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Agent based Image Segmentation Methods: A Review

Pooja Mishra
Department of Computer science
A.P.S.University
Rewa, India
Poojatrip2002@gmail.com

Navita Srivastava
Department of Computer Science
A.P.S.University
Rewa, India
navita.srivastava@gmail.com

K. K Shukla
Department of Computer Engineering
Institute of Technology, B. H. U
Varanasi, India
kkshukla.cse@gmail.com

Achintya Singhal
Department of Computer Science
B.H.U
Varanasi, India
Achintya.singhal@gmail.com

***Abstract*-Image segmentation is an important research area in computer vision and many segmentation methods have been proposed. This paper attempts to provide a brief overview of elemental segmentation techniques based on boundary or regional approaches. It focuses mainly on the agent based image segmentation techniques**.

I. INTRODUCTION

Image Segmentation is one of the most crucial part of image processing. Its applications include image visualization, image coding, image synthesis, pattern recognition, rendering displacement estimation, etc [33]. The categorization of images is based on their energy source; the principal source being the electromagnetic spectrum. Image segmentation is a process of dividing or partitioning of an image into certain regions such that each region is homogeneous and none of the union of two adjacent regions is homogeneous. Mathematically, the image segmentation can be defined as follows: Let F be a set of all image pixels and p(.) be a homogenous predicate defined over groups of connected pixels then the image segmentation is a partition of the set F into a set of connected subsets or regions (s_1, s_2, ...,s_n) such that equation (1)

$$\bigcup_{i=1}^{\cap} s_i = F \; and \; s_i \cap s_j = \emptyset, \; i \neq j \quad (1)$$

The homogeneity predicate p (.) = True for all regions s_i and p ($s_i \cup s_j$) =False for any two adjacent regions s_i and s_j[33]. The image segmentation can be applied in medical imaging such as the location of tumors and other pathological tests, measurement of tissue volumes, computer guided surgery, diagnosis and cure planning, etc. Further applications include the location of objects in satellite, face detection and finger print detection, etc. The quality of the concluding output depends on the quality of the segmented output. The uniformity of light intensity is measured by uniformity predicate [27].

The segmentation techniques are categorized into four classes: Edge based approaches, clustering based approaches; region based approaches and split/Merge approaches [33].Some representative approaches of each class are given in Fig. 1.

In the edge based approach an image is partitioned on the basis of abrupt changes in intensity. Image edges are detected and thus linked into contours that represent boundaries of image objects [25]. Most of the techniques use a differentiation filter in order to approximate the first order image gradient or the image Laplacian. Then, candidate edges are extracted by holding the gradient or Laplacian magnitude [11]. In the clustering based approach the

Image pixels are stored in ascending order as a histogram as per their intensities. Then, a Predefined cluster number is used to separate the intensity histogram based on the intensity values. The number of regions is unsupervised because the locations of pixels in the same cluster may not be adjacent. [33]. Several clustering - based approaches have been proposed, such as fuzzy-c-means (FCM) [5], [10], [36] and K means [3], [15], [34].

In the region based approaches, the segmented contours are always continuous and one - pixel wide [21]. It includes region growing [24], [29], [37], watersheds [2], [14], [19], and pyramidal segmentation [23].

In this approach an input image is first tessellated into a set of homogeneous primitive regions. Then, alike neighboring regions are merged according to certain decision rules [33]. Several split approaches are available, such as pyramidal segmentation [23] Watersheds [2], [14], [19], FCM [5] and K-Means [34]. In Merge process, region adjacent graph (RAG) [35] and nearest neighbor graph (NNG) [19] are both available structures. RAG and NNG are usually applied with a greedy merge process for removing inconsequential regions, until a predefined stop condition algorithms without setting any threshold have been anticipated for merging process [5]. Agents are new paradigm of Modern artificial Intelligence (AI) research in computer Science. In this paper some of the Agent based

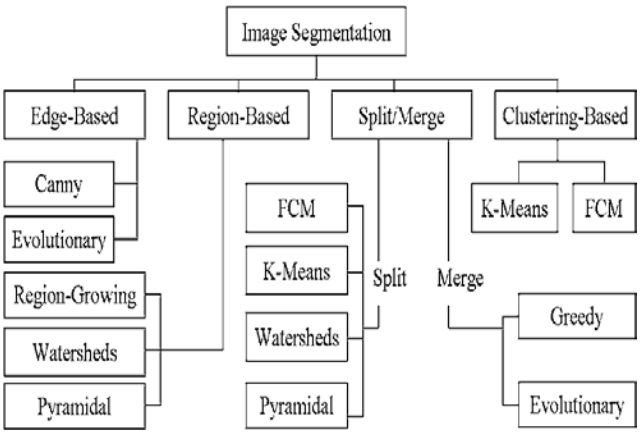

Fig.1 The relationship between various image segmentation approaches [6]

image segmentation methods and some of their applications are elaborated.

II. AGENTS

Agents are defined as a software or hardware entities that perform some sets of tasks on behalf of users with some degree of autonomy. Agents can be used in the next generation model engineering -complex, distribution system [20]. Agent based approaches have some advantages. They can be adapted to the locality. They are reliable in performance; are less sensitive to the noise, and are simple to represent and implement [6], [12], [22]. Agent based approach is widely used in such fields as traffic management, network monitoring, robotics control, electronic commerce, Medicine and computer vision [4].

III. AGENTS BASED APPROACHES

A multi agent system for living cell segmentation and recognition has been given by Boucher and Garbay [1]. The agent combines three basic behaviors, namely, segmentation, interaction and regeneration. Root of the segmentation behavior is region-growing process. Pixel assessment is done by inert and activity based criterion. The interactive nature of the two agents permits them to blend or to conclude parts of regions. The conclusion is the process of segmentation and refinement done by the agents. The regeneration behavior defines an exploration tactic of the image frames. Agents can push other neighboring agents to start functioning or else they can duplicate themselves in the next frame .Segmentation of the frame is carried out in the pipeline and the previous knowledge helps in the process of the current frame. The agents have different behaviors to achieve their objectives. Depending on the results that are derived from the basic behavior, normal region growing, other ones can be activated. Segmentation rectification is done by the conclusive behavior. The agent generation is defined by application parameters. The process infuses competition among the Agents to segment an image. They can label blend or conclude zones. An Agent's behavior is defined on the parameter of contest. It is triggered by past outcomes, which changes the priorities to sanction one of the Agents to run at a time. The autonomous agents are dispersed mathematical entities in the 2 D lattice of a digital image and give multiple responses [12]. Individual agents are capable to logically judge the local stimulus from their image atmosphere by means of assessing the gray level concentration of, in the vicinity associated pixel and set in motion their deeds hence situating the characteristic pixels efficiently. The agent is able to execute. i) characteristic marking at home pixels and self regeneration of progeny agents in the adjoining regions, if the local stimuli are found to suit feature conditions; ii) Diffusion to adjacent image regions if the feature conditions are not held, or (iii) death; if the agents go beyond their defined life. The path in which the agent will self regenerate and/or diffuse are innate from the track selected by high vigor parents. They put forth numerous investigational outcomes to make obvious the optimal pulling out of image characteristics by evolution of the distributed autonomous agent. This method is applied in the recognition of pathological foci of premature cancer and significant anatomical features from ultrasound images of a prostate [26].recognition of speculated lesions, micro calcifications and circumscribed lesions in scanning mammograms for breast cancer. The methodology is applied for forest fire detection [31]. Movaghati et al [31] studied the potential of agent in processing of remote sensing imagery.

KAGAWA et al [9] described uncomplicated rules; where in each agent has the characteristics such as color and moves onto a pixel which has most of the related characteristics. The pheromone which is the idea based on the chemical substance has the property to keep agents away. The pheromone is put by the agents on the pixel. The locus of each agent then becomes a segmented region. When the characteristics of two adjacent regions are similar, they are integrated into a larger region. After several such iterations, the region becomes an object.

The activities of agents in the different regions is given by the following equation

$$\text{Activity of agents} = \Sigma^{N}_{i=1\,D} \;/\; N \times (\text{region area}) \quad (2)$$

Where D is the distance which agent i goes in the region and N is the number of agents in the region.

In the image segmentation method proposed by Liu and Tang [13], the objective of the autonomous agent in Z (where Z is a digital image of discretized two dimensional array of size U x V that contains a number of pixels pertaining to a specific homogeneous segment) is to stopover and tag all the pixels in the homogenous segment. Agents are premeditated in such a way that they function

directly on the entity pixels of a digital image by ad infinitum sensing their adjacent regions and examining the homogeneity criterion of relative contrast, regional mean and for regional standard deviation. Based on the sensory response from their adjacent regions the agent will consequently choose and perform their behavior. As shown by them earlier [12], the agent may regenerate, move to adjacent pixels or vanish in the image. In this respect they consider the conduct of the agents as being reactive, as it is entirely activated and hence arrived at by the local atmosphere of the agents.

Melkemi et al [16] developed an innovative approach for image segmentation based on multi agent system (MAS) and Markov Random Field (MRF). A MAS is a group of agents working together on a predefined aim, and among which communications are exchanged in order to work together for the attainment of the main objective . In MAS, a set of segmentation agents and a co-coordinator agent are prearranged in star communication network. The segmentation agent is able to segment image by Iterated Conditional Modes (ICM) starting from its own initialization. The co-coordinator agent diversifies these initial configurations by genetic operations (crossover and mutation) in order to comply to superior configurations. This model is a hybridization of ICM and Genetic algorithms (GAs). Hybridization helps in the task of segmentation intensification.

Melkemi et al. [17] proposed a new chaotic multi agent system (CMAS) in place of MAS [16] for image segmentation, which improves their prior approach. They introduced a chaotic mapping as a new agent behavior in order to improve the efficiency of MAS. A chaos occurrence is a set of irregular behaviors. The special chaotic characteristic features such as ergodic property, stochastic aspect and reliance on initialization allow this approach to escape the local optimum and converge to a global optimum. Both synthetic and real images have been used to assess the validity and performance of the approach. Lab tests are very positive which proves the practicability, the convergence and the robustness of the method.

A new hybrid Island-Multi agent system for image segmentation was proposed by Melkemi and Batouche, [18] .Island MAS comprises of a set of agents called Island-agent. The Island-MAS is considered as a distributed hybrid GA in which a population of good initial images is divided into smaller subpopulations called demes and GA is executed on each subpopulation separately followed by ICM which started on its judged good off springs.

At each cycle of evolution of the Island MAS, each island agent: Receives individuals (initial images) from the different Island - agents, performs a GA on current - deme, performs a crossover on peer of parents and performs a mutation on one or several individual. It performs ICM starting from the judged good offspring and Updates the best segmented image, transmits this new-initial image to the different Island-agents for another segmentation process. The implementation of this model is feasible on parallel computers.

Sahba et al. [7] proposed a new method for image segmentation which used an opposition-based reinforcement learning (RL) scheme. RL means learning by iteration based on interaction with the environment [28], [32]. The RL agent is suitable for a dynamic atmosphere. Here the agent acts for a constraint modification to change its atmosphere i.e. the excellence of a segmented object. The agent responds to stimuli i.e. initiates an action when it gets an image. It gets a reward or punishment based on its comparison with the manually segmented version (gold image). The agent in process tries to find out which action can achieve the highest reward. Thereafter, with the accumulated reward, the agent has suitable knowledge for similar images. The ability of RL agent is that it can be trained using a very limited number of samples and also can gain extra knowledge during the segmentation process. Thus this method performs with less information to the approaches which need good amount of a prior or expert knowledge

Sahba et al. [8] applied this (RL) scheme later for the segmentation of prostate in transrectal ultra sound image in the field of biomedical imaging.

Mazouzi et al. [30] offered a multi agent modus operandi for range image segmentation. The method uses self-governing agents for the segmentation of a range image in its intricate planar regions. Agents advance on the image and accomplish local objectives on the pixels thereby allowing robust region mining and specific edge detection. In order to enhance the segmentation excellence, Bayesian edge regularization is applied to the resulting edges. A new Markov Random field (MRF) model is applied to model the edge smoothness, used as a priority modus operandi in edge regularization. Regions are progressively smoothed by aligning noise pixels to the adjacent planar regions. At the end of the progression, region margins consist of thin lines of one pixel wide. The regularization was performed characteristically for roof edges situated amid adjacent regions. The proposed approach aims to diminish inefficiency and to deal with the predicament of result accuracy. Bayesian edge regularization using a suitable MRF model allows enhancement in the segmentation results. The investigational outcome showed good effectiveness of the proposed approach for accurate segmentation of range images.

IV. CONCLUSION

Several techniques have been put forth with in literature to accomplish segmentation. These include Edge based, clustering based, and region based and split/merge based approaches. The advantage of the edge based approach lies in its diminutive computation time. The edge grouping method however suffers from a set of complications in setting appropriate constraint levels and producing

uninterrupted, one pixel wide contours. In clustering based approach the difficult threshold setting problem could be done away with by using iterative procedure but with a drawback that this may end up doing over segmentation. The difficulty experienced in the region growth approach is to set a threshold which is sensitive in measuring similarity. The computation time for pyramidal segmentation is diminutive. Both watersheds and pyramidal segmentation may cause the over segmentation problem. In split /merge process most of the evolutionary algorithms go through the time-consuming convergence rate. The autonomous agents permit the optimal extraction of image characteristics features and in short and less computation time. The agent based image segmentation methods are very viable, and robust.

With respect to real life applications, the proposed agent based approaches could have segmentation impact on difficult image analysis problems i.e. problem in which conventional edge and contrast enhancement have failed to extract critical characteristics. The remote sensing medical images (such as prostate of transrectal ultra sound image, dental radio graphs, Cat-scan(CT)images, and so on) can be optimally segmented with the help of agent based approaches.

Based on the comprehensive literature survey we find that there is considerable scope for improving the accuracy of the segmentation techniques especially for image containing textured backgrounds. Further the time complexity of the segmentation algorithms needs to be simplified or possibilities of implementing these algorithms on a parallel or distributed platform needs to be explored. Also Hybridization of two or more approaches to take advantages of their best properties can be attempted.

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