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Adaptive Segmentation for High Performance Image Coding

R. Leonardi and M. Kunt
Signal Processing Laboratory
Swiss Federal Institute of Technology
16 Ch. de Bellerive
CH-1007 Lausanne, Switzerland

In the context of image analysis and coding, various studies [1] have shown the utility of decomposing the original 2-D signal g(u,v) into a set of contiguous regions. Such process is called segmentation. Among its different applications, source coding and redundancy reduction is one of the most important topics. Segmentation allows a symbolic description of the image content (region shape and grey level approximation), so that high compression ratios can be reached. The region growing technique proposed by Kocher [2] to perform the partition of the original scene with each region being approximated by 2-D polynomials cannot reach a pixel precision in describing the region shape, except when using constant levels for the approximation. Unfortunately, the straightforward generalization of region growing to overcome this drawback is rather cumbersome. That is why a different approach is introduced to perform the partition of the analysed scene.

The method proposed is quite similar to human behaviour in analysing a natural scene. It starts from a global look at the entire image, then focuses to local area to examin details. Finally, different parts of the image are associated together on the basis of some similarity measure. This concept called split-and-merge introduced by Horowitz and Pavlidis [3] is made here adaptive by using an appropriate measure to control the segmentation process and reach the required precision. The ultimate goal of having the region borders corresponding to contours of the objects in the analysed scene can nearly be reached. The procedure works as follows: In a first step, the original image is divided iteratively into a set of squares of different sizes. Image data are approximated over each square usind 2-D polynomials. A square is divided into four identical sub-squares whenever the error between the original data within the square and their approximation exceeds a certain threshold. The error measure is chosen in order to preserve the image contour information (no real contours are lost, no artificial contours are created). This way, one is insured of mantaining most of the semantics associated to the image. The split step will certainly stop as it is possible to reach the pixel precision if necessary. In the second part of the segmentation, adjacent regions are merged if their joint approximation will cause the slightest degradation of the image content with respect to all other possible conjunction of any two contiguous regions. This comparison between all possible association of neighbouring regions allows to reach the optimal partition. The final segmentation will present regions of any shape and size. At each step of the merge process, the data are approximated with the same set of 2-D polynomials used in the split part. Their coefficients are adaptively modified in order to obtain the best approximation in the least square sense. In order to make the implementation of the proposed algorithm possible, we show that the best least square approximation of the data contained in a region resulting from the association of two regions can be obtained directly from the best least square approximation of the data within each of these two regions. This property is independent of the kind of approximating functions used. To reach the final segmentation, it is essential to modify the measure used to determine the degradation introduced by the merging of two neighbouring regions. This measure is chosen in order to take into account of the physical structure of the analysed scene. An overall strategy has to be developped.

Once the segmentation is performed, the data are presented in a symbolic way :

1 - the region shape and location,
2 - the approximation of the 2-D signal within each region.

Point 1 is equivalent to code a contour graph. If we do not admit to distort the region border defined by the split-and-merge process, algorithms requiring as few as 1.36 bits per contour point as proposed by Eden et al [4] can be used for this purpose.

Point 2 is equivalent to quantize the approximating polynomial coefficients. We show that atmost eight bits per coefficient are sufficient and even less if a vector quantization scheme using the Mahanalobis distance is used (no significant distorsion as far as the semantics is introduced). Using this overall coding method, acceptable quality images could be reproduced with compression ratios of 40 to 1.

References :

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[4] M. Eden and M. Kocher, "On the Performance of a Contour Coding Algorithm in the Context of Image Coding - Part II : Coding a Contour Graph with no Address Assignments", Signal Processing; (to be published).