A Real Time Image Fusion based Framework for Concealed Weapon Detection

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Abstract: In this paper, a well-organized hidden weapon detection (CWD) algorithm based on image fusion is presented. First, the images obtained consumingdissimilar sensors are decomposed into low and high occurrence bands with the double-density dualtree compound wavelet transform (DDDTCWT). Then two novel decision methods are introduced referring to the appearances of the frequency bands, which meaningfully improves the image fusion performance. The fusion of low frequency bands coefficients is strong-minded by the local contrast, while the high occurrence band fusion rule is developed by considering both the texture feature of HVS and the local energy basis. Finally, the fused image is attained through the inverse DDDTCWT. Experiments and comparisons establish the robustness and efficiency of the proposed approach and indicate that the fusion rules can be applied to different multi-scale transforms. Also, our work shows that the mixture result using the proposed fusion rules on DDDTCWT is superior to other mixtures as well as previously proposed approaches.

Keywords: *Image Fusion, Concealed Weapon Detection, Double-Density Dual-Tree Complex Wavelet Transform, Local Contrast, Human Visual System.*

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1. INTRODUCTION

Detection of hidden weapons is an increasingly important problem for both armed and police since worldwideviolence and crime have full-grown as threats over the years. Different devices, such as x-ray scanners and metal detectors, are used to search for hidden missiles. However, the applications of these devices require a large space for equipment and very small distance between the detection equipment and the each and every person undergoing inspection. Thus, these measures are time-consuming and unrealistic in crowded public places like airport terminals and office buildings. Therefore, detection of concealed weapons from a distance becomes a desirable way. Image processing has been developed as an efficient and convenient method for concealed weapon detection (CWD) procedures. Since it is difficult to provide adequate information with a single sensor in CWD applications, image fusion has been identified as a key technology to improve CWD procedures [1-4]. Image fusion is the procedure of combining images acquired using multiple sensors to construct a new image, providing backgroundimprovement of the scene being observed [5-10]. The fusion of a visual image and an image from a special sensor representative the concealed weapon is desirable, as the fused image would allow the viewer to see both the weapon and the attendance of the suspects resounding the weapon. Infrared (IR) sensors and millimeter wave (MMW) sensors are desirable among different types of submissive imagers, since they are able to capture images with clear weapon information from the distance within which the assessment of several persons at one time could be approved out without stopping them [11,12]. The available IR images are used with reverse polarity to highlight hidden weapons, which seem much darker than the adjacent human body due to their lower infection [1].

There are two main groups of image fusion techniques, non-multi-scale-decomposition-based (NMDB) fusion methods and multi-scale-decomposition-based (MDB) fusion methods [1]. The NMDB techniques, such as principal constituent analysis (PCA) [5] and adaptive weight averaging (AWA) [6] are simple, but suffer from problems such as reduced contrast and poor visual accuracy. In recent years, a variety of MDB fusion methods, including pyramid-based methods [7,8], discrete wavelet transforms-based methods [9] and discrete wavelet frame transforms-based methods [4,13], have remained proposed. A MDB fusion method can be generally divided into three steps. First, the source images are decomposed into low frequency bands encompassing the approximation coefficients and high incidence bands that consist of detail coefficients using pyramid or wavelet transform. Second, the transform coefficients are combined using different fusion rules. Third, the fused image is shaped through a multi-scale modernization. The MDB procedures are able to obtain high quality consequences with low cost.

In this paper, an algorithm for the discovery of concealed weapon is proposed. In the IR/MMW images, the bright regions that are invisible in the visual descriptions indicate the concealed weapons. In the visual images, the attention areas contain the attendance information of the suspects, which are the darker areas in the IR/MMW image. The complementary information is extracted from multi-sensor images to compose a fused image having the ability to show the personal identification evidence, such as appearance and apparel, from the visual image and the concealed weapons from the IR/MMW image. To identify both the doubtful and the concealed weapon, the input images are first disintegrated using the double-density dual-tree complex wavelet transform (DDDTCWT). Since the approximation coefficients reflect the average information of the input images, the coefficient values in the preferable regions should be larger than in the corresponding areas in the other image. Therefore, the local contrast between the estimate coefficients of multi-sensor images is used as the fusion dimension of the approximation coefficients at the highest decomposition level. Considering that the high frequency bands contain the edge and texture information of the images, the detail coefficient fusion dimension has been derived exploiting the local energy and a consistency masking based on the human visual system (HVS) model in order to improve visual accuracy. Experiments have been showed on different datasets to prove the efficiency and robustness of the projected fusion approach. Our work shows that the fusion rules can be operated with dissimilar multi-scale image disintegration schemes.

2.Proposed Gray-Scale Image Fusion Algorithm:

The core aim of this paper is to yield a high quality fused image that exhibitions both the hidden weapons and the face and figure characteristics of the person resounding the weapon for the opportuneness of observers. Therefore, two images from dissimilar sensors are first decomposed into low and high frequency bands using DDDTCWT. Then, two synthesis operations have been developed exploiting the merits of both DDDTCWT and HVS to fuse the low and high incidence bands. Finally, the fused image is produced through inverse DDDTCWT using the fused low and high incidence bands. The block diagram of the projected algorithm is shown in Figure 3. Also, the fusion approaches can be applied to other multi-scale disintegration schemes as shown in section 4.

2.1 Fusion of Low Frequency Bands:

The low frequency bands of DDDTCWT reflect the rougher approximation of the unique image. Averaging is a suitable method by which to fuse the estimate coefficients and maintain the reasonable mean intensity for the fused image. However, be around results in information loss and concentrated contrast. In CWD application, the preferable information is the concealed weapon in the IR/MMW image and the personal documentation in the visual image. Therefore, the desirable regions are those with larger illumination difference.

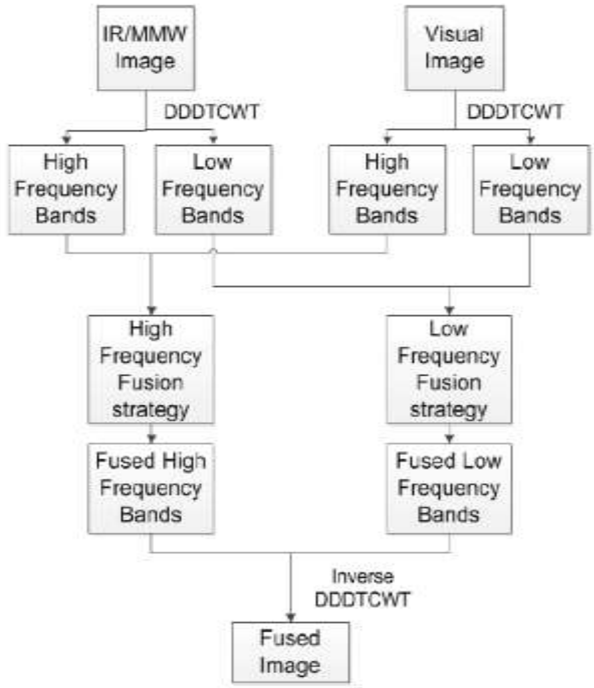

Figure 3. Block diagram of the proposed algorithm

2.2 Fusion of High Frequency Bands

High incidence bands contain most of the edge and consistency information. Thus, the texture feature of HVS has been taken into consideration to improve the graphic accuracy of the fused image. The Noise Visibility Function (NVF) [17] is used as a texture covering together with the local vitality to estimate the high incidence bands. The same fusion process is applied to all the 32 high occurrence bands.

3.Experimentsand Analysis

In our experiments, four datasets of graphic and IR/MMW images are used as foundation images. The proposed algorithm based on DDDTCWT has been associated with other methods and other decomposition schemes using the future fusion rules. The gradient pyramid (GP)-based method [7], DWTbased method [9], DTCWT-based method [3], frame let transform (also known as DDDWT)-based method [4] and an existing DDDTCWT-based algorithm [13] are used in the assessment. Better image fusion algorithms should preserve courtesy features from source images and should not introduce artifacts and discrepancies. Therefore, several objective quality metrics have been used to approximation the quality of the images. Higher metrics values elect better image quality.

3.2 Experimental Results

The presentation of the proposed algorithm is established through our experiments on different image datasets and our evaluations with other methods. The 256x256 source imageries used in the experiments are represented in Figure

4. In the experiments, the calculation window is chosen as3x3¸ when calculating the local contrast, NVF, and local energy. The highest decomposition level l is selected as 3.

The fused images using dissimilar fusion algorithms are shown in Figure 5. From Figure 5, it is clear that the concealed weapons are more extraordinary in the fused images with proposed fusion rules and the proposed fusion algorithm is more edge-preserving. The evaluation of the performance statistics for the algorithms can be found in Table 1. According to the results of our experiments, the proposed algorithm has preserved the pertinent evidence from the source images and enhanced the visual effect of the fused image. Some prevailing algorithms, such as those based on grade pyramid and DWT, suffer from the problematic of concentrated contrast. The existing algorithm based on the DTCWT performs well on some performance statistics, but suffers from presented inconsistencies that can be easily seen in the figures. The prevailing algorithm based on DDDTCWT performs poorly for several datasets because it uses PCA, which has no scale selectivity as the fusion operation of the low incidence sub-bands. In most cases, performance improves when the prevailing fusion rules are replaced by our proposed rules, proving their effectiveness. The proposed algorithm completes best on detached edge based quality, mostly because of the better directional selectivity of DDDTCWT, which leads to better preservation of edge information. Due to the compensations of DDDTCWT and the fusion rules utilizing HVS appearances, the proposed procedure performs better than the other measures.

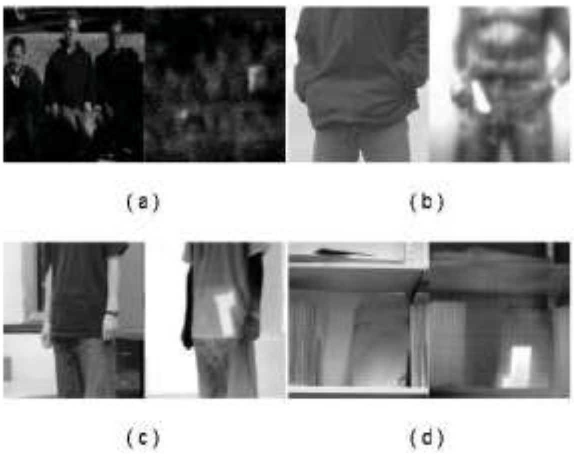

Figure 4 Source Images for (a) Dataset1 (b) Dataset2 (c) Dataset3 (d) Dataset4

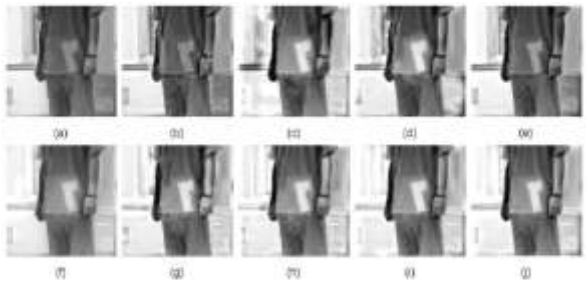

Figure 5 Fused images of datasets (a) Gradient Pyramid-based existing method, (b) Discrete WavaletTransform-based existing method, (c) DTCWT-based existing method, (d) Frame let transform-based existing method, (e) DDDTCWT-based existing method, (f) GP with projected fusion rules, (g) DWT with proposed fusion rules, (h) DTCWT with projected fusion rules, (i) Frame let transform with projected fusion rules, (j) Proposed Method.

4. Conclusion:

In this paper, a new image synthesis scheme for CWD application is obtainable with the aim of producing an image with a clear demonstration of both the identity information of the suspect and the hidden weapon. For this purpose, images from multi-sensors covering complementary information are fused to provide a detailed description of the person and weapon hidden beneath his/her fashion. The application of DDDTCWT with the proposed fusion schemes is presented as DDDTCWT possesses the advantages of both DDDWT and DTCWT. For the high and low frequency sub-bands obtained from the DDDTCWT of the source images, two fusion operations are industrialized considering the characteristics of HVS and DDDTCWT. The experimentation results show that the proposed method can reservation the information better and improve the quality of the fused image as compared to a variety of prevailing algorithms. Also, we demonstrate that the planned fusion rules can be applied to a variety of multi-scale decomposition schemes and that it performs well in the application of CWD. The DDDTCWT is superior to many other multi-scale disintegration schemes, especially since of its better directional discrimination. In addition, an interesting direction for the future work could be the development of the proposed fusion technique using region distinction based on image separation.

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