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An Algorithm for High-Resolution Satellite Imagery Pre-processing

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Abstract: During the few years, various algorithms have been developed to extract features from high-resolution satellite imagery. For the classification of these extracted features, several complex algorithms have been developed. But these algorithms do not possess critical refining stages of processing the data at the preliminary phase. Various satellite sensors have been launched such as LISS3, IKONOS, QUICKBIRD, and WORLDVIEW etc. Before classification and extraction of semantic data, imagery of the high resolution must be refined. The whole refinement process involves several steps of interaction with the data. These steps are pre-processing algorithms that are presented in this paper. Pre-processing steps involves Geometric correction, radiometric correction, Noise removal, Image enhancement etc. Due to these pre-processing algorithms, the accuracy of the data is increased. Various applications of these pre-processing of the data are in meteorology, hydrology, soil science, forest, physical planning etc. This paper also provides a brief description of the local maximum likelihood method, fuzzy method, stretch method and pre-processing methods, which are used before classifying and extracting features from the image.

Keywords: pre-processing, image transformation, image enhancement, geometric correction, radiometric correction, Satellite Imagery

INTRODUCTION

The continuous increase of technology of acquiring satellite data in supercomputer data acquisition and storage results in the growth of huge databases. With progressive increase and collection, the large amount of computerized satellite data has far exceeded human ability to completely do the visual and semi-automatic interpretation and use it in applications. For classification and feature extraction of development stages such as spectral bands, spatial resolution, radiometric quantization, etc. [1] are apriori confirmed application users, to provide capabilities for implementing actual requirements. The satellite rotates around the earth in the orbit. The camera fitted on the satellite scans the field of view and the data is captured in the CCD (Charged coupled devices). This data is converted to images. The images are further divided into pixels. Each pixel is assigned a digital number [2],[3]. This digital number represents the radiance of each pixel in the image form. The brightness level of each pixel is the measure of each digital value displayed by the computer [4]. Image brightness is proportional to pixel value therefore it means that 0 represent black and 255 represent white. The spectral curve represents the reflectance characteristics of an object, for sensors MODIS, SPOT, IKONOS, Landsat, LISS3 and WORLVIEW etc. The Motivation of this paper is to evaluate the effective pre-processing potential of satellite imagery in mapping purpose,

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street feature extraction and classification, analysis, and identifying areas of linear features. This paper provides a brief description of various pre-processing methods that are applied to the collected images to achieve the data quality of the image while classifying the image.

METHODOLOGY FOR DATA PRE-PROCESSING

This method of pre-processing of data is to extract specific information that proceeds for feature extraction and classification of an image. In this method, correct distorted or degraded image data is refined for the formation of more confidential images. Geometric corrections, image transformation, image enhancement, atmospheric corrections, radiometric corrections are the stages of pre-processing algorithms [5]. For the satellite image, the pre-processing is done both at the image dissemination and during the feature extraction process. These data are pre-processed to fill data gaps and correct data anomalies.

A. Satellite data input for data pre-processing

Input to data pre-processing algorithms satellite data is acquired for testing and experiments is of fine-resolution image LISS3 for classification of streets as shown in table 1 freely downloaded from www.bhuvan.nrsc.gov.in

Table 1. Specifications of Image

Image data characteristic	Features	Source
Band combination	3,2,1	NRSC www.bhuvan.nrsc.gov.in
Size	3.99 Gb	
Width	2.14 inch	
Height	2.14 inch	
Data type	8 Bit	
Format	Jpg, Tif	

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B. Data pre-processing of an image

Pre-processing of satellite images before image application is essential. Pre-processing commonly encompasses a series of sequential operations, such as atmospheric correction, image registration, geometric correction, radiometric correction and masking of the distorted raw image. The motivation of these corrections in pre-processing is to make images distortion-free for further usability. In image registration, spatially alignment of two or more scenes is obtained at a different time or from different sensors. The image registration is used in different works of literature as geometric registration and rectification of geometric distortion or polynomial affine transformation. The image acquired earlier date is known as a base image and, a recently acquired image with an error is to be corrected. Fig 1 shows the complete methodology for the implementation of pre-processing algorithms [6].

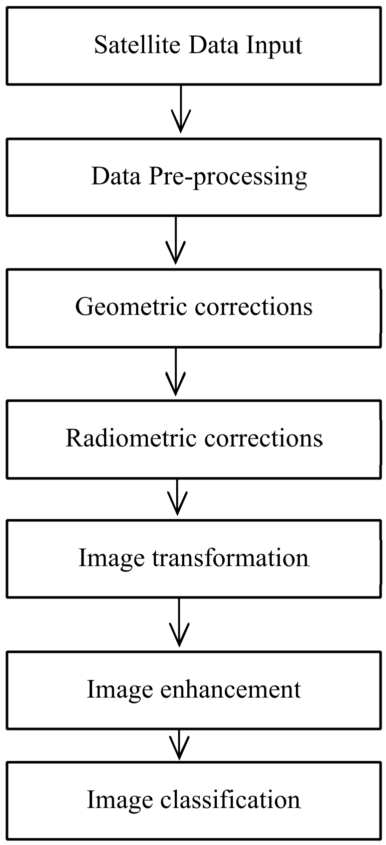

Figure 1. Flow chart of the methodology of data pre-processing

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ALGORITHM FOR DATA PRE-PROCESSING OF RAW INPUT IMAGE

A. Geometric corrections of an image

Geometric correction is done to enhance the image by camera angle, tilt, positional error corrections. In Geometric corrections geometric distortions because of variations in the earth curvature, are corrected. The imagery is converted to geographic coordinates. This distortion occurs because of the sensor height and speed of the camera. The Nonlinearities while capturing a sensor's field of view and due to the curvature of earth's atmospheric refraction relief displacement is the major cause of the distortions. The data is converted to real-world geographic coordinates are done by the use of seemly distributed Ground Control Points. The geo-referencing is done by referencing the image coordinates to the ground coordinates. The resampling method is used to get the digital number of those pixels which are put in the new corrected image pixel values. The resampling method also calculates the number of pixels from the original digital pixel values in the uncorrected image. In nearest neighbour resampling the original value of the pixel is calculated from the surrounding pixel values of the central pixel whose value is required to be changed in the corrected image [7]. By applying the nearest neighbour algorithm some pixels are changed but all the pixels change. In the bilinear interpolation resampling method, four surrounding pixels are considered of the centered pixel and the value of the new pixel is the weighted average of the four pixels.

B. Radiometric corrections of an image

The radiometric corrections of an input image are done to find the mismatches of data in the sensor and unnecessary camera sensor defects or noise in the atmosphere. The data is corrected for perfectly denoting the radiations emitted and reflected, for calculation by the sensor. In radiometric errors, colour parameters such as brightness and contrast etc. are used to represent the image's original radiance in the image as it is on the ground [8]. The image is also stretched by using the histogram equalization technique to improve the features from the input image.

C. Contrast Enhancement of an image

There is an available range of 8-bit or 256 levels in an input image. Generally, the raw input image does not represent the original data in a useful way. Only a small percentage of data is reflected from the available range. This method of contrast enhancement increases the divergence between background data and the target data. The contrast enhancement is also done by an image histogram. The basic enhancement techniques such as histogram identify the minimum and maximum range from the histogram and apply to transform to contract this limited set values to surround the supported values. For supported range values of input values across the full range values always does not enhance, for an initial set of digital number values are not distributed uniformly. In this case, a histogram-equalized stretch works well [9]. The

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method of Density slicing enhances the Digital numbers. In this method of Histogram, digital number values are plotted against the number of pixels having similar values by user interference for inputting the intervals. In the Spatial filtering method, a low pass filter is used to highlight larger, continuous groups of similar colour and minimise the quantity of minor feature information in an image.

D. Spectral Band Rationing of an image

In spectral band rationing, elusive variations are highlighted in the spectral behaviour of various land use and land cover features such as canopy, trees, forest etc. In the visible red band, dense vegetation absorbs strongly and in the near-infrared band, it reflects strongly [10]. There are various land use features such as soil and water that generally show the same reflectance in both the near-infrared and visible red bands. The image obtained by rationing Landsat multispectral band 7 by band 5 shows a ratio greater than 1.0 for vegetation. The same image for rationing for water and soil shows the ratio of nearby 1.0.

E. Transformation of an image

The basic image transformations apply image addition and subtraction operations etc. In this transformation of an image single image band or multi-band image are manipulated to form a new transformed image [9]. The polynomial transformation uses eq. in 1 and 2 for transforming image X to image Y. i, j stands for the order of the equations of the input images. The RMS error is calculated at an acceptable range of less than 0.5. Polynomial transform as shown in eq. (1) and (2).

$$X = \sum \sum aij\ u^{i-1} . v^{j-1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$Y = \sum \sum bij\ u^{i-1} . v^{j-1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

F. Enhancement of an image

In this method of image enhancement, image data is modified according to the preceptor's vision. Most enhancement methods do not correct the image for interpretation but distort the image digital values [11] [12]. If not used appropriately with the given range parameters. The methods of enhancements such as contrast enhancement, frequency filtering, could be applied to the image for better visualization and effects.

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IMPLEMENTATION DETAILS

Algorithm for Feature extraction and image classification

a. **Definition of Classification of different Class:**

In this classification algorithm the classes are Major road, River, Waterbody, Open land, Settlement etc. The tree and vegetation class may be considered. For classification Maximum likelihood and fuzzy is used. The output is in *.tiff,*.png,*.jpeg format. In image classification, the centralized organization of digital data storage is done by the repository of data. The hardware and software requirements are considered before proceeding to the algorithm implementation.

b. **A sampling of training data:**

From the original data, various features are available, but the desired features such as road, settlement etc. for sample selection. The maximum is the sample distinct from each other more is the sharpness in the output of the classification.

c. **Estimation of universe statistics:**

For maximum likelihood classification, the mean and standard deviation of all the classes is obtained. Mean and standard deviations are observed for these classes. For fuzzy, this estimated statistics is used.

d. **Feature extraction and supervised classification:**

The signatures of samples are collected using the signature editor for all the classes. Taken care of these signatures are distinct from each other and do not have overlap among each other. If the overlap is observed then it is removed by fuzzy classification. The Gaussian memberships function because it assumes that the classes are normally distributed from the mean. In this classification, the first maximum likelihood classification is used. It uses the training samples created in the above step for better matching with the desired classes. In supervised fuzzy classification [13], classes are assigned membership degree values to the pixels for classification. If the pixels have the highest degree of membership to belong to that class then it is assigned to that particular class. If the pixel belongs to more than one class. Other iso data, K-means are used for testing.

e. **Validation and analysis of Result:**

The supervised fuzzy classification generates the classified image with the feature class as shown in figure 2. The results are obtained from supervised fuzzy classification and analysed to find the number of pixels covered by the classes.

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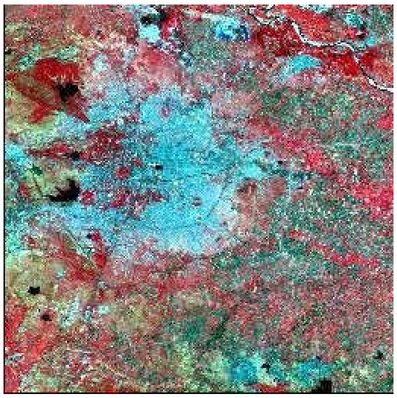
RESULT and ANALYSIS

As a result of pre-processing, the output parameters of the number of pixels are shown in table 2. A subtle 4.28% increase of major road class, 1.04% of the river, 1.97% of Open land as shown in fig 2. Tree canopy class shows 1.97% which is a subtle number of pixels in classification. In Fig. 1 the input image is shown with road and open land features. It is because of the statistical parameters mean and standard deviation spread across the image. In Fig. 2 the output image is shown with feature classes with cyan and red colour. From fig 2 it is observed that the deciduous and coniferous trees show smaller variability in the signature of each other class. This happens due to the signature difference between the two features. This may occur due to overlap of values in various bands, green band for road and settlement classes. This mixing of class pixels in other classes is due to the matching reflectance values found in other brands of the image.

Table 2. Pixels Area in classification

Class	Isodata	K-Means	ML (%) pixels	Fuzzy based (%) pixels	Difference (%) pixels
Major road (%)	13.52	14.43	15.52	19.8	4.28
River (%)	26.56	28.55	32.79	33.75	1.04
Openland (%)	16.52	15.80	14.43	16.52	2.09
Settlement (%)	17.2	16.46	18.1	16.85	1.25
Trees (%)	12.50	12.54	13.45	11.48	1.97
Waterbody (%)	1.24	1.24	1.27	1.26	0.01



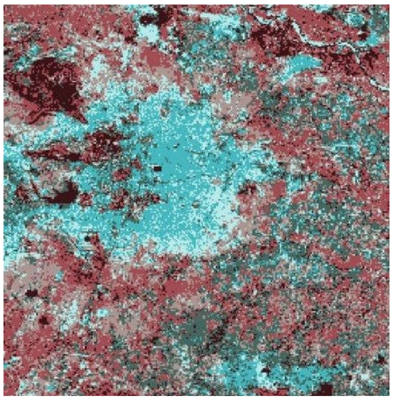


Figure 2. Input image LISS3 **Figure 3. Output image after pre-processing**

CONCLUSION

Due to pre-processing algorithms and the application of fuzzy-based classification and feature extraction found to perform satisfactorily for high-resolution images covering larger areas. There is a misclassified sample pixel of nearly of20%, which is due to the difference in the signatures. Pre-processing algorithms along with supervised classification is although as compared to traditional classification, requires sufficient time to perform classification. Though it consumes more time the accuracy of the output depends on the majority with pre-processing algorithms. More refined is the image more accurate are the results. For smoother classification pre-processing is required to be done in advance. The maximum output of 80% is achieved in the overall classification. These pre-processing algorithms were found to minimize the overlap between various bands. This paper elaborates on how the pre-processing methods could be used for the refinement of the original input. Pre-processing algorithms may be used for further input to various classifications. This paper provides pre-processing algorithm for satellite images to the defined images but for various other sensors, the techniques may vary with parameters, but one can further take analysis to other imagery sensors data.

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