ABNORMALITY DETECTION BY GENERATING RANDOM FIELDS BASED ON MARKOV RANDOM FIELD THEORY

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ABSTRACT
Image segmentation plays an important role in abnormality detection. In difficult image segmentation problems, multidimensional feature vectors from filter banks provide effective classification within homogeneous regions. However, such band limited feature vectors often exhibit transitory errors at the boundaries between two regions. At boundaries, the feature vector may make a transition through a region of feature space that is incorrectly assigned to a third class. To remove such errors, a new method is proposed based on binary random variables to eliminate boundary errors. The proposed method for eliminating the narrow misclassified regions proceeds in two steps, In the first step, pixels in the classified image whose neighborhood consists entirely of one class are left unchanged; otherwise, the pixel value is set to zero to indicate that the pixel is no longer assigned to any class. In the second step, the classified regions are propagated back into the unassigned regions based on the most common class within neighborhood system. The significant improvement is obtained compared to the traditional methods.

Key words:
Image segmentation, MRF, Probability density, misclassification, clustering.

INTRODUCTION:

Image segmentation is one of the oldest and most difficult problem in the field of image processing and analysis. Although gray-level thresholding is often too naive to produce useful results, this approach is still the subject of many papers suggesting new methods in order to obtain the right gray-level threshold automatically. Some methods work in the crisp mode while others work in the fuzzy mode. On the other hand, different image segmentation procedures attempt to avoid explicit gray-level thresholding by performing pixel clustering directly, without the need to compute the gray-level histogram. Again, hard and fuzzy clustering techniques can be distinguished, with the K-means technique in the first group and the fuzzy C-means technique in the second group, for instance. Neither histogram-based nor clustering-based methods, at least in their simplest implementations, take into account the coordinates of the pixels and the concept of connectivity. Taking these concepts into account leads to other types of segmentation approaches, such as region growing, snakes, watersheds etc., In a variety of difficult image segmentation problems, filter banks are used to generate effective features for segmenting an image into different classes of interest [1]-[6]. These filter outputs are then processed by a classifier to form a segmented image. After forming the segmented image, narrow regions near the boundary between two different classes are occasionally misclassified as a third class. This third “false class’ typically appears as a narrow strip of misclassified pixels at the boundary[8-10].These narrow misclassified regions can occur when the trajectory of the feature vector makes a transition through feature space at the boundary. As the feature vector changes, it can pass through intermediate feature-space regions assigned to a third class unrelated to the two original classes forming the boundary. A two-step novel method is proposed to remove these narrow misclassified regions. In the first step, pixels in regions whose neighborhood consists entirely of one class are left unchanged; otherwise, the pixel value is set to zero to indicate it is no longer assigned to any class. The neighborhood size is chosen to be proportional to spatial extent of filter- channel response. In the second step, the classified regions are propagated back into the unassigned regions based on the most common class within neighborhood system. The combined effect of these two steps is effective in removing the narrow misclassified strips at boundaries between regions. In the following, details of the proposed method are developed. Then experimental results are presented showing the efficacy of the proposed method.

HISTOGRAM BASED METHOD:

(a) performs image segmentation without the need to choose a threshold,
(b) takes into account the fuzzy nature of a pixel belonging to a class of pixels,
(c) takes into account the probability density function of the different classes of pixels which compose an image,

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(d) takes into account the complete structure of a pixel, i.e. its geometrical coordinates in addition to its gray level,
(e) It can be generalized to take into account several attributes of a pixel and to multi-component images.
The rationale for the method comes from a new clustering method developed [1,2]. This method is based on the estimation of the global probability density function; its partitioning obtained using tools originating from mathematical morphology and the partitioning of the image space according to the labels obtained in the parameter space. This hard clustering technique was recently extended towards fuzzy clustering [3,13]. For the specific
case of image segmentation, the results of fuzzy segmentation can still be improved. Neither histogram-based nor clustering-based methods, at least in their simplest implementations, take into account the coordinates of the pixels and the concept of connectivity [11-12]. Taking these concepts into account a new method is proposed in this paper.

NEW PROPOSED METHOD:

Before describing the proposed method, a one dimensional example will be used to describe the underlying problem. In this example, optimal classification thresholds are first calculated for three Gaussian-distributed classes. Then, a step boundary is blurred by a spatial Gaussian filtering operation to simulate the effects of a Gabor-filtered feature. Finally, it is shown that an inevitable band of misclassified pixels results near the boundary, because of the band-limited spatial filtering. A solution to this problem is proposed in the following section. To illustrate the transient misclassifications that can occur at region boundaries, consider the situation in Fig. 1, with three probability density functions corresponding to the output of a single filter channel for three different classes. It is straightforward to compute optimum thresholds, assuming equal *a priori* likelihood of the three classes [10]. For the example of Fig. 1, the optimal thresholds would be at gray-levels 48 and 165.

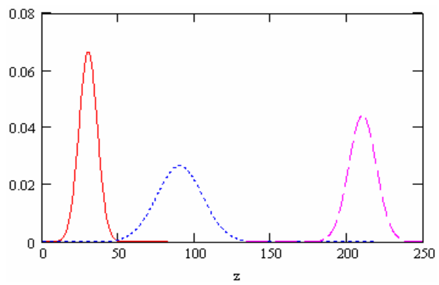


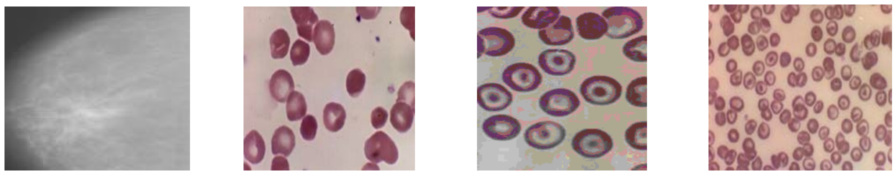
Fig 1. Three Gaussian probability density functions corresponding to filter output features for three different classes: class 1 solid red pdf with $\mu1=30$, $\sigma1=6$; class 2 dotted blue pdf with $\mu 2=30$, $\sigma2=15$; class 3 dashed magenta pdf with $\mu 3 = 210$, $\sigma3=9$. The optimum classification thresholds for these three pdfs would be at gray-levels 48 and 165.

The theory of Markov Random Field (MRF) provides suitable tool for us to model context dependent entities such as pixels or other characteristics of spatial correlation [8], [9]. Markov Random Fields are defined with respect to a system of neighborhoods. The mathematical Interpretation of the model is defined with respect to the corresponding set of cliques. In this paper, a systematic method has been used for neighborhood system in which the Markov Random field can be defined. In order to segment the image, we will use a vector called of directional homogeneity [10], which considers the relation between the pixel corresponding to a site *s* and all the remaining pixels of neighbourhood G_s .The relation to be established between the site and the other pixels of the neighbourhood will depend on the type of clique.
Let us suppose that x is a random field of class described in [8,9],with a space of discrete range $Z=\{Z_k,k=1,\dots,M\}$. Let us also suppose that we have an instance x of this random field that can be used for estimation parameters of the distribution. The proposed method for eliminating the narrow misclassified regions proceeds in two steps, beginning with a previously classified image c(x,y), where $c(x,y)\in\{1,2,3,\dots,N\}$ and N is the number of classes. In the first step, boundary regions are reset to an unclassified state. In the second step, classes are propagated back into the unclassified regions. Details are given below. In the first step, pixels in the classified image c(x,y) whose neighborhood consists entirely of one class are left unchanged; otherwise, the pixel value is set to zero to indicate that the pixel is no longer assigned to any class. The declassification of these pixels creates a new image
$I(x,y):I(Z_1,\dots,Z_k)=\{-1,$ if $Z_1=Z_2=\dots=Z_k$; 0, otherwise………(1)
In the second step, classified regions are propagated back iteratively into the unassigned regions. Each unassigned pixel is assigned to the most prevalent class within the neighborhood surrounding the pixel.
$I(Z_1,\dots Z_k)=\{ Z_k,$ if $Z_1=Z_2=\dots=Z_k$; *mode* otherwise……..(2)
Mode is the non-zero pixel value that occurs the greatest no of times in the neighbourhood. I(x,y) is the image at iteration n . In the event of the determining the "*mode*", the pixel is arbitrarily assigned to one of the relevant classes . Step(2) is repeated until all pixels are non-zero, giving the final. Unassigned pixels have been assigned to one of the N classes.

EXPERIMENTAL RESULTS:

The proposed method has also been tested on a wide range of natural and synthetic 150X150 pixel 8-bit gray-scale images. In these images, the average gray scale was equalized to prevent biased segmentation results due to leakage of the DC component through the filters . This method produced better results compared to traditional methods The pixels misclassified as a third texture at the texture boundary are removed by the proposed methods.

ORIGINAL IMAGES:



Breast sphero Codo1 codo2

HISTOGRAM METHOD:

NEW PROPOSED METHOD:

CONCLUSION:

A new method is presented for the removal of narrow bands of misclassified pixels near boundaries. In the first step, pixels in the classified image whose neighborhood consists entirely of one class are left unchanged; otherwise, the pixel value is set to zero to indicate that the pixel is no longer assigned to any class.

In addition, a one-dimensional example is used to illustrate the inevitability of transient misclassifications at region boundaries. The transients arise as a consequence of the bandwidth of a filtering process, as is commonly used to generate feature vectors. An example is given where the transient response of the filter must pass through regions of feature space causing erroneous classification. As a filtered image makes a transition between the mean amplitudes of two classes comprising a boundary, the feature amplitude may have to pass through an intermediate amplitude level erroneously assigned to a third class. We have tested this method on different images like skull, brain, lung, and breast to detect cancer and also tested on textures, barks, SAR images and fur. It produced better results compared with traditional methods. However this method may not produce better results for small and short distance objects in the image, it will constitute the subject of a forthcoming extension.

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