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A Survey on Clustering Based Image Segmentation

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Abstract – In computer vision, segmentation refers to the process of partitioning a digital image into multiple segments (Sets of pixels, also known as super pixels). This paper is a survey on various clustering techniques to achieve image segmentation. In order to increase the efficiency of the searching process, only a part of the database need to be searched. For this searching process clustering techniques can be recommended. Clustering can be termed here as a grouping of similar images in the database. Clustering is done based on different attributes of an image such as size, color, texture etc. The purpose of clustering is to get meaningful result, effective storage and fast retrieval in various areas.

Key Words – Clustering, Image segmentation, K-means, N-cut, Spectral Clustering.

I. INTRODUCTION

Clustering in image segmentation is defined as the process of identifying groups of similar image primitive [1]. Clustering techniques can be classified into supervised clustering-demands human interaction to decide the clustering criteria and the unsupervised clustering- decides the clustering criteria by itself. Supervised clustering includes hierarchical approaches such as relevance feedback techniques "[2], [3]" and unsupervised clustering includes density based clustering methods. These clustering techniques are done to perform image segmentation. Segmentation is the process of partitioning a digital image into multiple segments based on pixels. It is a critical and essential component of image analysis system. The main process is to represent the image in a clear way. The result of image segmentation is a collection of segments which combine to form the entire image [4]. Real world image segmentation problems actually have multiple objectives such as minimize overall deviation, maximize connectivity, minimize the features or minimize the error rate of the classifier etc [6].

Image segmentation is a multiple objective problem. It involves several processes such as pattern representation [5], feature selection, feature extraction and pattern proximity. Considering all these objectives is a difficult problem, causing a gap between the natures of images. To bridge this gap multi-objective optimization approach is an appropriate method "[7], [8], [9]".

II. CLUSTERING

Clustering is a process of organizing the objects into groups based on its attributes. A cluster is therefore a collection of objects which are "similar" between them and are "dissimilar" to the objects belonging to other clusters. An image can be grouped based on keyword (metadata) or its content (description).

In keyword based clustering, a keyword is a form of font which describes about the image keyword of an image refers to its different features. The similar featured images are grouped to form a cluster by assigning value to each feature.

In content based clustering "[10], [11], [23]" a content refers to shapes, textures or any other information that can be inherited from the image itself. The tools, techniques and algorithms that are used originate from fields such as statistics, pattern recognition, signal processing etc. Clustering based on the optimization of an overall measure is a fundamental approach explored since the early days of pattern recognition. The most popular method for pattern recognition is K-means clustering.

In K-means clustering a centroid vector is computed for every cluster. The centroid must be chosen such that it should minimize the total distance within the clusters.

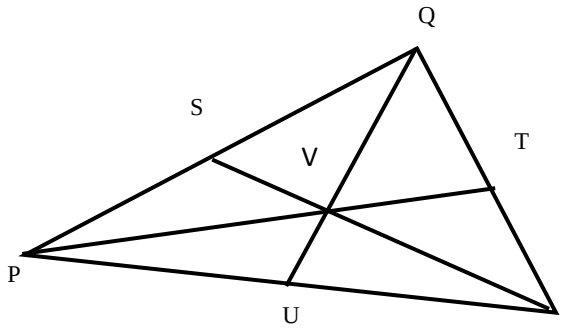

Figure-1

Figure-1 shows the preferred centroid (V) for the triangle. The points namely S, T, U are the midpoint for corresponding edges.

Both supervised and unsupervised clustering techniques are used in image segmentation. In supervised clustering method, grouping is done according to user feedback. In unsupervised clustering, the images with high features similarities to the query may be very different in terms of semantics [16]. This is known as semantic gap. To overcome this novel image retrieval scheme called as cluster based retrieval of images by unsupervised learning (CLUE) can be used [17]. This works based on a hypothesis: semantically similar images tend to be clustered in some feature space.
A variety of clustering techniques have been introduced to make the segmentation more effective. The clustering techniques which are included in this paper are relevance feedback [13], log based clustering [14], hierarchical clustering [15], graph based, retrieval-dictionary based, filter based clustering etc.

III. SEGMENTATION

Image segmentation is the important process of image analysis and image understanding [18]. It is defined as the process of partitioning the digital image into different sub regions of homogeneity. The objective of image segmentation is to cluster pixels into salient image regions i.e., regions corresponding to individual surfaces, objects or natural parts of objects.
A segmentation might be used for object recognition "[19], [20]" image compression, image editing, etc. The quality of the segmentation depends upon the digital image [21]. In the case of simple images the segmentation process is clear and effective due to small pixels variations, whereas in the case of complex images, the utility for subsequent processing becomes questionable.
Image segmentation is one of the best known problems in computer vision. Graph based methods were earlier considered to be too insufficient in practice. Recent advances in technology and algorithm "[22], [18]" have negated this assumption. Histogram "[24], [25], [26]" based methods are very effective while compared to other image segmentation methods because they typically require only one pass through the pixels. In this method a histogram is computed from all of the pixels in the image and the peaks and valleys in the histogram are used to locate the clustering of the image. Intensity can be used as the measure. This process is repeated with smaller and smaller clusters until no more clusters are formed. This approach can be quickly adapted to multiple frames which is done in multiple fashion.
Segmentation can also be done based on spatial coherence [27]. This includes two steps: Dividing or merging existing regions from the image and growing regions from seed points.

IV. CLUSTERING TECHNIQUES

An image may contain more than one object and to segment the image in line with object features to extract meaningful object has become a challenge to the researches in the field. Segmentation can be achieved through clustering.
This paper critically reviews and summarizes different clustering techniques.

IV.1. Relevance feedback:

A relevance feedback approach allows a user to interact with the retrieval algorithm by providing the information of which images user thinks are relevant to the query "[28],[29],[30]".Keyword based image retrieval is performed by matching keyword according to user input and the images in the database.
Some images may not have appropriate keywords to describe them and therefore the image search will become complex. One of the solution in order to overcome this problem is "relevance feedback" technique [41] that utilize user feedback and hence reduces possible errors and redundancy "[31], [3]".
This technique uses a Bayesian classifier "[12], [39]" which deals with positive and negative feedback. Content based clustering methods cannot adapt to user changes, addition of new topics due to its static nature. To improve the performance of information retrieval log-based clustering approaches are brought into the application.

IV.2. Log –Based Clustering:

Images can be clustered based on the retrieval system logs maintained by an information retrieval process [11]. The session keys are created and accessed for retrieval. Through this the session clusters are created. Each session cluster generates log –based document and similarity of image couple is retrieved. Log –based vector is created for each session vector based on the log-based documents [40]. Now, the session cluster is replaced with this vector. The unaccessed document creates its own vector.
A hybrid matrix is generated with at least one individual document vector and one log-based clustered vector. At last the hybrid matrix is clustered. This technique is difficult to perform in the case of multidimensional images. To overcome this hierarchical clustering is adopted.

IV.3. Hierarchical Clustering:

One of the well- known technologies in information retrieval is hierarchical clustering [15]. It is the process of integrating different images and building them as a cluster in the form of a tree and then developing step by step in order to form a small cluster.

The steps involved in this process are as follows: the images from various databases are divided into X-sorts. The classification will be calculated by modifying the cluster centers, sorts of the images and stored in the form of matrix m*m continuously which also includes dissimilarity values. At first it calculates the similarities between the queried image and the retrieved image in the image database. Secondly, it identifies the similarities between two closest images(In m*m matrix)and integrate them to form a cluster. Finally all the similarities are grouped to form a single cluster.

IV.4. Retrieval Dictionary Based Clustering:

A rough classification retrieval system is formed. This is formed by calculating the distance between two learned patterns and these learned patterns are classified into different clusters followed by a retrieval stage. The main drawback addressed in this system is the determination of the distance.

To overcome this problem a retrieval system is developed by retrieval dictionary based clustering [33]. This method has a retrieval dictionary generation unit that classifies learned patterns into plural clusters and creates a retrieval dictionary using the clusters. Here, the image is retrieved based on the distance between two spheres with different radii. Each radius is a similarity measure between central cluster and an input image. An image which is similar to the query image will be retrieved using retrieval dictionary.

IV.5. K-Means Algorithm:

In K-means algorithm data vectors are grouped into predefined number of clusters [32] [33]. At the beginning the centroids of the predefined clusters are initialized randomly. The dimensions of the centroids are same as the dimension of the data vectors. Each pixel is assigned to the cluster based on the closeness [34], which is determined by the Euclidian distance measure. After all the pixels are clustered, the mean of each cluster is recalculated. This process is repeated until no significant changes result for each cluster mean or for some fixed number of iterations.

IV.6. Ncut Algorithm:

Ncut method attempts to organize nodes into groups so that the within the group similarity is high, and/or between the groups similarity is low. This method is empirically shown to be relatively robust in image segmentation [36]. This method can be recursively applied to get more than two clusters. In this method each time the sub graph with maximum number of nodes is partitioned (random selection for tie breaking). The process terminates when the bound on the number of clusters is reached or the Ncut value exceeds some threshold T.

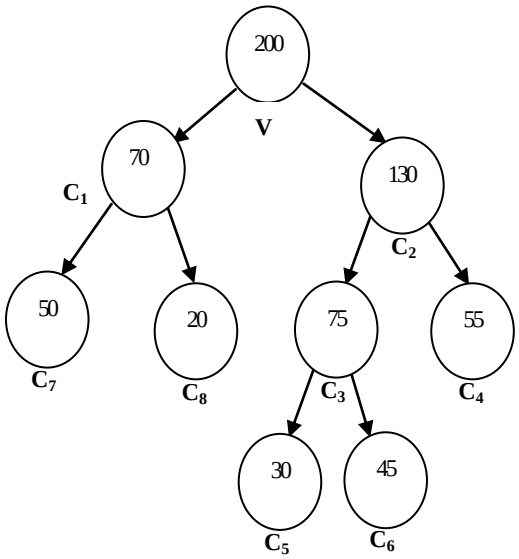

Figure-2

Figure-2 shows Ncut Nodes organized as groups.

The recursive Ncut partition is essentially a hierarchical divisive clustering process that produces a tree [37]. For example, Figure 2 shows a tree generated by four Recursive Ncuts. The first Ncut divides V into C1 and C2. Since C2 is larger than C1, the second Ncut partitions C2 into C3 and C4.Next, C3 is further divided because it is larger than C1 and C4. The fourth Ncut is applied to C1, and gives the final five clusters (or leaves): C4, C5, C6, C7 and C8.The above example suggest trees as a natural organization of clusters [35]. Nonetheless, the tree organization here may mislead a user because there is no guarantee of any correspondence between the tree and the semantic structure of images. Furthermore, organizing image clusters into a tree structure will significantly complicate the user interface.

V. CONCLUSOIN

To summarize, a comprehensive survey highlighting different clustering techniques used for image segmentation have been presented. Clustering concepts and image segmentation concepts have been analyzed. Through clustering algorithms, image segmentation can be done in an effective way. Spectral clustering technique can be used for image clustering because images that cannot be seen can be placed into clusters very easily than other traditional methods [38]. In general, clustering is a hard problem. Clustering techniques helps to increase the efficiency of the image retrieval process.

VI. REFERENCES

[1] Puzicha, J., Hofmann, T. and Buhmann, J. M.,"Histogram Clustering for Unsupervised Image Segmentation"., Computer Vision and Pattern Recognition , Vol.2.IEEEpress,602-608, 2000.
[2] Zhou XS, Huang TS. Relevance feedback in image retrieval: A comprehensive review. Multimedia Syst;8:536-544, 2003.
[3] Chundi, P., Dayal, U., Sayal, M., Hsu, M: US20077181678,2007.
[4] C.Harris and M.Stephens, "A Combined Corner and Edge Detection,"Proc.Fourth Alvey Vision Conf.,pp.147-151,1988.
[5] Saha, S., and Bandyopadhyay, S.: A new symmetry based multiobjective clustering technique for automatic evolution of clusters. Pattern Recognition,2010.
[6] Shirakawa, S., and Nagao, T., "Evolutionary Image Segmentation Based on Multiobjective Clustering".Congress on Evolutionary Computation(CEC '09),Trondheim,Norway,2466-2473,2009.
[7] Guliashki, V., Toshev, H., and Korsemov,C., Survey of Evolutionary Algorithms used in multiobjective optimization. Problems of Engineering Cybernetics and Robotics, Bulgarian Academy of Sciences,2009.
[8] Jones,D.F.,Mirrazavi, S.K. and Tamiz,M.,Multi-objective meta- heuristics:An Overview of the Current State-of the art. European Journal of Operational Research, 137,1-9,2002.
[9] Coullo, C.A.C.,"A Comprehensive Survey of Evolutionary-Based Multiobjective Optimization Techniques". Knowledge And Information Systems,1,129-156,1998.
[10] Yixin Chen, James Z.Wang, Robert Krovetz, "Content Based Image Retrieval by Clustering",Proc of the 5th ACM SIGMM I'ntl workshop on Multimedia information retrieval ,New York,ACM press,pp-193-200,2003.
[11] Huiyu Zhou, Abdul H. Sadka, Mohammad R. Swash, Jawid Azizi and Abubakar S. Umar., "Content Based Image Retrieval and Clustering: A Brief Survey" school of Engineering and Design, Brunel University, Uxbridge, UB8 3PH, UK
[12] D. Melas and S. Wilson, "Double Markov Random Fields and Bayesian Image Segmentation," IEEE Trans. Signal Processing, vol. 50, no. 2, pp. 357-365, Feb. 2002.
[13] Wang JZ, Li J, Wiederhold G. Simplicity: Semantics-sensitive integrated matching for picture libraries. IEEE Trans pattern Analysis Machine Intell;23:947-963, 2001.
[14] Jin J, Kurniawati R, Xu G, Bai X. Using browsing to improve content-based image retrieval. J Visual Common Image Represent;12:123-135, 2001.
[15] Huang Min,Sun bo,Xi Jianqing"An Optimized image retrieval method based on Hierarchical clustering and genetic algorithm"I'ntl forum on Information technology and applications,978-0-7695-3600-2/09-IEEE,2009.
[16] K. Barnard and D. Forsyth, "Learing the Semantics of Words and Pictures", proc. 8th Int'l Conf. on Computer Vision, vol. 2, pp. 408-415,2001.
[17] O.Stehling,M.A. Nascmento,X.A.Falcgo "An Adaptive and efficient clustering based approach for Content Based Image Retrieval in image databases",Proc of I'ntl database engg and application symposium,pp-356-365,2001.
[18] Shi. J, and Malik. J, "Normalized cuts and image segmentation", IEEE Conf. Computer Vision and Pattern Recognition, IEEE Computer

[19] J. Winn and J.Shotton, "The Layout Consistent Random Field for Recognizing and Segmenting Partially Occluded Objects", proc. IEEE CS Conf. Computer Vision and Pattern Recognition, vol. 1,pp. 37-44, 2006.
[20] P. Alvarado, A. Berner and S. Akyol, "Combination of High-Level Cues in Unsupervised Single Image Segmentation Using Bayesian Belief Networks", proc. Int'l Conf Imaging Science, Systems and Techonolgy, vol. 2, pp. 675-681,2002.
[21] X. Feng, C. Williams, and S. Felderhof, "Combining Belief Networks and Neural Networks for Scene Segmentation", IEEE Trans., Pattern Analysis and Machine Intelligence, vol. 24, no. 4, pp. 467-483,Apr. 2002.
[22] P. Felzenszwalb and D. Huttenlocher. Image segmentation using local variation. In IEEE Conference on Computer Vision and Pattern Recognition, pages 98–104, 1998.
[23] Zhang, Q.,Goldman,S. A., Yu,W.,and Fritts, J.E.."Content based image retrieval using multiple instance learning".In Proc.ICML,2002.
[24] C. Rother, T. Minka, A. Balke and V. Kolmogorov, "Cosegmentation of Image Pairs by Histogram Matching-Incorporating a Global-Constraint into MRFs", proc. IEEE Conf. Computer Vision and Pattern Recognition, pp. 993-1000, 2006.
[25] Jun Zhang and Jinglu Hu"Image segmentation based on 2D Otsu method with Histogram analysis", Int'l Conf. on Computer science and software engg, IEEE, 978-0-7695-3336-0/08, 2008.
[26] Hadjidemetriou, E., Grossberg,M. D.,and Nayar,S.K.2004."Multiresoultion Histogram and their use for recognition".IEEE Trans.Pattern Analysis and Machine Intelligence 26,7,831-847,2004.
[27] Zabih, R.; Kolmogorov, "Spatially coherent clustering using graph cuts", V.;Cornell Univ., Ithaca, NY, USA, ISSN: 1063-6919, On page(s): II-437 - II-444 Vol.2.
[28] I. J. Cox, M. L. Miller, T. P. Minka, T. V. Papathomas and P.Yianilos, "The Bayesian Image Retrieval System, PicHunter: Theory, Implementation and Psychophysical Experiments", IEEE Trans. Image Processing, vol. 9, no. 1, pp. 20-37, 2000.
[29] Y. Rui, T. S. Huang, M. Ortega and S. Mehrotra, "Relevance Feedback: A Power Tool for Interactive Content-Based Image Retrieval", IEEE Trans. Circuits and Video Technology, vol. 8, no. 5, pp. 644-655, 1998
[30] Rui Y, Thomas, S. Huang. "Content-based image retrieval with relevance feedback in MARS", In proceedings of IEEE international conference on image processing, pp. 815-818, 1997.
[31] Zhou XS, Huang TS. Relevance feedback in image retrieval: A comprehensive review. Multimedia Syst; 8: 536-544, 2003.
[32] Irani, A.A.Z. Belaton, "A K-means Based Generic Segmentation System B.Dept. of Comput. Sci., Univ. Sains Malaysia, Nibong Tebal, Malaysia Print ISBN: 978-0-7695-3789-4 On page(s): 300 – 307, 2009.
[33] Li Wenchao Zhou Yong Xia Shixiong China Univ. of Min. & Technol., Xuzhou, "A Novel Clustering Algorithm Based on Hierarchical and K-means Clustering" Print ISBN: 978-7-81124-055-9, On page(s): 605, 2009.
[34] Isa, N.A.M.; Salamah, S.A.; Ngah, U.K.; Sch. of Electr. & Electron. Eng., Univ. Sains Malaysia, Nibong Tebal, Malaysia , "Adaptive fuzzy moving K-means clustering algorithm for image segmentation" ISSN: 0098-3063 ,On page(s): 2145 – 2153, 2009.
[35] Feng SUN, Jin-Peng HE, "A Normalized Cuts Based Image Segmentation Method", Dept. Automation Harbin Engineering University, Harbin, China, 2009 Second International Conference on Information and Computer Science,2009.
[36] Jianbo Shi Malik, J.Robotics Inst., Carnegie Mellon Univ., Pittsburgh, PA ," Normalized cuts and image segmentation", ISSN: 0162-8828, On page(s): 888 – 905,2000.
[37] Emma Regentova, Dongsheng Yao, and Shahram Latifi, "Image segmentation using Ncut in the wavelet domain", International journal of image and graphics,world scientific Publishing company,vol.6(4),pp.569-582,2006.
[38] LI XiaoBin and TIAN Zheng"Multiscale stochastic hierarchical image segmentation by spectral clustering",Sci China Ser F-Inf Sci, vol.50 |no.2|pg.no-198-211,2007.
[39] Cox, I. J., Miller, M. L., Minka, T. P., Papathomas, T. V. and Yianilos, P. N. The Bayesian image retrieval system, pichunter: Theory, implementation and psychophysical experiments. IEEE Tras. Image processing 9, 1, 20-37, 2000.
[40] Hoi, C.-H. and Lyu, M. R. 2004a. "Group-based relevance feeedbacks with support vector machine ensembles. In Proc. IEEE ICPR,2004.
[41] Hoi, C.-H. and Lyu, M. R. 2004b. A novel log based relevance feedback technique in content based image retrieval. In Proc. ACM Multimedia,2004.

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