EEE F435
Digital Image Processing Project Report

Robust Gesture Detection and Gesture Recognition for Wearable Vision Sensors

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Project Motivation:-

Gesture detection and recognition can ease the process of operating and controlling any equipment or device. It can also improve portability of many devices and enhance user-device interactions. This technology can also be extended for helping physically challenged people.
Also one can find its uses in gaming/virtual reality industry. Many commercial gadgets do have gesture recognition software in them. Highly personalized Gesture recognition can also be used as a password for secure access into private databases.

Gesture recognition using vision sensors and cameras may be the next leap in human-computer interaction as it does not require any physical contact with the sensing device unlike touchscreens, mouse, trackpads, etc.
Also as there is no physical contact between the sensor and the user it eliminates chances of wear and tear of the sensing device hence increasing its life time.

I am fascinated by the present gesture recognition technology and its vast scope of usage, this was the motivation behind this project.

Objectives:-

1. Efficiently detect human presence and cancel background from the acquired image.

2. Isolate the targeted gesture generating part (Eg:-hands, face, etc), enhance it for detection and Gesture detection (using erode, dilate, etc)

3. Robust Gesture recognition (using contours and other techniques)

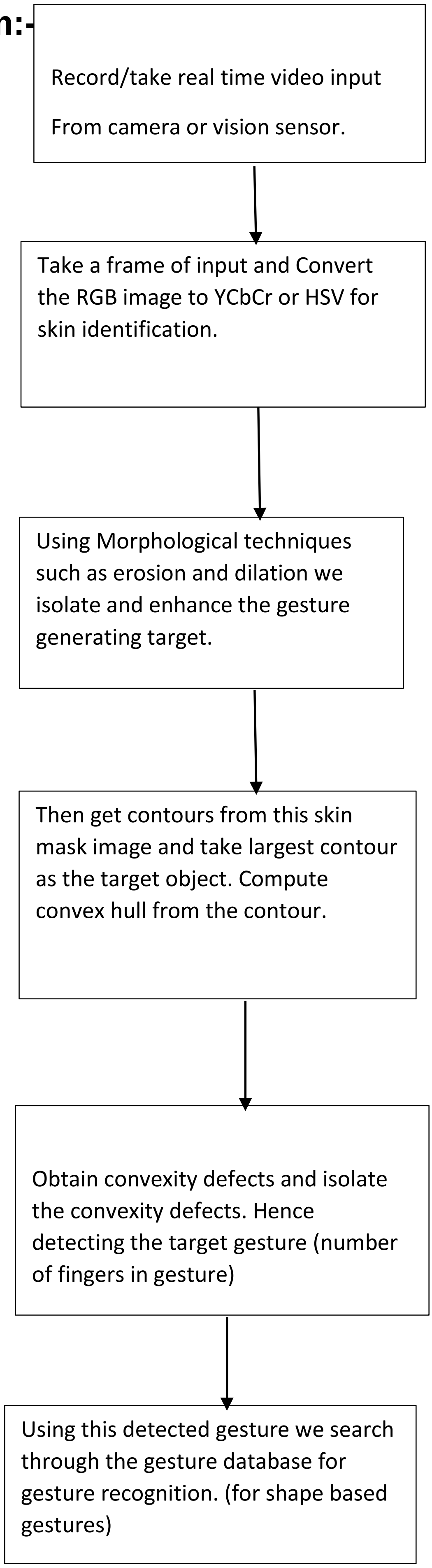
4. Test whether it performs the task after gesture recognition.

5. Optimize for speedy recognition and execution

TEST IMAGE INFORMATION:-

1) Test images are real time snapshots of the video input that are taken from a normal laptop webcam.
2) These images are taken for different gestures and in varying conditions.
3) Image Properties are as follows:-
   (i) colour image(RGB)
   (ii) 1280x720 & Jpeg format
   (iii) 24 bit depth
4) Images were named serially for easy testing.

Block diagram:-
(Approach)



Procedure:-

1) Record/take real time video input (snapshots/frames) from camera or any computer-vision sensor.

2) Take a frame of input and Convert the RGB image to YCbCr & HSV for skin identification i.e by using proper thresholds.

3) Fill holes in the acquired image then use Morphological technique close (with disk structuring element of radius 12) to isolate different body part regions in the image.

4) Identify and isolate the arm region among different skin regions of the user by calculating areas of the regions isolated then taking the region with largest area.

5) Then crops the image so that only the arm part (target) is retained.

6) Enhance the cropped region using morphological techniques close and open to get distinct fingers of the hand isolated and make it easier to recognise the gesture.

7) Calculate Convexity hull of the enhanced image to get fingertip points. Then retain only the fingertip points in the convexity hull matrix.

8) Calculate Statistical parameters like centroid and areas suspended by each finger with the centroid.

9) Use the statistical parameters calculated in the previous point and the convexity Hull points to roughly calculate the convexity defects hence isolating the fingers in the process.

10) Use the result of this isolation to count the number of fingers and differentiating normal (IIm is a normal gesture) and advanced gestures (example of advanced gesture - \m/).

11) Differentiating normal and advanced gesture based on area subtended at the centroid relative to convexity hull points (finger tips).

12) Finally displays the resulting frame containing number of fingers and the type of Gesture (normal/advanced)

13) This number and gesture type can be used to assign any task which it might represent hence performing the task later.

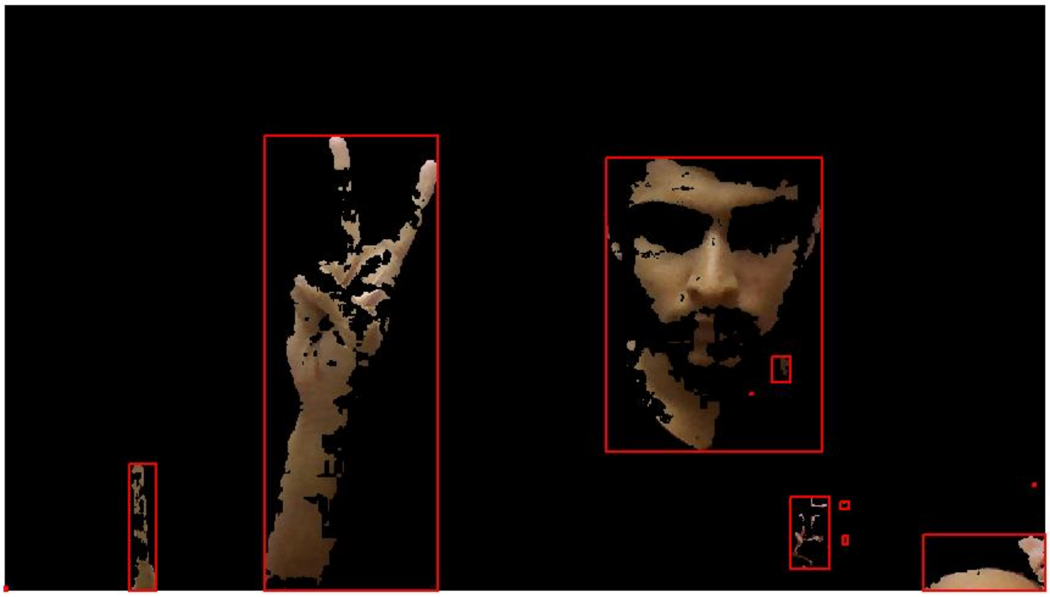
14) These frames can be put together to get a real time recognition of the gesture.

Results:-

1) Original test image

2) Skin isolated binary image

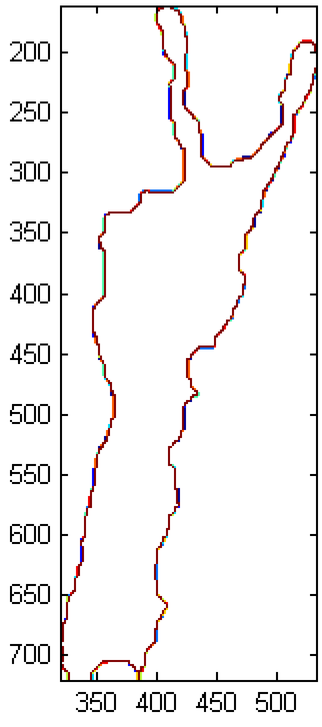
3) Different skin regions separated and then masked over original image



4) Isolated arm region and later performed morphology to get proper fingertips.

5) Cropping the arm region (target) from the original

6) Image with convexity hull points and centroid.



7) Contour of detected hand and final result image

Table showing the results of the project

Number of the image tested	Actual number of fingers	Number of fingers detected	Gesture type	Final remark
1	1	1	N	Correctly Recognised
2	3	3	N	Correctly Recognised
3	4	4	N	Correctly Recognised
4	2	2	A	Correctly Recognised
5	1	1	N	Correctly Recognised
6	1	1	N	Correctly Recognised
7	2	2	N	Correctly Recognised
8	4	3	N	Minute error in number of fingers due to tilting of hand
9	3	3	N	Correctly Recognised
10	5	5	N	Correctly Recognised
11	0	0	N	Correctly Recognised
12	2	2	N	Correctly Recognised

Discussion of results :-

The program successfully recognised the test images 11 out 12 (i.e 91.67% accuracy).

Even better recognition can be achieved if the segmentation part of the code is perfected and also performance improves if images contain only hand/arm region of the person without any other environmental noise. Also the performance improves if the person wears dark clothes and hence helping in segmenting the arm more easily.

We can also try taking many frames then averaging the fingers detecting in them to reduce error generated due to partial gestures and other environmental variations.

Also the code needs to be modified to consider no arm cases which can make it more versatile.

Conclusion:-

The program successfully recognises shape based gestures for the hand. Efficiency of recognition is 92%. Averaging of results from many frames and other statistical operations can be employed to improve the performance drastically.

Program listings in the zip file

1) Folders present :-
   (i)Test images
   (ii)Result images of gesture 12

2) Dipproject362.m is the Matlab file containing the project code

References:-

1. Pavlovic, V., Sharma, R. & Huang, T. (1997), "Visual interpretation of hand gestures for human-computer interaction: A review", IEEE Trans. Pattern Analysis and Machine Intelligence., July, 1997. Vol. 19(7), pp. 677 - 695.

2. R. Cipolla and A. Pentland, Computer Vision for Human-Machine Interaction, Cambridge University Press, 1998, ISBN 978-0-521-62253-0

3. Ying Wu and Thomas S. Huang, "Vision-Based Gesture Recognition: A Review", In: Gesture-Based Communication in Human-Computer Interaction, Volume 1739 of Springer Lecture Notes in Computer Science, pages 103-115, 1999, ISBN 978-3-540-66935-7,doi:10.1007/3-540-46616-9