Image Segmentation – A State-Of-Art Survey for Prediction

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Abstract

Image Segmentation is a technique that partitioned the input image into prerequisite semantic unique regions. Segmentation should stop as object of interest in an application is isolated. The ultimate goal is to make the image more simplified one and that to get more meaningful to analyze. Number of segmentation techniques are available but none of them satisfy the global properties and thus remain challenge for researcher. Many computer applications like Object Recognition, Automatic pictorial Pattern Recognition, Automatic Traffic control are based on this analysis. As per need of an application segmentation techniques can be selected . This survey addressed various segmentation techniques, discussed fundamental methodologies , and issues related with specific techniques. It discussed its limitations and probable solution to recover it. It also include discussion on segmentation technique based on graph partitioning which would be helpful to add intelligence for prediction. Concept of Ontology is introduced in short as technical bridge in between segmentation and image prediction.

Keywords : Image Segmentation , Ontology , Prediction .

1. Introduction.

From last decades, there is wide usage of Image processing in various applications. Broadly image processing breaks into two categories where one category gives major concentration on basic operations on image(Input and Output both are images) and the second category is image analysis whose outputs are attributes extracted from input image(Input is an image while output is extracted feature). Image segmentation is one of the important part of image analysis. Most of the major applications who uses image for their application need segmentation either at pre-processor level or at advanced level. Mass application like Object Recognition, Scene Understanding and analysis, Automatic pictorial Pattern Recognition, Automatic Traffic control systems, Locating Objects in satellite images like roads, maps etc.(Remote Sensing) , In Medical Imagining for Detection of Tumors and pathologies, measuring Tissue volumes etc, and many more treat segmentation as very first step of low level imaginary processing, Number of segmentation techniques are available but still it remains as a challenge for computer vision to satisfy global needs and hence selection of proper techniques is very important as per application. This paper is organize as follows : Section 2 reports various segmentation techniques , Section 3 discussed current trends in segmentation, Section 4 presents concept of Ontology, Section 5 narrates application of segmentation to prediction. Finally Section 6 draws Conclusion.

2. Segmentation Techniques.

Segmentation is a pre-process which partitioned image into unique multiple regions , where region is set of pixels. Mathematically segmentation can be defined as follows :

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If I is set of all image pixels , then by applying segmentation we get different unique regions like { S_1, S_2, S_3,…,S_n } which when combined formed 'I' . Basic formulation is as follows:

(a) $\bigcup_{i=1,n}^{n} S_i = I$ where $S_i \cap S_j = \emptyset$

(b) S_i is a connected region, i=1,2….n.

(c) $P(S_i)$ = TRUE for i=1,2.. n.

(d) $P(S_i \cup S_j)$ = FALSE for $i \neq j$.

Where $P(S_i)$ is a logical predicate defined over the points in set S_i.

Condition (a) indicates that segmentation must be complete, every pixel in the image must be covered by segmented regions. Segmented regions must be disjoint. Condition (b) requires that points in a region be connected in some predefined sense like 4- or 8-connected. Condition (c) deals , the properties must be satisfied by the pixels in a segmented region-e.g. $P(S_i)$ = TRUE if all pixels in S_i have the same gray level. Last condition (d) indicates that adjacent regions S_i and S_j are different in the sense of predicate P.

Several algorithms and techniques have been developed for image segmentation. All the techniques combined with domain knowledge can be applied for specific problem.

Different traditional and common segmentation techniques are as follows:

I. Threshold-based techniques.

Threshold-based techniques are generally used for gray scaled image. It is one of the popular technique as it is very simple to implement. But additional tools and techniques are required if we want to use it for colour and synthetic images.

For gray scale image f(x,y) ,the image is assumed to be divided into two parts namely: background and foreground. The foreground is defined as the interesting objects and the background as the rest. Threshold value T is first finalize by analysing all image pixels intensity. Any pixel (x,y) for which f(x,y) > T is called object point , otherwise , that point is called background point. Thus, intensity level is compared to the background image and a threshold value decides if the pixel differs enough to belong to the foreground or not. Global Thresholding with Additional filtering and clustering has to be considered for segmentation if background illumination is uneven[2] .

II. Histogram-based techniques.

Histogram based techniques are quite easy techniques as compared to other segmentation techniques. In this techniques first histogram of all the pixels are calculated and according to peaks and valleys different clusters are formed. Refinement techniques are applied on these cluster for further processing[1].

For colour imagining ,thresholds combined with histogram can be used for segmentation . In this technique , each pixel is characterized by three RGB values. A 3D histogram can be built from that , K-significant clusters are formed. Now image can get segmented by assigning arbitrary value to a pixel whose RGB components are closer to one cluster and another value to the other pixels in the image. The important thing is to formed clusters . Various Cluster seeking methods[8] are suggested by Duda, Hart and Stork can be used for the same.

III. Edge detection techniques.

Edge detection is by far the most common approach for detecting meaningful discontinuities in gray level[2]. First and second order derivatives like gradient and laplacian are used for detection of edges in an image. An edge is a set of connected i.e. same intensity level, between two adjacent pixels and can be distinguished by estimating the intensity gradient[3].

Edges in an image can generally be divided into two categories: intensity edges and texture edges. [5]Intensity edges arise from abrupt changes in the intensity profile of the image. Examples of intensity edges include step, roof and ramp edges .Texture edges are boundaries of texture regions that are invariant to lighting conditions. Many detection algorithms adopt a narrow concept of edges and are devoted to finding only.

In practice, Edge based techniques , set of pixels seldom characterizes an edge completely as of noise , and nonuniform illumination which effects spurious intensity discontinuities . Hence edge detection algorithms need additional post processing by using linking procedures to assemble edge pixels into meaningful edges. Famous edge detection algorithms are available under this category like Sobel(1968) edge detector[8] ,Prewitt(1970) edge detector and Roberts(1965) edge detector finds edges using their own designed approximations to the derivatives[13], Canny(1986) edge detector [14][15] finds edges by looking for local maxima of the gradient using derivative of Gaussian filter.

IV. Region-based techniques.

It has Region growing and Region splitting-merging procedures. In region growing procedure it groups pixels or subregions into large regions based on predefined criteria. Initially set of 'seed' points are created and from this point other regions grows up if neighbouring pixels have similar properties as that of 'seed' point. Selection of seed points is critical procedure for coloured images if priori information is not available . Hence set of descriptors based on intensity levels and spatial properties are required. pixel intensities. The mean and scatter of the A newer region growing concepts proposed by Haralick and Shapiro (1985)[16], is based on region and the intensity of the candidate pixel is used to compute a test statistic. If the test statistic is sufficiently small, the pixel is added to the region, and the region's mean and scatter are recomputed. Otherwise, the pixel is rejected, and is used to form a new region.

In region splitting-merging, an image is subdivided into arbitrary, disjoint regions and then either merge and or split to satisfy prerequisite constraints[2]. The algorithm is iterative. First split given image into four disjoint quadrants , then merge any adjacent regions which satisfy imposed constrained. Repeat splitting of regions and merging till no further merging or splitting is possible. image regions are implemented with the help of quadtree.

V. Watershed Transformation techniques.

This is one of the more stable technique than those discussed earlier. The Watershed transformation considers the gradient magnitude of an image as a topographic surface. Pixels having the highest gradient magnitude intensities (GMIs) correspond to watershed lines, which represent the region boundaries. Water placed on any pixel enclosed by a common watershed line flows downhill to a common local intensity minima (LMI). Pixels draining to a common minimum form a catchments basin, which represent the regions[2].

Direct application of this segmentation algorithm generally leads to oversegmentation due to noise and other local irregularities of the gradient. The problem of oversegmentation can be solved with the help of markers . A marker is a connected component of an image. Marker can be defined as per requirement of problem definition. The paper by Bleau and Leon[17] illustrated the approaches for dealing with problem of oversegmentation . The advance discussion is further available in paper ,given by Levner Adng Zhang[18].

VI. Graph Partitioning techniques.

In this method, the image being segmented is modeled as a weighted undirected graph. Each pixel is a node in the graph, and an edge is formed between every pair of pixels. The weight of an edge is a measure of the similarity between the pixels. The image is partitioned into disjoint sets by removing the edges connecting the segments. The optimal partitioning of the graph is the one that minimizes the weights of the edges that were removed . Shi's[19] algorithm seeks to minimize the "normalized cut", which is the ratio of the "cut" to all of the edges in the set.

In graph partitioning techniques, Let G = (V,E) be an undirected graph with vertices $V_i \in V$, the set of elements to be segmented, and edges $(V_i,V_j) \in E$ corresponding to pairs of neighboring vertices. Each edge $(V_i,Vj) \in E$ has a corresponding weight $w((V_i , V_j))$, which is a non-negative measure of the dissimilarity between neighboring elements V_i and V_j. In the case of image segmentation, the elements in V are pixels and the weight of an edge is some measure of the dissimilarity between the two pixels connected by that edge. In the graph-based approach, a segmentation S is a partition of V into components such that each component (or region) $C \in S$ corresponds to a connected component in a graph $G^{'} = (V ,E^{'})$, where $E^{'} \subseteq E$ [4].

All the above techniques can be implemented with advanced tools , by using different algorithms or applying different optimizing functions along with methodologies like cost optimization function, Evolutionary algorithms, or using Neuro-Fuzzy logics.

3. Current Trend For Segmentation.

Last three to four years scope of segmentation is not limited to traditional methodologies . It is expanded and thus the exhaustive nature of the topic makes it impossible to review each individual image segmentation technique in the literature. Haralick and Shapiro [9], Pal and Pal [10] have surveyed and categorized several image segmentation techniques. Current trends of segmentation and techniques are broadly classified based on its application domain like: i) In medical imaging ,3D segmentation techniques are very popular. These techniques can be used for MRI segmentation, cardio-vascular segmentation , Tomography segmentation , knee cartilage segmentation[11] etc.ii)In Bio-Informatics ,segmentation on protein localization data [20],microarray DNA segmentation etc. iii) Industry Automation , industrial inspection applications like patterned wafer segmentation [21] , open networking , feature extraction for industrial automation applications, in electronic industry segmentation is used for analysis of missing components or broken connection. iv) Remote Sensing , for aerial surveillance, evolution and analysis of remote images ,transactions on geosciences and many more. v) Pattern Recognition and Research, for authentic identification of pattern generated or available, number of tools are based on segmentation only.

Above mentioned and many more domains are using segmentation at different measures. Each domain adapts specific technique as its problem definition requirement, all the techniques are developed with different constraints and motivations , still the techniques which satisfies global properties and full accuracy is remain as a challenge for researcher .

4. Ontology.

Ontology is an “explicit specification of a conceptualization”. Formally An ontology structure O is defined as :

O = {C , R , A °}, Where

(a) C is a set of elements , called *concepts*.

(b) R $\subseteq$ C X C is a set whose elements are called relations.

For r= (c1,c2) $\in$R, one can write r(c1) = c2.

(c) A ° is a set of axioms on O.

Ontology consists of Concepts(Things you can discuss) , Relations between Concepts , Functions, Instants(Specific concept, not generic) , Axiomata(Knowledge on Concepts/ relation that can be checked on logics) In Simple term , [6]The ontology is a directed graph where nodes are concepts. Links between nodes are represented as slots and fillers. Slot names themselves are the class of concepts known as Properties except for the names of some ``bookkeeping" slots. Links are in fact multi-dimensional since each link can have several facets. Each facet can take one or more fillers. Ontology plays major role in finding relationship between the segmented image which helps directly in understanding of scene. For example[7] Begelrnan , Gur discussed how to find whether the given slide for observation contains cell nuclei or not using ontology.

5. Proposed Approach Used For Prediction Using Segmentation.

Though many research is continuously going on for segmentation which will be try match up with global properties till the date it is one of the big challenge in computer vision. In [4], efficient segmentation algorithm is suggested to march to achieve global properties . It is based on predicate that we can measure the evidence for a boundary between two regions using a graph based representation of an image. The algorithm applied to image segmentation using two different kinds of local neighborhoods in constructing the graph. An important characteristic of the method is its ability to preserve detail in low-variability image regions while ignoring detail in high-variability regions.

The working of algorithm based on Graph-Partitioning technique is as follows :

The input image is considered as graph G = (V,E), with n vertices and m edges. Pixels are considered as Vertices and an Edge can be formed based on non-negative measure of dissimilarity between V_i and V_j. The output is a segmentation of G into components S = (C1; : : : ;Cr). First all {E} are sorted by non-decreasing edge weight. Different components are construct Sq , as follows. Components are considered under segment. These components are compared while taking decision to merge different segment or not based on certain properties like intensity, texture etc.

This segmented image can be used for prediction of objects using Ontology . The segmented image can be stored with concepts and relations . The input image can be considered as an query . The query image is first pre-processed by applying segmentation technique. Each segmented part can be match with stored database image. An efficient searching method can be used while retrieving of query. Each retrieved segment gives in return concept stored in database with that segment . The inference can be found by concepts regain from database. Relations are framing out from those inference for separated regions. An algorithm is formulated to find relations and predict of the object present in input image. The flowchart of working model for above said is shown in Fig. 1.

6. Conclusion And Summary.

In this survey, the aim has been to investigate and discuss different traditional and popular image segmentation techniques. Fundamental properties and methodologies of different techniques have been highlighted. The limitation and probable remedy is discussed in short. Although number of techniques are available , each technique works on specific concept hence it is important which image segmentation techniques should be used as per application domain. Further use of segmentation can be used together with a ontology for prediction is illustrated with flowchart. Graph partitioning algorithm can be used for the procedure. With this survey we try to discussed use of segmentation for prediction which may lead to understanding of image. The concept can be really helpful to understand scenes more meaningfully for Robots like Mars on Rover using stored database available with them.

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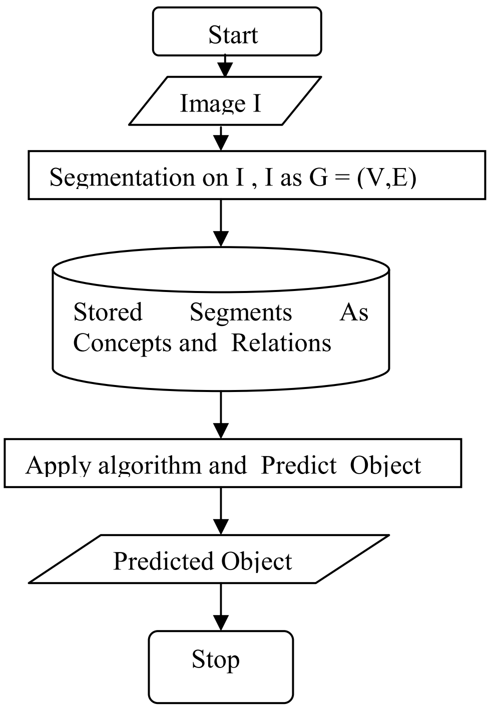

Fig. 1 Flowchart for prediction of an Object using Segmentation.