Gestures and Interaction

exploiting natural abilities in the design of interactive systems

Alessandro Soro

Outline

- Background and motivations
- Goals
- Related research
- Natural interaction
  - Gestures & Manipulations
  - Focus on gestures
- A space for group work
- Final remarks

Natural Interfaces

- familiar (Raskin, 1994)
- embodied (Dourish, 2004)
- understandable and predictable (Hofmeester and Wixon, 2010)
- based on existing skills (e.g. Buxton, 2010)

Raskin, J. Intuitive Equals Familiar, Communications of the ACM. 37:9, September 1994, pg. 17.

Dourish, P. Where the action is - The foundations of Embodied Interaction. The MIT Press, Cambridge, MA. 2004.

Hofmeester, K. and Wixon, D. 2010. Using metaphors to create a natural user interface for microsoft surface. In Proceedings of the 28th of the international Conference Extended Abstracts on Human Factors in Computing Systems (Atlanta, Georgia, USA, April 10 - 15, 2010). CHI EA '10. ACM, New York, NY, 4629-4644

Buxton, B. CES 2010: NUI with Bill Buxton. http://channel9.msdn.com/posts/LarryLarsen/CES-2010-NUI-with-Bill-Buxton/ 2010

Natural Interfaces

William Buxton on NUIs:

It's a real word because it has a Wikipedia page now, so it must be real, and it's one of the terms that I have a love/hate relationship with. [...] the term is used so much for so many different things [...] that it almost means nothing.

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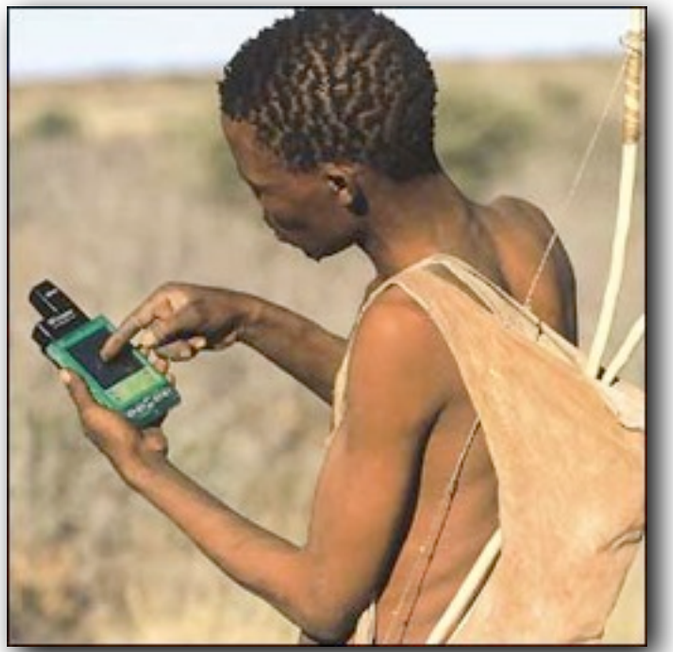
NUI, is the common parlance used by designers and developers of computer interfaces to refer to a user interface that is effectively invisible, or becomes invisible with successive learned interactions, to its users..

early examples: Multi-Touch

other examples: Perceptive Pixel, Microsoft Surface, 3D Immersive Touch, Xbox Kinect, Dragon Naturally Speaking.

Natural Interfaces

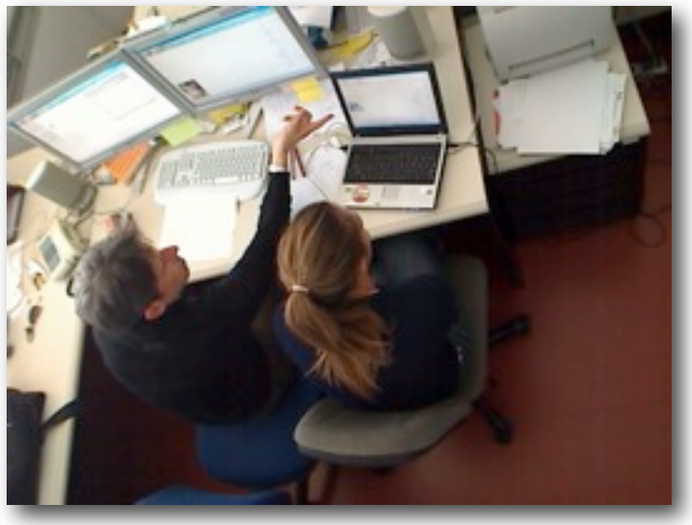
- Interface vs Interaction

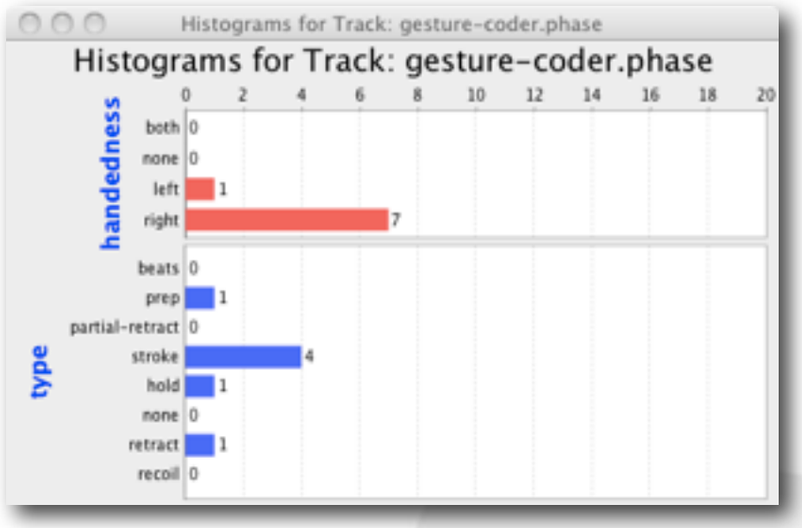


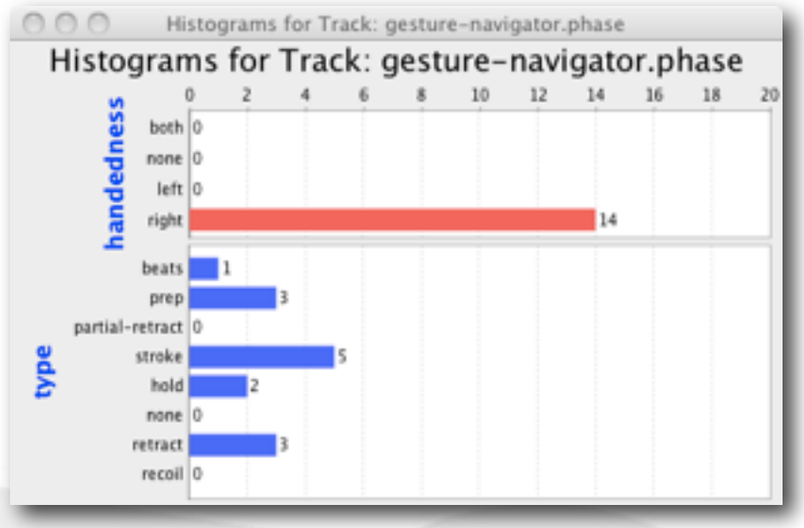
- what is really changing is: *who* is doing *what*, *where*, *with whom* for *how much* and *how* (Buxton)

- the design role is the construction of the "*interspace*" in which people live, rather than an "*interface*" with which they interact (Winograd)

A quick experiment







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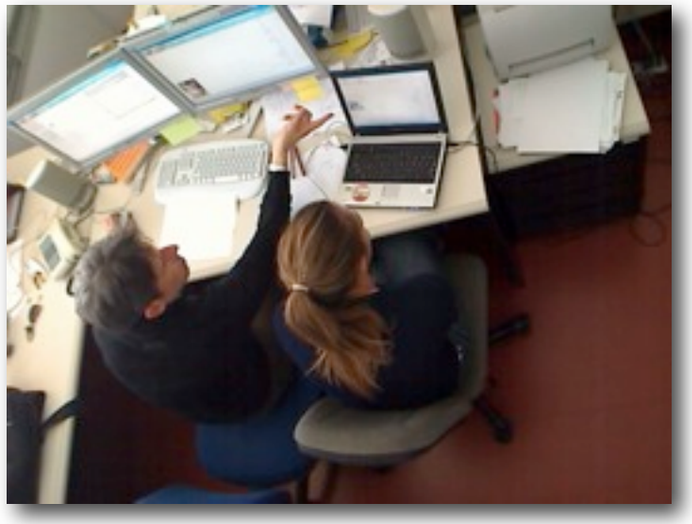

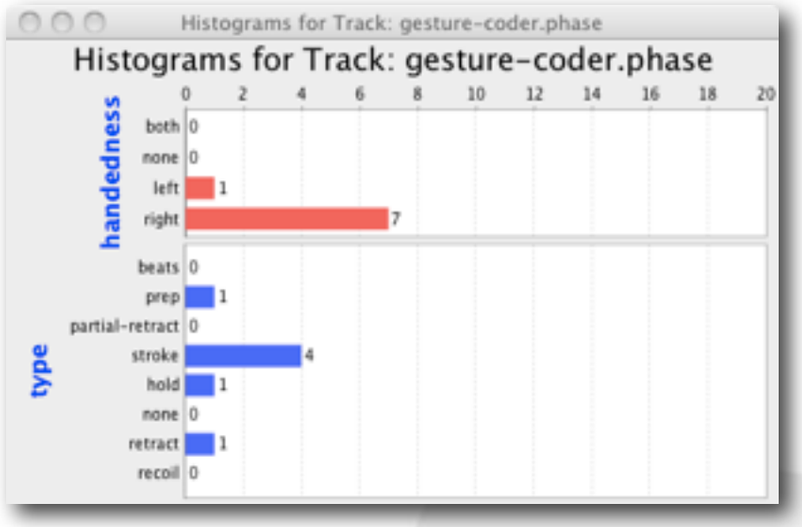

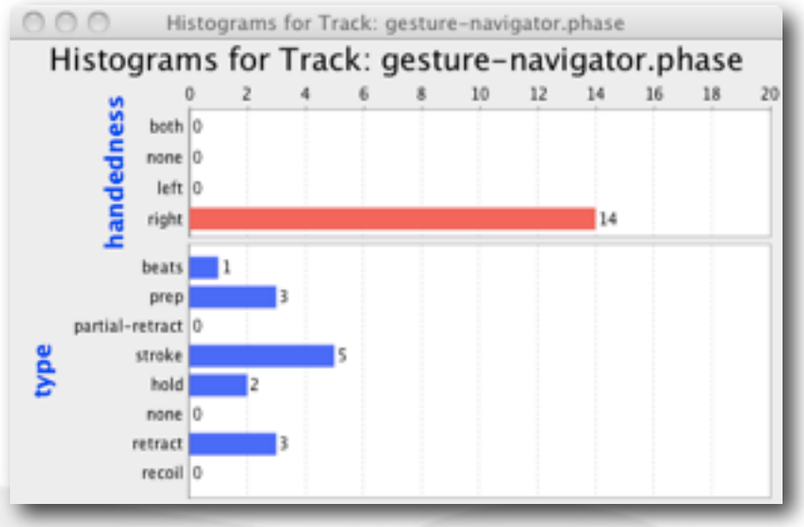

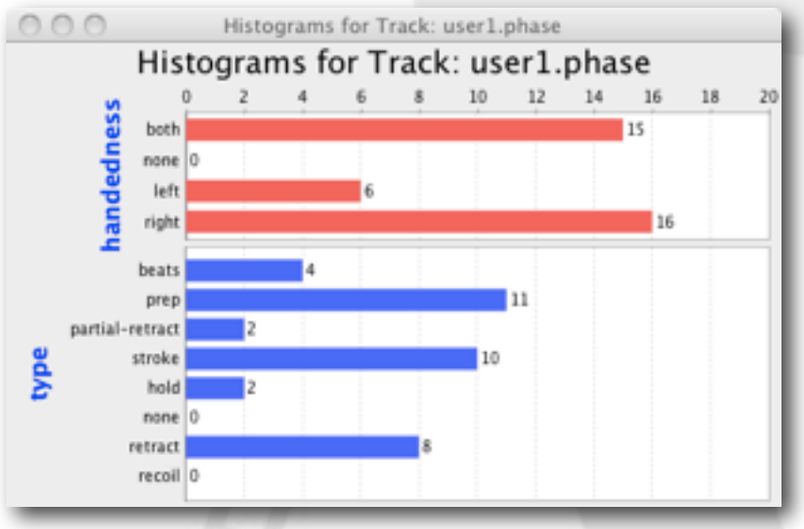

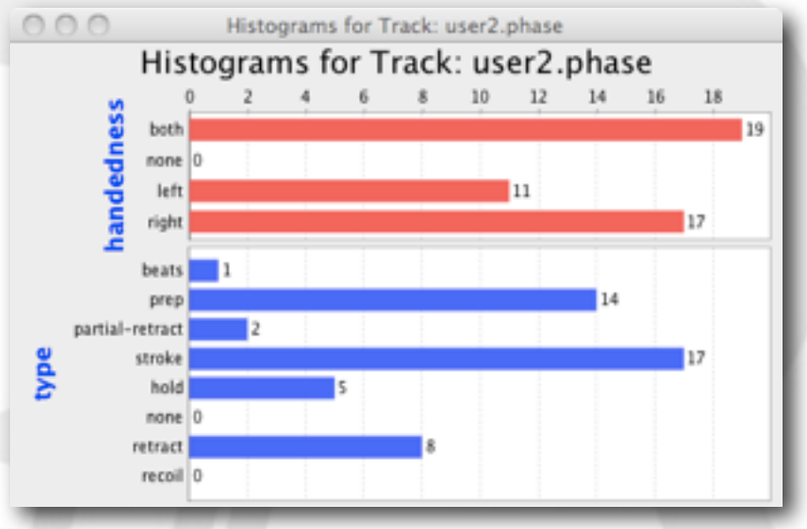

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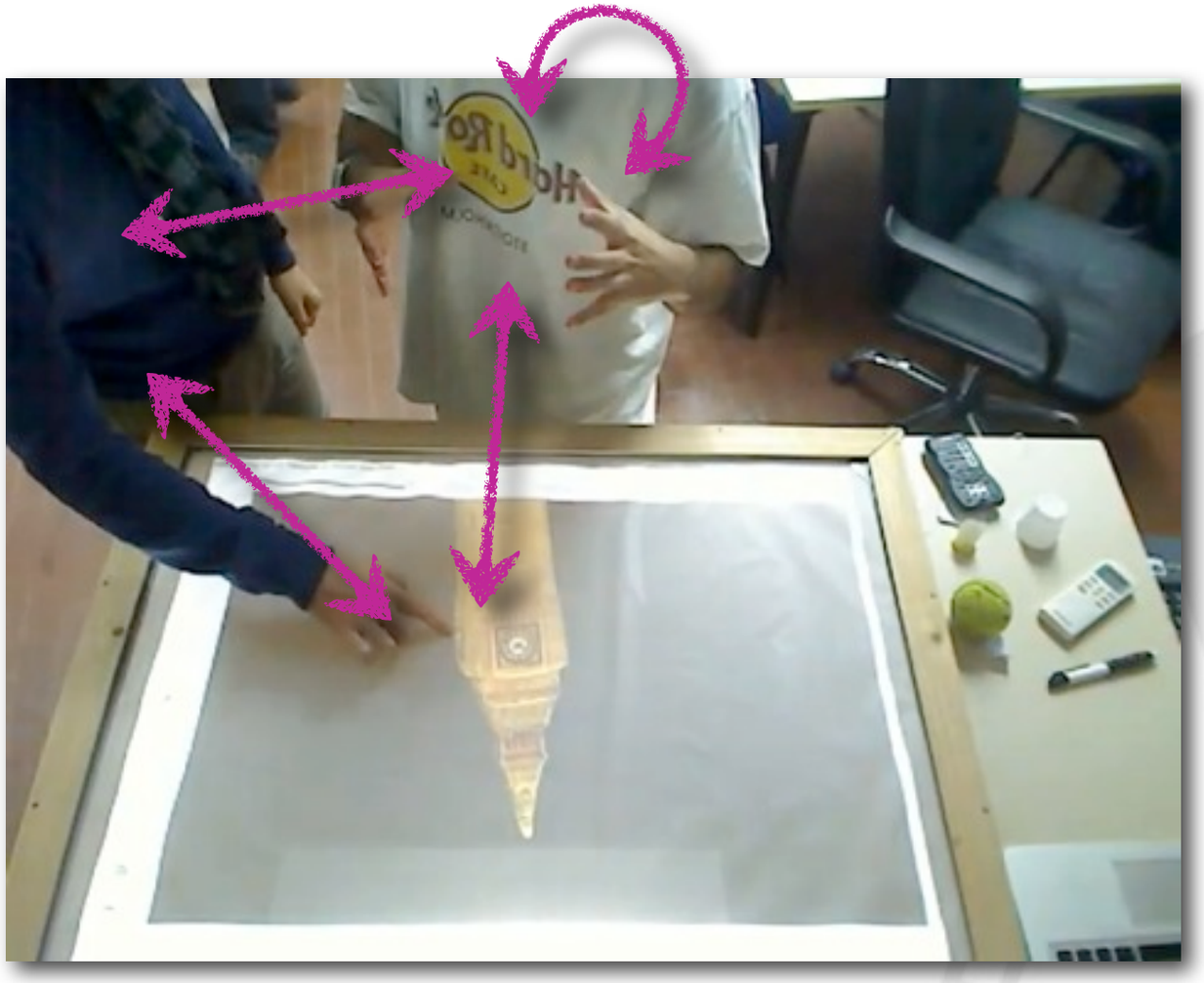

- there's a lot of action that happens away from the system
- people interact with each other at the same time
- gestures and manipulations are known to play a cognitive (unconscious) role
- sometimes technology can spoil this behaviors
- and sometimes it can enhance them

Research Questions

1. what can we learn from the way people use to gesture that can improve the design of our computers?

2. what new application fields can we devise for *natural interfaces* that take advantage of our gesturing skills?

3. can we say something of how *natural interfaces* can impact traditional application fields?

One step back

Let's forget (for now) about computers and think

1) how do people interact with their environment
- to make sense of it
- to change it

2) how do people interact with each other?

3) how do people cope with abstract (e.g. mathematical) thinking?

what can we learn from the above?

Flashback

A basic question: what is a gesture?

Kurtenbach, G. & Hulteen, E. (1990). Gestures in Human-Computer Communications. In B. Laurel (Ed.) The Art of Human Computer Interface Design. Addison-Wesley, 309-317.

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Sushmita Mitra and Tinku Acharya (2007) Gesture Recognition: A Survey
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Mitra and Acharya (2007):
Gestures are expressive, meaningful body motions *involving physical movements of the fingers, hands, arms, head, face, or body*

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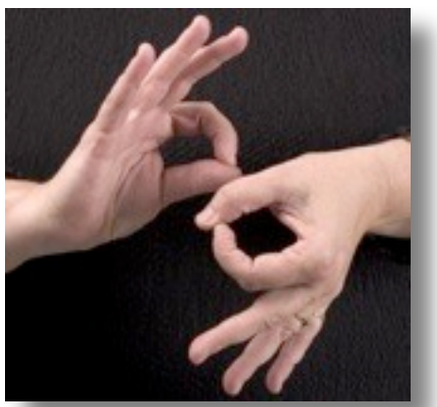
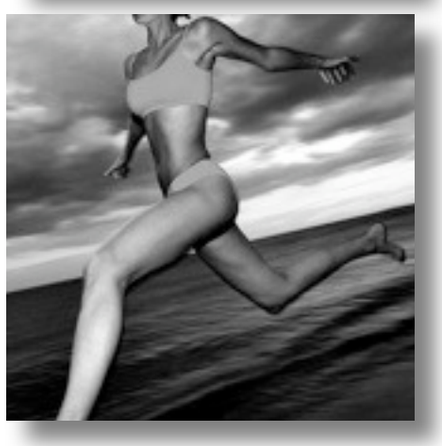
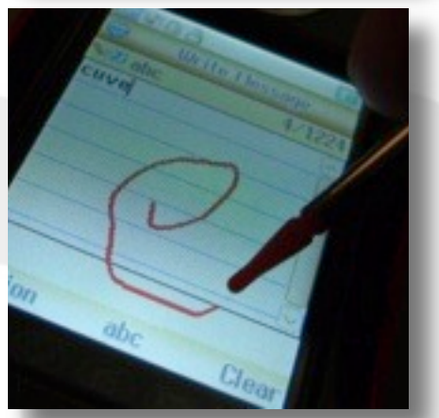
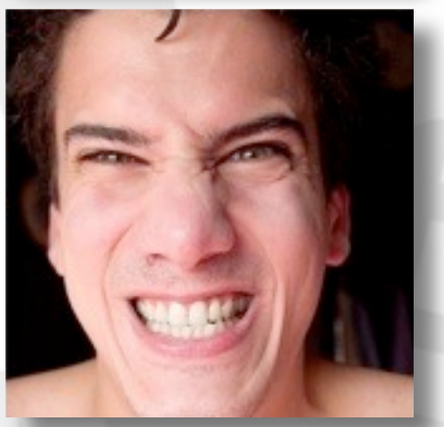







Cadoz on Gestures

Cadoz [1994] suggests a different perspective, classifying hand movements wrt their function:

Semiotic (meant to communicate)

Ergotic (to manipulate the environment)

Epistemic (to discover the environment)

Cadoz, C. (1994). "Le geste canal de communication homme-machine. La communication 'instrumentale'" Sciences Informatiques, numéro spécial: Interface homme-machine. 13(1): 31-61

Kendon on Gestures

- Kendon (1988) classifies gestures along a continuum:

1. **gesticulation**: spontaneous movements of the hands and arms during speech
2. **language-like gestures**: like gesticulation, but grammatically integrated in the utterance
3. **pantomime**: gestures meant to imitate or describe a concept/movement/shape
4. **emblems**: conventional gestures/postures, such as 'ok', 'stop', etc.
5. **sign language**: a set of gestures and postures for a full fledged linguistic communication system

Gesticulation

Language-like

Pantomimes

Emblems

Sign Languages

Kendon, A. (1988). How gestures can become like words. In F. Poyatos, ed., Crosscultural Perspectives in Nonverbal Communication. Toronto: C. J. Hogrefe, Publishers, 1988, pp. 131-141.

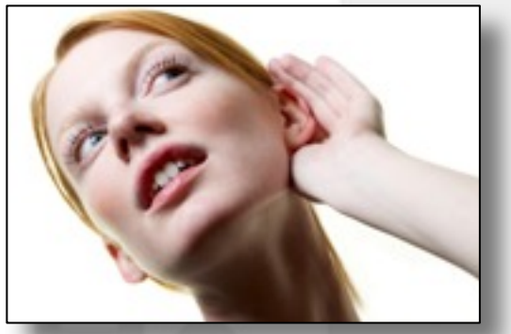
McNeill on Gestures

presence of speech

linguistic properties

Emblems

Gesticulation



Pantomimes

Sign Languages

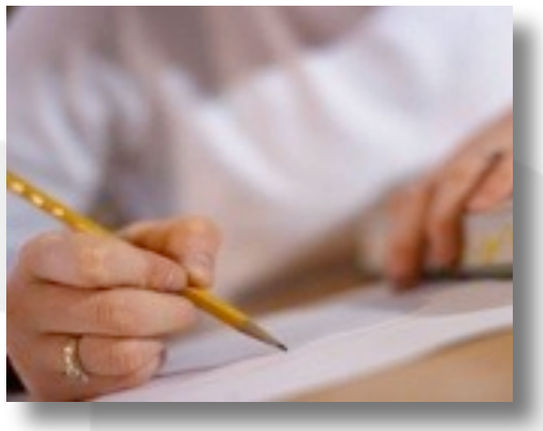
Morris on Gestures

Still another point of view, according to Morris [1977], human action can be either:

Innate

Discovered

Absorbed



Learned

... or a combination of the above

Desmond Morris, 1977. MANWATCHING: A FIELD-GUIDE TO HUMAN BEHAVIOUR. Jonathan Cape, London.

Manipulations and Reasoning

Epistemic vs Pragmatic Action

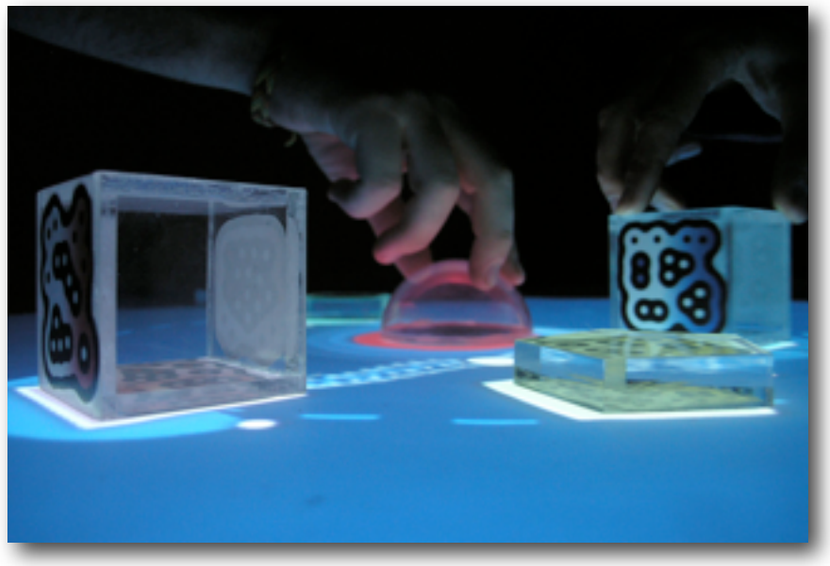
The difference among these types of motor activities have been described by Kirsh & Maglio. They observed that **skilled Tetris players tend to execute lots of fast and apparently useless moves** on the bricks while playing. Their hypothesis (confirmed by many experiments) is that these moves are executed by the player in order to reach a more convenient cognitive status, rather than to directly achieve one's goal.

- **Direct manipulation improves problem solving**
- **Epistemic action increases with skill**

Kirsh, D. and P. Maglio (1994). On Distinguishing Epistemic from Pragmatic Action, Cognitive Science 18, (1994), 513-549.

Maglio P. and Kirsh D. (1996). Epistemic action increases with skill. In In Proceedings of the Eighteenth Annual Conference of the Cognitive Science Society (1996), Erlbaum, pp. 391–396. 3

Manipulations and Reasoning (2)



Tangible User Interfaces build on these principles: with tangibles:

- the interaction takes place in the physical space; instead of manipulating graphical entities that represent digital objects, **the user manipulates objects themselves**;
- the interaction and its effects on an artifact happen at the **same time and in the same place**
- the interface encompasses the state of the model, i.e. the user interface is not meant to represent the state of the system, but rather **the interface is the state of the system**.

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Manipulations and Reasoning (3)

Multitouch Interaction

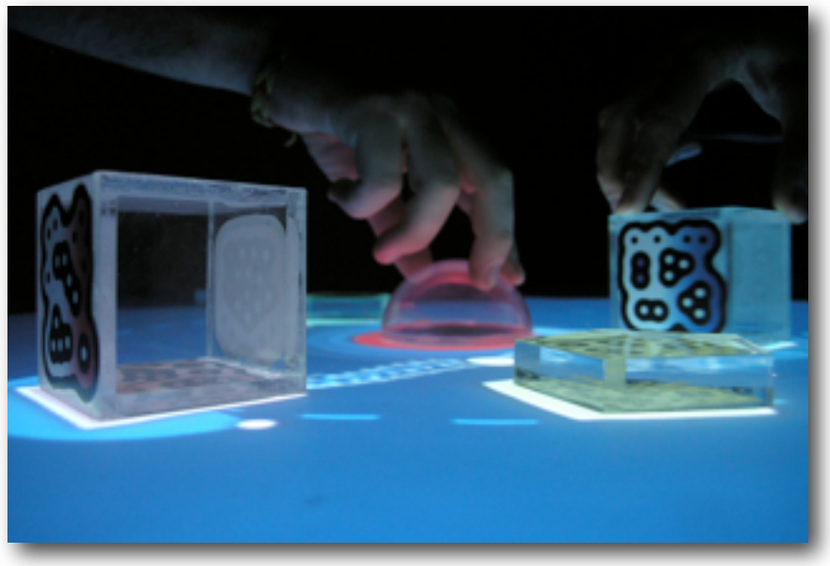
(some of) the power of Direct Manipulation without the burden of real world constraints

HAN J.Y.: Low-cost multi-touch sensing through frustrated total internal reflection. In UIST '05: Proceedings of the 18th annual ACM symposium on User interface software and technology (New York, NY, USA, 2005), ACM, pp. 115–118. 3

BUXTON B.: Multi-touch systems that i have known and loved (overview). 2007. 3

Owen, R and Kurtenbach, G and Fitzmaurice, G and Baudel, T and Buxton, B (2005) When it gets more difficult, use both hands: exploring bimanual curve manipulation. Proceedings of Graphics Interface 2005

Enabling Technologies



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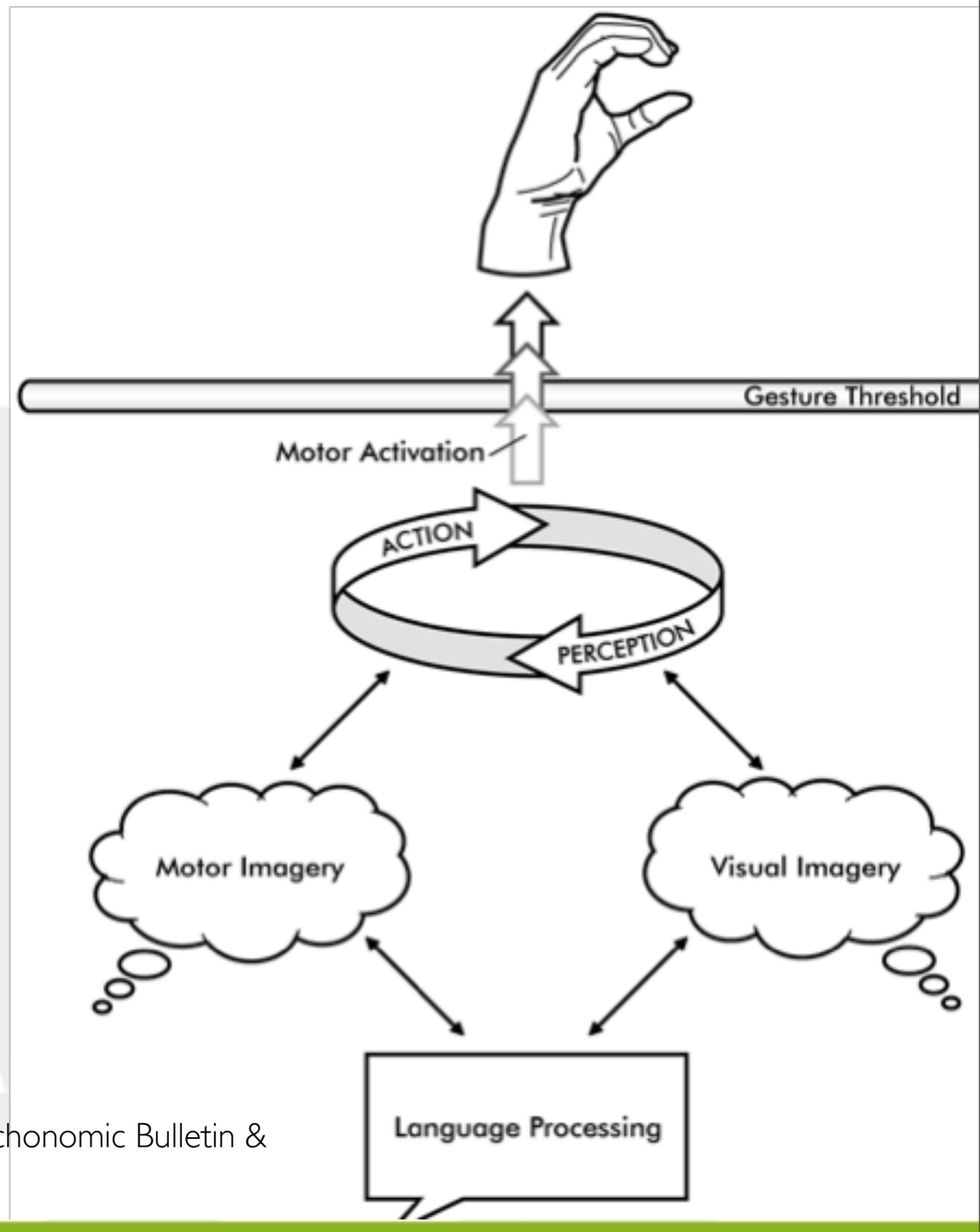
Other frameworks

GSA: Gestures as simulated action

- Simulating actions involves activating neural areas that are involved in planning physical actions
- Simulating perceptions involves activating neural areas that are involved in perceiving physical objects
- this involves activating neural areas that are involved in using or reacting to objects

- **The GSA framework contends that whenever ideas are being simulated in terms of perceptual and motor properties, regardless of whether the idea is about something physically spatial or only metaphorically spatial, a gesture can result**



Hostetter, A. and Alibali, M. Visible embodiment: Gestures as simulated action - Psychonomic Bulletin & Review 15(3), Springer New York. 495--514 (2008)

Gestures and Reasoning

- gesturing improves STM (Goldin-Meadow, et al. 2001) and learning (Wagner, et al. 2008)

Goldin-Meadow, S., Nusbaum, H., Kelly, S.D., & Wagner, S. (2001). Explaining math: Gesturing lightens the load. Psychological Science, 12, 516–522.

Susan Wagner Cook, Zachary Mitchell, and Susan Goldin-Meadow (2008) Gesturing makes learning last. Cognition. 2008 February; 106(2): 1047–1058.

A (rough) classification

	manipulations		gesticulations	proper gestures			
Kirsh & Maglio	pragmatic	epistemic					
Cadoz (1994)	ergotic	epistemic	semiotic				
Kendon (1988)			gesticulations	language-like	pantomime	emblems	sign-languages
Mc Neill (1992)			beats	metaphorics	deictics	iconics	
Morris (1977)			innate	discovered	absorbed	learned	
applications							
	exploration of MM / Tangible UI / and much more...		nat. language understanding / natural interaction / content based IR / Human Robot Interaction / emotion recognition	gestural interaction			sign lang recognition
sensing technologies							
	optical / capacitive MT sensors	fiducials / accelerometers / gyroscopes / position	computer vision / data gloves /				

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Gestures & Gesticulation

- Some actions are rooted more deeply in our biological evolution

- are these better candidates for a *universal* non verbal language?

Related projects & applications

- Gestures in Human Robot Interaction
- social gestures (such as hugs or caresses) may remain intact in patients affected by severe cognitive and behavioral disturbances related to Dementia

Interpretative Dynamics in Human Robot Interaction L Giusti, P Marti - Robot and Human Interactive Communication, 2006

Related projects & applications

Light&Sound Cylinders

The patient interacts with the can pile up LSUs in different configurations, obtaining different local visual and audible feedback

- evoking consolidated sensory-motor patterns, (e.g. rolling, grasping, shaking, piling objects one on top of another), patients can start interacting with the tools
- Natural interaction modalities trigger a behavioural answer
- designed to exploits the patients' residual skills, in particular the motor procedural memory, which is longer conserved

Marti, P., Giusti, L., Coupling the digital and the physical: a way on in the design of tangible media, Proceedings of HCI International, 2007, Beijing, China, 22-27 July 2007.

Related projects & applications

Natural Language Understanding, Content Based Information Retrieval

Bolt, R. A. and Herranz, E. 1992. Two-handed gesture in multi-modal natural dialog.
In Proceedings of the 5th Annual ACM Symposium on User interface Software and Technology

Alfred Kobsa; Jurgen Allgayer; Carola Reddig; Norbert Reithinger; Dagmar Schmauks; Karin Harbusch; Wolfgang Wahlster
Combining Deictic Gestures and Natural Language for Referent Identification
The 11th International Conference on Computational Linguistics

A few words on *context*

Chiediamo il conto!

Paul Dourish. 2004. What we talk about when we talk about context. *Personal Ubiquitous Comput.*8, 1 (February 2004), 19-30.

Related projects & applications

Sign Language Recognition

Real-Time American Sign Language Recognition Using Desk and Wearable Computer Based Video Starner, T. Weaver, J. Pentland, A. IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE PAMI1998, VOL 20; NUMBER 12, pages 1371-1375

Related projects & applications

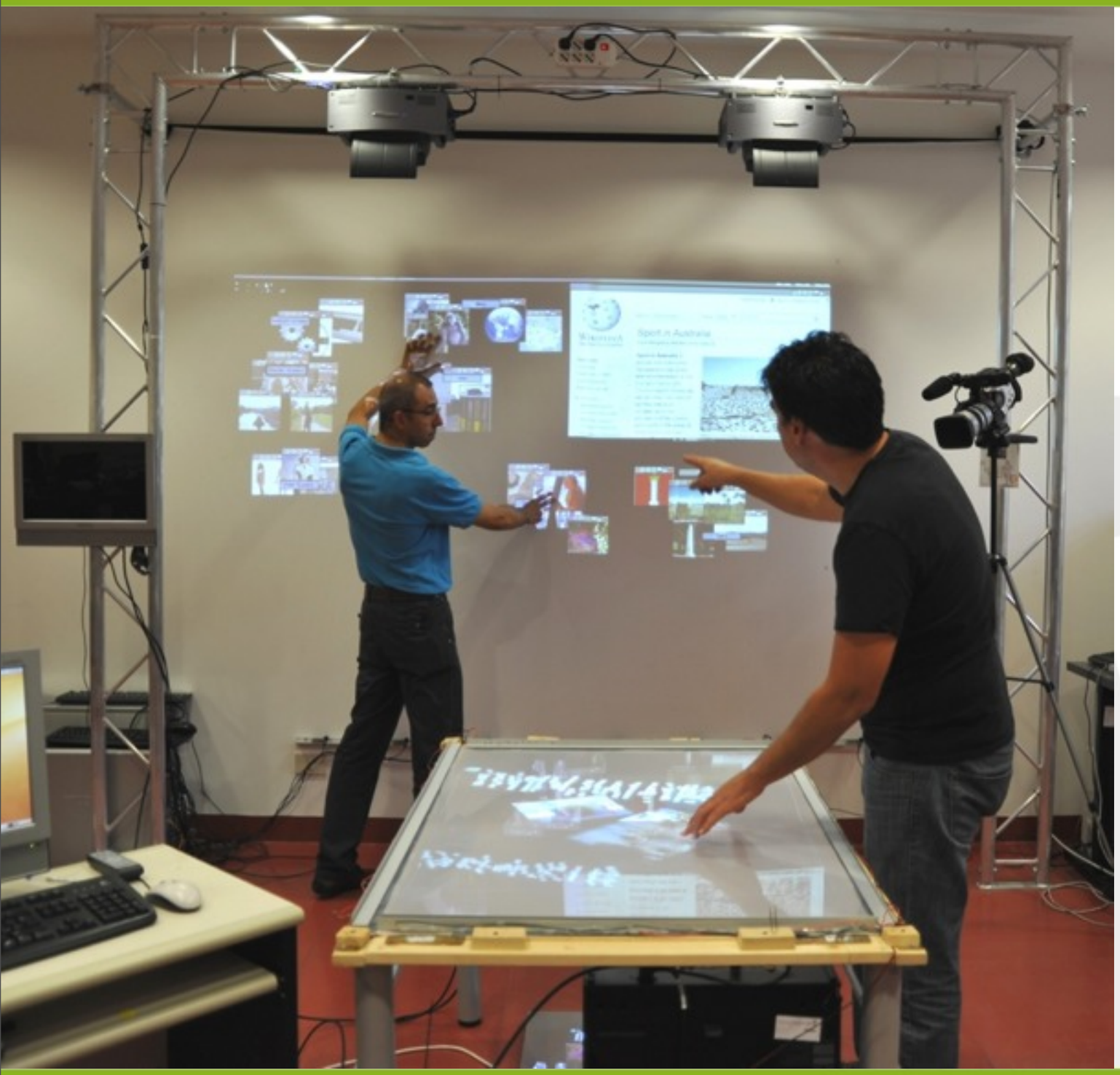
Emotions Recognition

A. Camurri, B. Mazzarino, M. Ricchetti, R. Timmers, G. Volpe
Multimodal analysis of expressive gesture in music and dance performances, in A. Camurri, G. Volpe (Eds.), "Gesture-based Communication in Human-Computer Interaction", LNAI 2915, Springer Verlag, 2004.

A Space for group work

Observing and measuring fluency in gesture and manipulative interaction settings.

Interactive Space



- 3 mt wide interactive video wall
- pixel precision finger pointing
- HMM based gesture recognition
- Programming framework for multiuser / multitouch apps
- support not conventionalized gestures
- explore user behavior in CSCW
- FTIR Multitouch table
- Surveillance Camera

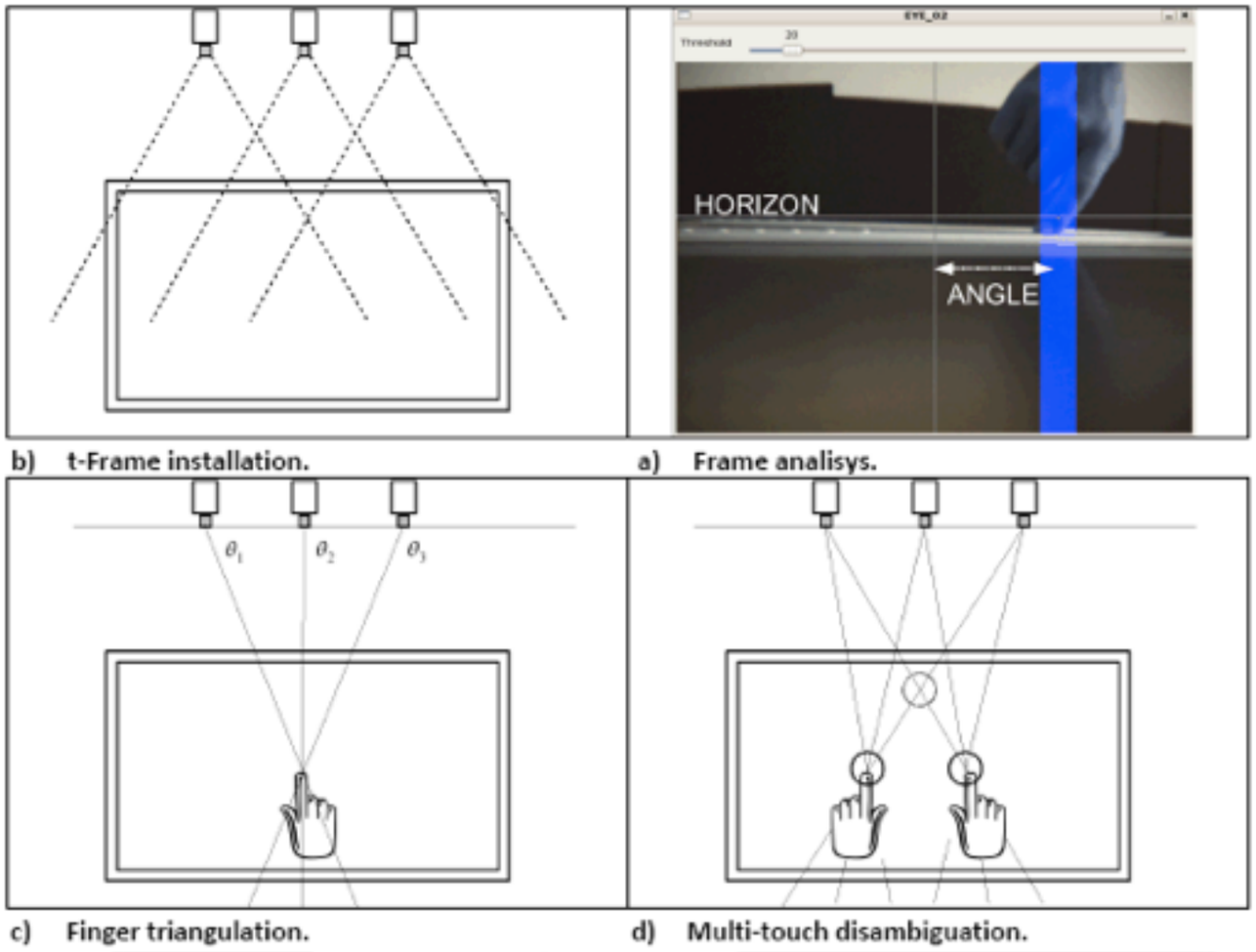
Interactive Space

- use of commodity hardware
- OS support (Qt)
- seamless calibration

Soro, A. and Paddeu, G. and Lobina, M., (2008) Multitouch Sensing for Collaborative Interactive Walls. In Proc. of the 1st Human-Computer Interaction Symposium. Springer Boston

A. Lai A. Soro R. Scateni.: (2010) Interactive Calibration of a Multi-projectors System in a Video-Wall Multi-Touch Environment. Adjunct Proceedings of UIST-2010,

Interactive Space



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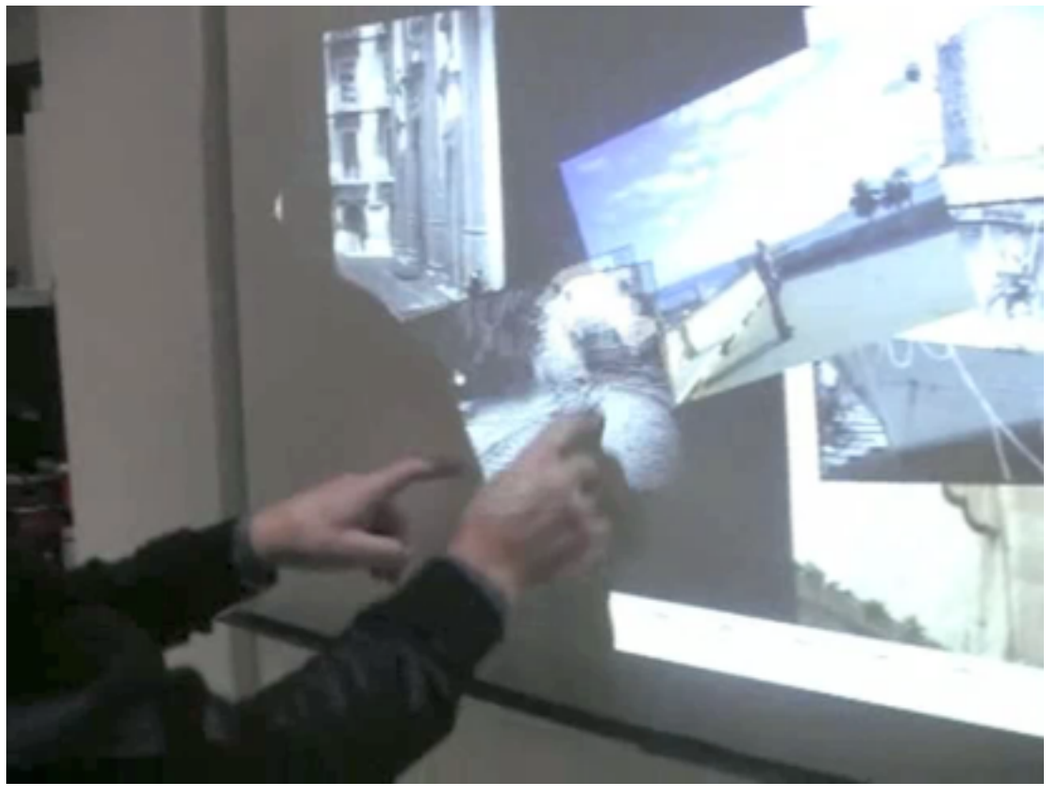

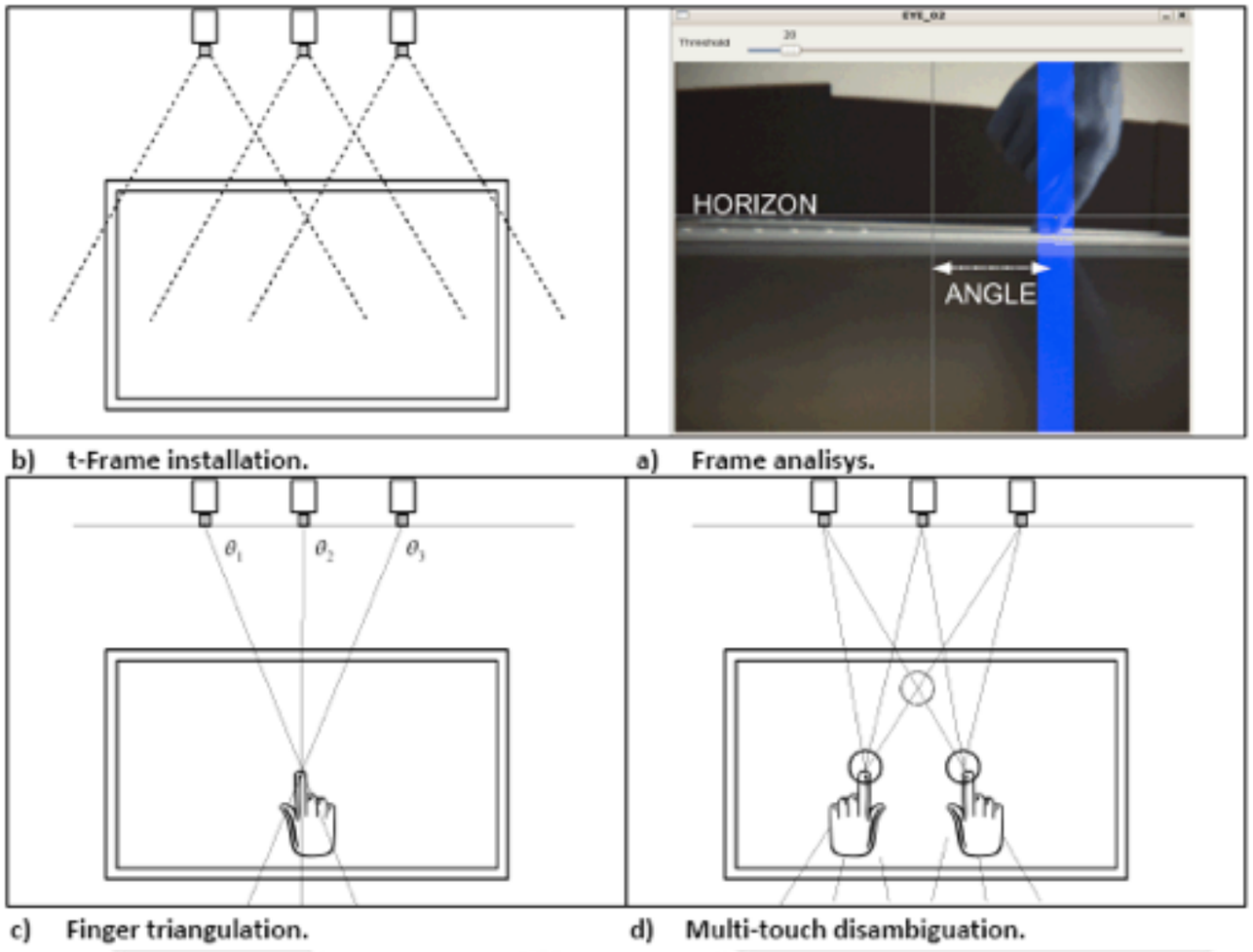

b) t-Frame installation. a) Frame analisys.

c) Finger triangulation. d) Multi-touch disambiguation.

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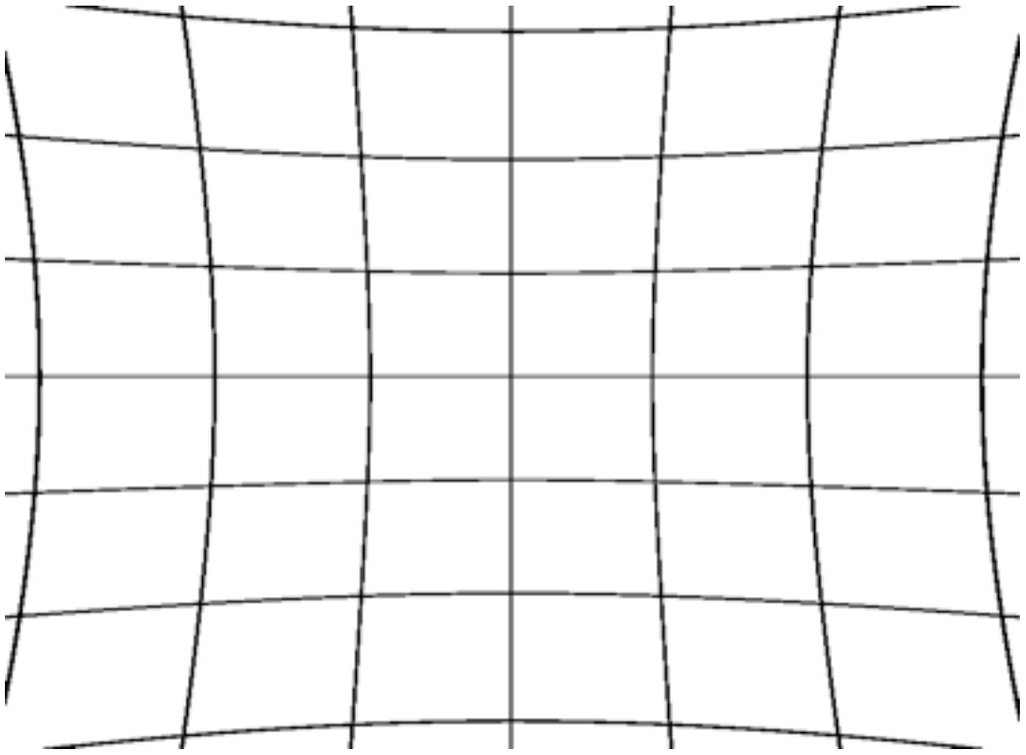

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- OS support (Qt)
- seamless calibration

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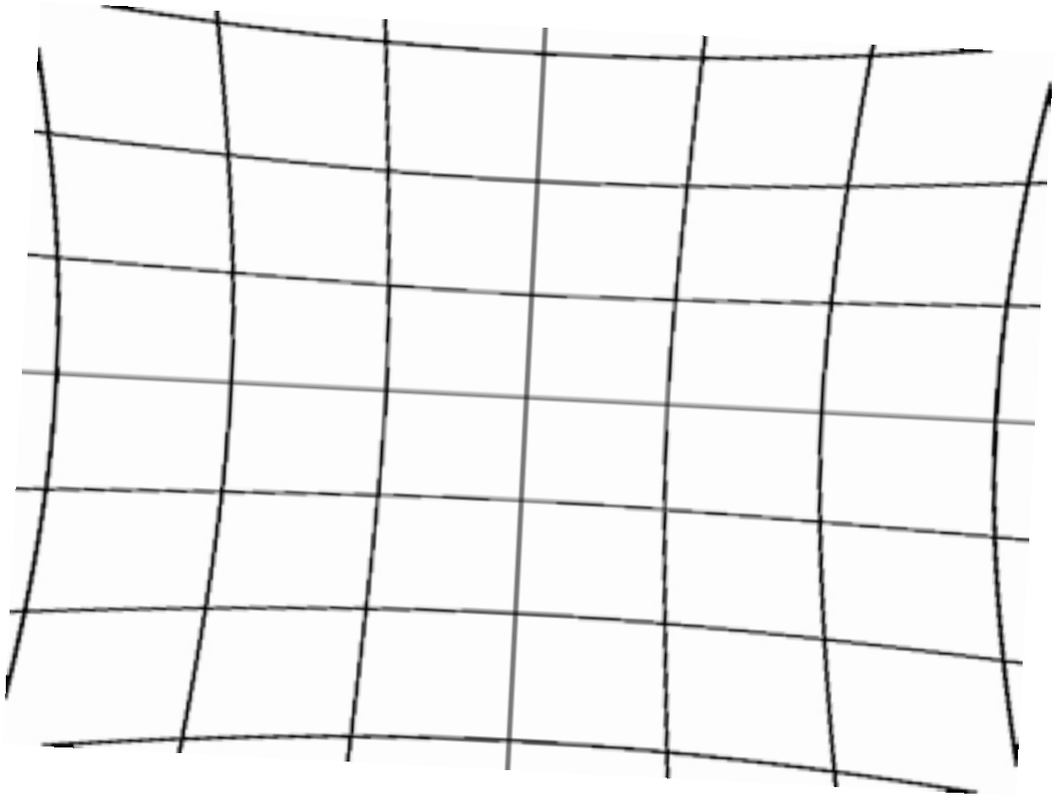

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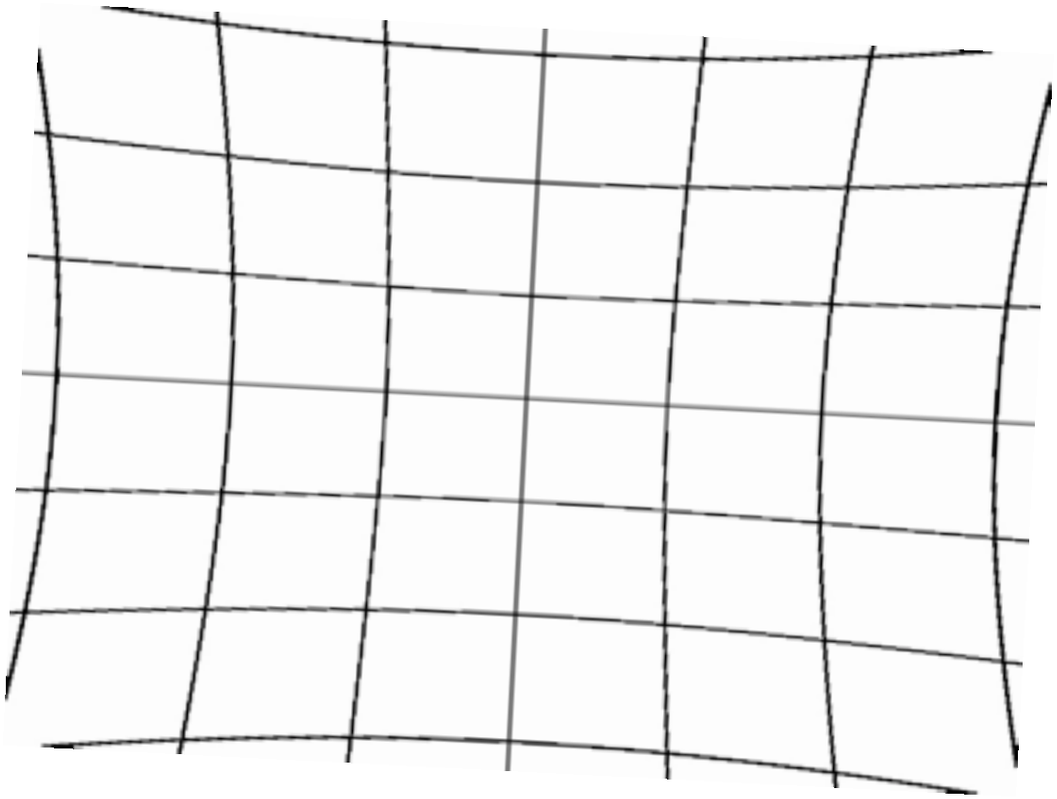

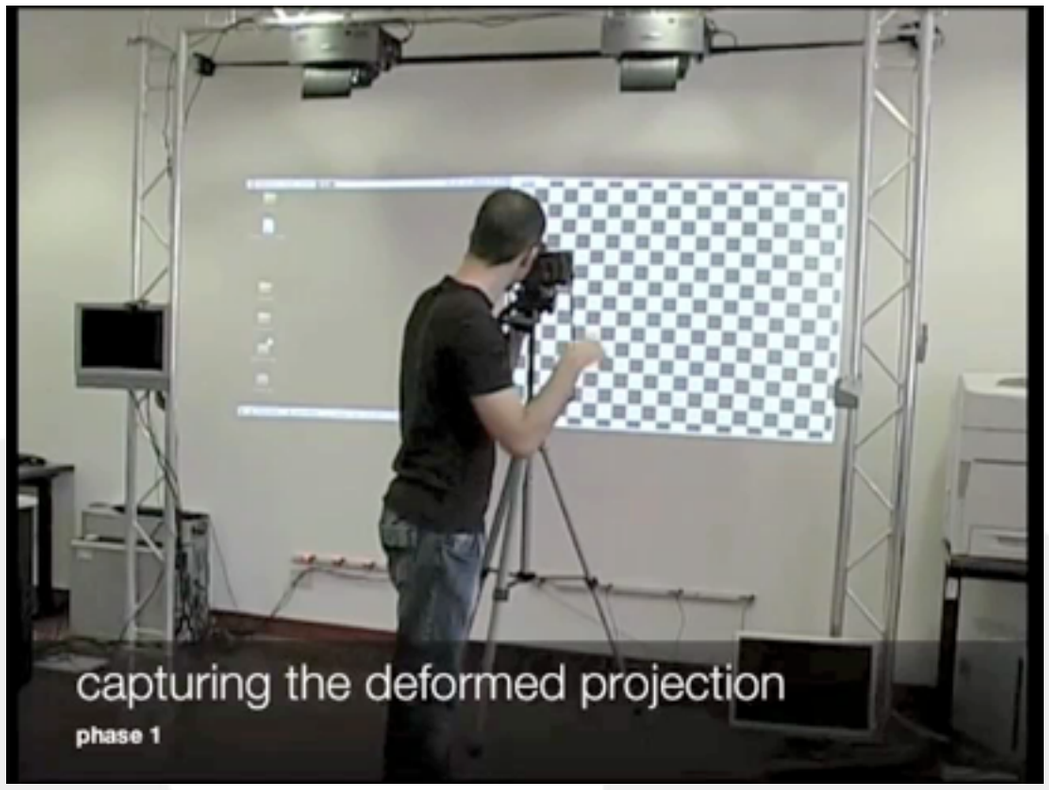

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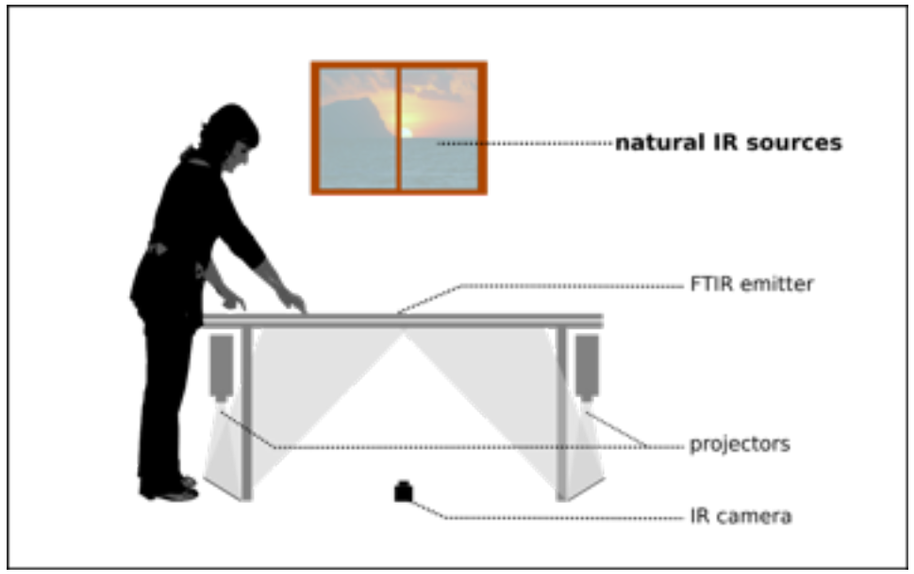

- pre-contact feedback
- robustness to changing light

S.A. Iacolina and A.Soro and R.Scateni, Improving FTIR Based Multitouch Sensors with IR Shadow Tracking. CRS4 Tech Report

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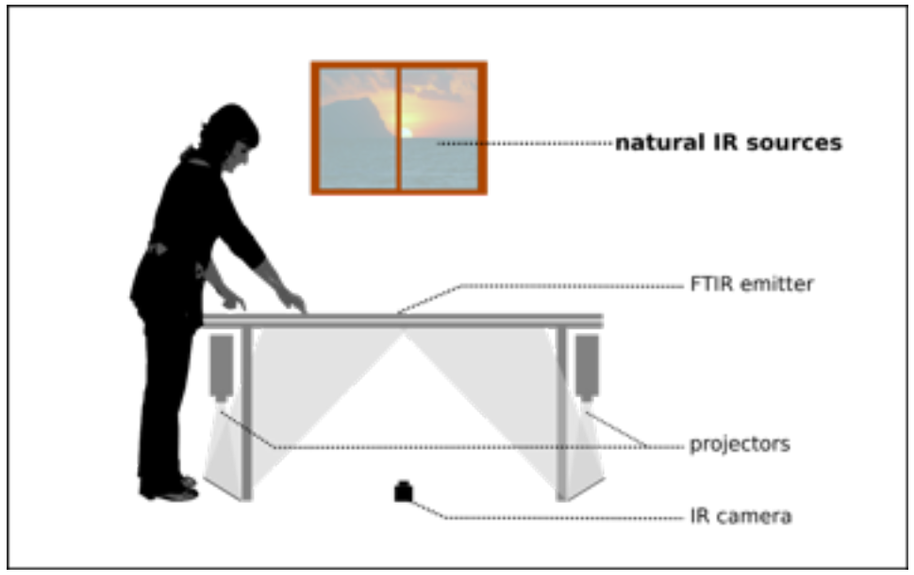

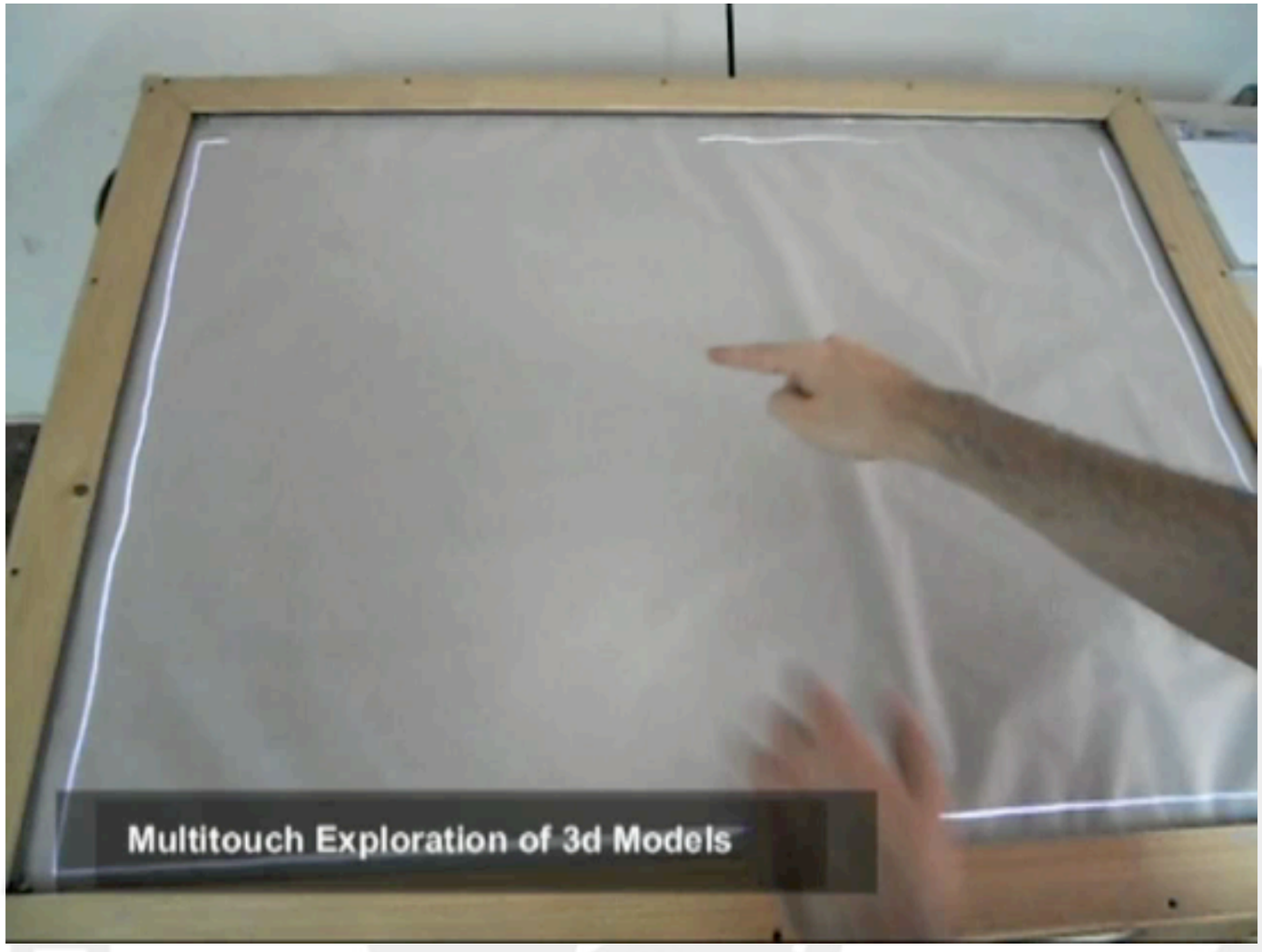

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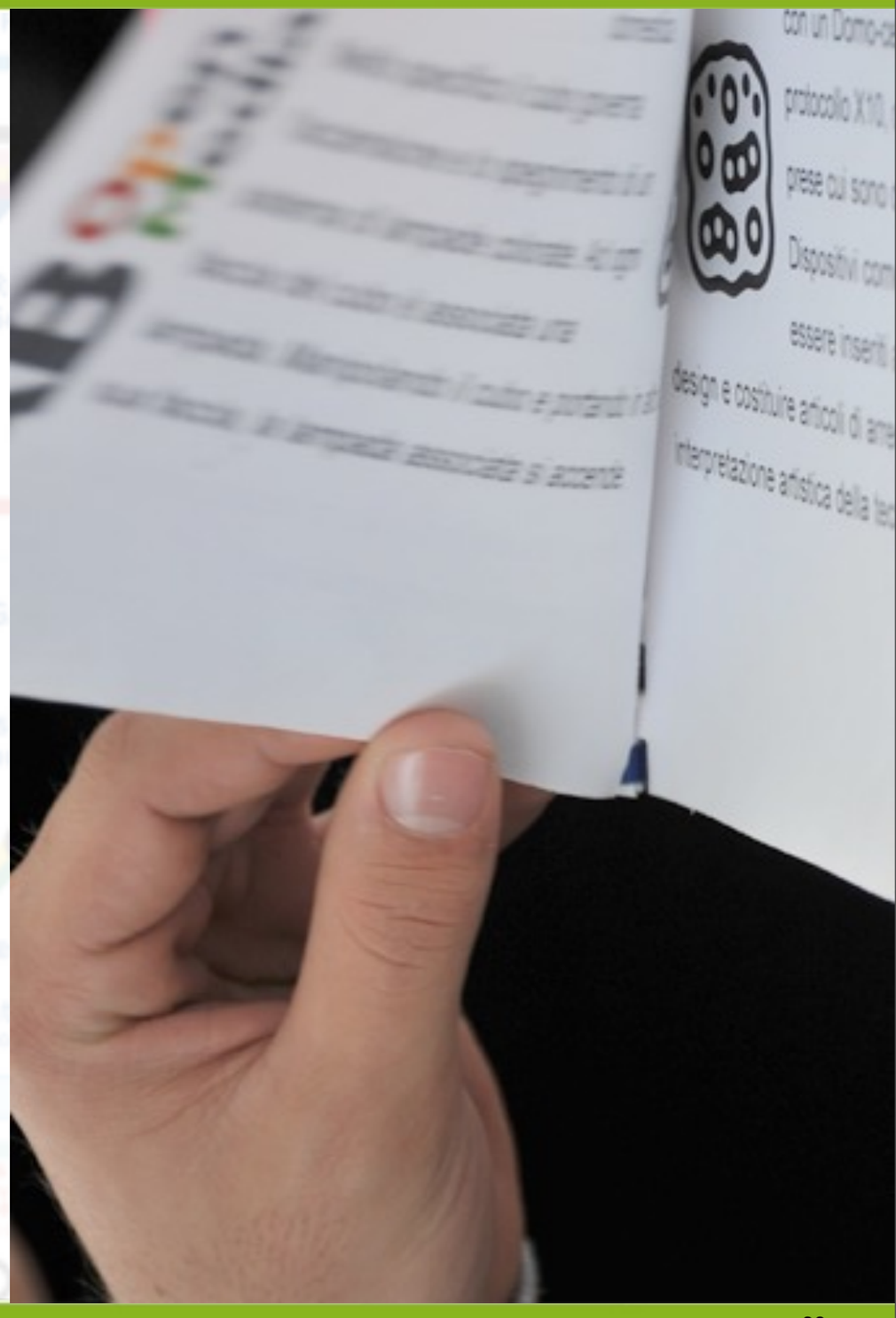
New Applications for NUIs

what new application fields can we devise for *natural interfaces* that take advantage of our social skills*?*

the Troll, a multimedia augmented booklet made from the combination of a paper brochure and a LCD display



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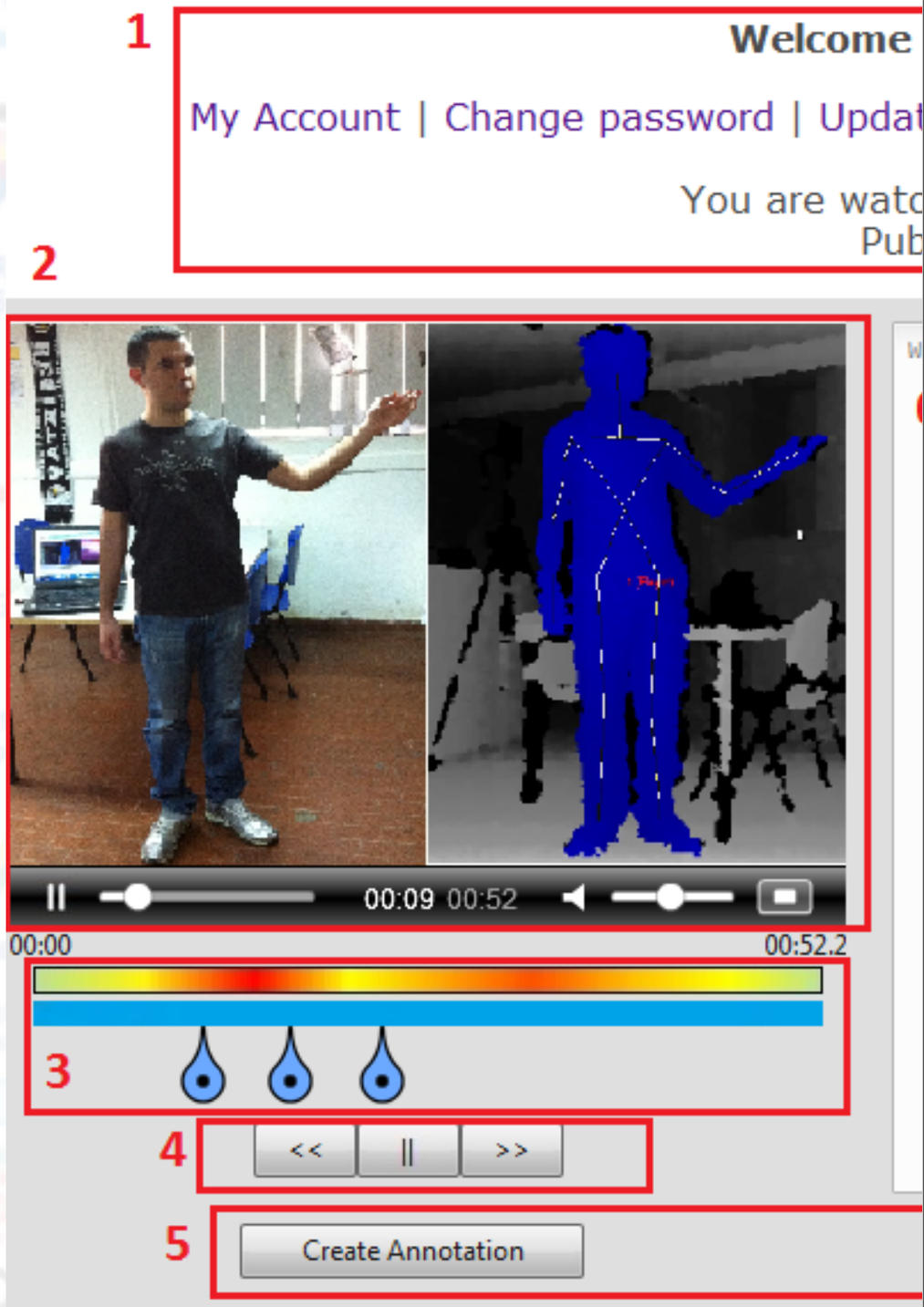

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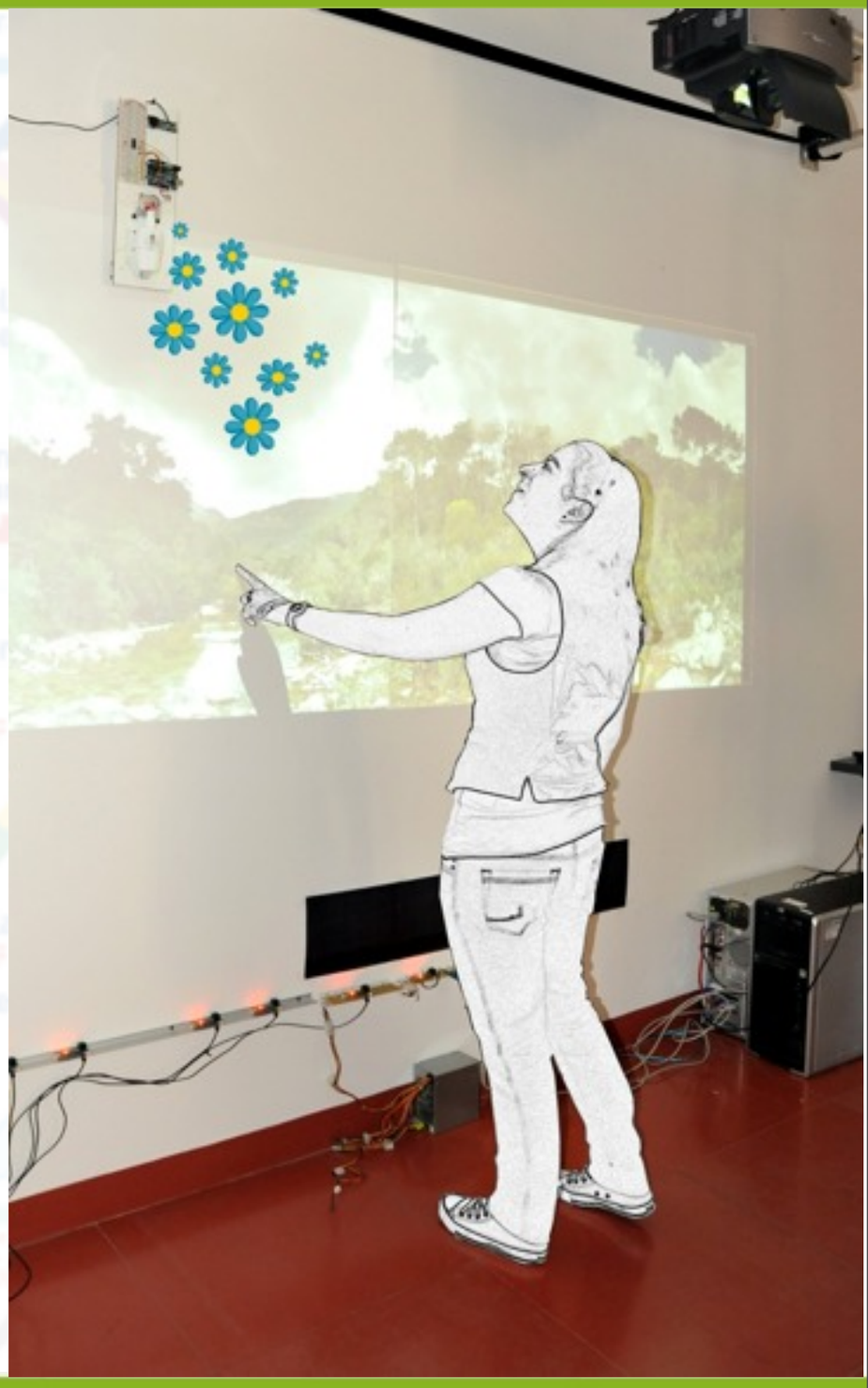
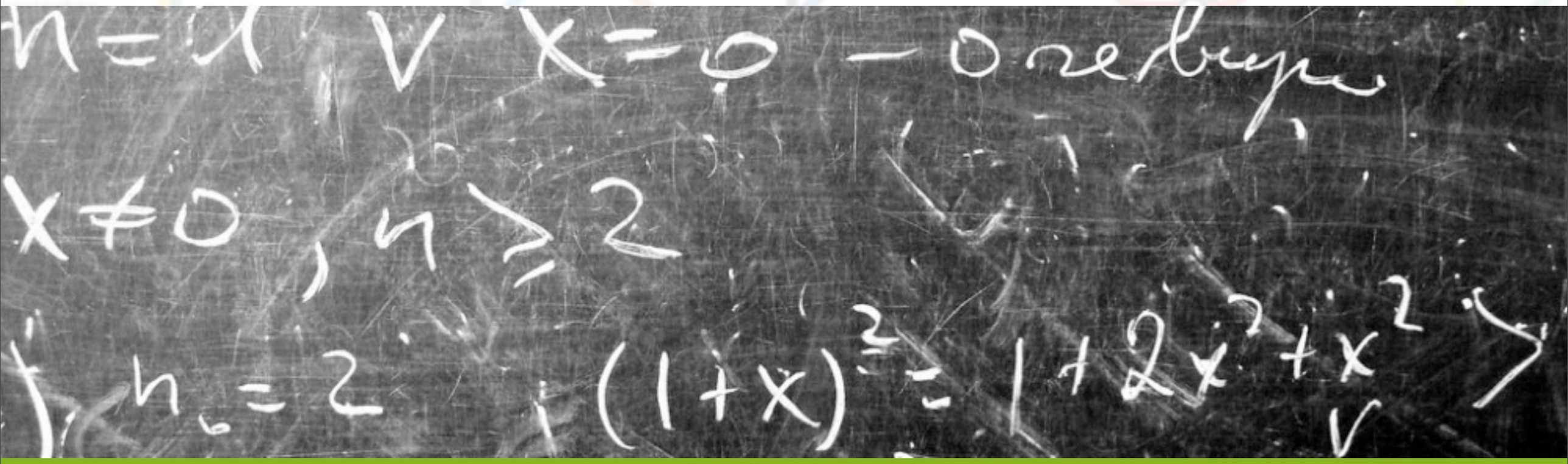
Interactive multi-sensory system, supported by presence sensors, multimedia contents and actuators



Evaluation of Natural Interfaces

Can we say something of how *natural interfaces* can impact traditional application fields?



Gesture Fluency in CSCW

- Goals -
- how do we evaluate a natural interface, is there a way to measure 'naturalness';
- do natural user interfaces provide a concrete advantage in terms of efficiency, with respect to more traditional interface paradigms?
- compare observations of user behavior in the task of pair programming, performed at a traditional desktop versus a multi-touch table

A. Soro, S. A. Iacolina, R. Scateni, S. Uras. Evaluation of User Gestures in Multi-touch Interaction: a Case Study in Pair-programming, 13th International Conference on Multimodal Interaction - ICMI 2011, (accepted).

Gesture Fluency in CSCW

44 people participated to this study, age 20-35, all students of computer science or ICT professionals, thus quite literate in computer programming.

Working in pairs, the testers were asked to review 7 snippets of C code (1 demo, and 6 exercises)

```
1 void test2() {
2   int i;
3   for (i=0; i<10; i=i+1)
4     if (i=2)
5       printf("i is 2\n");
6     else
7       printf("i is not 2\n");
8 }
```

```
 1 void bubble_sort(int array[], int n) {
 2   int i, j;
 3   // sort array of length n
 4   for (i = (n - 1); i > 1; i++) {
 5     for (j = 0; j < i; j++) {
 6       if (array[j] > array[j + 1]) {
 7         // swap values
 8         int tmp = array[j];
 9         array[j] = array[j + 1];
10         array[j + 1] = tmp;
11       }
12     }
13   }
14 }
```

Gesture Fluency in CSCW

GUI design is identical both on the MT and on the DT

Data collected during or following the test are:

1. the time spent on each exercise;

2. the proposed solution, that may or may not be correct;

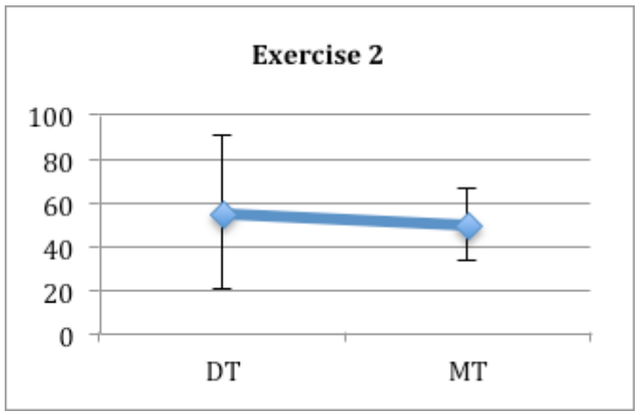
3. the video footage of the whole session.

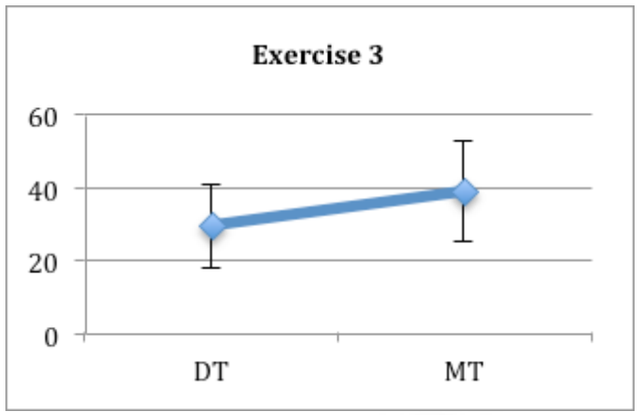
These were used in the analysis described in the next section. Other data gathered, but not discussed in detail here are:

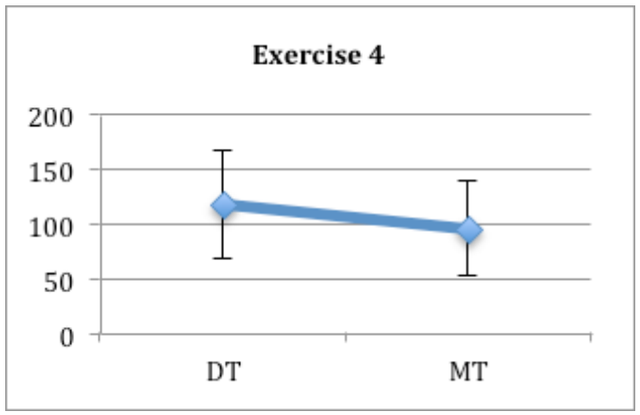
1. whether or not the testers were able to reach an agreement on the solution of the exercise;

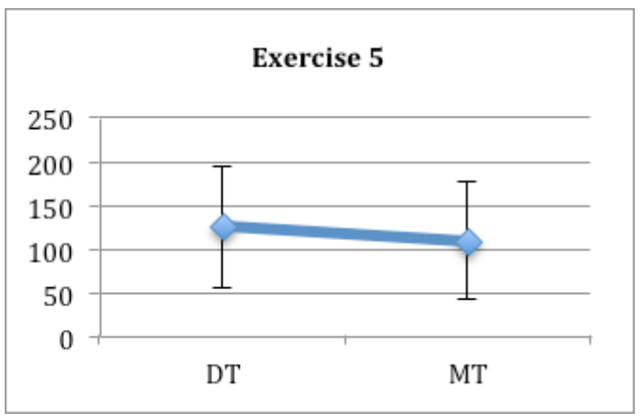
2. subjective scores of the difficulty of each exercise.

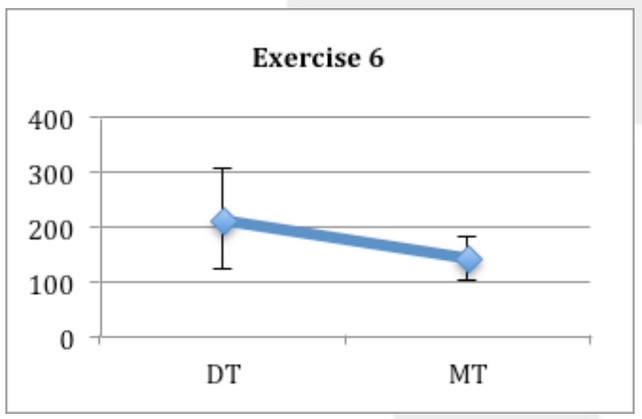
Gesture Fluency in CSCW

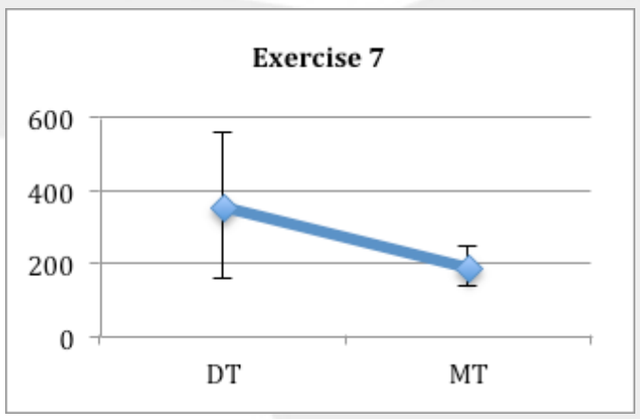






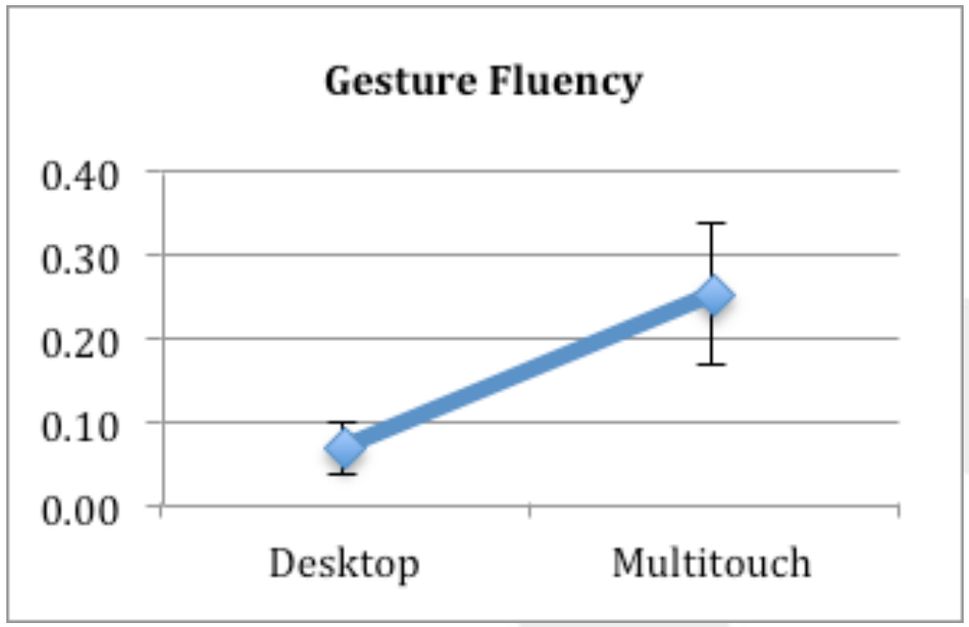






Users perform (mostly) better at the multitouch than at the desktop.

Gesture Fluency in CSCW



Gesture fluency is dramatically higher at the multitouch, which we argue accounts for the better performance and the 'naturalness' of the interface, naively perceived by the users

Gesture Fluency in CSCW

Related research:

The "around the-table" form factor, which is hypothesized to promote social comparison, increases performance and ***improves collaboration through an increase of equity****.*[1]

tabletop users ***switch more between roles****,* ***explore more ideas*** *and have a greater awareness of what each other is doing.*[2]

1. Stéphanie Buisine, Guillaume Besacier, Améziane Aoussat, Frédéric Vernier, How do interactive tabletop systems influence collaboration?, Computers in Human Behavior, Volume 28, Issue 1, January 2012, Pages 49-59, ISSN 0747-5632, 10.1016/j.chb.2011.08.010.
2. Yvonne Rogers, Siân Lindley, Collaborating around vertical and horizontal large interactive displays: which way is best?, Interacting with Computers, Volume 16, Issue 6, December 2004, Pages 1133-1152, ISSN 0953-5438, 10.1016/j.intcom.2004.07.008.

Gesture Fluency in CSCW

we **can** improve the design of our computers

there are plenty of new application fields that exploit natural forms of interaction

traditional application fields too benefit from a design more oriented to cooperation, and gesture fluency appears to be a metric of positive cooperation

Open issues:

- efficiency vs effectiveness, is accuracy improved at the multitouch?
- fluency vs efficiency, is there a correlation between gesturing and efficient problem solving
- pointing with the mouse. should it be treated as a gesture?

Future Work

collaborative research tools, such as video annotation applications

standard training sets and benchmarks for automatic recognizers

cultural, social, age dependence of gesturing and nonverbal communication

Text

further explore application domains, such as natural language understanding, content based multimedia information retrieval, human robot interaction, exergaming, education, rehabilitation

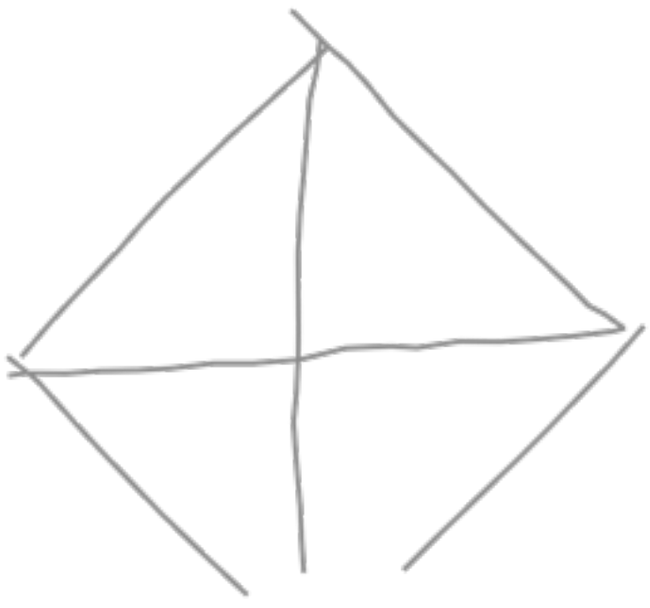
... more?

A final thought

YBC-7289 clay tablet

almost round - 8cm size
1800-1600 BCE
carved by a learner

A final thought



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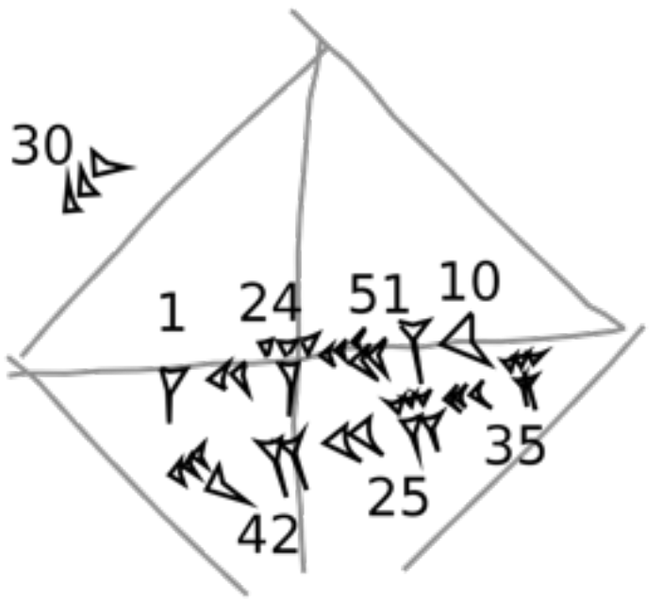

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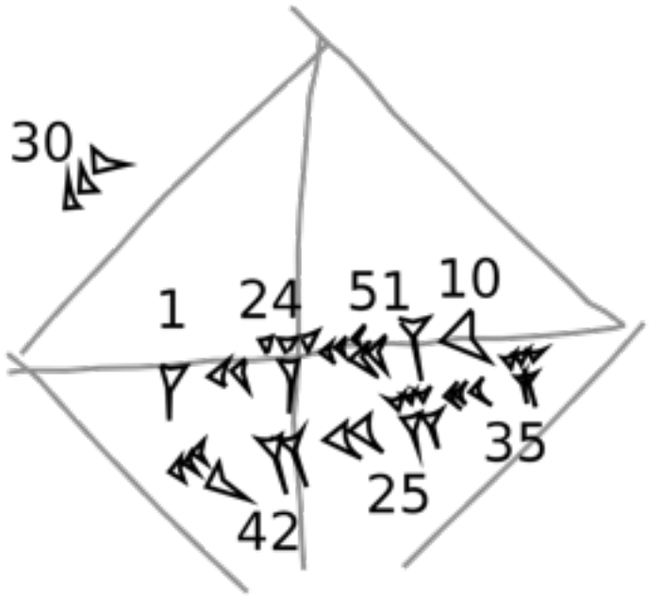

30

1;24,51,10

42,25,35

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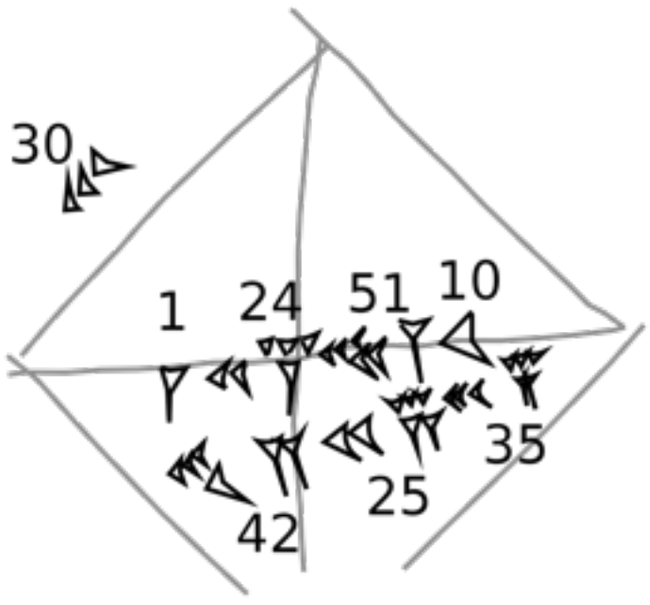

$$30 = \frac{30}{60}$$

$$1;24,51,10 = 1 + \frac{24}{60} + \frac{51}{60^2} + \frac{10}{60^3}$$

$$42,25,35 = \frac{42}{60} + \frac{25}{60^2} + \frac{35}{60^3}$$

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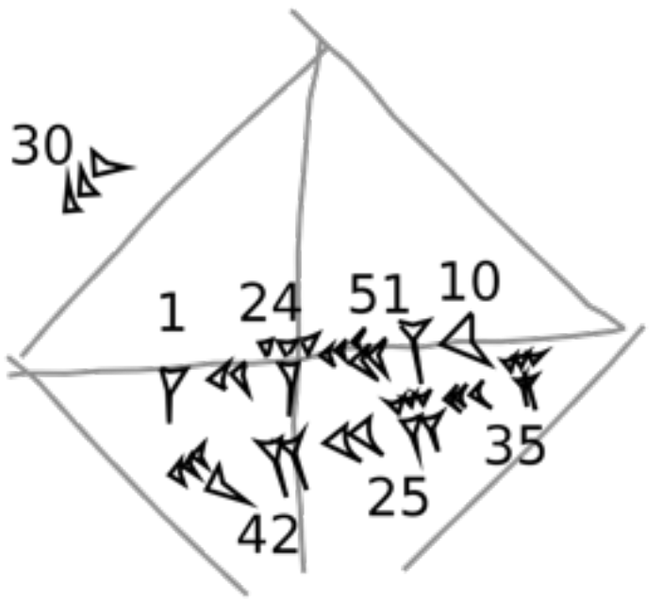

$$30 = \frac{30}{60} = 0.5$$

$$1;24,51,10 = 1 + \frac{24}{60} + \frac{51}{60^2} + \frac{10}{60^3} = 1.41421296 = \sqrt{2}$$

$$42,25,35 = \frac{42}{60} + \frac{25}{60^2} + \frac{35}{60^3} = 0.70710648 = \sqrt{2}/2$$

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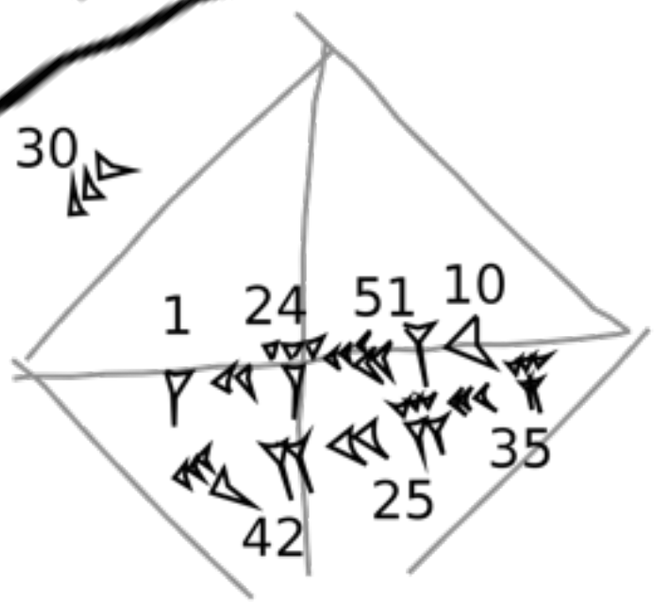
Pythagoras' Theorem



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Contacts

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CRS4 - Polaris, Ed. 1 09010 Pula
http://www.crs4.it
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Thank you for your attention