Comparative Analysis of Various Methods for Preprocessing of Satellite Imagery

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***Abstract* - The images obtained by remote sensing systems are not quite often sufficient for high precision applications due to various distortions. The distortions can be divided into three layers Geometric, Radiometric and Atmospheric distortions/Errors. The first layer deals with the steps to be carried out for correcting the Geometric distortions/errors through generic non-parametric models that relates remotely sensed image to terrain coordinates. The second layer is dealt about the five methods used for Relative Radiometric Correction (RRC) such as Pseudo Invariant Features (PIF), Radiometric Control Set (RCS), Image Regression (IR), No-Change set determined from scatter grams (NC) and Histogram Matching (HM) and the third layer deals with an Atmospheric Correction which is to retrieve the surface reflectance from remotely sensed imagery by removing the atmospheric effects by using theoretical model called look-up table. A comparative study of the various mathematical techniques has been discussed in this paper for the betterment of preprocessing of satellite images.**

Keyword- Atmospheric Correction, Radiometric Correction, Geometric Correction, Look Up Table, Thresholding.

I INTRODUCTION

A new piecewise polynomial correction method based on the nonlinear variability of distortions in different imaging angles has been discussed in Chunyuan WANG et al.[2] as most used geometric methods depend on ground control points to get a mathematical coordinate transformation and conventional methods also usually apply the same formula where few only has considered seriously distortions causing by imaging with a large view angle. In Lt.Dr.S.Santhosh Baboo et al [1], geometric correction has been carried out that deals with ground control points. And whenever the image is to be compared with existing maps or other maps, geometric correction of the image has been required. The remotely-sensed data that have been received from satellites should be removed geometrically, because of the acquisition system and the differences in the platform. Due to the acquisition system and the variations in the platform, the remotely-sensed data obtained from satellites or aircraft have to be geometrically removed.

Tengfei LONG et al. [4] proposed a novel geometric correction model based on image and object space features that should be used for for multisource image rectification and is not fixed to a specific imaging geometric model. Chunyuan WANG et al.[2] is based on an automatic piecewise method and a uniformly distributed CPs plan. And they proved experimentally by demonstrating that the piecewise polynomial correction method time after time outperforms the conventional whole image-based correction and experimental evidence is provided to support the benefits of uniform distribution strategy and thereby enhancing an image. Lt.Dr.S.Santhosh Baboo et al.[1] provides merit of computations and simplification of important terms in the geometric correction function. It proposed two methods as a process of using Geographic (Lat/Lon) as projection type WGS84 is Spheroid and Datum and a process of polynomial geometric and thereby enhancing the distorted image.

L. Markelin et al. [5] deals with five different processing versions for rectifying airborne hyperspectral imagery to surface reflectance. The process is dealt with radiative transfer calculations that describes about the radiometric correction of airborne hyperspectral imagery. And the output has been proved in an efficient way compared with those offered by current popular atmospheric correction software in Chun Chen et al. [11] of the vicarious radiometric calibration of the sensor in operational conditions and that the radiometric correction of airborne hyperspectral images. D. G. Hadjimitsis et al. [10] deals with the aim of using an atmospheric correction in accordance to retrieve original surface reflectance values and physical arguments of the Earth’s surface, by distorting atmospheric effects from satellite images. All the reviewed papers deal removing distortions from satellite images individually. Thereby, our paper aims to correct or preprocess satellite images using look-up tables, amplitude thresholding and mathematical techniques.

Thereby the section I deal with the existing and proposed methods for enhancement. And the related survey of the existing methodologies has been discussed in section II. The design of the preprocessing of satellite images and the comparative analysis of various methods has been discussed with their respective figures in section III. The conclusion with future enhancement of this paper has been given in section IV and relevant references have been discussed in section V.

II LITERATURE SURVEY

A new piecewise polynomial correction method has been discussed in Chunyuan WANG et al.[2]as most used geometric methods depend on ground control points to get a mathematical coordinate transformation and conventional methods also usually apply the same formula where few only has considered serious distortions, causing by imaging with a large view angle. Geometric correction has been carried out with ground control points Lt.Dr.S.Santhosh Baboo et al. [1] and because of the acquisition system and the variations in the platform, the data of remotely-sensed that has been retrieved from aircraft have to be removed. Tengfei LONG et al. [4] proposed a novel geometric correction model depends on image and object space parameters that is not assigned to a specific imaging geometric model, and can be used for multisource image rectification. Giuliano Fontinovo et al. [3] deals with a speedy procedure for the geometric correction of hyperspectral MIVIS images using algorithms such as the polynomial model (PM) and the model of rational functions (RFM).The objective of the paper is to get an effective geometric correction of MIVIS images by way of an optimal compromise of result precision and elaboration time and can be applied for large areas also. The aim has been achieved with that of all the advantages of overlapping the MIVIS images and their themes, with high-resolution images and take advantage of multi-temporal acquisitions of a particular area to monotoring environmental problems.

Christian Briese et al. [7] discuss about the Airborne laser scanning (ALS) that is used method for the sampling of the earth's plane. Depending on previous work of radiometric calibration of monochromatic (single-wavelength) ALS data, the paper focuses on the radiometric calibration of multi-wavelength ALS data. An Unmanned Aerial Vehicle (UAV) hyperspectral calibration of Ryan Hruska et al. [6] deals with testing of the radiometric calibration of the spectrometer and finding the georegistration correctness attainable from the on-board global positioning system (GPS) and inertial navigation sensors (INS) under operational conditions. And achieved planimetric accuracy based on RMSE as 4.6m with an airborne elevation of 344 m over earth point (AGL). The study of B. T. San and M. L. Suzen[9], proposed a comparison and evaluation of the achievement of the four different atmospheric corrections for Hyperion data. The existing algorithms have been compared with two different approaches as one with the reference data of regional-spectral correlations and the other with individual absorption features. Finally, as a survey, in overall evaluation, all the atmospheric correction methods applied on the data have been found to be successful with varying in different wavelength regions.

Cédric Jamet [8] presents an inter-comparison study of three processes that compensate for NIR waterleaving radiances depending on very different hypothesis: 1) the standard SeaWiFS algorithm 2) the algorithm developed depends on the spatial homogeneity of the NIR ratios 3) the algorithm based on a fully coupled atmosphere–ocean spectral optimization inversion. A detailed survey of the hypotheses of the processes is given for describing the differences between the procedures.

An approach of atmospheric correction approach, called ACVSS (Atmospheric Correction based Vector Space of Spectrum) has been proposed which is based on the vector space of the features' spectrum in Chun Chen et al. [11].The proposed method will remove the atmosphere effects, has become a key step to improve the qualities of images and to retrieve the actual reflectivity of surface features. The algorithm in P. Shanmugam [12] discuss about the diversity and variability of aerosols and strong sun glint patterns. The procedure generates for all visible bands, more spatial structures in water leaving radiance maps as well as positive water-leaving radiance. For the process of ocean colour imagery, the CAAS algorithm is an alternative scheme that operates under the presence of sun glint and strong aerosols. In future, with large in-situ datasets, a more detailed validation of this algorithm may be carried out. Tengfei LONG et al. [4] deals with the correction of geometric with the parameters of linear and areal that can been used as control parameters in order to cope with the misidentification issue of points and to register image exactly.

Christian Briese et al. [7] is based on the resultant reflectance information, at the three different wavelengths a spectral analysis of the radiometric behaviour of the sensed surfaces that has been possible. A detailed quality analysis of the resulting reflectance values which is essential has been proposed as a future work. D. G. Hadjimitsiset al. [10] deals with the aim of applying an atmospheric correction in order to get true surface reflectance values and to get physical arguments of the Earth's surface, by removing atmospheric effects from satellite images. They found and proved that, without applying any atmospheric correction, the real daily evapotranspiration was less than the one found after applying the darkest pixel atmospheric correction method. Thereby with the aerosol models which are very simple in K09 and rather low accuracy for the estimates of the aerosol optical properties achieved the results.

Chih-Chung Chang et al. [13] discussed that the intelligent computing systems such as Support Vector Machine (SVM) is capable for handling multispectral remote sensing image effective classification problems and also SVM can be used as an alternative for traditional statistical methods.

ManthiraMoorthi et al. [14] showed in their paper that SVM algorithm has shown better performance in satellite image classification compared to the Maximum likelihood Estimation Method. And proved that the overall accuracy is increased. In their research various comparative models have been used to prove that the SVM gives better accuracy level compared to likelihood estimation method.

Based on this survey, the SVM algorithm will give better accuracy for classification of multispectral satellite imagery compared with the likelihood method of classification. Hence, the SVM algorithm combined with other kernel types such as radial basis function and sigmoid function will give better performance for preprocessing of multidate data imagery.

Hence, based on the corrections that have been discussed in the above papers has been resolved individually. In this paper, the ABT using look-up table, amplitude thresholding and mathematical techniques have been used to preprocess satellite images for the experimentation purpose.

III PROPOSED ARCHITECTURE FOR PREPROCESSING OF REMOTE SENSING IMAGE

The architecture is proposed for preprocessing of Remote Sensing Image in figure 1. It describes about the flow of preprocessing a satellite image with three levels. The first level deals with input image from remote sensing (RS) satellites. The input image can be separated as geometric, radiometric and atmospheric corrections. The second level deals with the mathematical techniques as mean, standard deviation, variation, thresholding ,etc which is applied to preprocess an image and the results proved that the performance has been improved compared to surveyed papers. As a third level, an enhanced image should be stored in the database for further process of satellite images.

A Comparative Analysis

The statististical methods have been applied for comparing the three layers of satellite images using Mean, Standard Deviation with Thresholding in figure 2.

Mean

The mean which is otherwise called as average which can be computed as the sum of all the observed outcomes from a sample that has to be divided by the total number of events using x as given below:-

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x \qquad \text{……(1)}$$

where ‘n’ stands for sample size and x for the observed valued.

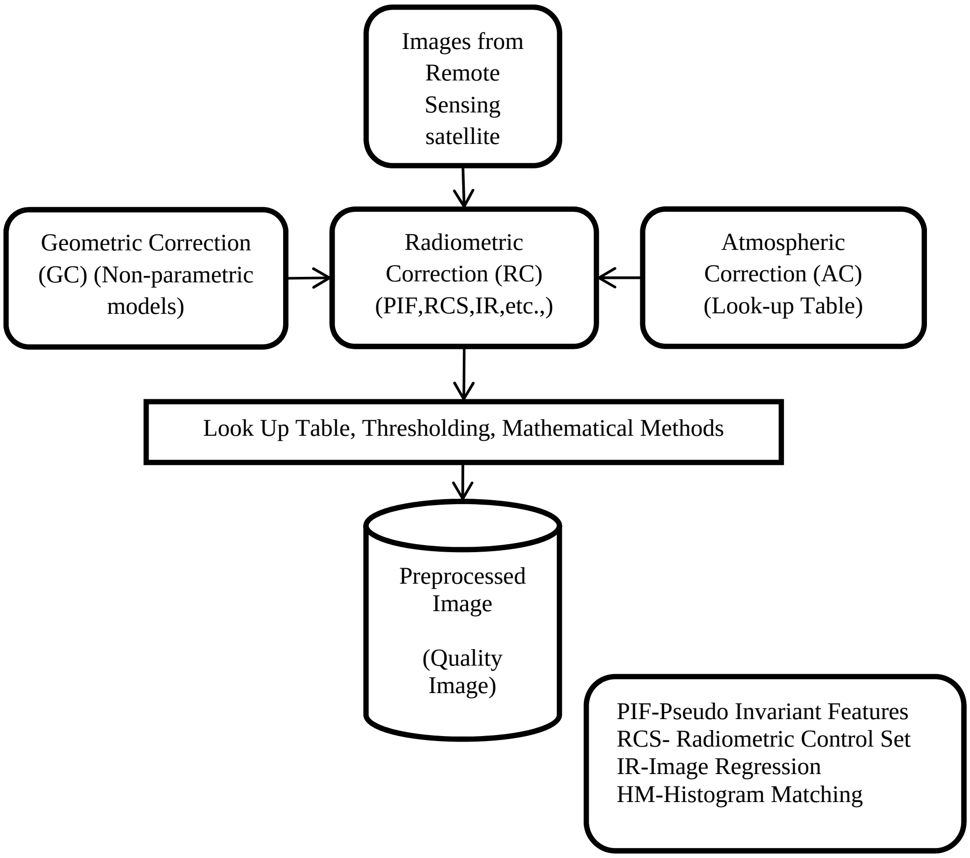

Fig.1. Architecture for Preprocessing of Remote Sensing Imagery

Variance and Standard Deviation

The techniques Variance and Standard Deviation are used to find mean, x which have to be read and subtracted from each observed value to a table format. Later we have to square the differences and added to the result to a table column. Lastly, divide by n-1 thereby getting the variance. And to compute the standard deviation we have to find the square root of the variance.

The variance can be calculated as

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x-\bar{x})^2 \qquad (2)$$

and the standard deviation as

$$S=\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x-\bar{x})^2} \qquad (3)$$

Thresholding

Processing boundaries of objects can be otherwise called as Thresholding. The process will be as taking one random images and mapping all the pixels of the image whose values fall between a low value to a high value and computing the destination image by comparison of distant various bands.

Histogram Analysis

Let the variable ‘r’ represent the gray levels of the image to be enhanced. We assume that ‘r’ has been normalised to the interval [0, 1], with r = 0 representing black and r = 1 representing white.

Later, we consider a discrete formulation and allow pixel values to be in the interval [0, L-1] where L is the highest gray level value with the results in figure 3.

For any ‘r’ satisfying the aforementioned conditions, we focus attention on transformations of the form

$$s = T(r) \quad 0 \le r \le 1 \qquad (4)$$

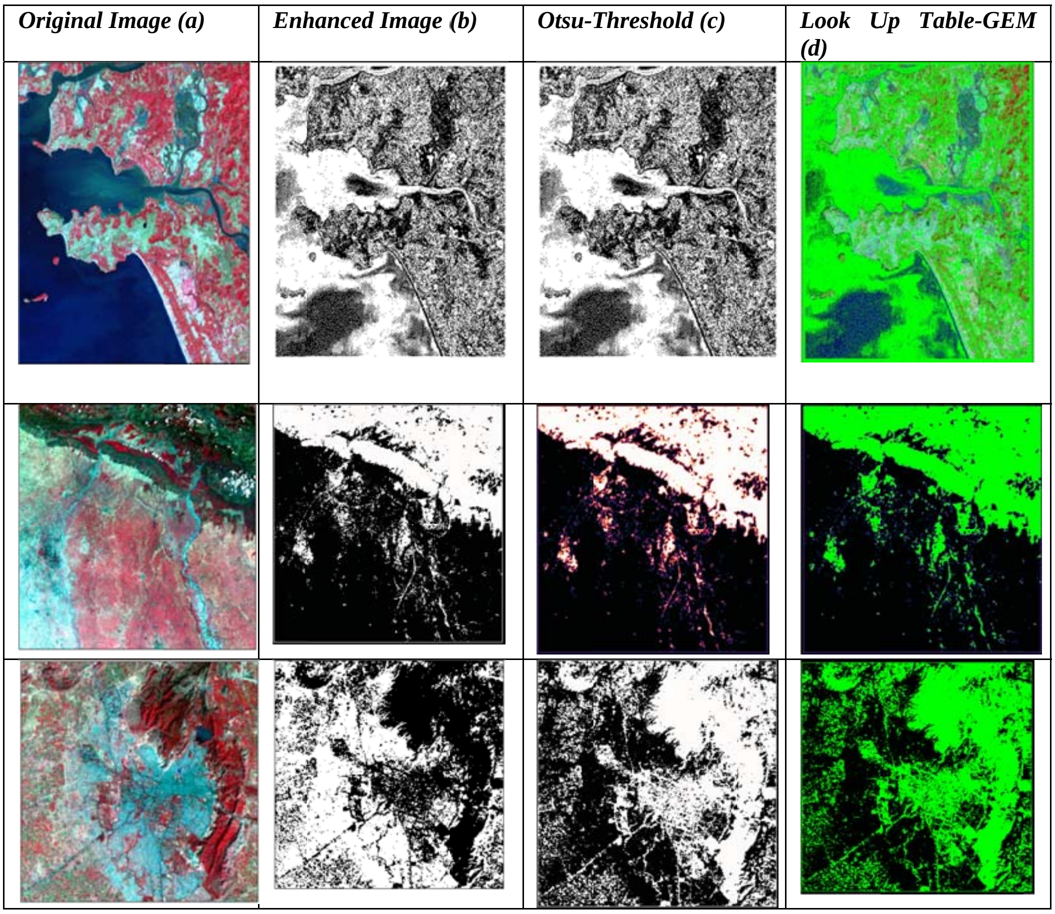

Fig.2 Comparative analysis of satellite images with threshold and look up table techniques

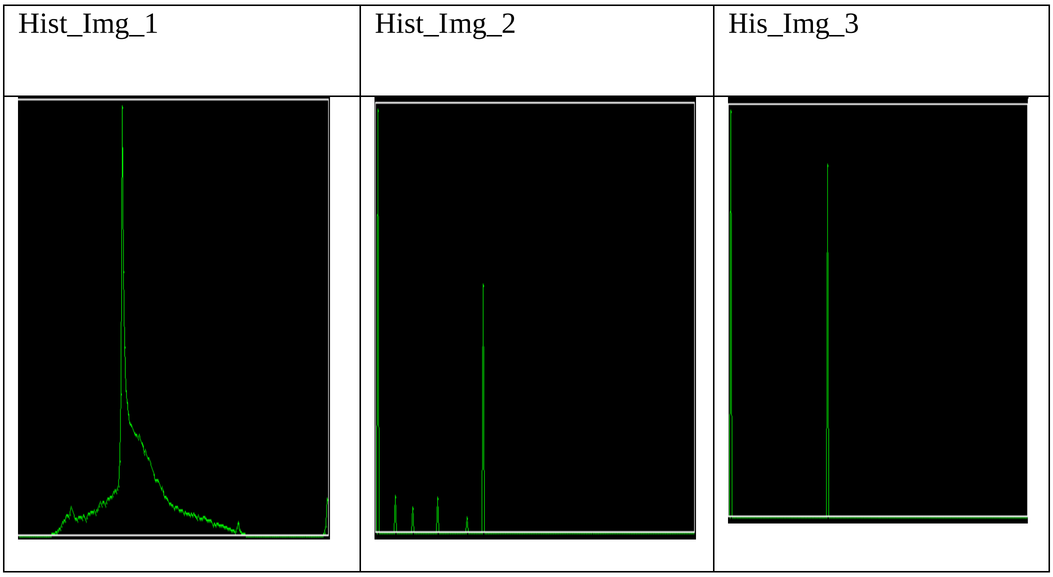

Fig 3. Histogram Analysis of Satellite Images

Table No.1 Mathematical Techniques with respective Thresholds

Input Image	Mean	StdDev	Variance	Threshold
1	149.6034	76.0684	146.5	186.5
2	85.0866	105.1819	124.5	101.5
3	134.5252	102.3184	128.5	145.5

The table 1 describes about the various mathematical methods for three images with their respective histograms of figure 3.

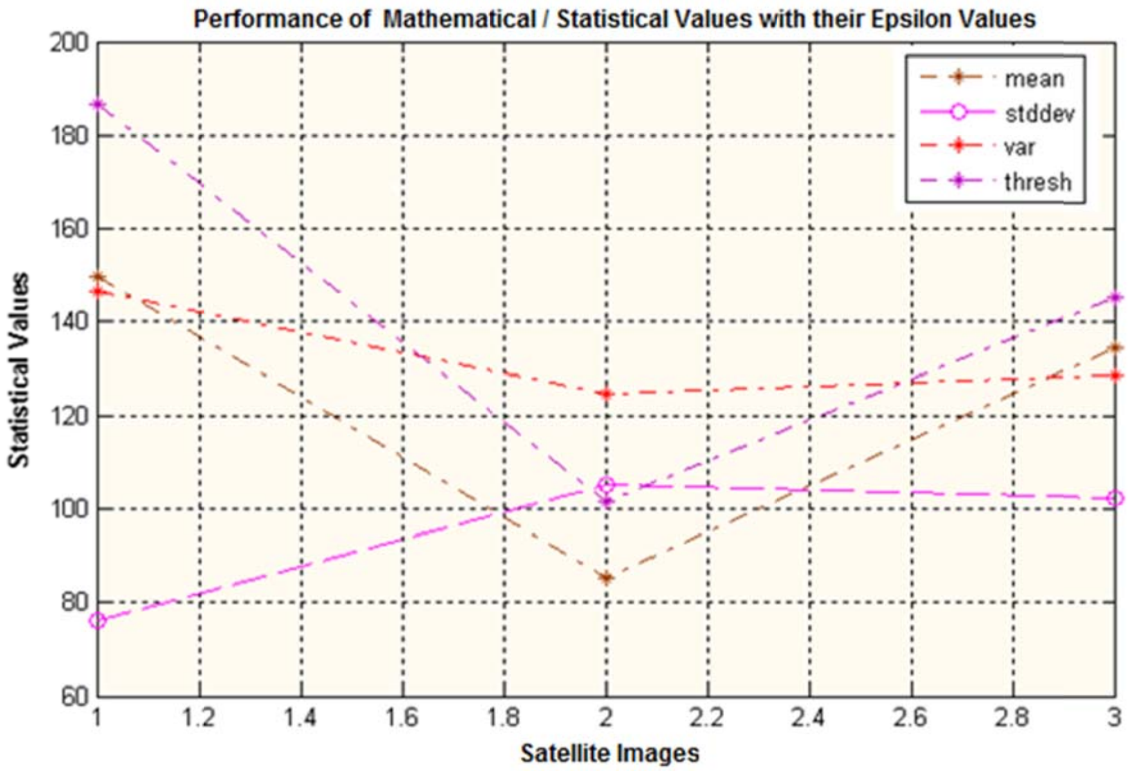

Fig.4. Graphical representation of various mathematical or statistical operations.

The figure 4 deals with the graphical representation of mean, standard deviation, variance, thresholding of sample three ISRO satellite images.

IV CONCLUSION AND FUTURE ENHANCEMENTS

The images that are acquired through remote sensing satellites always comes with 3 different distortions/errors ie., geometric, radiometric and atmospheric distortions/errors. This paper deals with the different methods/algorithms used to rectify all three distortions. The atmospheric, radiometric and geometric distortions arise due to extinction of light have to be reduced or removed by an algorithm which comprises of direct methods. Non-Parametric Models of remote sensing data products with a comparative study of the three layers has been processed in the surveyed papers for the betterment of preprocessing of three layers of satellite images. And the survey shows that the geometric correction dealt with polynomical correction method, automatic piecewise method and object space method. The radiometric correction discussed with radiative transfer equation and atmospheric correction deals with the SeaDAS algorithm,etc., which will remove the distortions separately. In this paper a comparative study has been carried out about the various methods/algorithms used for preprocessing of remotely sensed images and experimented with look-up table, thresholding and mathematical methods to preprocess the satellite images for better performance. As a future enhancement, we propose a method for automatic enhancement of satellite images instead of using a semiautomatic enhancement.

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