Pinch-n-Paste: Texture Transfer Gesture Interaction System with see-through HMD

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It is difficult to move, copy, and change an object’s texture in the real environment.
Umakatsu et al.’s Pinch-n-Paste\(^1\)

- Direct texture transfer interaction system in AR

Remaining Problems

- 3D Reconstruction
  - In-situ object reconstruction before interaction.

- Texture Transfer
  - Distortion of pasted texture

- Natural Hand Interaction
  - Inaccurate gesture recognition
  - Limited functions

- Display Device
  - Difference between user and camera viewpoints
Natural Hand Interaction

• Kinect sensor
• Skin color segmentation
• Hand approximation by spheres

• Collision detection-based gesture recognition
• Inability to recognize finger joint angles
• Misrecognition because of skin color variation
Display Device

- Using a monitor
- Difficulty in recognizing hand position in AR
Research Goal

- Add an authoring function with natural hand gesture
  - Accurate hand recognition
  - Implementation of gesture recognition
- Minimize visuo-proprioceptive sensory conflict
  - A see-through head mounted display (HMD)

Improvement Pinch-n-Paste
System Flow

Server

- Marker tracking
- Depth acquisition
- Model-based hand recognition
- Virtual hands creation
- Gesture recognition
- Physical simulation
- Communication

Client

- Communication
- Marker tracking
- Stereo rendering

Finger joint position, etc.

Server

Client

Kinect

HMD
# Gesture Function

<table>
<thead>
<tr>
<th>Texture</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinch</td>
<td>Move</td>
</tr>
<tr>
<td>Paste</td>
<td>Copy</td>
</tr>
</tbody>
</table>
Gesture Recognition Method

- Gesture recognition with a hidden Markov model (HMM)
  - Finger joint angles as a feature vector

- Collision detection
  - Sphere-based virtual hands
Model-based Hand Recognition

- 3Gear Systems (http://www.threegear.com/)
  - Hand tracking system using a Kinect sensor
  - Estimates 3-dimensional positions of finger joints
Gestures

Normal

Pinch

Grab
Estimation with Hidden Markov Model

- Hidden Markov Model
  - Probability model suitable for recognizing a sequential pattern
- Recognize Pinch, Grab and Normal from hand posture
  - Feature vector: Finger joint angles
Learning and Estimation

• Machine learning with Baum-Welch algorithm
  • Initial value: Mean vector of each state, Variance-covariance matrix, State transition probability
  • Maximize likelihood

• Recognizing a current state with Viterbi algorithm
  • Input: Sequential data of feature vectors
  • Output: Plausible list of state
Using HMD

VUZIX WRAP 920AR +
(Field of View: 31°)
Demo
Experiments

- Exp A: Comparison between monitor and HMD
- Exp B: Gesture recognition performance
- Exp C: Subjective evaluation

- 8 Participants
  - 6 male
  - 2 female
  - Average age: 24
Exp A: Comparison between Monitor and HMD

- Target pointing task
- Performance: No significant difference
- Work load (NASA TLX\textsuperscript{[2]}): No significant difference

\[ \log_2 \left( \frac{\text{distance}}{\text{size}} + 1 \right) \]

\[ \text{time} \]

Exp B: Gesture Recognition Performance

- **Recognition time**
  - Time taken from user’s showing a gesture to its recognition
  - Long recognition time due to slow system processing speed

- **Recognition accuracy**
  - Grab was more misrecognized

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**Recall(%)**

- Normal: 97.6
- Pinch: 97.4
- Grab: 56.1

**Precision(%)**

- Normal: 95.3
- Pinch: 48.4
- Grab: 99.1

**F(%)**

- Normal: 96.4
- Pinch: 64.7
- Grab: 71.6
Exp C: Subjective Evaluation

• Participants experienced texture transfer, moving and copying an object for a few minutes
• Questionnaire: Rank out of 5
  • Low rating
    • Recognition accuracy (1.56)
    • Processing speed (1.78)
  • High rating
    • Ease of learning gestures (4.56)
    • Matching between functions and gestures (4.22)
Conclusion and Future work

• Conclusion
  • Implementation of natural hand gesture-based interactions
  • Minimization of visuo-proprioceptive sensory conflict by a see-through HMD

• Future work
  • Implementation of additional functions
  • Real time reconstruction for authoring real objects in AR