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Extracting hand articulations from monocular depth images using curvature scale space descriptors

Key words: Curvature scale space (CSS), Hand articulation, Convex hull, Hand contour

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Motivation/Main ideas

➤ Motivation

We propose a framework of hand articulation detection from a monocular depth image using curvature scale space descriptors.

➤ Main ideas

- Extract the hand contour from an input depth image.
- Obtain the fingertips and finger-valleys of the contour using the local extrema of a modified CSS map of the contour.
- Recover the undetected fingertips according to the local change of depths of points in the interior of the contour.

Method (I)

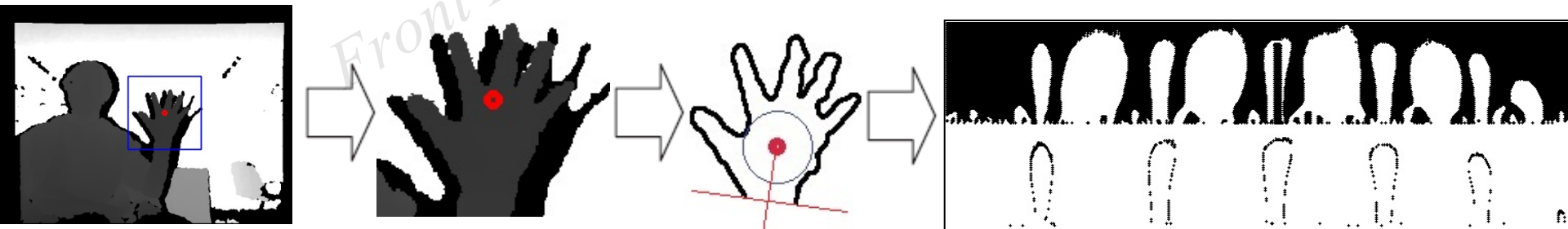
1. Extracting fingertips and finger-valleys using CSS

(1) Extracting the hand contour and palm center

(2) Extracting the fingertips and finger-valleys using the modified CSS

$$css_f^{\text{tip}}(t, \sigma) := \{(t, \sigma) : 0 < c_1 \leq k_\sigma(t) \leq c_2\},$$

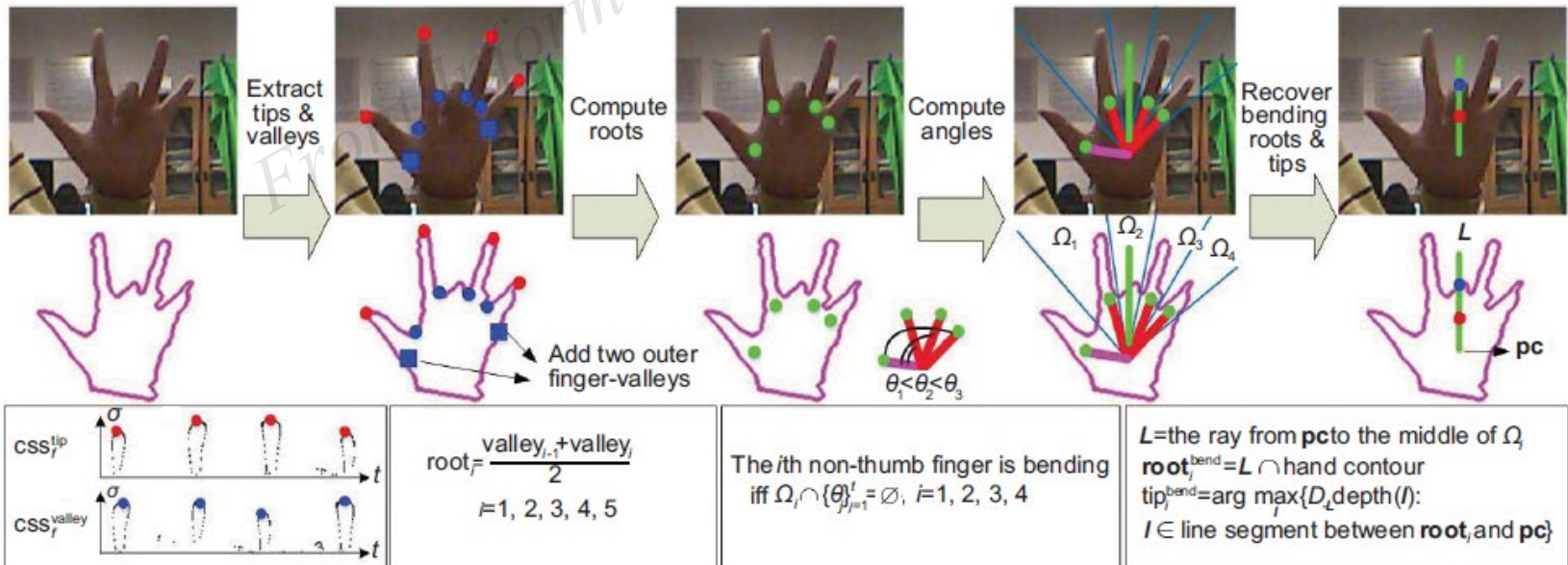
$$css_f^{\text{valley}}(t, \sigma) := \{(t, \sigma) : c_3 \leq k_\sigma(t) \leq c_4 < 0\}.$$



Method (II)

2. Recovering missing fingertips and missing finger-roots

- (1) Judge whether the thumb is bending
- (2) Judge whether the other non-thumbs are bending
- (3) Select the ray L from palm center to the middle of Ω_i , $i = 1, 2, 3, 4$
- (4) Missing finger-root = the nearest intersection between L and hand contour
- (5) Recover the fingertip of the thumb using the heptagon whose vertices are five finger-roots and the endpoints of the hand contour



Major results (I)

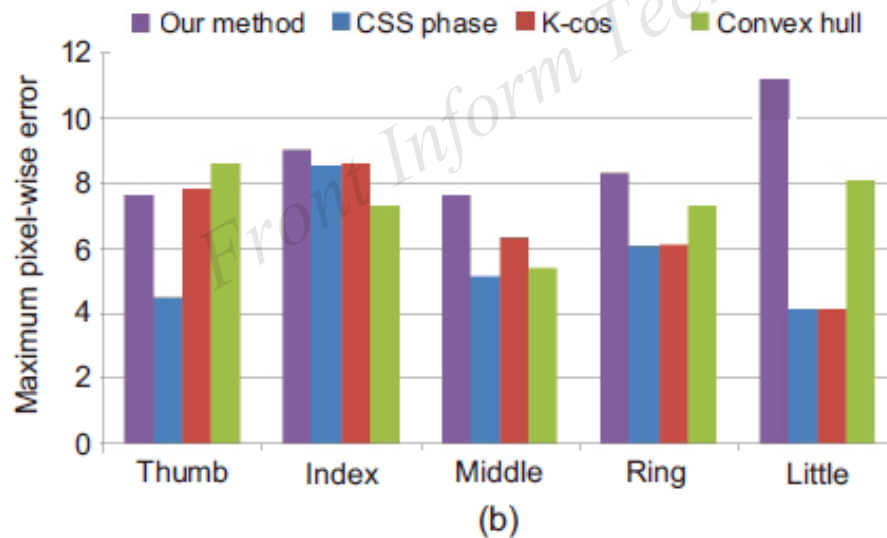
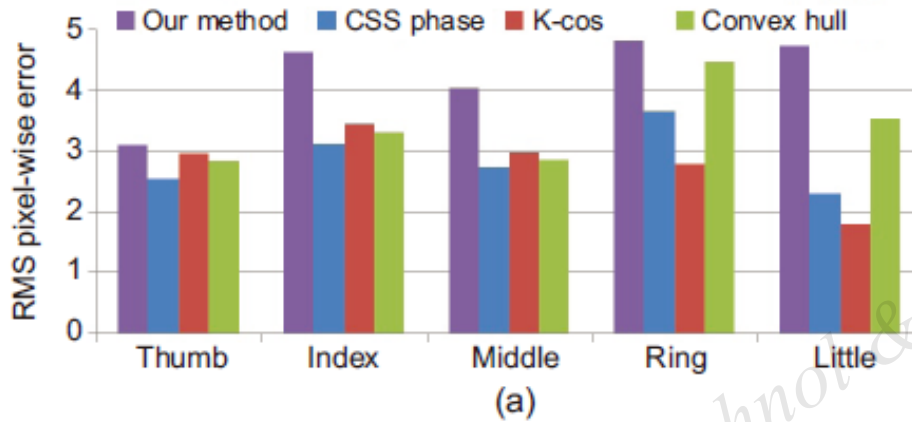


Fig. 5 The RMS error (a) and the maximum error (b) of all test images for each fingertip

Major results (II)

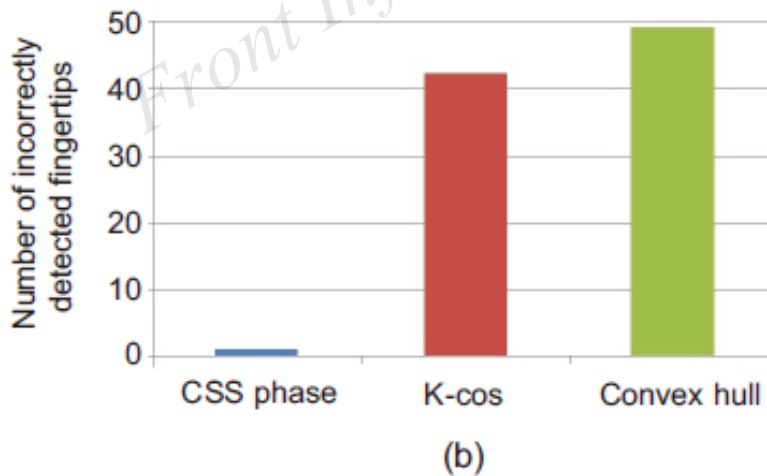
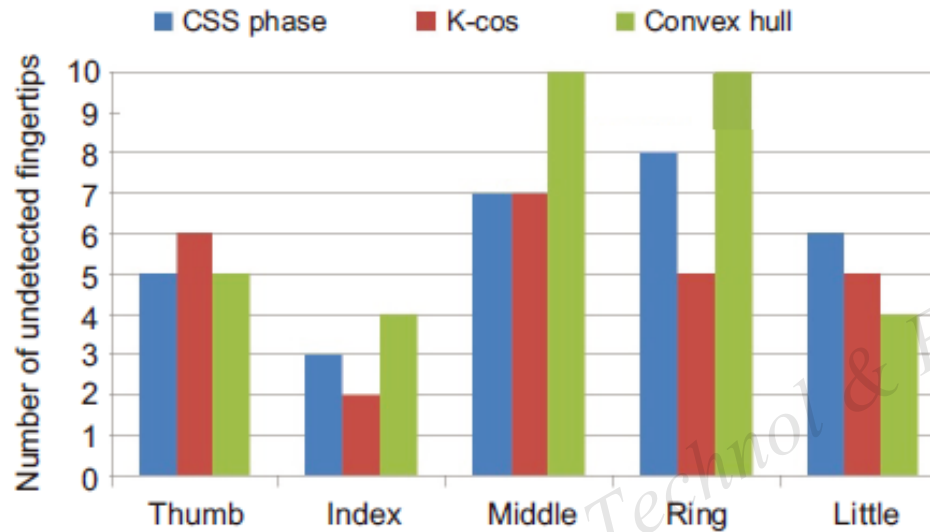


Fig. 6 The number of undetected fingertips (a) and the number of incorrectly detected fingertips (b) among all test images

Conclusions

- We have proposed an appearance-based method for extracting both straight fingers and bending fingers, using a modified CSS descriptor and the angle thresholds characterized by the finger-root of the thumb and the palm center.
- To improve our method, we shall consider extracting 3D CSS contours for 3D hand contours (i.e., the 3D curves around five fingers including bending fingers) and integrating the 3D CSS descriptors with a parametric model of human hands, which might better treat bending fingers.