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Efficient and Robust System to Recognize Gestures of Hands

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ABSTRACT: Gesture recognition is a tough task because of the complexity in the background, the uneven movements of hands and also the intensity of light in an image. This paper proposes new technique for hand gesture recognition starting with detection of hands, determining center and tracking hands to examine the variation in the location of hands and ending with the gesture recognition. The technique proposed above overwhelms the problem of background complexity and the distance from the webcam / camera should be fixed (maximum 2 meters). The results obtained are studied and it shows that the gestures are recognized at a good rate.

KEYWORDS: Gesture recognition of hands, Detection of skin and Tracing of hands.

I. INTRODUCTION

Gesture comprises of motion expressed by human body, face and hands. The most often and most communicative among all the gestures is the hand gesture. The easiest way to communicate with computers nowadays is the use of gestures. With the help of such interfaces the gesture of hand can be used extensively to control the variety of devices. The work which is done so far on this topic exempted the complex background and only concentrates on the stable background so as to recognize the gestures easily [1-6]. The necessary condition of glove-based interfaces is to wear the clumsy devices which contain the lots of cables connected to the computer. The gesture recognition system was proposed that can detect and recognize 46 ASL letter spelling alphabet and digits the gestures are static i.e., without any motion [7].

This paper focuses on recognition of dynamic gestures of hand and of which a single gesture is executed in a complex background. The proposed system does not use any marker or glove to recognize gesture [2]. The proposed techniques uses 2D image as an input, which further detects the hands tracks the movements of hands and examines the variation in the position of the hands, the obtained position is used to recognize the gesture of the hand.

II. SYSTEM WORKFLOW

The main approach is to design the low cost system that can be easily installed into the machine with the enabled webcam or camera, and the machine should be able to work under different intensity of lights and complex background. Fig 1 shows the proposed framework of the system.

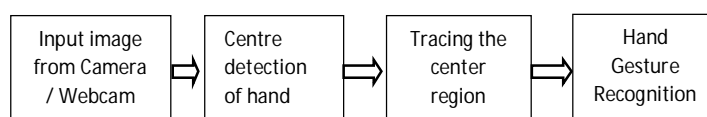


Fig 1. System Framework

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The steps for the proposed techniques are as follows:

- i. Acquisition: a frame of image is captured from the webcam / camera.
- ii. Segmentation & detection: the image is sectioned into two parts, both of them are controlled simultaneously before analyzing the resultant data, skin pixel and moving patterns are detected. The image containing the location of the center of the moving hand is created for further processing.
- iii. Tracing: The successive frame are traced endlessly, the center of the moving hands is detected for every frame.
- iv. Pattern Recognition: The database is created which contains several images of hand gestures, the detected image is compared with the database image, and the one which matches the most determines the gesture of hands.

III. HAND DETECTION

This technique is developed in such a way that it divides the input video frame into two parts and processes each of them separately keeping in mind that the processing for both the parts is alike and concurrent. For fast processing of image the operators should be kept low time consuming in order to achieve real time speed. The steps followed for detection are as follows:

- i. Skin tone detection: The skin is easily detected by using color tone information. RGB based color classifies as skin if:

$$0.08 < \frac{3 * B * R^2}{(R + G + B)^3} < 0.12$$

AND

$$1.5 < \frac{R * B * G^2}{G * B} < 1.8$$

AND

$$\frac{R + G + B}{3 * R} + \frac{R + G + B}{R - G} < 1.4$$

- ii. Motion detection: By using the above mentioned formula for skin detection it is observed that the non-skin regions are also appearing. By viewing only these non-skin regions will be excluded, by subtracting two successive frames [8] and thresholding the output the moving objects are detected.
- iii. Combining motion and skin color: The gesture of hand comprises of skin color and motion both so the logical AND operation is applied to combine them: $P_i(x,y) = M_i(x,y) \wedge S_i(x,y)$



Fig 2. (a) Original hand detected image, (b) Skin color region, (c) Combination of skin and motion pixels [10].

- iv. Region identification: The approach to determine the center of the hand is as follows:
 - a. The center of each motion and skin color is calculated with the help of Eq.1, and is stored in an array so as to store row's number as an address. The process of handling the midpoint is clarified in Fig 3.
 - b.

$$center\ of\ row's = \frac{\sum\ hit\ pixels\ (position\ in\ x-axis)}{total\ number\ of\ hit\ pixels} \quad \text{-----Eq.1}$$

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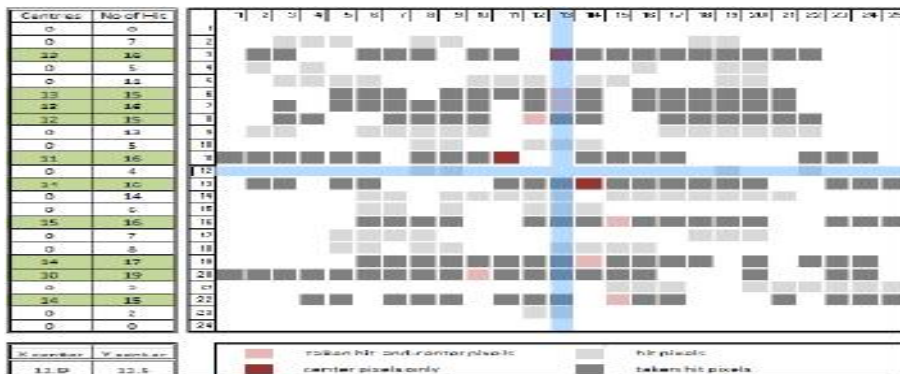


Fig 3. Hand center determination [10]

Light grey, dark grey and pink color pixels are satisfying both the motion and skin tone pixels and are hit pixels. Rows which contains more than 15-20 motion and skin tone pixels are colored as dark grey and are also counted under hit pixels. The table in left comprises of two columns. Left column shows the center of each row of hit pixels and right column contains the number of motion and skin pixels if each row. The red and pink color denotes the center of row in which pixels are not found.

- c. Calculating average by adding up all stored center values and then dividing by total number of rows which are stored in an array which results in the equitable lines, the calculation is depicted in Eq.2 and Eq.3.

$$\text{equitable line in } y - \text{axis} = \frac{\sum \text{center's}_i}{\text{total number of hit rows}} \quad \text{-----Eq.2}$$

$$\text{equitable line in } x - \text{axis} = \frac{\sum \text{address of rows}}{\text{row count}} \quad \text{-----Eq.3}$$

The particular for detection of center of hand is mentioned in Algorithm I.

Algorithm I Detection of center of hand [10]

```

for i←0 to imageHeight
for j←0 to imageWidth
if Px(i,j) satisfy Motion
AND inSkinRange then
TruePixel ← TruePixel + 1
XTruePx ← XTruePx + j
end if
end for
if TruePixel > 15 then
MPArray[i] ← (XTruePx / TruePixel)
Else
MPArray[i] ← 0
end if
end for
for i←0 to ImageHeight
if MPArray[i] ≠ 0 then
MPSum ← MPSum + MPArray[i]
TrueRow ← TrueRow + 1
YTrueRow ← YTrueRow + i
end if

```

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```

end for
if TrueRow > 0 AND YTrueRow > 0
AND MPSum > 0 then
X_Center ← MPSum / TrueRow
Y_Center ← YTrueRow / TrueRow
end if

```

Fig 4 depicts the results of the detection of hands in the variety of backgrounds.



Fig .4. Hands detected in an image [10]

IV. TRACING HAND GESTURE

The complete system for tracing hands is divided into two steps: the first step is to take care of the motion pixels and keep the record of them as shown in Fig 5(a & b), and the second step is to examine and work on these points as mentioned below:

From the centroid P(x, y) select the position of x-axis and store it in the variable named as X_{array} and repeat the same procedure for the y-axis and obtain Y_{array} with dropping the value at P(0, 0) as mentioned in the Table 1.



Fig 5 (a&b). Depicts the latest manipulated points [10].

X	2	3	0	6	9	11	0	14	X	2	3	6	9	11	14
Y	183	178	0	170	168	164	0	161	Y	183	178	170	168	164	161

Table 1(a): Actual array [10] Table 1(b): Array after elimination [10]

In this particular system only 10 frames per second are considered because it is not possible for the human to give more than 25 gestures in a second [9] or in other words it is concluded that tracking is not done for the complete analysis of the frame. The proposed work is in real time and has the application in the same. To calculate the angle and distance between each successive center in the midpoint array the Pythagoras formulas are used as shown in Fig 6.

(a) $d_{(a,b)} = \sqrt{x^2 + y^2}$

(b) $\theta_{(a,b)} = \tan^{-1} \frac{y}{x}$

(c) variations in two successive points at different angle [10] as shown in Fig 6.

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The above points (a), (b) denotes the equations which are used to find the distance and angle between successive points. Thus four variables are colligated with four main directions as shown below. To attain most appropriate results $\pm 15^\circ$ tolerance [10] is given at every angle as depicted in Fig 7.

$$\text{Variables} = \begin{cases} \text{var}_0, & \text{variable linked with } 0^\circ \\ \text{var}_{90}, & \text{variable linked with } 90^\circ \\ \text{var}_{180}, & \text{variable linked with } 180^\circ \\ \text{var}_{270}, & \text{variable linked with } 270^\circ \end{cases}$$

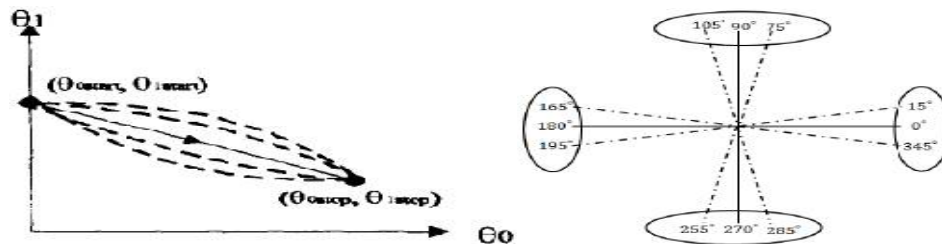


Fig 6. Variations in two successive points at different angles [10] Fig 7. Four major angles with $\pm 15^\circ$ tolerance [10]

The motions which were not related to any specified range are neglected and counting is done for predefined variables that were in the range. In the tracing stage two variables are to be created as: angleCounter to measure the number of movements from the reference value and sumDistance to add up all the distance travelled by hands from the reference angle. The evaluated angle is checked if the prestored angle lies within the four major directions then increment the angleCounter for that particular angle. Proceeding in this particular direction the information about the movements of hands is obtained. Algorithm II specifies the tracing of human hand.

Algorithm II Tracing human hand [10]

```

fori ← 0 to array.Length
d = distance between Ci(x,y) and Ci-1(x,y)
θ = angle between Ci(x,y) and Ci-1(x,y)
if -15 < θ < 15 then
rtl ← rtl + 1
Sum_rtl ← Sum_rtl + d
else if 75 < θ < 105 then
dtu ← dtu + 1
Sum_dtu ← Sum_dtu + d
else if 165 < θ < 195 then
ltr ← ltr + 1
Sum_ltr ← Sum_ltr + d
else if 255 < θ < 285 then
utd ← utd + 1
Sum_utd ← Sum_utd + d
end if
end for

```

V. RECOGNITION OF HAND GESTURE

The gesture is recognized by its axial movement. The recognition should be highly stable and can adapt to variations in the gestures. The analysis phase is subdivided into two categories first in which the variation of one hand is taken and

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second in which both the hands are moving. The centroid, angle and the motion counter is used for recognition of gesture. The Algorithm III&IV depicts recognition of one moving hand and both the moving hands respectively.

Algorithm III Recognition of one moving hand [10]

```
if Sum_rtl > 150 AND rtl > 4
AND ltr* < 2 then
DoEvent(Right To Left)
else if Sum_ltr > 150 AND ltr > 4
AND rtl* < 2 then
DoEvent(Left to right)
else if Sum_utd > 200 AND utd > 4
AND utd* < 2 then
DoEvent(Up to down)
else if Sum_dtu > 200 AND dtu > 4
AND dtu* < 2 then
DoEvent(down to up)
```

Algorithm IV Recognition of both the moving hands [10]

```
if Sum_utd > 200 AND Sum_utd* > 200
AND utd > 3 AND utd* > 3 then
DoEvent(Both hand up)
else if Sum_dtu > 200
AND Sum_dtu* > 200 AND dtu > 3
AND dtu* > 3 then
DoEvent(Both hand Down)
else if Sum_ltr > 150
AND Sum_rtl* > 150 AND ltr > 3
AND rtl* > 3 then
DoEvent(Zoom In)
else if Sum_rtl > 150
AND Sum_ltr* > 150 AND rtl > 3
AND ltr* > 3 then
DoEvent(zoom Out)
```

VI. EXPERIMENTAL RESULTS

For the proposed work 12 different gesture recognition is done with 40, 80 and 100 trails of each of three different users. The recognition rate of the proposed system seems good and is around 90-95%. The proposed work was carried out and the results are displayed in the table below:

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Hand Gesture	40 trail	80 trial	100 trials
both dtu	39	79	99
both utd	39	78	98
zoom out	35	75	95
zoom in	37	77	97
Right hand dtu	36	73	91
Right hand utd	38	74	94
Right hand ltr	39	78	97
Right hand rtl	39	78	97
left hand dtu	34	72	90
left hand utd	34	70	89
left hand ltr	38	78	95
left hand rtl	39	77	96

Table 2. Results of the system designed.

* dtu = down to up; utd = up to down; rtl = right to left; ltr = left to right.

VII. CONCLUSION

A new system is designed to increase the robustness, adaptability and efficiency of the gesture recognition system. The minimum possible hardware is used in the designing of the system. The implemented algorithm works well and provides the efficiency of around 90-95%.

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