Computer Engineering and Intelligent Systems www.iiste.org
ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)
Vol 2, No.4, 2011

Novel Image Segmentation through Agile Expanse Merging

S. Kathiravan
Department of Electronics and Communication Engineering
Kalaignar Karunanidhi Institute of Technology
Coimbatore, India
Tel: 0091-7708914377 E-mail: kathiravan.sss@gmail.com

A.K. Kamalraj
Department of Electronics and Communication Engineering
Kalaignar Karunanidhi Institute of Technology
Coimbatore, India
Tel: 0091-9585439431 E-mail: a.k.kamalraj@gmail.com

Abstract:

This paper gives the explanation of novel image segmentation by agile expanse merging. Initially, the image is segmented into many expanses and the expanses of the same colour are continuously merged by the proposed algorithm. The proposed algorithm for expanse merging process will seek for homogeneity among the expanses and merges it iteratively by Sequential Probability Ratio Test (SPRT) and minimal cost condition. This merging algorithm combines the expanses in an orderly manner and stops the merging according to the criteria which is set by SPRT TEST. The merging done here goes on the agile programming technique. The final segmentation is done based on the studied or perceived image after merging process. This algorithm acquires the global standards especially the speed in which the merging is carried out by using Nearest Neighbor Graph Method (NNG).

Keywords: Image segmentation, expanse, Sequential Probability Ratio Test (SPRT), Nearest Neighbor Graph (NNG), Agile programming.

1. Introduction:

Image segmentation is a process of dividing a digital image in to multiple expanses of pixels. A set of pixel in a expanse are called as super pixel. The major aim of segmentation of the images is to simplify them for analysis. It is used to find object, boundaries, lines and curves in an image.

The result of segmentation contains a set of expanses that collectively cover the overall image or a set of contours extracted from the image. Segmentation is an essential process in the fields of image processing, target tracking, image retrieval and so on. For instance, a large number of images are needed to be handled and the human interaction involved in the segmentation process should be less than ever. This constructs the way for computerized algorithms for segmentation. In the last few decades, there is a large amount of journalism on computerized image segmentation such as edge detection algorithms and expanse merging algorithms. These algorithms cannot give the desired output. In edge detection algorithm (R.C.Gonzalez and R.E. Woods 1992), the edges are detected by means of abrupt changes in intensity or color of the image. Thus the important edges are only detected. However the detected edges are often discontinuous or over detected and only provide the boundary information.

In merging algorithms, the homogeneity of the expanses is used as a parameter for merging two expanses. The cut criteria used for the segmentation widely are normalized cut (J. Shi and J. Malik 2000), minimum cut (S. Wang, J. M. Siskind 2003), and ratio cut (Z. Wu and R. Leahy 1993). However these algorithms are running short of the global optimization. The optimization processes are computationally inefficient for many applications. In expanse based methods, watershed algorithm is used but its major disadvantage is over segmentation of the image. In this paper, we implement the segmentation algorithm in expanse merging approach. It is efficient when compared to the previous methods. In the proposed method, similar neighboring expanses are continuously merged according to the merging parameters. The evaluations of similar expanses are based on the principle that in the same data set there should be consistent elements. Optical merging is done to minimize probabilities of error. The reliability of the segmentation is determined by sequential probability ratio test. It has two assumptions one is *"the tested data are reliable"* and the other *"the tested data are non reliable".* By using this similarities between the neighboring expanses are found out. In each iteration, an expanse finds it nearest neighbor according to minimum cost condition. This proposed algorithm meets the certain global properties by neither over merging nor under merging. The merging is done in the local expanses without any problems. To accelerate the merging process, nearest neighbor graph methodology is used for searching the merging expanses.

2. Expanse merging technique:

In the expanse merging technique, firstly the image is separated in to a collection of expanses and objects. These expanses and objects will have their own properties such as continuity, similarity and homogeneity. If the nearby expanses share a same reliability property, they are brought under the same roof. On the other hand, most of the presented expanse merging algorithms cannot provide an optimal merging output. As a result, the merged output is over merged, under merged or a combination of the both. The proposed method provides certain global properties for the output image after segmentation. It is based on finding the variation between pixels along the boundary of the two expanses. The image is represented by using graph method .The graph is a combination of nodes and edges present in an image. $G= (V, E)$ is an equation giving the relation between the nodes (V) and edges (E) whereas nodes corresponds to expanses and edge connects the nearby nodes. Every edge E has a certain weight W to measure the variation of the two nodes connected by that edge.

The expanses in an image are represented by the variable R. The variations between two expanses are given by the equation,

$$\text{Similarity } (R_1, R2) = \text{minimum weight of the edges} \quad (1)$$

The proposed merging method will decide the merging of two expanses by two features:

i. Variation measure of the expanses

ii. Reliability assessment which finds whether the expanses are homogeneous

$$\text{Expanse merging} \begin{cases} \text{True if (a) Similarity } (R_1, R2) = \text{minimum weight } (R_1) \\ \qquad = \text{minimum weight } (R_2) \\ \qquad \text{(b) } R_1 \text{ and } R_2 \text{ are reliable} \\ \text{False} \quad \text{otherwise} \end{cases} \quad (2)$$

Equation 2 says that expanse merging is done by combining the expanses if and only if those expanses are having minimum weight for the edge through which they are connected to each other. Then it seeks for reliability of those expanses. Clearly condition (a) finds the minimum cost of the edge and condition (b) acts as a stopping criterion otherwise all the expanses are merged in to a single image (Bo Peng, Lei Zhang 2011).

3. Reliability test:

The reliability test is carried out to find the similarities between the expanses while merging them. In the background of expanse merging, two assumptions are made that a pair of expanses is *"reliable"* and is *"un reliable".* In order to decide whether the pair of expanses belongs to the same group or not, the solution of the hypothesis test is certain. An efficient and famous technique for integrating the statistical evidence is the sequential probability ratio test (A. Wald 1947). The two assumptions are As_0 and As_1.

SPRT shows that the solution to the assumptions can be found by making the smallest number of observations and satisfying the limits on the predefined probabilities of two errors. The application of SPRT test provides a lot easier way of finding the reliability.

The parameters used are δ (evidence accumulator), α and β (probabilities of decision error), *A, B, d, n, N0*.

α=probabilities (Eliminating As_1 when As_1 is true)

β=probabilities (Accepting As_1 when As_0 is true)

δ is the evidence accumulator which gives the desired ratio of the two probabilities PO and P1.

ALGORITHM 1: Reliability test

Preset the value for λ

Calculate $A=log(1-\beta)/\alpha$, $B=log\,\beta\,(1-\alpha)$,$p0$,$p1$;

Input: a couple of neighboring expanses

Output: the decision *D* which says that the two expanses are *"reliable"(D=1)* or *"unreliable"* (*D=0*)

1. Set the evidence accumulator δ and trials counter n to be 0.
2. Randomly choose *m* pixels in each of the pair of expanses, where m equals the half size of the expanse.
3. Calculate values *A* and *B* and update.
4. Update the evidence accumulator δ.
5. If $n \le N0$

If $\delta > A$, return *D=1 (reliable)*

If $\delta < b$, return *D=0(unreliable)*

If $n > N0$

If $\delta > 0$, return *D=1(reliable)*

If $\delta < 0$, return *D=0(unreliable).*

(Bo Peng, Lei Zhang 2011)

4. Agile expanse merging:

The proposed agile expanse algorithm is started from a set of over segmented expanses. This is because a small expanse can provide more stable statistical information than a single pixel, and using expanses for merging can improve a lot the computational efficiency.

In order to authenticate the effectiveness of the agile expanse algorithm, initially the water shed segmentation is used to obtain the initially over segmented expanses. In an over segmented image, there are many expanses to be merged for acquiring a meaningful segmentation. By considering expanse merging as a labeling problem, the goal is to assign each expanse a label such that expanses belong to the same object will have the same label. There are two labels for a expanse R_i the initial label l_i^0 which is decided by the initial segmentation, then the final label l_i^n which is assigned to the expanse when the merging process stops.

The final label for a given expanse is not unique which signifies that the same initialization could lead to different solutions. This uncertainty mainly occurs from the process of SPRT with a given decision error. The test of reliability/unreliability of any expanse depends on error probabilities having α and β. To be specific, these decisions are perfect for homogeneous expanses. If a expanse contains a considerable part of non-homogeneous data, the SPRT might add a few more times of tests to verify its decision.

With negligible small error probabilities, the segmentation results will be more reliable. Almost in every case the segmentation is stable for a given image and it is assured that all the results satisfy the merging criterion. During the process of expanse merging, the label of each expanses is chronologically transferred from the initial expanse to the final expanse, which are given as l_1^0, l_1^1... l_1^n.

To find an optimal sequence of merging which produce a union of optimal labeling for all expanses, the minimization of a certain objective function F is required. The objective function F utilized in this algorithm is defined as a measure of transition costs in the space of partitions. The solution provided is based on the stepwise minimization of F, in which the original problem is broken down into several sub-problems by using the agile programming technique (Bellman, Richard 1957).

In the proposed algorithm, the minimization of the objective function is done by the principle of agile programming.

In the nth step of the algorithm, a merging occurs when two nearby expanses are combined by the minimum weight edge in every area.

ALGORITHM 2: Segmentation by dynamic agile expanse merging.

Input : the initially over segmented image S_0

Output : expanse merging output

1. Set i=0.

2. For each expanse in segmentation S_i, use Algorithm 1 to check the value of merging criterion with respect to its nearby expanses.

3. Merge the pairs of nearby expanses whose merging criterion is true, such that segmentation S_{i+1} are constructed.

4. Go back to step 2 until $S_{i+1} = S_i$.

5. Return S_i.

(Bo Peng, Lei Zhang 2011)

5. Implementation of nearest neighbor graph in the algorithm:

The expanse merging process is speed up by using the nearest neighbor graph method. The algorithm 3 requires the relationships between the neighboring expanses. This method will find the nearest neighboring expanses which has the minimum edge weight.

The NNG acquires the following properties,

1. along any directed edge in NNG, the weights are non-increasing
2. the maximum length of a cycle is two
3. NNG contains at least one cycle
4. The maximum number of cycles is given by number of edges divided by 2.

Algorithm 3: for accelerating the agile expanse merging:

Input: NNG of the image

Output: the expanse merging result.

1. Set $i=0$
2. For the NNG in the i^{th} graph layer, find the minimum weight edge using cycles
3. Use algorithm 1 to check the value of the merging criterion. If the cycle is true , merge the corresponding pair of expanses
4. Update NNG and cycles
5. Set $i=i+1$
6. Go back to step 2 until no cycle can be found
7. Return NNG.

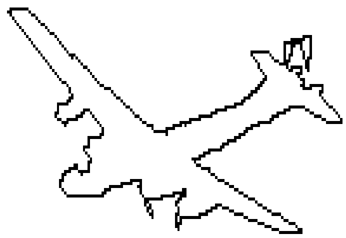
(Bo Peng, Lei Zhang 2011)

6. Experimental outcome and assessment of the output with recognized standards:

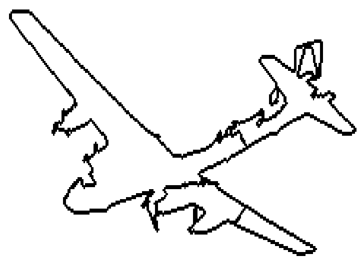
A. Original image

A.1 Segmentation result of the proposed method

A.2 Segmentation result of graph-based expanse merging method



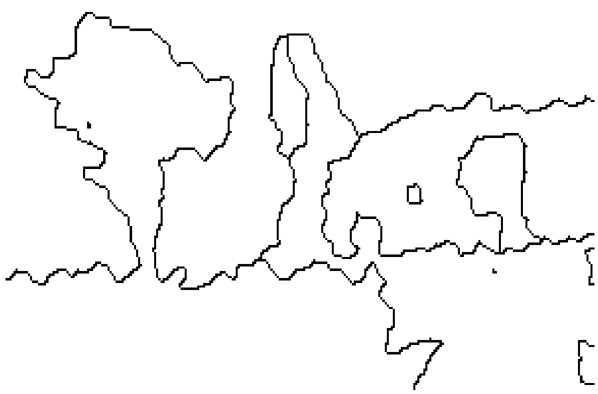
A.3 Segmentation result of mean-shift method



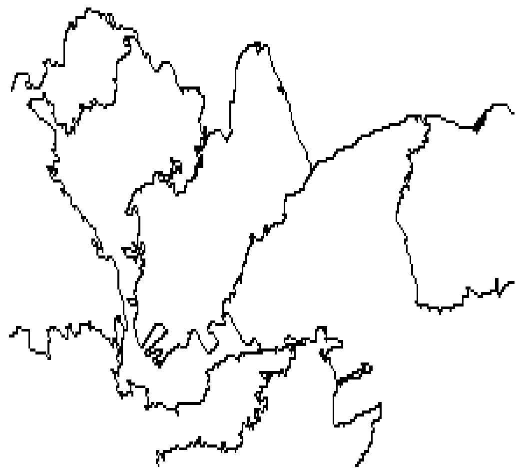
A.4 Segmentation result of Ground truth method

B. Original image

B.1 Segmentation result of the proposed method



B.2 Segmentation result of the graph-based expanse merging method



B.3 Segmentation result of Ground truth method

B.4 Segmentation result of mean-shift method

The performance characteristics of the proposed algorithm is given for the various merging consistency values,

Table 1: Merging consistency versus number of expanses

Merging consistency	0.3	0.4	0.8	1.0	1.01	1.02
No. of expanses	28	27	24	15	7	2

ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)
Vol 2, No.4, 2011

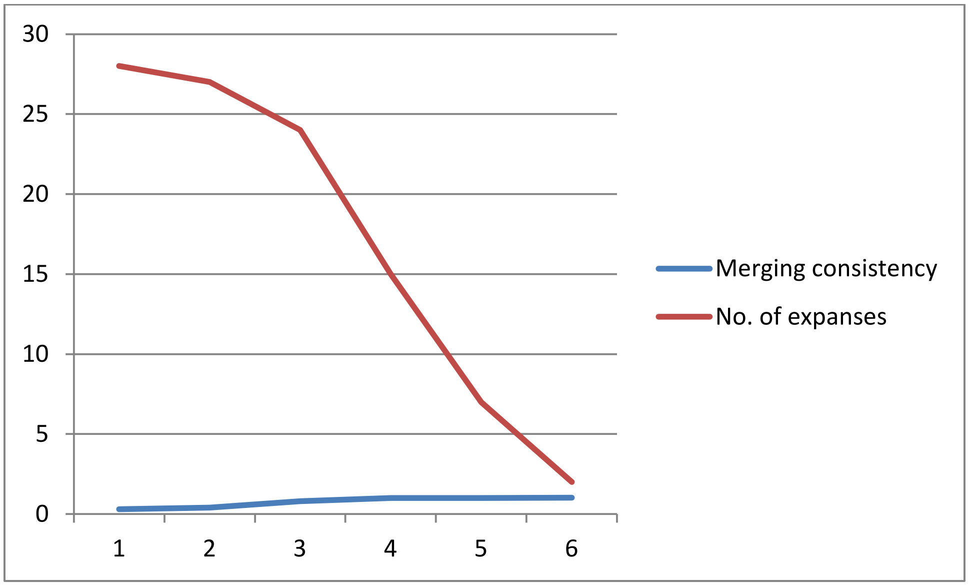


Figure1. Merging consistency versus number of expanses

Table 2: Merging consistency versus number of expanses

Merging consistency	1.0	1.1	1.2	1.5	1.9	2.0
No. of expanses	445	225	178	148	92	21

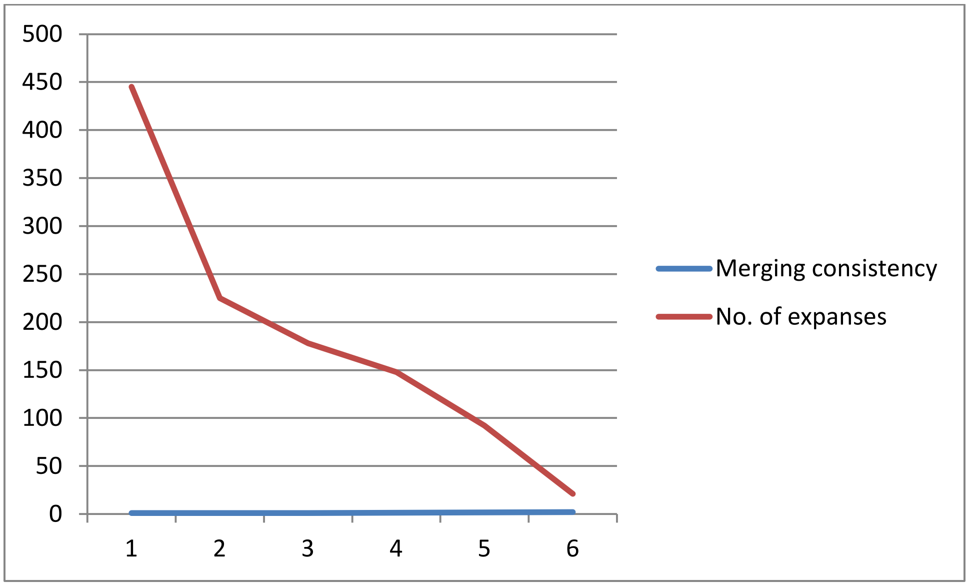


Figure 2.Merging consistency versus number of expanses

The above images show the efficiency of the proposed method because the segmentation results of the other methods are not precise. The graph for merging consistency versus the number of expanses tells that when the consistency of merging increases then the number of expanses decreases.

7. Conclusion:

This paper provides a novel method for segmenting the given input image in to expanses. Then those expanses are merged accordingly with help of merging criterion for the merging between two expanses. This was defined by the sequential probability ratio test (SPRT) and the minimum cost criterion. An agile expanse merging was then presented to cluster the initially over-segmented many small expanses. The proposed algorithm meets the global standards while merging the final segmented image. Nearest Neighbor Graph technique is used to speed up the merging process. The output image of the proposed algorithm provides a very great efficiency when compared to the basic familiar methods.

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