An Overview on Image Fusion Concept

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Abstract*—Image fusion has been a very popular research area for researchers. Image fusion is a technique for merging the information or data from two or more different source images that generates useful information for human visual perception. Fused images are more informative then original images. It's a very challenging task to focus on the particular area of unclear defocused images and to remove the blurring problem from that. In this paper, all popular terminologies and techniques are discussed to understand the basic concept of image fusion and looks into various techniques for future research. this paper is divided into 9 sections the first part is introduction that talks about what is image fusion and why it is important in the second part process of image fusion is discussed then in the third section pre-processing of image fusion is discussed in the forth section image fusion types are discussed then in the fifth section various application of image fusion are discussed in the sixth section image fusion is classified into various categories and in the seventh section various methods for image fusion are discussed the eight section is conclusion and future scope and finally in the ninth section references are given.

Keywords*— Image fusion, Multi-focus image fusion, spatial domain, Transform domain.

1. INTRODUCTION

Image fusion is a process of combining two or more than two images [1] from single or multiple modalities to get the useful information/data and to improve the image quality. Quality may be in terms of pixel or resolution. In other words, Image fusion is the simple process to integrate the useful information/data from two or more images of the same scene to get the resultant information because the resultant image will be more suitable for human perception. Image fusion techniques may be applied on different images like black and white images, gray image, infrared images, general images [2] and colour images.

Image fusion is one of the best applications in image processing and fused images having more and more information for user point of view. If we compare these images then it could be more informative. Fused image has complimentary spatial, spectral resolution. Image fusion is widely used in remote sensing, computer vision, medical imaging, microscopic imaging and robotics etc.

Generally there are two types of vision first is human vision and second computer vision. Human vision is refined system that acts on visual stimuli. It has been developed for number of years, primarily for survival or defence. Computer vision system needs a specific camera, a camera's interface and a computer. A feature closely related to image quality is in terms of image focus. Sharp and clear images generate useful information and this particular information would be better than blurry or uncleared images. However, in few environments it is very difficult to get totally focused images in just a single camera shot, since few regions appear to be blurred due to change in the depth of the scenario and of the camera lenses focus. This means that if the camera is currently focused at one side of the specific object, another region of the scene can be out of focus. An interesting solution is to take more pictures of the desired landscape in the same position, yet with focus centred in various elements of the scenery. Using the image fusion concept, lots of source images are exactly combined and then creating a single image having better focused regions. With the passage of time Image fusion is becoming extremely popular in the area of digital image processing. The prime object of any image fusion algorithm is to collect all the necessary human visual information from many multiple input images so that the informative image contains more complete and accurate information than the individual source images, without introducing any extra facts or information.[3][4][5]

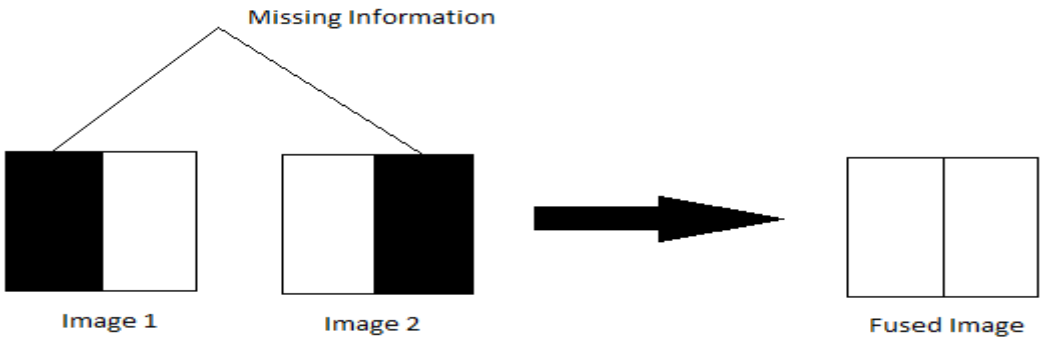

Fig. 1 Basic Concept of image fusion

2. PROCESS OF IMAGE FUSION

2.1 Single Sensor image fusion

In Single sensor image fusion technique a specific sequence of images are taken by the single sensor. The graphical representation of single sensor image fusion scheme is presented in this following figure

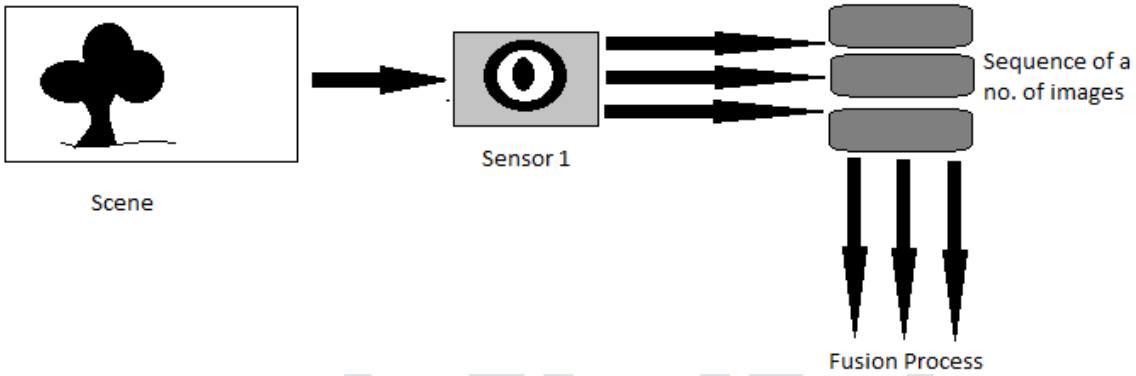

Fig. 2 Single Sensor image fusion

In this various images are taken by the single sensor and then this sequence of images are fused together to generate a new image with more information materials. The disadvantages of systems lies behind the limitations of the imaging sensor that is being used.[8] The environment under which the system can operate or generate the dynamic range, and resolution, etc. These all are restricted by the competency of the single sensor image fusion.

2.2 Multi Sensor image fusion:-

In this , large length of sequence of images captured by more than one sensor or it may be performed by multiple sensor. A multi-sensor image fusion scheme eliminates the particular limitations of a single sensor fusion by the help of merging the images from various sensors to form a good image.[9]

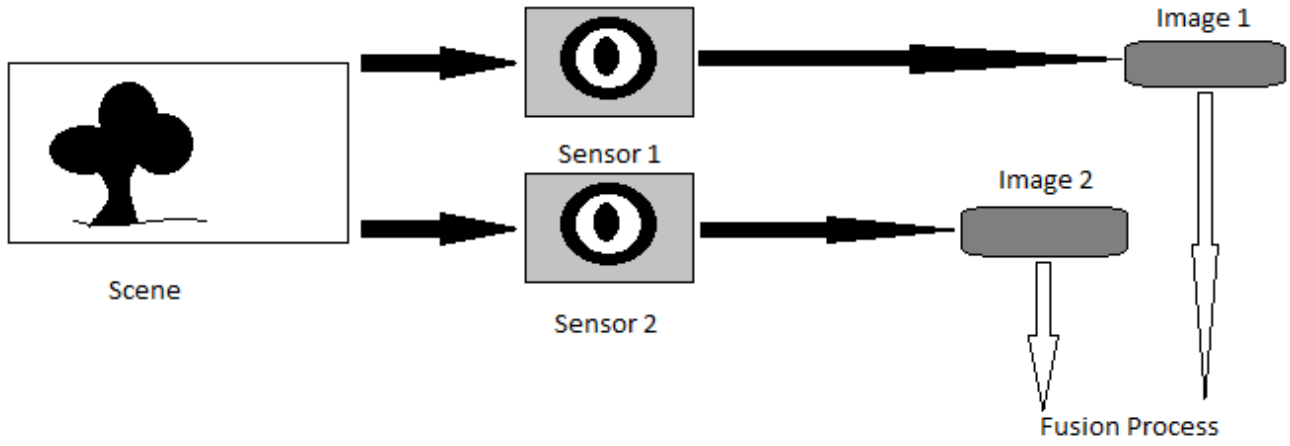

Fig. 3 Multi Sensor image fusion

Multi-sensor image fusion provide many benefits including Robust system performance, improved reliability, extended range of operations etc. [10]

3. PRE PROCESSING OF IMAGE FUSION

In pre-processing, various images can be taken at various angles of same scene sometimes it may cause distortion then out of those images best quality images are selected for fusion after that selected images are registered with the image fusion software. At this stage of fusion, we have to ensure that each and every image pixel at correlated images contain some connection between these images to solve and fix the unknown problem of distortion; By this way two images or more than two images having same scene may register side by side with the help of fusing software to bind multiple control points. After registration process, re-sampling is done to coordinate every image that is about to combine (fuse) to the exact similar dimension. After completing it, every image would be of the similar size. Many interpolation approaches can be used for doing this. After completing re-sampling progress, fusion algorithm will be applied to further process. One of the popular techniques of image fusion is pixel by pixel fusion. Same size images make the fusion process easy. Occasionally we have to change or transfer the fused image into different domain to check the scalability and if it is no required then we have not depending on that algorithm. Transform domain is very important and in transform domain, inverse transfer is necessary if image has been transferred into different domain. Fig.4 demonstrates the various steps used in image fusion pre-processing. So pre-processing is just a ordinary process in between the progress of image enhancement.[11-13]

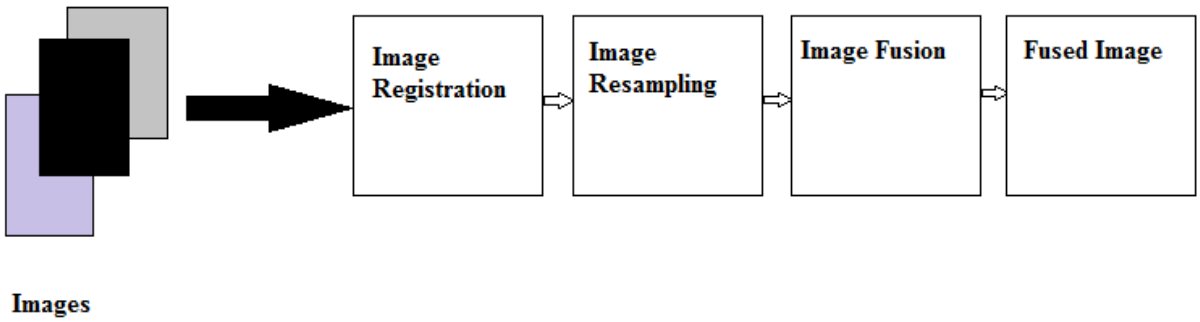

Fig.4 Basic Concept of image fusion

4. TYPES OF IMAGE FUSION

4.1 Multi-focus image fusion:-

Different images of same scene can have focus in different areas of image. So the goal of Multi-focus fusion [16][22] is that Image everywhere should be in focus and the objective is to identify the regions in focus and merge them together. This multi focus can be work on blurring problem of right side of the image and another blurring of left side of the image. After that fused image will be having all features of an original image.

4.2 Multi-Modal image fusion:-

Through different sensors, an image's multimodal fusion rises, that can be called through visible and infrared [26], CT and NMR, or panchromatic and multispectral satellite images. An image may be of any modality like PET, CT, MRI, visible, infrared, ultraviolet, etc. The ultimate objective is to reduce the amount of data and to accentuate band-specific data. Multi-modal image fusion has the capability of merging multiple images that may be from single or multiple imaging modalities, to enhance the imaging quality by preserving some correlated detailed features. Multimodal image fusion evolved from the multiple sensors (like visible and infrared, CT and NMR, or panchromatic and multispectral satellite images). [14][4]

4.3 Multi-Temporal image fusion:-

The two main purposes of using the multi-temporal image fusion is; first is to find and evaluate changes between the images of the same scene taken at different times and second is to obtain good visual quality image. Generally Multi-temporal image fusion algorithms are based on subtraction tricks

4.4 Multi-View image fusion:-

Multi-view fusion of images from the same modality and it can be taken at the same time but from different viewpoints.

Images of the same modality, taken at the same time but from different places or under different conditions

The main objective of multi-view is to supply complementary data from different views. Multi-view image fusion improves resolution in three-dimensional microscopy. It gives a non-blind, shift-invariant image processing technique that fuses multi-view three-dimensional image data sets into a single, high quality three-dimensional image. Multi view fusion of images is taken from the same modality and at the same time but from different viewpoints.[15]

4.5 Multi-Resolution image fusion:-

It's just a biologically inspired conceptually method which fused images at different spatial resolutions. It is very similar to the human visual system. This particular fusion approach operates by decomposing the input images into a resolution pyramid of numerous levels.

4.6 Multi-spectral image fusion:-

In this, fusion process performed at low level and provides a fused image in the spatially enhanced form which contains some rich and complimentary information.

5. APPLICATION OF IMAGE FUSION

Image fusion has wide range of applications in many areas from satellite images [16] to medical images.

5.1 ***Medical Imaging:-*** Image fusion has a big role in medical diagnostics. In this multiple images of a patient are taken and merged or overlaid to provide additional information. Final fused images can be created from multiple images from the same imaging modality, or by combining information from multiple modalities, such as magnetic computed tomography (CT), resonance image (MRI), single photon emission computed tomography(SPECT) and positron emission tomography (PET). In radiation oncology and radiology, these images serve different purposes. For example, CT images are used more often to ascertain differences in tissue density while MRI images are typically used to diagnose brain tumours. [17]

5.2 ***Remote sensing imaging:-*** In remote sensing applications, the increasing possibility of space borne sensors provides a large motivation for various image fusion algorithms.[18] Several situations in image processing require high spatial and high spectral resolution in a single image. Most of the available equipment is not capable of providing such data convincingly. Image fusion techniques allow the integration of different information sources. The fused image can have complementary spatial and spectral resolution characteristics. However, the standard image fusion techniques can distort the spectral information of the multispectral data while merging.

Image fusion in remote sensing has several application domains. An important domain is the multi-resolution image fusion (commonly referred to pan-sharpening). In satellite imagery we can have two types of images as below:-

- ***Panchromatic images: -*** An image collected in the broad visual wavelength range but rendered in black and white.
- ***Multispectral images****:* - Images optically acquired in more than one spectral or wavelength interval. Each individual image is usually of the same physical area and scale but of a different spectral band.

6. CLASSIFICATION OF IMAGE FUSION

6.1 ***Pixel Level Fusion:-*** Pixel/ Data level fusion is the couple of raw data from various sources into individual resolution of data, that are much more expected and to be extra large informative and synthetic than either of the input data or show the changes between data sets acquired at different times. Pixel level fusion works on raw data or pixel level data.

6.2 Feature Level Fusion:-

Feature level fusion cited various features those are edges, corners, lines, texture parameters etc., from various data sources and then just merge them into one or more feature maps that may be used instead of the original data for further processing. It is used as input to pre-processing for image segmentation or change detection. Features level fusion works on the features of image objects and it may change with the development of images.

6.3 Decision Level Fusion:-

Decision level fusion combines the result from various algorithms to produce a final fused decision. When the results comes from other algorithms are totally expressed with the confidences rather than decisions, it can be called as a soft fusion. Otherwise it will be hard fusion. All explored methods of decision fusion comprise voting methods, statistical methods and fuzzy logic based methods. [19][5]

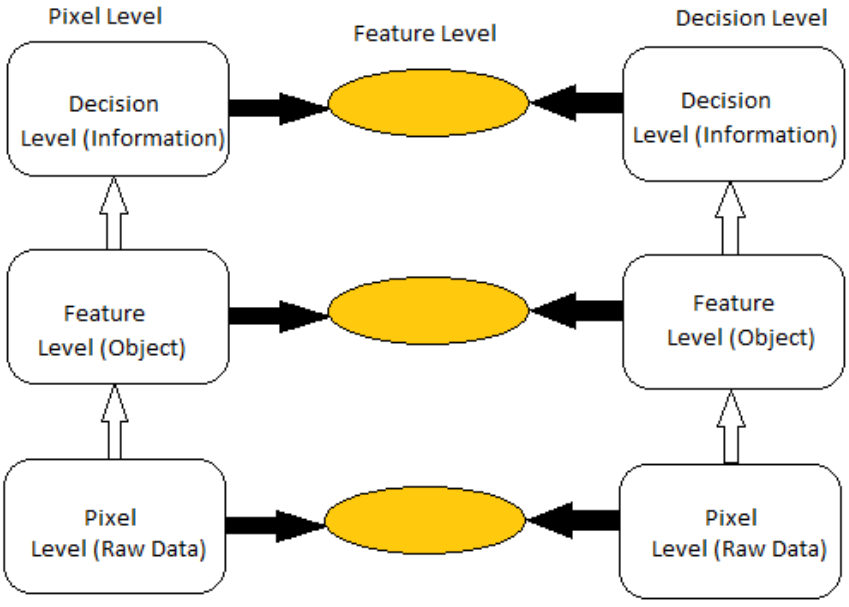

Fig.5 Level of image fusion

7 METHOD OF IMAGE FUSION

7.1 Spatial Method:-

Spatial domain deals with the pixels of image that can be intensity values. The pixel values are manipulated/changed to get the desired result. The value of the image (pixels) may be changed with respect to scene. There are various methods for calculation of correct pixel value such as averaging of neighbouring pixels taking median of the neighbouring pixels etc. If scenes are changed then features of images may be converting. If we compare between spatial and frequency domain then in frequency domain, we deal with the rate at which the pixel values are changing in spatial domain. Various methods are used in spatial domain[20][7] for calculating the correct pixel value some of the popular methods are-1.Averaging (Average Method), 2. Brovey methods, 3. Principal component analysis (PCA), 4.Intensity Hue Saturation (IHS), 5. Weighted pixel Averaging (Weighted), 6. Select Max/Min Method etc.

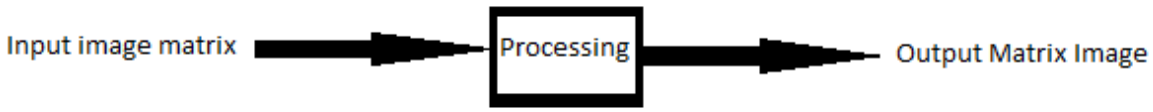

Fig.6 Basic Process of Spatial Domain

7.2 Transform Method:-

We have been dealing with images in multiple domains. Now we are processing signals (images) in transform (frequency) domain. Since this Fourier series and frequency domain is purely mathematics, so we will minimize the focus from the mathematical part and focus on its use in Digital Image Processing.

Transform domain method mainly deals with the frequency of an image. Where first an image is converted into frequency domain and then after applying certain operations in frequency domain resultant image is again converted into spatial domain. Digital wavelet transformation is one of the most popular transform domain method which transforms any image in four parts; one of which is low frequency component (known as approximation part that defines the appearance of an image) and three of them are high frequency components (known as detailed part that shows the proper structure (Corner and Edges) of the image.).[21-23]

The general process of transform domain can be understood from the following figure.

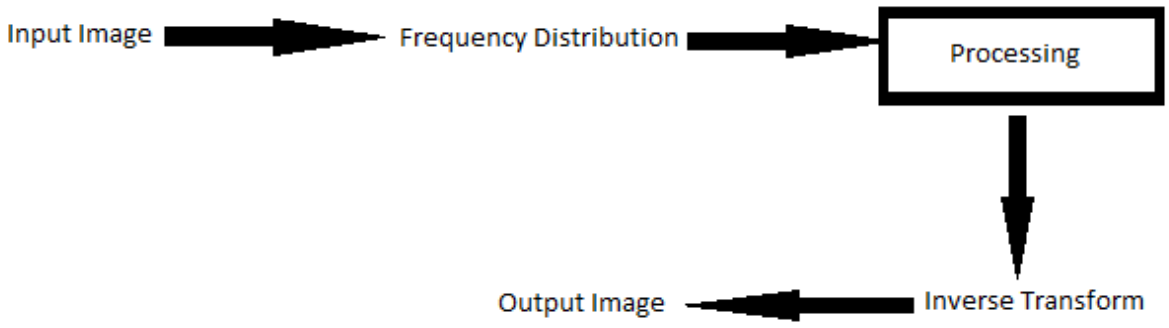

Fig.7 Basic Process of Transform Domain

8 CONCLUSION AND FUTURE SCOPE

Image plays a great role in many fields. Sometimes it is not possible to diagnose properly if the image is not of good quality. So here comes the role of computer discipline called image processing so the goal is to improve the quality of image using different techniques of image processing. This techniques can broadly be

divided into categories like image denoising ,image fusion in image denoising we improve the quality of single image using some image processing technique while in image fusion two or more images are combined together to give a good quality image that is good for human perspective. Satellite imaging and medical imaging are the two most popular and important fields where image fusion techniques are repetitively used. This paper talks about some of the techniques and terms used in the image fusion briefly. In future some image fusion algorithm can be proposed and implemented that gives good quality image.

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