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Survey on Image Fusion Algorithm

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Abstract

The objective of image fusion is to merge information from two or more images. The image fusion process is used to give a new resultant image which has better information and is more suitable for visual perception. Fusion is mainly to integrate complementary multi-sensor, multi-temporal and/or multi-view information into new fused image. It is used to minimize uncertainty and redundancy in the output while maximizing relevant information particular to an application. Image fusion has been used in many application areas. Multisensory fusion is used to achieve high spatial and spectral resolutions by combining images from two sensors, one of which has high spatial resolution and the other one high spectral resolution in remote sensing areas. The aim of this paper is to give a literature review on various fusion techniques like Principal component analysis, Pyramid method and wavelet based fusion methods. Many researches are going on detecting human skin regions in color image and in video sequence. It is very challenging to recognize a skin and non skin regions from an image. Skin detection is established by using skin modeling and segmentation of skin regions. Image fusion is a new technique which can produce more complete information which is useful for human perceptron and the fusion results can give better color preserve information which is highly useful for detecting skin regions and also applicable for face detection application. The various fusion applications have appeared in medical imaging like simultaneous evaluation of CT, MRI, and/or PET images, military applications like detection, location, tracking and identification of military entities.

Keywords: Image fusion, Types of image fusion

1. INTRODUCTION

The term fusion in general means, an approach to extract information that is in several domains. The image fusion (IF) process is to integrate multisensory or multi-view or multi-focus information into a new image that contains better quality features and is more informative of all the individual input information. Merging of different data/ image is done to improve the visual and analytical quality of the information. It extracts all the useful information from the source images but will not introduce artifacts or inconsistencies which will distract human observers or the following processing. The term quality, and its meaning and measurement depend on the particular application. Image fusion is reliable and robust to imperfections such as misregistration. Image fusion is to combine information from multiple images of the same scene. The result of image fusion is a new image which is more suitable for human and machine perception or further image-processing tasks such as segmentation, feature extraction and object recognition.

2. TYPES OF IMAGE FUSION

In order to achieve optimum fusion results, various wavelet-based fusion schemes had been tested by many researchers. In this review, a few new concepts/algorithms of the above scheme have been discussed.

2.1. Intensity-hue-saturation (IHS) transform based fusion

It is an improved Intensity-Hue-Saturation Method for IKONOS Image Fusion. This technique is used in various applications of remote sensing involves the fusion of panchromatic (Pan) and multispectral (MS) satellite images. The fusion of a panchromatic (Pan) image with a high spatial and low spectral resolution or multispectral (MS) images with a low spatial and high spectral resolution has become a powerful tool in many remote sensing applications that require both high spatial and high spectral resolution, such as feature detection, change monitoring, urban analysis, land cover classification, and recently GIS-based applications.

In general, the IHS fusion method converts a color image from the red, green, and blue (RGB) space into the IHS color space. The intensity (I) band in the IHS space is replaced by a high-resolution Pan image and then transformed back into the original RGB space together with the previous hue (H) band and the saturation (S) band, resulting in an IHS fused image. However the IHS method can be easily implemented by the procedure in which the fused images can be obtained by adding the difference image between Pan and I images to the MS images, respectively. This method is called the fast IHS fusion method.

Steps for obtaining IHS transform fusion image:

- The IHS fusion for each pixel can be formulated.
- The intensity component I is replaced by the Pan image.
- The fused image [F(R); F(G); F(B)]T can be easily obtained from the original image [R;G;B]T simply by using addition operations.

An improved IHS transform effectively transforms an image from the Red-Green-Blue (RGB) domain into spatial (I) and spectral (H,S) information with color distortion reduction. There are various models of IHS transformations available. Smith's triangular model is suitable for IHS sharpening. The multispectral image is transformed from the RGB color space into the IHS domain. The intensity component is replaced by the panchromatic image and then transformed back into the original RGB space with the previous hue and saturation components. The IHS fusion introduces color distortion when dealing with IKONOS images [16].

2.2. Principal Component Analysis (PCA) based fusion

PCA is a mathematical tool which transforms a number of correlated variables into a number of uncorrelated variables. The PCA is used extensively in image compression and image classification. The PCA involves a mathematical procedure that transforms a number of correlated variables into a number of uncorrelated variables called principal components. It computes a compact and optimal description of the data set.

In [7], using PCA algorithm, color components are considered as features from which a representative set is derived. This technique is used to reduce the number of components to a small number of components based on the respective weights of the corresponding Eigen values. An elliptical model classifier is used for classification of skin and non-skin pixels for skin detection.

For face recognition, the important step is to select the features [8]. The most extensively used classifier is principal component analysis which serves two purposes: feature extraction and classification or recognition. It is one of the extensively used classifiers which has low time complexity.

Feature extraction from human faces using PCA [9], proposes facial feature extraction step prior to performing PCA analysis which helps to address two requirements for this system. Firstly, the search for faces does not need to be carried out at every pixel location in the image since a small search space can be obtained using the detected facial feature points. Secondly, the face detection process can be carried out in one cycle over a normalized search space, thereby avoiding the requirement of processing the image at multiple scales.

2.3. MULTI SCALE TRANSFORM BASED FUSION

2.3.1.BROVEY TRANSFORM

Pixel level image fusion is done by using Brovey transform. Brovey performs a transformation using three multispectral and the panchromatic satellite image scene channels. Brovey transform is also called the color normalization transform because it involves a red-green-blue (RGB) color transform method. The Brovey transformation was developed to avoid the disadvantages of the multiplicative method. It is a simple method for combining data from different sensors. It is a combination of arithmetic operations and normalizes the spectral bands before they are multiplied with the panchromatic image. It retains the corresponding spectral feature of each pixel, and transforms all the luminance information into a panchromatic image of high resolution.

2.3.2 HIGH-PASS FILTERING METHOD

High-pass and low-pass filters are also used in digital image processing to perform image modifications, enhancements, noise reduction, etc., using designs done in either the spatial domain or the frequency domain. A high-pass filter, if the imaging software does not have one, can be done by duplicating the layer, putting a Gaussian blur, inverting, and then blending with the original layer using capacity (say 50%) . The unsharp masking, or sharpening, operation used in image editing software is a high-boost filter, a generalization of high-pass filtering scheme.

2.3.3. IMAGE PYRAMID APPROACHES-(PYRAMID METHOD)

An image pyramid consists of a set of low pass or band pass copies of an image, each copy representing pattern information of a different scale. Typically, in an image pyramid every level is a factor two smaller as its predecessor, and the higher levels will concentrate on the lower spatial frequencies. An image pyramid does contain all the information needed to reconstruct the original image.

a) GAUSSIAN PYRAMID

The Gaussian pyramid consists of low-pass filtered, reduced density (i.e., downsampled) images of the preceding level of the pyramid, where the base level is defined as the original image. The technique involves creating a series of images which are weighted down using a Gaussian average and scaled down. When this technique is used multiple times, it creates a stack of successively smaller images, with each pixel containing a local average that corresponds to a pixel neighborhood on a lower level of the pyramid.

b) LAPLACIAN PYRAMID FUSION

Laplacian pyramid (fundamental tool in image processing) of an image is a set of band pass images; in which each is a band pass filtered copy of its predecessor. Band pass copies can be obtained by calculating the difference between low pass images at successive levels of a Gaussian pyramid. In this approach, the Laplacian pyramids for each image component (IR and Visible) are used. A strength measure is used to decide from which source what pixels contribute at each specific sample location. Take the average of the two pyramids corresponding to each level and sum them. The resulting image is simple average of two low resolution images at each level. Decoding of an image is done by expanding, then summing all the levels of the fused pyramid which is obtained by simple averaging. The Laplacian pyramid is derived from the Gaussian pyramid representation, which is basically a sequence of increasingly filtered and down-sampled versions of an image.

The process of face detection is accomplished by using simple and efficient algorithm for multi-focus image fusion called Laplacian pyramid algorithm. Multi-resolution signal decomposition scheme is efficiently used for further

applications like gestures, texture, pose and lighting conditions while taking an image [1].

A kind of fusion approach is highly helpful for applications like Hand Gesture. Hand gestures play a significant role in Human Computer Interaction. They serve as primary interaction tools for gesture based computer control [2].

c) GRADIENT PYRAMID

Gradient pyramid Fusion- the Gaussian pyramid is a sequence of images in which each member of the sequence is a low pass filtered version of its predecessor. Gradient pyramid Fusion method uses Gradient pyramids instead of Laplacian with Gradient pyramids.

d) RATIO OF LOW PASS PYRAMID

Ratio of Low Pass Fusion- Ratio of Low Pass Pyramid is another pyramid in which at every level the image is the ratio of two successive levels of the Gaussian pyramid.

e) CONTRAST PYRAMID

Contrast Pyramid is similar to the ratio of Low Pass Pyramid approach. Contrast itself is defined as the ratio of the difference between luminance at a certain location in the image plane and local background luminance. Luminance is defined as the quantitative measure of brightness and is the amount of visible light energy leaving a point on a surface in a given direction.

f) FILTER-SUBTRACT-DECIMATE FUSION

Filter-Subtract-decimate (FSD) Pyramid technique is a more computationally efficient variation of the Gaussian Pyramid. This is similar to Laplacian fusion, the difference being in using FSD pyramid instead of Laplacian Pyramids.

g) MORPHOLOGICAL PYRAMID FUSION

This method uses morphological pyramids instead of Laplacian or contrast pyramids. Morphological Pyramid- The multi-resolution techniques introduced by Burt and Adelson etc. typically use low or band pass filters as part of the process. These filtering operations usually alter the details of shape and the exact location of the objects in the image. This problem has been addressed by using morphological filters to remove the image details without adverse effects.

2.4. WAVELET BASED METHODS

Wavelet methods are also a way to decompose image into localized scale specific signals. Wavelet transforms are linear and square integrable transforms whose basis functions are called wavelets.

2.4.1. DISCRETE WAVELET TRANSFORM

In the traditional wavelet based fusion once the imagery is decomposed via wavelet transform a composite multi-scale representation is built by a selection of the salient wavelet coefficients. The selection can be based on choosing the maximum of the absolute values or an area based maximum energy. The final stage is an inverse discrete wavelet transform on the composite wavelet representation. Different wavelet transform algorithms have been developed and applied to a variety of applications such as noise suppression, filtering, image restoration, image compression, and astronomical applications.

In wavelet image fusion scheme, the source images I1 (a, b) and I2 (a, b) are decomposed into approximation and detailed coefficients at required level using DWT. The approximation and detailed coefficients of both images are combined using fusion rule f. The fused image could be obtained by taking the inverse discrete wavelet transform (IDWT) as shown in figure 1[21].The fusion rule used simply averages the approximation coefficients and picks the detailed coefficient in each sub band with the largest magnitude

$$I(a,b) = \frac{DWT\{I1(a,b) + I2(a,b)\}}{2}$$

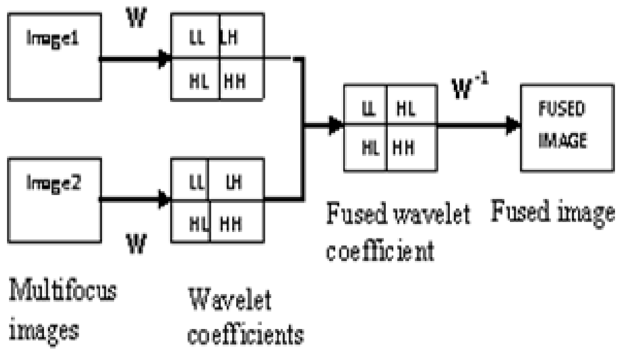

Figure.1 Discrete wavelet Transformation

The developed DT-CWT fusion techniques provide better quantitative and qualitative results than the DWT at the expense of increased computation. The DT-CWT method is able to retain edge information without significant ringing artifacts. It is also good at faithfully retaining textures from the input images. All of these features can be attributed to the increased shift invariance and orientation selectivity of the DT-CWT when compared to the DWT.

The discrete wavelet transform has a huge number of applications in Science, Engineering, Mathematics and Computer science. Most notably, it is used for signal coding, to represent a discrete signal in a more redundant form, often as a preconditioning for data compression. Practical applications can also be found in signal processing of accelerations for gait analysis in digital communications

Non-traditional methods for detecting human faces within color images or video frames [3] were proposed. A scheme is introduced for skin segmentation to prepare the input image for feature extraction. The methods used here are DCT and DWT. The wavelet sharpened images have a very good spectral quality.

Image steganography is presented in [5] that uses skin portion of an image in DWT domain for embedding of secret data. Embedding of secret data in only skin region enhances the security. Cropping also helps to maintain level of security because without the value of cropped region the message cannot be extracted. The proposed method will provide better performance in terms of PSNR.

The author proposed a framework based on steganography that uses Biometric feature i.e. skin tone region. Skin tone detection plays a very important role in biometrics and can be considered as secure location for data hiding. Secret data embedding is performed in DWT domain than the DCT as DWT outperforms DCT [6].

2.4.2. STATIONARY WAVELET TRANSFORMS

The Stationary wavelet transform (SWT) is a wavelet transform algorithm designed to overcome the lack of translation-invariance of the discrete wavelet transform (DWT). Translation-invariance is achieved by removing the downsamplers and upsamplers in the DWT and upsampling the filter coefficients by a factor of $2^{(j-1)}$ in the j^{th} level of the algorithm. The SWT is an inherently redundant scheme as the output of each level of SWT contains the same number of samples as the input – so for a decomposition of N levels there is a redundancy of N in the wavelet coefficients. A few applications of SWT are Signal de-noising, Pattern recognition etc

2.4.3. MULTI WAVELET TRANSFORM

Multi-wavelets have the capability of possessing properties such as orthogonality, symmetry, short support and higher approximation order simultaneously. So, they seem to be very good candidate for de-correlation in compression process.

The wavelets-based approach is appropriate for performing fusion tasks for the following reasons:

- It is a multi-scale (multi-resolution) approach well suited to manage the different image resolutions. In recent years, some researchers have studied multi-scale representation (pyramid decomposition) of a signal and have established that multi-scale information can be useful in a number of image processing applications including the image fusion.
- The discrete wavelets transform (DWT) allows the image decomposition in different kinds of coefficients preserving the image information. Such coefficients coming from different images can be appropriately combined to obtain new coefficients, so that the information in the original images is collected appropriately.
- Once the coefficients are merged, the final fused image is achieved through the inverse discrete wavelets transform (IDWT), where the information in the merged coefficients is also preserved.

2.4.4. CURVELET TRANSFORM

Curvelets are a non-adaptive technique for multi-scale object representation. It is an extension of the wavelet concept. Multi-resolution methods are deeply related to image processing, biological and computer vision, scientific computing, etc. The curvelet transform is a multi-scale directional transform, which allows an almost optimal non-adaptive sparse representation of objects with edges. It has generated increasing interest in the community of applied mathematics and signal processing over the past years. A multi-resolution geometric analysis (MGA), named curvelet transform, was proposed in order to overcome the drawbacks of conventional two-dimensional discrete wavelet transforms. In the two-dimensional (2D) case, the curvelet transform allows an almost optimal sparse presentation of objects with C^2-singularities. Combined with other methods, excellent performance of the curvelet transform has been shown in image processing[19].

Discrete Cosine Transformation

The other important transformations being used by researchers is DCT. Two dimensional DCT is used for extracting features of human face and main usage of DCT is for data compression. In addition the extracted features can be used for recognizing facial expression.

The new method of detection proposed in this system is based primarily on a technique of automatic learning by using the neural networks MLPs and a technique of compaction of energy by using the discrete cosine transform DCT. The DCT has a very great effectiveness in terms of compaction of energy, it makes it possible to store a maximum of information in a minimum of coefficients located low frequency and each time that one goes down again towards the high frequencies there will be a degradation of information. This makes it possible to eliminate the coefficients having relatively small amplitudes without presenting a deformation of the characteristics of the image [4].

3 .CONCLUSION

It has been found that the standard fusion methods perform well spatially but usually introduce spectral distortion. To overcome this problem, numerous multi-scale transform based fusion schemes have been proposed. Due to the numerous multi-scale transform, different fusion rules have been proposed for different purposes and applications.

For methods like HIS, PCA and Brovey transform, which have lower complexity and faster processing time, the most significant problem is color distortion. Wavelet-based schemes perform better than those methods in terms of minimizing color distortion. The development of more sophisticated wavelet-based fusion algorithms (such as Ridgelet, Curvelet, and Contourlet transformation) could improve performance result, but they often cause greater complexity in computation and parameters setting.

Image quality can be evaluated by means of quantitative measures like Root mean square error (RMSE) Entropy, standard deviation and so on. It is necessary to evaluate metrices for combining images without introducing some form of distortion.

Detecting human skin regions in color image is a difficult task. Image fusion is a new technique which can produce more complete information even in poor background and the fusion technique can give better color preserve information which is highly useful for detecting skin regions and also applicable for face detection application. Image fusion techniques may improve accuracy and robust property of human skin detection but it may produce localization error and matching error.

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