

Child Obesity Control through Computer Game

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Abstract- Due to urban life style and nuclear family culture, overweight or obesity becomes an epidemic for the future generation, i.e. children. Due to fast lifestyle parents have not enough time to play with their children. As a consequence children are addicted with TV programs or computer games to fulfil their fantasy. The future generation of the society is not at all interested on the physical exercise, which causes the obesity, because extra calorie is deposited on the fat cells. This game addiction cannot be removed. The objective of this work is to control child overweight or obesity by means of introducing physical activity into computer or video game. The proposed system achieved 96% accuracy for the test sets used to test this system.

Keywords- BMI; Dilation; Erosion; Fuzzy Logic; HSI Colour Format; Laplacian Filter

I. INTRODUCTION

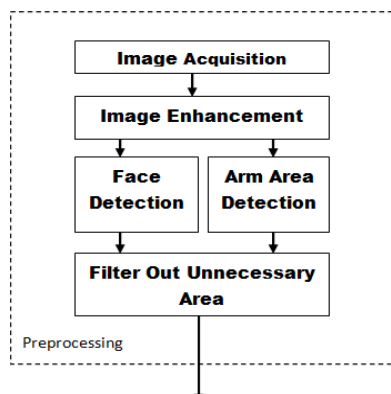
Overweight and obesity are defined as abnormal or excessive fat accumulation that impairs health. The World Health Organization (WHO) defines “overweight” as a BMI [2] equal to or more than 25 and “obesity” as a BMI equal to or more than 30 [1]. The probability of Cardiovascular disease (like stroke), Diabetes, Musculoskeletal disorders (especially osteoarthritis.) and some cancers (endometrial, breast, and colon) are proportionate with BMI increment. Stroke kills 17 million people a year, which is almost one-third of all deaths globally [2]. Survey report reveals that by 2015, approximately 2.3 billion adults will be overweight and more than 700 million will be obese. Physical activity or exercise can control the probability of overweight and obesity. But people spend their time over television and computer games instead of physical activity [3, 4]. There are lots of reasons for increasing popularity of computer game; some of them are top players or teams can earn real world rewards, there is no end to the game [5], sometimes it becomes the platform to fulfil the fantasy.

The control of computer game addiction is not easy. The objective of this work is to reduce the probability of overweight and obesity caused by playing the computer or video game by means of introducing physical activity into computer game. That means a computer game will be played by free hand exercise instead of mouse movement or pressing keys in the key board. Free hand exercise includes exercise using arm, neck, leg, etc. but in this work only arm movement is discussed. For example in a simple car racing game the direction of the car is changed by pressing left or right key but in this proposed work the left and right movement will be controlled by stretching the left or right hand accordingly. The system includes a computing element along with a CCD camera for snapshots of the player and then supplies the images to the computing element, computing element will analyse the images and determine the relative position of the player's arm and pass the information to the game controlling device. So the game controlling system looks like an intelligent system which is capable to understand arm signals for playing the game instead of pressing keys.

The rest of the paper is arranged as follows: Section II describes the proposed system; Section III presents the results and performance of the system and Section IV concludes the system with discussion on the future scope of work

II. OVERVIEW AND DESIGN PRINCIPALS

The entire work is divided into several steps: image acquisition, Image Enhancement, Face area Detection, Arm Area Detection, Filter out Unnecessary Area, Determine the relative positions of the arms with respect to the face, Decision making and convey the decision to the game controller. The sequences of these steps are shown in Fig. 1 as a block diagram.



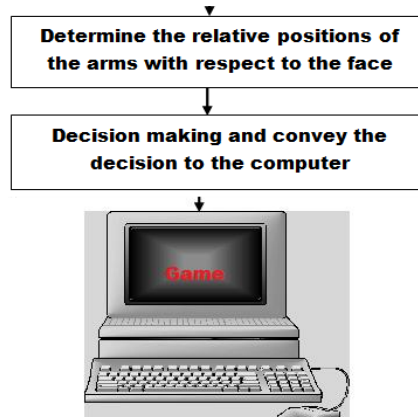


Fig. 1 Block diagram of the system

A. Image Acquisition

Image Acquisition is the first step. Bit map formatted images are extracted from the CCD [6] camera.

B. Image Enhancement

The images obtained from the CCD camera are not in good quality. Edge detection plays a major role in skin area detection and segmentation so Laplacian Filter [7] is used to sharpen the edges of the objects in the image.

The Laplacian gradient at a pixel position (x,y) is denoted by $\nabla^2 f(x,y)$ and it is defined as.

$$\nabla^2 f(x,y) = \frac{\partial^2}{\partial x^2} f(x,y) + \frac{\partial^2}{\partial y^2} f(x,y) \quad (1)$$

This equation is applied on all points (x,y) of the image through convolution [8]. The Laplacian filter is applied separately on Red, Green and Blue components of the colour images obtained from the CCD camera. After that the human skin region is segmented from the sharpened color image. The detection of skin area as well as arm area is discussed next.

C. Arm Area Detection

Human skin area detection is common to both face area detection and arm area detection. Colors are usually separated into luminance and chrominance components to exploit. The fact is that human eyes are less sensitive to chrominance variations. Psychophysical experiments indicate that perception of colors has three attributes: hue, saturation, and intensity [9] which is called HSI colour format; Where H stands for Hue i.e. Pure colour, S for saturation, i.e. the degree by which the pure colour is diluted using white light and I for intensity i.e. Gray level.

HSI color format will be used to identify skin region because it eliminates light intensity variation. The RGB to HSI color space conversion process is performed by using the equations given next.

$$H = \begin{cases} \theta & \text{if } B \leq G \\ 360^\circ - \theta & \text{otherwise} \end{cases} \quad (2)$$

Where,

$$\theta = \cos^{-1} \left\{ \frac{\frac{1}{2}[(R-G) + (R-B)]}{\sqrt{[(R-G)(R-G) + (R-B)(G-B)]}} \right\}$$

$$S = 1 - \frac{3}{(R+G+B)} [\min(R,G,B)] \quad (3)$$

$$I = \frac{1}{3}(R+G+B) \quad (4)$$

Human complexion chances person to person, Hue overcomes the light intensity variation but it is very difficult to define crisp set to identify the pure human skin colour from Hue value because Hue value of the skin changes from person to person.

To solve this problem fuzzy logic is used. In order to achieve a fuzzy membership [10, 11] function, a reference data set has been used. The advantage of this membership function is flexibility, i.e. by changing the reference data set or training set the response of the membership function (Equation 5) can easily be changed.

$$f(X) = \begin{cases} 0 & \text{if } X < \min(\text{DataSet}) \text{ or } \\ & X > \max(\text{DataSet}) \\ \sum_{i=1}^n Y_i \prod_{j=1, j \neq i}^n \frac{(X - X_j)}{(X_i - X_j)} & \text{otherwise} \end{cases} \quad (5)$$

where $f(X)$ is the response of the membership function, X is the input value, DataSet is the training set, n is the number of data in the DataSet, each element of the dataset is a pair of values (X_i , Y_i) where X_i stands for input and Y_i for corresponding output of the membership function.

After training is over the fuzzy membership function is ready to detect the “skin area” from Hue values of the skin; this is shown in Fig. 2.

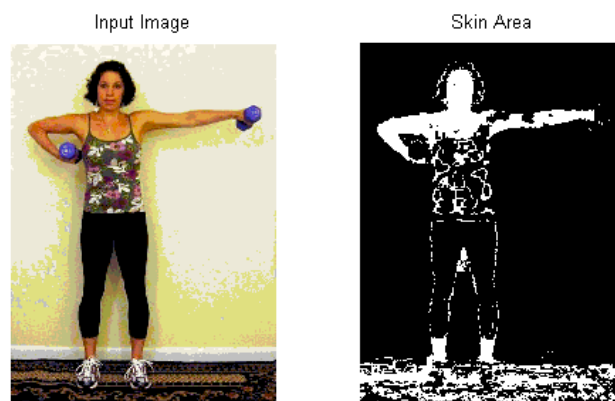


Fig. 2 Skin area have been detected for a particular input image

In Fig. 2 the “Skin Area” contains unnecessary points; these unnecessary points will be removed in the next step. It has been observed that the unwanted contours are small in size so by erosion^[12] these contours can be removed; this is shown in Fig. 3.

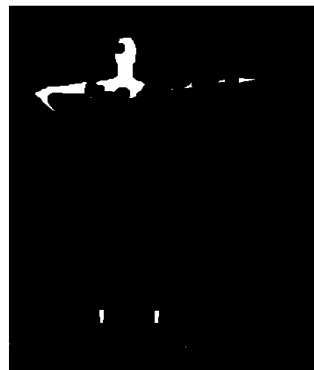


Fig. 3 Output image after applying erosion

After erosion unnecessary contours are eliminated because they are small in size. But valid contours are so mutilated because of erosion, that it is not possible to reconstruct the valid contours by dilation [13] after the erosion mentioned earlier. To overcome this problem a technique is used where the contours shown in Fig. 3 can be used as a seed points to filter out actual contours containing skin area from the binary image before erosion shown in Fig. 2. The next section demonstrates an algorithm to find out the valid skin region.

Algorithm 1: Find out the valid skin region contours.

Step 1: Apply label matrix technique in the binary image before applying erosion, and store the output matrix in LB variable. LB will have the same dimension as the binary image. The value ‘1’ in each contour in the binary image will be replaced by an integer number in the LB.

Step 2: count = maximum integer value stored in LB; so “count” will contain the number of contours in the input image.

Step 3: Seed Matrix is the binary image after applying erosion.

Step 4: index = 1

Step 5: Find the coordinates of the pixels of the LB where value of the pixel == index;

Step 6: local matrix is a binary image which has same dimension with Seed Matrix. Local matrix is filled with zero values except the coordinates which are selected in Step 5.

Step 7: Logically AND Seed Matrix with local matrix

if the result has at least one true value, the contour is valid and segments^[14] the contour for processing.

Else Not a valid contour

Step 8: index = index + 1;

Step 9: Repeat Step 5 to Step 8 until index > count

Step 10: Stop

After applying Algorithm 1 a binary image will be created in which skin area is denoted by Logical 1 and non skin area with 0, this is shown in Fig. 4.



Fig. 4 The actual skin area which have been filtered out

Fig. 5 shows a comparison between detection of skin regions before and after applying Algorithm 1; and the right side image shows unnecessary areas are being eliminated. Face area detection section provides the centre point of the face. Based on that point, a vertical split of the image, which contains actual skin area, has been made to identify the length of left and right arms. Before splitting the binary image has been dilated to eliminate patches. Fig. 6 shows the separation of left and right arm.



Fig. 5 Detection of skin regions before and after applying algorithm 1

Fig. 6 Separation of left and right arm

D. Face Detection

Eigenfaces [15] are used for face area detection because the eigenspace formulation leads to a powerful alternative to standard techniques such as template matching [16] or normalized correlation. The reconstruction error (or residual) of the

eigenspace decomposition is an effective indicator of similarity. The residual error is easily computed using the projection coefficients and the original signal energy. The detection is equivalent to matching with a linear combination of eigentemplates and allows for a greater range of distortions in the input image. A training set is used for the eigenvalue decomposition [17]. Fig. 7 shows the detected face.

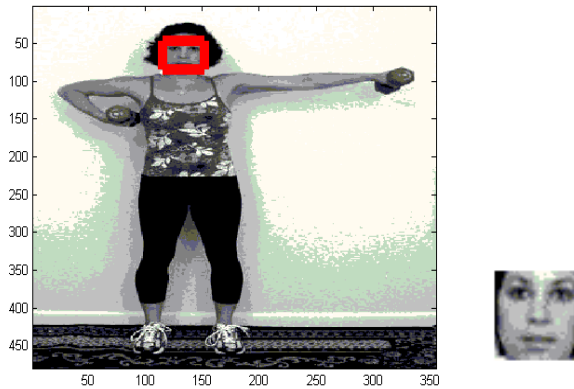


Fig. 7 Face area have been detected

E. Decision Making

The final step is decision making. Left and right hands have been detected early now the length of each hand has to be calculated. To do so find the farthest point in the detected left or right hand: calculate the column wise distance from face to farthest point. After that find the Euclidian distance [18] between face and farthest point if these two distances defer much then the conclusion is that the hand is parallel to the body and corresponding game controlling instruction is “neutral”. On the other hand if both hands are not parallel to the body then decision will depends on the maximum column wise distance. Algorithm 2 describes the decision making process.

The parallel port interface is used to communicate between decision making device and computer which is being used to play computer video game. However this parallel port will be replaced by USB and microcontroller combination in the next version.

Algorithm 2: Decision making.

- Step 1 Find out the farthest points of the left hand and right hand and store their coordinates in LP and RP respectively.
left_hand = false, right_hand = false, result = neutral
- Step 2 Store the column wise distance between LP and face centre into DLP, similarly RP and face centre into DRP.
- Step 3 Calculate Euclidian distance; ELP = Euclidian distance between LP and face centre; ERP = Euclidian distance between RP and face centre.
- Step 4 If absolute_value (DLP – ELP) > threshold then left hand is parallel to the body.
Else left_hand = true
- Step 5 If absolute_value (DRP – ERP) > threshold then right hand is parallel to the body.
Else right_hand = true
- Step 6 If left_hand == true and right_hand == false then
result = left.
- Step 7 If right_hand == true and left_hand == false then
result = right.
- Step 8 If right_hand == true and left_hand == true then
If DLP > DRP then
result = left.
Else
result = right.
- Step 9 Stop.

III. SIMULATIONS AND RESULTS

For simulation MatLab [19] is used. For the particular sensed image shown in Fig. 2 the result is correct. And it is shown in Fig. 8

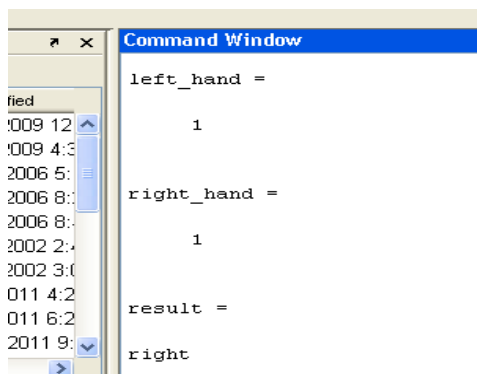


Fig. 8 Simulation result for the input image shown in Fig. 2

For another image the decision is correct. Fig. 9 shows the input image along with skin area. Fig. 10 shows the effect of Algorithm 1. Fig. 11 shows the separation of left and right arm based on the face detection shown in Fig. 12. The result is shown in Fig. 13. The system has been tested with 150 sample images out of which 144 give satisfactory results. So we can conclude the accuracy is 96%.

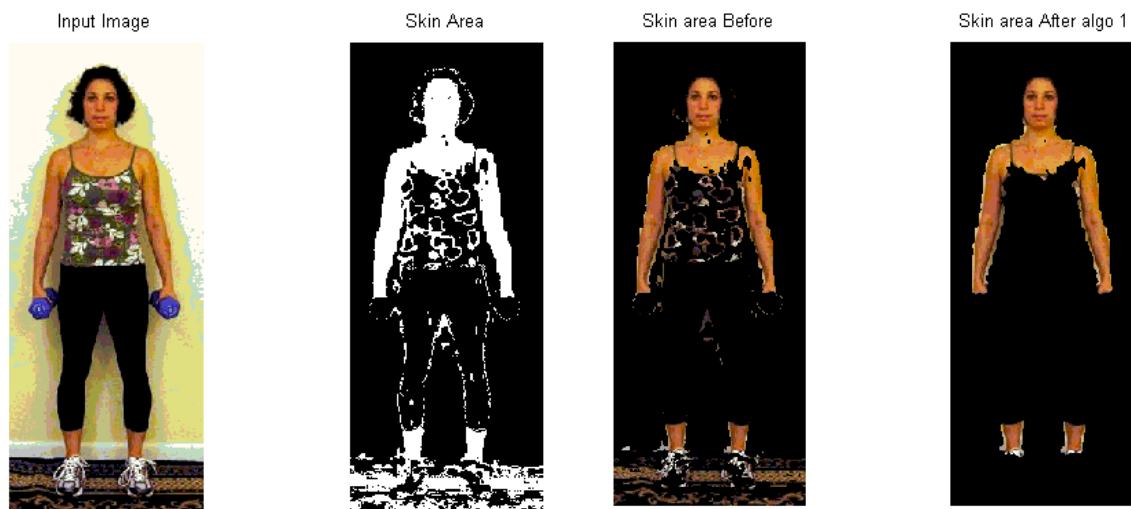


Fig. 9 Skin area have been detected for an input image

Fig. 10 Detection of skin regions before and after applying Algorithm 1

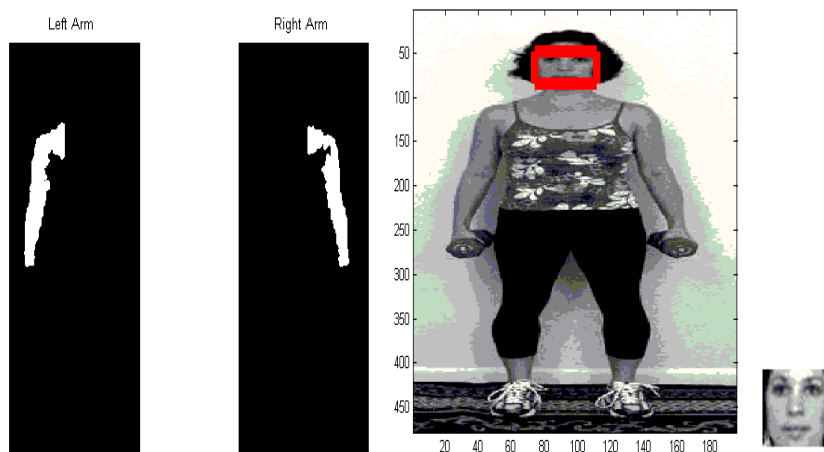


Fig. 11 Separation of left and right arm

Fig. 12 Face area have been detected

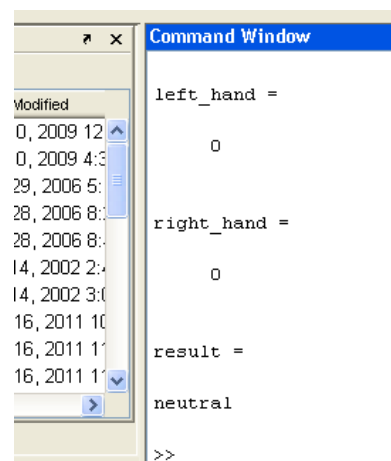


Fig. 13 Simulation result for the input image shown in Fig. 9

IV. CONCLUSIONS

This system is efficient and cheap. It is easy to install. It can reduce the probability of overweight or obesity, by introducing physical activity within computer game. However this approach provides 96% accuracy, although the entire system works on still images so computation time is large. Future plan of this work is to introduce video processing and relative computing to localize computing area and detecting acceleration that is vital in game controlling.

Sometimes it might be compared with Sony play station 3 [20] (ps3) but ps3 is costly and all computer games cannot be played in it. Moreover without Silicone Jackets [21] the motion cannot be detected in ps3. Silicone Jackets is a kind of wireless joystick. But this proposed system is free from such kind of limitations.

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