Implementation of Pixel Level Color Image Fusion for Concealed Weapon Detection

Vishnupriya G. L
Signal Processing and VLSI
SBMJCE
Kanakapura, India

K. S. Srinivas
Asst. Prof., Dept. of ECE
SBMJCE
Kanakapura, India

Abstract—Image fusion has various applications in the field of military, law and enforcement. Image fusion for Concealed Weapon Detection (CWD) has attracted lots of interest in the field of military. In this paper linear pixel level image fusion has been implemented using vector valued total variation algorithm (VTVA). It includes decomposition of covariance matrix of multispectral bands using cholesky decomposition. The decomposed data is linearly transformed and mapped. The statistical properties of the resultant fused image can be controlled by the user.

Keywords—Concealed Weapon Detection(CWD), pixel level image fusion, VTVA

I. INTRODUCTION

Image fusion [4] is a process of merging two or more images taken from different sensors to form a fused image which is more informative and efficient compared to the source images. It’s difficult to combine visual information simply by viewing multiple images separately by the human observer so we go image fusion. The pixel level image fusion performed on a pixel-by-pixel basis. It generates a fused image in which information associated with each pixel is determined. The performance of source image will be improved. In general pixel level fusion methods can be classified as linear and nonlinear methods.

In this paper the proposed algorithm is a linear pixel level image fusion. This method improves the visual quality of the fused image. The Concealed Weapon Detection (CWD) has been introduced in this paper, which detects the weapon or metal object hidden underneath a person’s clothing. The research activities are going on improving the quality of the fused image.

II. VECTOR VALUED TOTAL VARIATION ALGORITHM (VTVA)

![Fig 1. Block Diagram of VTVA](image_url)

Statistical properties of multispectral data set with X * Y pixel per channel and k different channels can explored if each pixel is described by a vector whose components are the individual spectral responses to each multispectral channel

$$\mathbf{M} = [M_1, M_2, M_3, ..., M_k] \trans$$

with mean vector given by

$$\mathbf{x}_m = \mathbf{E}[\mathbf{M}] = \left( \frac{1}{X \times Y} \sum_{i=1}^{X \times Y} M_i \right)$$

The mean vector is used to define the average or expected position of the pixels in the vector space.

A. Covariance matrix

The correlation between the multispectral bands can be defined by covariance matrix. If the off diagonal elements in covariance matrix are large then we can say that the multispectral bands are correlated with each other and diagonal elements of the covariance matrix are the variance. The covariance matrix is real symmetric and positive definite matrix. The covariance $\mathbf{C}_M$ can be obtained using equation

$$\mathbf{C}_M = \frac{1}{X \times Y} \sum_{i=1}^{X \times Y} \mathbf{m}_i \mathbf{m}_i \trans - \mathbf{x}_m \mathbf{x}_m \trans$$

The correlation coefficient ‘r’ is obtained by dividing the covariance matrix elements with the standard deviation of the corresponding multispectral component $(r_{ij} = c_{ij} / \sigma_i \sigma_j)$. The correlation coefficient matrix $\mathbf{R}_M$ has an elements the correlation coefficient between $i$th and $j$th multispectral components. The correlation coefficient matrix is shown below. The covariance matrix $\mathbf{C}_M$ and $\mathbf{C}_N$ are real and symmetric.

$$\mathbf{R}_M = \begin{bmatrix}
1 & r_{12} & \cdots & r_{1k} \\
r_{21} & 1 & r_{23} & \cdots & r_{2k} \\
\vdots & \vdots & \ddots & \vdots \\
r_{k1} & r_{k2} & \cdots & 1
\end{bmatrix}$$

The covariance matrix $\mathbf{C}_N$ can be obtained as the product of diagonal matrix and correlation coefficient matrix as below

$$\mathbf{C}_N = \mathbf{E} \mathbf{R}_M \mathbf{E} \trans$$
Where $E$ is the diagonal matrix and

$$ E = \begin{bmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \sigma_2 & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_k \end{bmatrix} $$

(6)

B. Cholesky decomposition

The $C_M$ and $C_N$ can be transformed into upper triangular matrix $Q_M$ and $Q_N$ respectively by making use of cholesky transformation matrix. The cholesky decomposition is applicable only for the real, symmetric and positive definite matrix. A real symmetric matrix $P$ can be decomposed by means of upper triangular matrix $Q$ so that

$$ P = Q^T \cdot Q $$

(7)

The factorized $C_M$ and $C_N$ can be written as

$$ C_M = Q_M^T \cdot Q_M $$

(8)

$$ C_N = Q_N^T \cdot Q_N $$

(9)

C. Transformation matrix

The transformation matrix transforms the fused multispectral components into a RGB or color image. The transformation matrix $A$ depends on the statistical properties of the original data set. The transformation matrix $A$ can be obtained using the cholesky decomposition method. The relation between the covariance matrices be

$$ C_N = A^T \cdot C_M \cdot A $$

(10)

Substitute (8) and (9) in (10)

$$ Q_N^T \cdot Q_N = A^T \cdot Q_M^T \cdot Q_M \cdot A = (A \cdot Q_M)^T \cdot Q_M \cdot A $$

(1)

Thus,

$$ Q_N = Q_M \cdot A $$

(12)

The transformation matrix can be written as

$$ A = Q_M^{-1} \cdot Q_M $$

(13)

D. Linear transformation

The linear transformation is to map the input and output components.

$$ N = A^T \cdot M $$

(14)

E. Scaling

The scaling scales the mapped image into the range $[0-255]$. The linearly transformed $M$ must be scaled in order to produce an RGB representation.

$$ N_{kl} = 255 \cdot \frac{N_{kl} - \min(N_{kl})}{\max(N_{kl}) - \min(N_{kl})} $$

(15)

Where $\min(N_{kl})$ and $\max(N_{kl})$ are the minimum and maximum values of transformed vector $N_k$ respectively.

III. SIGNAL TO NOISE RATIO

The signal to noise ratio (SNR) is calculated as the ratio of rms value of the reference input and the rms value of difference between reference input and mapped output image.

The SNR for the fused image at the output can be calculated by as below

$$ SNR = 10 \log_{10} \frac{RMS[reference \ image]}{RMS[reference \ image - output \ image(bit \ length)]} $$

(14)

<table>
<thead>
<tr>
<th>Table Head</th>
<th>SNR Value Of Previous Paper</th>
<th>SNR Value Of Proposed System</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-bit</td>
<td>77.20dB</td>
<td>72.8407dB</td>
</tr>
<tr>
<td>16-bit</td>
<td>98.15dB</td>
<td>73.1117dB</td>
</tr>
</tbody>
</table>

The previous SNR values and propose method values for 12-bit and 16-bit are shown in Table.1.

IV. EXPERIMENTAL RESULTS

Fig 2. Natural color image
ACKNOWLEDGMENT

This research work has been supported by my project guide Mr. K. S. Srinivas, Asst. Professor, Dept of ECE. I would like to thank my supervisors, friends and parents for their support.

REFERENCES


First a natural color image is taken, the RGB components are separated from color image. Next a gray scale image is taken where we can see the weapon hidden inside the clothing. This is shown in the first two figures. Last two images are fused images where the weapon hidden is clearly seen. The resultant fused image’s color is configurable. User can configure the color of the fused image.