CyclopsRing
Enabling Whole-Hand and Context-Aware Interactions Through a Fisheye Ring

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185 degree
Motivation
Related Work
[ShoeSense, CHI'12]
Cyclops  ShoeSense  OnmiTouch  Digits

most dedicated / flexible
Observing from outside
Observing from outside

→ Cause occlusions
e.g., rest wrist on surface
Observing from ... where is occlusion-free
comparing with other ring wearables...
Gesture + Environment
Applications
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CyclopsRing

Color camera with 185° fisheye lens
Implementation
Pipeline of Gesture Recognition

- Hand Gesture
- Foreground Extraction
- Gesture Recognizer

Discrete Input
- gesture set
- finger slider
- copy-paste
- palm-write
- and so on…

Continuous Input & Rich Interaction
- Heuristic algorithms
Pipeline of Gesture Recognition

Hand Gesture → Foreground Extraction → Gesture Recognizer → RDF

Discrete Input
- gesture set

Continuous Input & Rich Interaction
- Heuristic algorithms
  - finger slider
  - copy-paste
  - palm-write
  - and so on...
Random Decision Forest (RDF)

- Data-driven learning algorithm
- Notable example: Kinect
- RDF: a set of decision trees; each internal node is a weak learner

Feature response

\[ f(l,x) = \text{i}( \, x + u \, ) - \text{i}( \, x + v \, ) \]

image \quad offset\ intensity \quad offset\ intensity

image coordinate
Pipeline of Gesture Recognition

Hand Gesture -> Foreground Extraction -> Gesture Recognizer

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Continuous Input & Rich Interaction

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Heuristic algorithms

- finger slider
- copy-paste
- palm-write
- and so on…
7 gestures for applications

1. Palm
2. WriKng
3. Gun
4. Gesture
5. Finger
6. Slider
7. NonD Gesture
Gesture Recognition based on RDF

Gesture types are color encoded
Pipeline of Gesture Recognition

84% On seven gestures

Discrete Input

Continuous Input & Rich Interaction

Gesture set

Heuristic algorithms

finger slider
copy-paste
palm-write
and so on...
Pipeline of Gesture Recognition

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Continuous Input & Rich Interaction
- Gesture set
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- Finger slider
- Palm-write
- Copy-paste
- ... and so on...
On-Finger Slider (Continuous Input)

0. Raw Image

1. Gesture Recognition
On-Finger Slider (Continuous Input)

0. Raw Image  
1. Gesture Recognition  
2. Find the size of an enclosed area
Palm Writing

Viola-jones fingernail detector
Filtering with skin region
Stroke $\rightarrow$
  x-axis: x of the fingernail
  y-axis: size of the fingernail
Viola-jones
fingernail detector
Heuristics

1. Only keep windows that are in contact with background region.

2. Size/temporal coherent

Viola-jones fingernail detector
Viola-Jones fingernail detector

1. Only keep windows that are in contact with background region.
2. Size/temporal coherent

Heuristics
Pen Writing

Color filtering

Find the part in background region

Stroke →
x-axis: x of the cap
y-axis: size of the cap
Heuristics

1. Only keep the color cap that is inside the background region.
1. Only keep the color cap that is inside the background region.
Visual Feature Tracking / Recognition

1. Lens un-distortion
2. Feature tracking (SURF)
3. Motion estimation
Cyber Clipboard
Gestural Interaction Gaming
Experiment
Experiment

- 15 Participants; the lengths of their hands are recorded. ($M = 17.79\, \text{cm}, \text{Std} = 1.21\, \text{cm}$)
- Non-gesture hand motions were recorded by asking to casually stretch or curl their fingers.
Experiment
Leave-one-person-out cross-validation results

- Average gesture recognition rate: 84.75%
Experiment
Leave-one-person-out cross-validation results

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Leave-one-person-out cross-validation results

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Multi-lens CyclopsRing
Viewpoint from different webbings
Conclusion

• A ring-wearable for whole-hand and context-aware interaction

• Discrete Input with a gesture recognizer
  • Continuous/Rich Input with heuristics

• Envision this device with wide-angle short-range depth sensing in the future