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Concealed Weapon Detection in a Human Body by Infrared Imaging

Mahadevi Parande[1], Shridevi Soma[2]

[1]M.Tech, Department of Computer Science &Engineering,
Poojya Doddappa Appa College of Engineering & Technology, Gulbarga, Karnataka, India

[2]Associate Professor, Department of Computer Science & Engineering
Poojya Doddappa Appa College of Engineering & Technology, Gulbarga, Karnataka, India

Abstract: ***The detection of weapon concealed underneath a person's cloths is very much important for the security of the public as well as the safety of public assets like airports, buildings, and railway stations etc. The goal is to develop an automatic detection and recognition system of concealed weapons using sensor technologies and image processing. The goal of this paper is to present the Concealed Weapon Detection method by infrared imaging (IR). Normal image is the human perception vision, whereas the IR image produces the information about concealed weapon. Fusion of normal and IR image gives the relevant information of these two images. Segmentation is applied for fused image using Adaptive K-means clustering to clearly distinguish the concealed weapon from the surrounding. The detected Concealed Weapon will be fit into the bounding box.***

Keywords: Pre-processing, Image fusion, DWT, Segmentation, Infrared imaging.

1. Introduction

In the current work, the interest is to use image fusion to help a human or computer in detecting a concealed weapon using IR and visual sensors. Infrared images are depends on the temperature distribution information of the target to form an image. Usually the theory follows here is that the infrared radiation emitted by the human body is absorbed by clothing and then re-emitted by it. In the IR image the background is almost black with little detail because of the high thermal emissivity of body. The weapon is darker than the surrounding body due to a temperature difference between it and the body (it is colder than human body). One example is given in Figure 1. Figure 1(a) shows the color visual image and (b) shows the corresponding IR image.

(a) Normal image (b) Infrared image
Figure 1: Input images

The visual image is a mental image that is similar to a visual perception. The resolution in the visual image is much higher than that of the IR image. It is nothing but a RGB image that supports human visual perception. But there is no useful information on the concealed weapon in the visual image. The IR image produces the information about concealed weapon, so fusion of both visual and infrared images gives the efficient result for concealed weapon detection.

2. Organization

The organization of this paper is as follows. Section 2 presents a review of the existing image fusion and concealed weapon detection techniques. Proposed methodology is discussed in section 3. Section 4 briefs the result and analysis and, the concluding remarks are in section 5.

3. Related Work

Imaging techniques based on a combination of sensor technologies and processing will potentially play a key role in addressing the concealed object (such as handgun) detection problem. Detection of concealed weapon using terahertz imaging, Mili-Meter Wave (MMW) [1][2], has been developed. Also, detection systems go hand in hand with subsequent response by the operator, and system development should take into account the overall context of deployment. Concealed Weapon using the radar image [7] is proposed by Yu-Wen Chang et.all in which drawbacks such as glints and specular reflection or artifacts such as coherent interference these problems should be able to be overcome. Thi Thi Zin et.al [5] proposed Fusion of Infrared and Visible Images for Robust Person Detection. They presented person detection methods in FIR images and outlined image fusion approach for person detection. Seong g. Kong, and Knoxville [6] discussed "Multi-scale Fusion of Visible and Thermal IR Images for Illumination-Invariant Face Recognition": They described a new software-based registration and fusion of visible and thermal infrared (IR) image data for face recognition in challenging operating environments that involve illumination variations. Concealed weapon detection using Fusion of IR and visual images presented by the proposed method.

4. Proposed Method

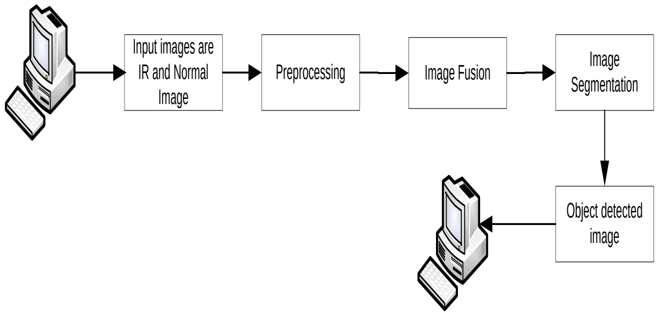


Figure 4.1: System Architecture of proposed method

The normal color image and Infra-red images are taken as input and, these images are preprocessed for the fusion process. The preprocessing methods are Resizing and, Color conversion. The preprocessed images have been fused by using Discrete Wavelet Transform (DWT) method. The fused image is segmented using Adaptive K-means clustering method. The concealed weapon can be fit into the rectangle bounding box for final output.

Algorithm for proposed method:

Input: Normal and Infra-Red images.
Output: Image with hidden object.
Method: Discrete Wavelet Transform and Adaptive K-mean clustering method.
Step1: Start
Step 2: Input a Visual color image, and an Infrared (IR) Image.

Step 3: Pre-processing of input images (Resizing and, Color conversion).

Step 4: Fusion of Visual and, Infra-red images by using Discrete Wavelet Transform (DWT).

Step 5: Apply segmentation on fused image using Adaptive K-mean clustering method.

Step 6: The concealed weapon is detected by calculating the threshold value .

Step 7: End

4.1 Input image

Two types of images have been considered for concealed weapon detection application. Normal RGB and, Infrared Image. Normal images are taken through normal sensor, whereas the infrared image is taken through low cost infrared sensor.

4.2 Preprocessing

Image pre-processing techniques are necessary, in order to remove the noise and to enhance the quality of the image for better recognition accuracy. Before any image-processing algorithm can be applied on image, preprocessing steps are very important in order to limit the search for abnormalities. The main objective of this process is to improve the quality of the image to make it ready for further processing by removing the unrelated and surplus parts in the back ground of the image. For the proposed work the preprocessing method used is image resizing.

4.2.1 Resizing

Since the two input images are taken from two different image sensing devices so they are of different size. So we first resize these two images because the image fusion and other operations are not possible if the sizes are not same. The images are resized to 256 X 256 using bilinear interpolation method.

4.2.2 Color conversion

We have converted image from RGB to gray scale for making the computation easier. rgb2gray (RGB) converts the true color image RGB to the grayscale intensity image I. this will reduces the pixel value from 512 to 256. Besides the gray scale, the LAB color space is also used. LAB color space is a uniform color space defined by the CIE (International Commission on Illumination). A color is defined in the LAB space by the brightness *L*, the red-green chrominance *A*, and the yellow-blue chrominance *B*. This color space is used for clustering process.

4.3 Image Fusion (Discrete Wavelet Transform)

Image fusion process combines relevant information of two images and then generates the output into a single relevant image. The resulting image will be more informative than any of the input images. We have used the Discrete Wavelet Transform method for fusing the input images

The DWT based method is one of many possible multi-scale-decomposition-based (MDB) fusion methods. It consists of three main steps. First, each source image is decomposed into a multi-scale representation using the DWT transform. Then a composite multi-scale representation is constructed from the source representations and a fusion rule. Finally the fused image is obtained by taking an inverse DWT transform of the composite multi-scale representation.

The input images, I_v (normal visual image) and I_{IR} (Infrared image) are decomposed into *K* (*k* =1, 2... *K*) Levels using DWT. The resultant approximation and detail coefficients from I_V are

$$I_v \rightarrow \{V_{A_K,}\{V_{H_k,}V_{V_k,}V_{D_k}\}_{\,k=1,2...K}\} \qquad ...... (1)$$

Similarly fromI_{IR}, the resultant decomposed coefficients are

$$I_{IR} \rightarrow \{IR_{A_K,}\{IR_{H_k,}IR_{V_k,}IR_{D_k}\}_{\,k=1,2...K}\} \qquad ...... (2)$$

From decomposition level 1 to k-1 we have selected the larger absolute value of the two DWT detail coefficients, because the detail coefficients corresponds to sharper brightness changes in the images such as edges, object boundaries etc. These coefficients are fluctuating around zero. This helps to differentiate between concealed object and the surrounding region. At the last level (*k* =*K*) the average of the DWT approximation coefficients are taken, since the approximation coefficients at last level are the smoothed (low passed) version of the original image. The fused image I_{V_IR} can be obtained using:

$$I_{V\_IR} \rightarrow \{f_{A_K,}\{f_{H_k,}f_{V_k,}f_{D_k}\}_{k=1,2\ldots K}\} \;\ldots\ldots (3)$$

Where $f_{A_K} = \frac{V_{A_K} + IR_{A_K}}{2}$

$$f_{H_k} = \begin{cases} V_{H_k} & |V_{H_k}| \ge |IR_{H_k}| \\ IR_{H_k} & |V_{H_k}| < |IR_{H_k}| \end{cases}, k = 1,2 \ldots., K \;\ldots (4)$$

$$f_{V_k} = \begin{cases} V_{V_k} & |V_{V_k}| \ge |IR_{V_k}| \\ IR_{V_k} & |V_{V_k}| < |IR_{V_k}| \end{cases}, k = 1,2 \ldots., K \;\ldots (5)$$

$$f_{D_k} = \begin{cases} V_{D_k} & |V_{D_k}| \ge |IR_{D_k}| \\ IR_{D_k} & |V_{D_k}| < |IR_{D_k}| \end{cases}, k = 1,2 \ldots., K \;\ldots (6)$$

The fused image contains the detail information about both the background and the concealed weapon.

4.4 Segmentation

In computer vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). In the similar way for partitioning the image we take up Adaptive K-means segmentation method, that clearly divides image into three clusters. The output of this method is the three segmented images containing the clusters for concealed weapon, background and human body respectively.

4.4.1 Algorithm for Segmentation using Adaptive K-Means Clustering:

Input: Image to be clustered
Output: Labeled Clustered Image
Step 1: Start
Step 2: Divide the original image into sub-images in order to produce a local intensity value for each sub-image.
Step 3: Convert each sub-image into LAB color format to allow easy separation.
Step 4: Apply the segmentation process using K-means method.
Step 5: Repeat the step4 for images which are wrongly classified.
Step 6: Merge the all segmented sub-image to produce a complete segmented image.
Step 7: End

The fused image is divided into three sub-images, and then converted into LAB format. For each sub-images the K-mean method is been used. Set of observations as (x1, x2… x*n*), where each observation is a *d*-dimensional real vector, initializing the seed point, clustering partition the *n* observations into *k* sets ($k < n$) S = {*S*1, *S*2… *Sk*} so as to minimize the within-cluster sum of squares (WCSS):

$$arg_S min \sum_{i=1}^{K} h \sum_{x_j \in S_i} \|X_j - \mu_i\| 2 \qquad \ldots. (7)$$

Where μ_i is the mean of points in S_i

Assign each observation to the cluster with the closest mean by

$$S_i^{(t)} = \left\{x_j : \|X_j - m_i^{(t)}\|| \le \|X_j - m_i^{(t)} *\| \right\} \qquad \ldots. (8)$$

Calculate the new means to be the centroid of the observations in the cluster.

$$m_i^{(t+1)} = \frac{1}{|S_i^{(t)}|} \sum_{x_j \in S_i^{(t)}} X_j \qquad \ldots (9)$$

The segmented image1 contains the cluster for hidden object; segmented image2 contains the cluster for background, and segmented image3 contains the cluster for the person.

4.5 Object Detection

Concealed weapon can be detected by the following method. First step is Object extraction which is an important step towards automatic recognition of a weapon, regardless of whether or not the image fusion step is involved. It has been successfully used to extract the gun shape from the fused IR and normal images. This could not be achieved using the original images alone. Object extraction computes multiple important thresholds of the image data in the automatic threshold computation (ATC) stage for Regions with distinguishable intensity levels, and Regions with close intensity levels. Regions with distinguishable intensity levels have multi modal histograms, where as regions with close intensity levels have overlapping histograms. The thresholds from both cases are fused to form the set of important Thresholds in the scene. At the output of the ATC stage, the scene is quantized for each threshold Value to obtain data above and below.

4.5.1 Feature extraction

A geometric feature is composed of several shape descriptors which are the object size, the major or minor-axis lengths, and the major and minor principal components, and size of each quadrant.

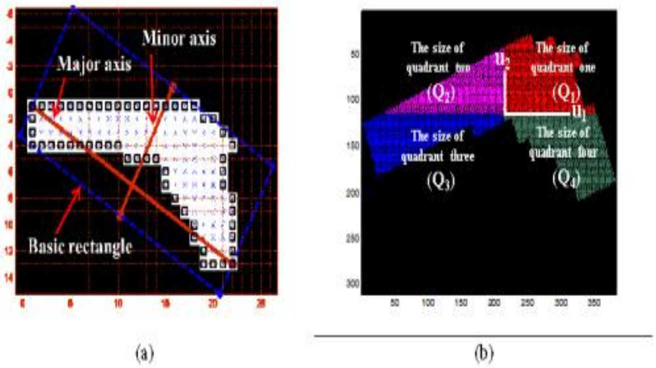


Figure 4.5.1 Geometric feature descriptors, (a) size number of pixels, lengths of major and minor axis, and the perimeter (number of boundary pixels), (b) size of each quadrant.

Fig.4.5.1 Shows the shape descriptors. The perimeter (*T*) of the concealed object is marked with „□“ in Fig.4.5.1. The area (*A*) is calculated as the total number of pixels marked by „×“ in Fig.4.5.1. The major (*w*) and minor (*h*) axis are the longer and the shorter side of a basic rectangle, respectively. The proposed feature is composed of several descriptors as listed below.

4.5.2 Shape feature

Based on the shape of the weapon the local features are extracted and mean value for that features are calculated:

a) Area: It is defined as actual number of pixels in the region. $F1 = \sum_{i=1}^{N} Area_i$ / N …. (10)
b) Perimeter: It is defined as the distance around the boundary of the region. $F2 = \sum_{i=1}^{N} Perimeter_i$ / N …. (11)
c) Major Axis: It is defined as the length of the major axis of the ellipse that has same normalized second central moments as the region. $F3 = \sum_{i=1}^{N} Majoraxis_i$ / N …. (12)
d) Minor Axis: it is defined as the length of the minor axis of the ellipse that has same normalized second central moments as the region. $F4 = \sum_{i=1}^{N} Minoraxis_i$ / N …. (13)

Where N is the number of connected components

A connected component in a binary image is a set of pixels that form a connected group. For example, the binary image below has three connected components. Connected component labeling is the process of identifying the connected components in an image and assigning each one a unique label as shown in the Fig4.5.2 (a).

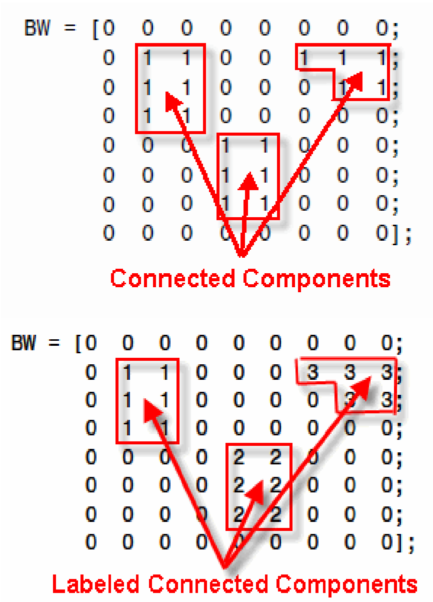


Figure 4.5.2 (a): Connected components and Labeled connected Components

The pixels labeled 0 are the background pixels and the pixels labeled 1 are the foreground pixels. In the Fig 5 the pixels labeled 1 is the first object, the pixels labeled 2 is the second object and so on.

The concealed weapon in the image can be show by bounding box around the object. The intensity distribution of the weapon is darker than the surrounding region. The Low and High threshold value for the area, height, width of the weapon are set based on the shape features. The noise removal is used to remove any white pixels that surround the weapon border. Finally the weapon is been fit into the bounding box. The rectangle bounding box used is shown in Fig4.5.2 (b).

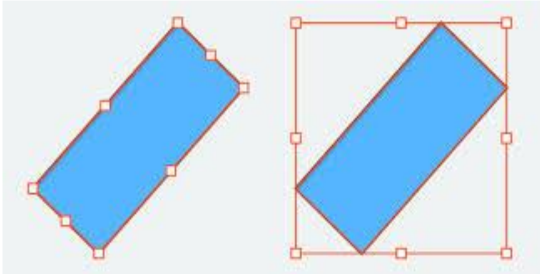
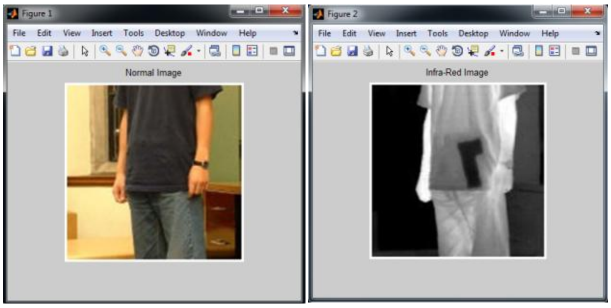


Figure 4.5.2 (b): Rectangle bounding box

5. Result and Analysis

We have considered two types of input images for concealed weapon detection in human body. Input image1 is Normal visual image and Input image2 is Infra-red image of input image1. Fig5.1 shows the source images. The images are resized to 256 X 256 using bilinear interpolation method. Resized images are fused using Discrete Wavelet Transform method. The output image contains the information for concealed weapon and the background. By segmentation using adaptive k-means clustering, we got three clustered images, in which cluster1 represents concealed weapon, cluster2 is background, and cluster3 is person respectively. The rectangle bounding box is been used to fit the concealed weapon for the final output. Two cases have been considered for the detection application of concealed weapon. Case1: human with tight clothing and, case2: human with loose clothing. Fig5.1-fig5.5 shows the results for case1. The fig5.1 (a)-fig5.5 (a) represents the results for case2. The low cost infrared images show the image about concealed object when clothing is tight enough. For loose clothing the emitted infrared radiation will be spread over a larger clothing area, thus decreasing the ability to image a weapon. This can be shown in Fig5.5 (a), in which you can see only half part of the weapon is visible.



Input image 1 Input image 2

Figure 5.1: Source Images

The source images are fused using the Discrete Wavelet Transform method. Fig5.2. Shows the Fused Image.

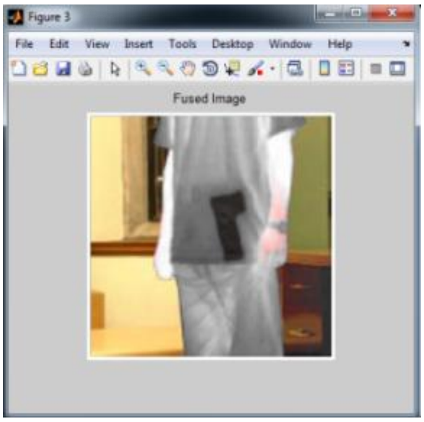


Figure 5.2: Fused image

Histogram of the fused image presents the intensity distribution of the image. Intensity distribution of the weapon is darker than the surrounding region, which helps for the threshold value computation. Fig5.3 shows the histogram of the fused image.

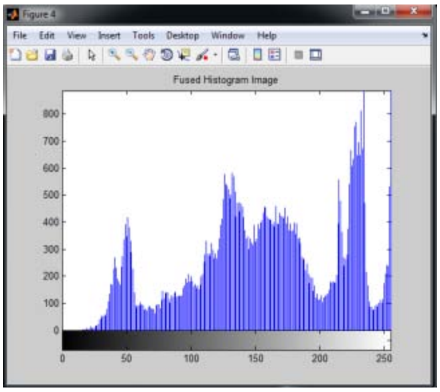
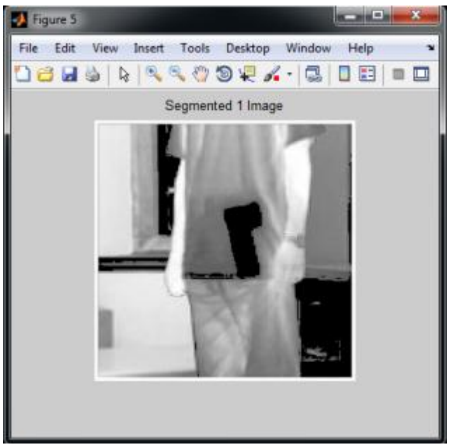
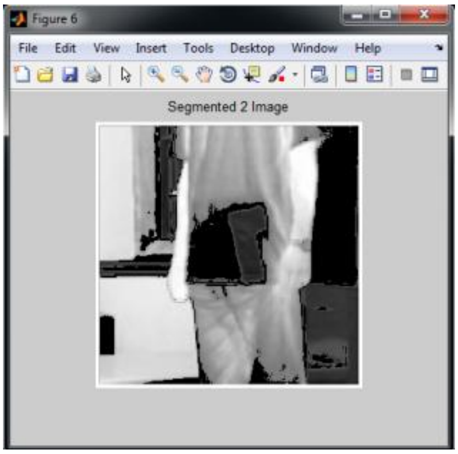


Figure 5.3: Histogram of the fused image

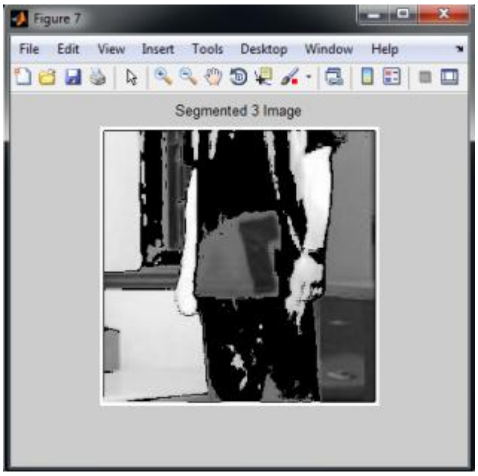
The Adaptive K-mean clustering method divides the whole image into three labeled clusters such as clusters. The cluster 1 represents the concealed weapon, the cluster 2 shows the background and the cluster 3 shows the person. The fig5.4.(a),(b),(c) show Clusters for three Segmented Images. The black shade shows the segmented region.



(a) Cluster for Concealed weapon



(b)Cluster for Background



(c)Cluster for human

Figure 5.4. (a), (b), (c): Clusters for three Segmented Images

The fig5.5 shows the Concealed weapon fit into the rectangle bounding box.

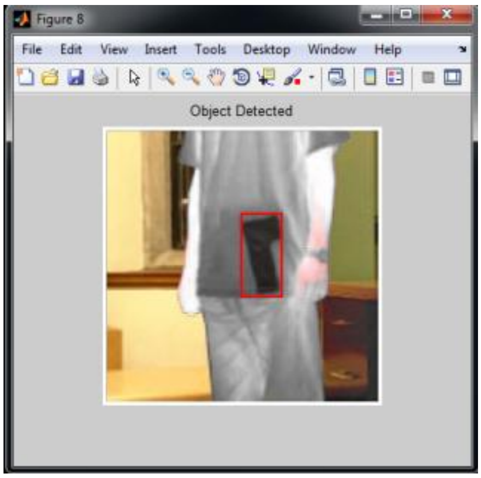


Figure 5.5: Concealed weapon fit into the rectangle bounding box.

Similarly the method is applied for case2 and following are the results.

Input image 1 Input image 2

Figure 5.1 (a) Source Images

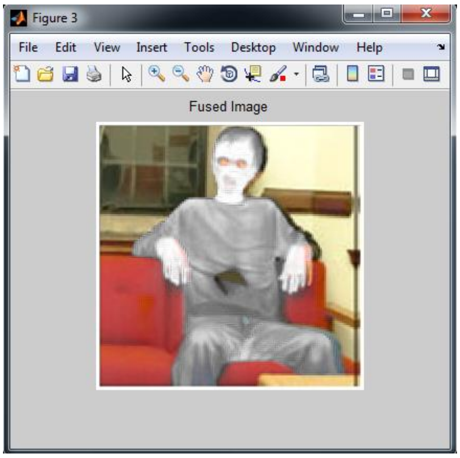


Figure 5.2 (a): Fused image

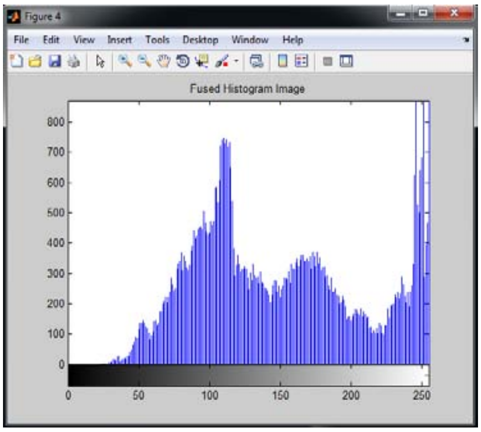
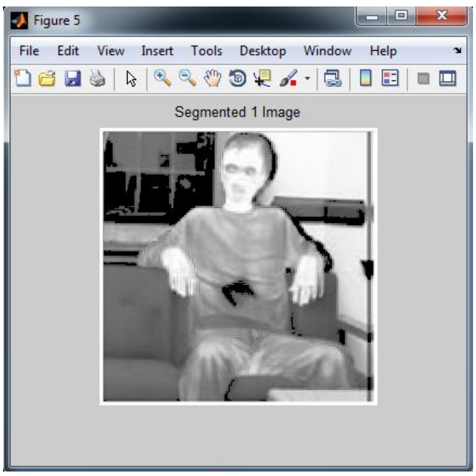
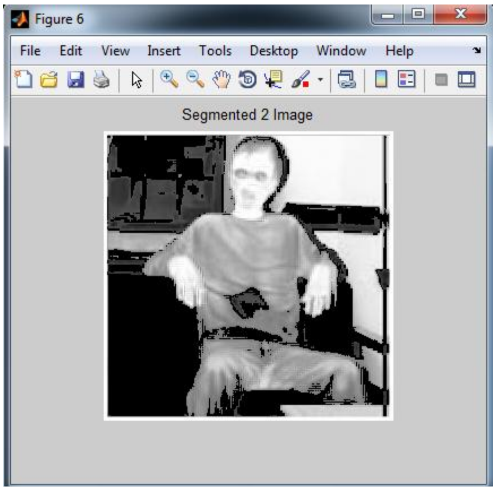


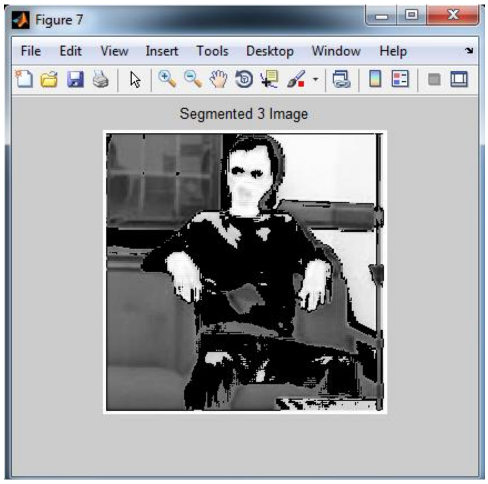
Figure 5.3 (a): Histogram of the fused image



(a) Cluster for Concealed weapon



(b)Cluster for Background



(c)Cluster for human

Figure 5.4 (a). (a), (b), (c). Clusters for three Segmented Images

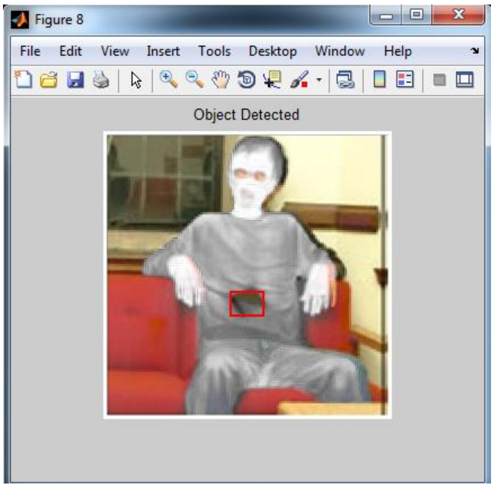


Figure 5.5(a): Concealed weapon fit into the rectangle bounding box.

6. Conclusion and Future Work

The source images are preprocessed by appropriate methods. The preprocessed images have been fused by using Discrete Wavelet Transform (DWT) method. The fused image is segmented using Adaptive K-means clustering method. The concealed weapon can be fit into the rectangle bounding box for final output. We have demonstrated the proposed method for two cases, and got the results.

The proposed method can able to detect the weapon concealed under person‟s clothes. But the low cost infrared images show the image about concealed object when clothing is tight enough. For loose clothing the emitted infrared radiation will be spread over a larger clothing area, thus decreasing the ability to image a weapon. This is the future work to be considered.

References

[1] Sheeja Agustin. A1et.al, "Image Segmentation of Concealed Objects Detected by terahertz imaging" shbin_das@yahoo.com 2010 IEEE International Conference on Computational Intelligence and Computing Research ISBN: 97881 8371 362 7
[2] Yu-Wen Chang, Michael Johnson "Portable Concealed Weapon Detection Using Millimeter Wave FMCW Radar Imaging" 189918: August 30, 2001 1998-DT-CX-K001
[3] Sudipta Roy [1] and [2] Prof. Samir K. Bandyopadhyay "Contour Detection of Human Knee" IJCSET |September 2011 | Vol 1, Issue 8, 484-487
[4] Hui Xia "An Improved Adaptive Fusion Image Windows Based Technology", International Journal of Information and Education Technology, Vol. 3, No. 2, April 2013
[5] Thi Thi Zin, Hideya Takahashi, Takashi Toriu and Hiromitsu Hama "Fusion of Infrared and Visible Images for Robust Person Detection", Graduate School of Engineering, Osaka City University, Osaka 558-8585 Japan
[6] Seong g. Kong,"Multiscale Fusion of Visible and Thermal IR Images for Illumination-Invariant Face Recognition", the University of Tennessee, and Knoxville, TN 37996-2100 First online version published in June, 2006
[7] Dr. Mohamed Mansoor Roomi et.al, "Detection of Concealed WeaponS in x-ray images using fuzzy k-nn" International Journal of Computer Science, Engineering and Information Technology (IJCSEIT), Vol.2, No.2, April 2012
[8] Tapas Kanungo, et.al, "An Efficient k-Means Clustering Algorith", IEEE transactions on pattern analysis and machine intelligence, vol. 24, no. 7, july 2002
[9] Swathy Nair et.al, "Pixel Level Image Fusion using Fuzzy let Fusion Algorithm", an ISO 3297: 2007 Certified Organization, Vol. 2, Special Issue1, and Dec, 2013
[10] Image source: rblum@eecs.lehigh.edu