Identification of Concealed Weapon Detection in a Human Body Using Infrared Images

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بسم الله الرحمن الرحيم

In the name of ALLAH,the most Beneficent, the Merciful

ABSTRACT

Concealed weapon detection (CWD) is a gradually more important topic in the general area of law enforcement and it appears to be a critical technology for dealing with terrorism, which appears to be the most considerable law enforcement problem for the next decade. This syndicate will endeavor a method to detect concealed weapon by using digital image processing techniques. The project is divided in to two parts i.e. image processing and video processing. Image processing is based on 5 keys steps that will take original RGB images and IR (infrared) images as an input which will be preprocessed. After preprocessing features are extracted to get the binary images of concealed weapons and their edges are detected to get the shape of weapons. For video processing first IR video will make converted in to frames and discrete wavelet transform is applied on frames and finally sobel filter for edge detection and homomorphic filter for increasing contrast of a canceled weapon. Experimental results will be evaluated on bases of two parameters i.e. visual inspection and computational cost.

DECLARATION

We hereby declare that we have developed this project entirely on the basis of our personal efforts under the sincere guidance of our supervisor Dr.AdilMasood. All of the sources used in this project have been cited and contents of this project have not been plagiarized. No portion of the work presented in this project has been submitted in support of any application for any other degree of qualification to this or any other university or institute of learning.

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Dedicated to our Parents and Teachers

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List of Abbreviations

1. CWD (Concealed Weapon Detection)
2. RGB (Red,Green,Blue)
3. IR (Infrared)
4. HSV (Hue, Saturation, Volume)
5. DWT (DiscreteWaveletTransform)
6. DWFT (DiscreteWavelet Fourier Transform)

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Detection of hidden weapons are a most important topic in the general area of law enforcement and it appears to be a critical technology for dealing with terrorism, which appears to be the most considerable law enforcement problem for the next decade. Terrorism rate has been increased so rapidly during last few years, which make causalities and injuries too. So it is very significant problem and needs an effective solution. By providing effective solution to this problem will strong the security system as well as to provides safety for public assets like airports, buildings, institutions and railway stations etc.The dramatic increase in shootings and blasting at public places brought the use of weapons detection systems to the forefront. Their acceptance and use varied significantly. A weapon is any object that can do harm to another individual or group of individuals. This definition not only includes objects typically thought of as weapons, such as knives and firearms, but also explosives, chemicals, etc. Figure 1.1 shows different types of weapon that can be hide easily and can cause heavy destruction.

Figure 1.1*Different types of weapons*

The detection of weapons concealed underneath a person's cloths is very much important to the improvement of security of the public as well as the safety of public assets like airports, buildings, institutions and railway stations etc. Manual screening is among one of the procedure to detect the concealed weapons but it gives unsatisfactory results when the object is not in the range of security personnel and when there is an uncontrolled flow of people. Our country is suffering from unbearable and critical situation i.e. terrorism. Current weapons-mounted robotic systems are too expensive and complex for general law-enforcement use and manually searching or checking individuals for security reasons is time consuming. Based on the problems identified in current security checking system, automated system for detecting concealed weapon was proposed by us, which will consumes less time and one's efforts.

Terrorist attacks staged in Pakistan have killed over 35,000 people, 5,000 of which are law enforcement personnel, and caused material damage to the Pakistani economy totaling US$67 billion by the IMF and the World Bank. An analysis by Iraq Body Count and co-authors published in 2011 concluded that at least 12,284 civilians were killed in at least 1,003 suicide bombings in Iraq between 2003 and 2010 and more than 1500 have been killed in India. Figure 1.2 shows the global estimation of terrorist attacks.

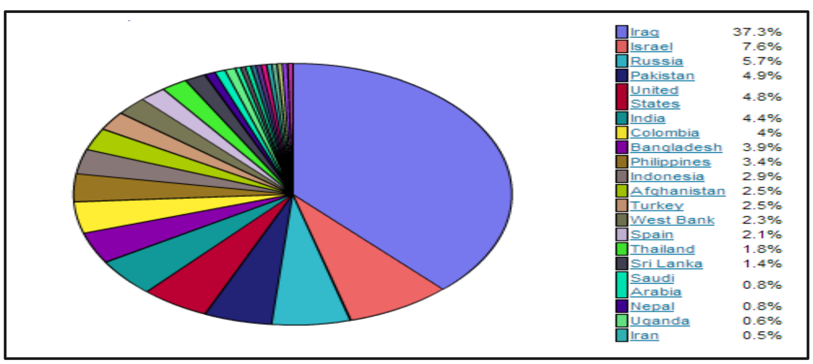

Figure 1.2 *Terrorist acts by country from 2000 to 2006*

Already used manual screening procedure sometimes gives wrong alarm indication, and fails. It also disappoints them when they try to identify a person who is the victim of an accident in future. They have recently witnessed the series of bomb blasts in Pakistan, India and Palestine. Bombs went off in buses and underground stations which have killed many and left many injured and left the world in shell shock. This situation is not limited to these countries only but it can happen or already happened anywhere and anytime in the world. People think bomb blasts can't be predicted before handled. In all of these cases CWD by scanning the images gives satisfactory results. But no single sensor technology can provide acceptable performance. So they tried to bring the eventual deployment of automatic detection and recognition of concealed weapons. It is a technological challenge that requires innovative solutions in sensor technologies and image processing.

1.2 PROJECT OVERVIEW

Manual screening is among one of the procedure to detect the concealed weapons but it gives unsatisfactory results when the object is not in the range of security personnel and when there is an uncontrolled flow of people. Our country is suffering from unbearable and critical situation i.e. terrorism. Current weapons-mounted robotic systems are too expensive and complex for general law-enforcement use and manually searching or checking individuals for security reasons is time consuming. Based on the problems identified in current security checking system, they propose the automated system for detecting concealed weapon which will consumes less time and one's efforts. The goal is to develop an automatic detection and recognition system of concealed weapons using sensor technologies and image processing techniques. This syndicate will endeavor a method to detect concealed weapon by using digital image processing techniques. The proposed methodology will take original RGB images and IR (infrared) images as an input. Initially the input images will be preprocessed to make it free from noise. Then the noise free segmented image of weapon will be extracted by applying different techniques of image processing using MATLAB. The performance of the method will be illustrated on publicly available dataset.

1.3 METHODOLOGY

Our proposed methodology will extract the concealed weapon automatically. The proposed algorithm works for both images and videos. Initially it will take original image (RGB) and Infrared images (IR) as an input. 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).The image contrast will be enhanced by applying image preprocessing techniques i.e. histogram equalization. After enhancing the contrast of images. H, S, V, planes will be extracted to make it free from noise and to get better contrast. Once they got images free from noise they will go for the segmentation and fusion techniques. Binary threshold technique will be used to extract the concealed weapon. The unwanted objects will be removed on size bases then sobel filter will be applied to extract the edges of extracted weapon. For video processing first IR video will make converted in to frames and discrete wavelet transform is applied on frames and finally sobel filter for edge detection and homomorphic filter for increasing contrast of a canceled weapon.

1.4 SCOPE AND OBJECTIVES

The goal is to develop an automatic detection and recognition system of concealed weapons using sensor technologies and image processing. Our main aim is to install a system in highly sensitive areas to identify and detect a suicide bomber from far off distance with high probability of detection and low probability of false alarm. One key step of CWD is to preventing terrorism and crime and it provides safety for public assets like airports, buildings, shopping malls and railway stations etc. It will also work for highly sensitive area e.g. Military headquarters, Air base stations and Religious places like Mosques, churches, temples etc. It can help a great deal in taking preventive measures, enhancing security, or complementing other security systems. It provides a great deal of safety to security officers by determining if a suspect is carrying a hidden weapon. The developed algorithm has very low Computational Cost and time saving also.

1.5 PLATFORMS USED

The platform used for the implementation of proposed algorithm is MATLAB. All results were evaluated on MATLAB on a core i7, 2.40 GHz system with 4GB RAM memory.

1.6 STRUCTURE OF DOCUMENT

This thesis consists of six chapters. Chapter 2 presents the related work and techniques of ways of automatic weapon detection available in the existing literature. A comprehensive explanation of all proposed and implemented methods and algorithms is given in this chapter 4. Chapter 5 shows the experimental results and analysis, followed by conclusions and the future work in chapter 6.

1.7 SUMMARY

Now a day, detection of weapon automatically holds a significant importance because terrorism is increasing so rapidly that kills millions of people all over the world. Public assets like mosques, hospitals, shopping malls etc needs to be very secure as well as military headquarters, Air base stations etc should be very safe to provide peace in all our regions in the world. The goal is to develop an automatic detection and recognition system of concealed weapons using sensor technologies and image processing techniques which will prevent the country from terrorism and provide security and peace across the world.

CHAPTER 2: LITERTURE REVIEW

2.1 BACKGROUND WORK

A varietyof imagefusiontechniqueshavebeen developed.They canbe roughlydividedintotwogroups, multiscale-decomposition-based (MDB) fusion m e t h o d s and non-multiscale-decomposition-based (NMDB) fusionmethods. MDB imagefusionschemeshave beencategorizedby ZhangandBlum[4].TypicalMDBfusion methodsinclude pyramidbased methods,discrete wavelet transformbased methods,and discretewaveletframe transformbased methods. However,basedon biologicalresearchresults,thehuman visualsystem isverysensitive tocolors. Toutilizethis ability,some researchersmap three individualmonochrome multispectralimagestotherespectivechannelsof an RGB imagetoproducea falsecolorfusedimage.Inmanycases, this technique is applied in combination with another image fusion procedure.Sucha techniqueissometimes calledcolorcompositefusion.

2.1.1. ColorImageFusionMethodology

Thefusion algorithm consists ofseveralstepswhichwill be explainedin detailin the following. Firstly,theinputvisualimage denotedas $V_{rgb}$is transformed fromRGBcolorspace(R:red,G:green, B: blue)intoHSV(denoted as V_{hsv})colorspace(H:hue,S: saturation,V:brightnessvalue).HSVcolorspaceisused forthesubsequent processingsinceitiswellsuitedfordescribingcolorsintermsthatarecloselyrelatedtohuman interpretation. Further HSVallowsadecouplingofthe intensitycomponentfromthecolor-carryinginformationin acolorimage. The*V*-channelofthevisualimage,which representstheintensityof theimage,willbeusedinthe fusion.Theothertwochannels,the*H*-channelandthe*S*- channel,carrycolorinformation.Thesetwochannelswill beusedtogivethefusedimageanaturalcolorwhichis similartothecolorofthevisualimage.BesidestheHSV colorspace,theLABcolorspaceisalsoused.LABcolor space is auniformcolor space defined by theCIE(International CommissiononIllumination). A colorisdefined intheLAB spacebythebrightness L,thered- greenchrominance*A*,andtheyellow-bluechrominance*B*. Thiscolorspaceisalsousedformodifyingthecolorofthe fusedimage.

In thefusionstep,boththeoriginalIRimageandthe reversepolarityoftheIRimageareused.Themotivation fordoingthisisthat,theconcealedweaponis sometimesmoreevidentin theIR imagewithreversepolarity.The$V$ channelof the visualimagein HSVcolorspace(denotedas VV)isnotonlyfusedwiththeIRimage(denotedasIR),but itisalsofusedwiththereversepolarityIRimage(denoted as IR^{-1}).Thediscretewaveletframe(DWF)basedfusion approachisusedinboththefusionoperations. Figure 2.1 shows the flow diagram of color fused images.

The DWFbasedmethodis one ofmanypossible multiscale-decomposition-based(MDB)fusionmethods.It consistsof threemainsteps.First,eachsourceimageis decomposed intoamultiscalerepresentationusingtheDWF transform. Then a composite multiscalerepresentation is constructed from the source representationsandafusionrule. Finallythefusedimage isobtained bytaking aninverse DWF transform ofthe composite multiscalerepresentation. The DWF is an over complete waveletdecomposition. Compared tothestandarddiscretewavelettransform(DWT),theDWFisa shiftinvariantsignalrepresentationwhichcanbeexploited to obtainamorerobustimagefusionmethod[4].This propertyofDWFisimportantforfusingavisualandanIR image.Animagefusionschemewhichisshiftdependentis undesirable in practice due to its sensitivity to mis registration.ForthecaseoffusingavisualandanIR image,itisdifficulttoobtainperfectregistrationduetothe differentcharacteristics ofvisualandIRimages. Hence, for our application, they use theDWFasthemultiscaletransform.Thefusionruletheyusedis:choosetheaverage valueofthecoefficientsofthesourceimagesforthelow frequencybandandthemaximumvalueofthecoefficients of thesourceimagesforthehighfrequencybands.Theyusedthistypicalfusionrulejusttoillustrat ethefeasibilityofthe proposedmethodoffusingacolorimagewithan IR image. Atlast,thefused imageis producedbyapplyingtheinverseDWFT. Afterobtainingthetwogray-levelfusedimages,a color RGBimageisobtainedbyassigningthe$V$ channelof the visual image inHSV colorspace(denotedas V_V)tothe greenchannel, thefusedimageof $V_V$andIRtothered channel,andthefusedimageof $V_V$andIR^{-1} totheblue channel.Theresultingcolorimageiscalleda pseudocolor image(F_{1rgb}). However,theirspecificapproachis somewhat different. In fact, in their approach, shunting neural networksareemployed.

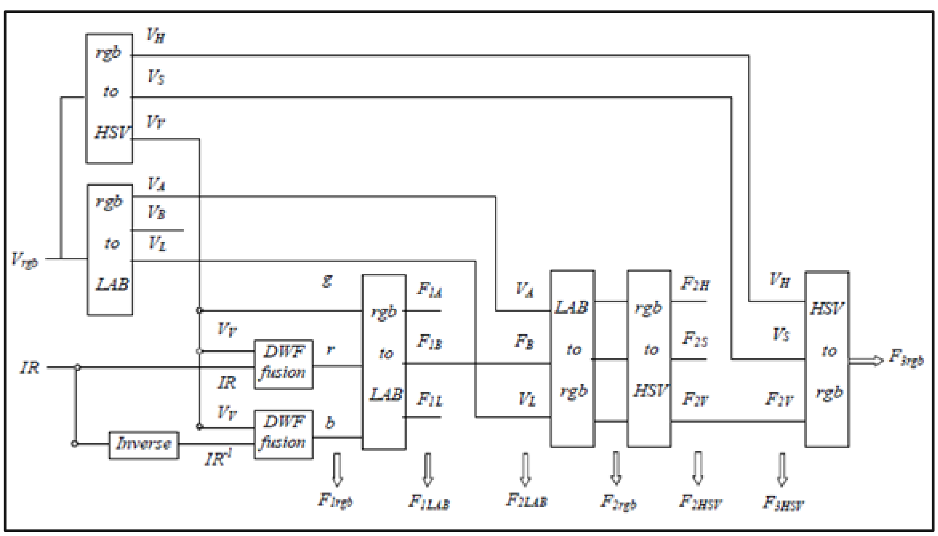

Figure 2.1*Color image fusions for CWD*

Thenextstepis toattempttogivethepseudocolor imagea morenaturalcolor(closeto the colorof the original visual image). Note that the cold regions (such as weapons)appearasbrightregionsinthereversepolarity of the IR image (IR^{-1}), and thus they appear as bright regionsinthefusedimageF_{1b} (obtainedbyfusing$V_V$and IR^{-1})also.SincethefusedimageF_{1b}isassigned totheblue channel,thecoldregionswillbeshowninbluecolorinthe pseudocolorimage F1rgb,whichisreasonable.Inorderto notonlymaintainthenaturalcolorof thevisualimagebut also keep thecomplimentaryinformationfromtheIR image (concealedweapon),thefollowingprocedureisappliedto thepseudocolorimageF_{1rgb}. First,both thepseudocolor imageF_{1rgb} andthevisualimageV_{rgb}aretransformedfrom RGBcolorspaceintoLABcolorspace(denotedasF_{1LAB} (F_{1L},F_{1A},F_{1B})andV_{LAB} (V_L,V_A,V_B),respectively).Thena newimageF_{2LAB} (F_{2L},F_{2A},F_{2B})isobtainedusingthe followingmethod(F_{2L},F_{2A},F_{2B}) (V_L,V_A,F_{1B})

Thatis,theL andAchannelsofF_{1LAB}arereplacedby theL and A channelsof visualimageV_{LAB}respectively.Then the image$F_{2LAB}$is transformedfromLABcolorspaceinto RGB colorspacetoobtaintheimage F_{2rgb}.IntheLABcolor space, the channel L representsthe brightness, the channel A represents red-green chrominance, and the channel$B$ representsyellow-bluechrominance. Hence,by usingthereplacementgiveninaboveequation,thecolor oftheimage F_{2rgb}willbeclosertothecolorofthevisual imagewhileincorporatingtheimportantinformationfrom theIRimage(concealed weapon). Howeverthereisstill someroomtoimprovethecoloroftheimage$F_{2rgb}$to make itmorelikethevisualimageinthebackgroundand forthe human bodyregion. This is most easily achieved by utilizingtheHandScomponentsofthevisualimageV_{HSV} inthe HSVcolorspacesincethe channelsHandS contain colorinformation(H:hueof the color,S:

saturationof the color). Therefore, inthenext step ofcolor modification, firsttheimage F_{2rgb} isconverted intoHSVcolorspace $(F_{2HSV}(F_{2H},F_{2S},F_{2V}))$,thenanewimage$F_{3HSV}(F_{3H},F_{3S},F_{3V})$ is obtainedbycarryingoutthefollowingprocedure,

Thatis,theHandSchannelofF_{2HSV}arereplacedbytheHandS channelofV_{HSV}respectively. The experimental result of the fusion technology is shown in figure 2.2.

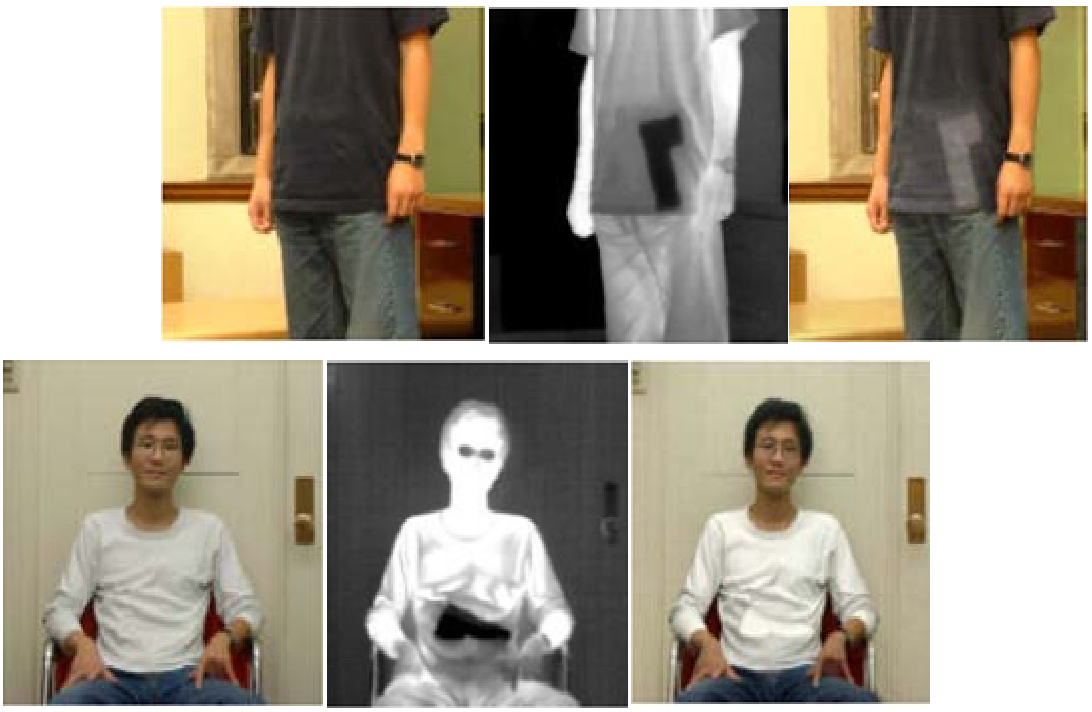

Figure 2.21st Row (L to R): Original image, IR image and fused image
2nd Row (L to R): Original image, IR image and fused image

2.1.2. HOMOMORPHIC FILTERING

Images are sometimes been acquired under poor illumination. Under this condition, the same uniform region will appears brighter on some areas and darker on others. This undesired situation will leads to several severe problem in computer vision based system. The pixels might be misclassified, leading to wrong segmentation results, and therefore contribute to inaccurate evaluation or analysis from the system. Therefore, it is very crucial to process this type of images first before they are fed into the system.

One of the popular methods used to enhance or restore the degraded images by uneven illumination is by using homomorphic filtering. Homomorphic filtering is a frequency domain method for contrast enhancement. Homomorphic filtering sharpens features in an image by enhancing high frequencies and sharpening object edges. It also flattens slighting variations in an image, bringing details out of shadows. It provides simultaneous dynamic range compression (reducing illumination variation) and contrast enhancement (increasing reflectance variation). Homomorphic filtering can thus prove to be most effective on images that have large variations in lighting. This model consider the image is been characterized by two primary components. The first component is the amount of source illumination incident on the scene being viewed $i(x, y)$. The second component is the reflectance component of the objects on the scene $r(x, y)$. The image $f(x, y)$is then defined as :

$$f(x, y) = i(x, y) * r(x, y) \qquad (3)$$

In this model, the intensity of $i(x, y)$changes slower than $r(x, y)$. Therefore, $i(x, y)$is considered to have more low frequency components than $r(x, y)$.Using this fact, homomorphic filtering technique aims to reduce the significance of $i(x, y)$by reducing the low frequency components of the image. This can be achieved by executing the filtering process in frequency domain. In order to process an image in frequency domain, the image needs first to be transformed from spatial domain to frequency domain. This can be done by using transformation functions, such as Fourier transform. However, before the transformation is taking place, logarithm function has been used to change the multiplication operation of $r(x, y)$with $i(x, y)$in Eq. 3 into addition operation. In general, homomorphic filtering can be implemented using five stages, as stated as follows:

- STAGE 1: Take a natural logarithm of both sides to decouple $i(x, y)$and $r(x, y)$components as in Eq. 4

$$z(x, y) = lni(x, y) + lnr(x, y) \quad (4)$$

- STAGE 2: Use the Fourier transform to transform the image into frequency domain as in Eq. 5

$$FFT(z(x, y) = FFT\{lnr(x, y)\} \quad (5)$$

Or

$$Z(u, v) = F_i(u, v) + F_r(u, v)$$

- STAGE 3: High pass the Z(u,v) by means of a filter function H(u,v) in frequency domain, and get a filteredversion S(u,v) as the following Eq. 6

$$S(u, v) = H(u, v)Z(u, v) = H(u, v)F_i(u, v) + H(u, v)F_r(u, v) \quad (6)$$

- STAGE 4: Take an inverse Fourier transform to get the filtered image in the spatial domain as shown in Eq. 7.

$$s(x, y) = FFT^{-1}\big(S(u, v)\big) = FFT^{-1}\{H(u, v)F_i(u, v) + H(u, v)F_r(u, v)\} \quad (7)$$

- STAGE 5: The filtered enhanced image $g(x, y)$can be obtained by using the following Eq. 8.

$$g(x, y) = \exp\{s(x, y)\} \quad (8)$$

The typical filter for homomorphic filtering process has been introduced in [8]. This filter has circularly symmetric curve shape, centered at $(x, y) = (0,0)$ coordinates in frequency domain. This filter is modified from Gaussian high pass filter, which is known as Difference of Gaussian (DoG) filter. The transfer function for DoG filter is defined as in Eq. 9.

$$H(u, v) = \gamma_h - \gamma_l \left[1 - \exp\left\{\frac{D(u,v)}{D_0}\right\}\right] + \gamma_l \quad (9)$$

Where, constant c has been introduced to control the steepness of the slope, D0 is the cut-off frequency, $D(u, v)$is the distance between coordinates $(u, v)$and the centre of frequency at (0, 0). For homomorphic filter to be effective it needs to affect the low- and high-frequency components of the Fourier transform in different ways. To compress the dynamic range of an image, the low frequency components ought to be attenuated to some degree. On the other hand, to enhance the contrast, the high frequency components of the Fourier transform ought to be magnified. Figure 2.3 depicts the algorithm used to implement the homomorphic filter used in this paper. The algorithm is based on the equations above.Filter hascircularly symmetric curve shape, centred at $(x, y) = (0,0)$coordinates in frequency domain. This filter ismodified from Gaussian highpass filter, which is known as Difference of Gaussian (DoG) filter. The transferfunction for DoG filter is defined as:

$$H(u, v) = \gamma_h - \gamma_l \left[1 - \exp\left\{\frac{D(u,v)}{D_0}\right\}\right] + \gamma_l (10)$$

where constant c has been introduced to control the steepness of the slope, $D0$ is the cut-off frequency, $D(u, v)$is the distance between coordinates $(u, v)$and the centre of frequency at (0,0). For this filter, three importantparameters are needed to be set by the user. They are the high frequency gain γh, the low frequency gain γl,and the cut-off frequency $D0$. If $\gamma h$is set greater than 1, and $\gamma l$is set lower than 1, the filter function tends todecrease the contribution made by the illumination (which occupies mostly the low frequency components)and amplify the contribution made by the reflectance (which occupies most of the high frequencycomponents). At the end, the net result will be a simultaneous dynamic range compression and contrastenhancement.

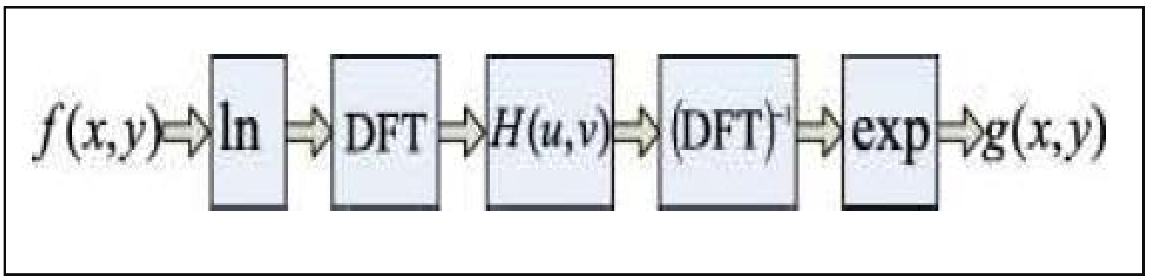

Figure 2.3 *Block Diagram for Homomorphic filtering*

2.2. SUMMARY

This chapter contains the work done related to the detection of concealed weapons that is present in existing literature. Two significant techniques are discussed which was implemented images obtained from publically available dataset. They had achieved good accuracy but tested their proposed algorithm on images. Videos are not used for the evaluation purpose.

CHAPTER 3: DESIGN AND DEVELOPMENT

3.1 DESIGN AND DEVELOPMENT

The proposed method for automated detection of concealed weapon uses a methodology for the enhancement of images preceded by extraction of characteristic feature. The key step involved in the automated detection of weapon system using images includes:

- Database Acquirement.
- Image Enhancement.
- Feature Extraction.
- Edge Detection.
- Resultant Images.

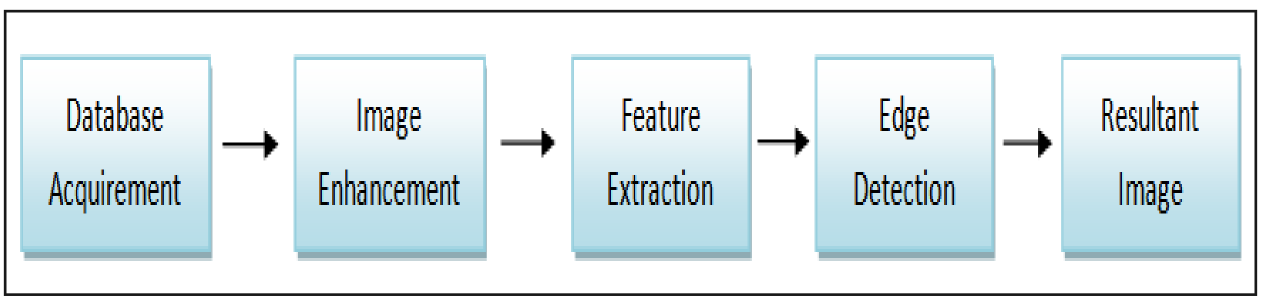

Figure 3.1 *Flow diagram of the automatic weapon detection system.*

Following are the steps used for the extraction of the concealed weapon.

- Two types of images i.e. RGB and IR images are collection from two different databases.
- Both types of images are resized to 180×180 and Gaussian filter is applied to smoothen the images.
- The resultant images are converted to double precision.
- In next step RGB images is added to IR images.

- IR images are complemented.
- The resultant complemented images in above step are added to original RGB images.
- In this step the images obtained from above step is converted into HSV image.
- H, S and V planes are extracted from HSV planes and V plane is considered for further processing.
- The V plane is converted into gray scale image.
- Mean of gray scale images is calculated; which is set to be a threshold in order to get binary image.
- The obtained binary image will contain some noise which is removed on size bases.
- In last step sobel filter is applied to get the edge shape of weapon. Flow chart of the proposed methodology is shown in figure 3.3.

3.1.1 Database Acquirement

The Proposed methodology used two types of images and videos for weapon detection which are mentioned below

- Original Images (RGB images)
- Infrared Images (IR images)
- IR videos

Database of RGB and IR images used for the detection of weapon are publically available on internet and some are provided by our institution also. Hence they have used two different databases which have different format and size. Images are converted into same format (.jpeg) and are resized to 180 ×180 where as Videos are provided by our supervisor. Figure 3.2 shows the original (RGB) and IR images.

Figure 3.2 *Original and their corresponding IR images.*

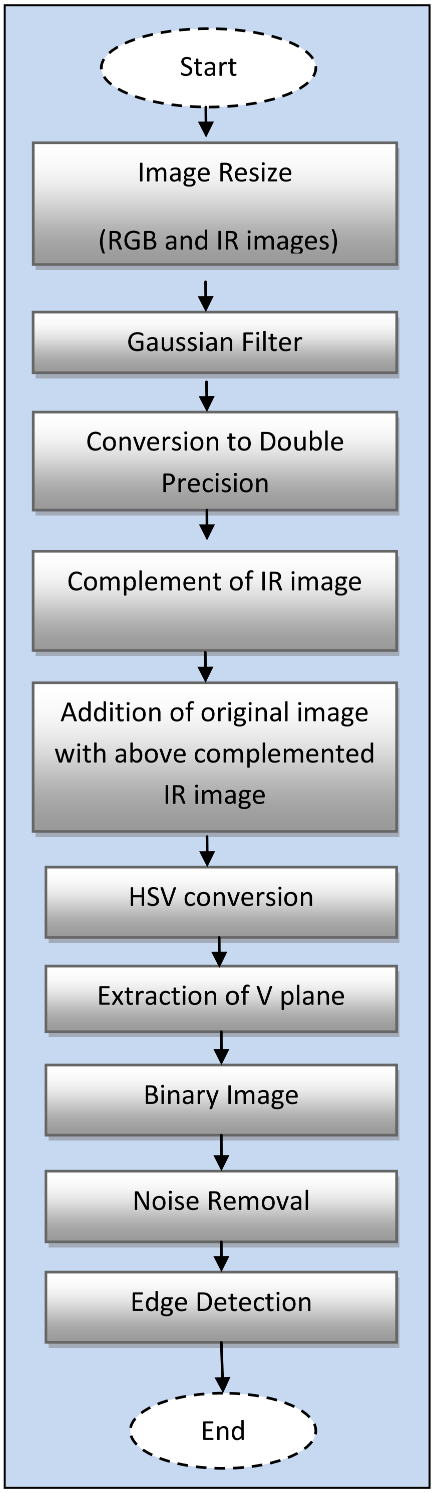

Figure 3.3 *Flow chart of proposed algorithm*

3.1.2 Image Enhancement (Preprocessing)

Preprocessing is done to refine the images by removing noisy area. The collected data base is noiseless already so no complex operation is done for the removal of noise instead of applying Gaussian filter. Both original and IR images are first smoothed by applying a Gaussian filter. The kernel of a Gaussian filter has size of 5 with a standard deviation of σ = 0.5 and the resultant images are shown in figure 3.4.

Figure 3.4 *images smoothen by Gaussian filter*

After smoothen both types of images the next step is to convert it to double precision which automatically handle the rescaling and offsetting of the original data of any image class. Figure 3.5 shows the images converted into double precision.

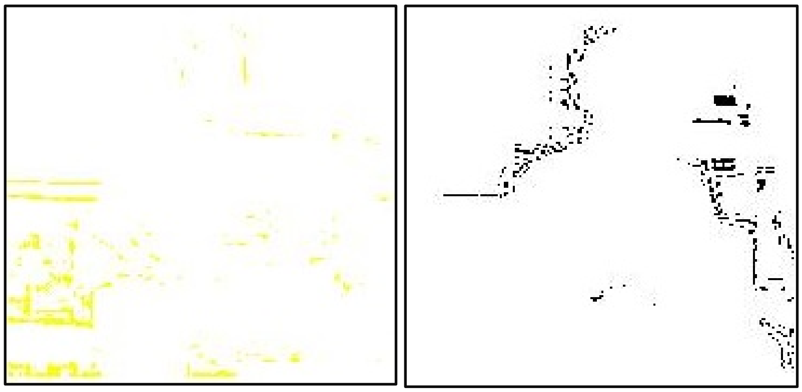

Figure 3.5*Converted images*

3.1.3 Feature Extraction

i. Image Complement

In order to extract concealed weapon, first IR images are complemented which will be used for further processing and is shown in figure 3.6.

Figure 3.6 *Combined images*

ii. Image Addition

In next step, above resultant images are added to original RGB image. Figure 3.7 shows the resultant images.

Figure 3.7 *RGB image added to complemented IR image*

iii. Extraction of Color space

In RGB color model, HSV is the most common cylindrical-coordinate representations of points. The representation rearranges the geometry of RGB in an attempt to be more intuitive and it is perceptually relevant than therepresentation of cube. HSV stands for Hue, Saturation, and Value, and is often called HSB where B is for brightness shown in figure 1.11. The angle around the central vertical axis corresponds to Hue in each cylinder, the distance from the axis corresponds to Saturation, and the distance along the axis corresponds to value, lightness or brightness. The range of Hue varies from 0 to 1.0; the corresponding colors vary from red, through green, yellow, magenta, cyan and blue, back to red, so that there are actually red values both at 0 and 1.0. The range of Saturation varies from 0 to 1.0, its corresponding colors varies from unsaturated shades of gray to fully saturate i.e. no white component. As brightness, ranges from 0 to 1.0, the corresponding colors become brighter.

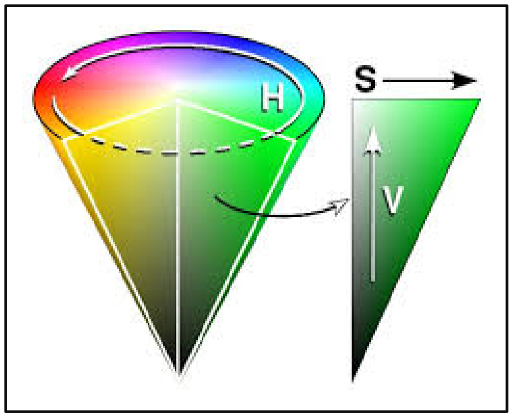

Figure 3.8 *HSV cone*

In order to extract the concealed weapon, HSV (Hue, Saturation, Volume) color space is used. The combined image shown in figure 3.6 is converted in to HSV image. The H, S, V planes are extracted separately. After analyzing a number of images it is concluded that V plane provides a better contrast for extraction of weapon. The HSV image and extracted H, S, V planes are shown in figure 3.9 (a) and (b).

Figure 3.9 (a) *HSV image with extracted H plane.*

Figure 3.9 (b) *HSV image with extracted H, S, V plane.*

iv. *Threshold Method*

To obtain the segmented weapon, threshold technique is applied. V plane is converted in to gray scale image then mean of the image is calculated which is set as a threshold [5]. A specific value is set as a threshold i.e. mean of grayscale image, the pixel values greater then threshold is changed to 1 whereas pixel values lower than threshold are turned to 0. Figure 3.10 shows the respective binary image of weapon.

Figure 3.10 Binary Images

v. *Removal of Unwanted Objects*

Binary detected weapon resultant images have some small unwanted objects i.e. noise. Objects connected by 4- connectivity and are fewer than 100 pixels produces another objects are labeled and then simply removed on bases of size. Resultant image are shown in figure 3.11.

Figure 3.11 Removal of unwanted objects.

vi. Boundary Detection

The boundary of weapon is extracted by applying Sobel Edge Detector. It detects the edges in a very robust manner. Technically, it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Sobel operator is either the corresponding gradient vector or the norm of this vector. The Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. On the other hand, the gradient approximation that it produces is relatively crude, in particular for high frequency variations in the image [6-8]. The boundary of weapon is shown in figure 3.12.

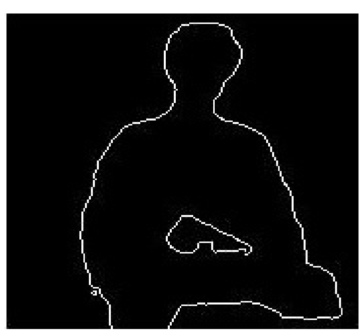

Figure 3.12 *Edged weapon*

3.2 IR VIDEO PROCESSING

3.2.1 Framing of IR Videos

The first step of video processing is the framing of the IR video using the build in matlab command for video processing. Firstly they have taken every frame and applied the processing techniques on each frame and after successfully applying the techniques then each frame is reassembled in the form of video. Figure 3.13 shows the extracted frame of video.

Figure 3.13 *Extracted frame of video*

3.2.2 Discrete Wavelet Transform

The second step they performed is the discrete wavelet transform of each frame obtained after framing. The discrete wavelet transform (DWT) is a linear transformation that operates on a data vector whose length is an integer power of two, transforming it into a numerically different vector of the same length. It is a tool that separates data into different frequency components, and then studies each component with resolution matched to its scale. DWT is computed with a cascade of filtering followed by a factor 2 sub sampling is shown in figure 3.14.

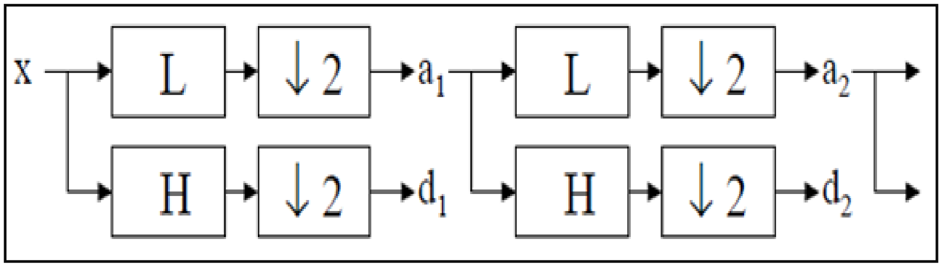

Figure 3.14 *DWT tree*

H and L denotes high and low-pass filters respectively, 2 denotes sub sampling. Outputs of this filters are given by equations (1) and (2)

$$a_{j+1}[p] = \sum_{n=-\infty}^{+\infty} l[n-2p]a_j\,[n] \qquad (1)$$

$$d_{j+1}[p] = \sum_{n=-\infty}^{+\infty} h[n-2p]a_j\,[n] \qquad (2)$$

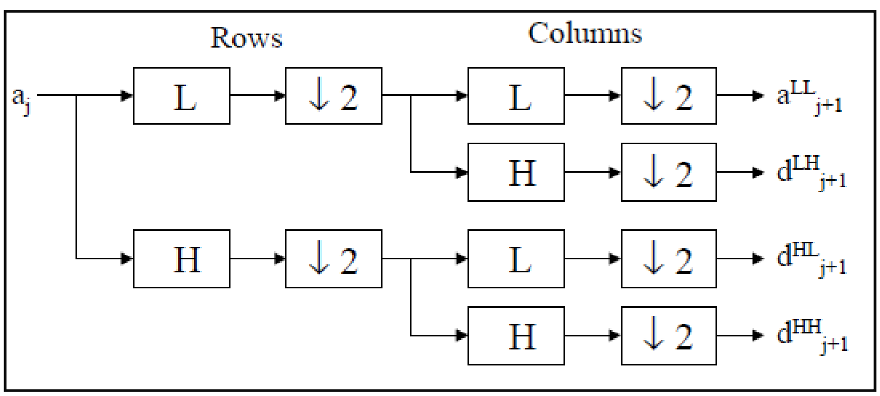

Figure 3.15 *Wavelet decomposition for two dimensional pictures*

The main feature of DWT is multi-scale representation of function. By using the wavelets, given function can be analyzed at various levels of resolution. The DWT is also invertible and can be orthogonal. Wavelets seem to be effective for analysis of textures recorded with different resolution. It is very important problem in ir imaging, because high-resolution images require long time of acquisition. This causes an increase of artifacts caused by subject movements, which should be avoided. There is an expectation that the proposed approach will provide a tool for fast, low resolution for CWD detection. Elements *aj*are used for next step (scale) of the transform and elements *dj*, called wavelet coefficients, determine output of the transform. *l[n]* and *h[n]* are coefficients of low and high-pas filters respectively One can assume that on scale *j+1* there is only half from number of *a* and *d* elements on scale *j*. This causes that DWT can be done until only two *aj*elements remain in the analyzed signal. These elements are called scaling function coefficients. DWT algorithm for two-dimensional pictures is similar. The DWT is performed firstly for all image rows and then for all columns shown in figure 3.15. Figure 3.16 shows the result of image after applying discrete wavelet transform.

Figure 3.16 *Resultant image after discrete wavelet transform*

3.2.3 Homomorphic Filtering

Homomorphic filtering is a frequency domain method for contrast enhancement. Homomorphic filtering sharpens features in an image by enhancing high frequencies and sharpening object edges. It also flattens slighting variations in an image, bringing details out of shadows. It provides simultaneous dynamic range compression (reducing illumination variation) and contrast enhancement (increasing reflectance variation). Homomorphic filtering can thus prove to be most effective on images that have large variations in lighting. This model consider the image is been characterized by two primary components. The first component is the amount of source illumination incident on the scene being viewed $i(x, y)$. The second component is the reflectance component of the objects on the scene $r(x, y)$. The image $f(x, y)$is then defined as :

$$f(x, y) = i(x, y) * r(x, y) \qquad (3)$$

In this model, the intensity of $i(x, y)$changes slower than $r(x, y)$. Therefore, $i(x, y)$is considered to have more low frequency components than$r(x, y)$. Using this fact, homomorphic filtering technique aims to reduce the significance of $i(x, y)$by reducing the low frequency components of the image. This can be achieved by executing the filtering process in frequency domain. In order to process an image in frequency domain, the image needs first to be transformed from spatial domain to frequency domain. This can be done by using transformation functions, such as Fourier transform. However, before the transformation is taking place, logarithm function has been used to change the multiplication operation of $r(x, y)$with $i(x, y)$in Eq. 3 into addition operation. In general, homomorphic filtering can be implemented using five stages, as stated as follows:

- STAGE 1: Take a natural logarithm of both sides to decouple $i(x, y)$and $r(x, y)$components as in Eq. 4

$$z(x, y) = ln i(x, y) + ln r(x, y) \qquad (4)$$

- STAGE 2: Use the Fourier transform to transform the image into frequency domain as in Eq. 5

$$FFT(z(x,y) = FFT\{lnr(x,y)\} \quad (5)$$

Or

$$Z(u,v) = F_i(u,v) + F_r(u,v) \quad (6)$$

- STAGE 3: High pass the $Z(u,v)$by means of a filter function $H(u,v)$in frequency domain, and get a filteredversion$S(u,v)$as the following Eq. 7

$$S(u,v) = H(u,v)Z(u,v) = H(u,v)F_i(u,v) + H(u,v)F_r(u,v) \quad (7)$$

- STAGE 4: Take an inverse Fourier transform to get the filtered image in the spatial domain as shown in Eq. 8.

$$s(x,y) = FFT^{-1}\big(S(u,v)\big) = FFT^{-1}\{H(u,v)F_i(u,v) + H(u,v)F_r(u,v)\} \quad (8)$$

- STAGE 5: The filtered enhanced image $g(x,y)$can be obtained by using the following Eq. 9.

$$g(x,y) = \exp\{s(x,y)\} \quad (9)$$

The typical filter for homomorphic filtering process has been introduced in [8]. This filter has circularly symmetric curve shape, centered at (u,v)=(0,0) coordinates in frequency domain. This filter is modified from Gaussian high pass filter, which is known as Difference of Gaussian (DoG) filter. The transfer function for DoG filter is defined as in Eq. 10.

$$H(u,v) = \gamma_h - \gamma_l \left[1 - \exp\left\{\frac{D(u,v)}{D_0}\right\}\right] + \gamma_l \quad (10)$$

Where, constant c has been introduced to control the steepness of the slope, D_0 is the cut-off frequency, $D(u, v)$is the distance between coordinates $(u, v)$and the centre of frequency at(0,0). For homomorphic filter to be effective it needs to affect the low- and high-frequency components of the Fourier transform in different ways. To compress the dynamic range of an image, the low frequency components ought to be attenuated to some degree. On the other hand, to enhance the contrast, the high frequency components of the Fourier transform ought to be magnified. Figure 3.15 depicts the algorithm used to implement the homomorphic filter used in this paper. The algorithm is based on the equations above and the resultant image is shown in figure 3.17.

Figure 3.17*resultant images after applying homomorphic filter*

3.2.4 Sobel Filter

Sobel filter is used in image processing for edge detection. The operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical. If they define **A** as the source image, and $\mathbf{G}_x$ and $\mathbf{G}_y$ are two images which at each point contain the horizontal and vertical derivative approximations, the computations are mentioned below and figure 3.18 shows the edges after applying sobel filter.

$$g_x \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} * A \ \ and \ g_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A$$

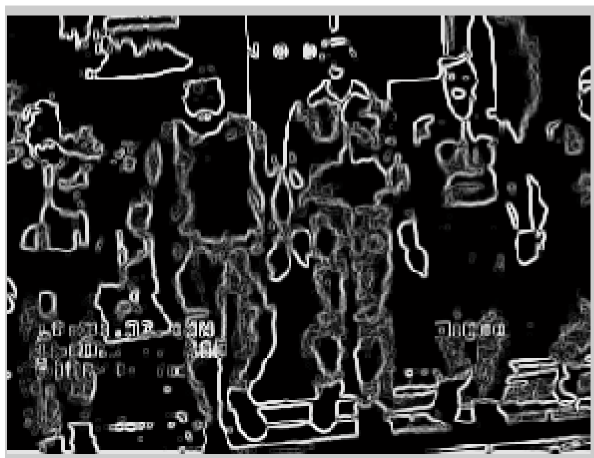

Figure 3.18*show the edges obtained by using sobel filter*

3.3 SUMMARY

System for the detection of Concealed weapon consists of preprocessing, feature extraction that includes addition of images, complement of images, extraction of HSV plane, threshold techniques, Gaussian filter and boundary. The purpose of preprocessing is to remove noisy area or background from the overall image to enhance the quality of acquired RGB and IR images and to lower the processing time. After preprocessing, hidden weapon is detected by using HSV plane extraction and thresholding techniques. Edges of weapon and image smoothing are then detected by sobel and gaussian filter respectively.

CHAPTER 4: PROJECT ANALYSIS AND EVALUATION

For all experimental results and analysis done in this project they have examined two parameters for our proposed algorithms.

- Visual inspection
- Computational Time

They have extensively tested our algorithms on Images Databases. They tested the proposed algorithm for all databases using three parameters i.e. visual inspection, accuracy and Computation time.

4.1. VISUAL INSPECTION

Human visual inspection is the best and quickest method used to approve results of any algorithm. But it is very simple, basic and subjective method of inspection and it doesn't give results at fine details. The proposed algorithm is evaluated on both images and videos.Figure 4.1 shoes the resultant images.

4.1.1 Image Preprocessing

Preprocessing is used to remove background, unwanted and noisy area from retinal images that can easily be removed by visual inspection. A specialist user can easily classify the results into successful preprocessed images and unsuccessful preprocessed images. Preprocessed images results for proposed algorithm are shown in figure 4.2.

Figure 4.2 Preprocessed images: *images smoothen by Gaussian filter*

4.1.2. Feature Extraction

Main feature was to extract the hidden weapon that can either be a gun, bomb or knife etc.In order to extract concealed weapon, first IR images are complemented and resultant images are added to original RGB image. In next step the resultant image is converted in to HSV image and as V plane provides a better contrast for extraction of weapon so it is considered for further processing.*V plane is converted in to gray scale image then mean of the image is calculated which is set as a threshold. The obtained binary has some small noise objects which are removed on the bases on size. Object fewer than 100 pixels produces another objects are labeled and then simply removed.*The boundary of weapon is extracted by applying sobel Edge Detector. Figure 4.3 and figure4.4 shows the step by step images obtained in proposed algorithm whereas figure 4.5 and figure 4.6 shows the only original and final resultant images.

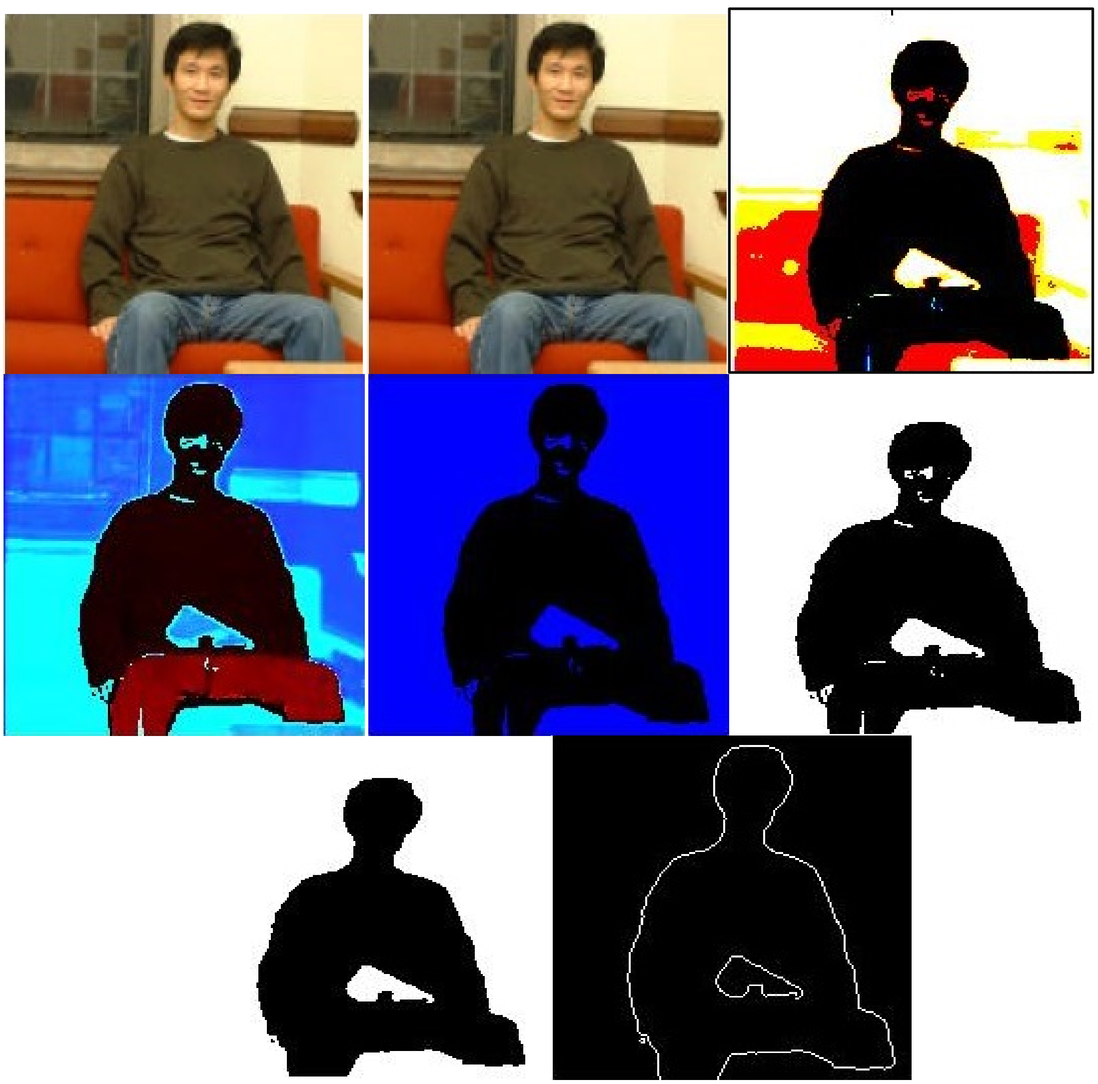

Figure 4.3 *1st row (L-R): Original image, smooth image, combined image,*
2nd row (L-R)HSV image, V plane, Binary image,
3rd row(L-R) Removal of noise, edged weapon image

Figure 4.4 *1st row (L-R): Original image, smooth image, combined image,*
2nd row (L-R)HSV image, V plane, Binary image,
3rd row(L-R) Removal of noise, edged weapon image

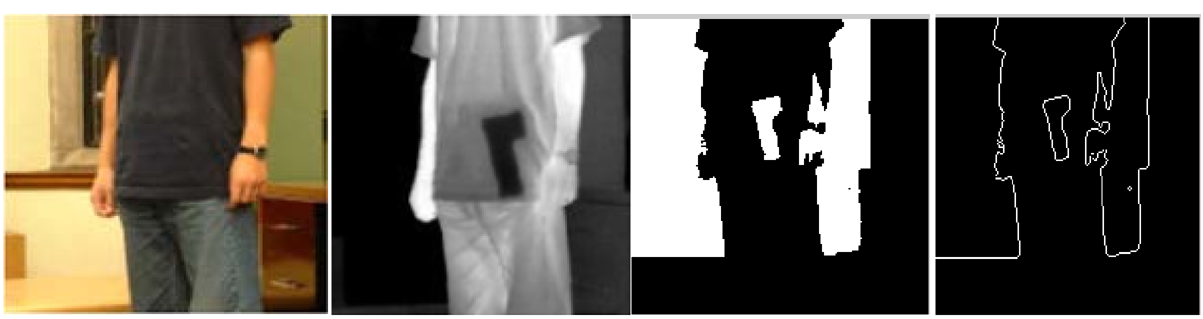

Figure 4.5 *original RGB, IR image, binary image and edged weapon image*

Figure 4.6 *Original RGB, IR image, binary image and edged weapon image*

4.2. VIDEO PROCESSING

Firstly video is splitted into frames for processing purpose. Each frame is considered as image individually. After the Discrete wavelet transform is applied. DWT is linear transformation that separates data into different frequency components, and then studies each component with resolution matched to its scale. In next step homomorphic filtering is applied to make its contrast better. Sobel filter is applied for the detection of weapon edges.The operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives i.e. one for horizontal changes, and one for vertical. In the end every frameis reassembled or combined in the form of video. Figure 4.7 shows the step by step images of applied procedure.

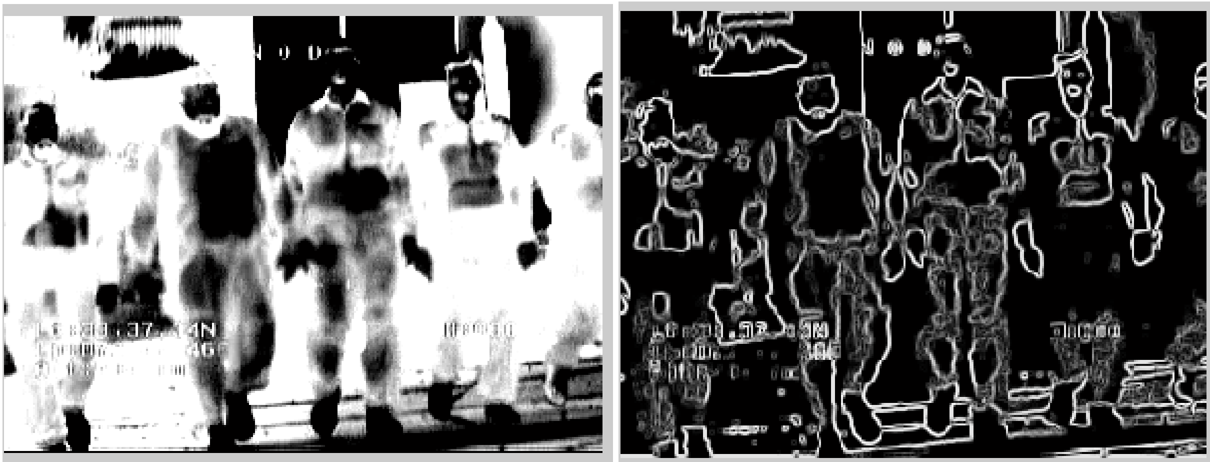

Figure 4.7 *1st row -2nd row(L to R): Original image, IR image, binary image and binary image fused image, 3rd row-4th row (L to R): Original frame, discrete wavelet transform, homomorphic filtering, sobel filtering.*

4.3. COMPUTATIONAL COST

The proposed algorithm is implemented in MATLAB on a core i7 2.20 GHz system with 4GB RAM memory. Time for all steps and is calculated separately and it is in progress. The algorithm for each image will be run 5 times and its mean computational time will be computed. This Phase is in progress. The parameters like accuracy, confusion matrix specificity and sensitivity will be measured later.

4.4. SUMMARY

This chapter contains the whole evaluation and analysis of the proposed methodology. All proposed algorithms are tested on confidential dataset provided by legal source. Two parameters are used to check the validity of proposed algorithm i.e. visual inspection and calculation time.

CHAPTER 5: FUTURE WORK AND CONCLUSION

5.1FUTURE WORK

The future work in this direction will be to integrate the proposed algorithm on FPGA to make it more efficient and reliable. Use the hdl coder of Matlab for implementation of the algorithm on to fpga. For implementation the first step is to define the data types then conversion of this data from floating point to fixed point. The next step is the hdl code generation and the final step is the hdl code verification. Then this hdl or verilog code is implemented onto fpga kit. There are many other constraints too during the implementation that can be solved by a good coder.

This implementation will make the processing time much less and the process will become much more efficient. Their will a hardware implementation of the software code. This hardware can easily be used in field and the size of this hardware is compact.

The IR camera used during this process is a cheaper one but for further work on this project it is recommended that an ir camera with advanced specs should be used so that the image processing results will be much more accurate.

This algorithm doesn't work well in crowded places where there is a lot of hustle. So in future this consideration should be taken into account. Another constraint in this process is how the suicide bomber is dressed if he is dressed such that he is wearing thick clothing then probability of his detection will be very less so it is recommended that in future a good ir camera will digital zoom should be used so that the probability of detection is high and probability of false alarm is very less.

5.2 CONCLUSION

Manual screening is among one of the procedure to detect the concealed weapons but it gives unsatisfactory results when the object is not in the range of security personnel and when there is an uncontrolled flow of people. This project provides the algorithm that can detect the weapon automatically which will consumes less time and one's efforts. The performance of proposed algorithm is measured on two basic parameters i.e. visual inspection and computational cost. The proposed algorithm will work on both images and videos and can detect hidden weapon by using image processing technique.

The basic technique that are used in image processing that is effective for detection of weapons is HSV filter and in case of video processing the technique used is DWT and for the edge detection of the weapon sobel filter is used.

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APPENDIX A

i. For Images:

```
clc;
clear all;
close all;

im1=imread('C:\Users\Fazal\Desktop\cwd\5.jpg');   % read rgb image
figure();                                        % showing rgb image in figure 1
imshow(im1);
title('rgb image')

[m n] = size(im1) ;                              %reseize image to 180*180
im1 = imresize(im1, [180 180]);
[x y] = size(im1);
figure();
imshow(im1);
title ('resized  rgb image')

g_filter = fspecial('gaussian', [5 5]);          %  gaussian filter making having kernek size of 5*5
im1 = imfilter(im1, g_filter);                   %apply gaussianfilkter on rgb image
figure();                              %showing filtered image
imshow(im1);
```

```
title('rgb image smoothen by gaussian filter');

im1=double(im1);                              % converterd into double precision
figure();
imshow(im1);
title('rgb image prcessed image');

im2=imread('C:\Users\Fazal\Desktop\cwd\6.jpg');  % reading ir image
figure();
imshow(im2);
title('ir image');

[m n] = size(im2) ;                                    %resized ir image
im2 = imresize(im2, [180 180]);
[x y] = size(im2);

g_filter = fspecial('gaussian', [5 5]);              % applying gaussian filter on ir image
im2 = imfilter(im2, g_filter);
figure();
imshow(im2);
title('irsmotthen image by gaussain filter');

im2=double(im2);                              % converterd into double precision
figure();
imshow(im2);
title (' ir image processed image');


comb_ir=imcomplement(im2);               %complemented ir image
figure();
imshow(comb_ir);
title ('complemented ir image');


 comb_img2=(im1+comb_ir);   %addition of original rgb and complemented ir image
figure();
imshow(comb_img2);
title('original and complemented ir image');

hsv_img=rgb2hsv(comb_img2);    %conversion ttohsv image from the resultant image in above step
figure();
imshow(hsv_img);
```

```
title('hsv image');

im_h = hsv_img;              %extraction of h plane from hsv image
im_h(:,:,2)=0;
im_h(:,:,3)=0;
figure();
imshow(im_h);
title('h plane');

im_s = hsv_img;            % extraction of s plane from hsv image
im_s(:,:,1)=0;
im_s(:,:,3)=0;
figure();
imshow(im_s);
title('s plane');

im_v = hsv_img;              %extraction of v plane from hsv image
im_v(:,:,1)=0;
im_v(:,:,2)=0;
figure();
imshow(im_v);
title('v plane');

im_v=rgb2gray(im_v);      % converstion of v plane into gray scale
figure();
imshow(im_v);
title ('gray image');

stndard=mean(mean(double(im_v)));    % mean of grayscale v plane is calculated
[r,c]=size(im_v);
for i=1:r
for j=1:c
      if im_v(i,j)>=stndard;       % binary threshold algorithm----pixel values  greater or equal  than mean is
set to be 1, if less it will be cahnged to 0.
new(i,j)=1;
else
new(i,j)=0;
end
end
end
figure();
imshow(new);
```

```
title('binary image');


unwanted_objects=bwareaopen(new,100);   %removal of noise or objects having size less than 100
figure();
imshow(unwanted_objects);
title ('removal of unwanted objects');

im5=edge(unwanted_objects,'sobel');    % soble filter to extract edges of weapon
figure();
imshow(im5);
title('sobel');
```

ii. For Videos

```
clc;
clear all;
close all;
IRimage='F:\project\vedios\k.mpg';    % wite the location of the video where it is placed.. if u don' know
how than contact me.
%implay('C:\Users\FAIZAN ZULFIQAR\Desktop\Project Concele Weapon Detection\3.mpg')
Imageread=mmreader(IRimage);
for k = 900:1000

Frame = read(Imageread, k);    % k is the number of frame
Frame=  Frame(:,:,:,1);     % red blue green 1 frame ,
subplot(2,3,1)
imshow(Frame);
title('orignal video');
   % Splitting an image into R G B
blue=Frame(:,:,3);
red=Frame(:,:,1);
green=Frame(:,:,2);
reda=red;
red=imadjust(red,  [0.35 .75], [0.6 .8]); % to increase contrast  removal of noise
A=red;

[A1,B1,C1,D1] = dwt2(A, 'db1');

[A2,B2,C2,D2] = dwt2(A1,'db1');

[A3,B3,C3,D3] = dwt2(A2,'db1');
A2 = idwt2(A3,B3,C3,D3,'db1');
```

```
A1 = idwt2(A2,B2,C2,D2,'db1');
 X = idwt2(A1,B1,C1,D1,'db1');

subplot(2,3,2)
imshow(X,[]);
title('resulting image after DISCRETE WAVELET TRANSFORM');

current_image=X;
 [mrows,ncolumns]=size(current_image);
current_image=mat2gray(current_image); % converts the matrix to the intensity image I. The returned
matrix contains values in the range 0.0 (black) to 1.0 (full intensity or white
 H = fspecial('disk',10);    % creates a two-dimensional filter h of the Circular averaging filter (DISK) .
fspecial returns h as a correlation kernel, which is the appropriate form to use with imfilter.
gray_filtering=current_image;
blurred_gray = imfilter(gray_filtering,H,'replicate');  %  performs multidimensional filtering according to
the Input array values outside the bounds of the array are assumed to equal the nearest array border
value
   k=2;
for i=1:1:mrow
for j=1:1:ncolumns
gray_enhanced(i,j)=mat2gray((gray_filtering(i,j)+(k.*(gray_filtering(i,j)-blurred_gray(i,j)))));
end
end


        subplot(2,3,4)
        imshow(gray_enhanced,[]);
        title('enhanced image after enhancing image')


           J=imcomplement(gray_enhanced);

            I=J/255;
        hy = fspecial('sobel');
        hx = hy';
        Iy = imfilter(double(I), hy, 'replicate');
            Ix = imfilter(double(I), hx, 'replicate');
        gradmag = sqrt(Ix.^2 + Iy.^2);

        subplot(2,3,5)
        imshow(double(gradmag),[ ]);
        title('detecting the parts')
```

```
%
%       img=gradmag;
%       map=colormap(summer);
%       [l,w] = size(map);
%               a = img;
%
%
%       % Calculate the indices of the colormap matrix
%       a = double(a);
%       a(a==0) = 1; % Needed to produce nonzero index of the colormap matrix
%       ci = ceil(l*a/max(a(:)));
%
%       % Colors in the new image
%       [il,iw] = size(a);
%       r = zeros(il,iw);
%       g = zeros(il,iw);
%       b = zeros(il,iw);
%       r(:) = map(ci,1);
%       g(:) = map(ci,2);
%       b(:) = map(ci,3);
%
%       % New image
%       res = zeros(il,iw,3);
%       res(:,:,1) = r;
%       res(:,:,2) = g;
%       res(:,:,3) = b;
```

```
%
%         [A1a,B1a,C1a,D1a] = dwt2(X, 'db1');
%
%       %   [A1b,B1b,C1b,D1b]=  dwt2(res, 'db1');
%         [m n]=size(D1a);
%         res=imresize(gray_enhanced,[m n]);
%         D1a=res;
%
%         A2 = idwt2(A1a,B1a,C1a,D1a,'db1');
%            subplot(2,3,3)
%          imshow(double(A2),[ ]);
```

```
%  S = X;
%    S3 =X<120;
%
%
%    se = strel('line',10,90);
%  S4 = imerode(S3,se);
%  se = strel('line',10,0);
%  S4 = imerode(S4,se);
%
%  S5 = bwlabel(S4);
%  [x,y]=find(S5==1);
%  subplot(2,3,4)
%  imshow(S5/255,[])
%  holdon;plot(mean(y),mean(x),'r*')
%
%
%
%
%
%
%
%
%
%
%
%
%
%
% % S=X;
% % [D1,D2,D3]=size(S);
% % ma=max(D1);
% % mb=max(D2);
% % if (ma>=250 || mb>=250);
```

```
% %     du=imresize(S,[250 250]);
% % else
% %      du=S;
% % end
% % if (D3>1)
% % Y=rgb2gray(du);
% % else
% %     Y=du;
% % end
% % % figure,imshow(Y);
% % % title(' source image');
% % H=fspecial('gaussian',1,75);
% % Gs=imfilter(Y,H);
% % G=edge(Gs,'canny',0.15);
% %   subplot(2,3,4)
% %     imshow(G,[]);
% % title('edge detection of source image');




dim=X;
I = dim;
I = im2double(I);
% I=rgb2gray(I);
I = log(1 + I);
M = 2*size(I,1) + 1;
N = 2*size(I,2) + 1;

sigma = 1000000;

[X, Y] = meshgrid(1:N,1:M);
centerX = ceil(N/2);
centerY = ceil(M/2);
gaussianNumerator = (X - centerX).^2 + (Y - centerY).^2;
H = exp(-gaussianNumerator./(2*sigma.^2));
H = 1 - H;


% imshow(H,'InitialMagnification',25)
```

```
H = fftshift(H);
alpha = 0.5;
beta = 1.5;
Hemphasis = alpha + beta*H;
size(Hemphasis);

If = fft2(I, M, N);
size(If);

Iout = real(ifft2(Hemphasis.*If));
Iout = Iout(1:size(I,1),1:size(I,2));

Ihmf_2 = exp(Iout) - 1;
% J1=imcomplement(Ihmf_2);

subplot(2,3,3)
imshow(Ihmf_2 /255,[]);
title('homomorphic filter')
end
```