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FOOD IMAGE REPRESENTATION BASED ON MODIFIED ORIENTATION MAP

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ABSTRACT

Orientation map is an image representation method representing edges of objects in an image as a set of short line segments instead of pixels representation. The orientation map approach not only aims to extract the key orientation information which constitutes the semantic framework of the visual scene, but also to remove the insignificant elements which barely play a role in image understanding. However, there are two main problems in the current computational approach of orientation map: 1-the outliers in the orientation map 2- the deformities in some line segments. These two problems have an adverse impact on any algorithmic work for image interpretation. This article proposes two improvements, heuristic based and genetic based, to reduce outliers and deformities respectively. Experimental results prove the significant improvement on the current computational approach of calculating the orientation map.

Keywords: *Orientation Map, Image Representation, Genetic Algorithm, Heuristic Approach, Ganglion Cells.*

1. INTRODUCTION

Pattern recognition, in computer vision, deals with extracting features and meaningful data from images [1]. It is especially useful in data reduction from huge pixel based representation to less quantity and more meaningful representation of images. Pattern recognition has found use in many applications such as face recognition [2], robotics [3] and surveillance [4]. Furthermore computer vision has found use in the food industry as well. In [5] the author has used computer vision for color and marble detection in beef and hence detecting the quality of the beef. In [6] the author has used computer vision in order to improve the quality inspection of food products. Furthermore, computer vision system and radar imaging for assessing physical properties of food has been used in [7].In [8], the author has presented a review on color measurements using computer vision for quality control.

The human visual system works in a similar manner to pattern recognition by capturing the important details in the surrounding while overlooking the trivial details [9]. In [10] a mathematical model is proposed to represent the response of human retinal ganglion cells. An orientation detection algorithm called the “orientation map” is then presented. Orientation map is an analytical representation of image. It uses binary version of the image and converts it to set of short straight lines based on a grid that consists of small windows. Each straight line is calculated based on the developed model of the response of ganglion cells to contrast stimuli.

Orientation map has an advantage in image segmentation applications in computer vision. Image segmentation is regarded as one of the most difficult problems in computer vision [11-13] due to the fact that image segmentation has a perceptual aspect that is highly difficult to model. Orientation map however is shown to outperform classical image segmentation algorithms in eliminating trivial details and maintaining the meaningful information in the image [10]. Moreover, due to its analytical nature in representing the image, orientation map is useful as an input to any semantic or perception layer.

There are however two issues in the application of orientation map that this paper aims at reducing. Firstly, unnecessary short lines or outliers that are either attached to the image contour or just randomly placed are observed in the orientation map image. Secondly, deformities due to wrong line parameters are also observed in the contour.

To solve the first type of problem i.e. outliers, this paper proposes a heuristic approached based on the

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graph representation of orientation map. Numerous approaches have been built on graph representation. In [14] the author presented a survey of the graph theoretical approach to image segmentation. Graph representation is further presented for object detection using thermal camera images [15].

Furthermore, this paper proposes a genetic algorithm based solution for deformities. Genetic algorithm, inspired by the concept of natural selection, has several attractive features such as parallel execution, high immunity to local minima, customizability, and capability of searching in wide space of solutions [16]. In the field of image segmentation, genetic algorithm has been used in various applications. Genetic algorithm was used to optimize the membership function of fuzzy entropy to improve image segmentation [17]. In [18] the authors have used a genetic algorithm to integrate short line segments into long contour lines using graph-based genetic representation

The remaining of the article is organized as followings. Section 2 presents the current computational approach. Section 3 introduces more quantitative description of the problem statement. Section 4 provides our approach of improvement. Experimental results are presented in section 5 Future work and challenges are presented in section 6, while conclusion is presented in section 7.

2. CURRENT COMPUTATIONAL APPROACH ON FINDING ORIENTATION MAP

Wei and Ren [10] presented a mathematical model of the working principle of the ganglion cells in the retina of a human eye. The presented model studied the response of the retinal ganglion cells to contrast stimulus and describes the response with respect to normalized coverage ratio and the centre/surround ratio. The model was computed by computing the difference between two Gaussian functions with shared centre at the centre of the cell. It was noted that the response curves obtained from the developed model were consistent with real life physiological data.

Based on the mathematical model developed further a computational approach for orientation detection known as orientation map [10]. The approach is based on the distance between the cell centre and the stimulus. The aim is to find the equation of the best fitting line to which the corresponding contrast stimulus triggers a response in the ganglion cells. Since natural images are large in size, the orientation detection was performed in small windows with each window taking in a small portion of the image and a contrast was formed after binarization of the image. The orientation map is hence a combination of the results of all the windows combined.

Experimental results for the orientation detection algorithm presented showed significant improvements with respect to the segmentation algorithms developed in the past and provided convincing results on different type of complex images. However there were few issues that were noted in the orientation map image. This paper discusses these issues in detail and further develops an algorithm to minimize them.

3. PROBLEM STATEMENT

From the experimental results of the orientation detection presented in [10] it is noticed that there are two issues that the orientation map faces that can be improved upon. The first issue is regarding the outliers or small unwanted lines that appear in the orientation map image and the second issue deals with the deformities in the object contour due to gaps between adjacent nodes.

Figure 1 shows some outliers (red circle) and gaps (blue circle) in orientation map.

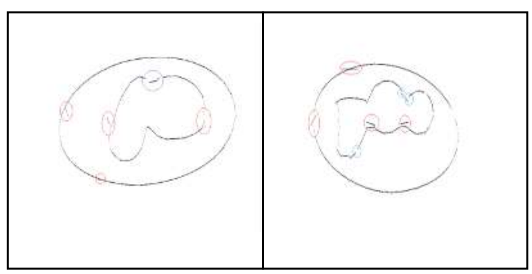

Figure 1: Some outliers and Gaps in the Orientation Map

Outliers in the orientation map image are small unnecessary lines that appear while extracting the main segments of the image. Outliers mainly appear in the image due to the non ideal nature of the binary image and emergence of noise. Outliers are further divided into two types. The first type of outliers consists of the lines that appear randomly in the image and are not connected to the object contour. These are made up of small limited number of nodes away from the main object contour. The second type of outliers consists of the lines that are attached to the object contour but none the less are unnecessary as they do not add any value in image segmentation and are in fact noise.

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Figure2 shows the two kinds of outliers where the first kind is inside the red circles and the second kind is inside the blue circles.

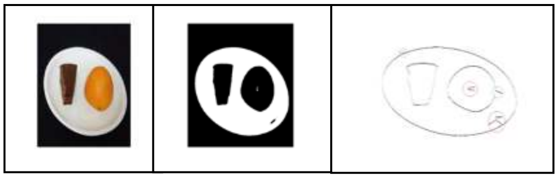

Figure 2: An Example about the Outliers in the Orientation Map

Deformities in the orientation map image are a result of the gaps between the lines of two adjacent windows. The bigger the gap between two adjacent line segments, the bigger is the distance between the two nodes representing these line segments. Deformities mainly occur due to the value of the chosen windows as no one value can suit all object shapes. Therefore in order to improve the overall representation of the orientation map image, it is imperative that theses gaps be reduced to a minimum. Figure3 shows a sample of a corrupted line segment.

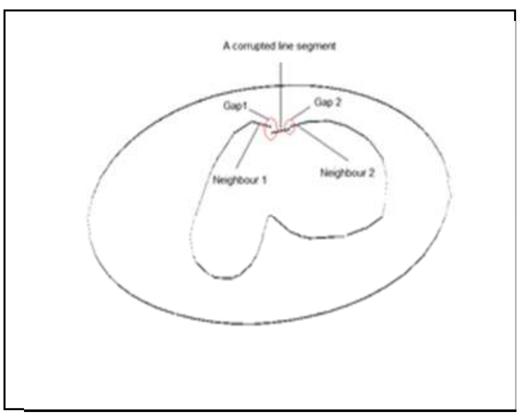

Figure 3: An Example about a Corrupted Line Segment

4. IMPROVED OIENTATION MAP

In order to solve the two issues mentioned earlier, a twofold approach was adopted. In order to remove the outliers from the orientation map image a heuristic mechanism was employed. The image was scanned for different nodes making up the line segments and then the nodes not meeting a threshold requirement were eliminated from the image.

In order to solve the problem of deformities a genetic algorithm was introduced. Genetic algorithm is an optimization technique and parallel randomized search inspired by natural evolution. It converges towards global solution. In genetic algorithm, a population of solutions or individuals is encoded in the form of chromosomes (strings). Individuals are randomly initialized from a large search space and coded often in binary. This population is then evolved from one generation to the other using genetic processes of crossover, mutation and selection. The selection operation is based on an evolutionary function called objective function which measures the goodness of the solution. The operations of selection, crossover and mutation are continually applied for individuals till termination condition is satisfied or a fixed number of generations is reached. In the case of deformities, firstly the corrupted lines that were responsible for the deformity were identified. The slopes of the corrupted lines were then assigned as the chromosomes for the genetic algorithm.

$$Chromosome = (k_1, k_2, \dots, k_m)$$

Where

m Number of corrupted line segments.

k_1 Slope of the first corrupted line segment

k_2 Slope of the second corrupted line segment, and so on.

k_m Slope of the m^{th} corrupted line segment.

The objective function is then defined as the sum of distances among each corrupted line segment and the two adjacent line segments in the object contour:

$$\mathrm{Fittnessvalue} = \sum_{i=1}^{m} \mathrm{distSum_i}$$

Where distSum is defines as the sum of the distance between the corrupted line segment and the two adjacent line segments. Genetic algorithm hence edits the slopes of the corrupted line segments to make the Fittnesvalue as small as possible, hence minimizing the gaps to as small as possible. The MATLAB built-in mutation and crossover operations were used for the experiments conducted.

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Define: N_{pre} //Pre chosen Number
X_n //Any number of nodes
d // Distance between two adjacent nodes
T_{con} //Threshold of connectivity
Closed// Min. sum of distance btw. Adjacent Contour nodes
Obj_func //Fitness Value

Input: Orient map image
IF $X_n < N_{pre}$: //Remove outliers of first type
Remove X_n from Orient map image
END

FOR each subgraph //Remove outliers of second type
Find closed contour
IF $d > T_{con}$
Remove outlier
ELSE IF $d < T_{con}$
Ignore
Next subgraph
END

Call Obj_func //Remove deformities
Call Gen_algorithm
Reduce (Gen_algorithm, Obj_func)
Output: Corrected Orient map Image

Output: Corrected Orient map Image

Figure 4: Pseudo Code for Improved Orientation Map Image

The pseudo-code presented in Figure 4 illustrates the methodology applied. It presents the pseudo-code for the algorithm developed to optimize the orientation detection algorithm presented in [10]. It can be seen from the Figure that the presented code is divided into two main parts. The first part deals with removing the two types of outliers namely, the short random lines and the unnecessary lines attached to the object contour. The second part deals with the removal of deformities in the orientation detection algorithm.

As seen from the Figure, the algorithm takes the orientation map image as the input which is generated from the orientation detection algorithm [10]. Firstly, a minimum number of nodes which constitute a valid line are defined as N_{pre}.

The orientation map image is then scanned for nodes that form different lines and are marked as X_n. If the number of nodes X_n is less than the number of predefined valid nodes N_{pre}, then the line formed by X_n is removed. The short unnecessary outliers are thus removed by this method.

To remove the outliers of the second type, a search process within adjacent subgraphs is performed to find closed contours. A contour is defined as "closed" if the distance d between two adjacent nodes in the contour is less than the threshold of connectivity T_{con}. If d is greater than the threshold of connectivity T_{con} , then the nodes are removed. Hence, the unnecessary lines attached to the contour are removed by this method.

To remove deformities in the orientation map image, a "corrupted" line segment is first defined. A line is said to be corrupted if the sum of the distance (distSum) between itself and its two adjacent line segments is greater than the allowed threshold of corruption T_{curr}. An objective function (Obj_func) is then introduced to represent the sum of the distances of all the corrupted lines. Lastly, a genetic algorithm is introduced (Gen_algorithm). The slopes of the corrupted lines act as the chromosomes for this genetic algorithm. The aim of the genetic algorithm is to reduce the objective function as much as possible by adjusting the slopes of the corrupted lines. The deformities are thus minimized by this process.

5. Results AND DISCUSSION

The experiments to be conducted involved image manipulation and the MATLAB environment were used.

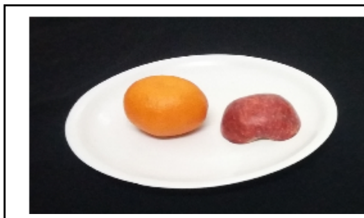

Figure 5: Original Image to Be Segmented

Figure 5 shows the original image to be segmented. It is seen from the image that the objects in the image are of different colors as well the background of the image is very contrasting. This is done to highlight the contrast between the different objects as the orientation map algorithm works on the contrasts in the image.

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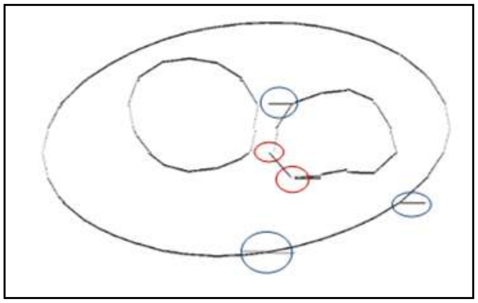

Figure 6: Image After The Processing Through Orientation Map Algorithm

Figure 6 shows the image after the application of the orientation map algorithm [10]. As can be seen from the image there are two visible drawbacks. First, the outliers are marked in blue circles. The two types of outliers, random stray lines and lines that are attached to the object contour are highlighted. Furthermore, deformities are highlighted inside red circles. The outliers are eliminated from the image using a heuristic algorithm whereas the deformities are eliminated using genetic algorithm.

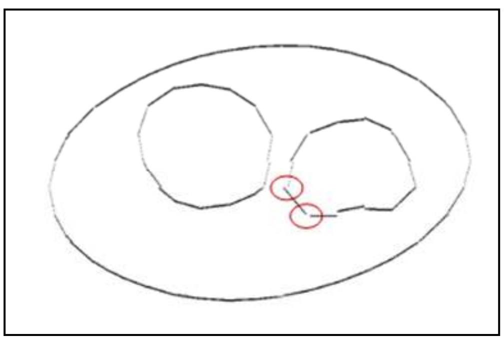

Figure 7: Image After Removal Of Outliers

Figure 7 shows the image after the removal of outliers through the application of a heuristic algorithm. From the image it can be seen that the algorithm is robust in removing the two types of outliers. Both the random stray lines as well as the random lines attached to the contour have successfully been removed from the image. However the deformities in the image still remain and are marked under red circles.

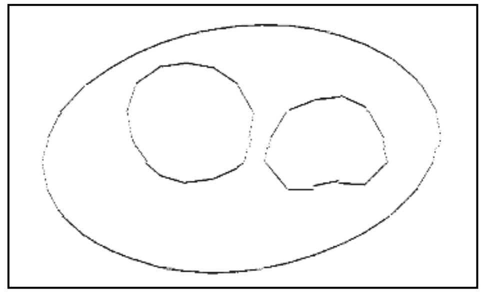

Figure 8: Image After Removal Of Deformities

Figure 8 shows the final image after the removal of all the outliers as well as deformities. It can be seen from the image that the deformities have been removed from the image by adjusting the slopes of the lines that form the contour. The final image hence produced, is free from outliers as well as the deformities that were found in the orientation map image. Table 1 shows the results of applying the proposed technique on multiple images and compare with the method in [10]. The left most images are the original images and. It is obvious that the proposed method has provided better orientation map quality than the original orientation map. Moreover, the proposed method has a strong immunity to noise comparing with the original map image and results can be regarded as useful information to any pattern recognition work based on extracting geometrical and analytical information from images.

6. CHALLENGES AND FUTURE WORK

The main goal of the proposed solution is to remove the outliers in the orientation map and to repair the deformities in some line segments. However, in some cases the proposed solution cannot close some gaps because of the constraints on values of permitted slopes as shown in Figure 9. It is predicted that the performance can be improved if the values of slope and constant in a corrupted line segment equation are changed together in order to minimize the sum of distances.

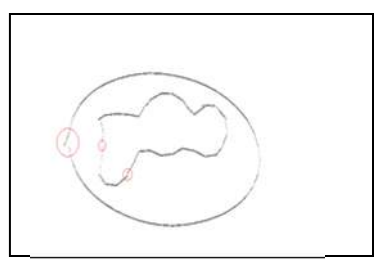

Figure 9: Example about Unclosed Caps

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7. CONCLUSION

A solution of two stages to improve the orientation map has been proposed. The first stage of solution is responsible for removing any undesired line segments (outliers) from the orientation map, whereas the second stage uses the genetic algorithm to reduce or cancel the gaps between adjacent line segments in object contours, which will enhance the representation of external object contours by using orientation map.

REFRENCES:

[1] Liu, J., Sun, J., & Wang, S. Pattern recognition: An overview. IJCSNS International Journal of Computer Science and Network Security,(2006),6(6), 57–61.

[2] Deepa, G. M., Keerthi, R., Meghana, N., & Manikantan, K. Face recognition using spectrum-based feature extraction. *Applied Soft* Computing, (2012),12(9), 2913–2923.

[3] Hebert, M. H., Thorpe, C. E., & Stentz, A. Intelligent unmanned ground vehicles: autonomous navigation research at Carnegie *Mellon* (Vol. 388), *Springer Science & Business* Media,(2012).

[4] Jones, G. A., Paragios, N., & Regazzoni, C. S. Video-based surveillance systems: computer vision and distributed processing, *Springer* Science & Business Media,(2012).

[5] Gerrard, D. E., Gao, X., & Tan, J. Beef marbling and color score determination by image processing,*Journal of Food Science*, (1996),61(1), 145–148.

[6] Brosnan, T., & Sun, D.-W. Improving quality inspection of food products by computer vision––a review,*Journal of Food Engineering*,(2004),*61*(1), 3–16.

[7] Abdullah, M. Z., Guan, L. C., Lim, K. C., & Karim, A. A. The applications of computer vision system and tomographic radar imaging for assessing physical properties of food,*Journal of* Food Engineering, (2004), 61(1), 125–135.

[8] Wu, D., & Sun, D.-W. Colour measurements by computer vision for food quality control–A review,*Trends in Food Science & Technology*, (2013),*29*(1), 5–20.

[9] Di Lazzaro, P., Murra, D., & Schwortz, B. Pattern recognition after image processing of low-contrast images, the case of the Shroud of Turin,*Pattern Recognition*, (2013),*46*(7), 1964–1970.

[10] Wei, H., & Ren, Y. A mathematical model of retinal ganglion cells and its applications in image representation, *Neural Processing Letters*,(2013),*38*(2),205–226.doi:10.1007/s11063-012-9249-6.

[11] Zhang, J., & Hu, J.. Image segmentation based on 2D Otsu method with histogram analysis. In, *International Conference onComputer Science and Software Engineering,* (2008),(Vol. 6, pp. 105–108). IEEE.

[12] Zuva, T., Olugbara, O. O., Ojo, S. O., & Ngwira, S. M. Image segmentation, available techniques, developments and open issues,Canadian Journal on Image Processing and Computer Vision, (2011),2(3), 20–29.

[13] Yi, F., & Moon, I.. Image segmentation: A survey of graph-cut methods. In Proceedings of ICSAI 2012: International Conference on Systems and Informatics,(2012), (pp. 1936–1941).

[14] Peng, B., Zhang, L., & Zhang, D. A survey of graph theoretical approaches to image segmentation,Pattern Recognition, (2013), 46(3), 1020–1038.

[15] Nguyen, H. V, & Tran, L. H. Application of graph segmentation method in thermal camera object detection. In IEEE 2015 20th International Conference on Methods and Models in Automation and Robotics (MMAR), (2015), (pp. 829–833).

[16] Bajpai, P., & Kumar, M. Genetic algorithm–an approach to solve global optimization problems,Indian Journal of Computer Science and Engineering, (2010), 1(3), 199–206.

[17] Muppidi, M., Rad, P., Agaian, S. S., & Jamshidi, M. Image segmentation by multi-level thresholding based on fuzzy entropy and genetic algorithm in cloud, In IEEE 2015 10th: System of Systems Engineering Conference (SoSE), (2015), (pp. 492–497).

[18] Wei, H., Tang, X.-S., & Liu, H. A genetic algorithm (GA)-based method for the combinatorial optimization in contour formation,Applied Intelligence,(2015) 1–20. doi:10.1007/s10489-014-0633-y.

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Table1: Results from Applying the Proposed Algorithm on Multiple Images and comparison with [10].

Original image	*Orientation map image[10]*	*Improved Orientation map after Removal of outliers*	*Improved Orientation map after Removal of deformities*