Image Fusion Algorithm Implementation Using Laplacian Pyramid

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Abstract* - This Paper represents an approach to implement image fusion algorithm i.e. Laplacian Pyramid. Image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images. The ImFuse tool kit now looks into considering the basic idea is to perform a pyramid, decomposition on each source image and finally reconstruct the fused image by performing an inverse pyramid transform. It offers benefits like resolution, S/N ratio (Signal to Noise Ratio) and pixel size. The aim of image fusion, a part 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 Based on this technique finally it reconstructs the fused image from the fused only two input images to be used. An option to load and fuse more than two input images at the same time can also be easily incorporated into the project. An option could be provided to the user on to select the number of input images available. Image Registration has not been incorporated in the work. Image registration, image alignment will certainly enhance the efficiency of the project as vast set of even unregistered images can be considered as set of input image. It would also help in possibility of more set of sample test images made available for assessing the image fusion algorithms.

***Keywords:* Image fusion, lap_fus, Laplacian Pyramid, Multi sensor image fusion, Signal to Noise Ratio, Single sensor image fusion.**

I. INTRODUCTION

The developments in the field of sensing technologies multi sensor systems have become a reality in a various fields such as remote sensing, medical imaging, machine vision and the military applications for which they were developed [6]. The result of the use of these techniques is an increase of the amount of data available. Image fusion provides an effective way of reducing the increasing volume of information while at the same time extracting all the useful information from the source images [3] [4]. Multi-sensor data often presents complementary information, so image fusion provides an effective method to enable comparison and analysis of 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 air craft in poor visibility Multi sensor images often have different geometric representations, which have to be transformed to a common representation for fusion [5].

This representation should retain the best resolution of sensor [10]. A prerequisite for successful in image fusion is the alignment of multi-sensor images. However, image fusion does not necessarily provide multi-sensor sources, there are interesting applications for both single-sensor and multi-sensor image fusion [6].

Image Fusion is the Process that combines information from multiple images of the same scene [9]. The Result of Image Fusion is a new image that retains the most desirable information and characteristics of each input image [3]. The main application of image fusion is merging the gray level high resolution panchromatic image and the color low resolution Multi spectral image. It has been found that the standard fusion methods perform well spatially but usually introduce spectral distortion. To overcome this problem numerous multi state transform based fusion schemes have been proposed. In image Fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more enhanced that any of the input images.

The Concept of image fusion has been used in wide variety of applications like medicine, remote sensing, machine vision, automatic change detection and biometrics etc. [6]. With the emergence of various image capturing devices; it is not possible to obtain an image with all the information. Image Fusion helps to obtain an image with all the information. Image fusion is a concept of combining multiple images into composite products, through which more information than that of individual input images can be revealed.

II. SINGLE SENSOR IMAGE FUSION SYSTEM

A single sensor image fusion system is shown in Figure 2.1 the sensor shown could be a visible-band sensor such as a digital camera. This sensor captures the real world as a sequence of images. The sequence is then fused in one single image and used either by a human operator or by a system to do some task. For example in object detection, a human operator searches the scene to detect objects such intruders in a security area maintaining the Integrity of the Specifications. In single sensor image fusion system only one sensor is used between one object to the different sequences. But in case of multi sensor image fusion system more than one sensor is used between object and different sequences. At the same time the multi sensor image fusion system is more complex rather than single sensor image fusion system.

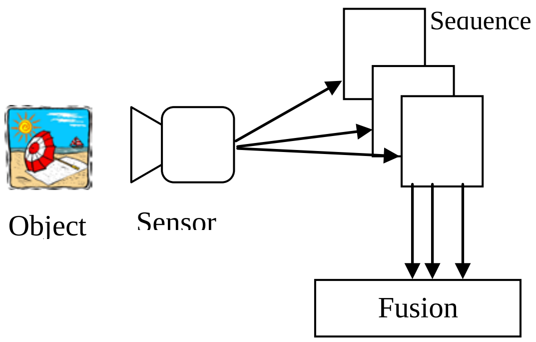

Fig. 2.1 Single Sensor Image Fusion System

The shortcoming of this type of systems lies behind the limitations of the imaging sensor that is being used.the single sensor image fusion system is less complex as compared to multi sensor image fusion system. Single sensor systems has some limitations due to capability of the imaging sensor that is being used.

III. MULTI SENSOR IMAGE FUSION SYSTEM

Figure 3.1 shows an illustration of a multi-sensor image fusion system.

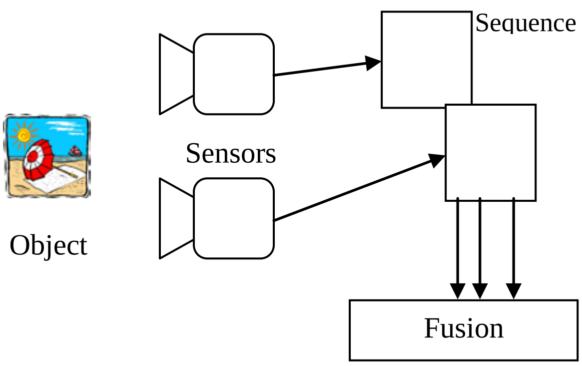

Fig. 3.1 Multi Sensor Image Fusion System.

In this case, an infrared camera is being used the digital camera and their individual images are fused to obtain a fused image. This approach over comes the problems referred to single sensor image fusion system, while the digital camera is appropriate for daylight scenes, the infrared camera is suitable in poorly illuminated ones. The Multi sensor image fusion system overcomes the limitations of a single sensor image fusion system by combining the images from these sensors to form a fused image.

The multi-sensor image fusion systems include several benefits like:

i) Extended spatial and temporal coverage–joint information from sensors that differ in spatial resolution can increase the spatial coverage.

ii) Extended range of operation–multiple sensors that operate under different operating conditions can be deployed to extend the effective range of operation.

iii) Increased reliability–the fusion of multiple measurements can reduce noise and therefore improve the reliability of the measured quantity.

iv) Reduced uncertainty–joint information from multiple sensors can reduce the uncertainty associated with the sensing or decision process.

v) Robust system performance–redundancy in multiple measurements can help in systems robustness. In case one or more sensors fail or the performance of a particular sensor deteriorates, the system can depend on the other sensors.

vi) Compact representation of information–fusion leads to compact representations. For example, in remote sensing, instead of storing imagery from several spectral bands, it is comparatively more efficient to store the fused information.

IV. FUSION TECHNIQUES

The important issue for image fusion is to determine how to combine the sensor images. In recent years, several image fusion techniques have been proposed [1]. The important fusion schemes perform the fusion right on the Source images. One of the simplest of these image fusion methods just takes the pixel-by-pixel gray level average of the source images. This simplistic approach has disadvantage such as reducing the contrast. With the introduction of pyramid transform, it was found that better results were obtained if the fusion was performed in the transform domain. The pyramid transform appears to be very useful for this purpose. The basic idea is to perform a multi resolution decomposition on each source image ,then integrate all these decompositions to form a composite representation, and finally reconstruct the fused image by performing an inverse multi-resolution transform [7].

Several types of pyramid decomposition or multi-scale transform are used or developed for image fusion such as

Laplacian Pyramid, with the development of wavelet theory, the multi-scale wavelet decomposition has began to take the place of pyramid decomposition for image fusion [5]. For all the image fusion work demonstrated in this thesis, it has been assumed that the input images must be of the same scene, i.e., the fields of view of the sensors must contain a spatial overlap. Again the input images are assumed to be spatially registered and of equal size as well as equal spatial resolution.

V. LAPLACIAN PYRAMID

Image pyramids have been described for a multi-resolution image analysis as a model for the binocular fusion for human vision. An image pyramid can be described as collection of low or band pass copies of an original image in which both the band limit and sample density are reduced in regular steps [19].

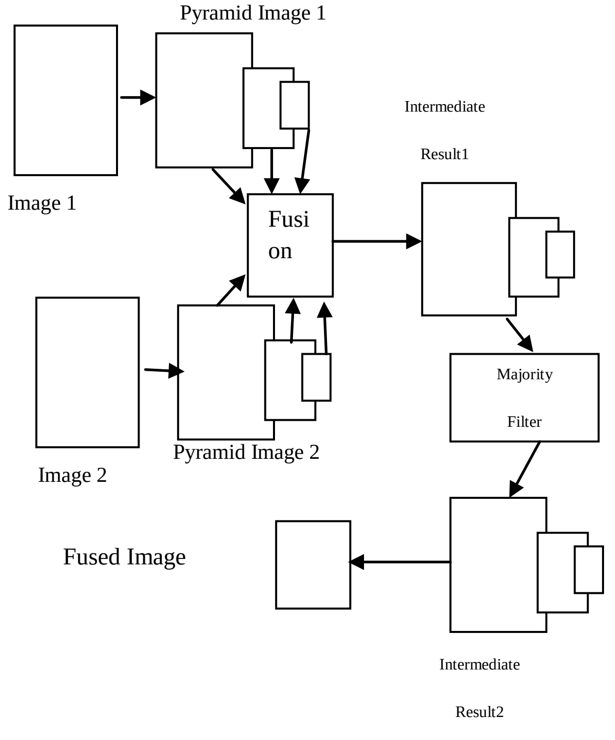

Fig.5.1 laplacian pyramid fusion method.

The Laplacian Pyramid implements a “pattern selective” approach to image fusion, so that the composite image is constructed not a pixel at a time. The basic idea is to perform a pyramid decomposition on each source image, then integrate all these decompositions to form a composite representation, and finally reconstruct the fused image by performing an inverse pyramid transform.

Laplacian Pyramid used several modes of combination, such as selection or averaging [10]. In the first one, the combination processes selects the component pattern from the source and copy it to the composite pyramid, while discarding the less pattern. In the second one, the process averages the sources patterns. This averaging reduces noise and provides stability where source images contain the same pattern information.

VI. LAPLACIAN PYRAMID IMPLEMENTATION

The function lap_fus was implemented in MATLAB to perform the Laplacian fusion.

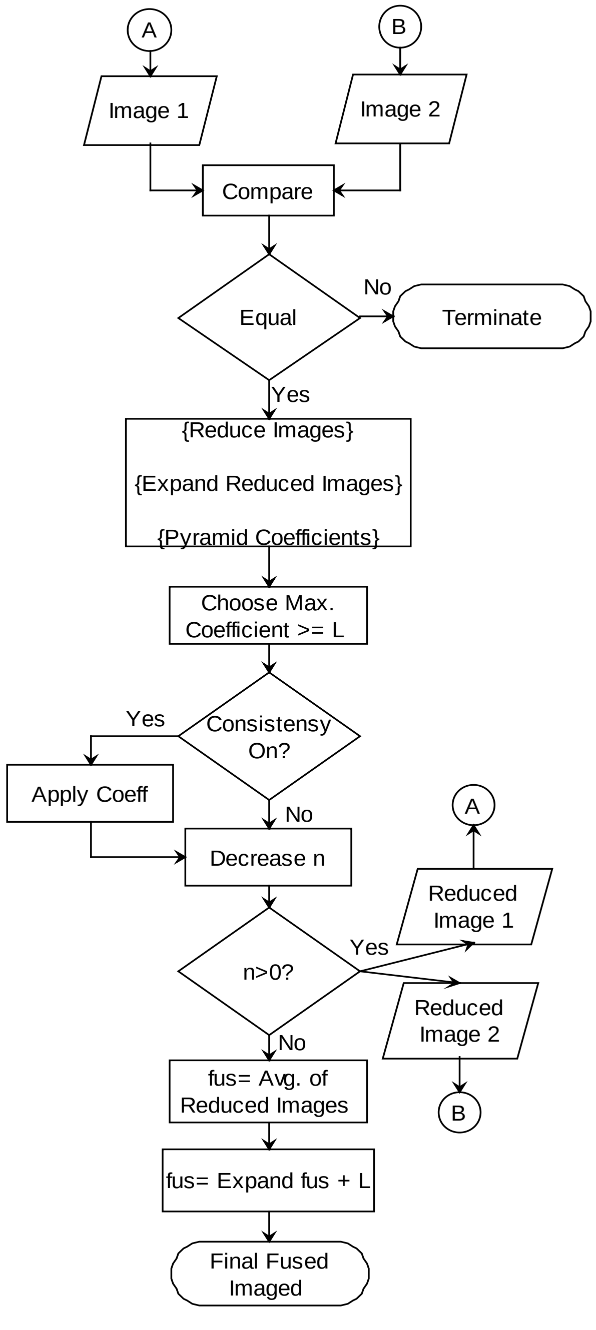

Fig. 6.1 lap_fus implementation flow chart

The input arguments of this function are:

Source images (image1, image2): must have the same size, and are suppose to register.

Number of scales (ns): is an integer that defines the number of pyramid decomposition levels.

Consistency check: logical variable, the consistency checking is applied if its value is'1'.

As shown in the flow chart, to implement these image fusion firstly to perform the pyramid decomposition on each source image then the wavelet coefficients are generated like LL, LH, HL,HH In both cases, the wavelet coefficient LL is very small so by performing the filtering operation LL is removed. Then remaining wavelet coefficients are LH,HL,HH Before fusion the wavelet coefficients of first image i.e. LH,HL,HH are compare with wavelet coefficients of second image i.e. LH,HL,HH then integrate all these decompositions to form a composite representation and finally reconstruct fused image by performing inverse pyramid transform.

VII. EXPERIMENTAL RESULTS

Image Fusion is the process of combining two or more images into a single image, for that purpose by combining magnetic resonance image and positron emission computed tomography. Magnetic resonance images are the images of muscles and positron emission computed tomography images are the images of scanning of brain waves. Figure 6 shows the fused image by combining both structural images and functional images. Here structural images describe the size, shape and integrity of the structures and functional images describe the changes in the blood flow.

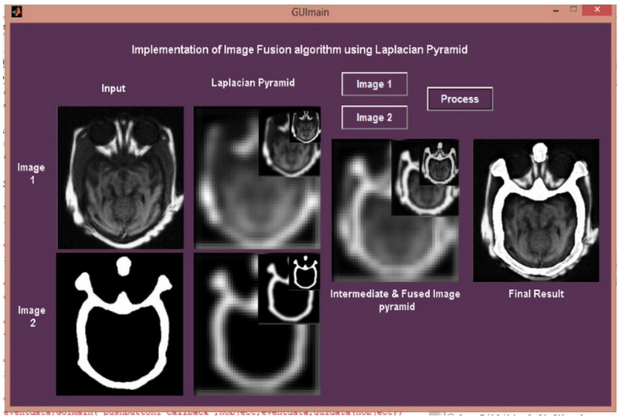

Figure 6: Image fusion is implemented using MRI and PET images

Figure 7 shows two different characteristics of the input images the first input image of the first part shows light back ground and second part of the input image shows more background. Similarly the second input image of the first part shows more back ground and second part of the input image shows light back ground. By combining both images using Laplacian pyramid its results fused image that type of Resultant image shows more resolution rather than that of the both input images.

Figure 7: Image fusion is implemented on different characteristic images

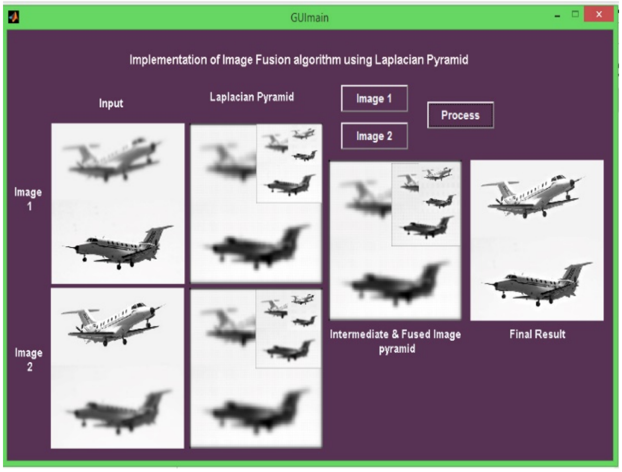

Figure 8: Image fusion is implemented on two refocused images

Figure 8 shows two input images one part of the first input image is light back ground and second part of the input image is more back ground. Similarly the first part of the second input image is more back ground and second part of the second input image is light back ground. By combining two input images and applying Laplacian pyramid transform to form fused image and that resultant image is more back ground as compared to the both input images.

VII. CONCLUSIONS

Image fusion algorithm has been implemented using MATLAB. There is also different image fusion techniques were carried out of which Laplacian Pyramid method gives better results rather than Gaussian Pyramid etc. For this purpose some psycho visual tests were carried out, where a group of individuals express their subjective preferences between couples of images obtained with different fusion methods and also Some psycho visual tests were carried out, where a group of individuals express their subjective preferences between couples of images obtained with different fusion methods Using MATLAB.

The Image Fusion quality has been assessed based on optical image sets with respect to a perfect image. The efficiency of the fusion can be better assessed if the same could be performed on many more multi variant images. The same could not be done due to lack of such set of test sample multi variate images. The ImFuse Toolkit now looks into considering only two input images to be fused. An option to load and fuse more than two images at the same time can also be easily incorporated into the project. An option could be provided to the user on to select the number of input images available.

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