**2. LITERATURE SURVEY**

**2.1 IMAGE FUSION**

The term fusion means in general an approach to extraction of information acquired in several domains. The goal of image fusion (IF) is to integrate complementary multisensor, multitemporal and/or multiview information into one new image containing information the quality of which cannot be achieved otherwise. The term quality, its meaning and measurement depend on the particular application.

Image fusion has been used in many application areas. In remote sensing and in astronomy, multisensor fusion is used to achieve high spatial and spectral resolutions by combining images from two sensors, one of which has high spatial resolution and the other one high spectral resolution. Numerous fusion applications have appeared in medical imaging like simultaneous evaluation of CT, MRI, and/or PET images. Plenty of applications which use multisensor fusion of visible and infrared images have appeared in military, security, and surveillance areas. In the case of multiview fusion, a set of images of the same scene taken by the same sensor but from different viewpoints is fused to obtain an image with higher resolution than the sensor normally provides or to recover the 3D representation of the scene. The multitemporal approach recognizes two different aims. Images of the same scene are acquired at different times either to find and evaluate changes in the scene or to obtain a less degraded image of the scene. The former aim is common in medical imaging, especially in change detection of organs and tumors, and in remote sensing for monitoring land or forest exploitation. The acquisition period is usually months or years. The latter aim requires the different measurements to be much closer to each other, typically in the scale of seconds, and possibly under different conditions.

The list of applications mentioned above illustrates the diversity of problems we face when fusing images. It is impossible to design a universal method applicable to all image fusion tasks. Every method should take into account not only the fusion purpose and the characteristics of individual sensors, but also particular imaging conditions, imaging geometry, noise corruption, required accuracy and application-dependent data properties.

**2.2 IMAGE FUSION TECHNIQUES**

The process of image fusion the good information from each of the given images is fused together to form a resultant image whose quality is superior to any of the input images .Image fusion method can be broadly classified into two groups –

* Spatial domain fusion method
* Transform domain fusion

In spatial domain techniques, we directly deal with the image pixels. The pixel values are manipulated to achieve desired result. In frequency domain methods the image is first transferred in to frequency domain. It means that the Fourier Transform of the image is computed first. All the Fusion operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. Image Fusion applied in every field where images are ought to be analyzed. For example, medical image analysis, microscopic imaging, analysis of images from satellite, remote sensing Application, computer vision, robotics etc [7][8]. The fusion methods such as averaging, Brovey method, principal component analysis (PCA) and IHS based methods fall under spatial domain approaches.

Another important spatial domain fusion method is the high pass filtering based technique. The disadvantage of spatial domain approaches is that they produce spatial distortion in the fused image. Spectral distortion becomes a negative factor while we go for further processing such as classification problem. Spatial distortion can be very well handled by frequency domain approaches on image fusion. The multi resolution analysis has become a very useful tool for analyzing remote sensing images. The discrete wavelet transform has become a very useful tool for fusion. Some other fusion methods are also there such as Laplacian- pyramid based, Curvelet transform based etc. These methods show a better performance in spatial and spectral quality of the fused image compared to other spatial methods of fusion.

There are various methods that have been developed to perform image fusion. Some well-known image fusion methods are listed below

(1) Intensity-hue-saturation (IHS) transform based fusion

(2) Principal component analysis (PCA) based fusion

(3) Multi scale transform based fusion

(a) High-pass filtering method

(b) Pyramid method

(i) Gaussian pyramid

(ii) Laplacian Pyramid

(iii) Gradient pyramid

(iv) Morphological pyramid

(v) Ratio of low pass pyramid

(c) Wavelet transforms

(i) Discrete wavelet transforms (DWT)

(ii) Stationary wavelet transforms

(iii) Multi-wavelet transforms

(d) Curvelet transforms

In computer vision, Multi sensor Image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images. Image fusion is the process that combines information from multiple images of the same scene. These images may be captured from different sensors, acquired at different times, or having different spatial and spectral characteristics. The objective of image fusion is to retain the most desirable characteristics of each image.

In remote sensing applications, the increasing availability of space borne sensors gives a motivation for different image fusion algorithms. Several situations in image processing require high spatial and high spectral resolution in a single image. Most of the available equipment is not capable of providing such data convincingly. The image fusion techniques allow the integration of different information sources. The fused image can have complementary spatial and spectral resolution characteristics. However, the standard image fusion techniques can distort the spectral information of the multispectral data while merging.

Some image fusion methods are:

* IHS transform based image fusion
* PCA based image fusion
* Wavelet transform based image fusion.

**IHS transform image fusion**:

The IHS technique is a standard procedure in image fusion, with the major limitation that only three bands are involved. Originally, it was based on the RGB true color space. It offers the advantage that the separate channels outline certain color properties, namely intensity (I), hue (H), and saturation (S). This specific color space is often chosen because the visual cognitive system of human beings tends to treat these three components as roughly orthogonal perceptual axes.

**PCA transform image fusion:**

The first principal component image contains the information that is common to all the bands used as input to PCA, while the spectral information that is unique to any of the bands is mapped to the other components. Then, similar to the IHS method, the first principal component (PC1) is replaced by the HRPI, which is first stretched to have the same mean and variance as PC1.As a last step, the HRMIs are determined by performing the inverse PCA transform .In data sets with many variables, groups of variables often move together. One reason for this is that more than one variable might be measuring the same driving principle governing the behavior of the system. In many systems there are only a few such driving forces. But an abundance of instrumentation enables you to measure dozens of system variables. When this happens, you can take advantage of this redundancy of information. You can simplify the problem by replacing a group of variables with a single new variable. Principal component analysis is a quantitatively rigorous method for achieving this simplification. The method generates a new set of variables, called principal components. Each principal component is a linear combination of the original variables. All the principal components are orthogonal to each other, so there is no redundant information. The principal components as a whole form an orthogonal basis for the space of the data. There are an infinite number of ways to construct an orthogonal basis for several columns of data.

**Wavelet Transform image fusion:**

A multi-resolution decomposition of an image in a bi-orthogonal basis and results in non-redundant image representation. This basis is called wavelets. First the images are transformed to the wavelet domain with the function wfusimg(), where the number of scales, the wavelet filter and the edge handling are specified .Then, a decision mask is built in the same way as it was explained in the Laplacian fusion implementation. The next step is carried out by constructing the fused transformed image with this decision mask. Finally, the fused

image is obtained by applying an inverse wavelet transform. Now let’s discuss the particular type of wavelet transformation used in this thesis i.e. the **Stationary Wavelet Transformation (SWT)**.

The Stationary wavelet transform (SWT) is a wavelet transform algorithm designed to overcome the lack of translation-invariance of the discrete wavelet transform (DWT). Translation-invariance is achieved by removing the down samplers and up samplers in the DWT and up sampling the filter coefficients by a factor of in the nth level of the algorithm. The SWT is an inherently redundant scheme as the output of each level of SWT contains the same number of samples as the input – so for a decomposition of N levels there is a redundancy of N in the wavelet coefficients. This algorithm is more famously known as "algorithme à trous" in French (word trous means holes in English) which refers to inserting zeros in the filters. It was introduced by Holschneider et al. Stationary Wavelet Transform (SWT), also known as Undecimated wavelet transform or Algorithme à trous is a translation-invariance modification of the Discrete Wavelet Transform that does not decimate coefficients at every transformation level

The following block diagram depicts the digital implementation of SWT.



A 3-level SWT filter bank.

In the above diagram, filters in each level are up-sampled versions of the previous (see figure below).



SWT filters

The fused images exhibited spectral accuracy with less spatial distortion and also show high correlation and entropy value compared to other two techniques. The paper for implementation of the techniques is reviewed. In this paper the three techniques are implemented namely HIS, PCA and wavelet. Also the comparison between three techniques based on parameters mean square error, normal cross correlation, peak signal to noise ratio is reviewed in this paper.

This review results that spatial domain provide high spatial resolution. But spatial domain have image blurring problem. The Wavelet transforms is the very good technique for the image fusion provide a high quality spectral content. But a good fused image have both quality so the combination of DWT & spatial domain fusion method (like PCA) fusion algorithm improves the performance as compared to use of individual DWT and PCA algorithm.

This paper reviewed has a reference of recent paper. Besides this paper one more paper is reviewed about implementation and comparison of these three techniques. Basically. This paper concludes that along this research, some image fusion approaches have been studied. All of them were found reliable fusion methods in multifocal applications, and in this paper has syntax, functions, implemented rules for the fusion techniques conjunction h. As previously mentioned, due to the subjective characteristic of the fusion quality evaluation they gave acceptable results in multisensory fusion schemes, excepting the spatial frequency approach, it is difficult to conclude which method is the best one for a certain application. The combination of the techniques of fusion is also done.

The techniques HIS + wavelet and PCA + wavelet. Review on the combination the technique is done by referring to the paper. This recent research concludes that PCA combined wavelet transform produce better results spatially, spectrally for the lunar image data compared to other methods.

A wavelet combined transform with HIS,PCA to obtain appreciable spatial and spectral resolution. The results shows that the combination of HIS and wavelet produce the fused image with high resolution, clarity and information with less spectral distortion. Morphological processing and Combination of DWT with PCA and Morphological techniques have been popular fusion of image.

These methods are shown to perform much better than simple averaging, maximum, minimum. Fusion applied in every field where images are ought to be analyzed. For example, medical image analysis, microscopic imaging, analysis of images from satellite, remote sensing Application, computer vision, robotics etc.

**2.3 STUDIES ON ADAPTIVE FUSION BASED NOISE REMOVAL**

Denoising an image is important process in digital image processing. In the literature, plenty of approaches and filters have been developed to clear noise in the corrupted images. But each has its own pros and cons. Many approaches introduce some of the side-effects which degrade the quality of denoising image.

Most of them are

Fuzzy edges induced by curvelet transform in the homogeneous regions Ringing effects introduced by DWCWT Staircase effect introduced by TV method Fusion technique plays a major role in the process of removing or reducing such kind of artifacts in the restored images. Although CMAP filter is more popular in removing speckle noise it does not provide assure to save edges [SHE03].

In 2011, Umamaheshwari J, and Radhamani G, [UMA11] proposed a hybrid method of removing Gaussian and speckle noise for DICOM medical images. In their work, one of the source images is smoothed by median filter and the rest is decomposed into wavelet coefficients. The coefficients are filtered out using threshold value. Resultant median filter image is having good performance in smooth region. Similarly the output image filtered by wavelet filter produces significant features like edge and texture. Finally fusion applied for both resulted images by pixel basis.

In 2006, Radford D, et al. [RAD06] gained an adaptive MR DCT based mechanism to clear speckle noise in Synthetic Aperture Radar (SAR) image. Totally they used four transform includes DWT, DWT (DB2.2)), DT-CWT and proposed MR-DCT to receive the MR coefficients. Every coefficient is denoised by applying threshold and fusion takes place by maximum choose rule. The final result image is derived by taking inverse MR transform. It provides efficient results with respect to denosie as well as fusion but takes more process time.

In 2003, Sheng Guofang, et al. [SHE03] implemented a fusion algorithm to acquire salient information in SAR images. To achieve their goal, they used a linear CMAP filter and wavelet filter. So, the methodology adapted here is the input SAR images are filtered by CMAP and threshold wavelet. The resulted denoise images put forward to decompose by bi-orthogonal wavelet coefficients. Based on selective fusion rule the orthogonal coefficients are getting fused. The inverse wavelet transform is computed over the fused images to acquire the result image.

To denosie a corrupted image, Naizhang Feng, et al. [NAI07] proposed a fusion algorithm which utilizes the features of Hidden Markov Tree model based wavelet (HWTD) and Curvelet. First the noisy images are put into the process of

denoising by CVT and HWTD form. The denoisy images introduce some kind of artifacts due to the nature of CVT denosing. A fuzzy partition based denoise algorithm was proposed to inhibit the artifacts existing in denoised images*.* The local attributes of the fuzzy window with required size was figured to the outcome images. Finally fusion can be done on the outcome images. Hui Cheng, et al. [HUI08] developed a fusion scheme to remove speckle noise in ultrasound images with the aid of modified wavelet coefficients by LSSVR method. LS-SVR method is an alternate mechanism to threshold and it is used to denoise wavelet coefficients in wavelet domain. The way to modify the coefficients is based on support vector calculation by integrating nearby coefficients. Results show that apart from reducing speckle noise it secures edge and texture data.

In 2009, Weihua Liu, et al.[WEI09] derived an adaptive fusion algorithm to remove noise in different domains. First noisy image is decomposed by steerable pyramid, NSCT and 2-D separable DFT modulated filter bank domains. Then the BLS-GSM algorithm is enforced over the coefficients obtained in the former step. Finally fusion of three denoised images takes place based on the local quality measures.

**2.4 LITERATURE SURVEY**

* VadherJagruti (2014) Implementation of dwt is done in this paper and author accomplish that Haar wavelet is best than other wavelet basis function. Comparison is done with the parameter Similarity Measure.
* S.JohnNisha et al. (2013) confer about the problems like spatial distortion, color distortion arises while performing fusion with techniques like HIS, PCA,Wavelet Transform etc. The author purposed a new fusion technique called linear pixel fusion main advantage of is no need of additional transformation and fused image is similar to natural color image.
* Huaxun Zhang (2013) This paper introduce a method based on wavelet decomposition and different characters of wavelet theory. It uses disassumble image to different frequency subband to save all information to have a perfect fusion. In this paper image fusion on medical images is performed and processing with DWT make calculation simple, improved fused image quality.
* RoshnaJ.Sapkalet.al (2013) proposed paper that talks about image fusion algorithm based on Fast DCT with different fusion rules. This paper discuss the limitation of DWT like it does not give better result during fusion of images containing curves. Statistical analysis of medical image is done using 7 quality metrics parameters.
* Mr.RajendaPanditDesale (2013) This paper talk over the Formulation, Process Flow Diagrams and algorithms of PCA (principal Component Analysis), DCT (Discrete Cosine Transform) and DWT (Discrete Wavelet Transform) based image fusion techniques. The comparative analysis of above techniques is performed and presented in the form of table. The PCA & DCT are conventional fusion techniques with many drawbacks, whereas DWT based techniques are more positive as they provides better results for image fusion.
* Om Prakash et al. (2013) propose a pixel-level image fusion scheme using multiresolution Biorthogonal wavelet transform (BWT).Maximum fusion rule is used to fuse Wavelet coefficients at different decomposition levels. BWT are capable to preserve edge information and reducing the distortions in the fused image because of two important properties wavelet symmetry and linear phase of BWT.
* SlavicaSavi (2012), gives review of related image fusion methods that in fusion process use pyramidal decomposition algorithms such as DWT and EMD. Subjective analysis of those methods, which had been performed on in-house multifocus images dataset, shown superiority of fusion method based on first level of EMD.
* Deepak Kumar Sahu et al. (2012) This paper converse about numerous fusion techniques like DWT, PCA, Average method, select maximum, select minimum etc. Comparison of these techniques, helps in selecting techniques in future research work. This paper concludes that the DWT and PCA with morphological processing will improve the image quality.
* YongYang (2010) this paper proposed that fusion of medical images helps in extracting features that are not visible by naked eye. DWT is applied to perform the image fusion.
* Hyoung Lee et al (2009) give review on detecting objects conceale1d underneath a person’s clothing using a form of electromagnetic radiation. Symlet wavelet is used to fuse visual image and PMMW image are fused using minimum fusion rule on CA coefficients and average fusion rule on detail coefficients.
* Xing-Wang Zhang et al. (2009) proposed in paper, thresholding method based on wavelet fusion of color image sub band. RGB Image is decomposed into three sub bands of red, green and blue. Then Dwt is applied on each band, maximum, minimum fusion rules are applied on them. Lastly otsu’s thresholding is applied .Image produced with this proposed algorithm are rich in quality than original image.
* V.P.S.Naidu (2008) In this paper implementation on Pixel-level image fusion using wavelet transform and principal component analysis are performed in MATLAB. Degraded performance is shown by average method.This paper conclude that DWT with higher level perform better than other techniques.
* Dong-Chen He et al. (2004) suggest that wavelet technique is far better than other techniques for fusion. The researcher proposed new and original method that is used to incorporate high resolution image with low resolution image with or without spectral relationship between these two images.
* HUANG Xisha ,CHENZhe proposed in paper that pixel level fusion by DWT on scene image remove infections like images covered by clouds and their shadows, which is failed by average fusion technique.