Clustering Techniques for Digital Image Segmentation

Bharti Tanwar
M.Tech Student, Department of Computer Science & Applications, Kurukshetra University, Kurukshetra-136119
Email: tanwarbharti05@gmail.com
Rakesh Kumar
Professor, Department of Computer Science & Applications, Kurukshetra University, Kurukshetra-136119
Email: rakeshkumar@kuk.ac.in
Girdhar Gopal
Assistant Professor, Department of Computer Science & Applications, Kurukshetra University, Kurukshetra-136119
Email: girdhar.gopal@gmail.com

----------***ABSTRACT***----------

An image analysis is a process to extract some useful and meaningful information from an image. Segmentation is one of the methods used for image analyses. Image segmentation has many techniques to extract information from an image. Clustering is a technique which is used for image segmentation. The main goal of clustering is to differentiate the objects in an image using similarity and dissimilarity between the regions. K-Nearest Neighbour is a classification method. K-mean is a clustering technique which is a simple and an iterative method. In this paper, details of both algorithms have been provided with the implementation results on an image dataset consisting of 4 images.

Keywords: Clustering, K-mean, Nearest-Neighbour, Segmentation.

1. Introduction

Computer vision tries to understand scene with the help of image processing and machine learning. Image processing is a process an image with the help of a processor. Image processing manipulates an image to analyze, to better understand, and to achieve required results. The centre of attention of digital image processing is to make a digital system with the help of efficient algorithm and techniques which is capable of processing an image. The input of that type of a system is an image and output of the system is an image or an attribute of an image. The biggest example of this is widely used image processing software, Adobe Photoshop [1]. A Digital Image Processing (DIP) is a process to deal with an image, in which an image is transformed into a digital image using some operations, algorithms, and techniques. DIP is used to achieve enhanced and improved image and get relevant information from an image which can be used for further analyzes. Digital image processing algorithm used to remove noise, prepare images to display, convert a signal into the digital image from an image sensor, compress image to storage and transmission, to resize, to extract an image etc [2].

Digital image processing has many methods to process an image. Segmentation is one of the methods which have used by image processing to deal with an image. In segmentation, an image is a partition into multiple parts. Image segmentation is used to identify boundaries and objects in an image. The main objective of segmentation is to change the representation of an image which helps to make an image simple, more meaningful, significant, and easy to analyze [3]. Segmentation has mainly two objectives: first objective is to divide an image into parts for further better analysis and the second objective is to process an image to change its representation [4]. Image segmentation uses many techniques to perform segmentation on an image. Image segmentation refers to break an image into two or more than two regions. These regions are similar in characteristics such as intensity, texture, color etc. Real life applications of segmentation are range from computer graphics, object identification, criminal investigation, satellite images (roads, forest etc.), airport security system, MPEG-4 video object (VO) segmentation, medical imaging applications (locate tumour, computer guided surgery etc.) etc. [5]. The field of image segmentation attracts people to research. Thousands of techniques are developed

over the years, but there is not even a single technique which applies to all types of images for segmentation. Based on different techniques, segmentation techniques basically divided into two categories, these are:

- Detecting discontinuities: In detecting discontinuities, partition an image is based on sudden changes in intensity. Edge detection is an example of detecting discontinuities.

- Detecting similarities: In detecting similarities, partition an image is based on similarity depending on a predefined criterion. Some techniques which are based on similarities are thresholding, region growing, region splitting, and merging [6].

Segmentation methods divide an image into multiple parts to get useful information. Segmentation has used many techniques to achieve region of interest. Edge based, region based, thresholding, matching, fuzzy based, k-nearest neighbour and k-mean techniques etc. are some techniques which are used by segmentation. K-nearest neighbour and K-mean techniques are discussed in this paper. K-nearest neighbour technique mainly based on nearest neighbour classification technique. K-mean technique decides a number of the cluster to segment an image.

This paper is organized in following sections. Section 2 gives an overview of K-Nearest Neighbour and K-mean algorithm and their implementation on different images. Section 3 gives detail about segmentation techniques like edge based, region based, thresholding, artificial neural network etc. Section 4 gives the result of an implementation of both algorithms. Section 5 gives the conclusion.

2. Problem Formulation

Segmentation techniques are used for recognition, detection, and measurement of objects and image analyses task. The success or failure of the aforementioned task depends on a result of segmentation. Segmentation is a gap filler between high level and low level image processing [7]. The research in the field of image processing and segmentation has reached a peak. There are hundreds of applications in the world which are used for image processing. Clustering method finds similar pixels to classify into clusters or classes. Cluster method also represents pixels, cluster and image patches as feature vectors. This method uses a distance function to calculate the distance between pixels and clusters, and classify pixels to their nearest cluster by distance. Distance measure function is different for different applications [8]. The principle of clustering is based on interclass class similarity maximization and intra class similarity minimization [9].

K-mean algorithm is an unsupervised clustering algorithm. Based on the inherent distances between data points, k-mean classified the input data points into multiple classes or clusters [10]. It is a simple method and the execution time of k-mean is very high [11]. K-mean algorithm is an iterative method which calculates new cluster centre in each phase and reassigns every pixel to their nearest cluster centre [12]. For more details about K-mean technique, one can refer the clustering webpage at: http://www.onmyphd.com/?p=k-means.clustering&ckattempt=1 [13].

KNN is firstly introduced by E. Fix and J. Hodges researchers in their paper Discriminatory Analysis: Nonparametric Discrimination: Consistency Properties, in 1951 [14]. K-Nearest Neighbour (KNN) is a supervised learning and a classification algorithm [15]. Rashi Aggarwal [16] gives an overview of KNN algorithm. The principle of the nearest neighbour chain algorithm is to discover cluster-pair to combine in the path which terminates until all the nearest pixels are not merged in the path [17]. The distance can be calculated by many different distance functions such as Euclidean distance, Hamilton distance, Squared Euclidean, Hamming Distance etc. In KNN technique, Euclidean distance function is used as shown in below eq.:

$$d = \sqrt{\sum_{i=0}^{i=n} (X_i - Y_i)^2}$$

All possible pairs of points (x, y) are made a distance matrix using this distance function. All the data points are identified by analyzing this distance matrix [14].

3. Related work

Segmentation is a process to subdivide an image into multiple segments. The segment can be a pixel or set of pixels which are homogeneous in characteristics such as texture, color, intensity etc. Many different techniques are developed till now. Some techniques addressed below:

Threshold method: Threshold technique is one of the simplest approaches for segmentation. It is a powerful technique for those images which have light objects on a dark background. Threshold algorithm can be automatically with the help of image information or can be selected manually as per previous knowledge [18]. A multilevel image changes to a binary image in threshold method. In this technique, an appropriate threshold value T is select to segment an image. The value of a pixel is lower than T, it is classified as black (0) means it is from the background. The value of a pixel is greater than T, it is classified as white (1) means it is from the region of interest [19].

Edge-based: Edge-based technique is applied on an image to identify pixels between different objects and connect these pixels as the closed boundary. Edge based technique mainly found edges between two different homogeneous regions with the help of edge detecting operators. This edge marks on image location where a discontinuity occurs in features like gray level, texture, color etc. Edge is the symbol of discontinuity and ending in an image [20]. Discontinuity in an image can be a step edge, ramp edge, spike edge, roof edge [19].

Region based: Edge-based technique applied segmentation based on abrupt changes in intensity near edges, but in the region based, segmentation is based on the similarity between the regions at predefined criteria [6]. In edge based technique, first find the boundary of an object and then detect the object automatically by filling boundaries but the region based technique used opposite approach to edge based [21]. The area which is detected for segmentation should be closed [22].

Segmentation Based on PDE (Partial Differential Equation): Partial differential equations and its numerical schemes are used to applied segmentation on an image. This method is firstly introduced by Kass et al. in 1987, to find known object in the presence of noise [9]. PDE performs segmentation using active contour and snakes [6].

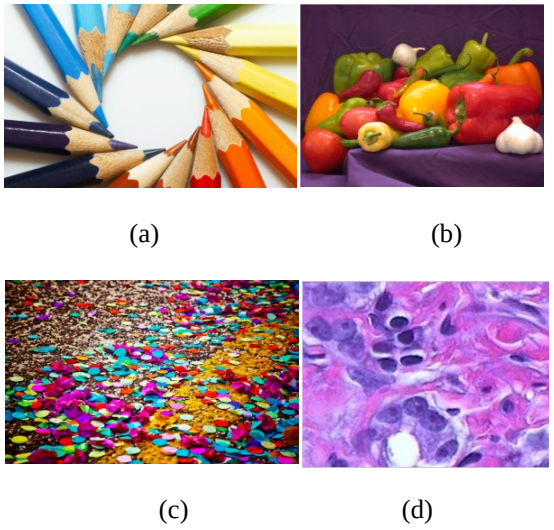
Artificial neural network (ANN): ANN system is a software or hardware system which tries to make a similar structure as a human brain [23]. One of the biggest advantages of ANN is that it can take decisions based on noisy and complex data [24]. In ANN, first image is mapped into a neural network. Every neuron is referred to as a pixel [6].

Fuzzy based segmentation: Fuzzy-based segmentation technique is able to integrate expert knowledge. This technique is less computationally expensive compared to fuzzy c-mean clustering [20].

Featured based: Featured based segmentation technique is based on the feature of an image means the technique is based on the difference in color, intensity etc. of the image. An image is transformed into histogram then, applied clustering method on the image [22].

4. Results & Discussion

KNN and K-mean techniques are used to implement image segmentation on different images. To implement both algorithms, Matlab platform is used. In both algorithms, RGB image is transformed into l*a*b* color space because rgb image is very large for the experiment. In their implementation, 4 images are used to compare KNN and K-mean algorithm. These images are shown in figure 1 below.



(a) (b)

(c) (d)

Fig.1: Different colored images used for implementation

The K-mean function [25] is used in the k-mean algorithm. In K-mean algorithm, the number of

centroids of clustering chooses randomly or from the user. KNN takes the sample for colored regions from users. It shows each sample in a new window. By using these sample regions, the image is segmented into different clusters. K-mean algorithm is unsupervised. In this implementation, if the selection of a number of clusters is more in K-mean algorithm, then the result is not so good. It is same for a low number of clusters. The balanced number of the cluster to extract image is very important. In comparison of both algorithms, K-mean algorithm is better than KNN algorithm. There is no need of sample region for color in K-mean algorithm. K-mean algorithm gives better result in the case of all image dataset. The result is given below in figure 2 with an original image and clustering results of KNN and K-mean algorithm.

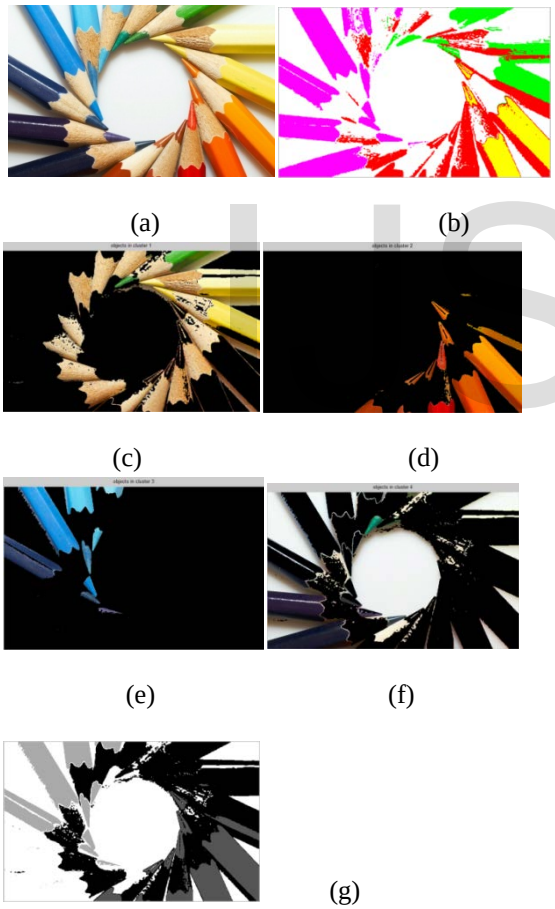


Fig. 2: Implementation result in various image (a) Original image (b) image with the result of Nearest Neighbour implementation, (c) (d) (e) (f) image with the result of K-mean & object in cluster 1, cluster 2, cluster 3 and cluster 4 (f) shows cluster index of K-mean in the image.

5. Conclusion

Digital image processing has many methods to analyses an image like: image acquisition, image enhancement, image compression, segmentation, representation, and description etc. Segmentation is an important step for image extraction and to identify an object from the image. Many techniques are available for segmentation. Each segmentation technique depends on the nature of an image. An image can be used in all type of techniques. But, there is not a single technique that is applied on all type of images. This paper provides the details of KNN and K-mean techniques. Both segmentation techniques are implemented using matlab platform and compared using different images. From experiment, the result comes out that K-mean performs better as compare to KNN algorithm in implemented datasets. KNN takes sample regions to segment an image from the user. In K-mean algorithm, the number of cluster is very important. If the number of cluster is very high or very low, then result is not so good. K-mean shows every cluster in a new window and it makes easier to analyze the image for further information. Multiple techniques are developed over the years and many new techniques are growing.

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