objects in source image [10]. Template matching finds all the points inside an image which match a template.
Suppose there is a template g[i, j] and wish to detect its instances in an image f[i,j]. An obvious thing to do is to place the template at a location in an image and to detect its presence at that point by comparing intensity values in the template with the corresponding values in the image. Since, it is rare that intensity values will match exactly, it require a measure of dissimilarity between the intensity values of the template and the corresponding values of the image. Several measures may be defined[12,13]

$$\max_{[i,j]\in R} |f - g| \quad (1)$$

$$\sum_{[i,j]\in R} |f - g| \quad (2)$$

$$\sum_{[i,j]\in R} (f - g)^2 \quad (3)$$

where *R* is the region of the template.

The sum of the squared errors is the most popular measure. In the case of template matching, this measure can be computed indirectly and computational cost can be reduced. It can simplify:

$$\sum_{[i,j]\in R} (f - g)^2 = \sum_{[i,j]\in R} f^2 + \sum_{[i,j]\in R} g^2 - 2\sum_{[i,j]\in R} fg \quad (4)$$

Now if it assume that f and *g* are fixed, then $\sum$ fg gives a measure of mismatch. A reasonable strategy for obtaining all locations and instances of the template is to shift the template and use the match measure at every point in the image. Thus, for an m * *n* template, then compute

$$M[i,j] = \sum_{k=1}^{m} \sum_{l=1}^{n} g[k,l]\, f[i+k, j+l] \quad (5)$$

where *k* and *l* are the displacements with respect to the template in the image. This operation is called cross correlation between f and g. Template matching approaches have been quite popular in optical computing: frequency domain characteristics of convolution are used to simplify the computation.

4. METHODOLOGY OF TEMPLATE MATCHING

4.1 CROSS-CORRELATION COEFFICIENT

Correlation is an important tool in image processing, pattern recognition, and other fields. The cross correlation coefficient [3,10,11] is defined as

$$\gamma(x,y)=\sum_{s}\sum_{t}\delta_{I(x+s,y+t)}\,\delta_{T(s,t)} \qquad (6)$$

where

$$\delta_{I(x+s,y+t)} = I(x+s,y+t) - \bar{I}(x,y)$$

$$\delta_{T(s,t)} = T(s,t) - \bar{T}$$

$s \in \{1,2,3,\text{---------},p\}$

$t \in \{1,2,3,\text{---------},q\}$

$x \in \{1,2,3,\text{---------},m-p+1\}$

$y \in \{1,2,3,\text{---------},n-q+1\}$

$$\bar{I}(x,y) = \frac{1}{pq}\sum_{s}\sum_{t} I(x+s,y+t)$$

$$\bar{T} = \frac{1}{pq}\sum_{s}\sum_{t} T(s,t)$$

The value of cross-correlation coefficient γ ranges from –1 to +1 corresponds to completely not matched and completely matched respectively. For template matching the template, *T* slides over *I* and γ is calculated for each coordinate *(x,y)*. After calculation, the point which exhibits maximum γ is referred to as the match point.

4.2 HUMAN BODY PARTS TEMPLATE MATCHING

A template is simply a smaller image. Typically template matching is only used in highly controlled environments. A template matching algorithm works by computing a fit score for each pixel in the image and then looking for local maximums. The tested images for various characteristic for sample real time image1,2 and 3 are given below. In image 1 the legs are folded. In image 2 hands are fully covered by the dress. In image 3 the left hand is inside the pocket. The below figure 3 shows the full image(a) and template image of face(b), left hand(c),right hand(d), left leg(e) and right leg(f) in image 1 . The figure 4 shows the template matching of Image 1.

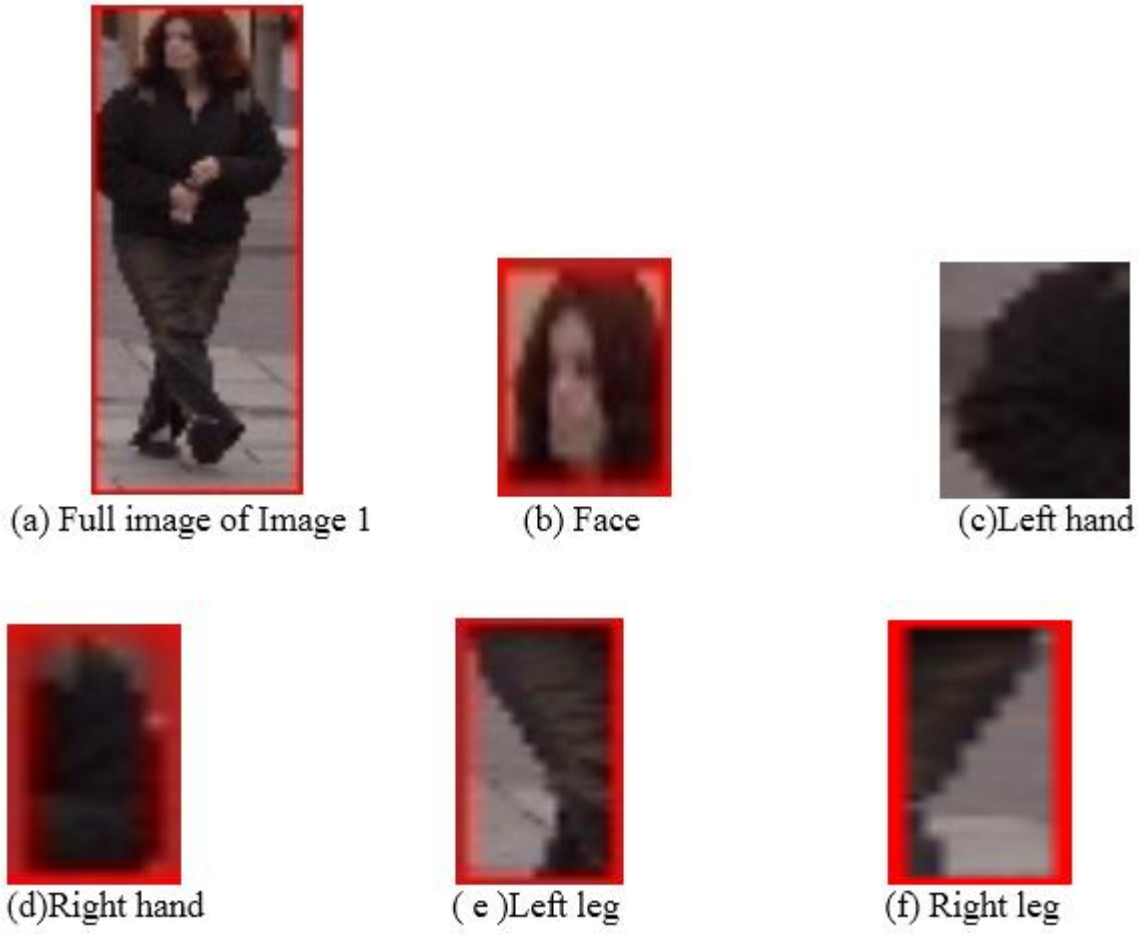
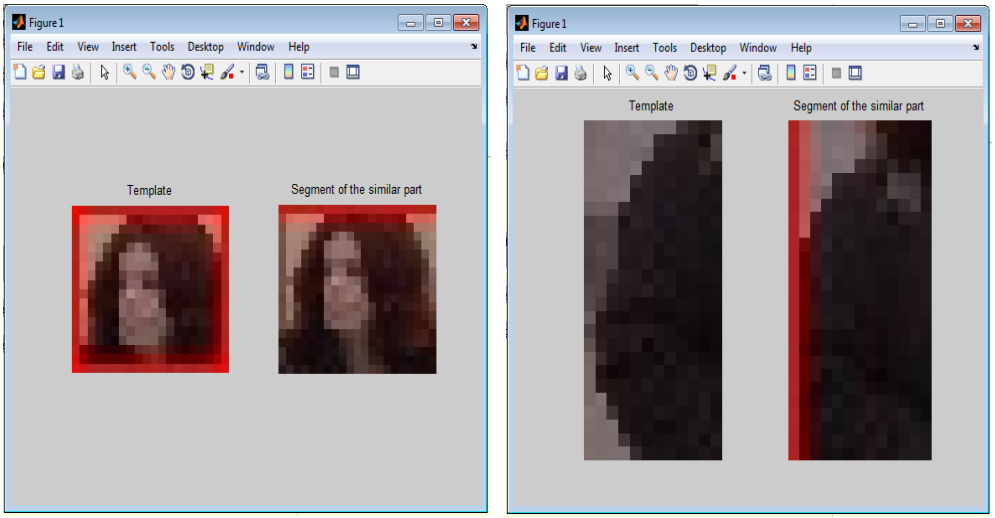
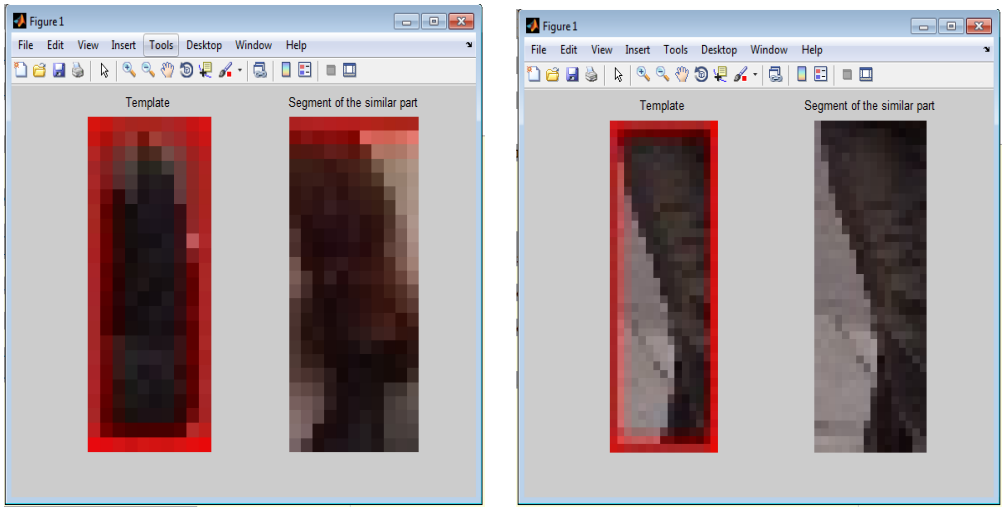


Figure 3. Template of Human Body Parts in Image 1



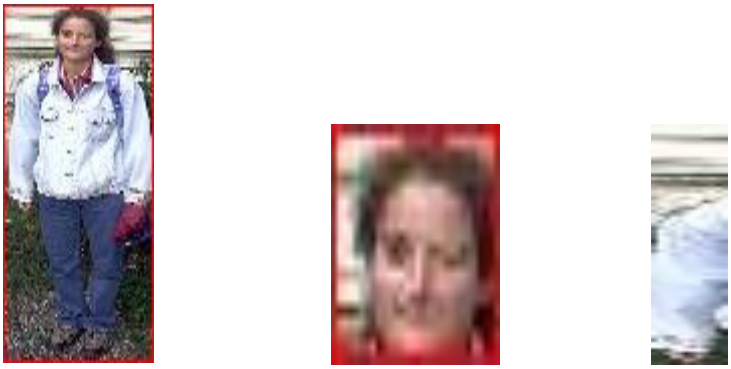
(a) Template matching of face (b) Template matching of left hand



(d) Template matching of right hand (f) Template matching of left leg

Figure 4. Template matching of Human Body Parts in Image 1

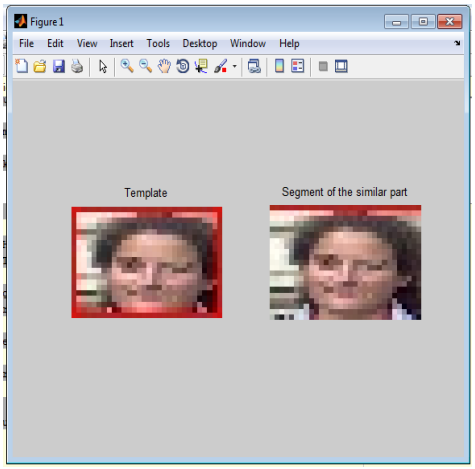
The below figure 5 shows the full image(a) and template image of face(b), left hand(c),right hand(d), left leg(e) and right leg(f) in image II . The figure 6 shows the template matching of Image 2.



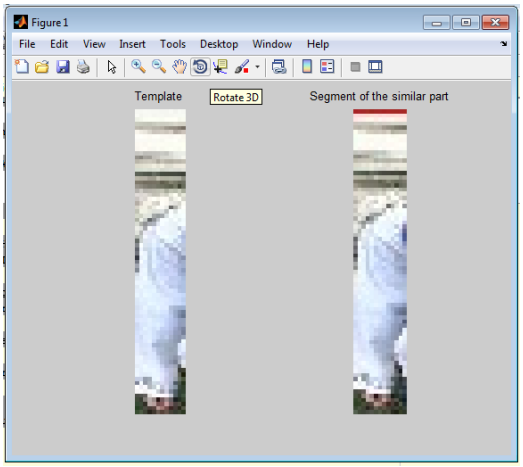
(a) Full image of Image 2 (b) Face (c)Left hand

(d)Right hand (e)Left leg (f) Right leg

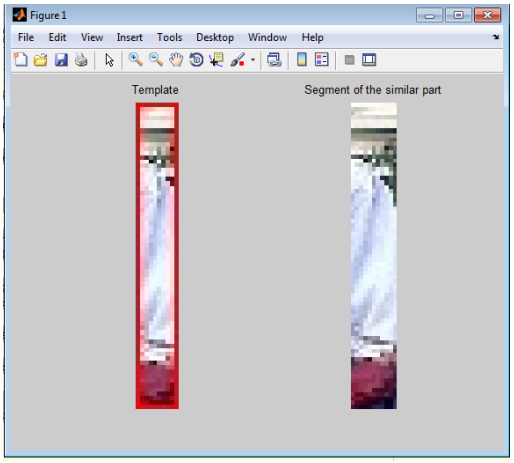
Figure 5. Template of Human Body Parts in Image 2



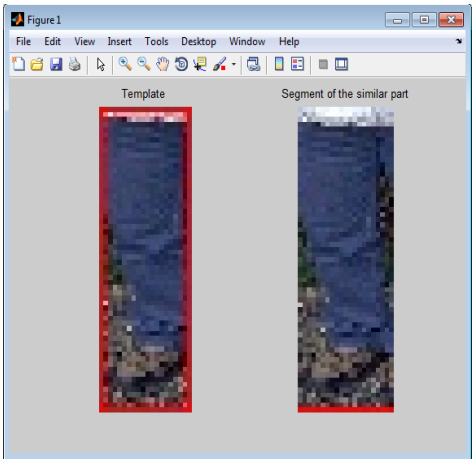
(a) Template matching of face



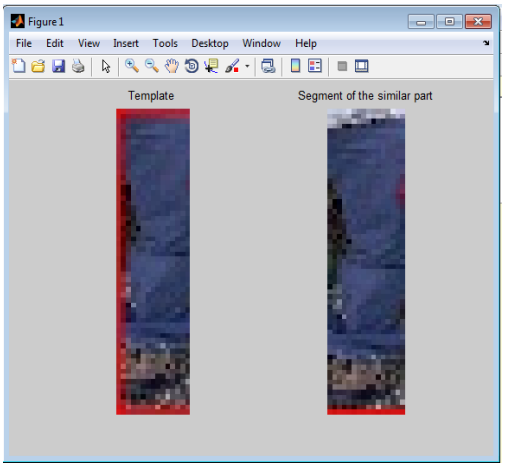
(b) Template matching of left hand



(d) Template matching of right hand



(f) Template matching of left leg



(g) Template matching of right leg

Figure 6. Template matching of Human Body Parts in Image 2

The below figure 7 shows the full image(a) and template image of face(b), left hand(c),right hand(d), left leg(e) and right leg(f) in image 3 . The figure 8 shows the template matching of Image 3.

(a) Full image of Image 3

(b) Face

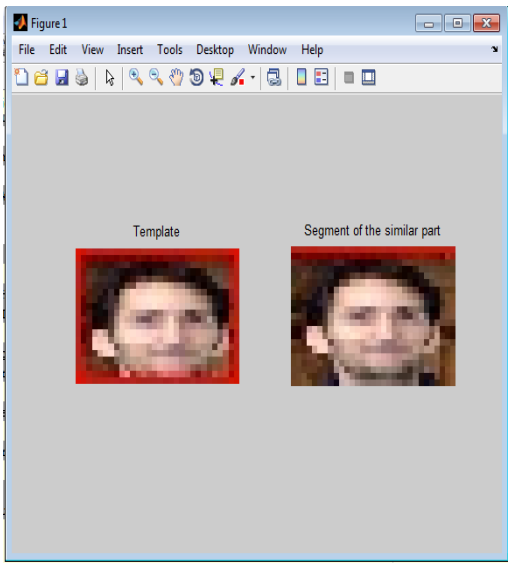
(c)Left hand

(d)Right hand

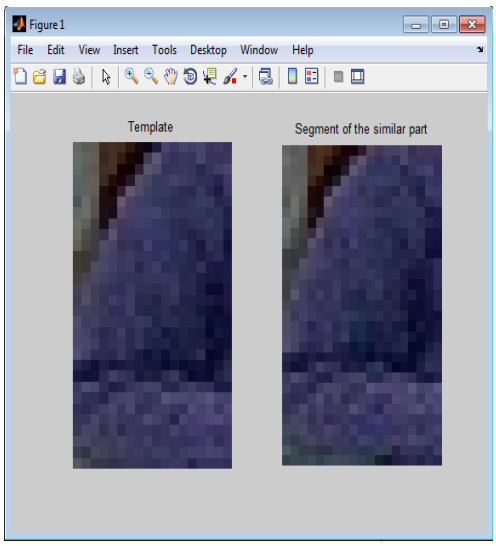
(e)Left leg

(f) Right leg

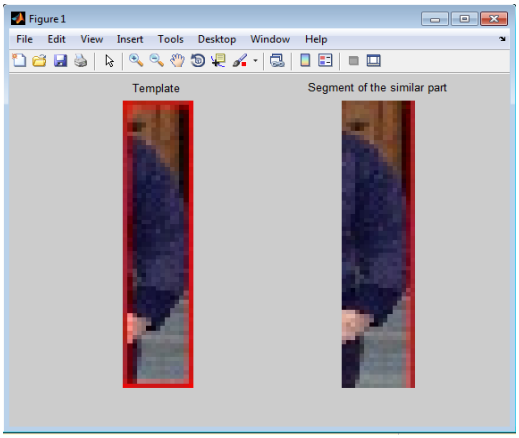
Figure 7. Template of Human Body Parts in Image 3



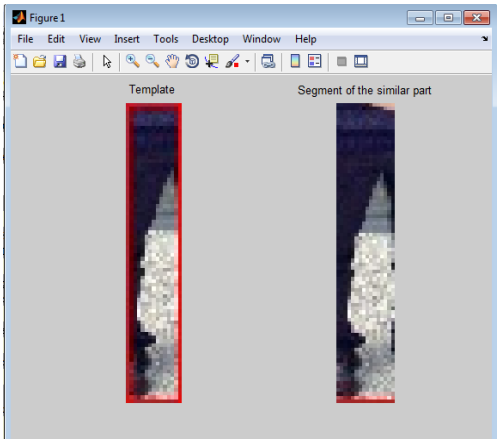
(b) Template matching of face



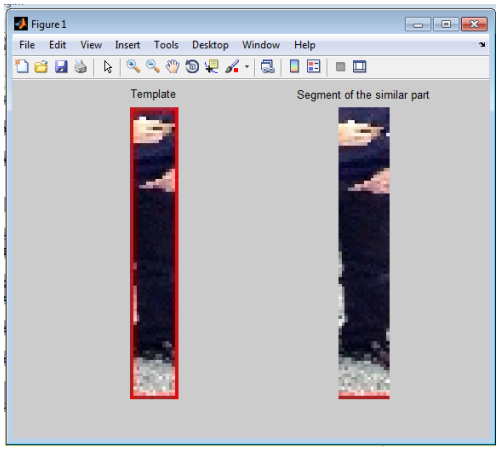
(b) Template matching of left hand



(d) Template matching of right hand



(f) Template matching of left leg



(g) Template matching of right leg

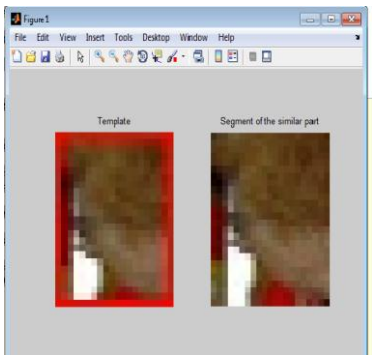
Figure 8. Template matching of Human Body Parts in Image 3

The following figure 9 shows the original image (a), orientation of the original image (b) at 45 degree (c) at 180 degree and the proposed algorithm using template matching technique the resulting figure (d) and (e) for extraction of human face. This shows that the proposed algorithm is rotation invariant.

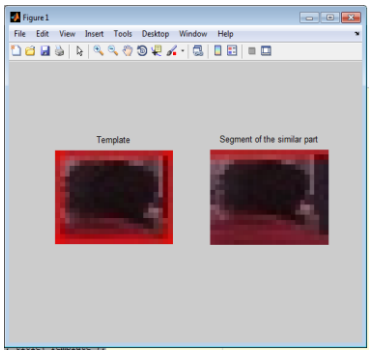
(a) Normal image

(b)Orientation at 45 degree

(c)Orientation at 180 degree



(d)Template matching for face detection at 45 degree orientation



(e) Template matching for face detection at 180 degree orientation

Figure 9. Different views of a human and Template matching

5. RESULTS AND CONCLUSION

The cross-correlation coefficient algorithm is applied for solving object recognition problem. In this research work the performance has been studied for number of human images with templates. The work was tested on a sample of twenty images from the database of 200 images for each and every parts of human body. Table 1 summarizes the time taken for the various human body parts recognition. The average time taken for the twenty samples are listed in Table 2. Correlation based algorithms are tested on three real time images, and it is found that in these algorithm the time taken for finding the position of face object is high in images (refer Figure 4,6 and 8).

The proposed algorithm successfully employed the cross-correlation method to solve the object recognition problem. The simple template matching algorithm presented here has achieved promising results of recognition rates and the time taken for each recognition around 0.07seconds to 0.09 seconds. The maximum cross-correlation coefficient value indicate the perfect matching of extracted object with the target image. The system successfully recognized the various objects at different altitudes and orientation.

Table 1: Time taken for object recognition

Human Object	**Time taken in seconds**		
	Image I	**Image II**	**Image III**
Face	0.123881	0.098145	0.087265
Left Hand	0.076225	0.079536	0.078127
Right Hand	0.078784	0.078630	0.078783
Left Leg	0.079029	0.078534	0.080135
Right Leg	0.078334	0.082170	0.081750

Table 2: Average time taken for object recognition

Human Object	**Time taken in seconds**
Face	0.091198
Left Hand	0.077942
Right Hand	0.078733
Left Leg	0.079441
Right Leg	0.080369

Figure 10 shows the variation in recognition time for a range of different values of human body parts because the templates of human body parts is various size and various illuminations. The result of table 1 is shown graphically using bar chart in figure 10.

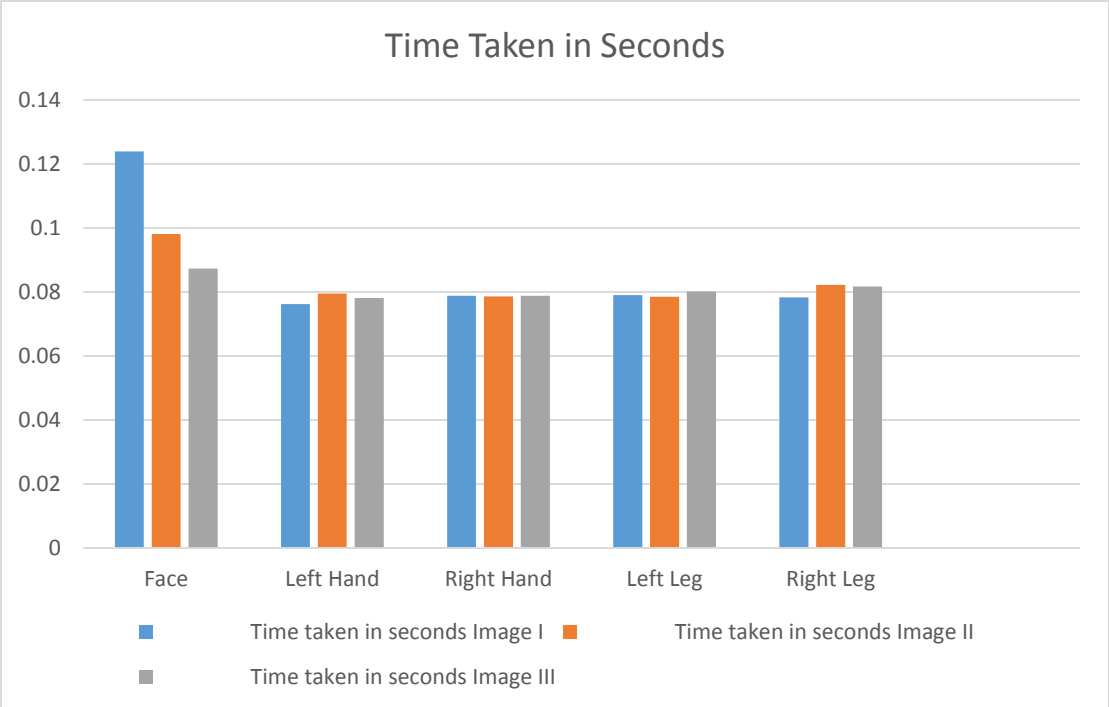


Figure 10. Plot of the Human body parts

The cross correlation algorithm could be extended for multiple target, multiple template recognition with reasonable computational time. The other methods of object recognition like normal correlation coefficient can be attempted in future.

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