Intelligent Bimodal Segmentation Applied on CFA Images of Food Products

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Abstract - Images segmentation is an essential step in the non-destructive analysis of food products by image analysis. It participates upstream in the operations of classification, identification or extraction of image attributes. To implement our segmentation approach, we extracted from each CFA image The R, G, B (for the RGB color space), and H, S, V (for the HSV color space). We then calculate the histogram of each of the color components. The component S for which the bimodal histogram was the most pronounced was selected and the binary mask has been created from this component. The created binary mask has been filtered using morphological closing and opening operations. The application of each binary mask to its image CFA host, allowed us to separate with success the pixels representing the food products from the pixels of the background of the image CFA.

Index Terms - segmentation, CFA images, binary thresholding, morphological filtering.

I. INTRODUCTION

Segmentation is a process which the purpose is to partition an image into sets of pixels called regions [1]. This is not a goal in itself but a downstream processing of image analysis. From an image I , we create a family of subsets R_i such as:

$$\begin{aligned} \forall i, R_i &\neq \emptyset \\ \forall i, j, R_i \cap R_j &\neq \emptyset \\ \bigcup_i R_i &= I \end{aligned} \quad (1)$$

A region is a connected set of pixels with common properties (gray levels, texture, etc.) that differentiates them from neighboring regions. Regions can sometimes be grouped by class in order to identify occurrences of an entity on the image (identify neurons, starch grains, etc.). Inspired by the process of human visual perception, two approaches have emerged that are commonly referred to as the area and border approaches. The notion of region refers to neighborhoods of pixels with similar properties, which leads to a direct partition of the image since each pixel is assigned to a region. The notion of boundary, on the other hand, refers to the phenomenon of discontinuity of properties between the pixels separating two regions; in this approach we find the methods of contour detection. There is duality between region and contour only in the case of closed contours [2].

Generally, in the field of food processing, image

segmentation consists of separating the pixels representing the background of the image of the pixels representing the food in question. Among image segmentation techniques, region-based segmentation and thresholding approach are most commonly used in food analysis control [3]. Putting these different segmentation approaches into practice is one of the most important steps in image analysis because poor segmentation automatically leads to erroneous measurement of calculated attributes [4].

The threshold segmentation of a gray-scale image is based on the hypothesis that objects can be distinguished from the background or between them by their gray levels. It was in fact a two-step method. We start with a one-dimensional classification: classes are built from gray levels of pixels without taking into account their spatial distribution. Then we build the regions by extracting from the image the connected components of pixels belonging to the same class [5]. The partition of the histogram in $n + 1$ classes thus implies the choice of n thresholds. The different techniques of image segmentation by thresholding are combined with other techniques to segment food images in a relevant way. In fact, thresholding provides relevant results if the gray levels of the objects of interest are uniform by class, and in addition these objects of interest are based on a background whose levels are totally different and uniform.

The thresholding approach is a simple approach to be implemented, but it does not always ensure the connectivity of the regions present on the food images. Despite its imperfections, the thresholding approach is by far the most important method applied in food industry because of its simplicity of implementation. We were inspired by this approach to implement in our paper an intelligent binary thresholding for CFA images.

II. MATERIAL AND METHODOLOGY

A. Food material used for CFA images acquisition

The segmentation method proposed here will be applied to the CFA images of the 5 varieties of beans, as shown in Table 1 below.

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Table 1. Beans samples used for acquisition CFA images

Samples	Varieties	Captured images
Red beans	DOR701
Red beans	Meringue
Red beans	Senegalese
Speckled beans	ECAPAN021
Speckled beans	MAC55

B. Methodology

Let $\tilde{I}^{CFA}$, the CFA image of the beans gains to segment. This image CFA is constituted on the one hand of the beans pixels and on the other hand the pixels of the background used to make the acquisition. Let H , the set of bean pixels of a CFA image and $\bar{H}$ the set of the background pixels (non-beans pixels) of the same image. We have:

$$H \cup \bar{H} = \tilde{I}^{CFA} \quad (2)$$

The segmentation here consist to separate the beans pixels from the background pixels. This segmentation is based on the hypothesis that two types of regions of different pixel levels are present on the image. In this case, these two types of regions correspond to one of the bean pixels and the other to the pixels of the background. Thus, the histograms of the pixel levels have two rather distinct peaks, each peak corresponding to a one type of region. A threshold placed between the two peaks separates the two types of region. To implement this type of segmentation, we will:

(i) construct the histograms of each image in the RGB and HSV color spaces, which gives of all 06 histograms whose a one histogram for each color component []. Here, the color components R, G, B (from RGB color space) and H, S, V (from HSV color space) will be extracted from the CFA image $\tilde{I}^{CFA}$.

(ii) choose among all the histograms, one for which the color component have the most pronounced bimodal mode;

(iii) create the binary mask of the color component choosed;

(iv) apply a morphological filtering of opening and closing to eliminate all the noises present in the binary mask;

(v) apply the binary mask obtained on the CFA image to segment.

For binary thresholding, we were inspired of the Otsu's method to define the binarization equation [5]. Considering that each histogram follows a bimodal distribution law, we obtain:

$$p(z) = P_1 \frac{1}{\sqrt{2\pi\sigma_1}} \exp\left(-\frac{z-\mu_1}{2\sigma_1^2}\right) + P_2 \frac{1}{\sqrt{2\pi\sigma_2}} \exp\left(-\frac{z-\mu_2}{2\sigma_2^2}\right) \quad (3)$$

where z represents the grey levels of the CFA image, P_1 the proportion of pixels belonging to the region 1 and P_2 the proportion of pixels belonging to the region 2.

For filtering, we have used the basic morphological gradient of Beucher [6], which operates by an arithmetic difference between dilation and erosion, and defined as follow:

$$\rho_B = \delta_B - \varepsilon_B \quad (4)$$

where is the structuring element.

III. RESULTS AND DISCUSSION

The figures 1 and 2 present the result of binary thresholding without filtering of the beans grains CFA images.

Fig 1. Binary mask of a CFA image of DOR701 without filtering.

Fig 2. Binary mask of a CFA image of MAC55 without filtering.

In regard to figures 1 and 2, it is noted that thresholding that is not combined with another filtering techniques or with image color spaces representation does not make it possible to obtain a good quality binary mask. We note that, to make a good segmentation of food images, we must combine the different image segmentation techniques using binary thresholding to other intelligent techniques. This gives the reasons why, for example, Szczypinski and Zapotoczny [8], to barley grains based on their surface folds, have used the binary thresholding segmentation combined with a double morphological filtering (opening and closing). Their results

obtained show that this combination of thresholding binary with a double morphological filtering has permitted to obtain a classification rate of 93 % of barley grains per variety.

We note also that, Kang *et al.* [9], to segment the images of bicolour mango “B74”, have used the thresholding segmentation in the $L^*a^*b^*$ color space. They exploited the properties of the component L^* according to which the values of L^* for a curvilinear surface (for example mango) are different from the values of L^* for a plane surface (for example the background). These properties allowed easy to apply a binary threshold on the image of L^* component to distinguish the mango pixels from the background of the image. That is why, Mendoza *et al.* [10], before analyzing the color of the bananas to determine the maturity level, have used a simple binary threshold to separate the banana pixels from the background pixels. However the original RGB image have been transformed into a gray level image (also called a luminance image, which is a monochrome image). Unfortunately, unfortunately only manual thresholding could be used to separate to separate the mango pixels from the background pixels. All of this shows that our proposed approach of segmentation finds its place technologically in the segmentation of food images.

The figure 3, 4 presents the results of binary thresholding with filtering of the beans grains CFA images.

Fig 3. Binary mask of a CFA image of DOR701 with filtering.

Fig 4. Binary mask of a CFA image of MAC55 with filtering.

The results presented in figures 3 and 4 show a successful separation between the beans pixels and the background pixels (non-beans pixels). Our results obtained confirm the

results reported by Mery and Pedreschi [11]. These authors have developed a binary thresholding segmentation using a morphological closing filtering in RGB color space. Their approach has permitted to separate very clearly the pixels images of pear from the background pixels images. Lee *et al.* [12] have used also the binary thresholding segmentation in RGB color space, combined with the morphological operation of closing and opening, to separate the pixels images of dates from the pixels images of the background.

The figure 5 and 6 present a CFA image before and after segmentation. The figure 6 shows that all the pixels of bean grains have been separated from the background. This shows well the convincing success of our approach.

Fig 5. CFA image before segmentation.

Fig 6. CFA image after segmentation.

IV. CONCLUSION

The objective of this paper consisted to segment the CFA images of food product using the binary thresholding segmentation combined with a morphological filtering based on opening and closing operation. To achieve these results, we have created some binary mask from the images represented in HSV, extracted from the CFA sources images. The results obtained show that, this approach is appropriate to use for classification, identification or quality evaluation of food products.

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