

Virtual 3D Model Construction with Bare- Hand-Based Interaction

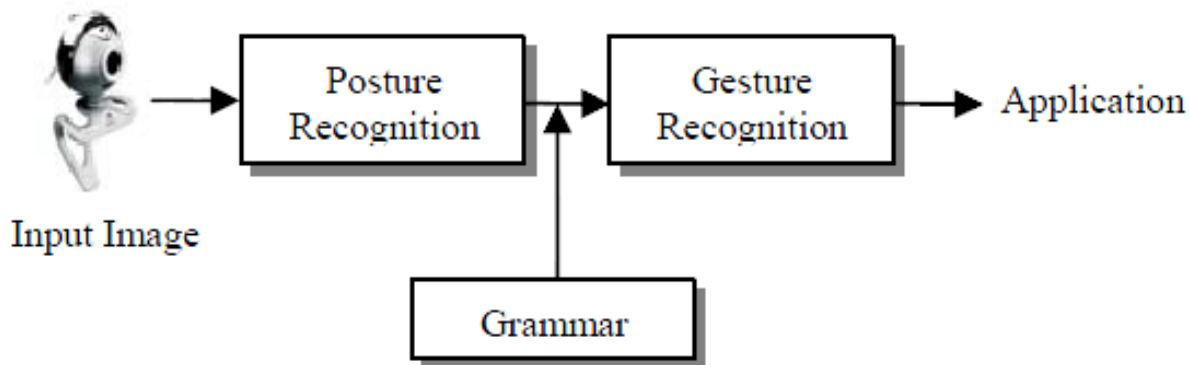
Lu Hong
Zhen Zeng



Introduction

- **HCI** (Human-Computer interaction) has been limited in keyboard and mouse for a long time. Hand-based interaction is more natural.
 - Our goal is to develop an application which could efficiently perform **bare-hand tracking** and **gesture recognition** to construct **virtual 3D** model from the user gesture. One simple example is to build a virtual 3D cubic using bare-hand gesture, and manipulate it (**DEMO**).
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Review on Appearance Based hand gesture recognition



Hand Gesture Recognition Process

Review on Posture Recognition

- Hand Segmentation
 - Background subtraction

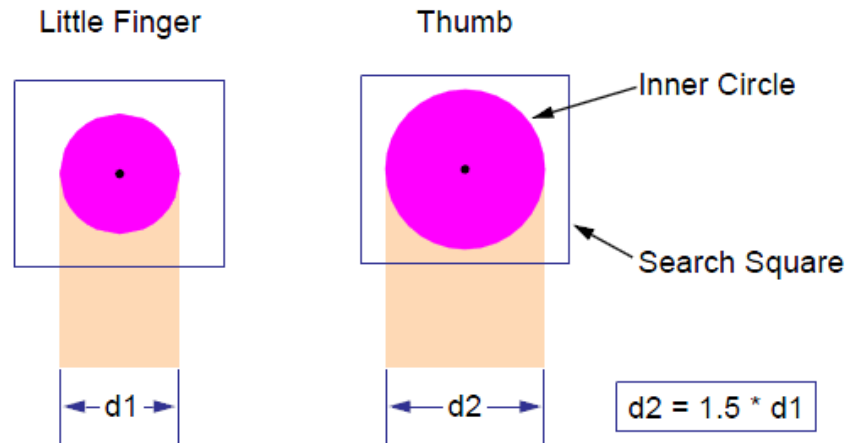


Image differencing with reference image. From left to right: input image, reference image, output image.

- Skin Detection
 - Represent skin and background pixels in a certain color space, build histogram-based classifier or use SVM for classification.

Review on Posture Recognition

- After segmentation
 - Fingertip Shape Finding



A simple model of the fingertip.

- Hand Contour Matching

Technical Part

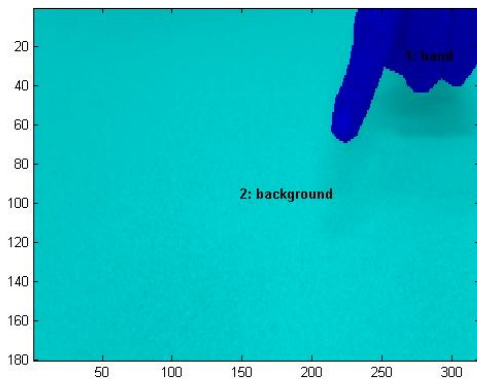
- Low level hand posture detection
- High level hand gesture recognition

Technical Part

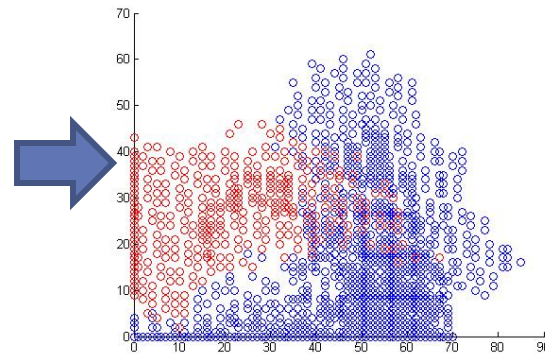
- Low level hand posture detection
- High level hand gesture recognition

Technical Part

- Bare-hand Segmentation
 - Skin Detection in RGB



Label hand and background



Plot differences: R-G, G-B
for hand and background

$R > 40 \ \& \ G > 20 \ \& \ B > 10$
 $\& \ R - G > 30$
 $\& \ R > B$

Technical Part

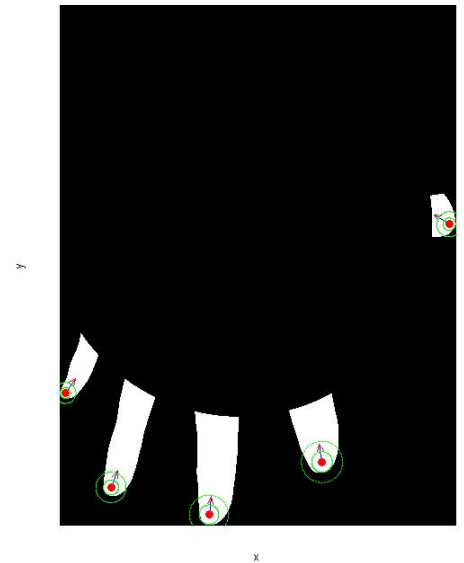
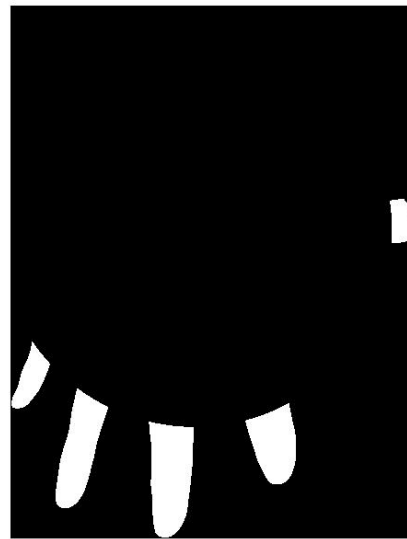
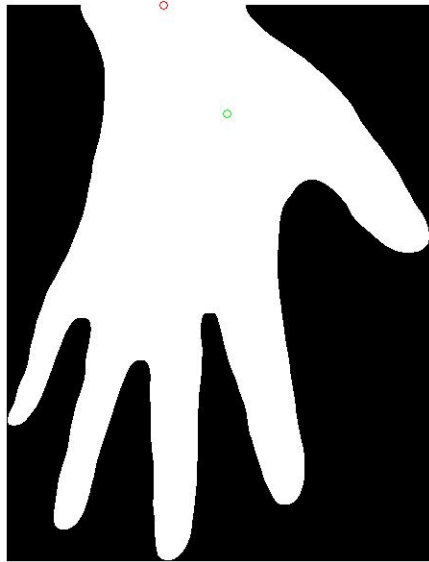
- Bare-hand Segmentation
 - Result (binary image)



- Mean filter to get rid of glitches
- Fill holes inside hand
- => Clean result!

Technical Part

- Pattern Recognition
 - Predict Fingertip Location



Find wrist and palm center

Cut hand with circle centered at palm center

Check each predicted fingertip with geometry constraint

Technical Part

- Pattern Recognition
 - Fingertip Shape Constraint



Radius is determined by the distance from the finger center to the nearest hand edge point.

Calculate the filled percentage of the small and the large circles,

$$\text{per}_s > 0.83 \\ \& \ 0.35 < \text{per}_l < 0.77$$

Technical Part

- Pattern Recognition
 - Fingertip Shape Constraint



Represent the orientation of each fingertip with a **vector** pointing from the fingertip to the palm center

The number and locations of fingertips, and the orientations are features used for posture classification

Technical Part

- Posture classify (5 categories): SVM



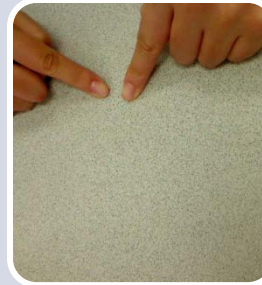
One tip



One
hand
two tips



One
hand
more
than
three
tips



Two
hands
one tip
per hand



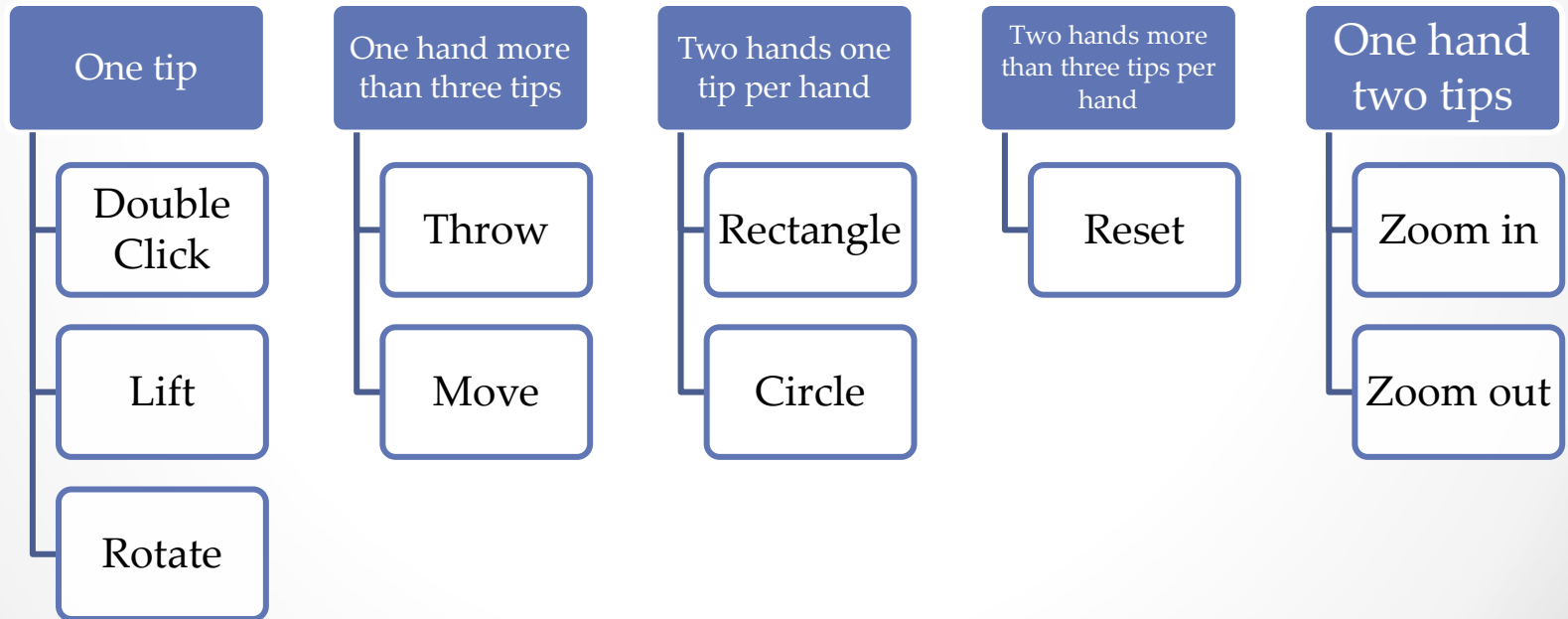
Two
hands
more
than two
tips per
hand

Technical Part

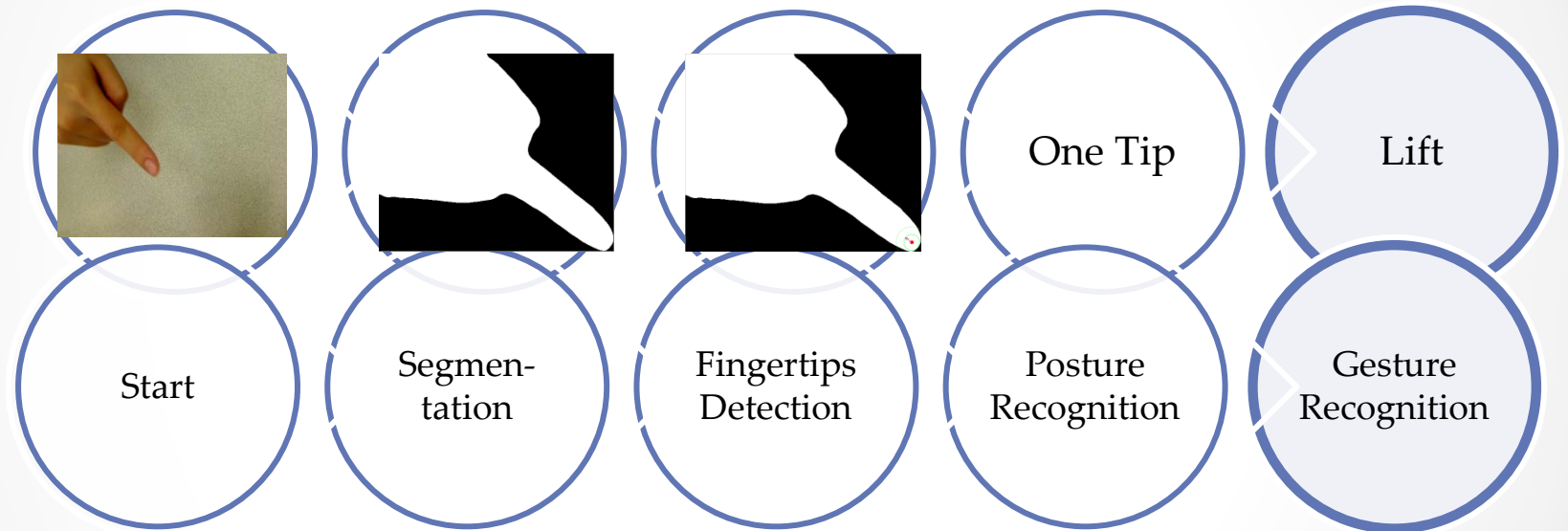
- Low level hand posture detection
- High level hand gesture recognition

Technical Part

- Gesture Recognition
 - Classify gestures in each category
 - According to speed and rotation
 - Using SVM



Technical Part



Current Result

- Execution Time:
 - Fingertip features extraction: ~ 0.07 s
 - Posture detection: ~ 0.0033 s

Current Result

- Confusion Matrix of postures

Predict \ Truth	1T	1H2T	1H3T	2H2T	2H3T
1T (61)	0.9	0.1	0	0	0
1H2T (42)	0.05	0.75	0.2	0	0
1H3T (30)	0.25	0.1	0.65	0	0
2H2T (40)	0	0.2	0	0.6	0.2
2H3T (18)	0	0	0.2	0	0.8

Conclusion

- Contributions

- We found a more efficient way to locate fingertips.
 - Efficiency: predict the fingertip location according to geometry constraint
- We developed a novel way of representing hand posture.
 - Number and locations of fingertips and the orientations

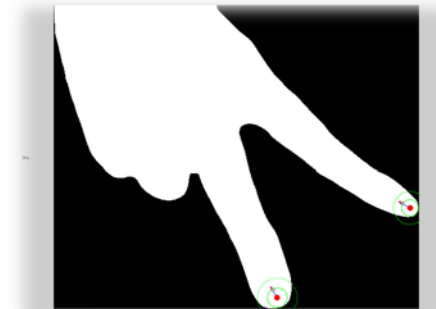
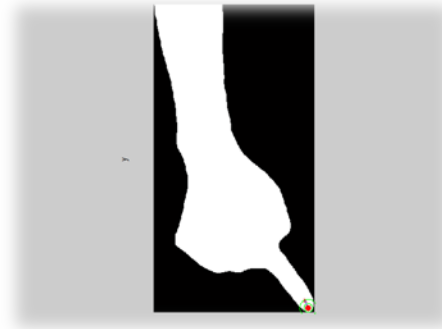
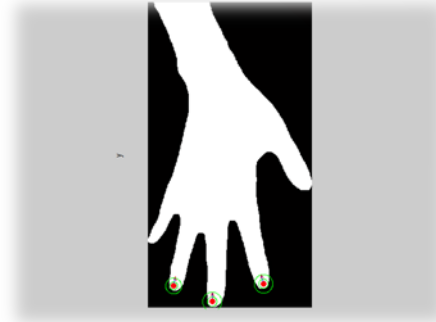
- Cont'd

- Use Kalman filter instead of SVM for gesture recognition
- After gesture recognition, input the gesture data to Simulink 3D to build model accordingly

References

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Demo



Questions?

