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SPECKLE NOISE DETECTION AND REMOVING BY MACHINE LEARNING ALGORITHMS IN MULTISENSORY IMAGES FOR 5G TRANSMISSION

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Abstract. The multispectral satellite sensor images have multibands, which have some typical noise. There is difficult to detect this tipical noise with low resolution image. The satellite local or gloval pixel information and quantificationare degraded due to this noise. Many standard transformations and filtering operations are developed for detection and removing of non-gaussion noise, which are not given sophisticated results with existing methods. These statistical characteristics are applied to those samples to identify and quantify present tipical noise. The higher-order statistical based machine learning algorithm is developing to remove the speckle noise from satellite image. In this proposed algorithm, implemented the higher order statistical approache such as skewness, kurtosis based adaptive curvelet methods are implemented for the detection and suppression of speckle noise with retrieve of spectral and spectral values. The proposed algorithm preserves smooth and sharp details and maintains the tradeoff level in multispectral bands is suitable for advanced high speed 5G communication with the effective rate of transmission. The proposed results are verified with suitable statistical parameters such as PSNR,Entropy and ERGAS values.

Key words: Satellite image, Machine learning algorithm, spectral values, spatial values ,curvelet transform

1. Introduction. In Real-time Satellite images play a vital role in remote sensing applications such as regular land surface monitoring and atmospheric application without any physical contact. The satellite sensors capture the earth's information with various sensors and give the total collected information in the form of MS or HS images, which collect the information across the electromagnetic spectrum. The main intensity of this imaging is to perform the pixel operation in the image of the scene for identifying or classifying the object or detecting process [5]. The various type of scanners has captured the information for different resolutions. There are push broom, whisk broom and band sequential scanners for spatial and spectral scanning. The scanning process can be performed to get the acquired images of an area with different frequencies, which frequencies give different information based on the applications. Generally, there are 4 types of resolutions available for multispectral or hyper spectral resolutions such as spatial, spectral, temporal and radiometric resolutions [6,8]. The MS images used in various applications and the multiple bands increase the utilization of satellites [2]. The combination Red, Green and Blue channels(bands) formed as RGB or color image [3], but the MS images formed by multi- frequency levels of bands of satellite to form as satellite multispectral images. Two types of noise Gaussian and Non Gaussian noise are added into bands due to various reason.

For Additive noise,

$$S(i,j) = n(i,j) + h(i,j) \tag{1.1}$$

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where $1 \leq i \leq M$, $1 \leq j \leq N$. For Multiplicative noise,

$$S(i,j) = n(i,j) \times h(i,j) \tag{1.2}$$

where M and N represents the size of the original image, $S(i,j)$ denotes noise image, $n(i,j)$ represents input image and $h(i,j)$ denotes adding noise.

Equation 1.1 and equation 1.2 shows the process of noise adding to the image. The additive noise are easily remove from the images using suitable filters. The Multipicative noise are difficult to remove from images. Earlier, the medium filters are preferred for removing the salt & pepper noise. The speckle and salt&pepper noise are non-Gaussian noise. There is not suitable filters are implemented for non Gaussian noise [4]. The median filters are very useful for removing the salt & pepper noise, but it is limited only for S&P noise. This filter is not suitable for speckle filter noise. The high variance of S&P and speckle noise are difficult to identify the two components with noise samples [16].

2. Machine Learning Algorithm. Machine learning (ML) is the study of computer automatic data algorithms for data analysis, which is based on sample data or training data to make predictions without being programmed. These predictions are based on computational statistics. Machining learning is the science of the attainment of the systems to act without being articulately programmed [1]. It has shown an important role in reducing the complexity in data learning systems. In previous days, very difficult to handle large data analysis with human intervention, commercial software or high human intervention needed, also not obtained sophisticated results in the case of large data analysis. Machine learning is one of the best methods for automatically analyzing and studying data [18].The handling or study of these large data is very difficult to analyze due to the complexity of the information as well as the difficultyof storing that information with less storage. This data can be processed for advanced applications, it can be easy to handle this data in many fields such as transmission, storage and classification. Nowadays the 5G network handles processed bigdata with accurate results in image restoration, transmission and storage [17].

Bruno Carpentieri et.al suggested compression algorithms for digital images in social media networks. In this research explored a unified approach to compression and security algorithms for secure transmission [19]. B.Silpa et.al proposed encoding technique for video data with optimized deeplaearnign technique. This technique helpful for efficient transmission of video data in 5G networks, which is useful in current speed network application in real time [20]. Haidar AF et.al perform digital image compression technique with advanced level of Dsicreat cosine transformation techniques with less power consumption and delay. The proposed result also give better performance compare with other existing method interms of reduction, energy , delay and accuracy levels [21]. Xiangshu Xi et al perfom dimensional reduction method for multispectral satellite images to perform segmentation operation. In this method, the complexity is reduced and obtained better classification results compare with low resolution of input data. D. Amarsaikhan et.al suggested brovey algorithm for fusion operation to retrieve the low and high frequenc compoentns for compressed data. He improved Bayesian classification makes use of several features derived from a feature derivation procedure as well as spatial thresholds determined by local information. When the modified classification's outcome is contrasted with the outcomes of a conventional technique, it shows increased accuracy.Yand c at.al developed algorithm for pansharpening technique with HIS transformation. In this process, create a fused image with high spectral and spatial resolution by combining spectral information from a multi-spectral (MS) image with spatial information from a panchromatic (PAN) image. The intensity-hue-saturation (IHS) transform is the foundation of many pan-sharpening techniques, which may result in noticeable spectral distortion [25]. Y.Feng et.al Suggested ICA transformation method for dimensionality reduction, compare with PCA , the independent component analysis is given sophisticated result due to non-orthogonality principle, which is suitable for hyperspectral images [26].

3. Methodology. The Skewness and Kurtosis can be measured to determine whether the pixel distribution is not symmetrical. Kurtosis assesses the highest level of either a positive or negative side distribution's skewness. In image pixel distribution is balanced the skewed value is zero.The smoothing factor is developed with skew and kurtosis factors, which is helpful to separate the high variance of non-gaussian noise [11].

$$SF = 0.5 \times \left| \frac{min(kurt_f, kurt_{kf})}{max(kurt_f, kurt_{kf})} + \frac{min(skew_f, skew_{kf})}{max(skew_f, skew_{kf})} \right| \tag{3.1}$$

$kurt_f$, $skew_f$:Noise samples of Kurtosis and Skew, $kurt_{kf}$, $skew_{kf}$:Noise samples of Kurtosis and Skew.

In this proposed method, wiener, mode and minimum filters are employed to detect Gaussian noise, salt and pepper, and speckle. With the aid of established approaches, it is fairly simple to identify Gaussian noise. The Min filter is only used to separate samples of Gaussian noise. Gaussian samples are the only ones represented by the skewness coefficient's minimum value. Higher-order smoothing factors are used to identify the remaining non-Gaussian samples using wiener and mode filters. The image's matching noise sample is represented by the maximum value of the SF value. Here, we take into account three spatial filters: the Skewness coefficient, which is derived from lower order statistics, and the Smoothing factor (SF) value, which is based on higher order moments. For distinct symmetric noise (Gaussian noise), recognized with the lowest value of SK, the SK value is chosen. Exceptfor the Min filter for Gaussian noise, SK values for all filters are at their maximum levels.There are many standard spatial and spectral enhancement techniques are applied for multispectral images. The brovay transformation technique is one of the standard techniques for satellite images, but it is limited to fixed three bands only. HIS is color transformation technique, but it is limited in the case of maintaining the tradeoff levels between intensity and hue values. The PCA is fixed for the orthogonal dimensionality reduction technique [9,13]. The ICA is similar to PCA but non-orthogonality components exist in ICA [10]. After dimensional reduction, the total PC or IC bands are formed concerning frequency level components. All frequency bands have not existed in the same bands. Avoid these limitations by using the proposed method.The effort of a temporal domain grid to construct curvelets at each orientation and scute is the primary distinction between the two curvelet transform ways, namely the fast Fourier transform approach, which is an unequally spaced approach, and the wrapping ideology approach.

The curvelet Coefficient is specified as

$$C(r,\theta,S)=\sum_{0\leq a}^{0\leq b}F(a,b)\phi_{r,\theta,S}(a,b) \tag{3.2}$$

Where r: is decomposition or scale value, θ: is angle, S=(s_1,s_2): are parameter translation, C: Coefficient of Curvelet, ϕ(a,b) : Curvelet, and F(a,b): satellite image with size M $\times$ N.

The overcome of limitations of curvelet such as isotropic scaling and orientation problems can be solved by curvelet.Generally, the threshold can be calculated using the formula:

$$\delta=\sigma\sqrt{2ln(n)} \tag{3.3}$$

where σ: standard deviation of noise components, n: sample length.

The curvelet thresholding can be defined as

$$CT(r,\theta,S)=\begin{cases} sgn(C(r,\theta,S))[|C(r,\theta,S)|] & \text{if}\,|C(R,\theta,S)|\geq T \\ 0 & \text{if}\ \ |C(R,\theta,S)|\leq T \end{cases} \tag{3.4}$$

Here, T: Threshold Level θ: is angle s=(s_1,s_2): are parameter translation, C: Coefficient of curvelet,

4. Proposed Method. For this research, the time series Landsat images are collected from www.usgs.gov website. Initially, all these images are perform the preprocessing technique for geometric and radiometric correctin. The dimensionality reduction technique such as Principle Component Analysis method is used for remove the redudennt information between bands, which are formed by converted into co-variance matrix and information is converted into Principle component values such as PC1, PC2, and PC3. The maximum information appears inform of intial three PC values [12]. These components are categorized into low to high-frequency values from initial PC to last Principal component image. The last components have high-frequency components, which contain masximum noise components [7].

Generally, the high frequency components consider as sudden changes such as edge, lines, dots etc. on that image. For satellite image, with this type object difficult to analyze the objects. So, separation of noise from this objects are mandatory. After Principal Component Analysis, the last principal component images are processed for separate the noise components for detection of noise. After detection of noise samples, apply adaptive threshold-based curvelet transform for removing the non-gaussian (Speckle) noise.

Proposed method Steps:

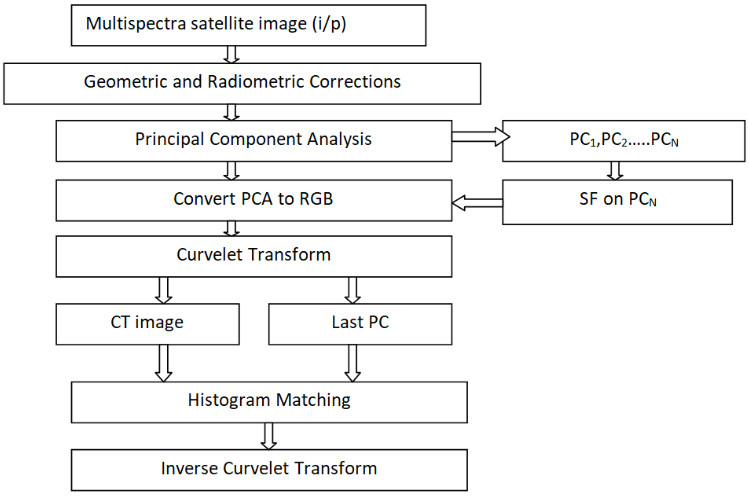
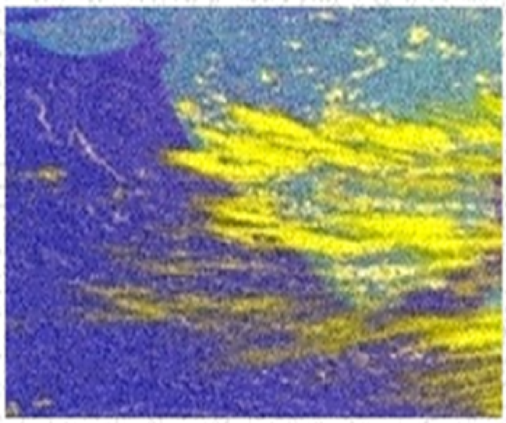


Fig. 4.1: Flow chart for proposed method

(a) NOAA-Multispectral image (Noise)

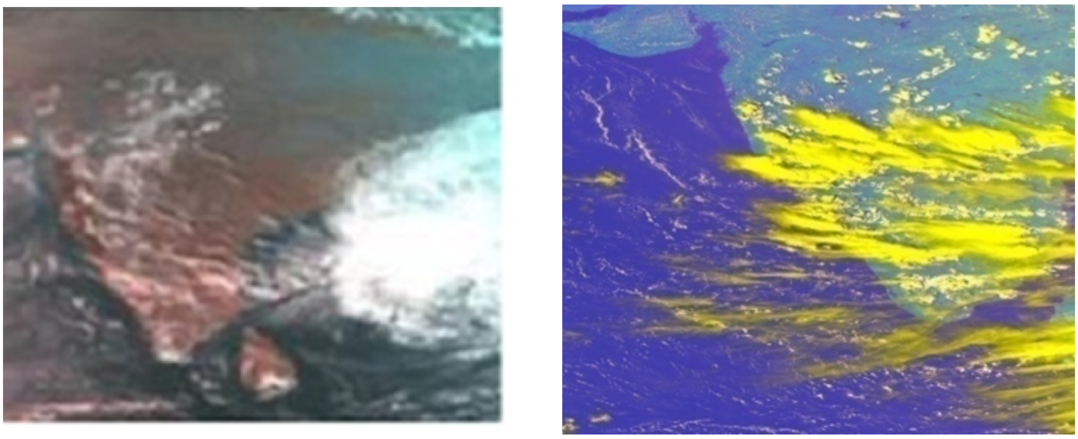


(b) NOAA-Multispectral image (Noise)

Fig. 5.1: NOAA-Multispectral image

1. Collect satellite image from satellite receivers or usgs website.
2. To do preprocessing operations for geometric and radiometric corrections.
3. Perform dimensionality reduction technique (PCA Transform) to multispectral satellite images.
4. Choose low frequency PC components (PC1,PC2 & PC3) and high frequency Principal Component image (Last PC).
5. Apply HOS-based smoothing factor (SF) to noise samples for detection of type of noise.
6. Threshold-based curvelet for removing the typical noise(speckle) in multispectral images.
7. Apply inverse transform to retrieve the original image quality values.

5. Results and Discussion. Principal Component Analysis (PCA)/Independent component analysis (ICA) is used as an unsupervised, non-parametric statistical technique primarily used for dimensionality reduction in machine learning [12,15].



(a) Proposed output (NOAA image) (b) Proposed output (Landsat image)

Fig. 5.2: Proposed output

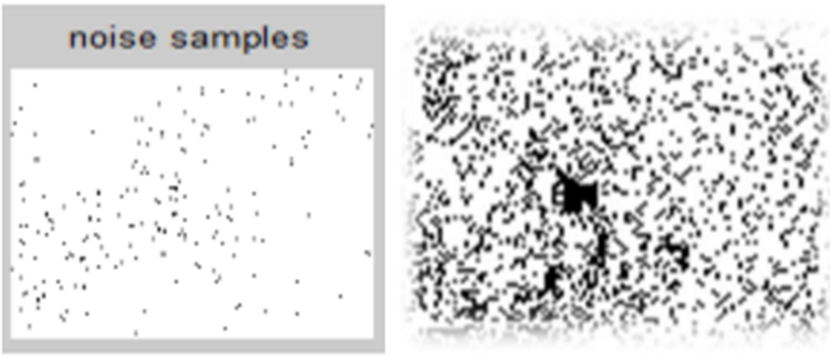


Fig. 5.3: Extracted Noise samples

Fig.5.1(a) and 5.1(b) represents the NOAAmultispectral satellite image, receive from HRPT receiver, This receiver located at Sri Venkateswara University,Tirupathi. Andhrapradesh. Fig. 5.1(b) is an example of of Landsat multispectral image collected from USGS webportal. These image influenced by noise. For satellite images, difficult to analze the pixel information with noise because each pixel represent some meters to kilometers distance based on pixel resolution of the spectrum band.

Fig 5.2(a) and Fig. 5.2(b) are proposed images, the noise components are detected by HOS based SF and noise removed by applying the proposed method dimensional reduction based curvelet transform. In this process the noise samples are tested with HOS based smoothing factor, these samples are shown in Fig. 5.3. Apply the higher order statiscs on that samples to identify the type of noise such as Gaussian or non gaussian.

Fig.5.3 shows extracted noise samples, which are obtained from the image subtraction process. In thisprocedure, the samples are separated from the non-Gaussian noise from the Gaussian scale. From Table 5.1 when salt and pepper noise is present, the SF value for the Mode filter is at its maximum, and when speckle noise is present, the SF value for the Wiener filter is at its maximum. Using these two elements, non-gaussian sounds are found, and Gaussian noise is recognized by selecting a minimum filter with a low SK value. The coefficient of Skewnes is used to distinguish Gaussian noise.

Table 5.1: Comparison HOS values of Noise samples for identification of type of noise

Image	Noise	SFM	SKM	SFW	SKW	SFW	SKW
1	Gaussian	1.6372	0.3014	0.0244	0.8959	0.5091	**0.2353**
	SP	**1.8247**	1.2494	0.2951	0.0858	1.0831	0.466
	Speckle	1.7236	0.2529	**1.3016**	0.4926	0.6403	0.407
2	Gaussian	1.6372	0.3014	0.0244	0.8959	1.494	**0.058**
	SP	**1.8247**	1.2494	**0.2951**	0.0858	1.8742	0.467
	Speckle	1.7236	0.2529	1.3016	0.4926	1.3941	0.4669
3	Gaussian	0.7824	0.4736	0.5401	1.0703	0.6314	**0.0942**
	SP	**1.5621**	1.2992	0.6421	0.2872	0.9475	0.6369
	Speckle	0.783	0.3497	**0.9782**	0.6582	0.7493	0.7811
4	Gaussian	0.7511	1.0373	0.517	0.681	0.5091	**0.2353**
	SP	**1.0776**	1.0373	0.5659	0.2587	1.0831	0.466
	Speckle	0.7909	1.2161	**0.9783**	0.4799	0.6403	0.407
5	Gaussian	0.2563	0.891	0.6326	0.5623	0.0043	**0.1216**
	SP	**0.7781**	1.3813	0.6877	0.1461	0.7962	0.4037
	Speckle	0.1413	0.7864	**0.7182**	0.4975	0.0591	0.2657

Table 5.2: Comparison of Results with different methods with proposed method

Transforms/ methods	PSNR	ERGAS	RASE	ENTROPY	Compression Ratio
HIS-Trans	33.24	14.94	49.31	6.71	32.35
Brovey	28.38	18.23	51.25	7.51	43.23
PCA	22.13	20.56	48.24	6.97	43.34
ICA	28.32	14.58	47.12	7.47	37.47
Proposed	**36.24**	**11.79**	**42.21**	**7.57**	**58.23**

Table 5.2 shows the comparison table. HIS transformation is one of the best techniques for improvement. it is suitable for enrich the spatial detail values. But not maitin the level between spatial and spectral values. Brovey transform is one of the best method for dimensionality reduction, the information is prespresent with less number of bits, but this transformation is limited to three-band multispectral images only. The PCA and ICA machine learning algorithms are suitable for dimensional reduction techniques, which is more beneficial than the standard compression technique. The main limitation of these dimensionality reduction methods are the original high frequency information is removied, which are appeared in last PC or IC values. The additional transformation technique is required using this transformations. [7][9].

Peak Signal to Noise Ratio(PSNR) is used to measure the quality of the compressed signal, this value is high for better compressed image. For multispectral images, Relative Dimensionless Global Error in Synthesis (ERGAS) is the one of the best parameter for measure the low frequency and multispectral image quality measure. The PSNR values are high and ERGAS values are low for proposed results. The entropy is used to measure the number of bits required to encode the image data. The proposed method maintin the minium entropy level, which represents the standard bits representation of the image. In image processing operation, the spectral values are important for perform the classification operations, if any spectral values are loss, it obtain misclassification results. This spectral quality is measured with Relative Average Spectral Error (RASE).The quality metric is low for proposed method, obtain the good spectral values compare withother methods. The compression ratio, compare with others, its maximum values. Overall, after the compression operation the spatial and spectral values are regained with good compression ratio for proposed image.

To obtain the loss components implement the dimensionality reduction and curvelet transformation algorithms, the color and bright values are normalize with the histogram matching technique. So, the low and high-frequency components are retrieved by using this proposed technique and values are measured the quality metrics are measured with parameters Peak signal to value(PSNR), Error Relative Global Dimensional Synthesis(ERGAS) and Entropy values. The PSNR values are high and ERGAS is low for proposed images with good pixel quality and compression Ratio.

6. Conclusion and Future Scope. The multispectral / Hyperspectral satellite images are difficult to transfer in 5G network due to large data and complexity. The non-gaussion noise (speckle) are difficult to detect to apply for applying suitable filters. The HOS based dimensional reduction technique (Principal component analysis) and curvelet transformations are suitable for detect the speckle noise and filtering operations. Higher Order Statistical methods are implemented for the detection of the type of noise and adaptive threshold-based curvelet transforms to improve the spatial and spectral values. These Including these applications, the proposed algorithms are very applicable to medical, satellite and computer vision digital images also. These quality pictures are transmitted and stored within 5G network applications with less complexity and occupy less storage space.

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