Introduction:

traditional user interfaces relying on interaction devices such as keyboard,mouse,pointing devices ,touch screen,these are all based on the user physically interacting with a device, generally with the hand and fingers[1]. in addition to the challenges in the operation room where those equipments should be sterilized therefore user wants a natural and intuitive ways to communicate with computer systems for example, gesture and voice.

1 Related Work

the majority of fingertip detection techniques fall in to three categories : template match [2, 3, 4] ,contour analysis [3, 6]and machine learning classifier[5].the hand segmentation is considered prerequisite stage of the fingertip detection, that it can be done through background subtraction, human skin segmentation or glove color segmentation.

oka et al[2]. they used infrared camera and extract the skin region based by binarization of the input image with a proper threshold .and determine a hand part of the arm region based on the orientation of the arm and localize fingertips within that part based on its geometrical shape(circular template). Kalman filter is used to track the fingertips. yang et al.[3]proposed approach that combine the analysis of sampled hand contour and circular feature matching. After they segment the hand region by differencing approach, they search for a rough fingertip position based on the analysis of the sampled hand contour instead of analysis of hand contour itself that it may be is distorted or blurred. and to multi-direction fingertips localization ,they proposed the circular features inspired from circular template matching. Ankur et al.[5] developed machine learning classifier that combines shape and appearance cues to robustly identify tip points. they mark a few hundred points from the database of training images as tip points or non-tip points (depending on whether or not they lie on a finger tip). These points are encoded,using local image patches of 88 pixels, as 64-dimensional signature vectors. after a linear decision rule in the form of Support Vector Machine is learned,any new point can be classified as a tip point based on its signature. Wang et al.[6]detect fingertips through analyzing hand contour using K-Curvature technique and filter the candidate fingertip by the cross product of vectors and the distance transform. an improved Kalman filter is employed to achieve the robust tracking of multiple.

2 Methods

2.1 Hand Segmentation

In this step, we extract the hand region from the background.where in the context of operation room, doctor wears white glove,so the pixel is classified as hand region if its intensity value for red,green and blue color greater than specific threshold as shown in figure1. also note that based on the glove color and illumination, the threshold value may vary.

Figure 1: Image Segmentation

2.2 Fingertip Detection

2.2.1 Template Matching

Based on the facts that the overall shape of a human finger can be approximated by a cylinder with a hemispherical cap and the width of the cylinder is almost same to different people[2].Template matching is considered an easy and direct approach to localize fingertips. User can initialize fingertip template based on a hand image at the start of the system to match with the foreground image as shown in figure 2.

Figure 2: Fingertip template match with current frame

2.2.2 K-Curvature

hand contour is represented as sequence of edge points, k-Curvature algorithm calculates the curvature for each edge point to determine whether this edge point fingertip or not where The curvature of a contour edge point is represented by the cosine value of , which is the angle between $P_i\vec{P}_{i-k}$and $P_i\vec{P}_{i+k}$ as follow :

$$\cos\theta = \frac{\vec{p_ip_{i-k}} \bullet \vec{p_ip_{i+k}}}{\|\vec{p_ip_{i-k}}\|\|\vec{p_ip_{i-k}}\|}$$

where $P_i, P_{i-k}$and P_{i+k} are the i^{th}, the $(i-k)^{th}$ and the $(i+k)^{th}$edge points in the contour, respectively. In practice, values of k between 5 and 25 work reasonably well[6].beside the high curvature value , the edge point is considered a fingertip, if the value of cross product of the two vectors is greater than 0.we noticed that the fingertip positions can be found on key edge points of hand contour . Hence, the polygon approximation algorithm is used to find key points as in[7]. Then the k-curvature algorithm apply on key edge points instead of all edge points to determine that it is fingertip or not.

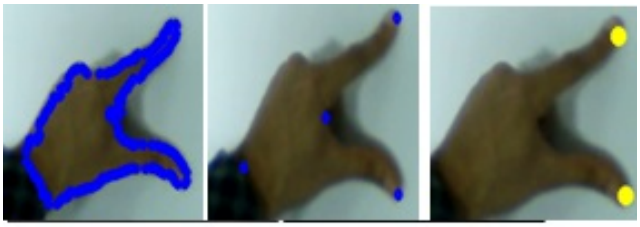

Figure 3: a)edge points of hand contour b)edge points after approximation c)detected fingertips

2.3 Fingertips Tracking

Once fingertips are detected, Kalman filter is used to track them to overcome the problems arising from occlusion or shadow. For the locationsX_k of fingertips in thek^{th} image frame. Kalman filter is used to predict the locationsX_{k+1} of fingertips in the $(k+1)^{th}$ image frame[2,5]. Then we use the nearest neighbor rule to associate fingertips between frames by comparing the predicted locations X_{k+1} with the detected locationsX_{k+1} in the $(k+1)^{th}$ image frame to achieve the robust tracking of multiple fingertips[2, 6].as shown in figure 3.

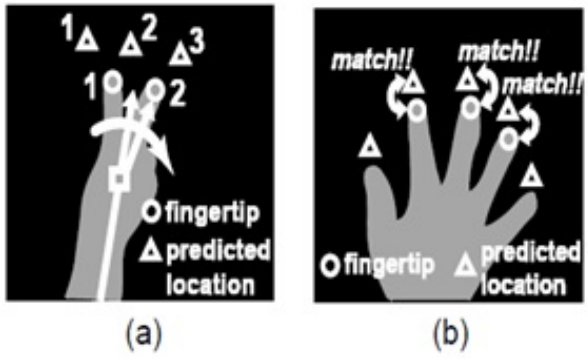

Figure 4: Prediction and matching of fingertips "Redrawn from [2]"

2.4 Gesture recognition system

we demonstrate the effectiveness of the explored methods for fingertip detection and tracking in controlling ImageJ 3d Viewer. The $N Multistroke Recognizer [8] is employed in our system to recognize the gestures,first we record template for each gesture as in figure 3, then compare new candidate gestures(fingertips trajectories) with predefined templates by iteratively searching for the optimal angular alignment between two gestures and comparing distances between corresponding points.

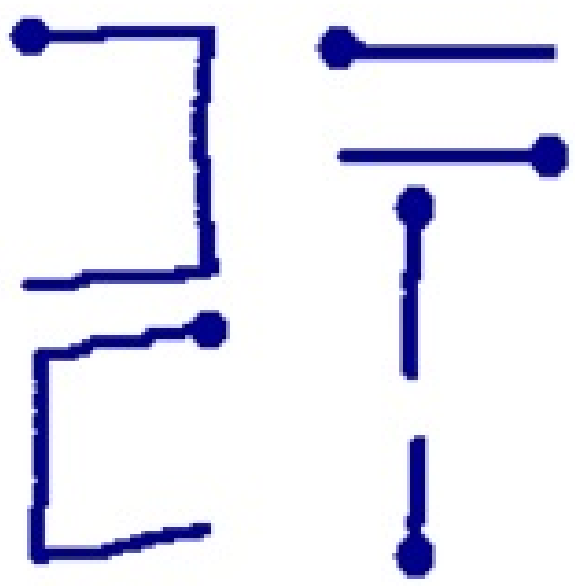

Figure 5: template of gestures (rotate right/left,translate left/right,zoom in/out)

References

[1] *B*OOK CHAPTER: Stereo Vision, Edited by: Asim Bhatti, Publisher: InTech Education and Publishing , Chapter 3: Stereo Vision for Unrestricted Human-Computer Interaction, by Ross Eldridge and Heiko Rudolph, pp 49-58.

[2] Oka. K, Sato. Y, Koike. H, Real-time tracking of multiple fingertips and gesture recognition for augmented desk interface system, Proceedings of the Fifth IEEE International Conference on Automatic Face and Gesture Recognition, pp 411 416,May 2002.

[3]]DD Yang, LW Jin, JX Yin "An effective robust fingertip detection method for finger writing character recognition system" Proceedings of 2005 International Conference on Machine Learning and Cybernetics, 2005.

[4] Jong-Min Kim; Woong-Ki Lee, Hand Shape Recognition Using Fingertips Fuzzy Systems and Knowledge Discovery, 2008.FSKD '08.Fifth International Conference on , vol.4, no., pp.4448,18-20 Oct. 2008

[5] Ankur Agarwal, Shahram Izadi, Manmohan Chandraker, Andrew Blake:High Precision Multi-touch Sensing on Surfaces using Overhead Cameras. Tabletop 2007: 197-200.

[6] Chunyang Wang, Bo Yuan: Robust Fingertip Tracking with Improved Kalman Filter. ICIC (1) 2014: 619-629.

[7] Kittasil Silanon, Nikom Suvonvorn: Fingertips Tracking Based Active Contour for General HCI Application. DaEng 2013: 309-316.

[8] Anthony, L. and Wobbrock, J.O. (2012). $N-Protractor: A fast and accurate multistroke recognizer.Proceedings of Graphics Interface (GI '12). Toronto, Ontario (May 28-30, 2012). Toronto, Ontario: Canadian Information Processing Society, pp. 117-120.