


**HCI Outlook:  
Tangible and Tabletop Interaction**  
multiple degree-of-freedom (DOF) input

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**Tangible and Tabletop UIs**

Pushing the edge of interactive technology ...

by constructing

- Tangible User Interfaces (TUI) (Ullmer, Ishii)
- Tabletop, Large Display User Interfaces (UI)

with potential benefits, for example

- Creative problem solving
- Science education
- Collaborative planning


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**Research Context: Collaborators**

- Education & Research  
*Individuals:* Postdocs; PhDs; MSc; BSc  
*Institutions:* ICVR at ETH Zurich, Harvard, Aparentas, ETA Lab
- Industrial Partners  
*SMEs* : Opera, SmartBoard, MacroFocus, Monator, Axiglaze, Hidden  
*Industry:* Google, Volvo IT, Sony Ericsson, Qualisys, Telenor, NCC
- Sponsors  
*Funding:* Swedish Science Foundation, STINT, VINNOVA, KBM  
*Material:* Apple, HP, Marshall, ALPS, Farnell, Analog Devices

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**Background and Goals**


Ubiquitous computing (Mark Weiser, 1993)

- Handheld, desktop, and large display
- Disappearing - or invisible - computer

Goals of research

- Human-centric user interfaces (UIs)
- Improved cognitive support
- Creative problem solving
- Improved collaboration
- Task in foreground, computer in background

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**HCI Theories and Principles**


HCI Schools/Theories

- Distributed cognition (Hutchins)
- Activity theory (Engeström, Hacker, Nardi)

HCI Principles

- Strengthen coupling betw. action and perception
- Capitalize on human motor skills
- Improve blend of time- and space-multiplexing
- Assure externalization of knowledge in tools
- Employ Augmented Reality principles (Azuma)

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**Areas and Projects**

**Vision-based UIs**

- Augmented Chemistry
- 3D Hand Tracking
- Ortholumen

**Touch-sensitive UIs**

- Force Feedback Slider
- SpaceCat: 6DOF Input
- Touch & Type

**XXL Display UIs**

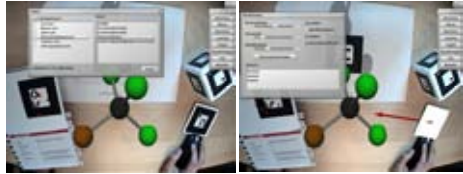
- BUILD-IT: Collaborative Planning
- Sketching: Tracking of IR Pens
- CollaBoard: Shared Whiteboard

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# Vision-Based UIs

## AugmentedChemistry (AC)

■ Science education - age 12-15 years - of organic chemistry, for instance octet rule and bondings




M. Fjeld, J. Fredriksson, M. Ejdestig, F. Duca, K. Bötschi, B. Voegtli, P. Juchli (2007): Tangible User Interface for Chemistry Education: Comparative Evaluation and Re-Design In Proc. ACM CHI07, pp. 805-808.

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## AugmentedChemistry (AC)

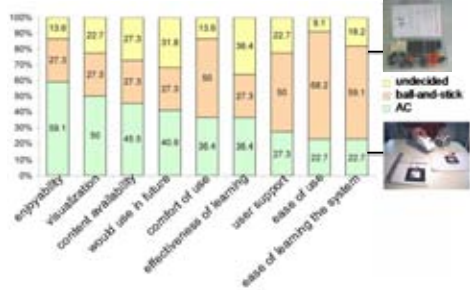
■ Comparative within-group study



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## AugmentedChemistry (AC)

■ Comparative study, preference ranking




Criteria	AC (%)	ball-and-stick (%)	undecided (%)
enjoyability	69.1	27.3	13.6
visualization	90	27.3	22.7
content availability	48.9	27.3	27.3
would use in future	40.4	36.4	31.8
comfort of use	36.4	27.3	36.4
effectiveness of learning	22.7	36	13.9
user support	22.7	68.2	8.1
ease of use	22.7	59.1	18.2

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## Combining AC and ball-and-stick

■ Ultrasound tracking, AM radio triggered

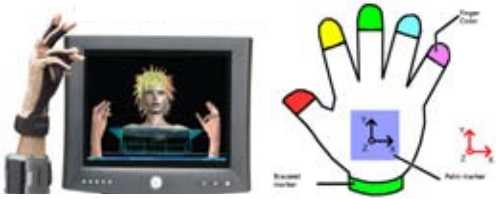


E. Larsson, H. Holm, J. Kemi, M. Ejdestig, T. Johansson (2006): Advances in the AC project and spatial ultrasound tracking. CSE/EE BSc project report.

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## Real-Time 3D Hand Interaction

■ Real-Time 3D Hand Interaction: Single PC (web) camera approach



Wireless CyberGlove II for Motion Builder: Up to 22 joint-angle measurements

F. Duca, J. Fredriksson, M. Fjeld (2007): 3D Hand Navigation. Proc. Workshop at the IEEE Virtual Reality 2007 Conference: Trends and Issues in Tracking for Virtual Environments.

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### Real-Time 3D Hand Interaction

J. Fredriksson, S. B. Ryen, M. Fjeld (2008): Real-Time 3D Hand-Computer Interaction: Optimization and Complexity Reduction. Proc. ACM NordiCHI 2008, pp. 133-141.

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### Ortholumen: Light-based input

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### Ortholumen: Light-based input

LED Pen(s)  
Translucent Screen

LCD Projector  
Mirror  
Web Camera

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### Ortholumen: Light-based input

T. Piazza, M. Fjeld (2007): Ortholumen: Using Light for Direct Tabletop Input. Proc. Second Annual IEEE International Workshop on Horizontal Interactive Human-Computer Systems (TABLETOP'07), pp. 193-196.

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### Applying Ortholumen: Tabletop and handheld map navigation

Headquarters

Field units

GPS or G3

Interactive table with light pens

Mobile phone with GPS

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### CERMIT (Ongoing): Emergency Response Manage (EMR):

Tool supporting creation of a Common Operational Picture

H. Heller, T. Piazza, M. Fjeld (2008): CERMIT: Co-located and Remote Collaborative System for Emergency Response Management. Proc. Shareable 2008.

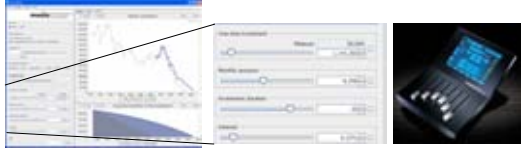
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# Touch-Sensitive UIs

## Slider, Mouse, Keyboard

### ForceFeedbackSlider: Set of Motivations

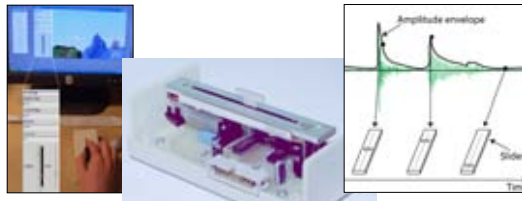
- 3D Interaction has been well investigated
- Economics, biology, and medicine may benefit from multi dimensional tactile interaction
- Multiple motorized sliders may serve this purpose
- Force and haptic profiles can give additional cues



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### ForceFeedbackSlider: Proof-of-Concept

Prototypical Uses (Analogue Version)



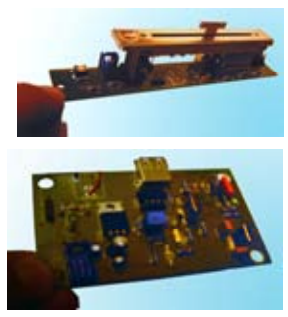
A. Kretz, R. Huber and M. Fjeld (2005): Force Feedback Slider: An interactive device for learning dynamic system behavior. Proc. IEEE Int. Conf. on Advanced Learning Technologies, pp. 457-458.

T. H. Andersen, R. Huber, A. Kretz and M. Fjeld (2006): Feel the Beat: Direct Manipulation of Sound during Playback. Proc. IEEE Int. Workshop on Horizontal Interactive Human-Computer Systems (TableTop 06), pp. 123-124.

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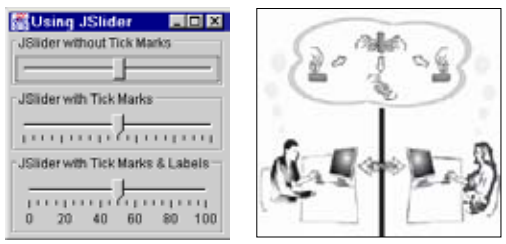
### ForceFeedbackSlider: Digital Design

- Digital System  
Motorized physical sliders that control position and force as input and output parameters for tangible computer interaction
- Digital Design:  
Communication with the computer through a mainboard using USB



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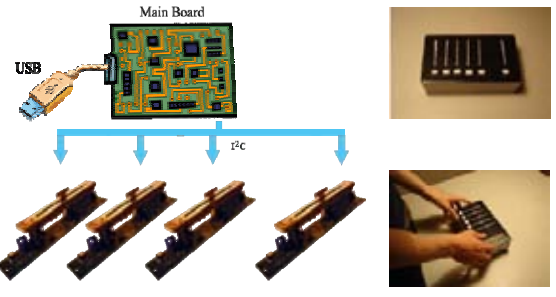
### FFSlider: JSlider & Remote Use



J. Jenaro, A. Shahrokni, M. Schrittenloher, M. Fjeld (2007): One-Dimensional Force Feedback Slider: Digital platform. Proc. Workshop at IEEE Virtual Reality 2007: Mixed Reality User Interfaces: Specification, Authoring, Adaptation (MRUI07).

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### ForceFeedbackSlider: Digital System




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### FFSlider: Multiple Sliders & Acoustic

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- Acoustic, physics-based synthesizer (with Johan Sandsjö, Hidden Interaction)



**ALPS**  
ALPS Nordic AB


R. Gabriel, J. Sandsjö, A. Shahrokni, M. Fjeld (2008): BounceSlider: Actuated Sliders for Music Composition. In Proc. ACM NIME 2008, pp. 127-130.

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### Future FFSlider: Economic Simulation

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- Multifactor economic modelling and trading (with Luc Girardin, MacroFocus Inc., Zurich)

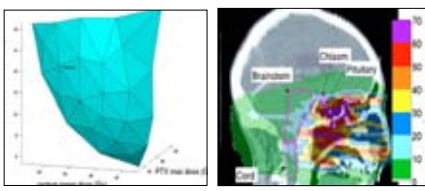


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### Future FFSlider: Radiation Optimization

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- Approximating convex Pareto surfaces in multiobjective IMRT (with David Craft, Harvard Medical School)



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### MDOF Input: Universal Input Device

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Ideal universal MDOF input device should allow for 2D pointing and precise manipulation and navigation within 3D environments.

MDOF Mouse Requirements:

- Six degrees of freedom (6DOF)
- Motion adapted to finger manipulation
- Elastic suspension for rich feedback
- Position and rate control




M. Sundin and M. Fjeld (in press): Elastic Computer Input Control in Six Degrees of Freedom. To appear in Int. Journal of Human-Computer Interaction (IJHCI).

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### MDOF Input: SpaceCat for Games

CHALMERS

Study (Sundin and Fjeld, in press) showed that SpaceCat is particularly well suited for *short and precise* movements.



Z. Franjic, M. Anglart, M. Sundin, M. Fjeld (2008): Softly Elastic Device for 6DOF Input. Proc. ACM NordiCHI 2008, pp. id5-id6.

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### Touch&Type: Cap Sensing

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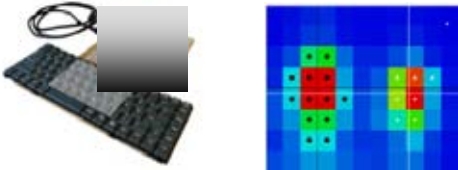


W. Fallot-Burghard, M. Fjeld, C. Speirs, S. Ziegenspeck, H. Krueger, T. Läubli (2006): Touch&Type: A Novel Pointing Device for Notebook Computers. Proc. ACM NordiCHI 2006, pp. 465-468.

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**Touch&Type: Multi-touch Cap Sensing** 

CHALMERS




E. Rehn, N. Berggren, I. Habib-Pourian, G. Josefsson, M. Fjeld (submitted):  
GorillaFist: An Alternative Pointing Device for Notebook Computers, Submitted to ACM CHI 2009.


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**XXL Display UIs**

**For Collaborative  
Planning & Sketching**


**BUILD-IT (PhD at ETH: 1997-2001)** 

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■ End-user: Daimler-Chrysler

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**BUILD-IT: Plant Layout** 

CHALMERS




■ End-users: Von Roll

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**BUILD-IT: Collaborative Uses** 

CHALMERS

**Architecture**      **Navigation**



■ End-users: ETH Architecture

M. Fjeld, F. Voorhorst, M. Bichsel, H. Krueger and M. Rauterberg (2000): Navigation Methods for an Augmented Reality System (video). In the video program / extended abstracts of CHI 2000, pp. 8-9.

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**Sketching: Tracking of IR Pens** 

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T. Nescher (2007): Synchronization box for tracking of IR pens with a high-speed camera. BSc thesis, Chalmers.

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### Sketching: Tracking of IR Pens

R. Hofer: Ph.D. dissertation, in progress

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### CollaBoard (EU Project, 2 PhDs)

- Shared application and editing
- Image segmentation by IR or by polarization
- Alpha blending on remote site

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### CollaBoard (EU Project, 2 PhDs)

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# Summary/Outlook

WHAT IS NOW  
PROVEN  
WAS ONCE  
IMAGINED

Udo Altmann / Why Not Associates, www.whynotassociates.com, designfiction, Michaela Baum, Stockholm (S)

### Summary and Outlook

- **State of projects:** Varying degree of maturity
- **Relation to theory:** Theory serves as framework, guidance in perceptual/cognitive issues
- **Relation to goals:** Some systems have a proven qualities, some remain to be tested in real use
- **Challenges ahead:** Staying at the intersection of good ideas, skilled and driven colleagues, and a challenging-creative atmosphere.

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## Thank you!



- Education & Research
  - Individuals:* Postdocs; PhDs; MSc; BSc
  - Institutions:* ICVR at ETH Zurich, Harvard, Aparentas, ETA Lab
- Industrial Partners
  - SMEs* : Opera, SmartBoard, MacroFocus, Monator, Axiglaze, Hidden
  - Industry:* Google, Volvo IT, Sony Ericsson, Qualisys, Telenor, NCC
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