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## A Wall-sized Focus plus Context Display

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Large Interactive Surfaces – Introduction















## Large displays become increasingly available:

- Most of them are not interactive
- Additional technologies are available but expensive

## Usage of large screens:

- Allow individuals and groups to organize large information sets that are visible at any time
- Distribution of digital objects in 2D space allows organization of work pieces

## → High need for interactivity on large screens





## Usage of traditional large surfaces (desk):

- Central focus area with high input and output precision in order to manipulate or create documents
- Peripheral (context) areas in order to cache unused documents in the meantime → low input and output precision needed!

## $\rightarrow$ Focus plus context display for both input and output







- 1. The Concept of Variable Precision Input
  - a) Real-Time Finger Tracking
  - b) Detecting Multiple Points
  - c) Input Fusion Architecture
  - d) Performance and Limitations
- 2. Multi-Precision Feedback
  - a) Accuracy of Interaction
  - b) Different Levels of Detail for Interaction
  - c) Size of Interaction Area
- 3. Demo Applications

Agenda

4. Conclusions and Future Work



#### Variable precision input and focus + context output:







## Central focus region:

- High precision tracking with fast position updates
- Off-the-shelf tracking technology (SMART DViT)

Peripheral context regions:

- Low precision sufficient (10-20 mm) with low-cost webcams
- Triangulation as the base tracking technology:
  - Determine the position of a finger in the captured image
  - Derive the angle between their optical axis and the connection line between the camera and the finger







#### Multiple fingers require more than two receivers:

- Calculate lines between each detected finger and all cameras
- Choose two cameras and intersect all detected lines
   → Temporary intersections
- In total, up to four intersections can be detected







### Validating a temporary intersection:

- Needs to be close to lines of the other two cameras
- Must provide at least three lines without having a pair of them nearly parallel (*Clearness of involved lines*)
- Two intersections must have at least three different lines involved (*Unambiguous mapping of lines to intersections*)







## Multiple tracking systems with variable accuracy:

- Fingers will cross the boundaries of differently tracked areas
- Should be seamless to the user
- Fingers detected by a different input system need to be associated with previous points if possible

Input abstraction layer for fusion of tracking data:

- Merges the incoming position streams
- Ensures the correct association of positions to fingers
- Adds actions (finger down, finger move, finger up)
- Creates and sends an input event (similar to mouse events)

#### → Seamless transitions between independently tracked regions





## Central focus region:

- Update rate of approximately 100 positions per second
- Pixel-accurate input

Peripheral context regions:

- Update rate of approximately 15 positions per second
- Accuracy dependent on the surface's dimensions (diagonal d), the width p of the captured image and the camera's aperture angle  $\alpha$
- $\varepsilon$  gives the maximum error of the tracking system

$$\varepsilon = d \cdot \tan\left(\frac{\alpha}{p} \cdot 1px\right);$$





## Several possible actions on information units:

- Creation, Modification and Deletion
- *Move* or *modify* the entire information unit
- *Move* or *modify* an object within the information unit
- Selecting of or pointing at a single information unit or a group of them
- → Not all of these actions can be carried out lowprecision areas!
- → Adequate feedback required for different accuracies:
  - Users do not recognize the tracking accuracy
  - Offer a limited or different set of possible interactions





## Show the tracking accuracy directly to the user:

- Region where the finger might be detected in
- Opaque colors for higher likelihoods
- More transparent colors for lower likeliness

→ Very small regions in high precision areas
→ Larger regions in low precision regions







#### Add an accuracy estimation to the detected position:

- Event handler of a document can decide what to do
- Events may be send to sub-objects if accurate enough
- **Disadvantage:** Limitation of interaction
- Advantage: Less user frustration due to error prevention

## Example "Touch an image in a text document":

- Low prec.: *move* entire document
- High prec.: *move* image







## Adjust interactive areas according to tracking accuracy:

- Users are not limited in their interaction
- Low precision areas need larger interaction regions than high precision areas
- Enlargement is associated to the decrease of accuracy
- **Example:** Accuracy halves → Size doubles

Disadvantage: Waste of screen real-estate





## General input setup:

- Wall's center: SmartTech SmartBoard (DViT)
- Periphery: Low-cost webcams (Logitech QuickCam Fusion)
- Different options for mounting the cameras



## **Display Setup:**

- Three back-projected screens built into the wall
- Steerable projector to project onto any place on the wall
- $\rightarrow$  Entire wall is one single display to the user





## WallDraw:

- Initial test application using all input and output components
- Multiple users are able to draw simultaneously
- Steerable projector displays individual tool palettes for each user upon their request (tapping on the wall)
- Interaction technique: Size of interaction area









## BrainStorm [1]:

- Combination of a tabletop display and our wall screen
- No use of the steerable projector at this stage
- Central area to create and annotate Post-it<sup>®</sup> notes
- Peripheral area for organization and shifting of clusters



[1] Hilliges, O., Terrenghi, L., Boring, S., Kim, D., Richter, H., Butz, A., *Designing for Collaborative Creative Problem Solving*, to appear in Proceedings of the 6th International Conference on Creativity & Cognition, Washington D.C., USA, June 13 - 15, 2007





## Wall-sized Focus plus Context Display:

- High input and output resolution: center display
- Low input and high output resolution: side displays
- Low input and output resolution: rest of the wall

## Three techniques for multi-precision feedback:

- Accuracy of interaction
  - Directly show the accuracy
- Different levels of detail for interaction
  - Allow or prevent detailed information according to the tracking accuracy of the detected position
- Size of interaction area
  - Enlarge the size of the interaction area for low accuracies





#### Increase robustness of the tracking system:

- *Problem:* The system has slight jitters caused by USB delays
- *Solution:* Apply temporal filters to the signals

#### Formally evaluate the display wall:

- First impressions are mostly positive
- Increase tracking accuracy in order to test our interaction techniques in combination with the display

## Scenarios for our wall-sized display:

- First real application: *BrainStorm*
- Develop further scenarios to test variable precision input and focus plus context output











# **Questions?**

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Sebastian Boring et al., PerCom 2007, White Plains, NY, USA

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