Mathematical Problems of Computer Science 28, 2007, 88 – 93.

Technique for Coherent Segmentation of Image and Applications

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Abstract

In this paper we describe a software tool created according to an algorithm, which was proposed earlier by authors for coherent and multi-scale segmentation of an image. The algorithm is based on the finding of all connected segments, the pixels of which belong to the same, determined beforehand and adjustable levels of intensity. Various modes of operation of the software are described, which allows to separate segments or to carry out full segmentation, as well as to transfer the parameters of one segment to others and to estimate quality of the carried out segmentation. It is shown that the segmentation procedure is able to determine simultaneously edges and contours in the image. The results of the computing experiments showing efficiency of developed system are given.

1. Introduction

Image segmentation is the first step in image analysis and pattern recognition. It is a critical and essential component of image analysis system, and one of the most difficult tasks in image processing, which determines the quality of the final result of analysis. Image segmentation is the process of dividing an image into different regions. The aim is to do the partitioning so that it would be helpful in further image analysis. In an ideal case the segments would directly correspond to the real-world objects present in the image. In practice it is virtually impossible to achieve such a complete segmentation in an unsupervised manner as the processes of segmentation and complete understanding of image contents are intrinsically intertwined.

The difficulty of segmentation is connected to the local/global duality problem. A region is declared homogeneous by analyzing small local neighborhoods. The larger these neighborhoods, the more reliable are the extracted spatial statistics given that the data in the neighborhood is indeed homogeneous. On the other hand, using a larger neighborhood increases the chances of analyzing nonhomogeneous data under the assumption of homogeneity. In certain situations to obtain a meaningful segmentation the higher level descriptions of the objects and often the relations among them must be taken into account.

The enormous material contained in the scientific literature on an image segmentation methods, does not allow realizing any detailed review in the present paper. It is possible to indicate only some references [1-3] of enough wide plans, containing such analysis. In practice one has to settle for partial segmentations, where the images are partitioned into regions that are homogeneous in terms of some visual property, such as intensity, color or texture. From this

point of view the image segmentation methods proposed in literatures, can be categorized as follows (this is not an exhaustive list):

a. *Histogram thresholding*. Assumes that image is composed of regions with different gray (or color) ranges, and separates it into a number of peaks, each corresponding to one region.

b. *Edge-based approaches*: Use edge detection algorithms such as Canny [4], for example. Resulting regions may not be connected; hence edges need to be joined.

c. *Region-based approaches*. Based on similarity of regional image data. Some of the more widely used approaches in this category are: Thresholding, Clustering, Region growing, Splitting and merging.

d. *Hybrid*. Consider both edges and regions and some special procedures.

Each of these methods being used "in pure form", has the certain advantages brightly shown on the "own" class of images and shortcomings, shown on others. One can note that hybrid methods, of course, are applicable on wider classes of images.

However, it is necessary to note that the tendency of development of more and more refined methods to problems or to classes of the images not absolutely effectively investigated earlier is looked through, with the purpose of reception of more acceptable decisions. And on the contrary, it is felt the shortage of the approaches or methods working, perhaps, less successfully on a wide class of images, but not demanding of specific (and sometimes difficultly checked) conditions of applicability of the algorithm. It is understandable if to take into account constantly growing needs to more effective algorithms of processing of images for embedding in the mobile and portable systems intended for digital communication.

Meanwhile, development of alternative, perhaps complicated and expensive methods (demanding of much machine time), remains as an actual problem, because there is rather big variety of types and classes of images, processing of which by simple and popular methods does not provide acceptable results.

In [6] the authors proposed an approach and appropriate algorithm for segmentation based on coherent segmentation idea with use of final number of thresholds, which allows finding all connected segments of an image. Thus each segment has pixels with levels of intensity, belonging to the same interval of intensity, determined by the specified thresholds. In the case of the uniform splitting of intensity interval, all process of segmentation is determined by one parameter L describing quantity of intervals that allows essentially simplifying and unifying the segmentation procedure to carry out comparison of segmentation results of different images and their interpretation.

In [7] software is created to realize the considered algorithm is described, and in [8] the algorithm and software are applied to a problem of restoration of the damaged images. The efficiency of the specified approach is shown by various examples; especially some restored images of cultural heritage are shown.

In the present paper, a related software tool is described and the results of processing of various images by proposed technique are given.

2. The brief description of software tool and its opportunities

The software tool was developed by the Borland Delphi. The functioning of the software is beginning by operator with a choice of a number of levels L of pixel intensities, unambiguously determining whole process of segmentation. Various modes of segmentation are supported:

- Choice and visualization of the separate connected segment initiated with any given pixel. Thus each found segment has pixels with the intensity belonging to one and only to one intensity interval, determined by fixed value of parameter L.. Therefore all found segments are unambiguously determined by parameter L;

- The determining of all connected segments according to any given value L and their consecutive visualization. Parameters of the found segments (criterion of uniformity [6], statistical characteristics of intensity, MSE etc.) are determined;
- Changing of intensity distribution of any found segment to the intensity distribution of other found segment (i.e. fillings of a segment by other contents). This mode provides three types of filling of a segment: "continuous" filling, filling under the casual law with the given parameters and filling by the given texture;
- Determining of edges and contours of the found segments, their separate and joint visualization with segments.

Concerning a mode of a finding of edges and contours it is necessary to notice the following. It was above marked that a group of an image segmentation algorithms is based on an outstripping procedure of the finding of edges and contours. It is made on the contrary in the proposed method: at first full segmentation is made then edges and contours are determined.

An opportunity of quality estimation of the carried out segmentation in the considered technique is stipulated by means of both the criterion of uniformity offered in [6] and the peak signal / noise ratio (PSNR). In [7] equivalence of these two criteria for an offered technique of segmentation is shown.

Let's note, that the variant of the program for processing color images is also developed; it is based on decomposition of the image to RGB channels, separate processing of the components and finally synthesis to the color image.

3. The results of computing experiments

Let's consider the results of some computing experiments to demonstrate certain opportunities and efficiency of considered segmentation method.

Experiment 1. In Fig. 1 is given the simulated image with a set of details, symmetrically located on by vertical and across. There are also given two segments initiated by the same pixel and obtained at L=4 and L=8 accordingly. This example illustrates the additional opportunities of software tool, which can be used in problems of morphological and fractal analysis and synthesis of complicated images.

Experiment 2. In Fig. 2a the photo of temple Khazanchechoc is given (Shushi, Nagornij Kharabakh), in Fig 2b the results of segmentation of this image at L=4 is given (each segment is filled by average value of intensity on a segment). The low value of L is specially chosen for testing of a degree of affinity of images at "rough" segmentation, however comparison of these two images by means of the peak signal / noise ratio already gives high enough result PSNR=25 дБ. The further improvement of affinity can be achieved, of course, by increasing of the parameter L.

Experiment 3. An image borrowed from a database of University of Berkeley (USA) [9]. It is known that this database contains a big number of standard images of various objects, animals, people etc. In Fig. 3a the image borrowed from this base is shown and in fig. 3b the result of segmentation executed by the method proposed in [10] is given. The results of the segmentation executed by our technique, are given in a Fig. 3c (at L=4) and a Fig. 3d (at L=13). The affinity of the specified images is estimated as PSNR = 27 dB (for a and b) and PSNR=31 dB (for a and d). However, on these images some distinctions connected to features of algorithms used in the present method of segmentation are looked through also.

Experiment 4. Determination of edges and contours by an image segmentation results. Fig. 4a represents the original image borrowed from a database of University of Berkeley. Fig. 4b shows the result of edge detection using the segmentation by proposed method, and Fig. 4c is obtained by means of MatLab tool, using Canny's algorithm [4]. Analogous results are obtained

by the algorithm, which is described in [5]. We see that the results of experiments are quite comparable in sense of quality of proposed edge detection procedure.

Experiment 5. Medical application. In Fig. 5a the image of section of the brain, received by MRI method and given in [11] is shown. Fig. 5b represents the results of segmentation by means of the proposed system, and Fig. 5c represents the segmentation executed manually by an operator.

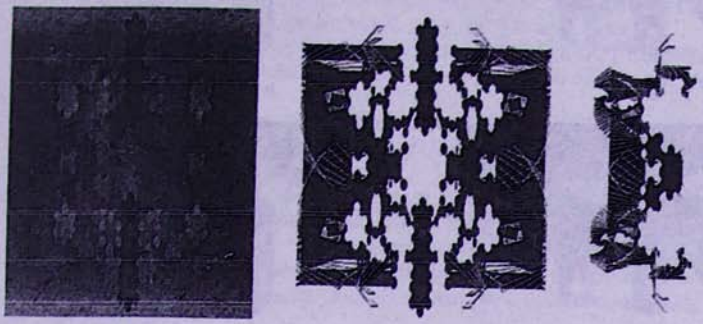


Fig. 1. Model of the complicated image and the segments initiated by the same pixel at L=4 and L=8 accordingly

4. Conclusion

In this paper we consider the novel approach, technique and applications to an image segmentation problem based on coherent splitting of image into connected pixels of the same intensity interval. The related software tool is described. It is shown that the whole of the segmentation process and the result are determined by single parameter L, which allows essentially to simplify and unify the segmentation procedure, carry out comparison of segmentation results of different images and their interpretation. Examples of segmentation results are considered to demonstrate the features and properties of proposed technique.

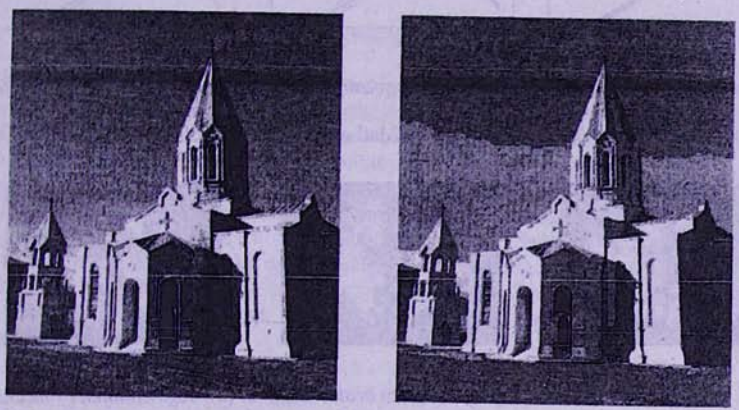
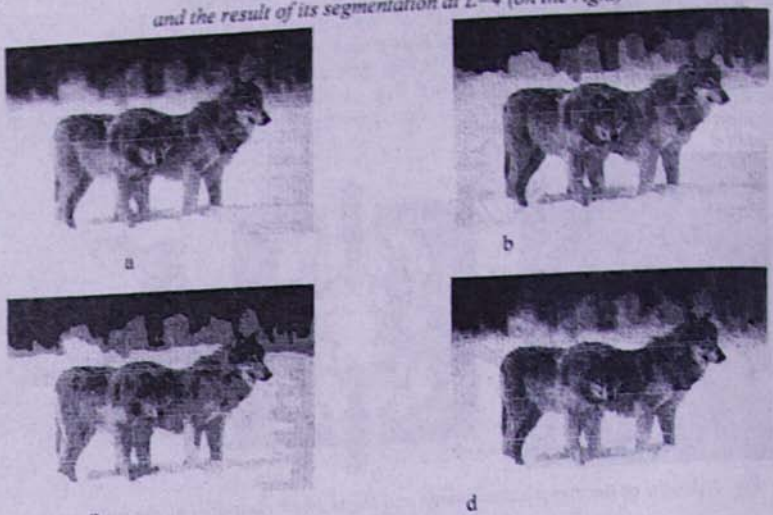


Fig. 2. The image of temple Khazanchechoc (Shushi, Nagornij Kharabakh) is given (on the left)

and the result of its segmentation at L=4 (on the right)



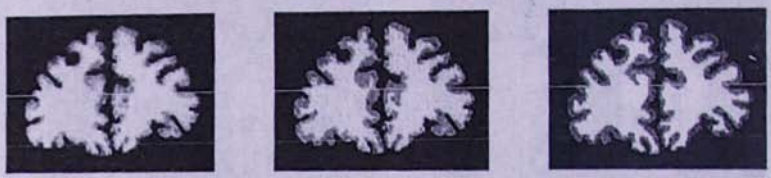
a b c d

Fig. 3. An image from the database of University of Berkeley (USA): original (a), segmentation result from [10] (b), segmentation by proposed method at L=4 (c) and at L=13 (d)

a b c

Fig. 4.Detection of edges and contours by segmentation results: original (a); edges detected

by proposed method (b); edges detected by MatLab tool by Canny's method (c);



a b c

Fig. 5. Segmentation of MRI image of a human brain: original (a); segmentation by means of the proposed tool (b); segmentation executed by the operator manually (c), see [11]

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Պատկերի կոհերենտ հատվածավորման եղանակ և կիրառություններ

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Ամփոփում

Պատկերի հատվածավորման խնդրում դիտարկվել են նոր մոտեցում, եղանակ և կիրառություններ, հենված պատկերի կոհերենտ տրոհման վրա՝ վառության միևնույն միջակայքին պատկանող կապակցված տարրերի ընտրությամբ: Նկարագրվել են համապատասխան ծրագրային համակարգը և դրա հիմնական և լրացուցիչ հնարավորությունները: Ցույց է տրվել, որ հատվածավորման ողջ գործընթացը որոշվում է միակ պարամետրով՝ վառությունների միջակայքերի քանակով, ինչը հնարավորություն է տալիս էապես պարզեցնել և միասնական դարձնել հատվածավորման ընթացքը, համեմատելի դարձնել տարբեր պատկերների հատվածավորման արդյունքները և դրանց մեկնաբանությունները: Բերվել են տարբեր բնագավառներից վերցված պատկերների հատվածավորման օրինակներ, որոնք ստացվել են առաջարկվող համակարգի օգնությամբ: