FUZZY COLOUR DISTANCE APPLIED TO REGION GROWING IN IMAGE PROCESSING

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Abstract

In this work, a new approach to region growing problem is presented. The region growing procedure is modified in order to apply a fuzzy knowledge based system to evaluate the distance between a pixel and the region. This fuzzy colour distance is based on a set of rules that evaluate the three distance components (R, G, B) jointly. The results presented show a improvement with the traditional crisp distance.

Keywords: Image Processing, Fuzzy Distance, Knowledge Based Systems.

1 INTRODUCTION

The objects tracking in images sequences obtained through a camera, located in a fixed position is a problem that could be approached with a classic tracking filter. In order to accomplish the tracking process in image, the definition of the interest zones for each acquired image is required [3]. In this work, a region growing procedure is use to obtain a set of interest zones that are moving at time and therefore they appear in different positions in each one of the images. The extraction of the information of the interest zones in movement can be obtained through the segmentation from each acquired image [6]. This procedure has a high computational cost, since each acquired image should be processed for finally only use concrete segments in the tracking process. In this case a high amount of information is required and probably any machine is able to accomplish the processing of all images in an acceptable time. However, the quantity of information of the sequence is reduced if only a subset of global image is considered, the neighbourhood in an environment of zones. Then, once the zones that are found in movement are determined, the information of the position of the zone in an image can be used in the following image to obtain the region on which to accomplish the segmentation, reducing the calculation space and therefore the execution time.

Each zone remains determined by a set of parameters, on those which is produced a filtered and a prediction that allows to locate the neighbourhood window in the following instant. The used filter is a filter α - β. The proposed scheme, in general, can be observed in Figure 1.

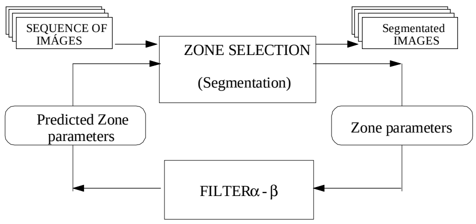


Figure 1: Scheme of segmentation and prediction system

The segmentation scheme is based on region growing [1]. The algorithm searches inside a image regions that have the same type of parameters. In this way, a zone is defined by the set of pixels that has the same characteristic.

In traditional algorithms [2], the equality restriction (zero distance) is very strict, and they use likelihood intervals between the pixels to define the belonging of a given zone. In this work, the problem of calculating the distance between a pixel and the value of the zone is approached through a fuzzy system [4]. These systems will be able of considering the distance between the value of a pixel and the one of the zone through a knowledge base that reflect a diversity of options greater than using the classic method of the difference in absolute value of the colours.

2 DISTANCE AND SEGMENTATION

To accomplish the region growing, the method departed from an complete image on which certain windows are predicted. The windows are located in the zones that are needed to extract from the image for tracking process.

The existence of overlapping between windows is not relevant for the problem, since zones are considered independent. The independence is reached by the following method: on the original image is opened a window and, a copy of the values within the same is accomplished in an array. The original is not modified in any case, therefore if other window is overlapped with the previous, the copy has the original values to accomplish the segmentation.

2.1 PIXELS DISTANCE

The definition of the characteristics of a pixel is based on the colour. The colour of a pixel is defined through a vector of three components (R, G, B) [2] and the distance used between the pixels will be the distance between each one of the coordinates, thus the "likelihood" between two pixels, A (R_A, G_A, B_A) and B (R_B, R_B, B_B), is calculated in this way:

$$d_R = R_A - R_B$$
$$d_G = G_A - G_B$$
$$d_B = B_A - B_B$$

Two pixels are equals, or a pixel and the zone characteristics, when any colour distance is over certain threshold. Typically the threshold is located in the interval from 10 to 20 [1].

2.2 SEGMENTATION INSIDE A WINDOW

Once a piece of image where the zone is found, the segmentation process is accomplished. The method chooses pixels of the image and compares the parameters of the pixel with ones of the zone. If the comparison result gives that the pixel is similar to the zone, the pixel is included in the zone and the new parameters of the zone are calculated making the average of all the colour values of the zone pixels [2]:

- A zone is defined by a set of $pixels_{i,j}$ with colour values (R_{ij}, G_{ij}, B_{ij}) }
- The number of pixels that belong to the zone is n
- Then the zone parameters are: $R_{zone} = (\sum R_{ij})/ n$, $G_{zone} = (\sum G_{ij})/ n$, $B_{zone} = (\sum B_{ij})/ n$.

In the first step of algorithm, the zone is composed of a pixel, therefore the zone parameters are the same that the pixel ones: the pixel colour RGB. In the next step new pixels are included and the method must re-define the value of parameters with new pixel colours. The iterative process finishes when surrounding the zone do not exist pixels that could belong to such zone [2]. In this procedure two types of problems should be outlined, on one hand the growing in zones that suffer a demoted soft from colour and additionally the concave zones.

In the first case, if a zone is growing following colours that are removed gently from the first zone value, the zone parameters could be evolving with the new points towards a final value that is far from the real one. The real value is obtained using only the pixels that reality belong to the zone (Figure 2). To solve this problem, the growing must follow a path in spiral so that the withdrawal by the central zone will be gradual and the change in a peripheral part of the zone does not produce a change of the same (Figure 3).

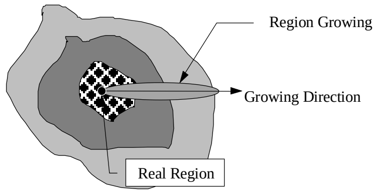


Figure 2: Straight Line Growing in a Image with Degraded Colours

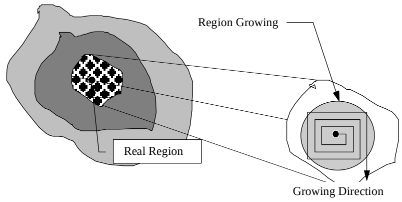


Figure 3: Spiral Growing in a Image with Degraded Colours

In concave zones, some pixels could remain outside the zone (Figure 4). In order to avoid this problem a new region growing method is developed based on spiral growing but always considering the shape of the region that grows.

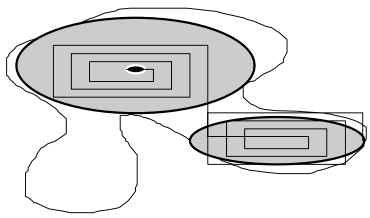


Figure 4: Concave Zone Problems in Region Growing

3 DISTANCE EVALUATION USING A FUZZY SYSTEM

The proposed fuzzy system has as input variables the distance in each colour component of the pixel and the zone. Depending on the value of these distance (Small, Medium or High) and applying the rules of system, a linguistic variable, <Distance> is obtained. This variable is defined by three membership functions (Small, Medium or High). The defuzzification process determines a value that defined the final distance [7]. If this distance is less than certain value, the pixel would be included in the region. The method to calculate the new parameters of the region, including the new pixel, would be the same that in the traditional algorithm.

3.1 INPUT AND OUTPUT VARIABLES

The fuzzy sets that define each input would be identical for each variable (d_R, d_G, d_B) and they would be defined by three levels (**S**mall, **M**edium or **H**igh) that could be observed in Figure 5. Each input variable represents the difference in absolute value between a pixel and the centre of the region, this difference is the value that is fuzzified to apply the knowledge base, the implication used is the Mamdani one[5], and to obtain the defuzzified distance. The fuzzy sets of output would be defined three levels (**S**mall, **M**edium or **H**igh) that could be observed in Figure 6.

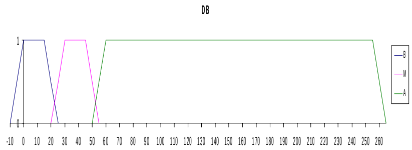


Figure 5: Input Membership Functions

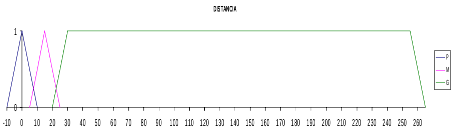


Figure 6: Output Membership Functions

3.2 RULE BASE

The system rules are shown in Tables 1, 2 and 3.

		DG		
		S		
DR	S	S	S	H
	M	S	M	H
	H	H	H	H
		S	M	H
		DB		

Table 1: Distance Rules for Small Green.

		DG		
		M		
DR	S	S	S	H
	M	M	M	H
	H	H	H	H
		S	M	H
		DB		

Table 2: Distance Rules for Medium Green.

		DG		
		H		
DR	S	H	H	H
	M	H	H	H
	H	H	H	H
		S	M	H
		DB		

Table 3: Distance Rules for High Green.

4 RESULTS AND CONCLUSIONS

The experiments carried out has been proven the segmentation algorithm on different images changing the threshold from which is considered that pixel belongs to a region or not. With the traditional distance, considering the absolute value, thresholds of 10, 15 and 20 has been considered. With the fuzzy calculation of the distance this threshold must be function of the centroids of the fuzzy sets that define the labels of the output linguistic variable. In this case the thresholds of experiments have been: 0, 2.5, 5, 7.5, 10, 12.5 and 15. In Figure 7, 8 and 9 are shown the results for one of the images.

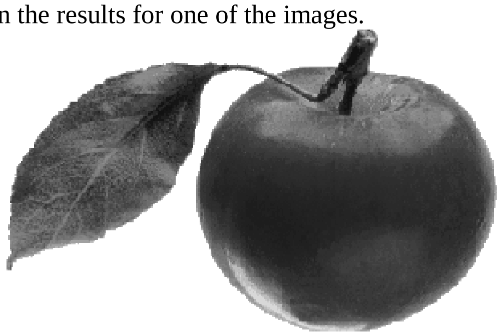
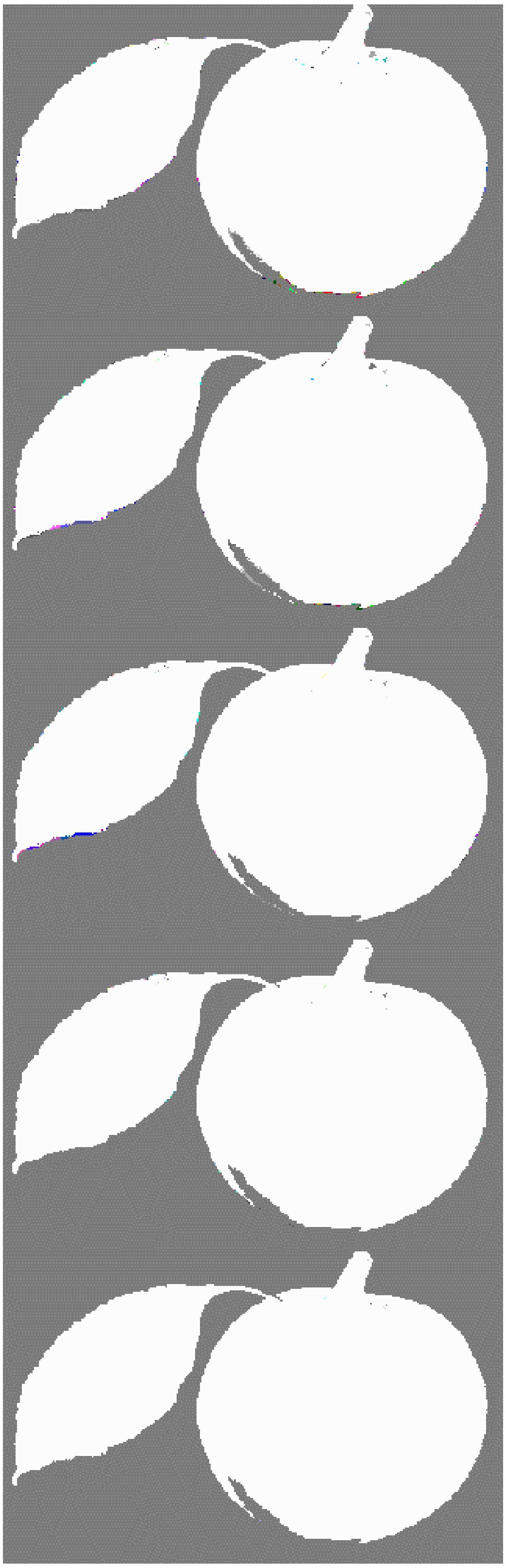


Figure 7: Original Image

Figure 8: Results for traditional distance with thresholds of 10, 15 y 20 respectively



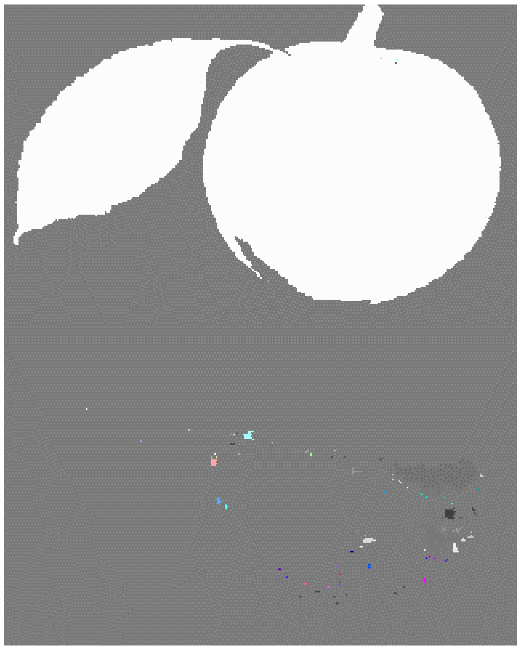


Figure 9: Results for fuzzy distance with thresholds of 0, 2.5, 5, 7.5, 10, 12.5 y 15 respectively

In Figure 8 and 9 the results show that the fuzzy distance produce less zones than traditional one. This result is relevant in order to avoid irrelevant zones with few pixels that produce something like noise, see Figure 9. Following the evolution of image in Figure 9 and 10, the results show that a threshold is the most important parameter of the algorithm, because if the threshold is high no regions grow in the image, and if the threshold is low many regions produce a blurry image.

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