Training Simulations, Expertise & VIRTUAL REALITY

A/Prof Manolya Kavakli
Director of VR Lab
Simulation Hub

Director of Postgraduate Program
Department of Computing
Macquarie University

20th JULY 2015

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

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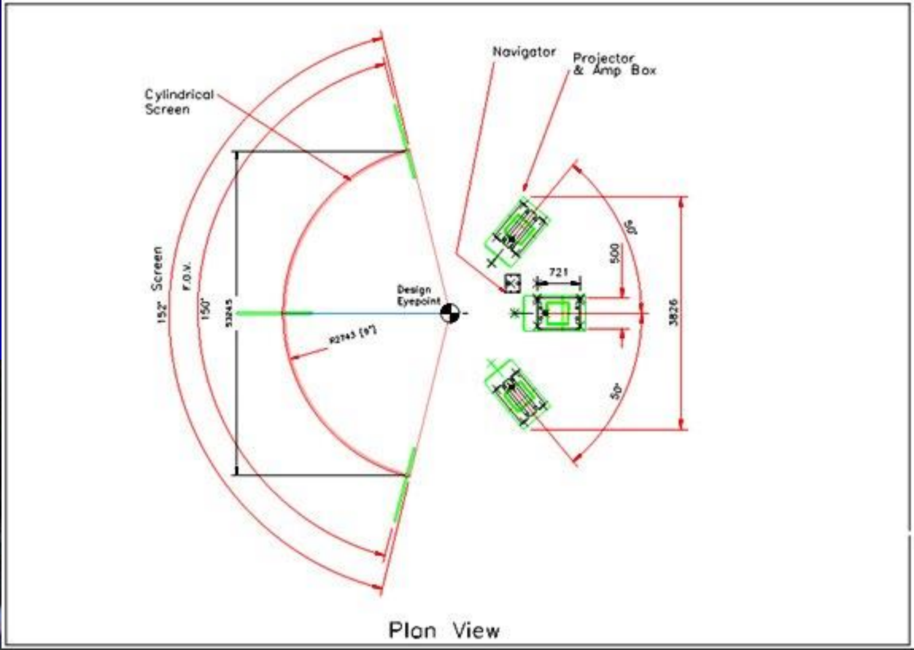
VR Lab, 2005


06-Jul-07 12:02 pm


Cylindrical Screen
Navigator
Projector & Amp Box
152° Screen
150° F.O.V.
Design Eyepoint
721
500
3826
Plan View

Simulation Hub 2015

VISOR @ VR Lab

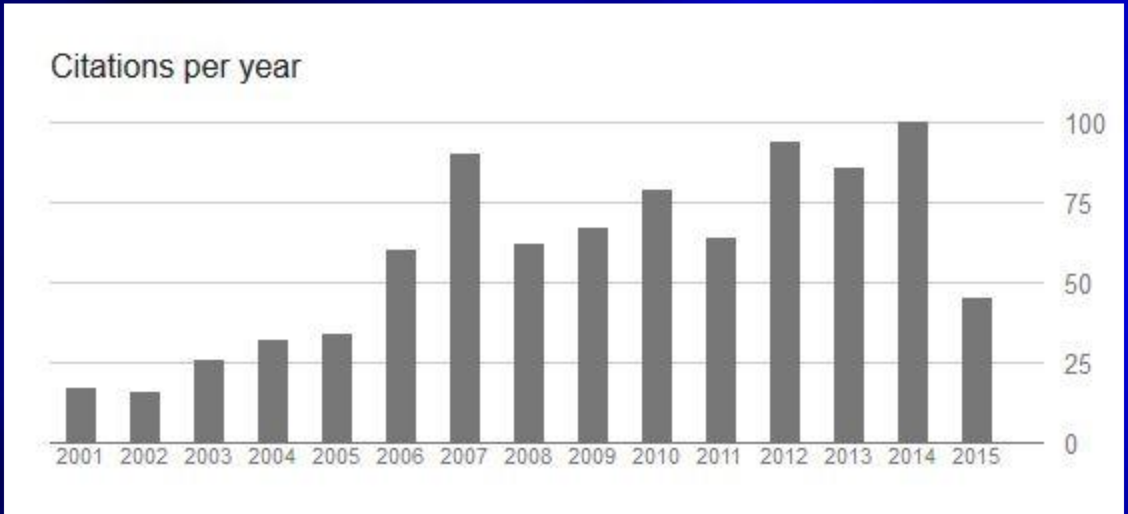
- 6 Postdocs
- 12 PhD students graduated
- 6 current PhD students
- 7 Honours students
- 21 MIT students
- 9 MEng interns
- 6 Programmers
- 67 in total

ARC Grants

- 2009-2012 Australian Research Council Discovery Grant, DP0988088 (Kavakli) A Gesture-Based Interface for Designing in Virtual Reality ($220K)
- 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
- 2013 Best Paper Award, ICIET 2013, International Conference on Information and Educational Technology,

  International Association of Computer Science and Information Tech.
- 2012 Best Paper Award, MMEDIA 2012, International Conferences on Advances in Multimedia, IARIA International Academy, Research and Industry Association

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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

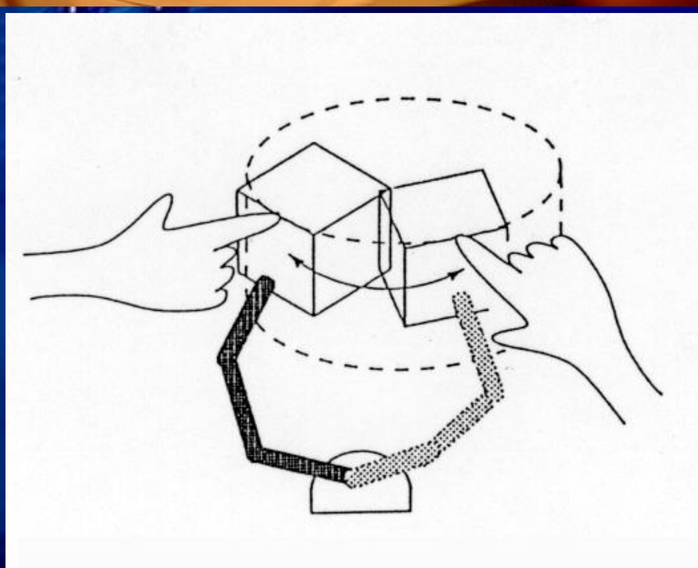
- VISOR (Virtual and Interactive Simulations of Reality)
- CEPET (Centre for Elite Performance, Expertise, and Training)
- Understanding expertise is important for the design of training programs.
  - Principles and mechanisms proposed to underlie expertise can be used to evaluate the theories about basic cognitive processes and capacities, and thus explain human performance more generally (Loft et al, 2009).

VR

Jaron Lanier (1989)

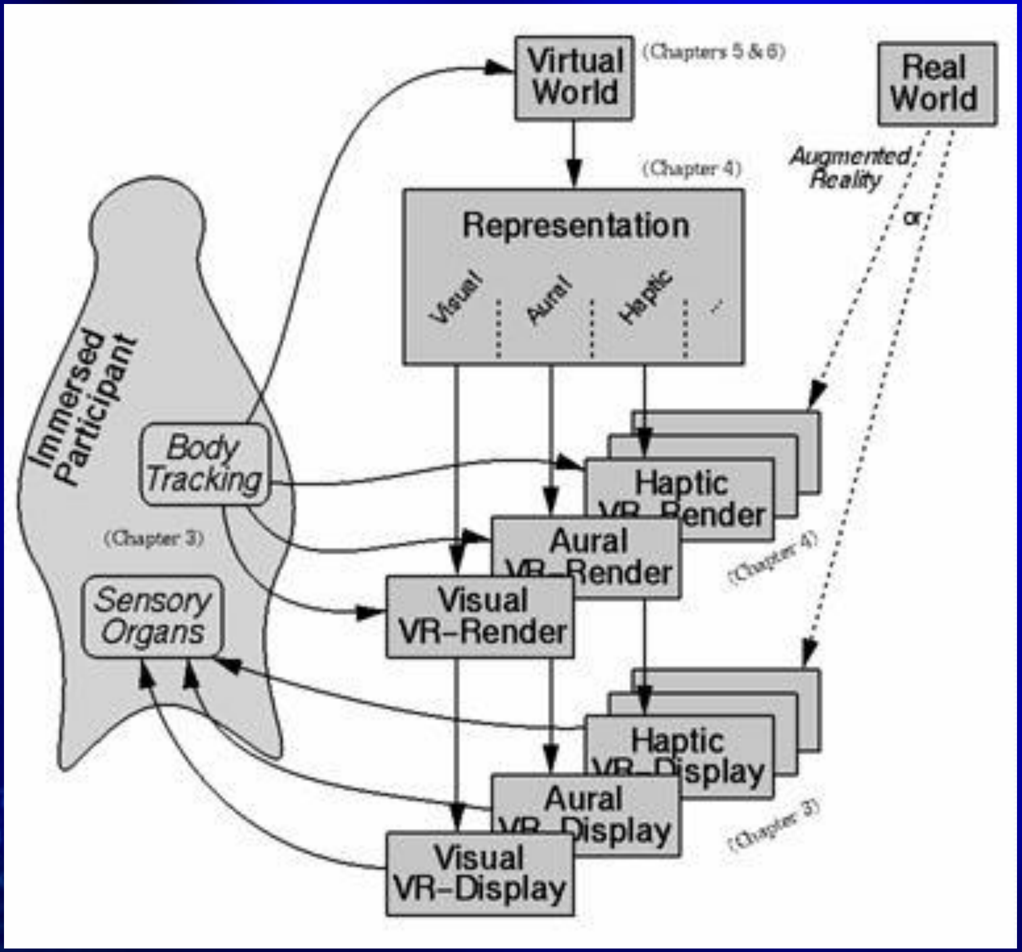
- *a medium composed of interactive computer simulations*
  - *sense the* participant's *position*
  - *replace or augment the feedback to senses*
  - *giving the feeling of*
    - *being immersed or*
    - *being present in the simulation.*
- Immersion / Visualization:
  - The computer generates visual, 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.

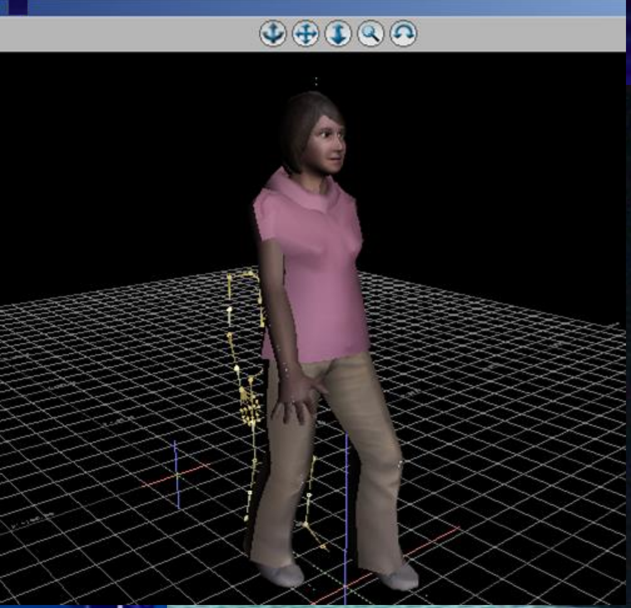

1 8 2005

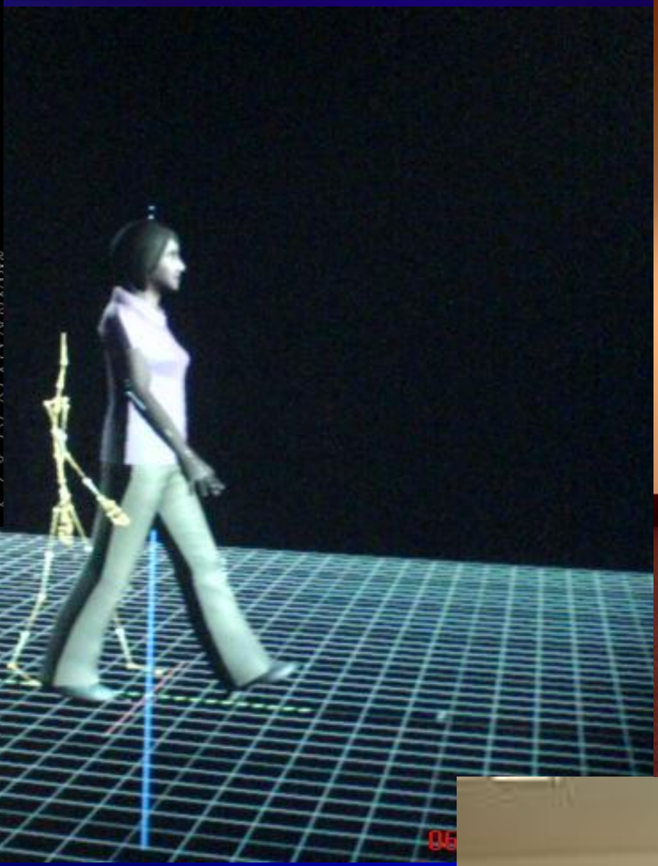


VR & AR

- ※ http://www.youtube.com/watch?v=bBjvqnKQsTI&list=PLDF1BBECCE066EE5E
- ※ https://www.youtube.com/watch?v=V34gCw4fyLs







Tracking motions

Tracking emotions

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 <u>high-stress conditions</u>.
- 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.

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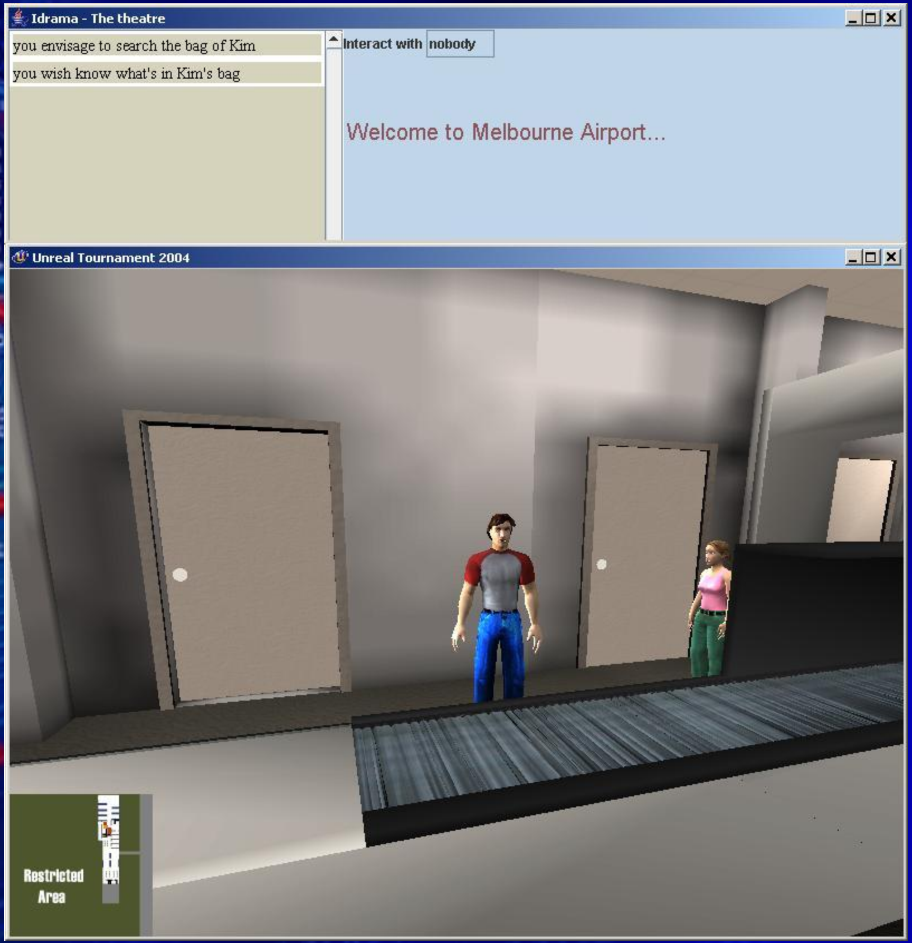
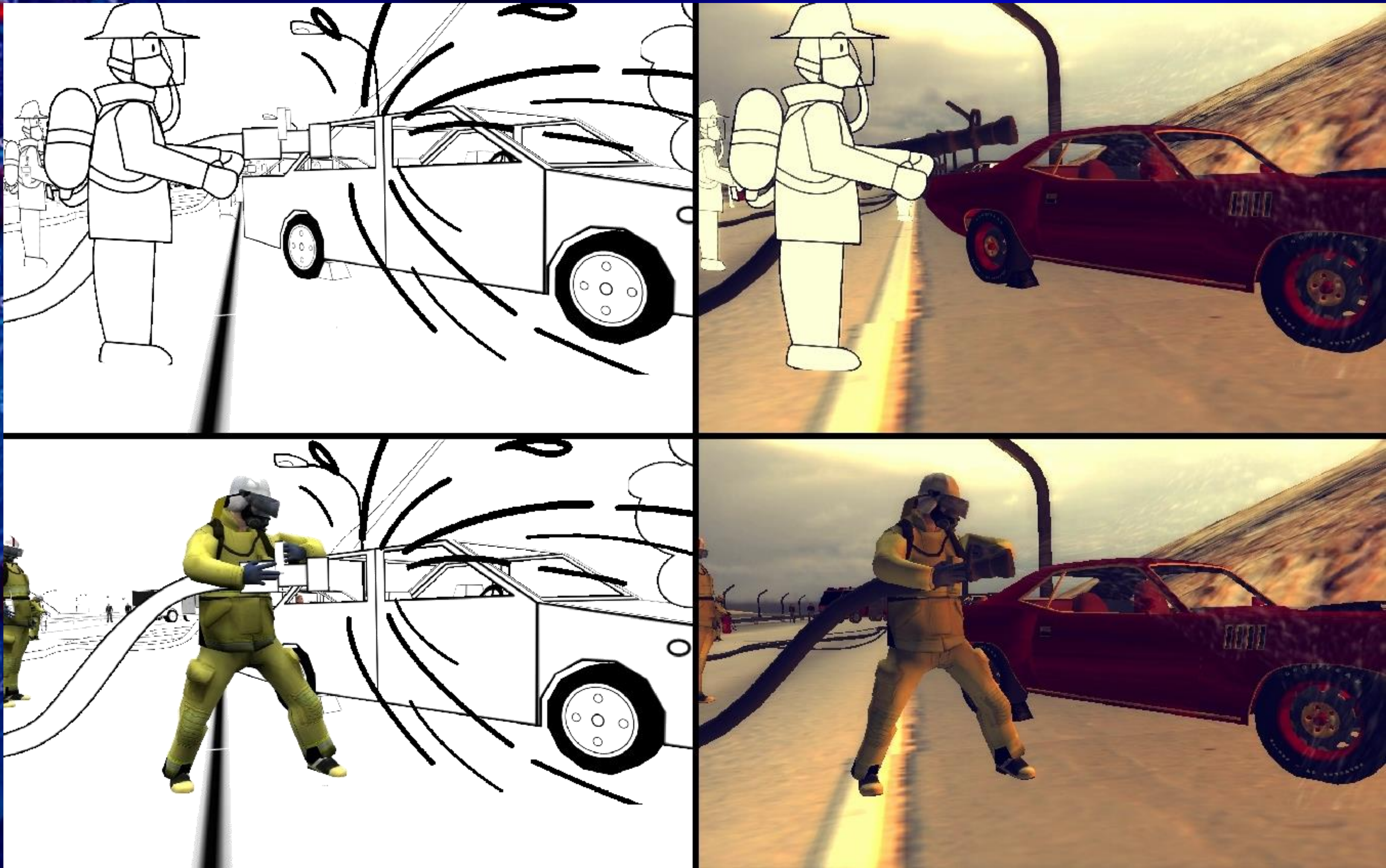
Border Security Sim



VisoR: Virtual and Interactive Simulation of Reality Research Group 2008

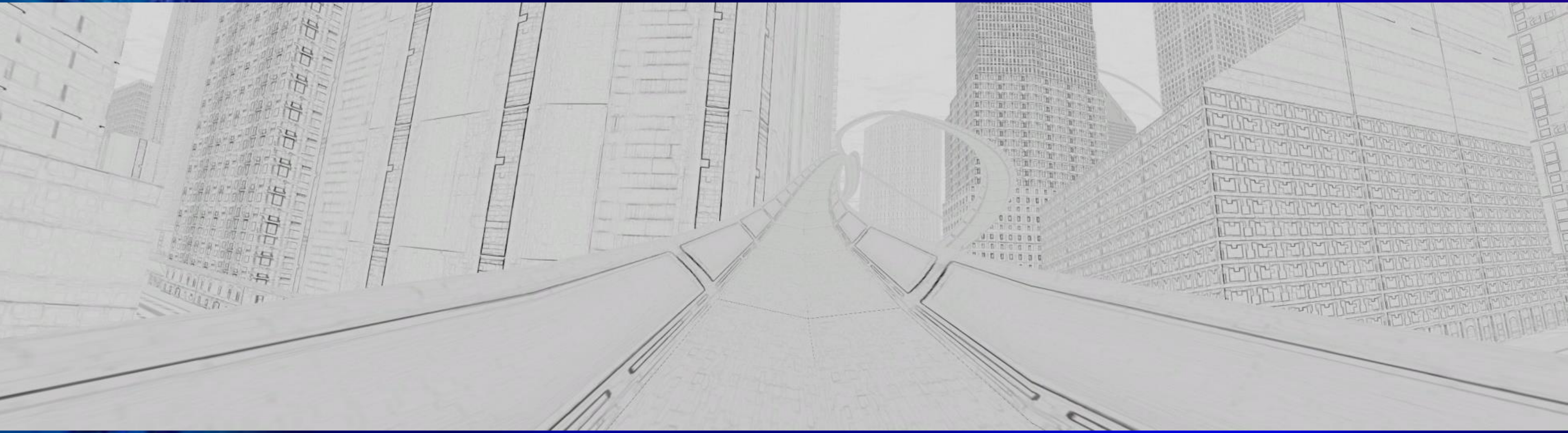
Speech & Gesture Recognition

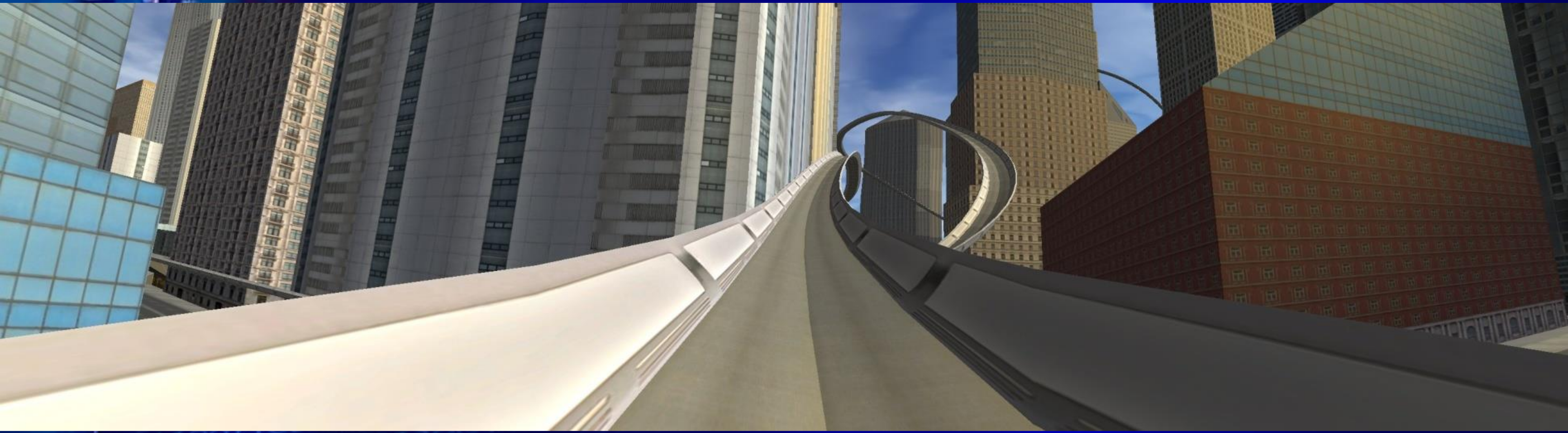
Fire fighting Simulation



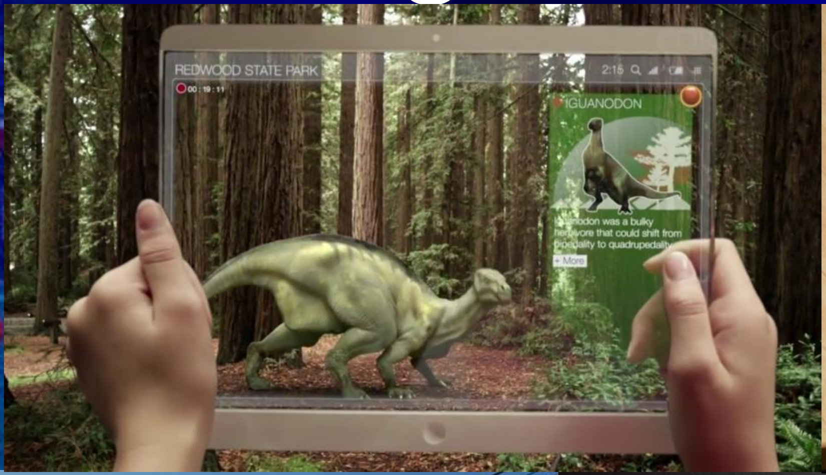
Scene Complexity

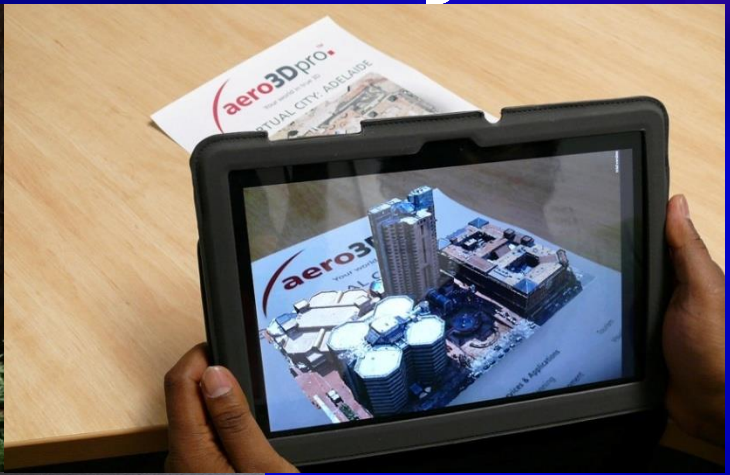
Simulator Sickness

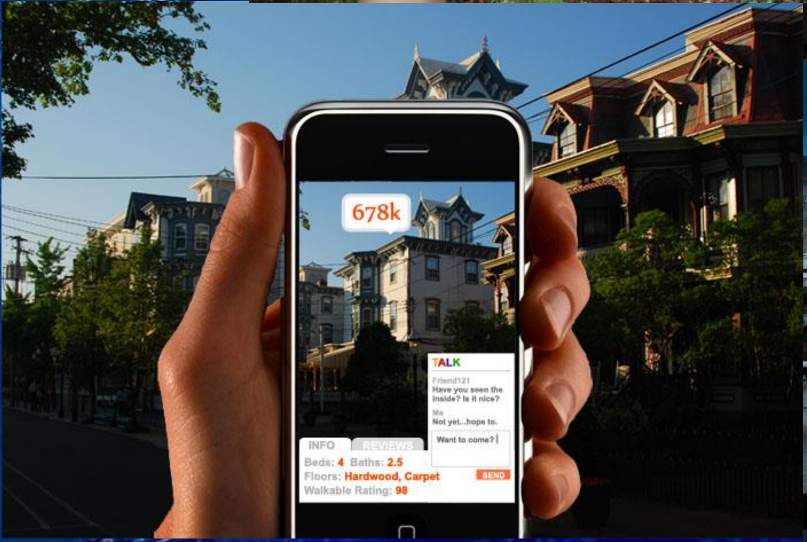




Augmented Reality







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

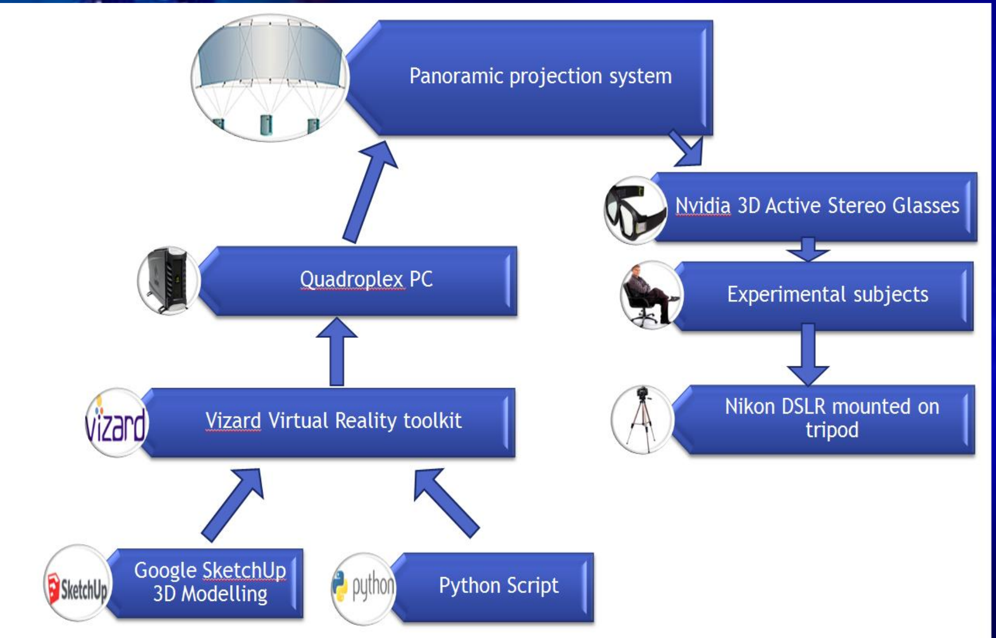
A Multimodal Augmented Reality System for Spatial Design

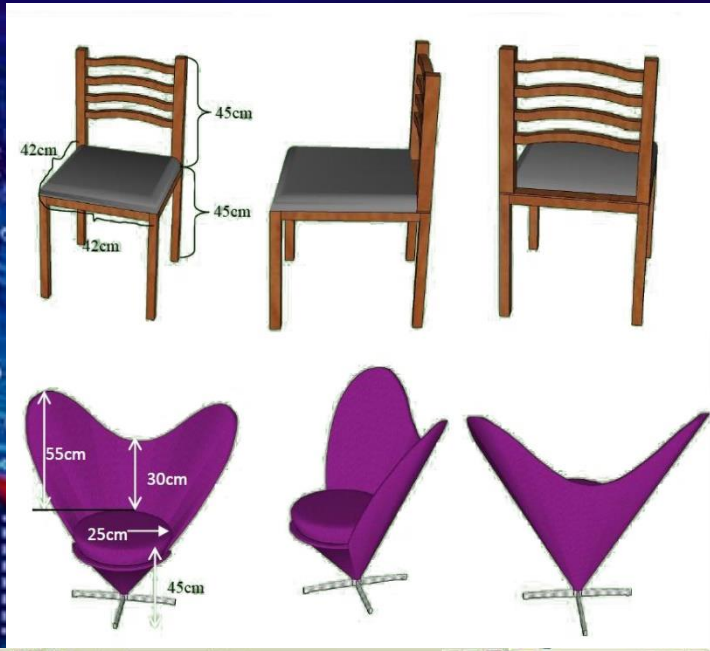
- Using the **GPS** location, accelerometer and gyroscope of the smart tablet, and Google glasses, we will generate a mobile AR system.
- The AR system (I-DeSIGN) will facilitate design communication by
  - using **3D architectural objects** such as walls and windows
  - to push and pull to shape and create a virtual built environment,

Experiment on Immersion

Is Information Processing in VR different from Non-VR?

- 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”.





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30cm
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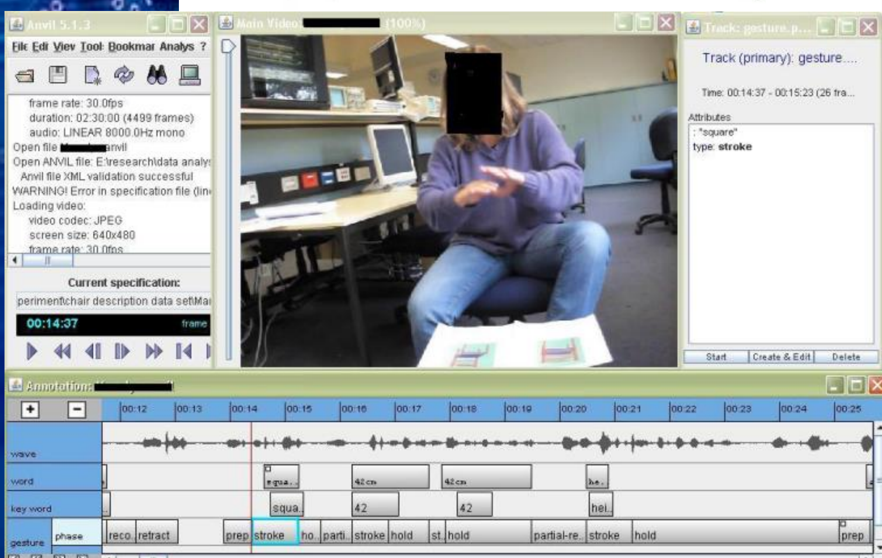

Anvil 5.1.3
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Current specification:
periment\chair description data set\Mai
00:14:37
Main Video: [redacted] (100%)
Track (primary): gesture....
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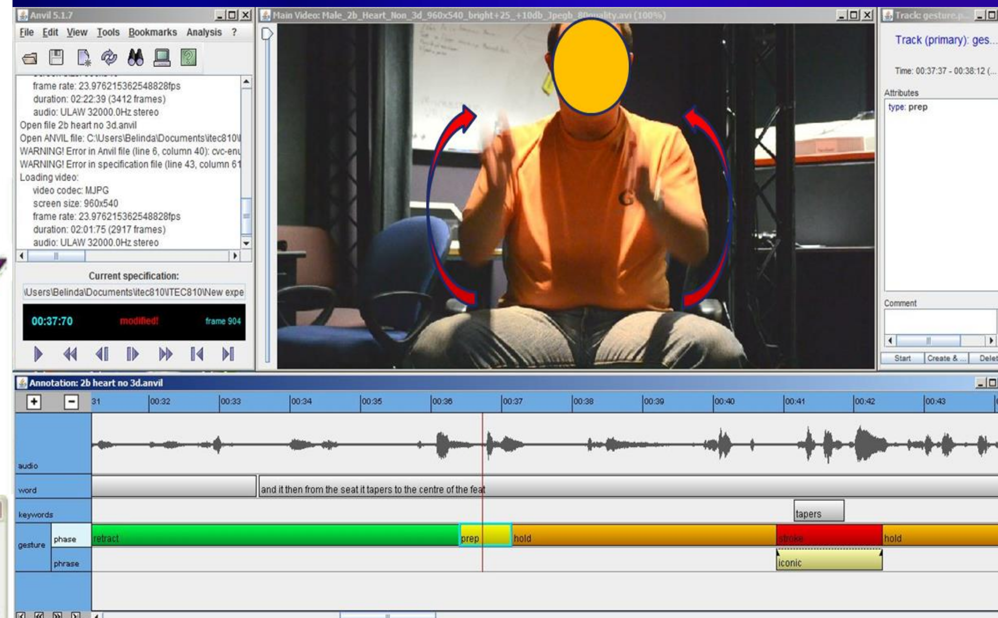

Anvil 5.1.7
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frame rate: 23.976215362548828fps
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audio: ULAW 32000.0Hz stereo
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frame rate: 23.976215362548828fps
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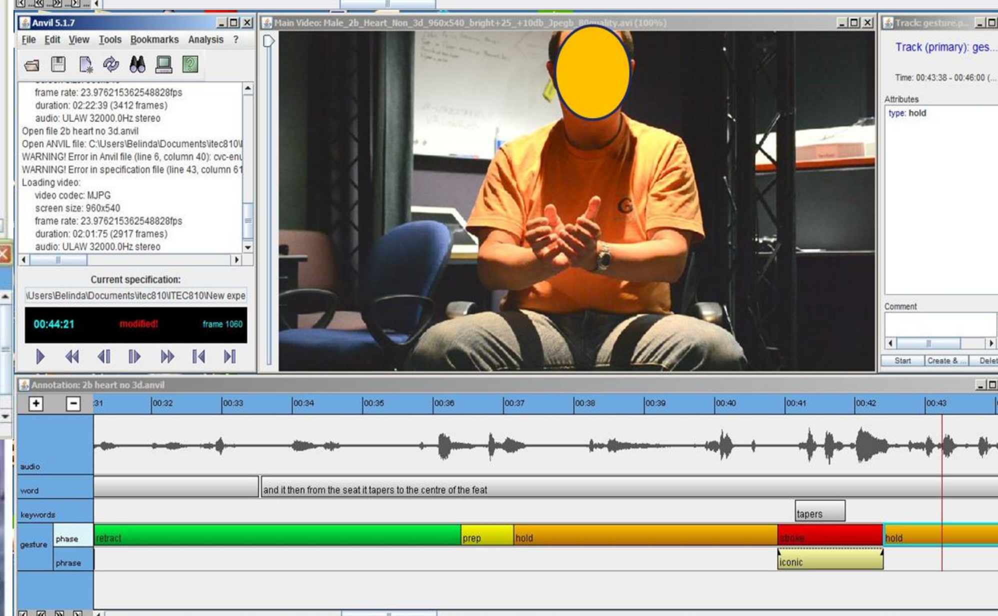

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phrase
and it then from the seat it tapers to the centre of the feat
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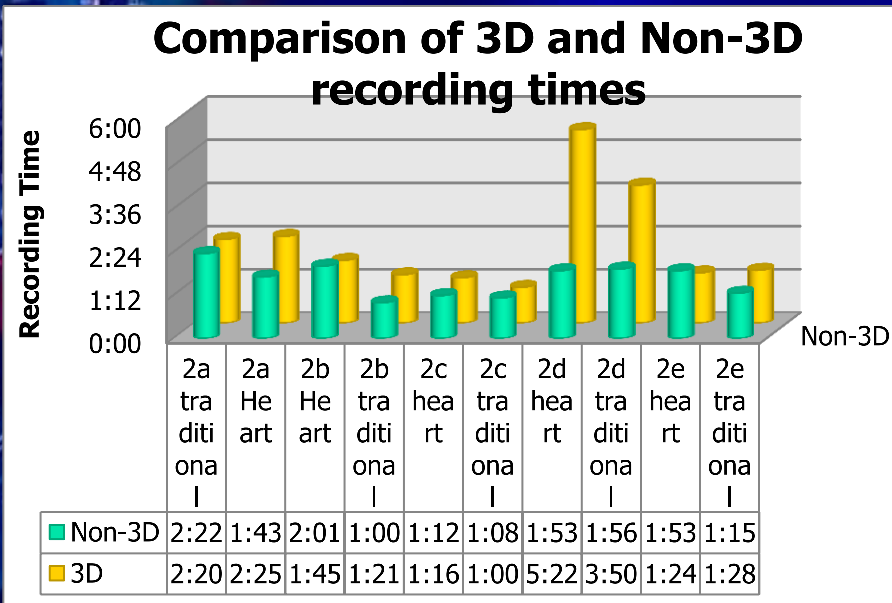
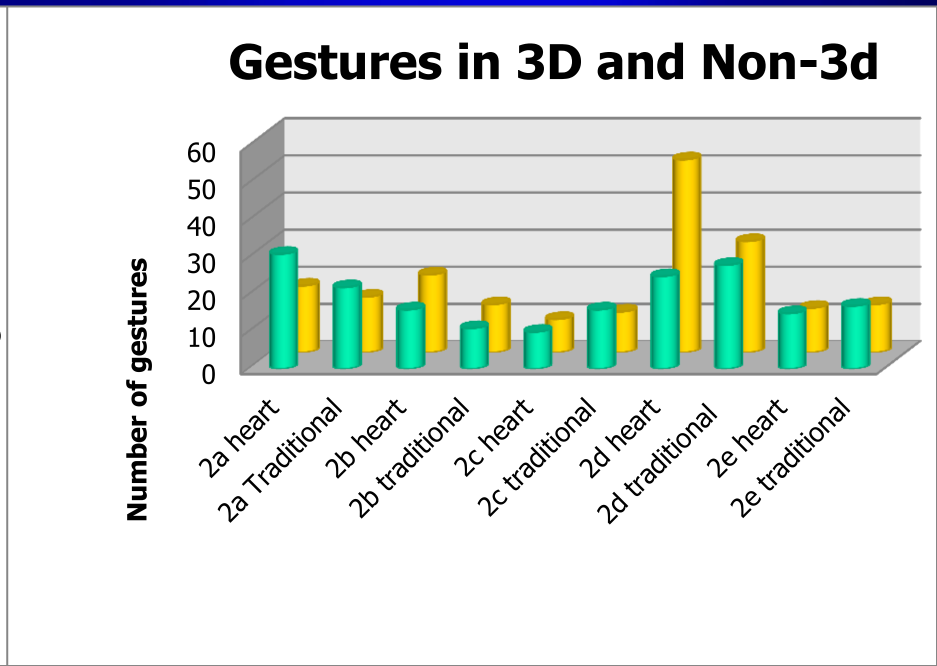
prep
hold
stroke
hold
iconic

Task completion

- **Finding 1: Task times were** **longer in the 3D VR** environment especially for some participants, compared to the non-3D environment.

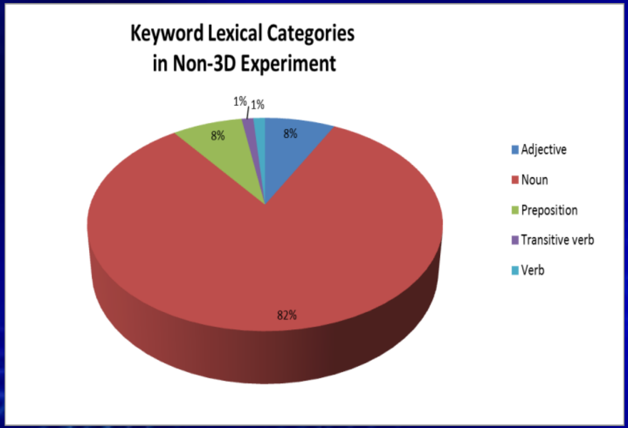


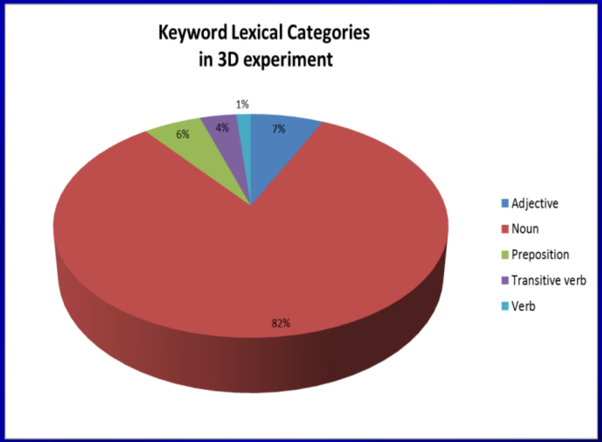
	2a traditional	2a Heart	2b Heart	2b traditional	2c heart	2c traditional	2d heart	2d traditional	2e heart	2e traditional
Non-3D	2:22	1:43	2:01	1:00	1:12	1:08	1:53	1:56	1:53	1:15
3D	2:20	2:25	1:45	1:21	1:16	1:00	5:22	3:50	1:24	1:28



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.

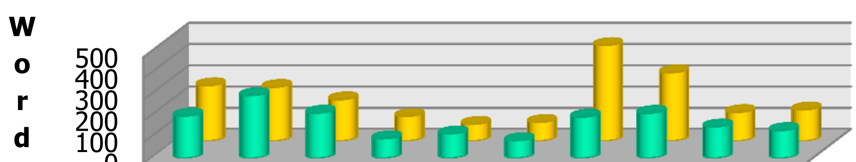




Keywords

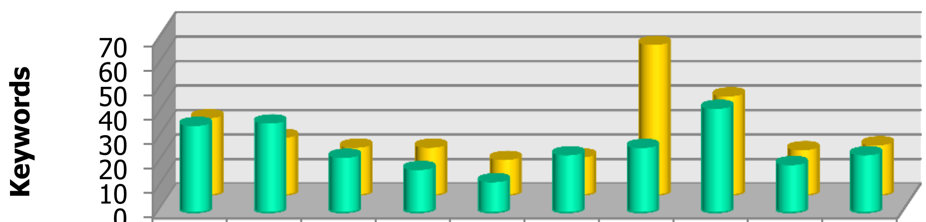
- **Finding 4**: The 3D environment produced some **unique keywords** which reflected differences between the 2D and 3D objects, these include details.
- **Finding 5**: **Keywords and iconic gestures are correlated in both** 3D and non-3D environments.
- **Finding 6**: **Nouns dominated keywords in both** 3D and non-3D environments.

Words in 3D and Non-3D



	2a heart	2a Traditional	2b heart	2b traditional	2c heart	2c traditional	2d heart	2d traditional	2e heart	2e traditional
non 3d	200	296	214	93	116	84	195	213	149	132
3d	262	254	196	117	80	89	451	323	136	148

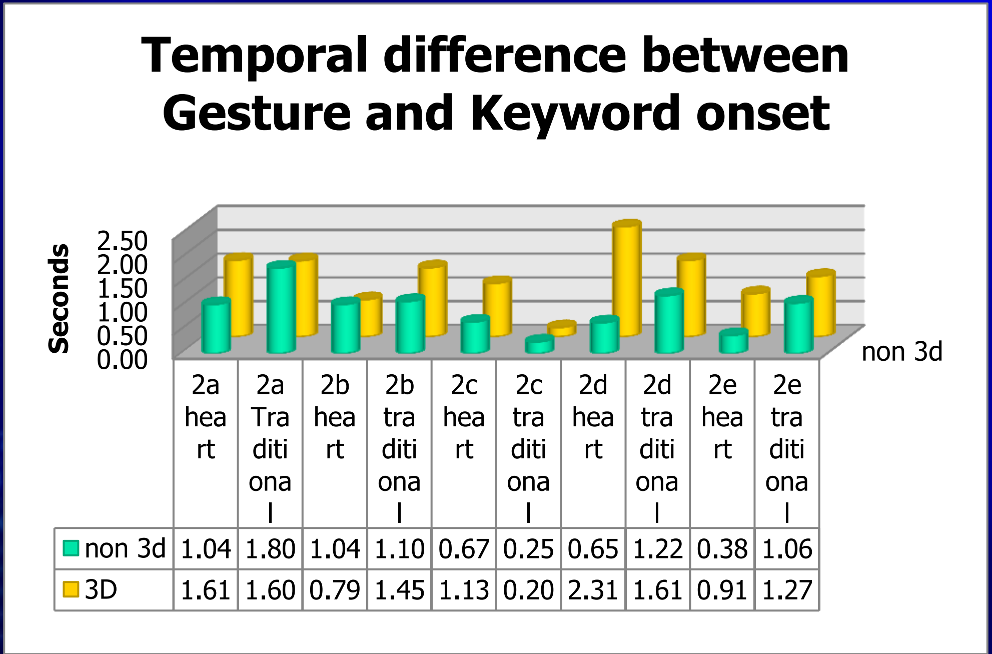
Keywords in 3D and Non-3D



	2a heart	2a Traditional	2b heart	2b traditional	2c heart	2c traditional	2d heart	2d traditional	2e heart	2e traditional
Non 3d	36	37	23	18	13	24	27	43	20	24
3d	32	24	20	20	15	16	62	41	19	21

Temporal difference

- **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**.



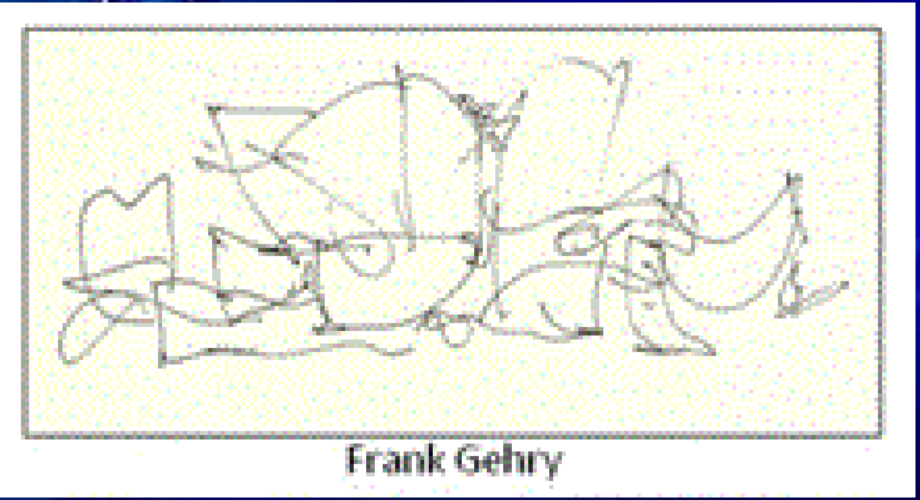
	2a heart	2a Traditional	2b heart	2b traditional	2c heart	2c traditional	2d heart	2d traditional	2e heart	2e traditional
non 3d	1.04	1.80	1.04	1.10	0.67	0.25	0.65	1.22	0.38	1.06
3D	1.61	1.60	0.79	1.45	1.13	0.20	2.31	1.61	0.91	1.27

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?”

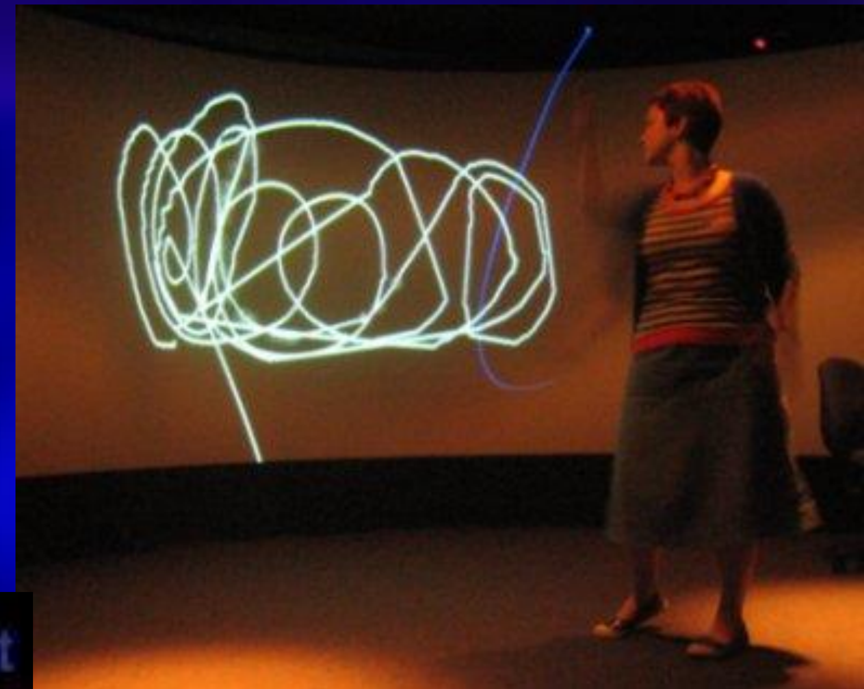
Postdoctoral fellowship: Sketchpad Development

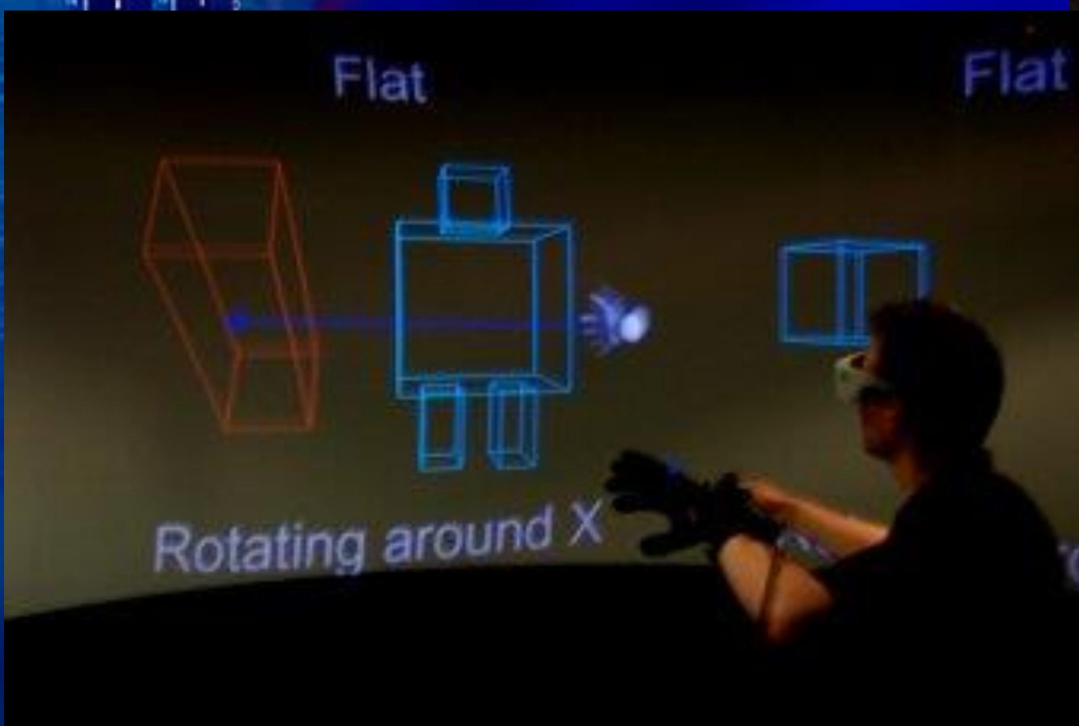
- NATO Science Fellowship (1996, UK)
  - An AI Application for the Transformation of a 2D Sketch to a 3D Geometric Model
  - Project Report:
    - The NATO Science Fellowship Program for Post Doctoral Studies, NATO area code: 4301, NATO list code: 51/B96/TU

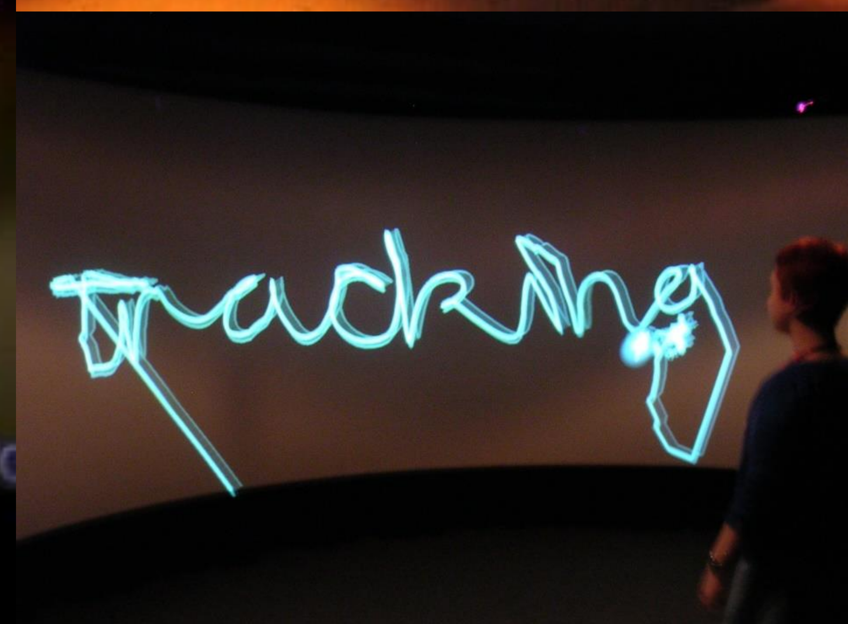


Gesture Recognition

- HCI
  - VR Programming
  - Motion Tracking







Gesture Recognition

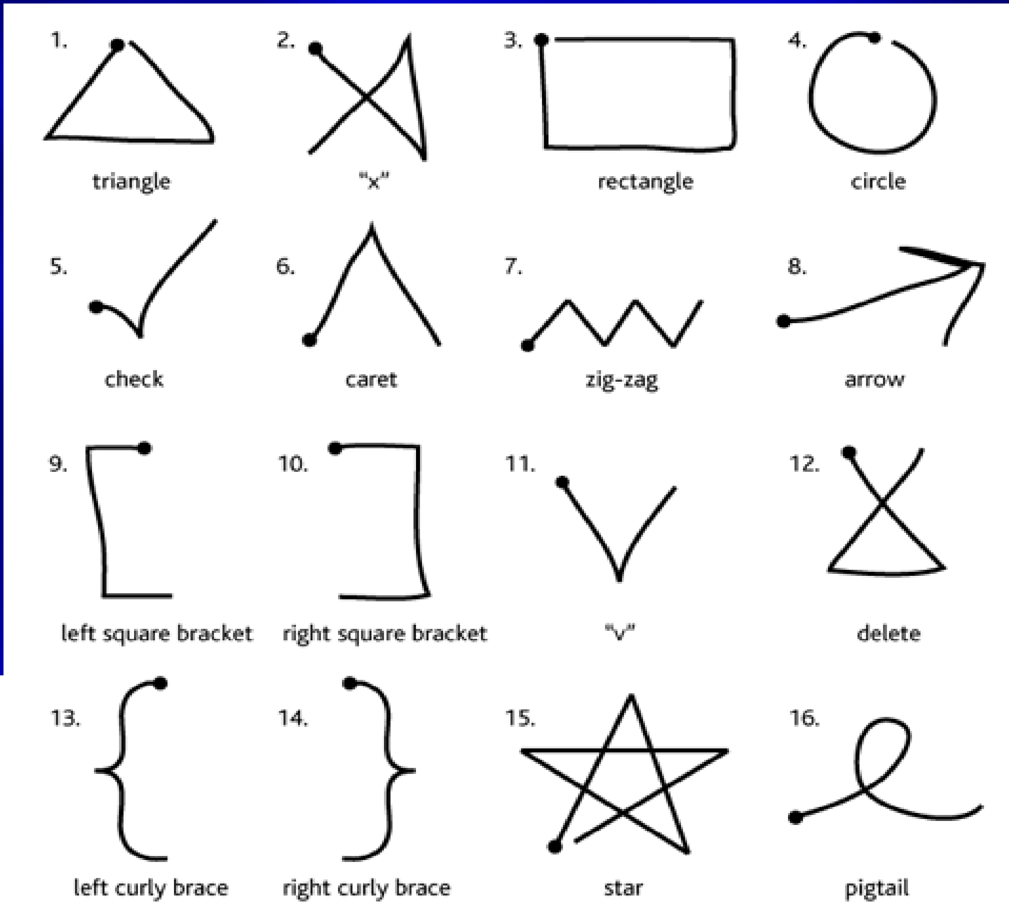
- ※52 individual piezzo resistive sensor strips
- ※located from wrist to shoulders on the right and left side of the t-shirt.
- ※The data is acquired by the National Instrument Data Acquisition Unit.

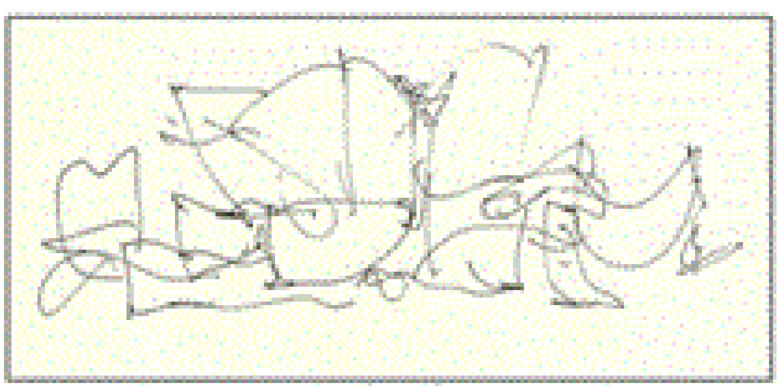
Findings

- 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**.



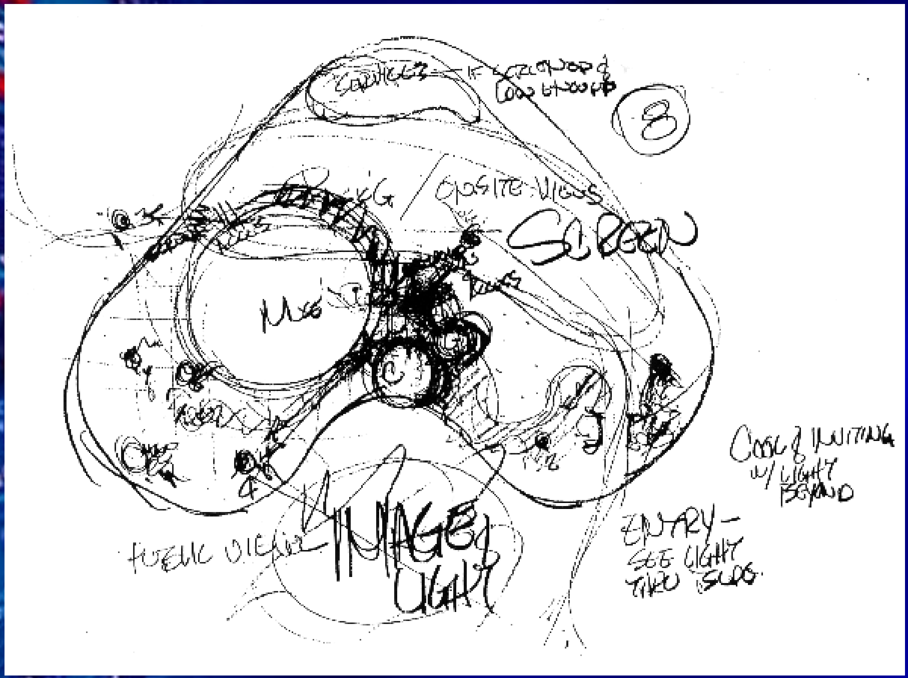

Frank Gehry

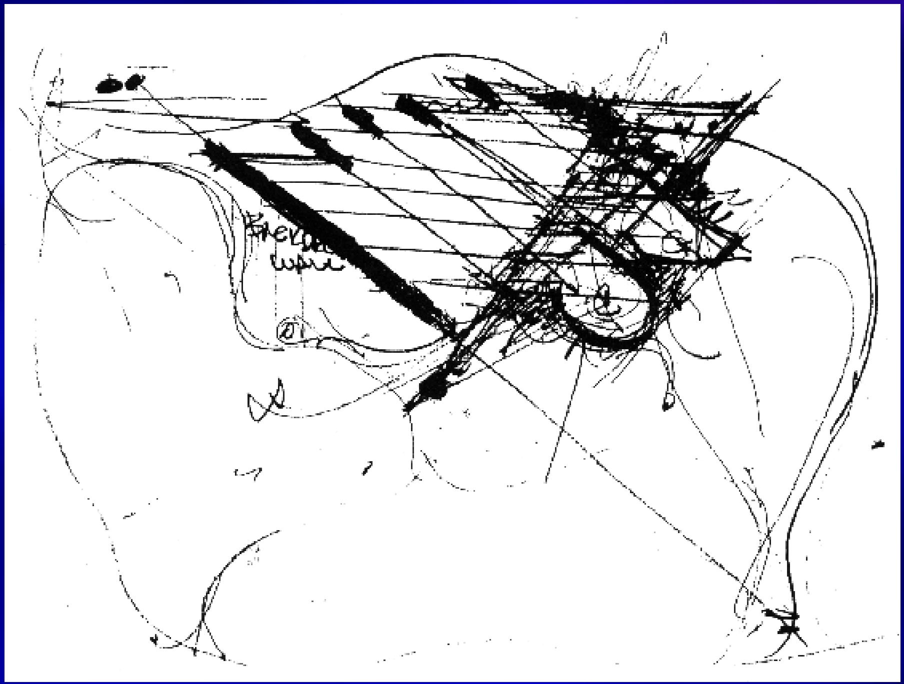
Experiment on Expertise

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.

Sketches I





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.

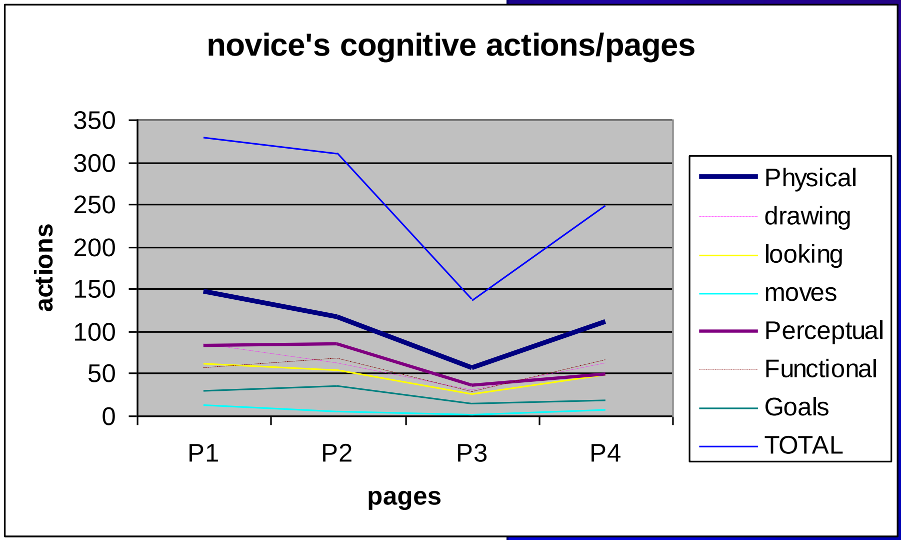
Retrospective Protocol Analysis

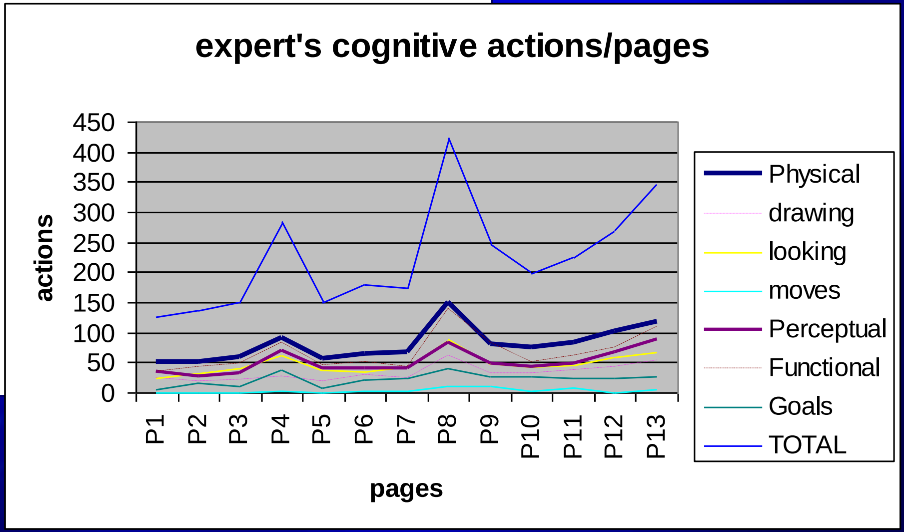
Segment no: 248	so I am going to have to segment this a little bit. Something has to be here and something back here. And I am not going to bisect the main space.				
Action type	index	class	Description (where, of what, among what?)	Dependency	
				index	On what
Drawing Dc	new	Circle 3			
Looking L1	old	Line 67			
Moves					
Perceptual Psg Prn1 Prn2	New New new	i-space l-relation g-relation	The rest space spatial rel (separate): the two spaces spatial rel (included): the new space is on the side of the building	New/new New/old	Dc, Psg Dc, L1
Functional					

Goals			
type	content	Source Seg/type	Trigger what?
Type 2 Type1.3	I am not going to bisect the main space of the building I am splitting the building on the side, not in the center	256	Type1.3 Prn1, Prn2

Table A Correlation coefficients of cognitive actions across design depictions (Dc)

	Expert	*Novice*
Drf	0.03	0.34
Dts	0.58	0.98
Dtd	0.25	-0.75
Dsy	0.35	0.74
Dwo	0.32	0.75
L	0.81	0.99
Psg	-0.17	0.71
Posg	0.27	0.64
Pfn	0.45	0.66
Pfp	0.15	0.90
Pof	0.53	-0.27
Prp	0.74	0.98
Prn	0.70	0.28
Por	0.57	0.92
Fn	0.75	0.86
Frei	0.20	0.21
Fo	0.83	0.51
Fnp	0.31	0.60
Fop	0.68	0.21
Fi	0.24	0.26
G1-1	0.45	-0.29
G1-2	0.67	0.73
G1-3	0.44	0.21
G1-4	0.14	0.85
G2	0.34	0.38
G3	0.21	0.71
G4	0.19	0.58
Ma	0.31	-0.29
Mod	0.07	0.60
Moa	0.69	0.89





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!

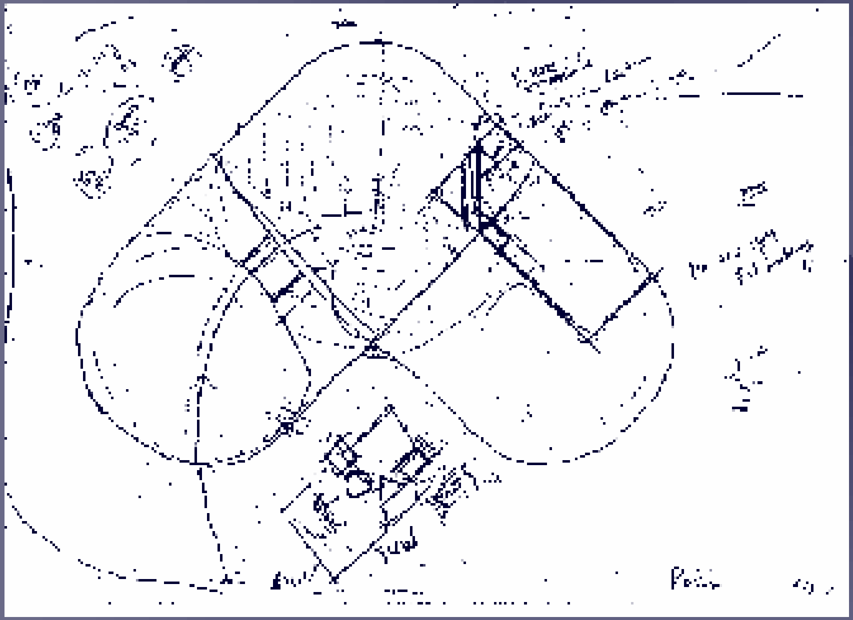
manolya.kavakli@mq.edu.au

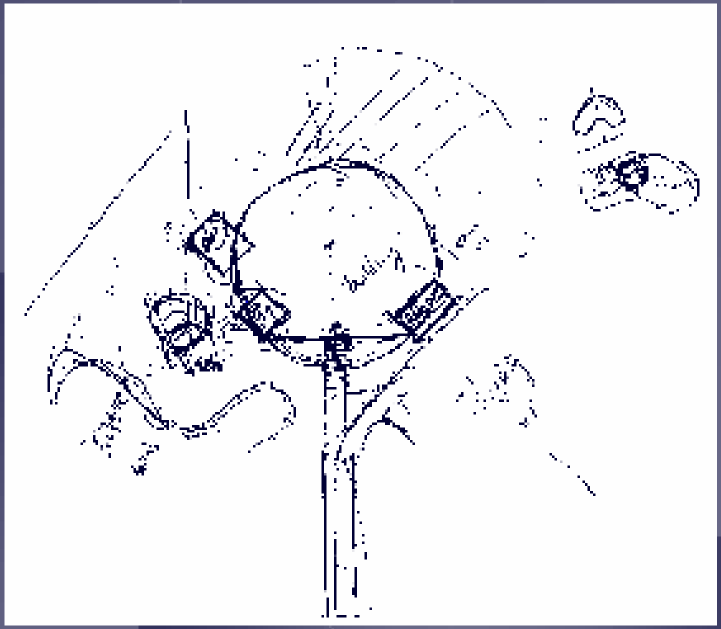
http://www.comp.mq.edu.au/~manolya/

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, χ^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





Correlation Results in pages

Table 5. *Correlation coefficients of cognitive actions in pages*

expert-page	*Drawing*	*Looking*	*Perceptual*	*Functional*	*Goals*	*Moves*
Drawing	1.000					
Looking	0.864	1.000				
Perceptual	0.998	0.909	1.000			
Functional	0.998	0.951	0.998	1.000		
Goals	0.995	0.829	0.996	0.996	1.000	
Moves	0.975	0.635	0.968	0.978	0.975	1.000

novice-page	*Drawing*	*Looking*	*Perceptual*	*Functional*	*Goals*	*Moves*
Drawing	1.000					
Looking	0.968	1.000				
Perceptual	0.786	0.898	1.000			
Functional	0.744	0.828	0.670	1.000		
Goals	0.655	0.806	0.981	0.617	1.000	
Moves	0.951	0.862	0.680	0.504	0.529	1.000

Sketching as Mental imagery processing

- 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).

FOR MORE INFO...

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...

- *Kavakli, M., Gero, J.S., 2002: The structure of concurrent cognitive actions: A case study on novice and expert designers, Design Studies, Vol 23/1, 25-40, January ISSN 0142-694X (143 citations) [ERA A*]*

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