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ABSTRACT

The technique of image fusion enhances the features of images and helps balance the information of those images. The main idea behind the image fusion is to provide more detailed information of the fused images, merging information of the same view of images with low quality to make a high resolution image. The proposed method is based on image fusion exploitation Laplacian pyramid and spatial frequency. An effective and simple method used for image fusion is spatial frequency; the proposed algorithm is a combination of spatial frequency and Laplacian Pyramid filter. A novel technique of image fusion algorithm is proposed by aggregate spatial frequency of multiple images along with Laplacian Pyramid Filter, it will ultimately improve the fusion results in the end. The previous image fusion techniques which we have studied had certain issues, i.e. the issues of blurred edges and some issues regarding the edge detection. The proposed method will eliminate the issue of blurred fused images and less accurate edge detection. Same size of images with same scene will be used for experiments. In the proposed method will be taken two images of the same view and fuse them by using the spatial frequency and after fusing the images will fuse the second image with the fused image. The Laplacian Pyramid filter will be applied to the secondly fused image. The outcome of that purposed method will provide better-fused results.

Chapter 1

Introduction

The wider area of analysis for students is image processing. In image processing, the most important research subject is image fusion. Nowadays, the most researcher using the technique of image fusion and work on pixel level image. In computer vision and image analysis, image fusion has become a vital topic. Image fusion refers to produce a new image with better than the input image. An image is a Quantity of two-dimensional. It is a process of merging two or additional images coming from the same sensors, therefore get a new informative image than any of the original images to achieve a pixel level image. The fused image carries more information and much better for human vision and machine perception and further image processing tasks. Information that is carried from the fused images is more qualitative. This fusion method can be split into three levels such as decision level, pixel level, and feature level. Application of image fusion is included areas like object revelation, object recognition, satellite and use in medical diagnosis and treatments. Basically, the objectives of this fusion method are to obtain better quality images and to get more information about the images than the input images. Introduce two methods for fused the image to get better quality images. The image fusion algorithm using spatial frequencies which combine pixel level. The basic idea behind the spatial frequency is to split the input images into blocks and then selects the parallel blocks with greater spatial frequency.

There are certain issues which arise with the fused image and we will try to tackle those issues in our proposed method. The proposed method will focus to eliminate the issue of blurred images and certain regions with blurred effect and secondly, we will try to preserve the edges of the images with the help of the proposed algorithm. The main problems which the above methods faced were the small blurry areas in the image which is coming after the Fusion and the second one was the preserve the edges of the images. We will try to solve out these problems in our proposed method.

To fuse the image using spatial frequency firstly the image is decomposed into two blocks, after decomposing the images into blocks the spatial frequency of each block is calculated and it will compare the frequencies of both the decomposed blocks, by doing that we will fuse both the images. The Gaussian filter was also used in the algorithm to reduce the noise from the images and make the images more and smoother (Li *et al*. 2001).

Image fusion using Laplacian pyramid is used to improve the edge preservation of the images the algorithm used here to select two images of the same scene and fuse them by using the wavelet transform in two phased. In the first phase the images are fused by using wavelet transformation and in the second phase the fused image is further fused with the second image by using wavelet transform methods and after fusing all the images the Laplacian Pyramid is applied to improve the fusion results (Singh and Patil, 2016).

This method is computationally very accurate and the results can be quantified as well as they can be observed by Human perception. In spatial frequency, we will take two images coming from the same sensor with same distance and depth of field, low quality images will be used for image fusion. In the proposed algorithm in the first phase, we will divide the images into blocks, then calculate the spatial frequency and fuse the two input images. In the second phase After the fusion of two input images we will fuse the resultant image with the second image which was previously used as the input image. After fusing the images in the second phase the Laplacian Pyramid filter will be applied to the fused image which is produced in the second phase. The selection of the Laplacian Pyramid has a very important impact on the quality of the final fusion image.

Motivation

The idea of image fusion returns to the 1950's and 1960's with the scan for constructing method for blending images from different sensors to give a composite image which could be better distinguish common and synthetic items. In the previous decades, autonomous vehicle navigation, night vision, concealed weapons detection, surveillance system and medical imaging are just a portion of the applications that have profited from such multi sensor exhibits. Inspiration for image fusion is basically the progression toward later innovative progresses in the fields of image fusion procedure strategy. Increased resolution and improved robustness of present day imaging sensors and, all the more fundamentally, accessibility at a lower cost, have made the utilization of numerous sensors, basic in a scope of imaging applications. In this image fusion method utilizing spatial frequency and Laplacian pyramid technique expands the quality of the image.

Problem formulation

Initially, the method of image fusion merges the two images from the same sensor of the same scene aimed to generate the final fused image that is more informative and qualitative.to get the final image without loosing the information of an original one. A prposed algorithm is used to enhace the qlatiy of image by using two different method spayial frequency and laplaycian pyamid .by using spatial frquncy take two images coming from the same sensor with same distance and depth of field, low quality images will be used for image fusion. In the proposed algorithm in the first phase, divide the images into blocks, then calculate the spatial frequency and fuse the two input images.Image fusion using Laplacian pyramid is used to improve the edge preservation of the images the algorithm used here to select two images of the same scene and fuse them by using the wavelet transform in two phased. In the first phase the images are fused by using wavelet transformation and in the second phase the fused image is further fused with the second image by using wavelet transform methods and after fusing all the images the Laplacian Pyramid is applied to improve the fusion results (Singh and Patil, 2016).This method is computationally very accurate and the results can be quantified as well as they can be observed by Human perception.

Image Fusion

A very important technique in digital image processing is image fusion. In image fusion technique the combination is the way toward building up suitable information from the at least two images into solitary image. The subsequent image will be more upgraded than any of the taking images. The idea of image fusion has been utilized in a wide collection of utilization like remote sensing, automatic change detection, medicines, biometric, machine vision and so forth. With the development of different devices in which we take an image it is difficult to acquire an image with detail information. Sometimes a total picture has not been constantly achievable since the optical lens of a camera. Image fusion servers to acquire an image with whole information. Image fusion is the idea of joining numerous image into composite items, that has a more information than the singular image can be uncovered.

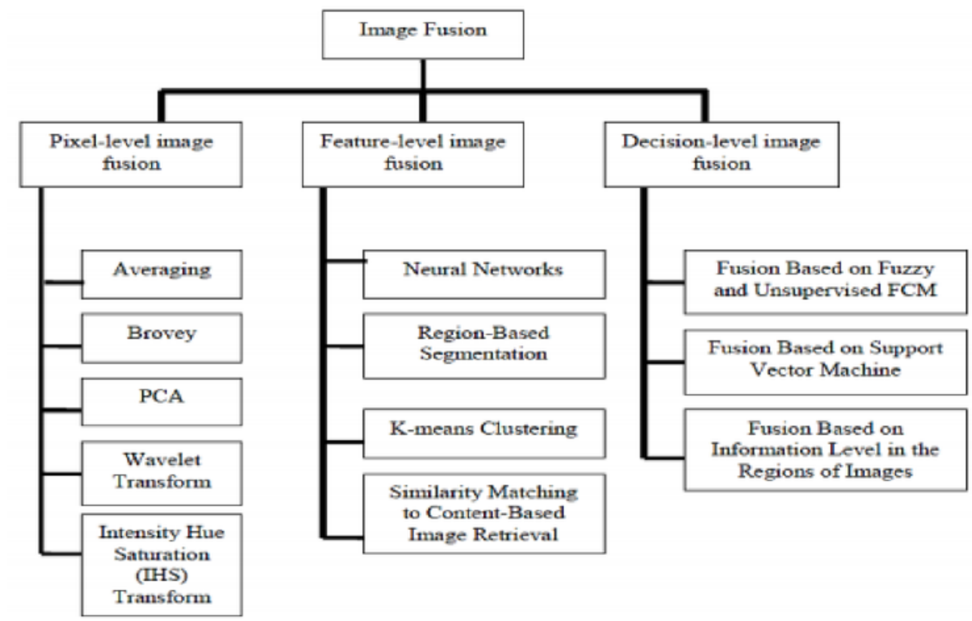

Figure 1 Level classification of the various popular image fusion methods based on the computation source.

Single Sensor Image Fusion System

The basic single sensor image fusion scheme has been presented in Figure below. The sensor shown could be visible-band sensors or some matching band sensors. This sensor captures the real world as a sequence of images. The sequence of images is then fused together to generate anew image with optimum information content. For example in illumination variant and noisy environment, a human operator may not be able to detect objects of his interest which can be highlighted in the resultant fused image

The shortcoming of this type of systems lies behind the limitations of the imaging sensor that is being used. The conditions under which the system can operate, the dynamic range, resolution, etc. are all restricted by the competency of the sensor. For example, a visible-band sensor such as the digital camera is appropriate for a brightly illuminated environment such as daylight scenes but is not suitable for poorly illuminated situations found during night, or under adverse conditions such as in fog or rain.

Multi-Sensor Image Fusion System

A multi-sensor image fusion scheme overcomes the limitations of a single sensor image fusion by merging the images from several sensors to form a composite image. Figure 1.4illustrates a multi-sensor image fusion system. Here, an infrared camera is accompanying the digital camera and their individual images are merged to obtain a fused image. This approach overcomes the issues referred to before. The digital camera is suitable for daylight scenes; the infrared camera is appropriate in poorly illuminated environments.

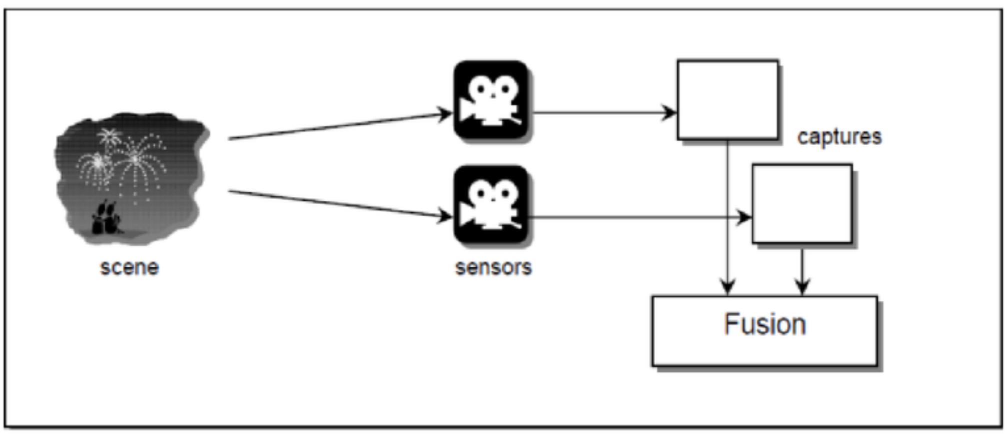

Figure 2 multi sensor image fusion

The benefits of multi-sensor image fusion include :

Improved reliability:– The fusion of multiple measurements can reduce noise and therefore improve the reliability of the measured quantity.

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

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.

Extended range of operation:– Multiple sensors that operate under different operating conditions can be deployed to extend the effective range of operation. For example, different sensors can be used for day/night operation.

Extended spatial and temporal coverage:– Joint information from sensors that differ in spatial resolution can increase the spatial coverage. The same is true for the temporal dimension. vi. Reduced uncertainty – Joint information from multiple sensors can reduce the uncertainty associated with the sensing or decision process.

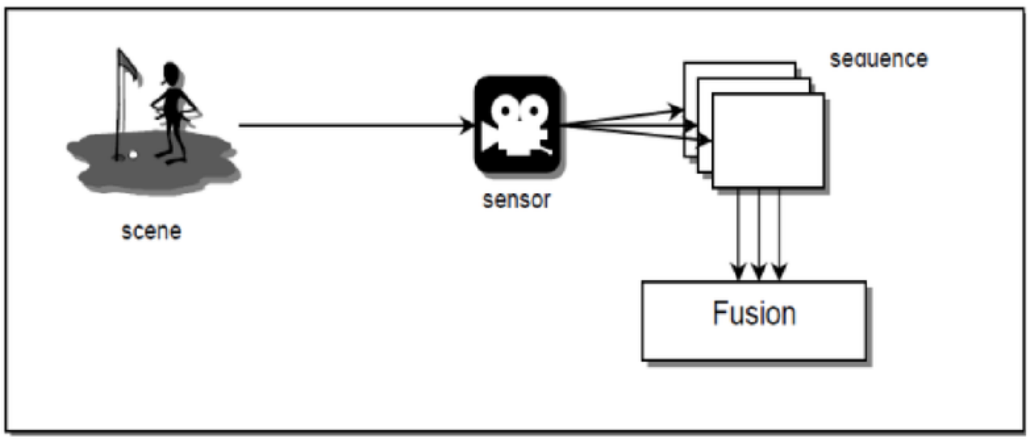

Figure 3 single sensor image fusion

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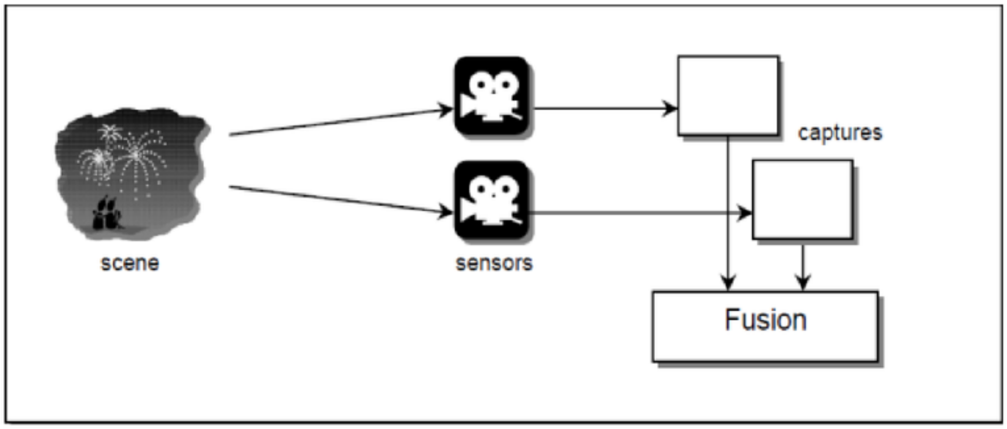


Figure 4 multi sensor image fusion

The benefits of multi-sensor image fusion include:

Improved reliability:-The fusion of multiple measurements can reduce noise and therefore improve the reliability of the measured quantity.

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

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.

Extended range of operation :- Multiple sensors that operate under different operating conditions can be deployed to extend the effective range of operation. For example, different sensors can be used for day/night operation.

Extended spatial and temporal coverage :- Joint information from sensors that differ in spatial resolution can increase the spatial coverage. The same is true for the temporal dimension. vi. **Reduced uncertainty**:-Joint information from multiple sensors can reduce the uncertainty associated with the sensing or decision process.

4 Image Fusion methods based on domain

Based on domain, image fusion methods can be categorized into two domains :

• spatial domain

Spatial domain deals directly with pixel to integrate relevant information. Some of the spatial domain techniques include Averaging, select maximum/minimum method, Bovey transforms, Intensity hue saturation method (IHS), High pass filtering method (HPF), Principal component analysis method (PCA). Drawbacks of Spatial domain fusion include spatial distortion in new fused image. This spatial distortion problem is solved in frequency domain.

• frequency domain

In frequency domain, image is transformed in frequency domain and frequency coefficients are combined to get fused image.Some of the transform domain fusion techniques include discrete wavelet transform, stationary wavelet transform.

Image Fusion based on Input data

Based on the input data and the purpose , image fusion methods are classified as:

• Multi-view fusion

Multi-view fusion combines the images taken by a sensor from different view- points at the same time. Multi-view fusion provides an image with higher resolution and also recovers the 3 − D representation of a scene.

• Multi-temporal fusion

Multi-temporal fusion integrates several images taken at various interval time to detect changes among them or to produce accurate images of objects.

- **Multi-focus fusion**

It is impossible for the optical lens to capture all the objects at various focal lengths. Multi-focus image fusion integrates the images of various focal lengths from the imaging equipment into a single image of better quality.

- **Multi-modal fusion**

Multi-modal fusion refers the combination of images from different sensors and is often referred as multi-sensor fusion which is widely used in applications like medical diagnosis, security, surveillance, etc.

Images from multiple sensors usually 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. The alignment of multi-sensor images is also one of the most important preprocessing steps in image fusion. Multi-sensor registration is also affected by the differences in the sensor images. However, image fusion does not necessarily imply multi-sensor sources. There can be single-sensor or multi-sensor image fusion, whichhas been vividly described in this report. Analogous to other forms of information fusion, image fusion is usually performed at one of the three different processing levels: signal, feature and decision. Signal level image fusion, also known as pixel-level image fusion, represents fusion at the lowest level, where a number of raw input image signals are combined to produce a single fused image signal. Object level image fusion, also called feature level image fusion, fuses feature and object labels and property descriptor information that have already been extracted from individual input images. Finally, the highest level, decision or symbol level image fusion represents fusion of probabilistic decision information obtained by local decisionmakers operating on the results of feature level processing on image data produced from individual sensors. Figure shows instances a system using image fusion at all three levels of processing. This general structure could be used as a basis for any image processing system, for example an automatic target detection/recognition system using two imaging sensors such as visible and infrared cameras. The main objective is to detect and correctly classify objects in a presented scene. The two sensors (1 and 2) survey the scene and register their observations in the form of image signals.

Two images are then fused atpixel-level to produce a third fused image and are also passed independently to local feature extraction processes. The fused imagecan be directly displayed for a human operator to aid better scene understanding or used in a further local feature extractor. Feature extractors act as simple automatic target detection systems, including processing elements such as segmentation, region characterization, morphological processing and even neural networks to locate regions of interest in the scene. The product of this process is a list of vectors describing the main characteristics of identified regions of interest. Feature level fusion is then implemented on the feature sets produced from the individual sensor outputs and the fused image. This process increases the robustness of the feature extraction process and forms a more accurate feature set by reducing the amount of redundant information and combining the complimentary information available in different individual feature sets. Feature level fusion may also produce an increase in the dimensionality of the feature property vectors. The final processing stage in an ATD system is the classification stage. Individual sensor and fused feature property vectors are input to local decision makers which represent object classifiers, assigning each detected object to a particular class with proper decision. Decision level fusion is performed on the decisions reached by the local classifiers, on the basis of the relative reliability of individual sensor outputs and the fused feature set. Fusion is achieved using statistical methods such as Bayesian inference and the Dempster-Schafer method with the aim of maximizing the probability of correct classification for each object of interest. The output of the whole system is a set of classification decisions associated to the objects found in the observed scene.

Image Preprocessing

Analogous to signal processing, there are very often some concerns that have to be normalized before the final image fusion. Most of the time the images are geometrically misaligned. Registration is the techniqueto establish a spatial correspondence between the sensor images and to determine a spatial geometric transformation. The misalignment of image features is induced by various factors including the geometries of the sensors, different spatial positionsand temporal capture rates of the sensors and the inherent misalignment of the sensing elements. Registration techniques align the images by exploiting the similarities between sensor images. The mismatch of image features in multisensor images reduces the similarities between the images and makes it difficult to establish the correspondence between the images. The second issue is the difference in spatial resolution between the images developed by different sensors. There are several techniques to overcome this issue such as the Superresolution techniques. Another methodology is to use multi-resolution image representations so that the lower resolution imagery does not adversely affect the higher resolution imagery.

Image Fusion Techniques, Theory

An image fusion method consists of taking two images from the same sensor and these images with spatial frequency and Laplacian pyramid are utilized for image fusion. To fuse the image by this method we get a single image which has more informative and better quality. A Technology that merges the distinctive images to produce a fused image that is clearer and more informative for the human perception and machine vision. Different image fusion types like multi-focus, multi-sensory, and multi-modal image fusion. In the method of multi modal image fusion, fused the two different types of images such as merge a high-color image with the high resolution image. In the method of multi sensor image fusion, gather an image from the different sensor such as joined an image with digital sensor to from a depth sensor. In the method of multi focus image fusion, gather the images of the same scene with the differing focus area and then combine for the get more informative image for the human vision.

Depend on the fusion processing strategies, image fusion strategies break down into different levels. These strategies have different subgroup level like the decision level pixel Level, and feature level.Image Fusion Techniques The most essential dispute concerning image fusion is to decide how to merge the sensor images. In recent years, a number of image fusion methods have been projected . One of the primitive fusion schemes is pixel-by-pixel gray level average of the source images. This simplistic method often has severe side effects such as dropping the contrast. Some more refined approaches began to develop with the launching of pyramid transform in mid-80s. Improved results were obtained with image fusion, performed in the transform domain. The pyramid transform solves this purpose in the transformed domain. The basic idea is to perform a multiresolution decomposition on each source image, then integrate all these decompositions to develop a composite depiction and finally reconstruct the fused image by performing an inverse multi-resolution transform. A number of pyramidal decomposition techniques have beendeveloped for image fusion, such as, Laplacian Pyramid, Ratio-of-lowpass Pyramid, Morphological Pyramid, and Gradient Pyramid. Most recently, with the evolutionof wavelet based multi resolution analysis concepts, the multi-scale wavelet decomposition has begun to take the place of pyramid decomposition for image fusion. Actually, the wavelet transform can be considered one special type of pyramid decompositions. It retains most of the advantages for image fusion but has much more complete theoretical support.The real Discrete Wavelet Transform (DWT) has the property of good compression of signal energy. Perfect reconstruction is possible using short support filters. The unique feature of DWT is the absence of redundancy and very low computation. Therefore, DWT has been used extensively for Multi Resolution Analysis (MRA) based image fusion. The Discrete Wavelet Transform primarily suffers from the various problems (Ivan, W. Selesnick, Richard G. Baraniuk, and Kingsbury, N., 2005) such as oscillations, aliasing, shift variance and lack of directionality.

With the rapid development of information processing technology, we are now living in an information society, and among various kind of information people obtain in their everyday life , 75% is received from vision, i.e. imaging information has already turned into a main carrier that people gain and exchange information. Thus, under large and growing demand on information data processing, how to quickly and efficiently handle massive image data has become a top issue to be solved. As a significant branch of image processing, image fusion also develops rapidly. With the explosive growth of visual information and the rapid development of image analyzing processing in both hardware and software fields, these achievements solidly lay a foundation of the research and application of image fusion.The objective of image fusion is to combine information from different source images of the same scene to achieve a new image which can provide much more visual information than the source images.Comparing with the source images, the visual information contained in the fused image is much more comprehensive and is much more convenient for people to do some subsequent works. Owing to the capacity to not only enhance the the clarity of images and amount of visual information and improve but also improve the accuracy of extraction and analysis of image character, image fusion is widely used in military,remote sensing, agriculture, medicine and other fields.

Hierarchicalclassification of image fusion(Capstone and Project n.d.):

A recognized classification of image fusion divides into 3 levels, which are pixel level fusion, feature level fusion and the decision-making level fusion.

In pixel level fusion, which is at the bottom of all image fusions, we process images in pixels with the original image data and are able to retain more original information. The image fusion based on pixel level can generate fused image as well as providing supports for the higher level fusion. Compared with the feature level fusion and the decision-making level fusion, in the pixel level fusion, the correspondence between original images is much more accurate which leads to it's higher requirement of image matching Metric. The research and application based on pixel level are far more widespread and represent a greater opportunity in the near term.

The method of feature level fusion process the point, edge, angle, texture and other characteristics extracted from the source images. These characteristics are used to fuse into the images effectively. The feature level fusion processing can providethe decision-making level fusion with supports. But not like the pixel level fusion, feature level fusion processing does'trequire the high image matching metric. Besides, since the feature level fusion processing merely contains the information of characteristics, the data size has greatly diminished which leads to it is easier to compress visual information and transmit data.

The decision-making level fusion, which makes optimal decision based on the data information extracted from the pixel level fusion or the feature level fusion, is the top level of image fusion processing. The first step of decision- making level fusion is the objective extraction and classification of several source images. Secondly, according to credibilitycriterion to process image after making decision aiming to a specific objective. The decision-making fusion is a artificial intelligence application based on a cognitive model, doing intelligent analysis and recognition. While doing decision-making level fusion, we can reduce both redundancy and uncertain information meanwhile retain the useful information of images to serve some subsequent works better. Image fusion should satisfy three aspects before we call it efficient. First, the fusion image should retain all the characteristic information of the source images as far as possible. Second, should not bring any artificial or contradictory information in images while doing image fusion. Last but not least, should reduce the impact of the unfortunate characteristics of source images as possible.

Image Fusion By Using Laplacian Pyramid

The concept behind the Laplacian pyramid is to accomplish the pyramid breakdown on each source image, then merge these decorations to make a composite image and then finally carry out the inverse pyramid transform to recreate the fused image. There are different stages that consist on Laplacian pyramid are as follows:

1. For each input image develop a pyramid first.

2. Then, by using the feature selection decision method fusion method is actualized at each dimension of the pyramid

3. From the input images, the feature selection method chooses the most noteworthy pattern and duplicates it to the composite pyramid.

4. At last, by executing an inverse pyramid transform fused image is achieved

Implementation of Laplacian Pyramid

A pyramid structure contains different levels of an original image. 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 (Chao Wang et al. 2018). 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:

$$\mathbf{G}_k = [\omega * \mathbf{G}_{k-1}]_{\downarrow 2}$$

Where w is the low-pass filter we use.

Input image: (512*512)

Figure 5 laplacian filter im-1

This is what we get when k=1, which means that we filtered the original image once. Notice that the image gets blurred because we used a low-pass filter and the high frequency part of has been removed. Image(256*256):

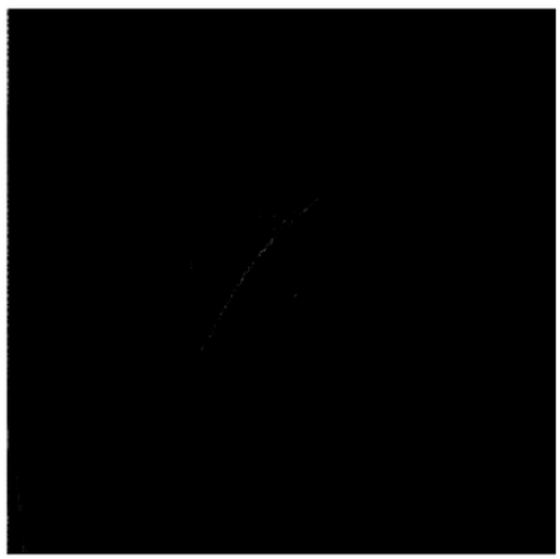
Figure 6 laplacian filter im-1

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:

$$\mathbf{L}_k = \mathbf{G}_k - 4\omega * [\mathbf{G}_{k+1}]_{\uparrow 2}$$

Where w represents a low-pass filter. With the same original image as above and the second level in Gaussian pyramid, we obtained the following image:

Figure (512*512)



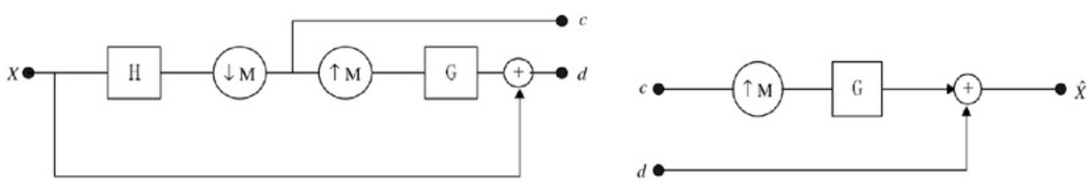
Notice that the image is almost pure black, because after we do the subtraction, most pixels are near zero. The function is as follows: function LLk = Lk(k,address) Now, we do the reconstruction part to reconstruct the original image using the first level of Laplacian pyramid and the filtered, upsampled version of (k+1)-th level of Gaussian pyramid. The equation is as follows:

$$\hat{\mathbf{G}}_k = \mathbf{L}_k + 4\omega * \left[\hat{\mathbf{G}}_{k+1}\right]_{\uparrow 2}$$

Then we get the first level of reconstructed Gaussian pyramid:

Laplacian Pyramid (LP) Decomposition

Following diagram shows the decomposition process taken under LP:

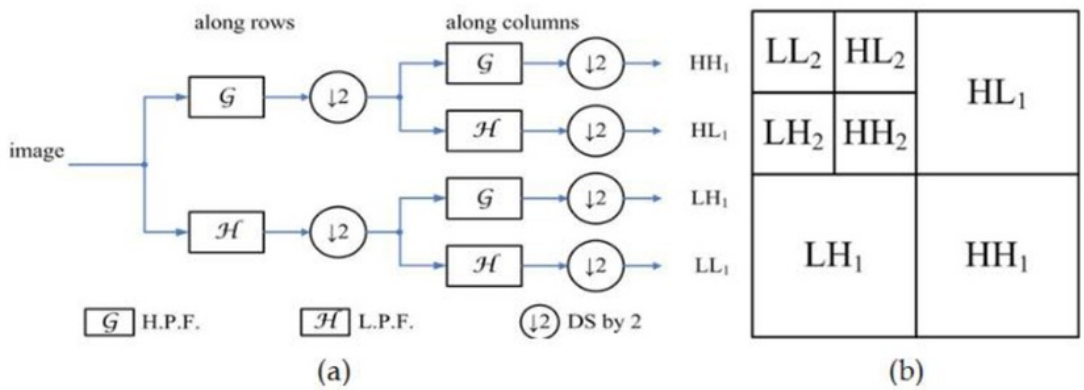


(a) (b)

Discrete wavelet transform (DWT)

The mathematical basis of the wavelet transform is the Fourier transform. In the wavelet analysis, the size of the window is fixed while the shape is changeable, as well as the time window and the frequency windows. Thus, wavelet analysis has respectively better resolution yet worse time resolution in low frequency band, and vice versa (Deshmukh and Malviya 2015). Discrete wavelet transform (DWT) is one of the most popular methods for the decomposition of an image, which has been widely used in a large number of researches.

The decomposition algorithm of DWT is shown below by the following figure:



The preceding result is applied to the next stage of 2-D DWT decomposition and this process is going to be repeated recursively in each stage. The low-pass filter h and high-pass filter g correspond to a particular type of wavelet used.

For more understanding the given fig shows the frequency distribution of wavelet based image fusion(Balachander and Dhanasekaran 2016)

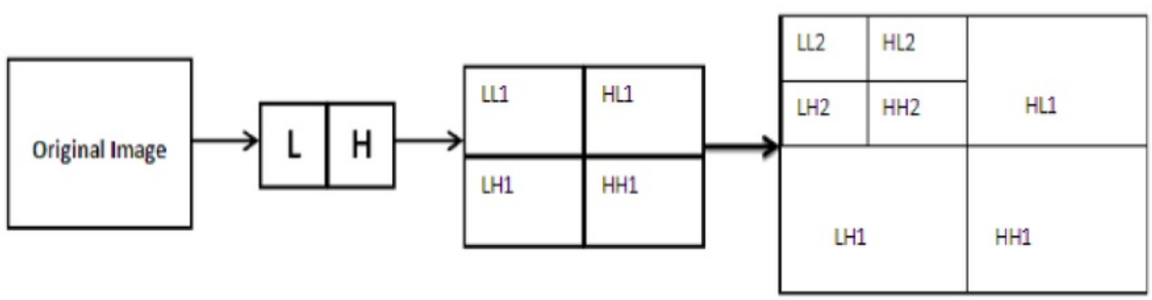


Figure 7: frequency dist of wavelet based image fusion

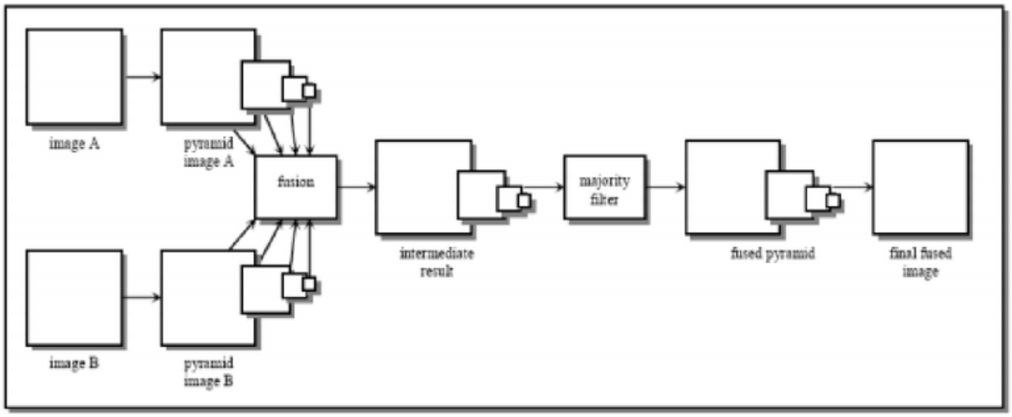


Figure 8 laplacian filter working

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. 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.

Image Fusion By Using Spatial Frequency

Thw overall active level of an image is measured using spatial frequency.if a block of image F is of dimension MxN has a gray value F(m,n) ,then the value of SP is calculated as follows (S. Singh and Patil 2016)

$$SF = \sqrt{RF^2 + CF^2}$$

Here RF and CF is for row and column

$$RF = \sqrt{1 / MN \sum_{m=0}^{M-1} \sum_{n=1}^{N-1} \left(F(m,n) - F(m,n-1)\right)^2}$$

$$CF = \sqrt{1 / MN \sum_{m=1}^{M-1} \sum_{n=0}^{N-1} \left(F(m,n) - F(m-1,n)\right)^2}$$

It is seen that the value of spatial frequency decreases as an image becomes more blur. In other words, it also gives the degree of clarity of an image.

Implementation of spatial frequency

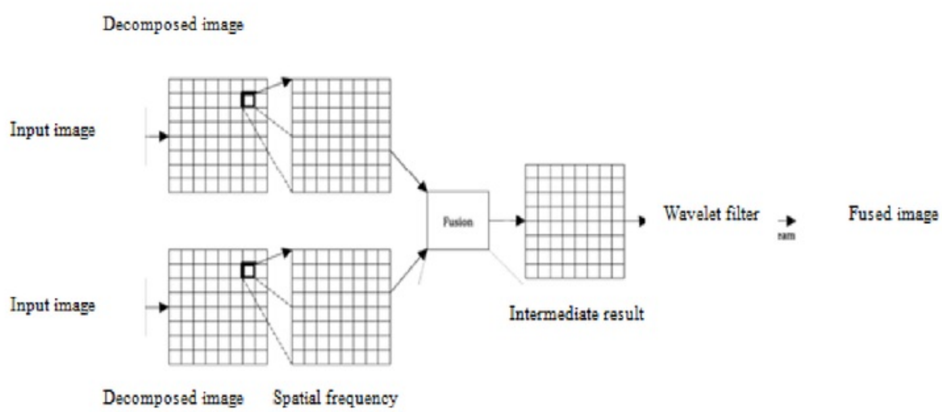


Figure 9 spatial filter

Comparative Anylasis of different fusion techniques

S. No.	Image fusion algorithm	Domain	Advantages	Dis-advantages
1	Simple Average [5]	Spatial	Simple average image fusion algorithm is considered to be the simplest image fusion algorithm.	Pixel level image fusion algorithm does not always produce a clear output image from the given set of source images.
2	Simple Maximum/Minimum [5]	Spatial	Resulting in a highly focused image output obtained from the input image as compared to simple average. [5]	Image output obtained from pixel level image fusion technique has a blurring effect which in turn affects the image contrast.
3	Principal component analysis (PCA)	Spatial	PCA transformsa number of correlated variables into a number of uncorrelated variables which are used in image fusion [5].	This type of fusion produces spectral degradation.
4	Discrete Wavelet Transform (DWT)	Transform	DWT fusion method outperforms the basic image fusion methods, reduces spectral distortion and has a better signal to noise ratio.	Final fused output image has less spatial resolution.
5	Combine DWT, PCA	Transform	Multi-level fusion technique where the image fusion is done twice using efficient fusion algorithm.Output image has high spatial and spectral resolution.	The transformation is complex in nature and requires better fusion techniques for good results.

Figure 10 comparison table (Balachander and Dhanasekaran 2016)

Chapter 2

REVIEW OF LITERATURE

The most well known method in image fusion, for the enhancement of image different kinds of filters is applied to the image. The spatial frequency and lapyacian pyramid are presented in this literature survey. In this chapter of literature there are also some other papers are presented that make use of enhancing the image with the image fusion using the data set. Matlab is used to perform the image fusion method. The literature survey presented the some papers that consist of different algorithms.

Shah and Shah (2014) examined a two different approaches for fused the image, namely as transform fusion and spatial fusion. PCA is implemented in the spatial domain technique and discrete wavelet transform is implemented in transform domain. Blur problem is occurring in spatial domain method. High quality spectral content provides transform domain method. The stationary wavelet transformation method is used to overcome this problem. It is a better image fusion technique, then the DWT and PCA.

Kong *et al*. (2008) explored that image fusion algorithm using genetic algorithm and spatial frequency algorithm. The idea behind the using of this algorithm is to split the input images into blocks and choose the parallel block with high frequency value to obtain the fuse image. To search for the optimum size of the block genetic algorithm is introduced.

Li *et al*. (2001) examined that Image fusion is a technique to combine the multiple images to get the fuse image that is more suitable for the human vision and machine perception. This paper presents the step by step approach in which firstly we decompose the images into blocks and they calculate the spatial frequencies and reconstruct the image into fused image.

Singh and Patil (2016) described that Due to the limited focus of cameras sometimes a scene does not describe the correct information on the behalf of the single image. So multiple images combine to get a clear description of single images. This paper presents a stationary wavelet transform with spatial frequency and contrast analysis to perform multi focus image fusion.

Balachander and Dhanasekaran (2016) found that different technique of image fusion that is Transform domain technique and spatial domain. The purpose of using this method to get the final fuse image that is a combination of multiple images. The fusion process is used to identify the significant features and transfer them without loss the detail information of the input image.

Wang *et al.* (2018) examined that in image fusion a problem has occurred that how to find a focus area addionally accurately. The image fusion is predicted on region optimization and Laplacian operator is planned. With the Laplacian operator, simply recognize the focus area and out of focus area. For acquiring the precise decision map edge optimization and focus area consist on regional connectivity are taken. Then finally input images are fused through the decision map.

Mukane *et al.* (2012) explored a wavelet transform method and Laplacian pyramid method. Same size of images is used for experiments. Well-established images are used for experiments and for blur an input image, average filter is used. Mean Square error, peak signal ratio, and normalized error are measured forgetting the final fused image.

Mukane *et al*. (2015) described the idea of merging multiple images modalities to produce one, increased image is well established completely different fusion ways are planned in literature. This paper is predicated on image fusion exploitation Laplacian pyramid and wavelet transform methodology. The image of the same size is used for experimentation. Images used for the experimentation area unit normal images and averaging filter is employed of equal weights in original pictures to burl. Performance of image fusion technique is measured by mean sq. error, normalized absolute error and peak signal to noise magnitude relation. From the performance analysis, it's been determined that MSE is diminished just in case of each the way wherever as PSNR magnified, NAE minimized just in case of the Laplacian pyramid wherever as consultant for wavelet transform methodology.

Zeng *et al*. (2014) examined the objective of image fusion is to gain the information from the multiple images that is coming from the same sensor. The fused image provides the precise description which is suitable for further processing task and machine perception. The paper presents a Laplacian pyramid transform methodology to fuse the image. Android application is proposed for real practical situation.

Wang and Chang (2011) explored that laplacian pyramid method is used for image fusion for multi focus this method is divided into three basic steps. First, decompose the source image, and then calculate the high level of the Laplacian pyramid transom. Finally the fused image is obtained with maximum region injury.

Wang and Tu (2014) described that the visible dynamic range of the image is really high 108:1 from the bright sunlight into the dark shadows; the dynamic range of the eye is almost 104:1 but the visible dynamic range of lower cost camera is very low round about 102:1 which is the reason why we use image fusion to get the most out of the relatively inexpensive cost camera images. The relatively inexpensive cost camera images cannot produce HDR images and to solve this issue we use an image fusion method which will merge the images taken from the low cost camera and make a high quality fused image.

(Deshmukh and Malviya 2015) found that the digital image process has wide areas of application. One among the foremost important applications of image processing is in image fusion. Image fusion may be a technique that is used for combining relevant data from two relevant data from two or additional images into one image. This fused image contains additional data than any of the two input images. The fused image will have complimentary spatial and spectral resolution characteristics. The methodology applies in remote sensing application as well as satellite imaging application. During this proposed work, two images are fused based on the wavelet transform exploitation totally different fusion techniques. The target of this projected work is to fuse the two images in such how that we are able to improve results that contain additional data. The reserved result can evaluate mistreatment parameters like pseudo signal to noise quantitative relation, root mean sq. Error, standard deviation and entropy.

Hua *et al.* (2018) analyzed that a vital to extract a transparent scene for laptop vision and increased real fact of the scene. Basically, background extraction assumes the fact of a clean background shot through the source sequence, however realistically, things might violate hypothesis like road traffic videos. However, he proposed a probabilistic model that is based on methodology as the input sequence of background patches as random walk drawback and supported their spatial and temporal relationship. A fixed background ought to have greater temporal coherence between frames, and so, tend to improve our fusion preciseness with a temporal distinction filter. Basically, he proposed the algorithm to track the motion of the camera and the relationship between the frames to find the fixed background.

Rani and Sharma (2013) explored that the different technique of image fusion. Image fusion enhances the features of images and helps balance the information of that image. The main idea behind the image fusion is to provide the information image than the real one. Merging information of the same view of images with low quality to make a high resolution image. Image fusion refers to produce a new image with better than the input image. An image is a Quantity of two-dimensional. He examined the different techniques like principle compound analysis and DWT. And he compression all the techniques and bring to end with better technique.

Singh and Julka (2016) described that Image fusion is the methodology of blending a pair of or additional images to create an additional information processing resultant image than any of the images used as the input image.Image fusion is completed to induce an additional increased and informative and additional quality image from a pair of or additional images that area unit taken from fully totally different views, fully totally different detector, completely modal and different temporal. The applying areas of image fusion include each military and domestic functions and even medical functions. Several techniques are a unit designed until date for economical fusion like Principal component Analysis, separate wavelet primarily based fusion etc.

Zhang *et al.* (2011) explored that image fusion is a crucial visualization technique of integration coherent and temporal data into compact type. Laplacian fusion may be a method that mixes region of images from a totally different source into one fused image supported a saliency choice rule for every region. He proposed a tendency to planned associated degree algorithm approach employing a mask pyramid to rise localize the case method. A mask pyramid operates in several scales of the image to boost the united image quality on the far side a worldwide choice rule. Many samples of this mask pyramid technique area unit provided to demonstrate its performance in a very type of applications.

Suthakar *et al.* (2014) explored an overview of image fusion. Image fusion is a procedure of consolidating various images into a solitary image which contain prefab depiction of the scene over the one given by any of the single incoming images. The melded image gives detailed data about the scene which is more valuable for machine recognition and human vision observation or further image preparing work. This overview paper basically investigates the techniques, strategy and applications which support for scientist to all the image fusion ideas.

Boiangiu *et al*. (2016) described that in image processing, image resampling is a procedure that includes an exchange off, between sharpness productivity, and smoothness. By and by, in the digital world, it is a procedure that we experience in every world now on the printing, on the internet, on the TV, in science and even in the photography when watching inaccessible universes. To a make a new image, a method is used in image resampling, from the unique one, which has an alternate height in pixel and width. Decreasing the measure of an image is called down sampling, while at the same time expanding its size is called up sampling.

Sahu and Parsai (2012) analyzed that an image fusion is a procedure of joining the pertinent data from a lot of images into a solitary image, where the resultant image will be more complete and informative than any of the pervious images that is coming from the input side. The technique of image fusion enhances the image quality and gave more informative image. Basically, this paper presents a review of literature on different fusion methods for image fusion methods like, discrete wavelet transforms based fusion, and principle component based fusion.

Paris *et al*. (2011) found that for breaking down images into different scales and is broadly utilized for analysis of images a universal Laplacian pyramid is used. Because since it is developed with spatially invariant Gaussian kernels, for edge-aware operations such as smoothing, tone mapping and edge-preserving the Laplacian pyramid is generally expected. To handle these undertakings, an abundance of elective strategies and portrayals have been proposed. E.g., neighborhood filtering specialized wavelet bases and anisotropic diffusion. While these techniques have exhibited effective results, they come at the cost of extra multifaceted nature, frequently joined by higher computational expense or then again the need to post-process the process outcomes. Standard Laplacian pyramids are used for state-of-the-art edge-aware processing. Expanding upon this outcome, we propose a lot of Image filters to accomplish detail enhancement inverse tone mapping tone mapping, smoothing, and edge-preserving. . The benefit of our methodology is its effortlessness and adaptability, depending just on a basic point-wise nonlinearities and little Gaussian convolutions; no post-preparing and advancement is required.As we illustrate, our technique creates reliably good results without introducing halos cutting edges.

Aymaz and Kose (2019) explored that in multi focus method of image fusion gather two images into a solitary image that is more informative and clear. By using the fusion method for multi focus image, merge the two or more images which have a distinctive focus of the same scene. The significant image is more clear which is progressively instructive and valuable for human perception and machine vision. A novel technique is proposed for multi focus image fusion. The strategy of hybrid method with high-resolution is proposed. Firstly, for enhancing the information about an image super resolution method is applied to all the input images. Then, lower resolution image is converted in to high resolution images. Secondly, Stationary Wavelet Transform (SWT) is executed and images are isolated into four sub-groups due to decaying these source images. These sub-groups are LH (low– high), HL (high– low), HH (high– high) and LL (low– low). For fuse the image principle component analysis is executed and greatest eigenvector of each subgroup of input images is chosen independently in all these subgroups. At that point, for the fused sub group inverse Stationary wavelet transformation is utilized to recreate. At last, fused image is resized to unique input image after utilizing the quality of the proposed strategy. Distinctive matrix with reference image and without reference image is selected for the gauge the achievement of technique. Results demonstrate that the proposed technique to produce great visual recognition clear edges, great visual recognition, great clearness.

Zope *et al*. (2015) found that the most important technology for image processing is image fusion. It's become most important in different application areas. In image fusion technique the combination is the way toward building up suitable information from the at least two images into a solitary image that is more informative and clear rather than input images. Here two methods are used for fusing the image that is wavelet transform and laplacaian pyramid. We characterize a lot of proportion of viability for similar performance analysis and after that utilized on proposed algorithm that has been put on a different set of images.

Agrawal K. (2015) analyzed that image combination is the way toward joining pictures from various sensors, perspectives or foci to shape a composite picture without presenting any handwork. The sensors can have various attributes like perspectives, center or are from various sensors like X-ray camera, infrared camera or obvious light cameras. An algorithm of image fusion requires a large portion of the fusion algorithm for the fusion of source images to be spatially adjusted from proficient results. Image registration is at the procedure that is an imperative predecessor to fusion and brings these pictures onto a typical portrayal. The process of image fusion is upgrading the data content inside a solitary composite image and that is helping with machine preparing and human discernment of such images. Image registration and image fusion have discovered numerous applications in super resolution, object tracking, in the medical field, in machine learning, in an MRI scanner, super goals, object identification and many other applications. Sometimes such applications are utilized in on field camera frameworks which require constant outcomes for quick judgment. This work introduces a novel technique of feature detection utilizing SIFT and utilizing Laplacian pyramid disintegration on Xilinx Virtex 5 ML505 FPGA in image fusion.in this image fusion technique focus on images that is coming from different sensors.in the part of feature detections, parallelization of handling has been abused in feature generation and a look into table based methodology in gradient property calculation has prompted huge increases in speed while at the same time lessening unpredictability and keeping up great outcomes. In the Laplacian pyramid fusion method, information parallelization has been utilized alongside a re-usable reserve based plan to decrease gadget utilization and give successful outcomes. The structure has been advanced to give a yield of 30 fps for a picture of 320x256 for enrollment and combination while giving lower control utilization than GPU based structures.

Jin et *al.* (2005) found a method of image fusion has turned into a key point in the field of image processing as a significant ingredient of image fusion information. It is another method to manage distinctive input Images artificially. To fuse the image so that, the expectation of combination is to get a progressively precise, complete and dependable image that is more informative than the source images. The paper is based on wavelet transformation, Laplacian pyramid Directional Filter Banks are formulated. In the technique of image fusion, for enhancement of image DFB is presented through this directional filter bank merge the direction information with various resolution studies. Merging with the Laplacian pyramid process further, a fusion technique consists of Laplacian pyramid directional filters bunks are given.

Gupta and Gupta (2015) Exhibit an assessment of various image fusion methods. There are many image fusion methods which have been created in various applications. Image fusion merges the important information from a few source images of one scene to get an informative image which is convenient for human visual, machine perception or for further analysis. The quality of image is firmly associated with the focus of an image. In the field of image processing the method of image fusion has become more important. In method of image fusion, discrete cosine changes (DCT) is presented that is more reasonable for time saving and energy consumption in real time for videos and still images

Yang (2011) explored that an image fusion takes part in many kinds of field. These days, with the quick improvement of various imaging sensors, image fusion has been broadly utilized in numerous fields, for example, machine vision remote sensing, medical imaging, etc.. A process of combing the multiple images into a single image without losing the information. Due to this, the final image is more suitable for the human visual, machine perception and for the further analysis task. Wavelet transform, a novel technique of image fusion is presented. Wavelet coefficients, which is formed by considering the meaning of physical coefficient.

Matire and Bloch (1997) presented the fundamental discussion about the technique of image fusion. Discussed the portion about the technique of image fusion that is not perfect for lots of the fusion methods. On the other hand presented the important tool that is used to create a fuse images, and also discuss the essential of these related tools. The role of the user is also presented for the method of image fusion. Clearly, image fusion is still in its outset. Further work is required if outcomes are not yet accessible.

He *et al*. (2017) exhibits that image fusion is the most important motivation behind visible and infrared image fusion is to is to incorporate the helpful data and produce a new image which has higher dependability and understandability for human and machine vision. So as more reliability and better result is to preserve the interesting criteria and relating information. For the fusion of the imaging multiscale method is presented that is consisting on interesting criteria detection. Initially, the Mean Shift is utilized to distinguish the interesting criteria with the Background region and salient items of visible and infrared. After that used to guide filter on the interesting criteria for the process. For background region decomposition infrared and visible, NSCT is used to take a series of high-frequency layers and low-frequency band. For the low frequency of the fuse image weighted average technique is used. For each high-frequency band of fuse image PCNN is used. At the end, by using the fusion methods the image is gotten by fusing the background criteria and interesting criteria.

Zhang and Blum (2000) exhibit that in the application of digital camera, various image registration algorithms are presented for the object of image fusion. A unique method is presented for the fusion of the image, hybrid method that is used both intensity based and feature based. For the intensity based technique edge based approach is promoted. The possibility of coarse-to-fine multi-scale iterative refinement is additionally used. The merging of these techniques leads to pay for in general make up for any deficiencies in the individual techniques. Results demonstrate that our methodology gives precise results from the application of digital camera of the image registration.

Shabu *et al*. (2013) found that the method of image fusion is to merge the related information from one or more image into a solidity images .the method of image fusion is used to recognized the tumor, that gave solution to elaboration problems using methods, like crossover, mutation and selection. Features are extracted of the images before put genetic algorithim.features extraction is a type of dimensionality decrease and it tends to be either general feature, like texture ,shape feature and extraction of color.

(Aymaz and Köse 2019) Multi-focus image fusion combines two or more images which have different focus values of the same scene using fusion rules. The meaningful image is named all-in-focus image which is more informative and useful for visual perception. In this paper, a novel approach for multi-focus image fusion is proposed. The method is a hybrid method with super-resolution. Firstly, super-resolution method is applied to all source images to enhance information like contrast. Thus, low-resolution source images are converted to high-resolution source images. Secondly, due to decomposing these source images, Stationary Wavelet Transform (SWT) is implemented and images are divided into four sub-bands. These sub-bands are LL (low–low), LH (low–high), HL (high–low) and HH (high–high). LL is the approximation coefficient of source images and others are the detail coefficients of source images. For all these sub-bands, Principal Component Analysis (PCA) is implemented and maximum eigenvector of each sub-band of source images is selected separately to fuse images. Then, Inverse Stationary Wavelet Transform (ISWT) is used to reconstruct the fused sub-bands. Finally, to measure quality of the proposed method objectively, fused image is resized to original source image's size using interpolation based resizing method. To measure the success of method, different metrics without reference image and with reference image, are selected.

Results show that the proposed method produce clear edges, good visual perception, good clarity and very few distortion. The proposed hybrid method is applied to produce better quality fused images. Results prove success of the approach in this area. Also visual and quantitative results are very impressive.

(Sharma 2016) Image fusion is process of combining multiple input images into a single output image which contain better description of the scene than the one provided by any of the individual input images. The need of image fusion for high resolution on panchromatic and multispectral images or real world images for better vision. There are various methods of image fusion and some techniques of image fusion such as IHS, PCA, DWT, Laplacian pyramids, Gradient Pyramids, DCT, SF. Several digital image fusion algorithms have been developed in a number of applications. Image fusion extracts the information from several images of a given scene to obtain a final image which has more information for human visual perception and become more useful for additional vision processing. It also intends to review quality assessment metrics for image fusion algorithms. The gray-scale image fusion techniques are explored at pixel level, feature-level and review the concept, principals, limitations and advantages for each technique.

(Sharma 2016) This paper describes a survey of image fusion. Image fusion is process of combining multiple input images into a single output image which contain better description of the scene than the one provided by any of the individual input images. The fused image provides detail information about the scene which is more useful for human vision perception and machine perception or further image-processing tasks such as segmentation, feature extraction and object recognition. This survey paper mainly looks into the methods, technique and applications which helpful for researcher to refer image fusion concept.

(Sharma 2016)Automated blood vessel segmentation of retinal images offers huge potential benefits for medical diagnosis of different ocular diseases. In this paper, 2D Matched Filters (MF) are applied to fundus retinal images to detect vessels which are enhanced by Contrast Limited Adaptive Histogram Equalization (CLAHE) method. Due to the Gaussian nature of blood vessel profile, the MF with Gaussian kernel often misclassifies non- vascular structures (e.g., step, ramp or other transients) as vessels. To avoid such false detection, this paper introduces Laplacian of Gaussian (LoG) filters in the vessel segmentation process. The inherent zero-crossing property of LoG filter is used in the algorithm, along with the MF, in order to extract vessels reliably from the retinal images. The proposed method is validated against three publicly available databases, STARE, DRIVE and HRF. Simulation results show that the proposed method is able to segment vessels accurately from the three database images with an average accuracy that is competitive to the existing methodologies.

(Y. Wang, Wu, and Chen n.d.) Noise reduction is an active research area in hyperspectral image processing due to its importance in improving the quality of image for the subsequent applications. To improve the accuracy and efficiency of object recognition and classification using hyperspectral imagery (HSI), we propose a novel smoothing algorithm by coupling a Laplacian-based reaction term to a classical anisotropic diffusion partial differential equation (PDE). In addition, an adaptive parameter is introduced to regularize the proposed reaction-diffusion PDE by explicitly integrating the inter- band correlations with the noise level of each band in hyperspectral images. As a result, our algorithm is more effective at controlling the behavior of the diffusion function when compared to previous multi/hyperspectral diffusion algorithms.

(He et al. 2018) The most fundamental purpose of infrared (IR) and visible (VI) image fusion is to integrate the useful information and produce a new image which has higher reliability and understandability for human or computer vision. In order to better preserve the interesting region and its corresponding detail information, a novel multiscale fusion scheme based on interesting region detection is proposed in this paper. Firstly, the MeanShift is used to detect the interesting region with the salient objects and the background region of IR and VI. Then the interesting regions are processed by the guided filter. Next, the nonsubsampled contourlet transform (NSCT) is used for background region decomposition of IR and VI to get a low-frequency and a series of high-frequency layers. An improved weighted average method based on per-pixel weighted average is used to fuse the low- frequency layer. The pulse-coupled neural network (PCNN) is used to fuse each high-frequency layer. Finally, the fused image is obtained by fusing the fused interesting region and the fused background region. Experimental results demonstrate that the proposed algorithm can integrate more background details as well as highlight the interesting region with the salient objects, which is superior to the conventional methods in objective quality evaluations and visual inspection.

(Patil et al. 2018) Continuous vital signs monitoring plays a critical role in proactively managing people's health in their daily lives. Thus, more affordable, portable, convenient, and reliable health monitoring systems are highly demanded. In this study, we present a new approach capable of extracting photo- plethysmogram (PPG) from facial videos using the Laplacian pyramid based signal amplification technique, with the goals of improving the estimation accuracy and enhancing the robustness to varying environmental and operational conditions. To validate our approach in the day-to-day setting, 10 videos from each of the 10 subjects were recorded under various lighting and illumination conditions at different places, over a period of one month. All the results are compared against the popular PPG extraction technique based on the region of interest (ROI) averaging method, as well as the PPG waveforms extracted with the standard pulse oximeter. It is shown that the proposed approach can generate comparable results with improved SNR and a high level of consistency and stability.

(Yu and Yiquan 2018) Local Laplacian filter is an edge-preserving image filter which can smooth image details and preserve image edges very efficiently. In the filtering process of the local Laplacian filter, a simple criterion is used to distinguish large-scale edges from small-scale details. A global threshold is used in the criterion. The intensity distance of a pixel in the input image is defined as the absolute value of the difference of the intensity of that pixel between a reference value. Those pixels with intensity distances smaller than the threshold are considered as small-scale details while those pixels with intensity distances larger than the threshold are considered as large-scale edges. However, this criterion can make wrong decisions when dealing with strong textures or weak edges. Pixels belonging to the strong texture region can have intensity distances larger than the threshold while pixels belonging to weak edges can have intensity distances smaller than the threshold. In such situations, textures which should be smoothed are considered as large-scale edges and they are preserved. Weak edges which should be preserved are considered as small-scale details and they are smoothed. In this paper, this criterion is improved by introducing the concept of the relative total variation. The global threshold is replaced by a local threshold. The local threshold is dependent on the relative total variation and it can make right decisions when dealing with strong textures or weak edges. Experimental results show that, compared to the original local Laplacian filter and several other state-of-the-art edge-preserving image filters, the proposed method can get significantly better image smoothing results especially when there are strong textures.

22

(Asif and Akram 2017)In this paper address separation of the two layers from single image where layer one is smother than other layer. In the removal of interference reflection and intrinsic image decomposition mostly arises this problem. Decomposition of layers from single input image is ill conditioned and additional constraint is required for enforced solution. For regularizing two layers they propose a strategy based on the Yu li and Michael s. Brown work-propose an optimization technique that solves regularization within few iterations. We apply propose technique for reflection removal and intrinsic image. Propose technique is quite fast and produced high quality results on par with existing technique. We use MIT dataset, OCT medical image data and on local images.

19

Color image enhancement is one of the vitalemerging techniques in the field of Digital Image Processing. In this paper, wepropose Color Image Enhancement usingLaplacian filter and Contrast Limited Adaptive Histogram Equalization.

19

(Bhairannawar and Patil 2017)The original RGB color image is considered from Computer Vision Group database and is converted to Hue- Saturation-Value (HSV) with Laplace filter applied to S and V components. The processing block which involves local correlation, variance and luminance enhancement are performed on laplacian output of V and S components and the Contrast Limited Adaptive Histogram Equalization (CLAHE) is applied on enhanced luminance component output followed by contrast stretching on S component. Finally, the HSV components are converted to RGB and performance parameter of enhancement is obtained. It is observed that the proposed method obtain better PSNR compared to existing methods.

24

(Li 2018) To improve contrast for remote sensing image without suffering from insufficient details, this paper proposes an enhancement method for different remote sensing images based on nonsubsampled shearlet transform (NSST) and local laplacian filter. The input image is first decomposed into low- frequency and high-frequency components. Then, the chosen local laplacian filter is used to process the low-frequency coefficient, and the adaptive threshold is used to suppress the noise included in the high-frequency coefficient. Finally, the NSST is inversed to obtain the enhanced image. Visual and quantitative analysis indicate the significance of the proposed image enhancement scheme, as compared to state of the art techniques

(Pamungkas et al. 2018) the FCM (Fuzzy C-Mean) is on of algorithms used in the background image separation research. This study aims to improve the quality of image segmentation using FCM algorithm with Local Laplacian Filter. Thus, we applied the Local Laplacian Filter into the V (Value) and S (Saturation) component of the image. The result of Laplacian Filter then clustered using FCM method. The result of segmentation using FCM and Local Laplacian Filter will be compared withground-truths images to reveal the value of the PSNR (Peak Signal to Noise Ratio) and the MSE (Mean Square Error). This study also compared the results of the MSE and PSNR with the FCM and K-Mean algorithms. The image is done preprocessing first by using Local Laplacian Filter which gives the color contrast to the image. So the image becomes sharper and when the image changed to the color space HSV already looks quite striking color differences between objects with the background. The results of this study indicate that segmentation using FCM and Local Laplacian Filter has the best MSE and PSNR results compared to the 2 tested algorithms.

(Khaparde and Deshmukh 2017)Optical imaging systems or cameras have a convex lens with limited depth of field. So, multi- focus images are obtained when such systems are used to capture an image of a particular scene. These images are fused to get all-in-focus image. This paper proposes a new simpler method of multi-focus image fusion. Instead of decomposing input image into blocks in pyramid style, the proposed algorithm considers the complete image for edge detection. The proposed algorithm uses the genetic algorithm (GA) to find out the optimum weights from extracted edges and then fuses the images with the fusion rule based on optimized weights. Experimental results show that this superimposition method performs well; consumes less computation time and thus proves to be suitable for hardware implementation.

(H. Singh 2018) Recent computational photography techniques play a significant role to overcome the limitation ofstandard digital cameras for handling wide dynamic range of real-world scenes contain brightly and poorly illuminated areas. In many of such techniques it is often desirable to fuse details from images captured at different exposure settings. One such technique is High Dynamic Range (HDR) imaging that provides a solution to recover radiance maps from photographs taken with conventional imaging equipment. One of the long-standing challenges in HDR imaging technology is the limited Dynamic Range (DR) of conventional display devices and printing technology. Due to which these devices are unable to reproduce full DR. Although DR can be reduced by using a tone-mapping, but this comes at an unavoidable trade-off with increased computational cost. Therefore, it is desirable to maximize information content of the synthesized scene from a set of multi-exposure images without computing HDR radiance map and tone- mapping. This thesis attempts to develop a novel detail enhanced multi-exposure image fusion approach, which exploits the edge preserving capability of adaptive filters.

(Id 2018)Multi-focus image fusion is an effective approach to obtain the all-in-focus image. Focus detection is the key issue of multi-focus image fusion. Aiming at the shortcoming of spatial domain and transform domain algorithms for multi-focus image fusion, a novel multi-focus image fusion algorithm is proposed by combing focus detection in spatial domain and non- subsampled contourlet transform (NSCT) domain. At first, the focused pixels are detected by the sum-modified-Laplacian algorithm in spatial domain. At the same time, the focus detection method is proposed in NSCT domain, namely by MPCNN and voting fusion meth-ods for high-frequency subbands of NSCT. Then, the morphological operation is utilized to correct the focus detection results in spatial domain and NSCT domain. At last, synthesis of detection results is implemented and the fused image can be obtained. Experimental results verified that the proposed algorithm outperformed some state-of-the-art fusion algorithms in terms of both subjective observation and objective evaluations.

(Madhav and Shrivastava 2018)During extraction of information from advanced quality of multiple image data and their functionality has led to search for various algorithms of enhancement which overcome the technology limitations. Image Fusion intends at the mixing of dissimilar and complementary data to improve the information perceptible in the images in addition to increase the consistency of the understanding. The proposed methodology implemented here performs better fusion as compared to the existing technique of fusion of the source images. The comparison between existing and proposed work is done on the basis of various parameters.

(Srivastava 2016) Image fusion is a popular application of image processing which performs merging of two or more images into one. The merged image is of improved visual quality and carries more information content. The present work introduces a new image fusion method in complex wavelet domain. The proposed fusion rule is based on a level dependent threshold, where absolute difference of a wavelet coefficient from the threshold value is taken as fusion criteria. This absolute difference represents variation in the image intensity that resembles the salient features of image. Hence, for fusion, the coefficients that are far from threshold value are being selected. The motivation behind using dual tree complex wavelet transform is due to failure of real valued wavelet transform in many aspects. Good directional selectivity, availability of phase information and approximate shift invariant nature of dual tree complex wavelet transform make it suitable for image fusion and help to produce a high quality fused image. To prove the strength of the proposed method, it has been compared with several spatial, pyramidal, wavelet and new generation wavelet based fusion methods. The experimental results show that the proposed method outperforms all the other state-of- the-art methods visually as well quantitatively as in terms of standard deviation, mutual information, edge strength, fusion factor, sharpness and average gradient.

(Kumar.T et al, 2011) Detected a human face in an image can represent the presence of a human in a place. Because the automatic work aims to detect the face .main aim of recognition of the face for automatic system. And human face detection is main working for the image processing there is different technique like feed forward convolutional network deep model and Artificial neural network. Face detection approach relies on transformation fast Fourier transform (FFT) neural networks, which can be used to detect faces by using this algorithm. Different face image of different size and some same size then load the in MATLAB and make a .mat file. MAT file is use for as a database. If there are some image in the folder is create error it can be load again. Its simplicity and capability the Multi-Layer Perception (MLP) with a back propagation learning algorithms was selected for the proposed system due to in supervised pattern matching. It has been completely applied to different pattern classification problems.

(Yun et al. 2017) We propose a three-dimensional (3D) face-modelling method from a single two-dimensional (2D) face image using a gallery of 2D face images and their corresponding 3D face models. Unlike existing methods, which require human effort, we provide a simple way to reconstruct 3D face models without user interaction. Our main approach is based on the idea that a particular coefficient that linearly combines vectors of 2D face images and outputs a vector that approximates the input image vector in terms of the vector norm can be reused in 3D models. Therefore, the pair of a 2D image and its 3D model plays an important role in our algorithm. Using the FaceGen software allows us to avoid the employed in previous works procedure whereby the 3D model is generated in a labor-intensive, expensive way. As a result, we are able to easily establish our 2D and 3D database.

(nandan 2015) At present face recognition has wide area of applications such as security, law enforcement. Imaging conditions, Orientation, Pose and presence of occlusion are huge problems associated with face recognition. The performance of face recognition systems decreases due to these problems. Discriminant Analysis (LDA) or Principal Components Analysis (PCA) is used to get better recognition results. Human face contains relevant information that can extracted from face model developed by PCA technique. Principal Components Analysis method uses eigenface approach to describe face image variation. A face recognition technique that is robust to all situations is not available. Some techniques are better in case of illumination, some for pose problem and some for occlusion problem. This paper presents some algorithms for face recognition. We discuss how greater accuracy can be achieved by extracting features from the boundaries of the faces by using Active Shape Models and, the skin textures, using Active Appearance Models, originally proposed by Cootes and Talyor.

(Hua et al. 2016)It is important to extract a clear background for computer vision and augmented reality. Generally, background extraction assumes the existence of a clean background shot through the input sequence, but realistically, situations may vio- late this assumption such as highway traffic videos. Therefore, our probabilistic model-based method formulates fusion of can- didate background patches of the input sequence as a random walk problem and seeks a globally optimal solution based on their temporal and spatial relationship. Furthermore, we also design two quality measures to consider spatial and temporal coherence and contrast distinctness among pixels as background selection basis. A static background should have high tem- poral coherence among frames, and thus, we improve our fusion precision with a temporal contrast filter and an optical- flow-based motionless patch extractor.

Experiments demonstrate that our algorithm can successfully extract artifact-free back- ground images with low computational cost while comparing to state-of-the-art algorithms.

(Balachander and Dhanasekaran 2016) The process by which different images or information from multiple images are combined is termed as Image fusion which is achieved by applying a sequence of operators on the images. Recently, a number of image fusion techniques have been developed. This paper presents a review on the main categories of image fusion namely spatial domain technique, transform domain technique and statistical domain fusion technique. Image Fusionis one of the latest fields adopted to solve the problems of digital image; image fusion produces high-quality images which contains additional information for the purposes of interpretation, classification, segmentation and compression, etc. The principle requirement of the fusion process is to identify the most significant features in the input images and to transfer them without loss of detail into the fused image. Image Fusion finds its application in vast range of areas. It is used for medical diagnostics and treatment. This paper presents a brief description of some of the extensively used image fusion techniques. Comparison of all available image fusion techniques concludes a better approach for future research on image fusion.

(Kosesoy, Cetin, and Tepecik 2015) In the study, an interface toolbox for image fusion (IFT) is developed and implemented of using the Matlab programming language. MATLAB developed by MathWorks is suitable for rapid application development and also its scope is scripts and functions can be run as m-files in the open source program Octave. In program, the interface toolbox is created to integrate from different types of satellite images to a single enhanced image. This image fusion toolbox is useful at the undergraduate students to understand the results of the image enhancements technique and the integration of remotely sensed image.

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PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26

PAGE 27

PAGE 28

PAGE 29

PAGE 30

PAGE 31

PAGE 32

PAGE 33

PAGE 34

PAGE 35

PAGE 36

PAGE 37

PAGE 38

PAGE 39

PAGE 40

PAGE 41