# Exploring Fusion Techniques for Satellite Image

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**Abstract—** ***With the advance in multispectral imaging, the use of image fusion has become a new and important research area. A solitary caught picture of a certifiable scene is generally deficient to uncover every one of the points of interest due to under-or over-uncovered areas. Amid the most recent twenty years, numerous strategies, for example, Multiplicative Change, Brovey Transform, Principal Component Analysis (PCA), and IHS Transform have been grown great quality melded pictures. Inspite of the very great visual outcomes, numerous analysts have announced the restrictions of the above combination procedures. The most huge issue is twisting of shading ,Another basic issue is that the combination quality frequently depend upon the administrator's combination encounter and upon the informational collection being melded. The goal of this paper is to examine different combination systems utilized for satellite pictures and dissect these methodologies intently for different situations. Likewise talk about the progressions which have been made while creating different combination methods their constraints and so forth. Combination methods on satellite pictures empower us to break down various sorts of information like climate estimate, Forest Area, Identify Roads for Maps, Water Bodies and so on altogether.***

***Keywords— Multispectral image(MS), High Pass Filtering (HPF), Panchromatic image(PAN),Ground Sample Distance(GSD), SVR(Synthetic Variable Ratio***

## I. INTRODUCTION

Remote detecting is the art of acquiring and translating data from separation, utilizing sensors that are not in physical contact with the question being watched. It is turning into a powerful device in checking neighborhood, territorial and worldwide ecological issues. The investigation of remote detecting in its broadest sense incorporates elevated, satellite, and rocket perceptions of the surfaces and climates of the planets in our nearby planetary group, however the Earth is clearly the most regular focus of study. The motivation behind obtaining remote-detecting picture information is to have the capacity to distinguish and survey, by a few means, surface materials and their spatial properties[1]. Picture upgrade calculations are connected to remotely detected information to enhance the presence of a picture for human visual examination or at times for resulting machine investigation [2]. With the advancement of imaging innovation, an expanding number of picture modalities wind up accessible. Multispectral and hyperspectral remote detecting pictures regularly have broad interband connections. Thus, the pictures may contain comparative data and have comparative spatial structures [3]. Information combination on remote detecting is one of imperative issue in current picture handling strategies, as the remote detecting information is monstrous, high-arrange repetitive and non-negative. The picture combination is a vital part of information combination. Many review papers have been distributed as of late, giving diagrams of the history, advancements, and the current best in class of picture combination in the picture based application fields [5-7], distributed with an accentuation on enhancing combination quality and discovering more application zones.

## II. IMAGE FUSION

Picture combination is the mix of at least two pictures to deliver a solitary honed picture that is utilized for further understanding. Pohl and Genderen Van, 1998 conceptualized that "Picture combination is the blend of at least two unique pictures to frame another picture utilizing a specific calculation". Likely the most famous picture combination strategies are those dependent on the force shade immersion change (IHS) [4]– [8] and primary segment investigation (PCA) [9]. The fundamental downside of these techniques, often called "segment substitution" strategies [6], is the high bending of the first phantom data that the subsequent MS pictures present [9], [10], [11].

According to the different processing level the image fusion is divided into three categories:

(i) Pixel-Based image fusion.
(ii) Feature-Based image fusion.
(iii) Decision-Based image fusion.

Pixel-based image fusion is based on the pixel-by-pixel fusion or through the fusion of the associated local neighbourhood of the pixels in each of the images used for the fusion. This is the lowest level of processing. Feature based picture combination is the second dimension of preparing. In this picture combination system different highlights reported in the diverse information sources are arranged together and after that melded highlight astute to get another picture. The choice based or decision based picture combination, esteem included information is utilized where the individual pictures are refined for data extraction. At that point some choice guidelines are connected to consolidate the removed data to develop a typical comprehension of the highlights. Henceforth, this dimension of handling is additionally called as understanding dimension of picture combination.

### *2.1 Existing Techniques for Image Fusion and Limitations*

Fusion techniques are discussed below:

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*2.1.1 IHS Transform Method*

The IHS change technique can consolidate a three-band low-goals multispectral picture with a high-goals panchromatic picture (Figure 1). To start with, the multispectral picture and the high-goals panchromatic picture are co-enlisted and the multispectral picture is resampled to the goals of the high-goals picture. At that point, the three multispectral groups, R, G, and B, of the low-goals picture are changed to the IHS shading space as per the accompanying conditions (Carper 1990).

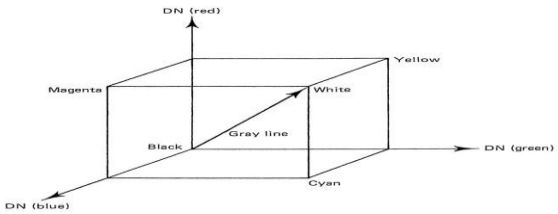



**Fig. 1 The RGB color cube (Schowengerdt 1983)**

*2.1.2 Pca Method:*

The PCA strategy, otherwise called Karhunen-Loeve change, is a normally utilized device for breaking down multispectral remote detecting information, particularly for picture upgrade and information pressure. It directs a straight change of the multispectral space to the eigenvector space of the information. Let X represent a n×1 vector of n image bands. Then a principal component transform is

$$XAT=Y \qquad (1)$$

where the matrix A is the matrix of eigenvectors, which orthogonalizes the covariance matrix of X such that the covariance matrix of Y is a diagonal matrix, as shown in the following equation (Faust 1989):

Where $\lambda_1 > \lambda_2 > \ldots > \lambda_n$. The result of the principal components is a set of decor related images whose variances of energies are ordered in amplitude.

Using the PCA method to merge a multispectral image of low resolution and a high-resolution image, the multispectal bands (which could be more than 3) are first transformed into the same number of independent principal components.

*2.1.3 Brovey Transform*

The Brovey change utilizes expansion, division, and duplication for the combination of three multispectral groups. Its idea can be portrayed with the accompanying recipe (ERDAS2004):

$$Band1new=[band1/(band1+band2+band3)]*PAN \qquad (3.1)$$

$$Band2new==[band2/(band1+band2+band3)]*PAN \qquad (3.2)$$

$$Band3new==[band3/(band1+band2+band3)]*PAN \qquad (3.3)$$

Where band1, band2, and band3 are the three groups of the multispectral picture, and Pan is the panchromatic picture with higher spatial goals.

The Brovey change was produced to outwardly build differentiate in the low and high closures of a picture histogram (i.e., to give differentiate in shadows, water, and high recurrence zones, for example, urban highlights). Limitation of these strategies:

1) One of the fundamental impediments of HIS and Brovey change is that the quantity of info different otherworldly groups ought to be equivalent or under three at any given moment.
2) These picture combination strategies are regularly effective at enhances the spatial goals, be that as it may, they will in general twist the first phantom marks to some degree.
3) More as of late new systems, for example, the wavelet change appear to decrease the shading contortion issue and to keep the measurable parameters invariable.

## III. WAVELET TRANSFORM

Wavelet changes are fit for breaking down a computerized picture into an arrangement of multi goals pictures, joined by wavelet coefficients for every goals level. The wavelet coefficients for each dimension contain the spatial contrasts between two progressive goals levels. Wavelets are a plan of non-coordinate bases.While anticipating a capacity regarding wavelets, the wavelet premise capacities are picked by the capacity being approximated. Subsequently, in contrast to groups of direct bases where the equivalent, static arrangement of premise capacities are utilized for each information work, wavelets utilize a dynamic arrangement of premise works that speaks to the info work in the most productive way. Along these lines wavelets can give a lot of pressure and are thusly exceptionally well known in the fields of picture and flag preparing. Alfred Haar found another orthonormal arrangement of capacities, with the end goal that for any constant capacity f(x), the arrangement meets to f(x) consistently over the interval $0 \le x < 1$

$$f(x) = \sum_{j=0}^{\infty} \sum_{k=0}^{2^j-1} a_{2^j+k}\, w(2^j x - k), \qquad for \quad 0 \le x < 1$$

For 1D Haar to extend a vector into wavelets, we just take a spot result of the information vector with every one of the premise vectors. The 1D Haar Transform can be effortlessly reached out to 2D. In the 2D case, we work on an information lattice rather than an information vector. To change the information network, we initially apply the 1D Haar change on each line.

*3.1 Comparison with other techniques*

The standard picture combination strategies, for example, IHS based strategy, PCA based technique and Brovey change strategies work under spatial space. Be that as it may, the spatial area combinations may create phantom corruption. This is especially urgent in optical remote detecting if the pictures to intertwine were not procured in the meantime. In this way, contrasted and the perfect yield of the combination, these strategies regularly create poor outcome. Over the previous decade, new methodologies or enhancements for the current methodologies are consistently being proposed to beat the issues in the standard strategies. As multi goals investigation has turned out to be a standout amongst the most encouraging techniques in picture handling, the wavelet change has turned into an exceptionally valuable apparatus for picture combination. It

has been discovered that wavelet-based combination methods outflank the standard combination strategies in spatial and phantom quality, particularly in limiting shading twisting.

*3.2 Wavelets Based Image Fusion*

In 1989, Mallat put every one of the techniques for wavelet development into the structure of utilitarian examination and depicted the quick wavelet change calculation and general strategy for building wavelet orthonormal premise. On the premise, wavelet change can be extremely connected to picture decay and reproduction. Wavelet changes give a structure in which a picture is deteriorated, with each dimension relating to a coarser goals band.

Think about that the PAN and MS pictures are obtained from a remote IKONOS sensor. IKONOS is a business earth perception satellite. It offers MS and PAN symbolism described by 4-meter and 1-meter spatial goals separately. The PAN picture is without shading data while the MS picture covers three otherworldly groups. On account of intertwining a MS picture with a high-goals PAN picture with wavelet combination.

For instance, on account of intertwining a MS picture with a high-goals PAN picture with wavelet combination, the Pan picture is first decayed into an arrangement of low-goals Pan pictures with comparing wavelet coefficients (spatial subtle elements) for each dimension.

The high goals spatial detail is infused into every MS band by playing out an invert wavelet change on every MS unite as one with the comparing wavelet coefficients as appeared in Figure 2.

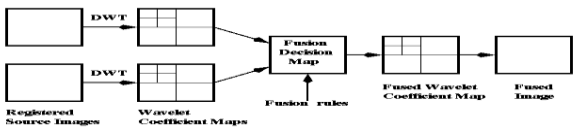



**Fig.2 Flow diagram for Wavelet Based Image Fusion**

The stream can be isolated into the accompanying advances

1) Decomposition of a high goals panchromatic picture into low-goals Pan pictures with comparing wavelet coefficients (spatial points of interest) for each dimension.
2) Use detail coefficients from panchromatic picture and inexact picture from groups of multi ghostly picture.
3) Individual groups of the MS picture at that point supplant the low-goals Pan at the goals dimension of the first MS picture.
4) The high goals spatial detail is infused into every MS band by playing out a turn around wavelet change on every MS gather as one with the relating wavelet coefficients.

We perform skillet honing with the assistance of wavelets. It disintegrates the panchromatic picture and the multispectral picture as appeared in Figure 3 and after that takes the guess coefficients of the multispectral band and the detail coefficients of the panchromatic picture to reproduce a band. The combination happens by coordinating comparing coefficients in both these pictures.

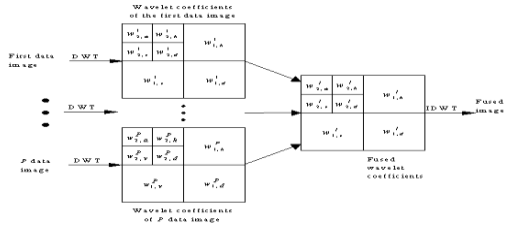



**Fig.3 Coefficient wise segments mapping for PAN Image and MS**

In the wavelet-based combination plans, detail data is extricated from the PAN picture utilizing wavelet changes and infused into the MS picture. Bending of the phantom data is limited contrasted with the standard strategies. Structures and liner objects (roads,etc.) could be effortlessly recognized from intertwined pictures.

*3.3 Implementation Detail*

The wavelet function we have implemented takes following as input arguments-

a) Pan Image : High Resolution Panchromatic Image
b) MS Image: Low Resolution Multi Spectral Image Which has already been upscaled so that it has same size as high resolution
c) Level: Level of the wavelet decomposition used for reconstruction
d) Wavelet: Wavelet name that is being used (Default HAAR)

Once we are done down sampling and fusing the pan image with multi resolution image we perform reconstruction of wavelet to image using the matlab function waverec().

## IV. RESULTS & ANALYSIS

For testing purposes we have gathered different satellite pictures originating from various satellites and purposes.Information combination is a procedure managing information and data from numerous sources to accomplish refined/enhanced data for basic leadership. container honing depicts a procedure of changing an arrangement of coarse (low) spatial goals multispectral (shading) pictures to fine (high) spatial goals shading pictures, by melding a co-georegistered fine spatial goals panchromatic (dark/white) picture. Regularly, three low-goals noticeable groups - blue, green and red - are utilized as fundamental contributions to the procedure to deliver a high-goals common (genuine) shading picture. The usage for every one of the strategies was finished utilizing MATLAB. Likewise we figured out how to get few satellite pictures from geo satellite sites which bargain in satellite symbolism for different applications. We have made examination of following combination strategies:

a) PCA
b) IHS based fusion
c) Brovey
d) Wavelet based fusion

Change discovery is the way toward distinguishing contrasts in the condition of a question or wonder by watching it at various occasions. Change location is an essential procedure in observing and overseeing characteristic assets and urban advancement since it gives quantitative examination of the spatial conveyance of the number of inhabitants in intrigue. Picture combination for change discovery exploits the distinctive setups of the stages conveying the sensors. The blend of these worldly pictures in same place upgrades data on changes that may have happened in the region watched. Sensor picture information with low transient goals and high spatial goals can be melded with high worldly goals information to upgrade the changing data of certain ground objects. Figure 4 shows SPOT5 image of Monteverdi Marittimo Italy on which different combination methods have been connected.. We can see that the roads are better identified in wavelet based technique. The shading balance has been all around kept up. Structures and liner objects (roads,etc.) could be effectively recognized from melded pictures.. Brovey's generated fused image was able to segregate the trees, garden quite effectively compared to other techniques.

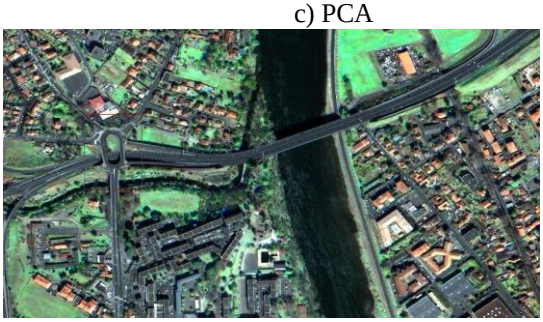
Figure 5 shows an image on which various fusion techniques have been applied. We can see that in wavelet based technique the image has got a little blurred although the color balance is till maintained. IHS technique showed best results in terms of generating a crisp image separating the water bodies and vegetation.

a) Multispectral Image

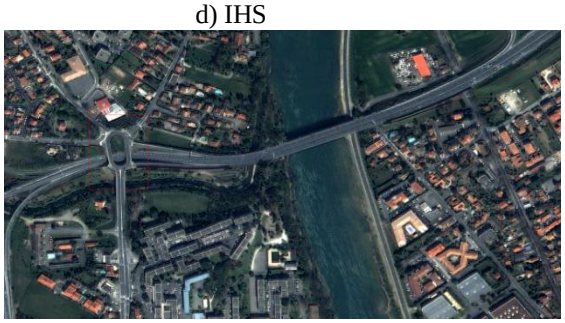
b) Pan Image

c) PCA

d) IHS



e) Brovey



f) Wavelet

**Fig. 4 Comparison of various fusion techniques on SPOT5 Image of Satellite image of Monteverdi Marittimo, Italy**

Multispectral Image

PAN Image

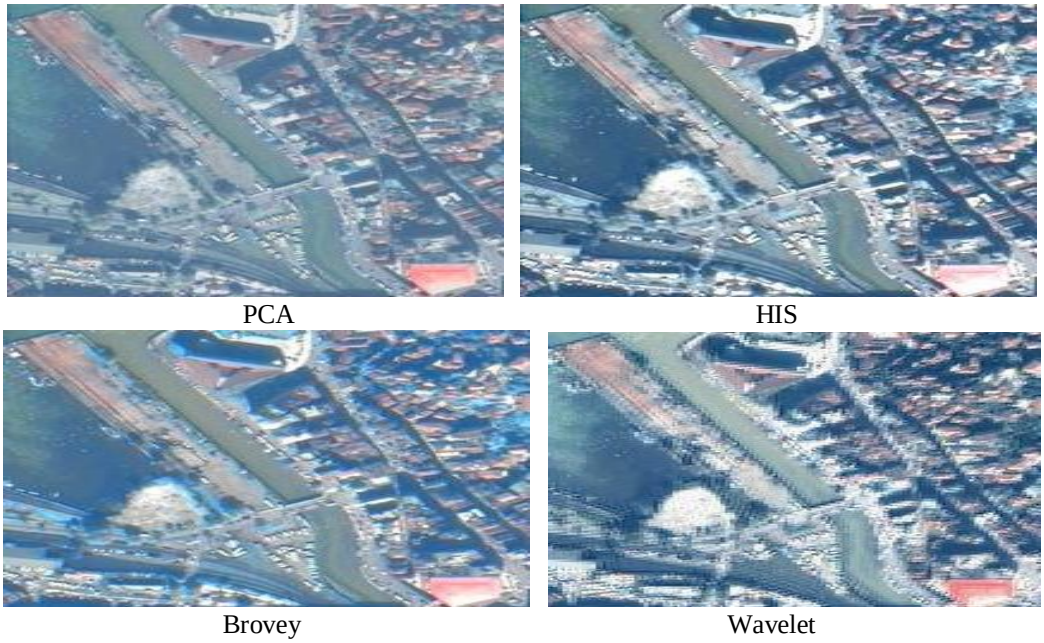



**Fig.5 Comparison of various fusion techniques for satellite image from 1m GSD of IKONOS**

Based on visual analysis and evaluation, combining with statistics which reflect spectral information such as mean of grayscales (TABLE 1), the fused images are analyzed and evaluated by subjective qualitative analysis and objective quantification

**Table 1 Statistics Of Images Fused By Different Methods For Quickbird And Spot5**

| Norm | Fusion Technique | SPOT5 | | | QuickBird | | |
|---|---|---|---|---|---|---|---|
| | | B1 | B2 | B3 | B1 | B2 | B3 |
| | Original | 65.14 | 75 | 71 | 104.6 | 97 | 84 |
| Mean | PCA | 120.4 | 127.5 | 124.8 | 196 | 210 | 204 |
| | HIS | 121.2 | 129.4 | 126 | 432 | 316 | 235 |
| | Brovey | 44.3 | 30.2 | 49.8 | 84.2 | 161 | 103 |
| | Wavelet | 65.3 | 75.1 | 71.3 | 88 | 97 | 103 |

After the integrated analysis, experiment result indicates the following conclusions: compared with original multi-spectral images, the fused images are greatly improved in spatial resolution and clarity. It is proved through the visual compare analysis of residential areas, roads, building outline and image details. Since PCA method has no band limitation, so more spectral features of the their original multi-spectral images are reserved by PCA method, which indicates PCA strategy is a decent decision if the ensuing application needs better ghastly characteristics, and the texture information in construction district especially in city center is more clearly by PCA method. IHS method can improve the texture features of images, but the band number of original multi-spectral images must be three, and spectrum distortion is a little serious.

So IHS transformation method is not suitable if the application of fused image is mainly based on Spectral analysis. The hue of fused image by Brovey method is a bit on darker especially in urban areas, but the greenbelt can be easily separated. Color distortion may be caused by use of Brovey method, so Brovey method is not used if the radiation information of original image is more important and need to be retained. Late examination demonstrated that urban development could be effectively checked utilizing satellite pictures with multi-transient and multi-spatial goals.

A multi-sensor choice dimension picture combination calculation dependent on fluffy hypothesis are utilized for arrangement of every sensor picture, and the characterization results are intertwined by the combination rule.

Intriguing outcome was accomplished for the most part for the rapid arrangement and proficient combination of corresponding data. Land-utilize/arrive cover characterization had been enhanced utilizing information combination strategy. The test results demonstrate that the astounding execution of arrangement when contrasted with existing order methods. Picture combination techniques will prompt solid advances in land utilize/arrive cover orders by utilization of the integral of the information showing either high spatial goals or high time dreariness.

CBERS numerous ghastly picture with spatial goals of 19.2 m of Yiwu City, Zhejiang Province, China, in 2007 was intertwined with CBERS-HR PAN picture with spatial goals of 2.4 m.

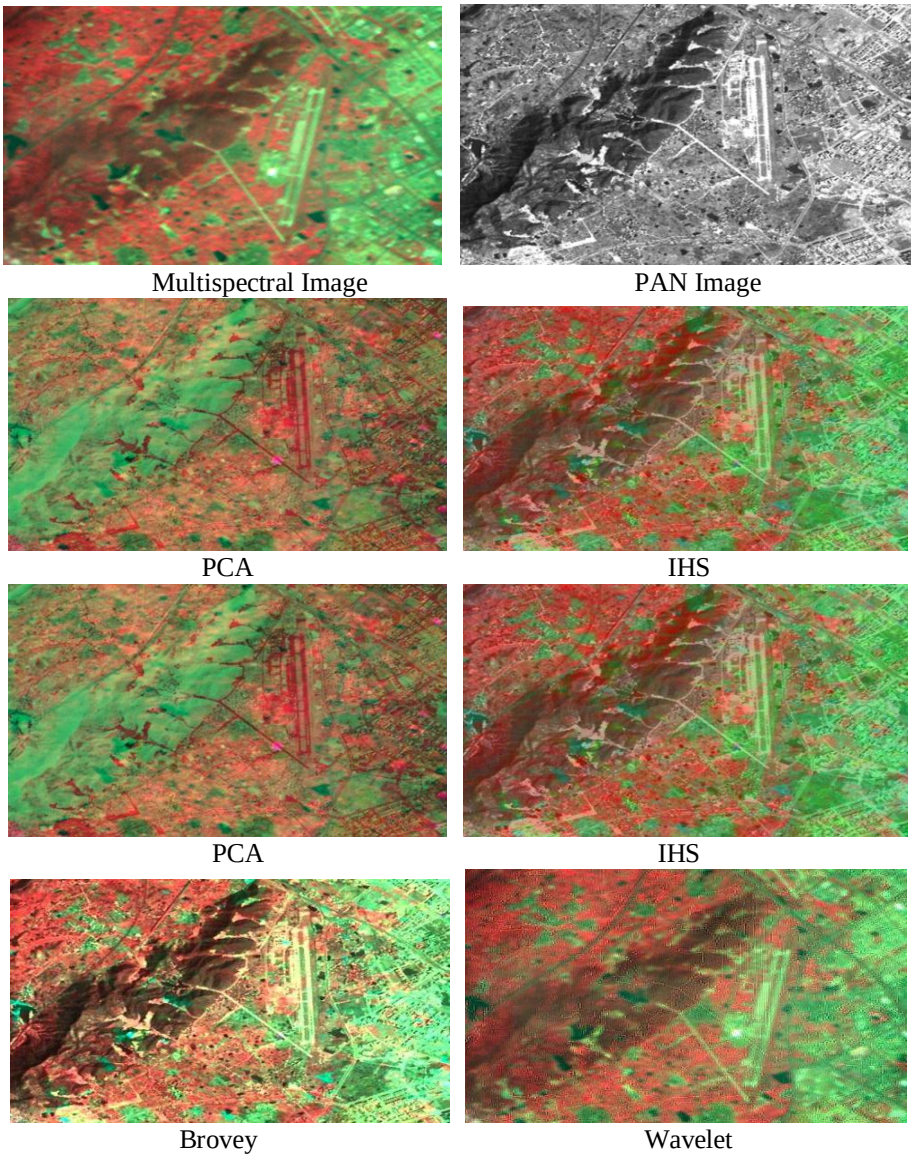



**Fig.6 Fusion results on a CBER satellite image of Yiwu City, Zhejiang Province, China**

In this case brovey was able to differentiate various regions significantly and has fine line of separation compared to other techniques. If we closely observe in PCA the portion has been marked as green which is clearly not the case while comparing with the multispectral image.

**Table 2 Standard Deviation for various band images from SPOT5 and QUICKBIRD**

| Norm | Fusion Technique | SPOT5 | | | QuickBird | | |
|---|---|---|---|---|---|---|---|
| | | B1 | B2 | B3 | B1 | B2 | B3 |
| | Original | 25.2 | 19.6 | 18 | 57.8 | 89.2 | 158.3 |
| Standard | PCA | 12.7 | 11.9 | 8.8 | 26.5 | 39.6 | 27.3 |
| Deviation | IHS | 13.6 | 14.9 | 19.3 | 236.2 | 129.3 | 159.2 |
| | Brovey | 4.2 | 8.8 | 5.1 | 26.4 | 37.9 | 24.3 |
| | Wavelet | 5.3 | 7.9 | 6.3 | 19.6 | 29.4 | 31.7 |

The above table displays the standard deviation for band images of SPOT5 and QUICKBIRD satellites just providing a statistical insight of variations in each of the band images generated by these satellites.

## V. CONCLUSION & FUTURE WORK

We could presume that we could investigate the majority of the standard strategies being utilized for picture combination and got the opportunity to actualize every one of them and break down their individual results.For techniques like IHS, PCA and Brovey change, which have bring down multifaceted nature and quicker handling time, the most critical issue is shading mutilation. Wavelet-based plans perform superior to those strategies regarding limiting shading contortion. The advancement of more refined wavelet-based combination calculation execution result, yet they

frequently cause more noteworthy multifaceted nature in calculation and parameters setting. Another test on existing combination systems will be the capacity for preparing hyper-otherworldly satellite sensor information. Counterfeit neural system appear to be one conceivable way to deal with handle the high measurement nature of hyper-phantom satellite sensor information.

Programmed quality appraisal is exceedingly attractive to assess the conceivable advantages of combination, to decide an ideal setting of parameters for a specific combination plot, and to contrast results acquired and distinctive calculations. Scientific techniques are utilized to pass judgment on the nature of consolidated symbolism in regard to their enhancement of spatial goals while saving the otherworldly substance of the information. Factual files, for example, cross entropy, mean square mistake, motion to-commotion proportion, have been utilized for assessment reason. In any case, all in all, no programmed arrangement has been accomplished to reliably create superb combination for various informational indexes. It is normal that the consequence of combining information from different free sensors will offer the potential for preferred execution over can be accomplished by either sensor, and will diminish defenselessness to sensor particular countermeasures and arrangement factors. We expect that future research will address new execution appraisal criteria and programmed quality evaluation strategies.

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