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CONTRAST ENHANCEMENT OF IMAGES USING IMAGE FUSION BASED ON LAPLACIAN PYRAMID

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Abstract — *The goal of contrast enhancement is to improve visibility of image details without introducing unrealistic visual appearances or unwanted artefacts, this article presents a fusion-based contrast enhancement technique i.e. LAPLACIAN PYRAMID. 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. The image is created after the fusion is more suitable for image processing task such as segmentation, object recognition, its main application in remote sensing, medical imaging, military and law enforcement, intelligent robots.*

Keywords*-Contrast enhancement;image fusion; Laplacian pyramid; Gaussian pyramid; Histogram Equalization.*

I. INTRODUCTION

Image fusion is the process of combine the information two images. Image fusion provides an effective way of extracting all the useful information from the source images. In the process of image acquisition the image quality is depend upon the focal length or focus of the optical systems. If the lens focusing is poor then we get the blurred image. Also it is not possible us to focus all the object in scene equally. So the fusion technique is essential to create image which contains all the objects are in focus from two or more images. Image fusion can be done using single sensor and multi sensor. 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.

The limitations in image acquisition and transmission systems can be remedied by image enhancement. Its principal objective is to improve the visual appearance of the image for improved visual interpretation or to provide better transform representation for subsequent image processing task (analysis, detection, segmentation, and recognition). Removing noise and blur, improving contrast to reveal details, coding artefact reduction and luminance adjustment are some examples of image enhancement operations.

This paper represents an approach for contrast enhancement where, we take two images of the same scene, one from digital camera and second from infrared camera, and then fuse them to obtain fused image, which is more better than the previous one.

II. MULTI- SENSOR IMAGE FUSION SYSTEM

In multi sensor image fusion systems images are taken from two different sensors and then fused in one single image. So that it overcome the limitation of single sensor image fusion systems. In single sensor image fusion systems we takes sequence images and combine them to form fused image. But it is suitable only for daylight condition and not for night situation or in poor illumination. This drawback is overcome in multi sensor image fusion systems [3]. In this system we can take two images of the same scene from two different sensors. In this thesis we are using one is digital camera and other is infrared camera. Digital camera is useful for daylight condition and infrared camera is useful for poor illumination or night condition. 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. Fig.1 shows an illustration of a multi-sensor image fusion system.

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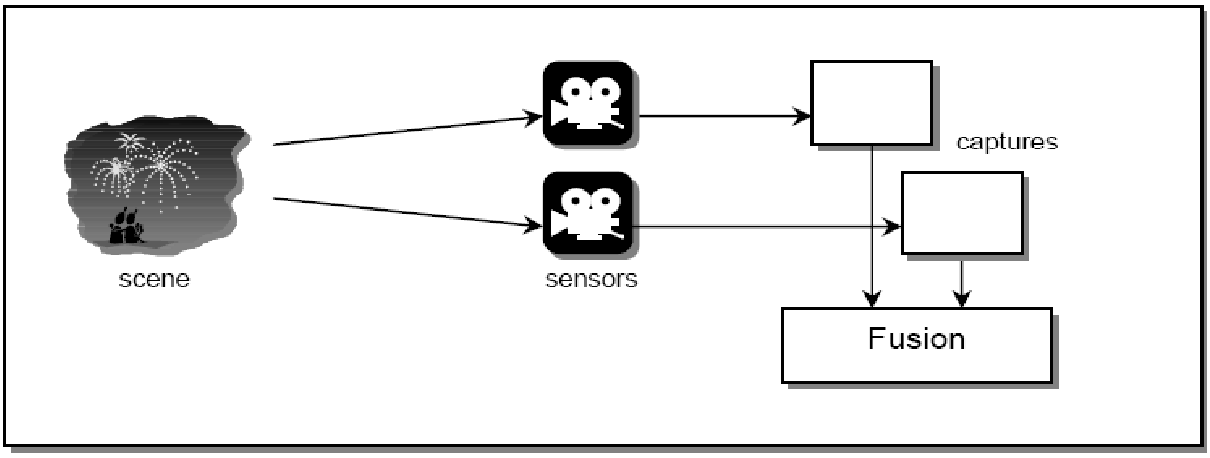

Fig.1 Multi -Sensor Image Fusion System

III. FUSION METHODS

In recent years, several image fusion techniques have been proposed. Image fusion algorithms can be categorized into different levels : The pixel level, feature level and symbolic levels. The pixel-level method works in the spatial domain, such as averaging, the Brovey method, principle component analysis (PCA), and IHS based methods fall under the spatial domain approaches,. In feature-level algorithms, segment the image into contiguous regions and fuse the regions together using their properties. Decision-level fusion algorithms combine image descriptions to the fused image, such as in the form of a relational graph.

The disadvantage of pixel level algorithm that it reduces contrast as it takes the pixel-by-pixel grey level average of the source images. Better result is obtained by using pyramid transform; in this we perform fusion in transform domain.

A) **Pyramid Transform Algorithm:** Image pyramid consist of set of low pass or band pass copies of images. The basic idea in pyramidal transform algorithm that constructs the pyramid transform of fused images from the pyramid transform of source image and then fused image is obtained by taking inverse transform. At every higher levels will concentrate upon the lower spatial frequencies. Several types of pyramid decomposition or multi - scale transform are used or developed for image fusion such as Laplacian Pyramid. A pyramid structure contains different levels of an original image. As shown in fig.2. The pyramid would be half the size of the pyramid in the preceding level and the 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 begun to take the place of pyramid decomposition for image fusion.

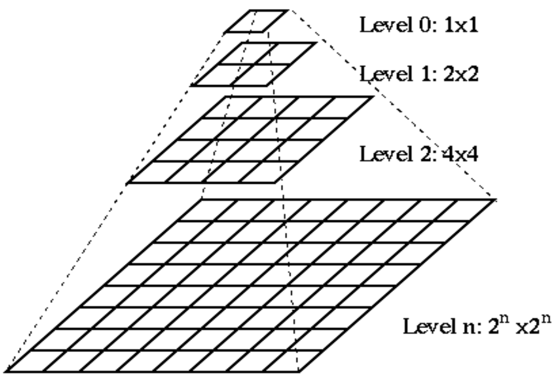

Fig.2. Pyramid Structure

Here are some major advantages of pyramid transform:

- It can provide information on the sharp contrast changes, and human visual system is especially sensitive to these sharp contrast changes.
- It can provide both spatial and frequency domain localization.

IV. LAPLACIAN PYRAMID

The Laplacian Pyramid implements a "feature selective" approach to image fusion, in this method fused image is formed is not a pixel at a time but feature 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. Fig. 3 Schematic diagram of proposed method.

These levels are obtained recursively by filtering the lower level image with a low-pass filter. We first make a Gaussian pyramid by filtering each level of image using a low-pass filter and do the down sampling. As the level goes up, the image is getting smaller and smaller. The equation to get an upper level of Gaussian pyramid from a lower level is as follows:

$$G_k = [w * G_{k-1}] \qquad (1)$$

Where w is the low-pass filter we use.

Notice that the image gets blurred because we used a low-pass filter and the high frequency part of has been removed. The k-th level of Laplacian pyramid is obtained by first, upsampling the (k+1) th level of Gaussian pyramid and do the low-pass filtering, then, subtract it from the k-th level of Gaussian pyramid. The equation is as follows:

$$L_k = G_k - 4w * [G_{k+1}] \qquad (2)$$

Now, we do the reconstruction part to reconstruct the original image using the first level of Laplacian pyramid and the filtered, upsampled version of (k+1)th level of Gaussian pyramid. The equation is as follows:

$$G_k = L_k + 4w * [G_k] \qquad (3)$$

Higher levels of the pyramid are increased scale versions and reduced resolution of the original image. The lowest level of the pyramid has the same scale as the original image and contains the highest resolution information.

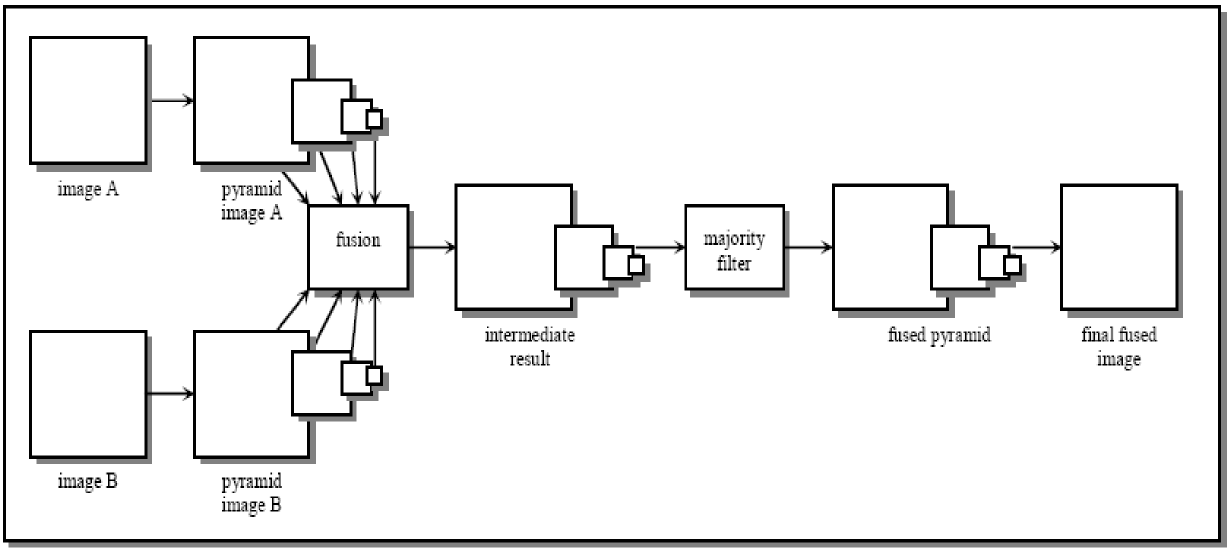

Fig.3 Schematic Diagram of Proposed Method

V. CONTRAST ENHANCEMENT

The limitations in image acquisition and transmission systems can be remedied by image enhancement. Its principal objective is to improve the visual appearance of the image for improved visual interpretation or to provide better transform representations for subsequent image processing tasks (analysis, detection, segmenta- tion, and recognition)[1]. Removing noise and blur, improving contrast to reveal details, coding artefact reduction and luminance adjustment are some examples of image enhancement operations. Image processing is avast and challenging domain with its applications in fields like medical, aerial and satellite images, industrial applications, law enforcement, and science. Often the quality of an image is more often linked to its contrast and brightness levels enhancing these parameters will certainly give us the best result.

A. *Image Enhancement Parameters*

- Peak Signal to Noise Ratio (PSNR) is

Defined as log of the ratio between the square of the peak value to the Mean Square Error multiplied to the value 10[4]. This basically projects the ratio of the highest possible value of the data to the error obtained in the data. It is generally used in measuring the quality of reconstruction done on lossy compression codecs.

$$\text{PSNR}=10 \times \log_{10}\left(\frac{Peak^2}{MSE}\right)$$

- Mean Squared Error (MSE) is

Mean square error is one of the most commonly used error projection method where, the error value is the value difference between the actual data and the resultant data[3]. The mean of the square of this error provides the error or the actual difference between the expected/ideal result to the obtained or calculated result. The error between the fused image and the perfect image is calculated as the Mean Square Error and the ratio value if obtained. If both the fused and the perfect images are identical, then the MSE value would be 0.

VI. IMPLEMENTATION

Below is syntax where lap_fus is the function is implemented in Matlab, it construct the Laplacian pyramid of source images, perform fusion on each level of the decomposition and reconstruct the fused image from the fused pyramid(as shown in Fig.3). im1 and im2 are the two input images, ns is the number of scales(here we taking the 5)[4].

Syntax : fusion = lap_fus (im1,im2,ns,consistency)

After that we perform the histogram equalization by using Matlab function imhist enhances the contrast of images by transforming the values in an intensity image, or the values in the colormap of an indexed image, so that the histogram of the output image approximately matches a specified histogram.

VII. FUSION PROCESS

Fig. 4 Shows the flow chart of proposed method.
Step 1: Verify all the Images are of same size or not if not reject the fusion process.
Step2: Decompose the Images into multiple resolutions at different scales by using multiresolution transform.
Step 3: Check consistency (Default 1)
Step 4: Reconstruct the image by performing inverse transform [2].

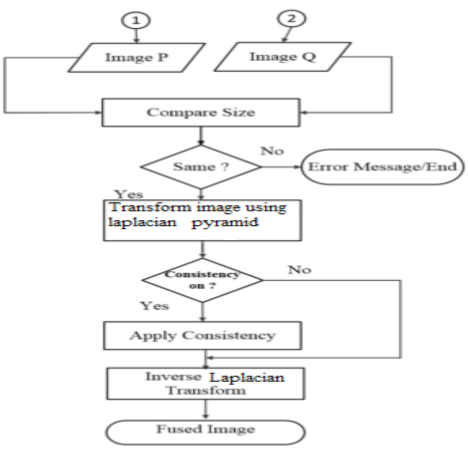

Fig.4 Flowchart of the proposed fusion process

VIII. RESULT

Here Fig. 5 is infrared image and Fig.6 is visible image, as visible image is somewhat low contrast image when we get combine with the infrared image, its contrast is increased. The output is shown in Fig. 7.

Fig.5 IR image

Fig.6 Visible image

Fig.7 Fused image

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Table 1

Sr. No.	Parameters	O/P image
1	PSNR	39.30
2	MSE	40.22

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IX. CONCLUSION

This article presents a fusion based contrast enhancement method for grayscale and colour images. In this way we can fuse two images one is obtained from digital camera and other obtained from infrared camera, and we get the output image which is more enhanced and clear. The proposed fusion-based enhancement methodology is especially well suited for non-real-time image processing applications that demand images with high quality. The results are promising and image fusion methods open a new perspective for image-enhancement applications.

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