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Designing for Tangible Interaction

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Overview

- What is Tangible Interaction?
- Collaborative planning: current problem areas
- Our Tangible User Interface (TUI)
- Advantages of tangible interaction to collaborative planning
- My main contributions to the research field of TUI design:
  i) Navigation tools and ii) Usability evaluation
- My further contributions to the BUILD-IT project
- Design conclusions
- Future challenges in field of TUI research

What is Tangible Interaction?

The subject of **Tangible Interaction** is the design of interfaces between humans and digital information, making use of physical objects.

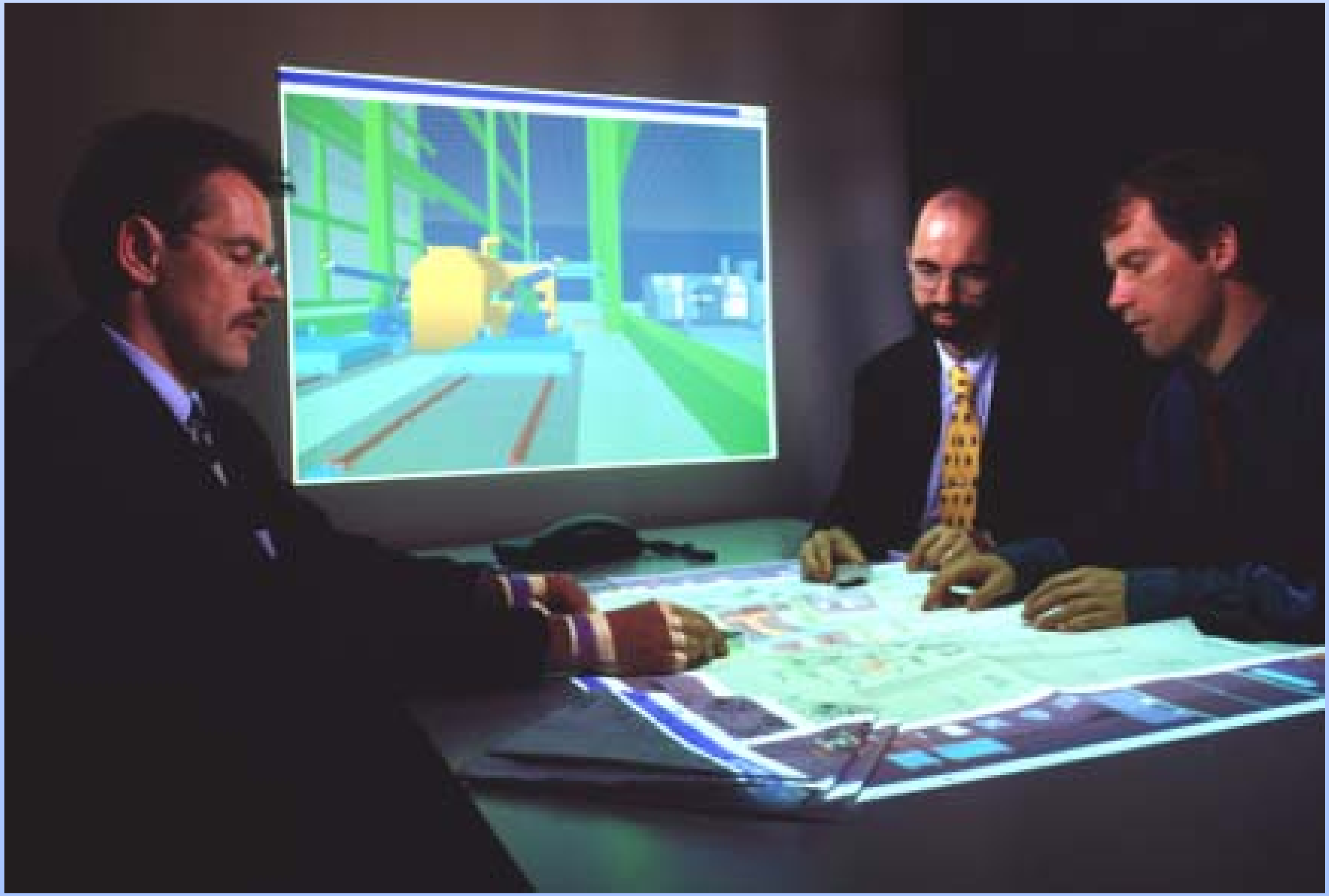
"People have developed sophisticated skills for sensing and manipulating their physical environments." (Ishii, 2001)

Tangible User Interfaces (TUIs) aim to draw on these skills by giving physical form to digital information, seamlessly coupling the real world with virtual worlds.

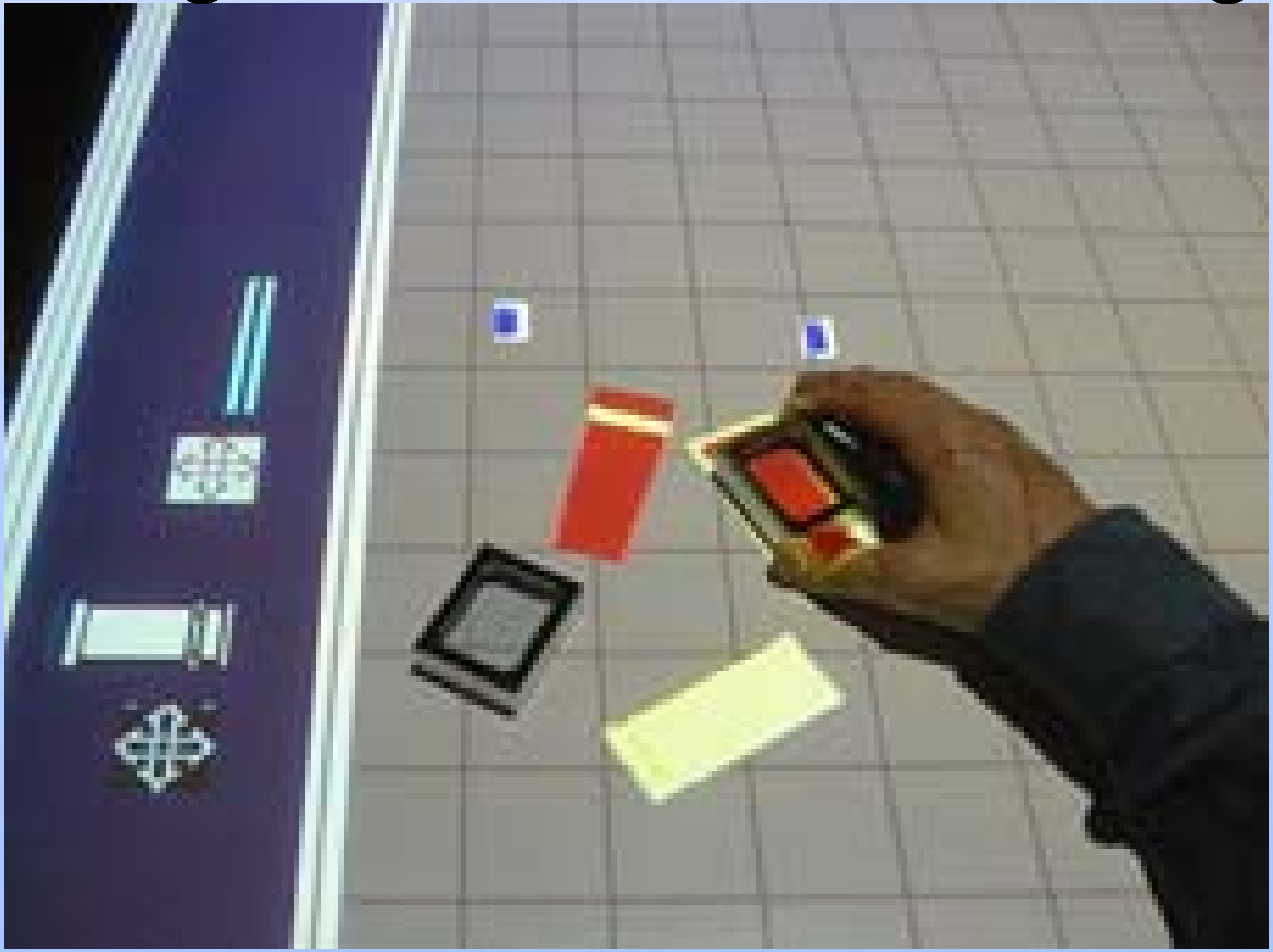
Collaborative Planning: Current Problem Areas

- Mostly single-user work-stations
- Little use of everyday gestures and two-handed skills
- Little input using physical space and graspable devices
- Low degree of immersion; less spatial information
- Little haptic feedback; less spatial embodiment
- The use of CAD systems requires extensive training
- Access to the design process requires substantial skills

Our TUI 1/2: The BUILD-IT System



Our TUI 2/2: Tangible Interaction Using Bricks



Advantages of Tangible Interaction to Collaborative Planning

- Co-located groupware with multi-user, concurrent input
- Draws on everyday gestures and two-handed skills
- Uses physical space and tangible input devices
- Physical interaction supports embodied computation
- Immersion supports spatial information and 3D feel
- Little training required, typically 5 - 10 minutes
- Gives most kinds of users access to design processes

My Main Contributions to the Research Field of TUI design

- Design and implementation of navigation tools *
- Usability evaluation of navigation tools *

    * (Will be focused on next)

- A theoretical framework for TUI design
- A set of design guidelines for TUIs

Navigation 1/5: The Need for Navigation

+ **shift**
  rotation
  zoom

- **tilt**
  roll

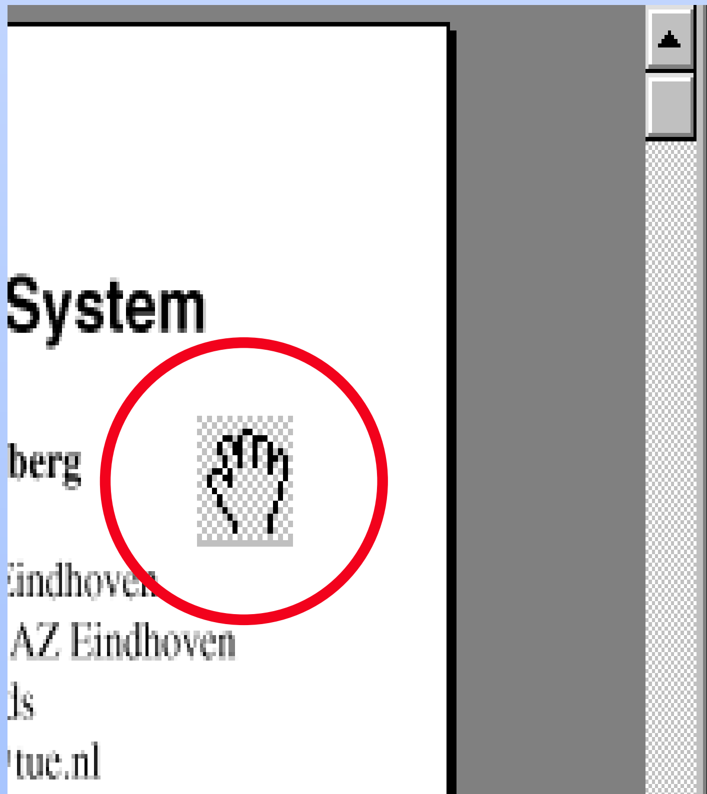
Navigation 2/5: Positioning of a Virtual Scene

Control of the positioning of a virtual scene may employ two alternative fundamental methods:

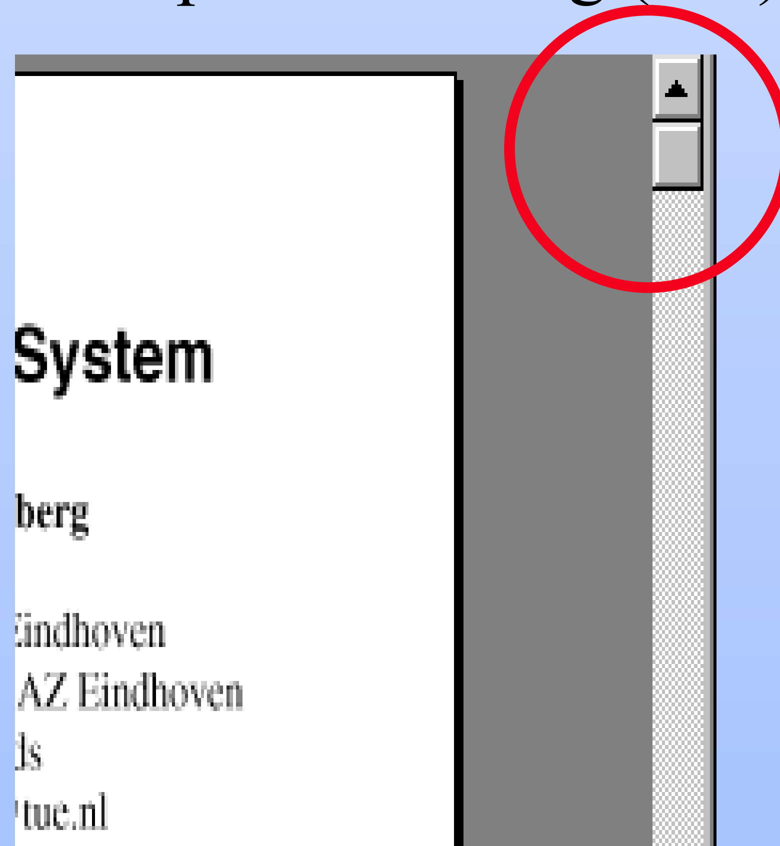
- Scene Handling (SH), or
- Viewpoint Handling (VH)

Navigation 3/5: Positioning Methods

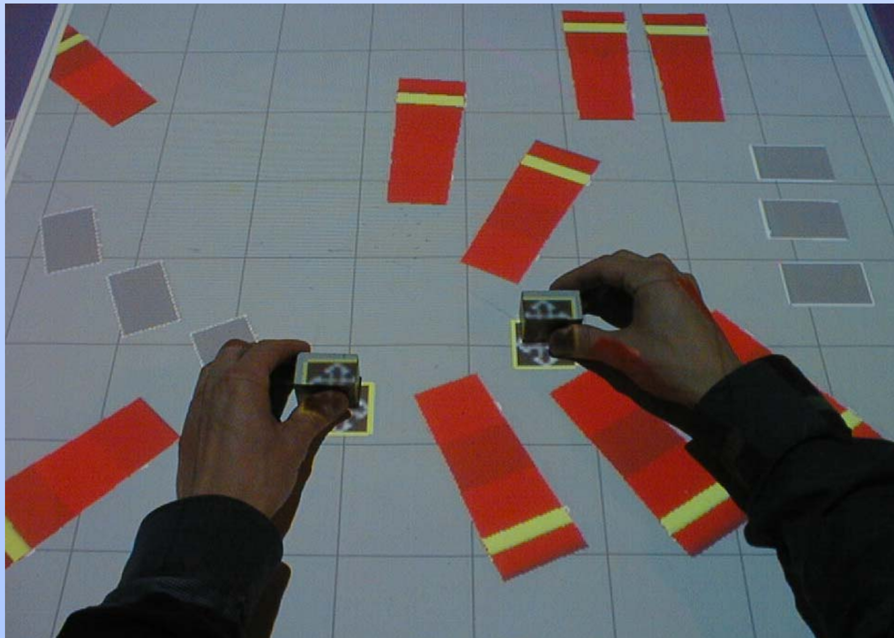
Scene Handling (SH)



Viewpont Handling (VH)



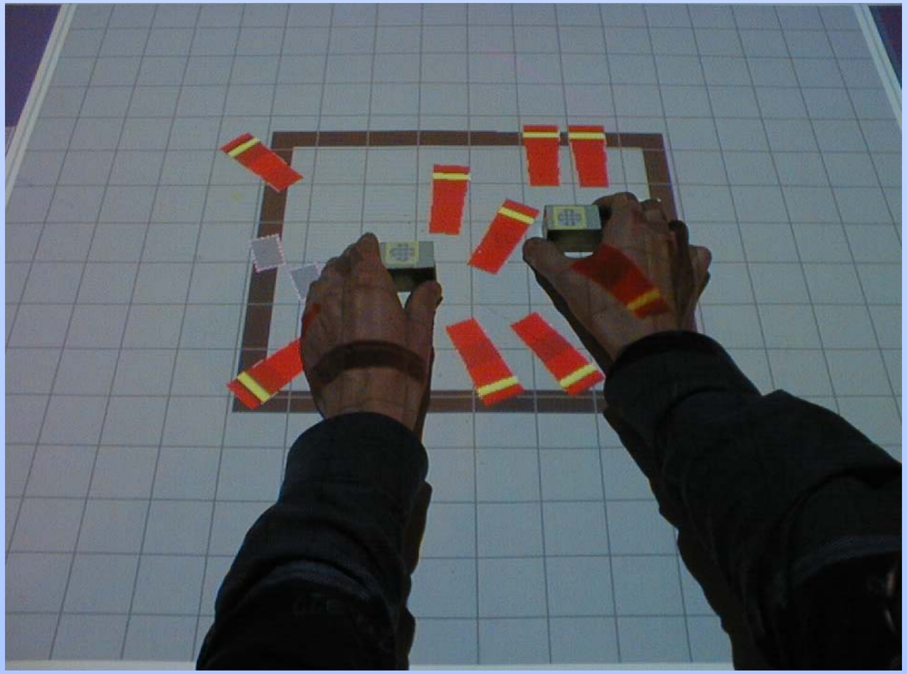
Navigation 4/5: Scene Handling in Plan View



Scene selection

Scene rotation and zoom

Navigation 5/5: Viewpoint Handling in Plan View



Viewpoint selection

Viewpoint rotation and zoom

CHI 2000 Video

Usability Evaluation 1/3: Conjectures

- SH outperforms VH in both views
- Higher performance may be explained by
  difference in exploratory use and/or
  difference in bimanual interaction
- Users prefer SH to VH

Usability Evaluation 2/3: Experimental Design

Task: Search-and-position, models hidden in a maze

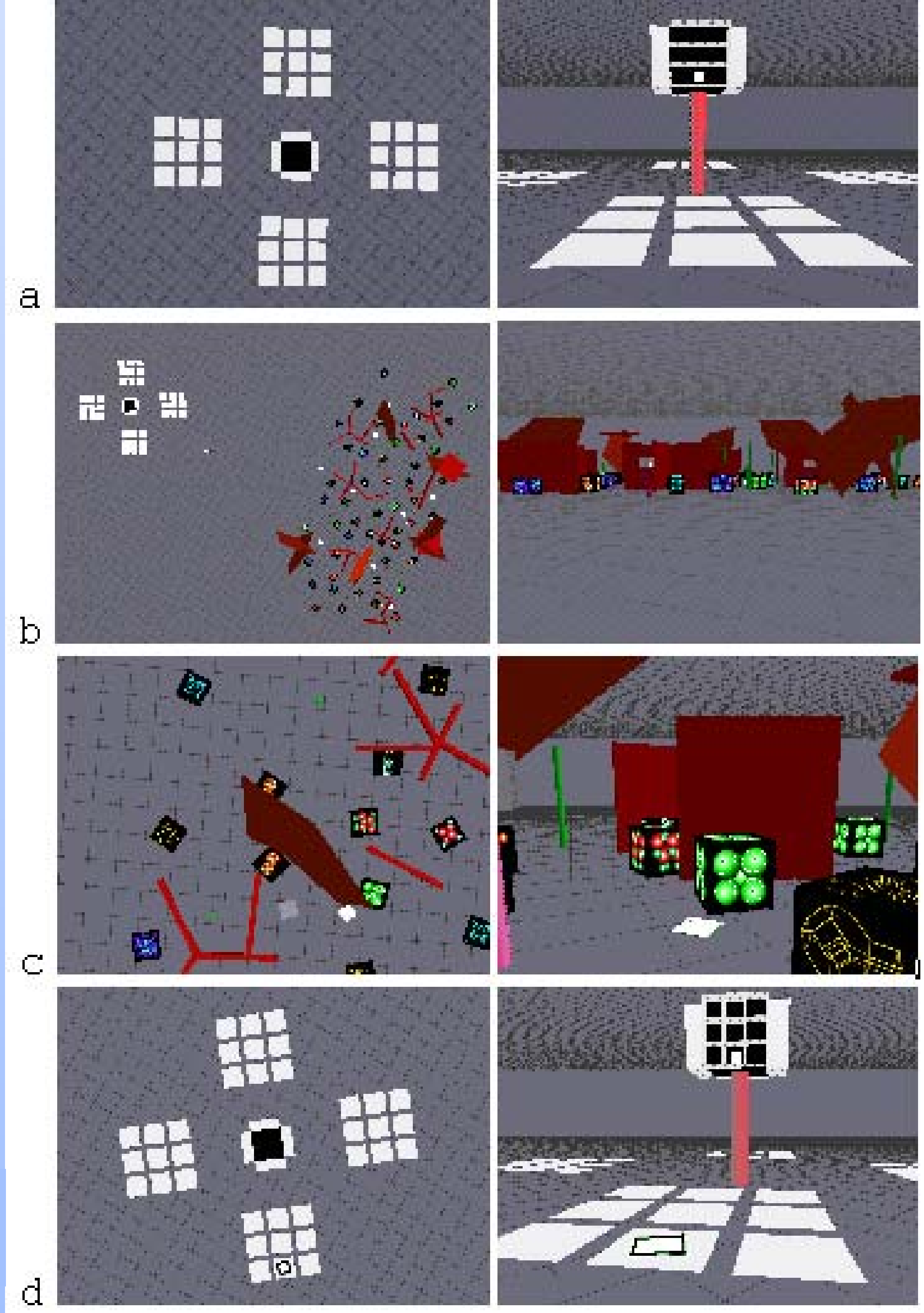
Independents:

- Handling Method (SH, VH)
- View (Plan View, Side View)

Dependents:

- Performance (trial completion time)
- Exploratory use (# stop-and-go)
- Bimanual interaction (# zoom-selections)
- User preference (preferred tool per view)

Search-and-position Task with Models Hidden in a Maze



Usability Evaluation 3/3: Empirical Results

Plan View

- No performance difference between SH an VH although users prefered SH
- SH differed from VH in exploratory use and in bimanual interaction

Side View

- SH outperformed VH which was comfirmed by user preference
- No difference in exploratory use nor in bimanual interaction

My Further Contributions to the BUILD-IT Project

- Task analysis (e.g. interviewing project partners)
- Informal user studies (e.g. brick design, height tools)
- Software developement (object-orientation, many bricks)
- Selection and handling of virtual models
- Video documentation

Design Conclusions

- Tangible User Interfaces (TUIs) require minimal learning and support teamwork
- Bricks are beneficial as handles to virtual models
- Coinciding action-perception spaces (plan view) give more freedom in the design of navigation methods
- Separate action-perception spaces (side view) raise perceptual problems in the design of navigation methods
- Vision-based input causes latency and precision problems

Future Challenges 1/3: HCI

- Efficient bimanual input
- Effective explorative use
- Optimal degrees-of-freedom (DOF) in physical-virtual binding (brick-model locking, # bricks and navigation)
- Integration of the 3rd dimension on the table-top
- Bricks as input-output (IO) devices (propelled bricks)

Future Challenges 2/3: CSCW

- *How* may shared physical and virtual resources serve as mediators for collaborative design?

- *How* can common understanding be reached using co-located groupware?

- *How* may remote collaboration be supported using physical bricks as input-output (IO) devices?

Future Challenges 3/3: Technology

- Lower latency tracking
- Extendible software through multimedia framework
- Improved selection and locking
- SW-integration with existing applications
- Non-dedicated computer
- Portable HW (see photo)
- Networked systems