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A Novel Optimization Technique for Detection of Concealed Blade in Mmw Imaging

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Abstract

Millimeter-wave imaging is well suited for the detection of concealed weapons or other contraband carried on personnel, since millimeter waves are non-ionizing, readily penetrate common clothing material, and are reflected from the human body and any concealed items. The concealed weapon, like blade, detection and identification is one of the most puzzling task faces by security agency. Researchers have demonstrated MMW imaging systems to detect concealed targets like gun, knife and scissors but detection of small size target like blade with different orientation is still challenging due to resolution limitation of MMW imaging system. The success of small size concealed target detection depends upon scanning step size of imaging system and dielectric property of covering cloths and hidden object. Therefore, resolution enhancement techniques may play a very important role for small size concealed target detection. For this purpose, a critical analysis of various signal and image processing has been carried out and integrated following algorithms like singular value decomposition (SVD) for clutter reduction, discrete wavelet transform (DWT) for resolution enhancement, thresholding for target detection and in last artificial neural network (ANN) based algorithm for rotation invariant target identification. We implemented a novel integrated technique for blade detection from MMW images.

Index Terms: MMW imaging, SVD for clutter reduction, DWT for resolution, ANN

I.INTRODUCTION

Full body, real-time, millimeter-wave imaging systems have been developed at the Pacific Northwest National Laboratory for the detection of body-worn, concealed weapons and contraband at security checkpoints. These security systems employ methods derived from microwave holography techniques that utilize phase and amplitude information recorded over a two-dimensional aperture to reconstruct a focused image of the target. Millimeter-wave imaging is well suited for the detection of concealed weapons or other contraband carried on personnel, since millimeter waves are non-ionizing, readily penetrate common clothing material, and are reflected from the human body and any concealed items. In this paper, we integrated three techniques to get the high performance even under critical conditions.

The concealed weapon detection and identification is one of the most desirable works for researchers due to security and safety of human. Every target has unique electromagnetic dielectric property. The detection and identification of concealed weapons depend upon application of appropriate signal processing techniques on extracted EM signature. Researchers have demonstrated several imaging techniques like Walk-Through metal detection (WTMD), MRI body cavity imager (MBCI), and Microwave radar imager, MMW imaging system and X-rays for concealed weapon detection [1-3]. Each imaging techniques have own merit and demerit such as WTMD detects on the basis of presence or absence of metallic targets in a very short range distance,

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MBCI works on powerful magnetic field which attract iron containing objects like hearing aids, jewelry and watches and may pose a possible risk to the person and portability and short range detection are also one of the main problem, Microwave radar imager has poor cross range resolution due to low operating frequency and X rays may effect on human health due to ionizing radiation [2-3]. Active MMW imaging technique attracts more attention for concealed weapon detection because of its high resolution but acquires blurred raw images due to diffusive scattering and the speckle effect of EM wave. For this purpose, the image processing techniques have been proposed for concealed blade detection and artificial neural network (ANN) has been used for rotation invariant target identification.

Singular Value Decomposition (SVD) is said to be a significant topic for clutter reduction.SVD has many practical and theoretical values; Special feature of SVD is that it can be performed on any real (m, n) matrix. Resolution is one of the most significant features of small size concealed targets like blade. Therefore increasing resolution of images will overcome the limitation of MMW imaging system which is done by using DWT in proposed work. An artificial neural network is an interconnected group of nodes, akin to the vast network of neurons in a brain. Here, each circular node represents an artificial neuron and an arrow represents a connection from the output of one neuron to the input of another. In proposed work we used ANN for rotation invariant.

Therefore, several signal processing steps has been critically analyzed and after that a methodology is proposed as shown in fig 1.

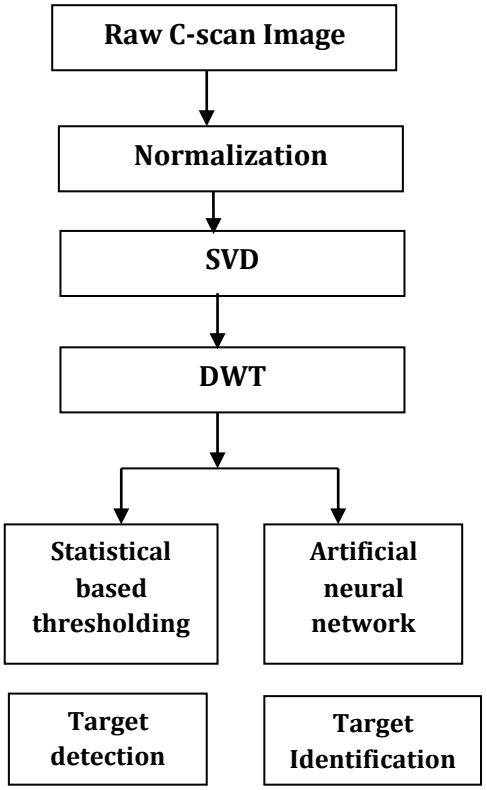

Fig. 1. Flowchart showing different signals processing steps for concealed weapon detection and identification

II. BACKGROUND

[1] A. Alan, L. Yong, T.Y.Gui, B.Nick and L.stephen "A Review of Concealed Weapon Detection and Research in Networking, Sensing and Control", this paper reviews recent developments in the area of concealed weapon detection using largely electromagnetic methods including metal detection, magnetic field distortion, electromagnetic resonance, acoustic and ultrasonic inspection, millimeter waves, Terahertz imaging, Infrared, X-ray etc.

[2]. G. I. Allen, P. Czipott, "Initial evaluation and follow on investigation of the Quantum Magnetics laboratory prototype, room temperature gradiometer for ordnance location", The localization software included both FrabmWynn and the newer "Magnetic and Acoustic Detection of Mines (MADOM)" algorithms, both of which were evaluated against a variety f ordnance type targets.

[3] N. Berrah, L. Fang, T. Osipov "Ultraintense x-ray induced multiple ionization and double core-hole production in molecules", We report novel results on multiple photo ionization of the N2 molecule by femtosecond x-ray pulses from the Linac Coherent Light Source free electron laser. Ion spectroscopy reveals the ionization and dissociation dynamics, including a molecular mechanism of frustrated absorption that suppresses the formation of high charge states at short pulse durations.

[4]. Agarwal S.,Bisht A., Singh D. and Pathak N.P.,"A Novel Neural Network based Image Reconstruction Model with Scale and Rotation Invariance for Target Identification and Classification for Active Millimeter Wave ImaginJ"

For identification of regular shape targets: mean-standard deviation based segmentation technique was formulated and further validated using a different target shape. For classification: probability density function based target material discrimination methodology was proposed and further validated on different dataset. Lastly, a novel artificial neural network based scale and rotation invariant, image reconstruction methodology has been proposed to counter the distortions in the image caused due to noise, rotation or scale variations.

[5]. Gaikwad, A. N., Singh, D. and Nigam, M. J., Application of clutter reduction techniques for detection of metallic and low dielectric target behind the brick wall by SFCW radar in UWB range.

We have demonstrated the detection results of an object behind wall in situ environment by using SFCW radar operating in the 3.95–5.85 GHz frequency range. Owing to the presence of wall, target is dislocated from its original position. We have calculated the delay time through the wall compared to the free-space propagation and have accordingly corrected the shift in range profile.

[6]. G. Akanksha, N. V. Shashi "Wavelet based resolution enhancement for low resolution satellite images", Satellite images play a major role in the analysis of land cover, topographic analysis, geosciences etc. There has always existed a tradeoff between the image resolution and the image cost. In this paper, a modified discrete wavelet transform and interpolation based technique is proposed for enhancing the resolution of satellite images having low resolution in such a way that a highly resolved satellite image can be obtained without losing any image information.

III. PROPOSED METHODOLOGY FOR IMAGE RECONSTRUCTION

Nowadays there are many applications of image processing which helps for real time object detection, segmentation, tracking, reconstruction and many more. Various image processing steps has been followed for image reconstruction which is one of the main aim of this paper. Therefore, in this paper various image processing techniques have been critically analyzed and suitable image processing technique has been proposed for reconstructing the considered target i.e. blade. Resolution is one of the most important characteristic of small size concealed targets like blade. Therefore DWT has been proposed for increasing resolution of images after critically analyzed of various resolution enhancement techniques. Orientation effect is one of the main problems because blade may not be always in one direction so we developed a new technique which is rotation invariant known as ANN.

3.1 Normalization Technique

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The intensity value of raw image of concealed blade under woolen cloth lies between 0.005 to 0.03. The back ground intensity value lies between 0.005 to 0.018 and remaining intensity values are corresponds to blade. Hence for making intensity value on single scale (between 0 to 1), normalization techniques has been applied so that remaining image processing techniques like thresholding, DWT and ANN may be successfully applied on various data [4]. It is also helpful to compare different clutter removal techniques and thresholding on single data.

3.2 Clutter removal technique

In an image there is information signal as well as clutter data like antenna- air interference signal, reflection and refraction due to multipath propagation, background reflection and covering cloth reflection.There are different techniques for reduction of this clutter. The main objective of clutter removal techniques to separate data into two subspaces called target signal and clutter signal to increase signal to noise ratio. It is found that SVD based clutter removal technique provides better result to other techniques like ICA, PCA and FA on the basis of peak signal to noise ratio (PSNR).

3.3 Target detection using thresholding

Researchers have proposed various algorithm for calculating optimum threshold level in order to detect clutter based threshold method, entropy based threshold method, adaptive threshold method and statistical based threshold method.

$$T = \mu + n * \sigma \qquad (1)$$

Where, μ and σ are the mean and standard deviation of DWT image and n is a scaling constant dependent upon particular image type and is selected after number of iterations.

3.4 Target identification using artificial neural network (ANN)

Artificial neural networks (ANNs) or connectionist systems are computing systems inspired by the biological neural networks that constitute animal brains. Such systems learn (progressively improve performance) to do tasks by considering examples, generally without task-specific programming. For example, in image recognition, they might learn to identify images that contain cats by analyzing example images that have been manually labeled as "cat" or "no cat" and using the analytic results to identify cats in other images. They have found most use in applications difficult to express in a traditional computer algorithm using rule-based programming.
The blade can be differentiated on the basis of boundary of threshold image with other pocket material like pocket diary, cigarette box and match box. Generally blade size is quite less than in comparison to these pocket material. First, the area of threshold image has been calculated and if it is less than the other pocket material then it has been trained with ANN for reconstructing the image. Therefore, ANN based algorithm has been developed for orientation invariant concealed blade detection and identification. However, in this paper, our main objective is to detect and identify of concealed blade at any orientation under various fabric. For this purpose, two targets- one is blade and other is paper cardboard of same size as blade have been considered. Targets have been rotated at every 300 between 00 to 900 under two different covering fabrics like, cotton and woolen. To get the better performance again we converted ANN output into gray scale and operated to binary format.

IV.RESULTS

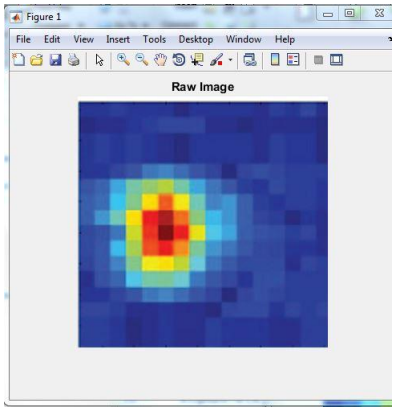

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Fig 4.1 Raw MMW image for blade detection

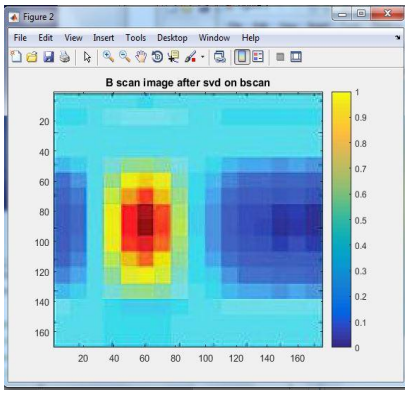

Fig 4.2 B-scan Image after application of SVD

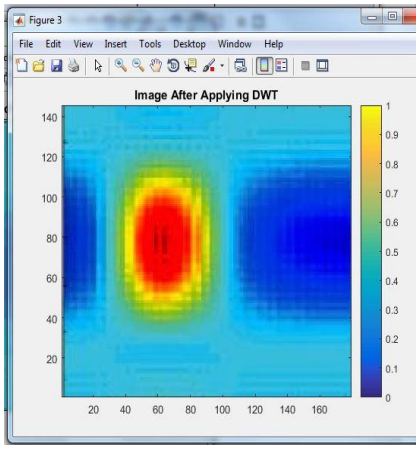

Fig 4.3 DWT output for SVD image

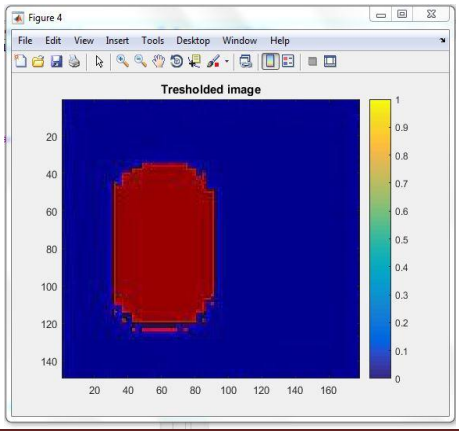

Fig 4.4 Threshold output

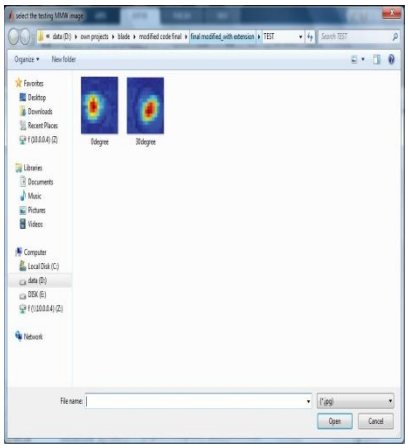

Fig 4.5 selects the image having different notation

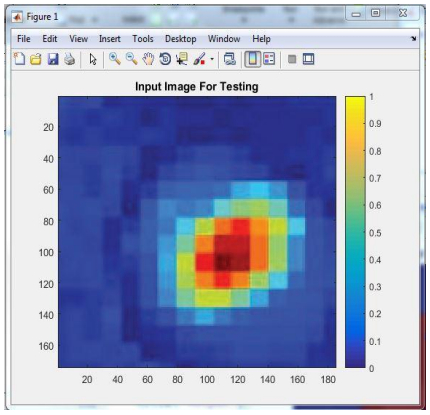

Fig 4.6 Selected rotated image as input

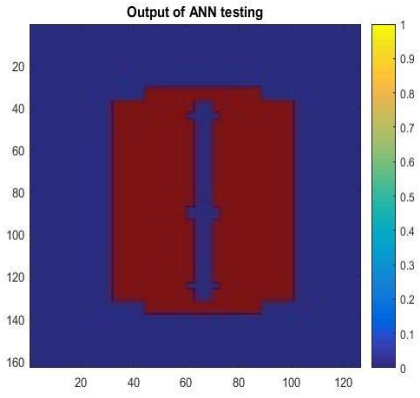

Fig 4.7 Output of ANN testing

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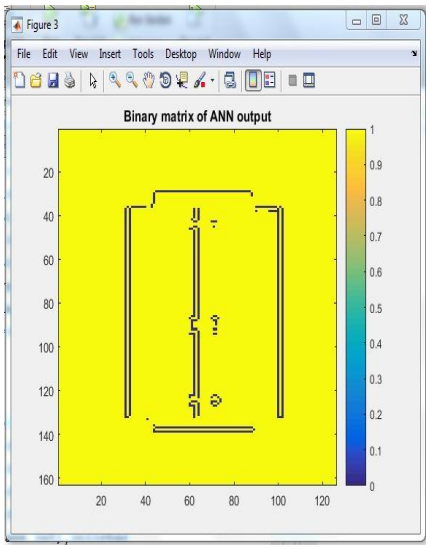

Fig 4.8 binary matrix for ANN output

V.CONCLUSION

We implemented a novel technique which demonstrates the concealed weapon detection and ANN based algorithm has been used for orientation invariant target identification. DWT has been used for resolution enhancement so that quality of image can be improved and also overcome the limitation of MMW imaging system. The main advantage of DWT over interpolation is that it preserves high frequency components of image. ANN based algorithm has been used for target identification at any orientation. We studied some existing methods for detection of different object and concluded that blade detection is one of the best techniques which can easily detect blade from MMW images.In future we can go for detection of objects with sharp edges.

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