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Application of Image Fusion Using Wavelet Transform In Target Tracking System

Patil Gaurav Jaywantrao
RKDF, Institute of Science & Technology, Bhopal

Asst. Prof. Shabahat Hasan
H.O.D, RKDF, Institute of Science & Technology, Bhopal

Abstract

The abstract The fusion of images is the process of combining two or more images into a single image retaining important features from each. Fusion is an important technique within many disparate fields such as remote sensing, robotics and medical applications. Wavelet based fusion techniques have been reasonably effective in combining perceptually important image features. Shift invariance of the wavelet transform is important in ensuring robust sub-band fusion. Therefore, the novel application of the shift invariant and directionally selective Dual Tree Complex Wavelet Transform (DT-CWT) to image fusion is now introduced. The successful fusion of images acquired from different modalities or instruments is of great importance in many applications, such as medical imaging, microscopic imaging, remote sensing, computer vision, and robotics. With 2D and 3-D imaging and image processing becoming widely used, there is a growing need for new 3-D image fusion algorithms capable of combining 2D & 3-D multimodality or multisource images. Such algorithms can be used in areas such as 2D & 3-D e.g. fusion of images in Target tracking system, Synthetic Aperture Radar (SAR) etc. In case of target tracking system the time is the very important factor. So we take time as a comparison factor to compare different methods which we implement. In order to improve the efficiency of the project, Elapsed time for the fusion to run is being formulated.

1. Introduction

With the rapid advancements in technology, it is now possible to obtain information from multisource images. However, all the physical and geometrical information required for detailed assessment might not be available by analyzing the images separately. In multisensory images, there is often a trade-off between spatial and spectral resolutions resulting in information loss. Image fusion combines perfectly registered images from multiple sources to produce a high quality fused image with spatial and spectral information. It integrates complementary information from various modalities based on specific rules to give a better visual picture of a scenario, suitable for processing. An image can be represented either by its original spatial representation or in frequency domain. By Heisenberg's uncertainty, information cannot be compact in both spatial and frequency domains simultaneously. It motivates the use of wavelet transform which provides a multiresolution solution based on time-scale analysis. Each subband is processed at a different resolution, capturing localized time-frequency data of image to provide unique directional information useful for image representation and feature extraction across different scales.

With the recent rapid developments in the field of sensing technologies multisensor systems have become a reality in a growing number of fields such as remote sensing, medical imaging, machine vision and the military applications for which they were first developed. The result of the use of these techniques is a great increase of the amount of data available. Image fusion provides an effective way of reducing this increasing volume of information while at the same time extracting all the useful information from the source images. Multi-sensor data often presents complementary information about the region surveyed, so image fusion provides an effective method to enable comparison and analysis of such data. The aim of image fusion, apart from reducing the amount of data, is to create new images that are more suitable for the purposes of human/machine perception, and for further image-processing tasks such as segmentation, object detection or target recognition in applications such as remote sensing and medical imaging. For example, visible-band and infrared images may be fused to aid pilots landing aircraft in poor visibility. Multi-sensor images often have different geometric representations, which have to be transformed to a common representation for fusion. This representation should retain the best resolution of either sensor. A prerequisite for successful in image fusion is the alignment of multi-sensor images. Multi-sensor registration is also affected by the differences in the sensor images.

2. Multi-sensor image fusion system

Multi-sensor image fusion systems overcomes the limitations of a single sensor vision system by combining the images from these sensors to form a composite image. Figure 1-1 shows an illustration of a multi-sensor image fusion system. In this case, an infrared camera is supplementing the digital camera and their individual images are fused to obtain a fused image. This approach overcomes the problems referred to before, while the digital camera is appropriate for daylight scenes, the infrared camera is suitable in poorly illuminated ones.

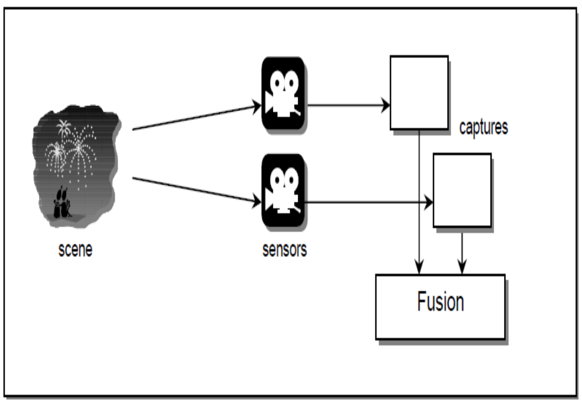

Figure 1. Multisensor Image Fusion System

The evolution of image fusion research:-

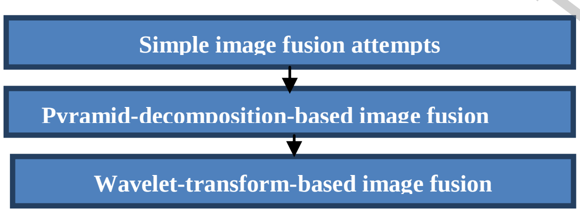

Figure 2. Evolution process of image fusion research

Methodology: -

For that research we choose a technique as a Wavelet Transformation.

Image fusion using wavelet transform:-

The block diagram of a generic wavelet-based image fusion scheme is shown in the following figure.

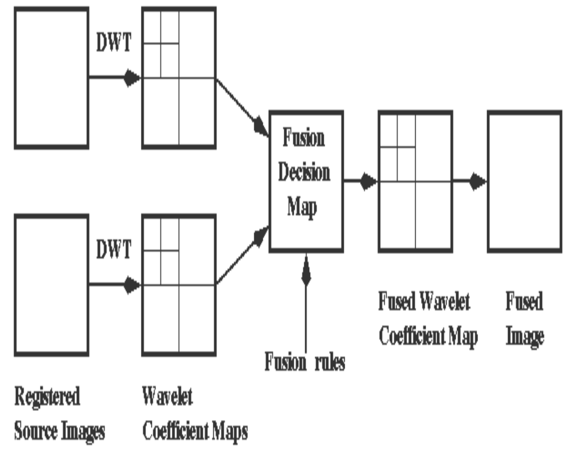

Figure 3. Process of Image fusion

Wavelet transform is first performed on each source images, and then a fusion decision map is generated based on a set of fusion rules. The fused wavelet coefficient map can be constructed from the wavelet coefficients of the source images according to the fusion decision map. Finally the fused image is obtained by performing the inverse wavelet transform.

From the above diagram, we can see that the fusion rules are playing a very important role during the fusion process. Here are some frequently used fusion rules shown in below figure.

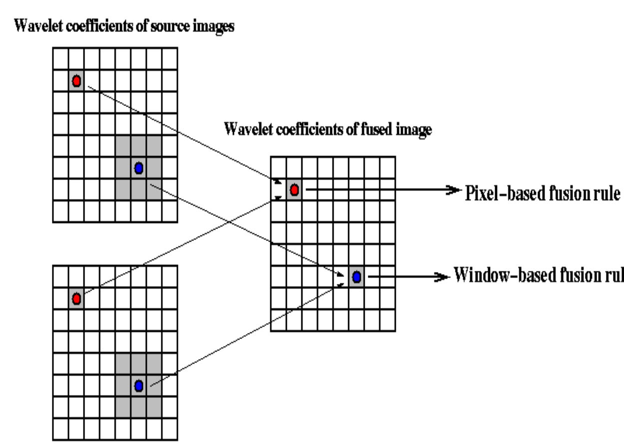

Figure 4. Pixel and window based image fusion

Wavelet Transformation

The wavelet transform is a powerful tool for multiresolution analysis. The multiresolution analysis requires a set of nested multiresolution sub-spaces as illustrated in the following figure.

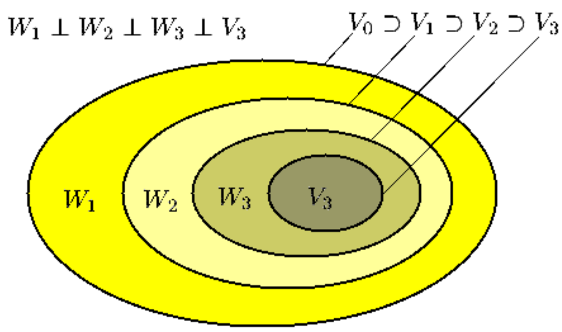

Figure 5. Wavelet Transformation

The original space V0 can be decomposed into a lower resolution sub-space V1, the difference between V0 and V1 can be represented by the complementary sub-space W1.Similarly, we can continue to decompose V1 into V2 and W2. The above graph shows 3-level decomposition. For N-level decomposition, we will obtain N+ 1 sub-space with one coarsest resolution sub-space Vn and N difference sub-space Wi, i is from 1 to N. Each digital signal in the space V0 can be decomposed into some components in each sub-space.

2 D Discrete wavelet transform (DWT)

Since image is 2-D signal, we will mainly focus on the 2-D wavelet transforms. The following figures show the structures of 2-D DWT with 3 decomposition levels.

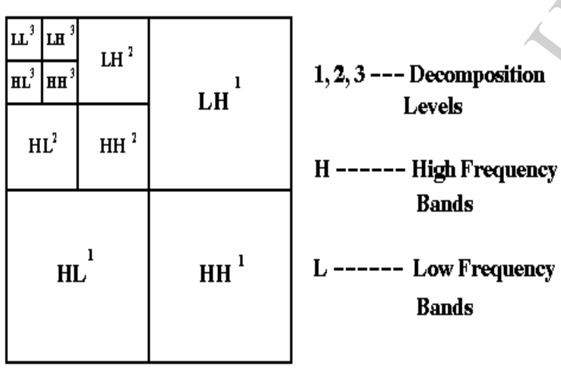

Figure 6.2 D Discrete wavelet transform.

Wavelet Families/types

- Haar
- Daubechies
- Biorthogonal
- Coiflets
- Symlets

Haar wavelet:

The Haar wavelet is the simplest wavelet. It uses averaging and differencing terms, storing detail coefficients, eliminating data, and reconstructing the matrix such that the resulting matrix is similar to the initial matrix.

$$W_H(X) = 1 \qquad for\ 0 < X < 0.5$$
$$W_H(X) = -1 \qquad for\ 0.5 < X < 1$$
$$W_H(X) = 0 \qquad otherwise$$

Daubechies Wavelets:

The names of the Daubechies family wavelets are written dbN, where N is the order, and db the "surname" of the wavelet. These wavelets have no explicit expression except for db1, which is the Haar wavelet.

$$P(y) = \sum_{k=0}^{N-1} C_k^{N-1+k} y^k$$

Then, $$|m_0(w)|^2 = (cos^2\left(\frac{w}{2}\right))^N P(sin^2\left(\frac{w}{2}\right))$$

Therefore, $$m_0(w) = \frac{1}{\sqrt{2}} \sum_{k=0}^{2N-1} h_k e^{-ikw}$$

Symlets wavelet

Take a look at the discrete filters and the scaling/wavelet functions of Daubeches wavelets. These functions are far from symmetry. That's because Daubechies wavelets select the minimum phase square root such that the energy concentrates near the starting point of their support. Symmlets select other set of roots to have closer symmetry but with linear complex phase.

$$W(z) = U(z)U\left(\frac{1}{z}\right)$$

Coiflets wavelet

For an application in numerical analysis, Coifman construct a family of wavelets that have p vanishing moments, minimum size support and the equation below can be taken as some requirement about vanishing moments of the scaling function. The resulting coiets has a support of size (3p -1).

$$\int_{-\infty}^{\infty} \emptyset(t)dt = 1$$
$$\int_{-\infty}^{\infty} t^k \emptyset(t)\,dt = 0 \qquad for\ 1 \le k \le p$$

Flowchart

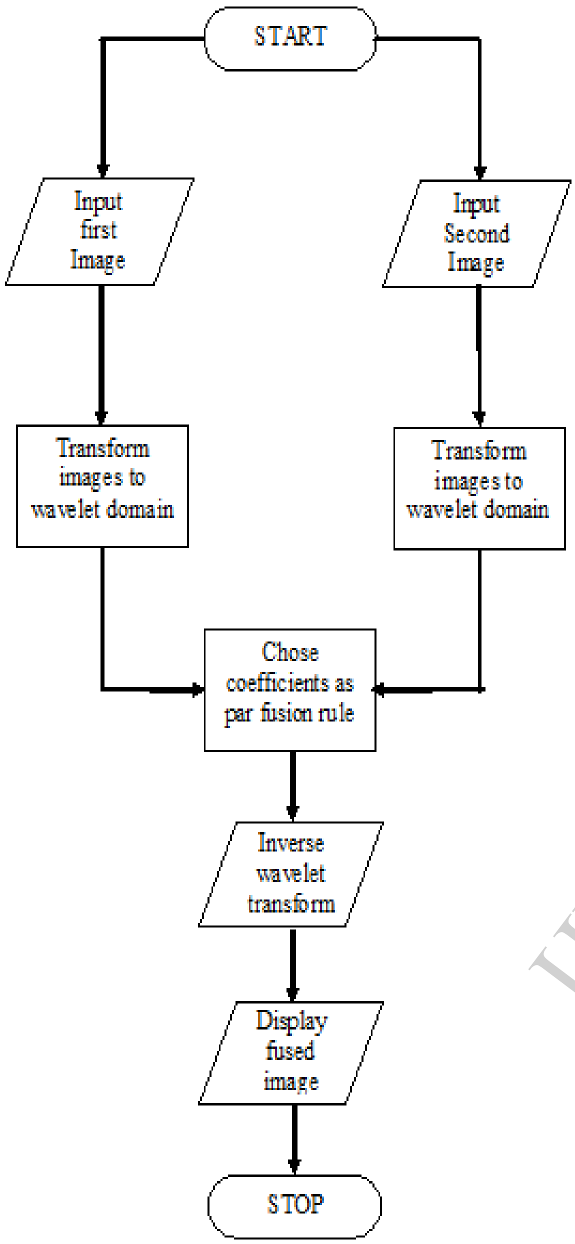

Figure 7. Flowchart

Experimental results and discussion

Several image databases are built in order to test the system. A number of experiments are performed on different images as described below. We fuse the two images using different wavelet transform. The aim of the project is to test each technique by the calculation of execution time for 2D images and for some combinations for 3D images.

Results for 2-D-:

Following table shows the comparison between all the wavelets on the basis of time. So here we are taking time as parameter to find out best wavelet transform for RADAR or remote sensing images. Hence from observations haar is best suited for 2-D and Coiflets required highest time for fused 2-D image.

Table 1. Results for 2-D

Wavelet name	Time in ms
Haar	0.38491
Daubechies	0.39215
Symlets	0.38912
Coiflets	0.47570
Biorthogonal	0.40373

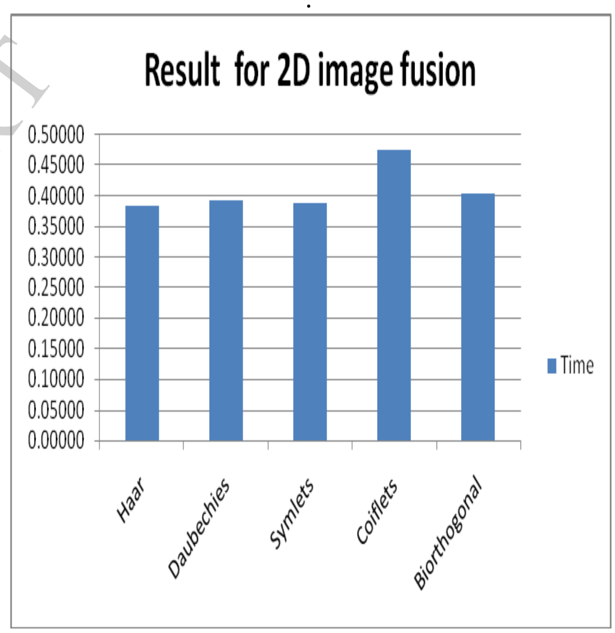

Figure 8. Result graph for 2-D

Results for 3-D-:

So here for 3-D again by taking time as comparison factor same as 2-D we compare all transforms on the various combinations of 3-D images as follows.

Table 2. Results for 3-D

Wavelet name	Time in ms

Haar	0.3547
Daubechies	0.3877
Symlets	0.4649
Coiflets	0.3754
Biorthogonal	0.3930

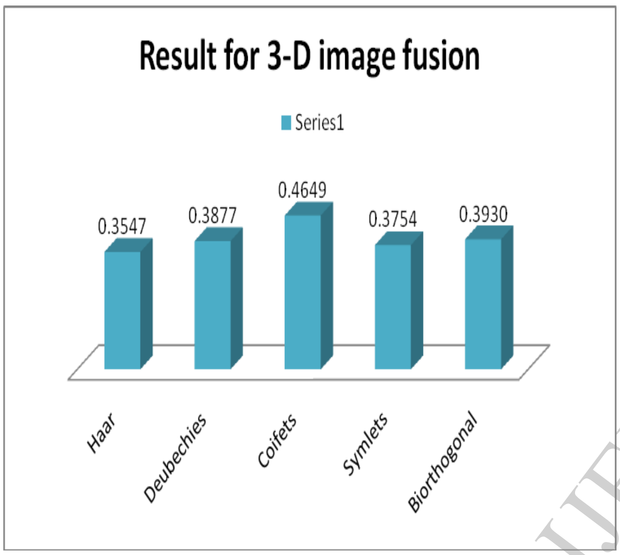

Figure 9. Result graph for 3-D

From the above comparisons we conclude that haar transform required minimum time to give the output than other and Coifets required maximum time so it is not preferable for 3-D wavelet transform.

Conclusion

In this work a new approach to 3-D image fusion using wavelet transform. Several known 2-D WT fusion schemes have been extended to handle 3-D images have been proposed. The goal of this project is to present the new framework for 3-D image fusion using the wavelet transform, rather than to compare the results of the various fusion rules. Wavelet transform fusion diagrams have been introduced as a convenient tool to visually describe different image fusion schemes. A very important advantage of using 3-D WT image fusion over alternative image fusion algorithms is that it may be combined with other 3-D image processing algorithms working in the wavelet domain. So finally I conclude that Haar wavelet is the best for both 2-D as well as 3-D image fusion as per the time response.

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