, Kosslyn, 1995).

Modality-specific interference (Osherson, 1995):

Multisensory integration, also known as multimodal integration, is the study of how information from the different sensory modalities, such as sight, sound, touch, smell, self-motion and taste, may be integrated by the nervous system.

Imagery and perception can often be considered functionally equivalent processes (Finke, 1980, Shepard, 1984).

Kavakli, M., Gero, J.S., 2001: Sketching as mental imagery processing, Design Studies Vol 22/4, 347-364, July, ISSN 0142-694X (123 citations) [ERA A*]
Concurrent Cognitive Processing I

- **Primary concurrent actions:**
  - the cognitive actions that directly correlate with depicting drawings.

- **Secondary concurrent actions:**
  - the cognitive actions that highly correlate with the primary actions.

- **(constant-4) Strong correlations** in both design protocols:
  - between depicting drawings (Dc) and looking actions (L),
  - discovery of a relation (Prp),
  - association of a new depiction with a function (Fn).

- **(4+2):** In addition to the constant-4, in the expert's design protocol:
  - creation of a new relation (Prn)
  - revisited thought of a function (Fo)

  there are weak correlations in these categories in the novice's design protocol.

*FOR MORE INFO...*

Training Simulations

- Controlling emotion (fear and anger) and retaining active cognition during complex operations is a critical component of success in military operations.
- Fear and anger can overwhelm prefrontal cognitive processes (Russo et al., 2005).
- The ability to control emotion varies across personnel, and often relates to experience.
- An expert can be viewed as having developed the level of skill required to control emotions during high stress operations, over time and through experience.

https://www.youtube.com/watch?v=V34gCw4fyLs