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Image Processing Tools for Improved Visualization and Analysis of Remotely Sensed Images for Agriculture and Forest Classifications

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ABSTRACT

This paper suggests Image Processing tools for improved visualization and better analysis of remotely sensed images. There are methods already available in literature for the purpose but the most important challenge among the limitations is lack of robustness. We propose an optimal method for image enhancement of the images using fuzzy based approaches and few optimization tools. The segmentation images subsequently obtained after de-noising will be classified into distinct information and the appropriate conclusions would be drawn with regard to forest, agriculture, environmental effect, and crop assessment etc. The tools and techniques are useful for Scientists, Researchers and Academicians working in the area of remote sensing, weather forecasting, crop assessment etc.

1. Introduction

The idea of this Proposal originated from my previous publications. A paper entitled "Speckle reduction in Ultrasound Image processing" was published in Journal of Acoustical. Society of India, 35(01): 36-39 (2008). In same volume of the journal one more paper "Contrast enhancement of underwater images" was published (pp. 33-35). Study of "Assessment of Image Restoration Techniques to Remote Sensing Applications" was carried out that has been published in i-manager's Journal on Future Engineering & Technology, 05(03): 33-37 (2010). When CHANDRAYAAN sent the image of moon then researchers started their research works on the data. Now, number of satellites has been increased that have been moving around for different purposes. There are many examples where remotely sensed images play very important role such as: Impact study of soil moisture content and guiding the farmers; doing the detective work for fraudulent crop insurance claims; Detecting oil spills for marine life and environmental preservation, Identifying forest stands and tallying their area to estimate forest supplies etc.

This paper suggests addressing the challenges pertaining to poor image quality of the remotely sensed images and improving the quality and subjecting them for improved analysis and applications.

2. Related Research

Remotely sensed images carry huge amount of information. If the quality of the images are not good or the analysis of images does not use optimum set of features then the impact of study based the images would be adversely affected. So, the image processing tools especially image enhancement has been extensively studied and few important contributions at international level have been highlighted here with their findings and limitations.

Tang et al (2001) proposed a novel approach for color image denoising that is based on separating the color data into chromaticity and brightness, and then processing each one of these components with partial differential equations or diffusion flows. The concerns of the paper include uniqueness of solutions. Yun and Chao (2006) worked on image enhancement algorithms to improve the quality of fingerprints used in minutiae extraction from finger print images and to improve the performance of the system. An adaptive preprocessing method extracted five features from the fingerprint images, analyzed image quality with clustering method, and enhanced the images as per their characteristics. Although the method improves the performance of the fingerprint identification significantly but robustness remains challenging issue with this work also. Future work aims to develop image characteristic factors for the identification system in real worlds. Pollak et al. (2000) introduced a family of first-order multidimensional ordinary differential equations (ODE's) with discontinuous right-hand sides and demonstrate their applicability in image processing of SAR (synthetic aperture radar) images. It has used a new approach to edge enhancement and segmentation for its application to signals and images with very high levels of noise, as well as to blurry signals. Ho et al. (2013) presented an alternative effective sonar image enhancement algorithm which was composed of two steps, including noise reduction and image sharpening. The sonar image is de-noised using Wiener, median filters and enhanced using un-sharp masking and histogram equalization. The method was tested on many sonar images of different underwater structures. The results were better in terms of noise reduction, and sharpening sonar images in comparison with existing research works.

Kojima et al. (2016) concerned with the image enhancement technique for the mixed illumination variant images by applying the stochastic resonance (SR) using the auto-tuning process. The method aimed at working on the images with the mixture of darkness and brightness. The previous work was faster but this work is effective and worthy also. Fryer and Mclntosh (2001) suggested resolution enhancement in the field of digital photogrammetric images.

Shen et al. (2010) discussed that the performance of remote sensing images in some applications is often affected by the existence of noise, blurring, stripes and corrupted pixels, as well as the hardware limits of the sensor with respect to spatial resolution. So, the method is used to improve the image quality by performing image de-noising, de-convolution, de-striping, in-painting, interpolation and super-resolution reconstruction. The results are presented to illustrate the effectiveness of the proposed method. Choi et al. implemented perceptual image enhancement and applied in applications on the perceptual aspects of human vision. These methods of image enhancement have been extensively applied to practical applications for better perception, interpretation, and subsequent analysis of the images. As mobile cameras become very widely used, enhancement of pictures acquired using mobile devices such as image stabilization, color balance, and noise reduction under a low light condition pose challenges to existing perceptual image enhancement. Gabarda et al. (2007) presented quality improvement method based in a pixel-wise analysis and generalized Rényi entropy has been applied to real-world surveillance video images that present hazy atmospheric degradations. An important feature of the method is its reduced computational cost. Farsiu (2005) suggested a framework addressing the main issues related to designing a practical image fusion system, namely reconstruction accuracy and computational efficiency. Reconstruction accuracy refers to the problem of designing a robust image fusion method applicable to images from different imaging systems. The reduction of computational complexity and memory requirements were attempted.

Bartunek et al. (2013) proposed several improvements to an adaptive fingerprint enhancement method that is based on contextual filtering. Its future work aims to perform a detailed and systematic analysis of the impact of the different chosen design parameters. Moreover, various optimizations of the implemented processing steps could reduce the number of instructions required. Fu et al. (2016) proposed straight forward and efficient fusion-based method for enhancing weakly illumination images that uses several mature image processing techniques. The proposed fusion-based framework, images under different weak illumination conditions such as backlighting, non-uniform illumination and night time can be enhanced. However, haze removal could be further achieved. Fu et al. (2015) suggested an effective enhancement method for remote sensing images to improve the global contrast and the local details. The method uses an empirical approach by using the regularized-histogram equalization (HE) and the discrete cosine transform (DCT) to improve the image quality. It can generate enhanced remote sensing images with higher contrast and richer details without introducing saturation artifacts. Moreover, the proposed method has satisfactory computation time, suitable for enhancement of both remote sensing and ordinary images. However, this method does not consider the noise issue, which would become noticeable after enhancement process. Hnatushenko (2016) proposed a remote sensing image fusion method which combines the Independent Component Analysis (ICA) and optimization wavelet transform; and based on selection of multi-scale components obtained after the ICA of images. The information capacity of multispectral images is increased with the use of the method, the contrast and the number of gradations of brightness increase, the correlation decreases, which indicates the increase of the information entropy of the images.

Zhang et al. (2014) discussed enhancing the spatial resolution of the multi-angle remote sensing images by the super-resolution reconstruction technique. Adaptive weighted super-resolution reconstruction is used to alleviate the limitations of the different resolutions. In imaging process, different angle images are degraded by different levels of blurring and noise. Lu et al. (2016) proposed a non-convex low-rank approximation for reconstructing the images and the performance of the method is evaluated both qualitatively and quantitatively. However, the proposed method has limited performance for the regions and bands where the spatial correlation is not high. Zhang et al. (2013) proposed an image enhancement method to optimize photo composition, by rearranging foreground objects in the photo while keeping the original scene content. More factors which influence aesthetic subjective sensation, like affections could be also considered. Krishnan and Ravi (2016) implemented medical Image fusion by multi-resolution discrete cosine transform (MDCT) algorithm. It was observed that in fusion methods a single level of decomposition alone may not suffice though there is no significant advantage and no degradation of quality it will enable to act as an assistive way for clinical observation. Janani et al. (2015) presented an an overview of Image Enhancement Processing Techniques in Spatial Domain like histogram equalization. Different types of noise are assessed and desired filters were applied for the removal of the noises. Wiener filter may be used for removing almost all kinds of noises. However, the optimum values of performance measures could be still achieved. Verma et al. (2011) presented a novel approach for the enhancement of high dynamic range color images using fuzzy logic and modified Artificial Ant Colony System techniques.

Buddhiraju et al. (2006) presented an image processing tutor specifically for remote sensing applications and along with it a framework for a collection of tools to make it self-contained, catering to the needs of working professionals. Somvanshi (2011) studied that forest plays an important role in amelioration of climate, soil and water conservation, biodiversity conservation, habitat for variety of fauna, tourism and recreation etc. And hence better management of forest it is essential to know the present status of forest in terms of its area, type of forest, growing stock and spatial distribution. Remote Sensing and Geographical Information System (GIS) technology provide essential tool for the required assessment and systematic observation on forest resource. In the Spatial filtering, sharpening filter gives the best result.

Kumar (2004) describes the basic technological aspects of Digital Image Processing with special reference to satellite image processing. The enhancement procedures are applied to image data in order to effectively display the data for subsequent visual interpretation. It involves techniques for increasing the visual distinction between features in a scene. The main aim of using enhancement is to replace visual analysis of the image data with quantitative techniques for automating the identification of features in a scene. This involves the analysis of multispectral image data and the application of statistically based decision rules for determining the land cover identity of each pixel in an image. Information extraction is based on digital classification and is used for generating digital thematic map which hugely depends on quality of the images.

Kumar (2015) implemented enhancement to remote sensing Indian remote sensing satellite P6 Liss IV remotely sensed data like Near-Infrared band. Four filtering techniques were used for image enhancement based on spatial domain filters and frequency domain filters such as median filter, wiener filter, bilateral filter and Gaussian homomorphic filter and salt and pepper noise and Gaussian noise were considered. Gaussian homomorphic filtering technique is suitable for image enhancement of the Liss IV remotely sensed Near-Infrared band. It was found that a filtering strategy based on spatial domain tool and frequency domain tool allows the enhancement of near infrared band. An important task for the future is the development of smarter and more detailed enhancement schemes for remote sensing IRS P6 Liss IV near-infrared band list. Lal and Anouncia (2016) presented an enhanced dictionary-based sparse representation (EDSR) for multi-temporal image fusion. Multi-temporal remote satellite images acquired on the same geographical area at different acquisition dates are merged to obtain a fused image for further analysis. The method utilizes the regularization parameter adaptively and effectively and takes advantage of the adaptive regularization parameter and chooses the maximum absolute fused vectors for fusion.

3. Method and Recommendations

The suggested method includes following major steps of the methodology:

Step1- Acquisition and Pre-processing the data

Remotely sensed images are available as open source data. We also would write to Indian Remote Sensing Department, Hyderabad and other agencies to provide specific data of multi-temporal in nature so that we can analyze the data with changing time. The images once acquired would be subjected to pre-processing so that images are ready to be used for further analysis and applications. There are different types of noises sources that corrupt the images that need to be removed. The flow diagram for implementing the method is shown in Fig. 1, where Image processing tools for Remote Sensing applications has been highlighted with all necessary steps.

Step 2- Development of Optimal and Fuzzy based Image De-noising Methods

This step includes developing novel and optimal image enhancement method for almost robust image processing tool for image de-noising.

There are a number of methods available in literature on image enhancement methods and the biggest challenge among all is robustness. In Gonzalez (2003), the most prominent author of image processing has admitted that there is no general theory in image processing and image enhancement is in particular purely subjective matter. Therefore, an attempt would be made to:

- Selecting optimum performance filter or enhancement method available in literature; and
- Optimizing the method using optimization tools and fuzzy based approach so as to maximize the performance measures.

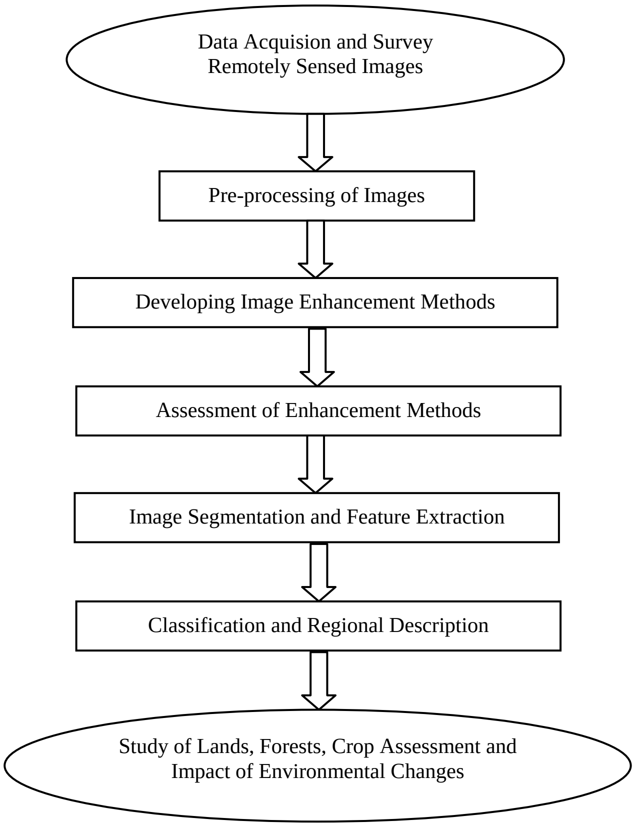

Fig. 1- Flow diagram of the proposed method

Step 3- Performance Evaluation of Image Enhancement

The robustness will be evaluated in terms of suitable set of performance measures such as PSNR (peak signal to noise ratio), MSE (mean square error), CC (correlation coefficient) etc. The evaluation will also be optimized. There are other set of measures available such as CNR (contrast to noise ratio) and hence this process would also be considered seriously while selecting the appropriate set of perforate evaluation parameters. Extensive study of the papers will certainly help in devising some new parameter or metrics.

Step 4- Segmentation

The different regions of different parts of the country will be segmented for classification and description. Fuzzy c-means or similar method will be used so that the detailed information could be brought out from the digital images.

The information and the images are very much diverse in nature and therefore, few important segmentation methods will be tested and the one with optimal results will be chosen and recommended. The segmentation methods that would be tested are:

- Region based approaches;
- K-means method; and
- Watershed based method.

Finally, fuzzy based approaches such as application of fuzzy in k-means, fuzzy c-means will be experimented and the evaluation of segmentation results will be made using classification.

Step 5- Feature Extraction and Classification

A number of image features such as contrast and brightness values; shape and size; region based dimensions; textures etc. will be extracted and on the basis of these features, classification would be made among the different regions.

The features will be of different types such as:

- Region based features;
- Area, shape and others; and
- Image based features such as contrast, brightness and intensity values.

Step 6- Study of agricultural, forest, weather, climate, earthquake impact in different regions

The agricultural and forest resources are abundant in both the states of Telangana and Chhattisgarh. Moreover, these states depend heavily on natural and agricultural resources and hence the study and image processing based analysis will be made.

Step 7- Study of habitats, plants and forests based on the classification of data.

4. Conclusions

Image Processing Tools including Enhancement and Segmentation are developed. Optimal method of image de-noising can help in dealing with the noise signals in the remotely sensed images. The paper gives useful information for Scientists, Researchers and Academicians working in the field of remote sensing, weather forecasting and GIS; and it has addressed socio-economic issue and its impact due to change in environmental conditions.

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