Survey on Classification and Segmentation for HDR Satellite Imagery

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Abstract

Now a day's the most interesting research area in field of Digital Image Processing is Remote sensing. Currently Remote sensing (RS) is being widely used technology which plays most important role in Image analysis. Remote Sensing (RS) generally refers to the use of satellite based sensor technologies respectively. However, the luminance of natural scene present over a large dynamic range. Thus, with a regular camera it becomes complicated to capture the details of an entire scene with good clarity in a single shot. To overcome this problem HDR (High Dynamic Range) imaging has been used. TMO (Tone Mapping Operator) is used to convert HDR image into LDR image which serves good quality of an image, so that we can visualize it over LDR display. Currently in the field of Image processing an image with big data becomes quite difficult to understand. To overcome this analysis problem there is need of image segmentation. Image segmentation is used to compress the data which will helpful to understand. Satellite imagery is one of the wide areas in segmentation and classification. There are various image segmentation techniques are there like edge, threshold, region, clustering and neural network segmentation method. This work focuses image segmentation towards ANN (Artificial Neural Network) because it has some advantages as compare to rest of methods. Image classification techniques like supervised and unsupervised learning discussed in this paper.

Keywords— *Remote Sensing (RS), HDR (High Dynamic Range), Tone Mapping Operator (TMO), Image Segmentation techniques, Supervised Classification, Unsupervised Classification*

I. INTRODUCTION

In the digital era Remote sensing (RS) is widely used technology to monitor the different resources available on Earth's surface from remote location. Remote sensing is the science of acquisition of information about Earth surface
without being in contact with it [3]. Over a couple of decades remote sensing useful for the assessment of many things; due to this many countries are launching satellites for purpose of various applications like in agriculture we can do crop analysis with the help of this modern technique , mapping, disaster management, environmental assessment and monitoring, military and metrology [4]. Now a day's, the term "remote sensing" generally refers to the use of satellite or aircraft based sensor technologies used to detect and classify objects on Earth. Basically there are two types of remote sensing as Active Remote Sensing (ARS) and passive Remote Sensing (PRS) respectively. In Active Remote Sensing a signal is emitted by a satellite and its reflection by the object is detected by the sensor. Whereas in is Passive Remote Sensing the reflection of sunlight is detected by the sensor, respectively [2].

II LITERATURE SURVEY ON SEGMENTATION AND CLASSIFICATION

The literature survey focuses its attention towards Classification and Segmentation in HDR Satellite Imagery Using Artificial Neural Network. This literature review divides in two parts as 'Review on Segmentation of satellite images' and another one is 'Review on Classification of satellite images' respectively.

Part 1: Survey on Segmentation of satellite images

There are various image segmentation techniques are available like edge, threshold, region, clustering and neural network method . To understand image easily image segmentation is necessary.

In [5] paper respective authors presented Fuzzy C-means clustering an image segmentation technique for detection purpose . Fuzzy c-means (FCM) is a method of clustering in which one piece of data is belongs to two or more clusters. The result by this algorithm are more reliable, efficient and easy to understand respectively [5].

In [6] paper respective authors presented Grab Cut Image segmentation method which is most popular method in the field of image segmentation. A Grab Cut image segmentation uses texture and boundary information of image. In this work the Grab cut algorithm achieved good result with small number of user interaction. But this algorithm has two drawbacks/: the first one is when background and objects are very similar and complex , then in such case segmentation will not be very good, whereas on the other hand the presented algorithm has limited applications due to the presence of complex iterative process. To overcome this problem the author has presented combination of grab cut and graph based image segmentation which is useful in more complex situations [6].

In [7] work the respective authors reviewed various image segmentation techniques such as Thresholding method, Edge Based segmentation, Region based segmentation, Clustering based segmentation , Watershed based segmentation, Partial Differential Equation based segmentation, ANN(Artificial Neural Network) based segmentation with its advantages and disadvantages respectively. Image segmentation is very useful in object recognition task and image compression as well [7].

In [8] Image segmentation is essential for various image based applications such as Texture extraction, Target tracking and Tumor detection etc,. This paper presented the detail information of various image segmentation methods such as Active contour, Level set, K-means clustering and Fuzzy clustering to get improved efficiency. Intensity and Texture based segmentation are two levels of 'Level set method' respectively. After the detailed survey and comparison it is found that Combination of both intensity and texture based segmentation provides better segmentation results as compare to traditional method. The combination given in this paper analyzed noise present in an image. This paper analyzed the performance of various parameters such as accuracy, confusion matrix parameters and Kappa's coefficient on traditional methods need to be improved [8].

In [9] paper gives a review on various image segmentation method based on image features like pixel intensity value, color and texture etc,. In this paper comparison of various image segmentation techniques is to be done on the basis of two approaches like Discontinuity detection based approach and Similarity detection based approach respectively. It is found that these segmentation methods has various application in the fields like, medical imaging for the detection of cancer, in remote sensing to detect the roads and bridges as object recognition and detection purpose respectively [9].

In [10] Image segmentation plays most important role in image processing for the image compression and object recognition purpose. The segmentation also done in two ways as supervised and unsupervised image segmentation when we perform segmentation by ANN(Artificial Neural Network) method. The supervised segmentation is used when we have a known information or prior knowledge whereas unsupervised segmentation is used when we don't have any prior knowledge. It means for unsupervised segmentation there is no need of training data. In this paper Kohonen's Self Organizing Map (SOM), an unsupervised and non parametric ANN(Artificial Neural Network) methods has used for the identification of main features in an image respectively. In this paper , it is found that SOM used GA(Genetic Algorithm) to get the optimal segmentation result [10].

In [11] K-means Clustering for the segmentation purpose discussed.. K-means is based on unsupervised learning which solve the well known clustering problem. The goal of this algorithm is to find groups in the data, with the number of groups represented by the variable *K*. Achieved better segmentation results using Active Contours method for satellite image segmentation. A Active Contours method is an energy minimizing, deformable spine influenced by constraint and image forces that pull it towards object contours and internal forces that resist deformation [11].

Part 2: Review on Classification of satellite images

In [12] Presented Artificial Neural Network as a Machine Learning Classifier for the classification purpose. Artificial neural networks (ANN) are computing systems vaguely inspired by the biological neural networks that constitute animal brains. The neural network aims to work many different machine learning algorithms together and process complex data inputs. In this work they have used Artificial neural

networks (ANN) with supervised learning for the classification of the LISS-III satellite image. Basically (or error matrix) is usually used as the quantitative method of characterizing image classification accuracy. A Kappa coefficient will be used to verify the presence of the themes that were presented. By using Artificial neural networks (ANN) classifier the result shows that whenever the number of neurons are increases in the artificial neural network then there is the downfall in the accuracy of the neural network based classification[12].

In [13] Presented work a hybrid clustering algorithm and feed-forward neural network classifier for land-cover mapping of trees, shade, building and road. However this work used the concept of image segmentation and classification. The effective segmentation is achieved by genetic Artificial Bee Colony (ABC) algorithm and FCM (Fuzzy C-Means) algorithm. To handle unconstrained benchmark optimization functions ABC algorithm was introduced. Fuzzy c-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters. In this work the algorithm which is used perform better than the existing algorithms[13].

In [14] Presented Artificial Neural Network (ANN) for classification and segmentation purpose. Artificial neural networks (ANN) or connectionist systems are computing systems vaguely inspired by the biological neural networks that constitute animal brains. The neural network itself is not an algorithm, but rather a framework for many different machine learning algorithms to work together and process complex data inputs [14].

III. TMO (TONE MAPPING OPERATOR)

Over a couple of decades High Dynamic Range (HDR) imaging has become a crucial topic across all of the imaging disciplines like photography, computer graphics, image processing and computer vision. Basically High dynamic range (HDR) contains a very wide range of luminance from moonlight to bright sun shine to accomplish the requirement of a real world visual scenes. According to Human Visual System (HVS) the HDR model displays are capable of a contrast ratio 1,000,000:1 with a peak luminance of 4000 cd/m2 [10]. However, all available gadgets display is having adaption range of 1000:1 luminance range context. Hence, the demand of high dynamic range (HDR) imaging has been increased which results in low availability of HDR displays, the need for efficient tone mapping techniques become very essential. The tone mapping operators have been used to compress the HDR images into LDR (Low Dynamic Range) images to visualize scene over normal displays. In 1993 the thought of tone reproduction was introduced by Tumblin and Rushmeier. Since then, several methods of tone mapping operators have been proposed [11].

Intents of TMO:

Basically Intent is nothing but goal. Depending on the particular application the goals of tone mapping is to be differently declared. Like, the main goal in some cases is producing just “nice-looking” images, while other applications 'reproducing as many image-details as possible', or might maximize the image contrast. Whereas in realistic rendering applications the goal might be to obtain a perceptual match between a real scene and a displayed image even though the display device is not able to replicate the full range of luminance values. However, achieving such a match is possible because the visual system of humans has limited capacity to detect differences in absolute luminance levels, and concentrates more on aspects of spatial patterns when two images is to be compared [10].

List and details of TMO's useful in HDR satellite Imagery

In the field of HDR (High Dynamic Range) Imaging there are various well known TMO's are available which is to be useful in the Remote sensing platform based application; like, Tumblin and Rushmeier TMO, Ward TMO, Reinhard TMO, Stockham’s TMO, Chiu’s TMO, Ferwerda’s TMO, Schlick’s TMO, Pattanaik’s TMO, Logarithmic TMO, Ashikhmin TMO, Fattal et al TMO, Durand and Dorsey TMO, Adaptive Gamma Correction TMO, Gamma correction TMO, Dargo et al TMO, Duan et al. TMO, Guangjun and Yan TMO, Li etHowever , we have selected best Reinhard TMO among available TMO' according to its popularity and also verified by feature extraction for further preprocessing to enhance the quality of a satellite image. Over Reinhard TMO the Image Quality Assessment (IQA) is to be done on the basis of feature extraction like, MSE, PSNR, SSIM, etc,. Image quality is to be done in two ways as Subjective assessment and another one is objective assessment. So that we can meet with the details of the

real world al. TMO, Exponential (ETM) TMO etc,. Among these TMO's we have selected some well known TMO's like Ashikhmin TMO, Logarithmic TMO, Rushmeier TMO, Ward TMO, Reinhard TMO, Dargo et al TMO etc,. in HDR satellite Imagery for purpose of image quality enhancement [10].

1] Reinhard TMO

The Photographic Tone Reproduction proposed by Reinhard et al., which is based on "dodging and burning" concept used in photography and with the help of this it is possible to adjust local contrast[16]. They used the zone system for mapping HDR world image into LDR ones. So, in order to compute the dynamic range the photographer firstly selects the middle grade key in the image and then selects the darkest and brightest points in this zone system. This process is done manually by photographers then the image is corrected using dogging (darkening) or burning (brightening) process [17]. Now a days this method operates automatically freeing the user from setting parameters that are not particularly perceptive [16]. Reinhard's global operator which is a well known TMO is given by

$$L_d(p) = \frac{L(p)}{1+L(p)} \text{ .....(1)}$$

where ,The scaled luminance $L(p)$ is calculated as

$$L(p) = \frac{\alpha}{\overline{L_w}} L_w(p) \text{.....(2)} \quad [15].$$

2] Logarithmic tone-mapping operator

The Display luminance D(l) is given by,

$$D(I) = (D_{max} - D_{min}) * \frac{\log(I+\tau)-\log(I_{max}+\tau)}{\log(I_{max}+\tau)-\log(I_{max}+\tau)} + D_{min} \text{.....(3)}$$

Where Lmin = Minimum luminance of the scene,
Lmax = Maximum luminance of the scene,
Dmax = Maximum display level of the visualization devices
Dmin = Minimum display level of the visualization devices and
τ = The value which controls the overall brightness of the mapped image.

In general, as max value of τ makes the mapped image darker and smaller one makes it brighter respectively. For the divided regions it is important to determine the appropriate τ value [13].

- Global Logarithmic Tone Mapping

The response of the HVS to the stimulus luminance L is to be described by brightness B. This response is to be expressed in logarithmic function as ,

$$B = k_1 \cdot \ln(L/L_O) \text{.....(4)}$$

where L_O = luminance of the background and k_1 = constant factor.

The relation has been derived in psychophysical threshold experiments through examining just noticeable differences ΔL for various L_O, called the Weber-Fechner law. In general, HVS senses brightness as an approximate logarithmic function according to the Weber-Fechner law [14]. To compress the dynamic range of an HDR scene, we use a global mapping function as follows:

$$L_g(x,y) = \frac{\log(L_W(x,y)/\overline{L_w}+1)}{\log(L_{wmax}/\overline{L_w}+1)} \text{.....(5)}$$

where L_w (x, y) = original luminance value at a pixel (x,y) ,
L_{wmax} = maximum luminance value of the original luminance values.
L_w = log-average luminance as follows.

Log average luminance is given by,

$$\overline{L_w} = exp(\frac{1}{N}\sum_{x,y} \log(\delta + L_w(x,y))) \text{.....(6)}$$

where *N* = total number of pixels in an image; and 'd' is small value to avoid the singularity which occurs if black pixels exist in an image [15].

3] Ashikhmin TMO:

Ashikhmin et. al proposed a perception-motivated algorithm which uses local adaptation level for each pixel to decide upon the non-linear compression applied to the luminance of the pixel. Since this suppresses high frequency details in the image, those details must be re-introduced at a final step [16].

4] Dargo TMO

Dargo et al. proposed adaptive logarithmic operator for compressing the luminance values by adaptively varying the logarithmic bases. To improve the contrast of dark areas in image they used contrast enhancement.

III. IMAGE SEGMENTATION

Over a couple of decades there is great importance of Image segmentation process in image processing. The image segmentation is the initial but most important step in the image analysis to gather necessary information. Image segmentation is the technique or method of dividing or partitioning an image into parts, called segments. It can be used to partition an image into meaningful parts having similar features and properties. So Image segmentation is an important and challenging process of image processing. Image segmentation is used to segment the parts from image for image compression and object recognition purpose.

The image segmentation approaches can be categorized into two types based on properties of image as Discontinuity based detection and Similarity based detection

A] Discontinuity based detection: In this approach an image is to be segmented into regions based on discontinuity..

B] Similarity based detection: In this approach an image is to be segmented into regions based on similarity.

IV. CLASSIFICATION OF IMAGE SEGMENTATION TECHNIQUES

In this digital era several existing techniques is to be used for the purpose of image segmentation. These all techniques have their own importance. Whereas all techniques can be approached from two basic approaches of segmentation i.e. region based or edge based approaches. Whereas on different images various techniques can be applied to perform required segmentation. For simplicity Objective assessment is to be avoided and Subjective assessment is to be done for all techniques. The most popular image segmentation techniques are: thresholding method, edge detection based techniques, region based techniques, clustering based techniques, watershed based techniques, partial differential equation based and artificial neural network based techniques etc which can be used for image segmentation purpose. All these techniques has its own speciality in respect to segmentation. Figure 1 shows classification of Image segmentation.

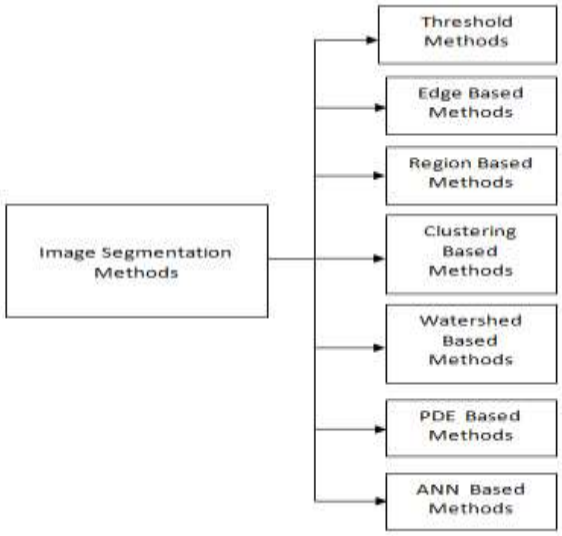

Fig. 1. Classification of Image Segmentation.

1] Artificial Neural Network (ANN)

Basically a neural network is an artificial representation of human brain that tries to simulate its learning process. An artificial neural network (ANN) is also called a neural network or simply neural net. For the purpose of decision making the artificial neural network based segmentation methods simulate the learning strategies of human brain. In this digital era currently this method is mostly used for segmentation of medical images. The required image is to be separated from background by using two types ANN based segmentation. Basically a neural network is made of large number of connected nodes and each connection has a particular weight. This method is independent of PDE. In this the problem is converted to issues which are solved using neural network. This method has basic two steps to perform segmentation of an image : extracting features and segmentation by neural network [19].

V. IMAGE CLASSIFICATION

There is a common use of remotely sensed image data is to monitor land cover and to inform land use planning, along with military surveillance and weather forecasting. The term land cover either refers to the kinds of vegetation , or there are some kinds of materials that form the surface where vegetation is absent. In 1949 a World Land Use Commission adopted an early classification system which has been consisting nine primary categories, including cropland, settlements and associated non-agricultural lands, horticulture, tree and other perennial crops, improved permanent pasture, woodlands, unimproved grazing land, swamps and marshes, and unproductive land. As in the digital era the 'digital image processing' , specially trained for the personnel drew land use maps by visually interpreting the shape, size, pattern, tone, texture, and shadows cast by features shown in aerial photographs. This was might be an expensive, time-consuming process. It's not surprising, that the Commission appointed in 1949 failed in its attempt to produce a detailed global land use map. The digital image processing is very essential(potential) to automate land use and land cover mapping. For the assurance of this potential, image analysts have developed a family of image classification techniques that automatically sort pixels with similar multispectral reflectance values into clusters which ideally correspond to land cover categories and functional land use. To categorize all pixels of a digital image into one of several land cover classes, or "themes" is the main goal or intent of the classification process. This categorized data may be used to produce thematic maps of the land cover present in an image. Usually, to perform the classification we used multispectral data (Lille sand and Kiefer, 1994). The objective of image classification is to identify and describe, as a unique gray level (or color), the features in an image occurring in terms of the object or type of land cover whereas these features actually represent on the ground. It perhaps that Image classification plays most important role in digital image analysis. The thing is very good to have a nice-looking picture or an image, showing a magnitude of colors illustrating various features of the underlying terrain, but it is quite useless unless to know what the colors mean. (PCI, 1997) [20]. Basically there are two general types of image classification techniques have been developed: supervised and unsupervised techniques [21].

- **Supervised classification**

Basically Human image analysts plays crucial roles in both types of classification procedures as supervised and unsupervised image classification. In supervised classification, the analyst's plays important role in to specify the advance the multispectral reflectance or if we say about in the case of the thermal infrared band it specifies the emittance values of each land use or land cover class. Usually reflectance's recorded in Thematic Mapper (TM) bands 2 (visible green), 3 (visible red), and 4 (near-infrared) which normally shown in blue, green, and red colors respectively. If we have to perform a supervised classification of the Landsat Thematic Mapper (TM) data into various land cover categories, like Vegetation and urban ,slum, water land, rods etc. So initially we would first define several training fields that are representative of each land cover class. To achieve the most reliable classification possible we can define as many as 100 or more training fields per class. Basically the training fields consist of clusters of pixels with similar reflectance values. If we perform a good job while supervising the training stage of the classification, then in that case each cluster would represent the range of spectral characteristics exhibited by its corresponding land cover class. After defining the clusters , we would apply a classification algorithm to sort the remaining pixels in the scene into the class with the most similar spectral characteristics. The statistical probability of each pixel belongs to each class is to be computed by one of the most commonly used algorithms is ' maximum likelihood classifiers'. With the help of this algorithm pixels are then assigned to the class associated with the highest probability. By the use of supervised classification, we identify land cover type in the image. These are called "training sites". After training stage to develop a statistical characterization of the reflectance for each information class an image processing software system is used. This stage is called "signature analysis" or generate signature file and may involve developing a characterization as simple as the mean of reflectance on each bands, or as complex as detailed analyses like mean, variances and covariance over all bands. Once a statistical characterization has been achieved for each information class, the image is then classified by examining the reflectance [21]. Basically there are three steps of supervised classification as : Select training areas, Generate signature file and Classify an image.

- **Unsupervised Classification**

In 'Unsupervised classification' there is no need to train the data. Unsupervised classification is used to determine the large number of unknown pixels and then divides those pixels into a number of classes based on natural groupings present in the image values. There is no need of training data to perform the unsupervised classification. The process of unsupervised classification depends on statistical clustering algorithm which is used to sort pixels into distinct spectral classes. By the use of unsupervised classification the image analysis may or may not even specify the number of classes in advance [22]. The main responsibility of unsupervised classification is to determine the correspondences between the spectral classes defined by the algorithm, functional land use and land cover categories established by agencies like the U.S. Geological Survey. The basic principle of unsupervised classification is that , the class which . have similar gray levels should be place close together in the measurement space ; whereas data which have very different gray levels in different classes should be comparatively well separated (PCI, 1997; Lille sand and Kiefer, 1994; Eastman, 1995) . The unsupervised classification represents the result are in the form of spectral classes which is based on natural groupings of the image values. However , at initial stage we don't know the identity of the spectral class. So due to this we must compare classified data to with some reference data to compute the identity and informational values of the spectral classes. Thus, in the supervised classification method, we provide useful information to train the data and then determines their spectral reparability ; whereas in the unsupervised approach the computer initially do computation of spectrally separable class, and then define their information value. (PCI, 1997; Lille sand and Kiefer, 1994) Unsupervised classification is becoming very popular in agencies involved in long term GIS database maintenance. Now a days , there are various systems uses clustering procedures which are extremely fast and requires little operational parameters [23].

CONCLUSION

In this work, the need of TMO (Tone Mapping Operator) and its classical types studied at length. Among available TMO's (Tone Mapping Operator's) best TMO is to be selected and studied at length on feature based quality assessment of LDR (Low Dynamic Range) images for the purpose of LDR display. On the basis of result we conclude that the Reinhard TMO gives better result than the rest of the other TMO's. The TMO has various advantages like; Tone Mapped images better reflect reality seen and it provide fast processing.

In this work we have discussed about the image segmentation and image classification techniques and methods. In this work various image segmentation techniques like Thresholding method, Edge based method, Region based method, Clustering based method, Watershed ,method, PDE (Partial Differential Equation) based method, and ANN (Artificial Neural network) based methods described in detailed with its advantages and disadvantages for the image segmentation purpose.

This paper provides detailed information about the different classification techniques and methods. Main classification techniques are divided into two categories such as Supervised Classification, Unsupervised Classification.

ACKNOWLEDGMENT

I would like to thank my guide Mr. Sunil L. Tade, Associate Professor in Electronics & Telecommunication Department for their continuous support, encouragement, valuable guidance and enhancing me for this work through aspiring ideas in mind. He motivated me greatly which contributed tremendously to my work.

I would like to thank Dr. M. T. Kolte, PG coordinator for his insightful suggestions .I am also thankful to Dr. N. B. Chopade, HOD Electronics & Telecommunication Department and Dr. A. M. Fulambarkar, Principal, Pimpri Chinchwad College of Engineering for their support. I would also like to express my sense of gratitude to all the people who directly or indirectly supported me in completing this paper work.

At the last but not least, I am thankful to my parents, who encouraged and inspired me with their blessings

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