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A review and analysis of image segmentation approaches in change detection analysis

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ABSTRACT
In change detection analysis, change detection accuracy does not only depend on the image registration accuracy but it also depends on segmentation approach used during segmentation that's after image registration. poor segmentation approach leads to wrong classification results hence leading to poor change detection results hence leading loss of lives, property e.t.c. Research shows that Errors that arise from poor Image registration can be reduced if an appropriate segmentation approach is applied during segmentation This paper reviews some of the available segmentation approaches and proposes the use of knowledge based multiscale segmentation approach to be used during segmentation. The approach is involved with few segmentation errors and less information loss, also through the use of this approach, true changes can be easily isolated from the false changes which will lead to production of right segmentation results.

Keywords: Image Segmentation, Change Detection, classification

1 INTRODUCTION

IN image segmentation, pixels of the images under study are grouped using an appropriate segmentation technique then later classified in to different categories using a classification technique. According to research, errors that arise from poor Image registration can be reduced if an appropriate segmentation approach is applied during segmentation. Therefore a good segmentation approach is required for good quality change detection results. However literature shows that many approaches have been proposed for the reduction in the influence of image registration errors on change detection(where the changes in images captured at different time are sensed), results show there is still much effort required in order to get better change detection results. This paper reviews some of the image segmentation approach in section 2, Discusses the findings in section 3,and Concludes this paper section 4.

2 SEGMENTATION APPROACHES

The three categories of segmentation approaches include image driven approaches, multiscale segmentation, knowledge based segmentation. Image driven techniques are sensitive to noise and involve loss of information (it's hard to incorporate spartial feature in images during segmentation), this is because there operations are pixel based. Both knowledge based segmentation and multiscale segmentation can be applied in image driven techniques. Knowledge based segmentation could be a best technique only that it requires human expertism, multiscale segmentation enables changes to be modelled at different scale levels inorder isolate real changes from false changes. According to [4], it would be better if images are segmented at different scales in order easily understand and classify image objects in to water and non water at various scales. Image object information can easily be manipulated in order to isolate false changes and missed changes in the changed image[10][9][1], and also in order to identify and eliminate the irrelevant changes in the changed image at a higher conceptual level [2]. The three categories of segmentation are explained below and summarised in table 2.0.

(a) Image Driven Approach

Approaches that fall under this category operate directly on the image pixels
and they extract region basing on the image statistical features obtained from the pixels. Among the techniques that fall under this category include edge based techniques, region based techniques.

(i) Edge Based Segmentation

Edge based techniques detect edges of the regions and closes the regions using the contour line algorithm such as K-mean clustering.

- **K- Mean Clustering**

K-means algorithm is unsupervised learning algorithms that partition image pixels in to K objects iteratively. The algorithm aims at minimizing an objective function(eqn 2.0), called the squared error function, In this algorithm, K centroids are defined for each of the clusters and the quality of results depend on the initial set of clusters and the value of K and the number of iteration[11][5]. Such as the centroids should always be placed far from each other

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in order to obtain better results [5] and the algorithm must be run many times in order to reduce sensitive to the initial randomly selected cluster centres[11][5], and also therefore in order to produce better results.

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|^2 \quad \text{……(2.0)}$$

Where $\left\| x_i^{(j)} - c_j \right\|^2$ denotes distance measure between a data point $x_i^{(j)}$ and the cluster Centre c_j , refers to an indicator of the distance of the n data points from their respective cluster centres. However the algorithm is divided in to four steps [5]:-

Pick K cluster centres, either randomly or manually or based on some heuristic

Assign each pixel in the image to the cluster that minimizes the distance between the
pixel and the cluster centre. The distance is the difference between cluster centre and
the pixel.

Re-calculate the cluster centres by averaging all of the pixels in the cluster.

Repeat steps 2 and 3 until convergence is attained. According to[6],the algorithm is computationally fast but it's hard to estimate the number of K that should be included due to production of a fixed number of cluster and also the method is involved with more segmentation error since its segmentation operations are pixel based.

According to[5], K-means algorithm performs better if combined with Fuzzy Logic.

(ii) Region Based Segmentation

In region based segmentation, homogeneous areas are identified via the application of the homogeneity criteria among candidate segments. Despite the fact that Region based segmentation methods are good in dealing with noisy mages, they are involved with more segmentation errors, this because segmentation process is pixel based. They are faced with loss of information. And also suffer from a lack of control in the break off criterion for the growth of a region [14].

Region based segmentation can be performed in two ways i.e. through growing regions(called region growing) and splitting the image into regions and then later merging them up(called split and merge).

• Region Growing Method

In this method, segmentation process starts from the initial seed pixels without any prior knowledge about the scene; in here the seed regions are augmented with neighbouring pixels so long as they meet the specified criteria. In this method region's growth is determined by the specified threshold level. Threshold can be in terms the maximum number of pixels per region (size of regions expected) and the shape. Regions grow until no more pixels can be allocated to any region and repeats until the entire image is segmented. A typical region growing algorithm consists of several steps which include [3]:-

(i) Starts with pixel m in the image region

(ii) Evaluates the neighbourhood pixels using the defined condition and then later adds the adjacent pixels to m so long as they satisfy a defined condition. Let's say for example n is a pixel adjacent to m. n will be evaluates using the specified condition, it will be added to m so long as n satisfies the condition. An example of Condition is given in eqn(2.1):-

If z (m;n)>T..... (2.1)

Where m and n are adjacent pixels Z (m;n) denotes a similarity measure. T denotes a threshold.

(iii) The process continues for all pixels in the image until all pixels in the currently investigated neighbourhood do not satisfy the inclusion criteria (Regions grow until no more pixels can be allocated to any region and repeats until the entire image is segmented).

• Split and Merge

The segmentation algorithm consists of a few steps which include [3]:-

1. Starts by evaluating the whole image region R using specified criteria.
If R satisfies the criteria, R is left unchanged and the process ends
2. Otherwise R is split in to specified number of quadrants.
3. Repeat Step 1 and 2 for all newly created regions.
4. The splitting process stops when all Quadra tree satisfy the criteria.
5. Two adjacent regions in the image are merged in to homogeneous region so
long as they satisfy a given condition
6. The merging process continues using no merging is possible.

According to[3], the method is computationally expensive

(b) Multi-scale Image Segmentation Approach

In multiscale segmentation approach, the input image is first of all segmented at small scale by uniting the most similar objects, followed by a set of multiscale objects with their topological relationship fully obtained. During multiscale the image is converted in to object primitives that share a certain spectral behaviour, spatial behaviour. However, multiscale representation enables differentiation of the image objects on different levels, hence leading to proper identification of image object.

In this method, homogeneous image object primitives can be created in a desired resolution taking in to consideration local contrast without any prior knowledge about the image. It can be easily classified at various scales using the image object based classification method. With this type of method, an image can be understood. And if hierarchical network is created, information can be properly isolated in order to isolate false changes and missed changes in the changed image[1][12][9] and also through using a hierarchical network semantic meanings

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of the changes can be understood, in order to identify and eliminate the irrelevant changes in the changed image at a higher conceptual level [9][2].

The only challenge faced with the techniques that apply this technique is finding the appropriate scale for segmentation.

(c) Knowledge Based Segmentation Approach

This method is composed of two stages, during the first stage, spatial and spectral knowledge is usually integrated in to the segmentation process to extract targeted regions. The kernel information obtained is then combined with the domain knowledge to ascertain their identities.

During the second stage, specific covers of targeted regions are narrowed down hierarchically basing on the spectral behaviour of the covers and spatial knowledge. Formation of the targeted region may rely on region growing, edge based segmentation. Spatial knowledge can be used to adjust regions. A key to success of knowledge based segmentation is the way the knowledge is represented and accuracy of rule generation from training samples. According to [8], the more unique the rules the more accurate the subsequent segmentation results. The advantage with this method is that it is flexible in such a way that it can be applied to various geographic areas. The method also allows incorporation of not only knowledge got from the image itself but also external knowledge into segmentation. External knowledge is useful for devising the confidence level at which a segmented region is labelled. However the confidence level may be due to a detected edge which detected using an edge detector for example correlation between the coincident edge in an image and the boundary of the model. The method also is involved with less segmentation errors compared to traditional methods of image segmentation such as edge based and region based segmentation algorithms. The method does not over suffer from wastage of spatial information since its segmentation operation is not based on pixel value. However the method requires more spatial rules in order to produce accurate segmentation results. And also requires one to be an expert. Another drawback of this method is that it slow in such away that most of its operations are manual based.

TABLE 2
SUMMARY OF SEGMENTATION APPROACHES

Approach	Strength	Weakness
K-means clustering	- Computationally fast	-hard to **estimate** the number of clusters -more Segmentation errors. -loss of -
Region growing	- Better in noisy images	-More Segmentation errors -Loss of information.
Split and merge	- Better in noisy images	-Computationally intensive -More Segmentation errors. -loss of information
Knowledge based	-It is flexible, can be applied on any	-It needs expertism, -Consumes a lot

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	Geographical region. -less segmentation errors. -less loss of information	of time, since its operations are manual based
Multiscale Segmentation changes	-True can be easily isolated from false changes. -less segmentation errors -less loss of information	-hard to get an appropriate scale for segmentation

3 DISCUSSION OF SEGMENTATION APPROACHES

Image driven techniques are involved with more segmentation errors and involve loss of information (its hard to incorporate spartial feature in images during segmentation), this is because there operations are pixel based, however a combination of image driven techniques with knowledge based segmentation would yield better segmentation results. Since knowledge based enables incorporation spatial, spectral and external knowledge which minimises on the loss of information (spatial information, spectral information). And also an application of multiscale segmentation enables isolation of true changes from missed changes in the changed image [1][2]. However a combination of image driven segmentation technique with knowledge based and multiscale segmentation technique would yields accurate results. Although knowledge based segmentation method has been reported as
being the best way in which information loss and segmentation errors can be minimised. knowledge based segmentation method requires expertism and it takes a lot of time since some operations are manual based. Also although multiscale segmentation leads to isolation of real changes from false changes, it's really hard to find appropriate scale for segmentation. According to [13][7], a small scale yields better segmentation results therefore a combination of knowledge based approach and the multiscale based approach would yield better change detection results since both of the approaches are involved with few segmentation errors and less information loss,also through the use of multiscale based segmentation, true changes can be easly isolated from the false changes which will lead to production of right segmentation results.

4 CONCLUSION

The accuracy of change detection results doesnot only depend on the image registration phase but also the image segmentation and the errors that arise from poor image registration are mitigated if an appropriate approach is applied during image segmentation therefore a need for a better image segmentation approach is foreseen. This paper proposes the use of combination of knowledge based multiscale segmentation approach for better change detection results

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