# A Weight Coefficient Index Based Remote Sensing Image Segmentation Approach

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***Abstract -*** An effective analysis and interpretation of remotely sensed imagery lies in efficient segmentation of different regions in the image. The conventional pixel based methods of remote sensing image analysis cannot give satisfactory results as the individual pixels usually cannot convey themselves. Segments form a complete disjoint coverage of an image thereby offering a more appropriate means of analysis. In literature, graph based segmentation approaches are found be most efficient in terms of both accuracy and computational time. This paper offers an enhanced graph based segmentation approach which utilises a weight coefficient index for efficient segmentation thereby achieving more accurate results as compared with the traditional approaches. The proposed approach is tested on various remotely sensed images through quantitative and qualitative analysis. The experimental results show that the proposed enhanced graph based segmentation approach employing weight coefficients index outperforms the conventional software eCognition fractal network evolution based segmentation method both in terms of accuracy and efficiency.

***Keywords -*** *Weight Coefficient Index, Remote Sensing, Segments, Graph Theory, Cropping.*

## I. INTRODUCTION

Since the birth of remote sensing, the rich spectral content of remote sensing images has been showing its strength in the identification of various land cover classes. But for the efficient interpretation of remotely sensed imagery, it is not always enough to utilise only spectral information but to include the neighbourhood information of the pixels. To overcome this drawback, segmentation was introduced in remote sensing with the aim of extracting neighbourhood information and preserving natural homogeneity. Thus, the application of segmentation is not an option, but a necessity in the efficient analysis and classification of remote sensing images. Additionally, in the land cover classification of remotely sensed image, the segmentation should be accurate and proper, since the outcome of this has enormous effect on the stages following it. In the field of remote sensing image analysis, the graph based segmentation methods are considered as one of the best approaches which results in correct recognition of regions upto great extent and also these methods are time & space efficient. However there is always a scope for improving the accuracy of segmentation from previous graph based segmentation methods. We try to enhance the accuracy of prevailing methods by suggesting to utilise a weight coefficient index which can be used for checking the presence of a boundary between the two regions in an image. By utilising this weight coefficient index an efficient segmentation algorithm is developed which generate segmentation that fulfils the global properties. The computational time of this algorithm is linear to the number edges in graph and is also found to be fast. A significant property of this technique is its capability to preserve detail in region with low variability and disregard detail in regions of high variability.

## II. RELATED WORK

Due to the extensive advantages of region based information analysis in remote sensing information extraction, more and more research is being done on the topic of similar feature fusion and the identification of homogeneous elements employing the high resolution remote sensing image segmentation. The graph theory has found to be an efficient tool in isolating the homogeneous regions from the image. Precisely, the spectrum graph theory technique is widely employed for data dimension reduction, clustering and for segmentation of images segmentation [1][2]. The concept of graph theory was first promoted by [3] in 1971 for image segmentation. He performed the clustering and image segmentation by utilising the Minimum spanning tree of graph theory (Minimum spanning tree). Thereafter, a number of researchers had developed a number of image segmentation methods based on the graph theory concept [4][5][6][7][8][9][13]. Taking forward the Zahn's[3] research, [9] proposed a fast minimum spanning tree approach by combining the minimum spanning tree method and region merging algorithm. This new approach was based on adaptive threshold technique and performed segmentation by exploring and comparing the similarity and differences of two regions [10]. This method was not yielding proper results as other feature coefficient were not considered in segmentation process. A new hybrid approach[10] by utilising the minimum spanning tree algorithm in combination with Mumford Shah theory was proposed for getting good segmentation results but at the expense of slower processing rate. A new hybrid approach [12] was proposed by utilising the combination of spectral, textural and shape information for image segmentation. This method relatively improved the segmentation but only on images with rich texture content. We try to overcome the limitation of the earlier methods by proposing to utilise a weight coefficient index employing the graph theory concept for implementing efficient image segmentation.

## III. PROPOSED SEGMENTATION METHOD

As with certain classical graph based image segmentation methods our methodology is also based on choosing the edges from a graph in which each pixel corresponds to a node and the neighbouring pixels are connected by the undirected edges. The weight of each edge is the criteria for measuring the dissimilarity between pixels. The traditional image segmentation approaches take widely varying intensities in the image as the criteria for isolating the image into multiple segments. Since such large intensity variations are commonly found in remote sensing images, it may not be sufficient and proper to assume that the image has constant or mild intensity variations. Thus, to properly segment such images, a type of adaptive or non-local measure must also be included. We try to enhance the accuracy of the earlier segmentation approaches by introducing weight coefficient index which is utilised for detecting the border between any two regions of an image. All the weights corresponding to each node or pixel of the image is indicated in the weight coefficient index and by comparing different weights of the nodes the presence boundaries are detected. The weight on each node is assigned based on its parameter like intensity, colour and motion of pixels. In this method, the region prediction is made by utilising graph theory concept as described below.

Let $G = (V, E)$ represents an undirected graph in which,

- The vertices $v \in V$, are the group of element (pixels) to be segmented.
- The edges $(v_i, v_j) \in E$ corresponds to the pairs of neighbouring pixels.
- Every edge $(v_i, v_j) \in E$ has an associated non-negative weight $w(v_i, v_j)$ with it, which is used as a dissimilarity criteria between neighbouring vertices *vi* and *vj*.

In the proposed approach of remote sensing image segmentation, the set of vertices in $V$ are pixels and the criteria for measuring the variations between the two pixels is the weights on the edge that connects these two pixels. This dissimilarity measure is based on intensity, colour and motion of pixels. In this method, a segmentation $S$ of an image is defined as a separation of $V$ into regions in such a way that each region $R \in S$ relates to a connected region in the graph $G' = (V, E')$, and $E' \subseteq E$. In other words, the subset of edges in $E$ causes the segmentation.

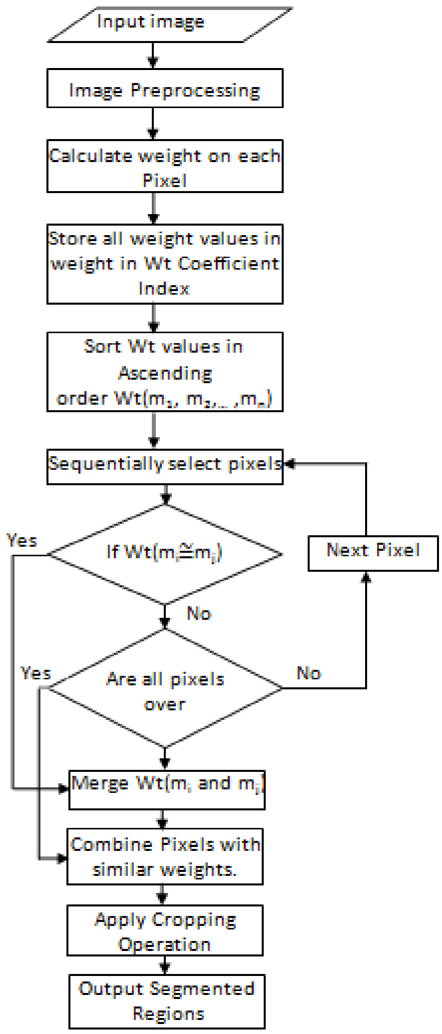


Fig. 1: Block diagram of the proposed segmentation approach.

The figure 1 shows the block diagram of the proposed segmentation approach. The input image is first converted into binary image and converted to appropriate size in the pre-processing phase. All the pixels and their corresponding edges are detected in the second phase. The weight on each detected pixel is estimated based on the pixel intensity. To speed up the processing, the estimated weights of all pixels are stored in a data structure named as Weight coefficient index. Each weight value will be pointing to a pixel in the image. All the weight values are sorted in ascending order and rearranged accordingly. The pixels are selected for processing one by one in a sequential order and the weight of pixels are compared to find all the pixels with similar weights. The pixels with similar weights are grouped together to form distinct regions of the image. The detected regions with similar pixels are separated employing the cropping operation.

## IV. THE PROPOSED ALGORITHM DEFINITION AND ITS PROPERTIES

It will be proved through the following definitions that the proposed segmentation approach fulfil the characteristics of being neither too coarse nor too fine.

***Definition 1.*** The segmentation S is said to be too fine when there is a pair of regions $R_1, R_2 \in S$, such that there is no proof of boundary found between them.

For defining what is required for a segmentation to be too coarse in which the regions are very less, the notion of refinement has to be used. For two segmentations denoted by $S$ and $T$ performed on the same image, $T$ is called a refinement of *S*, if every region of $T$ is included in (or at least equal to) some region of *S*. Apart from this, *T* is said to be in proper refinement of *S* if $T \neq S$. Similarly, $T$ can be achieved by dividing one or more regions of *S* if the *T* is a proper refinement of *S*. If $T$ is found to be a proper refinement of *S*, it indicates that the *T* is finer than *S* and that *S* is coarser than *T*.

***Definition 2.*** The segmentation S is said to be too coarse when a suitable refinement of S is present which is not too fine.

This leads to the concept that, if the resulting segmented regions can be further subjected to segmentation and if new regions are obtained from them, then the result of initial segmentation had very less regions.

In general there is always a possibility for a segmentation that is not too coarse or fine and such segmentation cannot be unique. And also there is an option of some segmentation which is not too coarse and not too fine as can be proved by the following properties.

**Property.** There is some segmentation S for a (*finite*) *graph G* = (*V*, *E*) which is neither *too coarse nor too fine.*

It can be easily proved as to why this property holds good. Suppose there is segmentation in which all the elements are present in the single region. Obviously, because of only one region, this segmentation cannot be too fine. If the segmentation is additionally not too coarse then it is proved. Or else, by the definition of what it suggests that to be too coarse there ought to be a correct refinement that's not too fine.

Choose one of the refinement and keep repeating this process till a segmentation is obtained which is not too coarse. This process can progress just for $n-1$ steps, as a result whenever we have a tendency to choose a correct refinement we also have tendency to increase the amount of regions for the segmentation by a minimum of one, and also the finest segmentation that we are able to achieve is the one in which every region contains only its elements.

The minimum weight paths are predicted depending on the estimated weight values and the edge links are extracted. The boundaries of the regions are declared by connecting the minimum weight edge elements. The minimum weight edges together form a bounding region for each distinct region of the spatial image. The predicted bounding regions of the spatial image are then isolated using image cropping operation performed on the specified location coordinates.

## IV. RESULTS AND DISCUSSION

For estimating the accuracy of our proposed algorithm, we choose various remote sensing images captured at different altitudes and having varying intensities and features. The input images are first transformed into monochrome images for efficient processing. For finding the different regions present in the input image, an undirected graph $G$ is defined, in which each image pixel has a associated vertex $V$. An edge weight function is used for estimating the absolute intensity difference among the pixels that are connected by the edge. The algorithm traverses around the image to find paths with low weights that correspond to significant edges. These edges connected together build a bounding region for every distinct region present in the spatial image.

(a) Original Image (b) eCognition result (c) Our Algorithm Result

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Fig 2: The comparative segmentation results for three input images.

The figure shows the three input images and corresponding segmentation results obtained with eCognition approach and our proposed algorithm. As can be noted from figure 2 our method is giving more precise results. The proposed method is able to correctly isolate the distinct regions in the images.

Table 1: Time taken by various segmentation methods

| Input Image | Time taken by eCognition method | Time taken by our approach |
|---|---|---|
| Image 1 | 5 Second | 3 Second |
| Image 2 | 7 Second | 4 Second |
| Image 3 | 4 Second | 3 Second |

The table 1 shows the comparative time taken for segmentation by eCognition method and our approach. As can be observed, our approach takes much less time as compared with eCognoition approach. The figure 3 and figure 4 shows the comparative segmentation accuracy and average time for segmentation for eCognition approach and our proposed method.

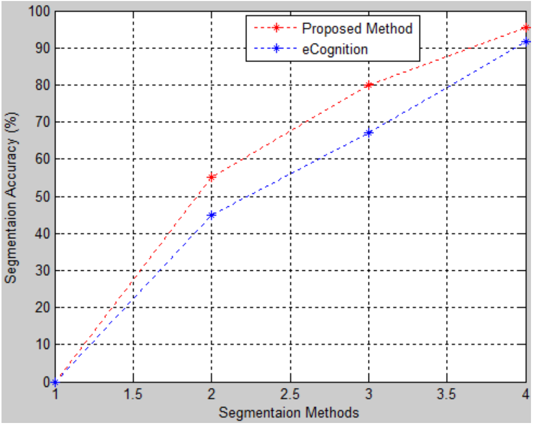


Fig 3: Comparative segmentation accuracy

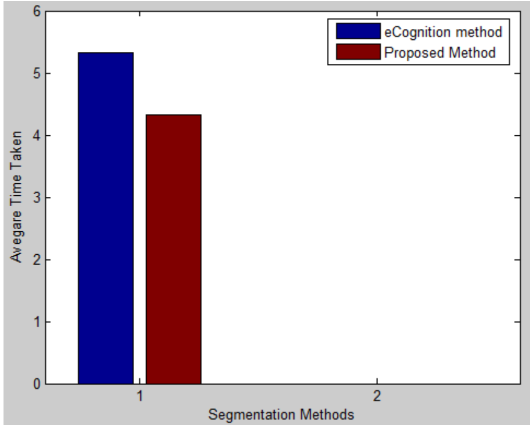


Fig 4: Comparative Average time taken for Segmentation

## V. CONCLUSION

In this paper an improved graph based algorithm for dynamic segmentation of remote sensing images is proposed. This algorithm is unique, in the sense that it is both extremely efficient and also overcomes the internal variation problem in regions. By employing a weight coefficient index, an efficient segmentation algorithm is proposed that generate segmentation that fulfils the global properties. The computational time of our algorithm is linear to the number edges in graph and is also found to be fast. A significant property of this technique is its capability to preserve detail in region with low variability and disregard detail in regions of high variability.

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