
COMPUTER AIDED ENGINEERING AND SIMULATION

DIRECTED MOVEMENT OF A FINGER MECHATRONIC TO IMPROVE THE VISIBILITY OF ARGOPECTEN PURPURATUS'S KIDNEY USING COMPUTER VISION

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Abstract: *The shucking of the Argopecten Purpuratus (scallop) is a process where the viscera and the kidney are removed. The use of computer vision is an alternative to automate this process, however the extraction of the kidney is the most difficult task because in many cases the scallop's stem covers the kidney avoiding the kidney extraction. Due to this circumstance the whole shucking process fails. This paper proposes a method of computer vision to determine the movement direction of a finger mechatronic, which move the stem in the opposite direction of the kidney improving its visibility. In order to achieve this improvement we use image segmentation, logical operations on images, geometric and mathematical calculations, etc. The proposed method provides the efficiency 99.38% for removing Argopecten Purpuratus's kidney.*

Keywords: *segmentation, computer vision, image processing, colors spaces, robotic finger, Argopecten Purpuratus.*

ACM Classification Keywords: *J.7 Computers in other systems.*

Introduction

The exportation of Argopecten Purpuratus (scallop) has increased significantly over the past few years. This increase is due to high demand that exists in countries like United States and France, not forgetting the Asian Continent, which is the biggest importer of Argopecten Purpuratus in the world. In factories, this increase means additional number of human inspectors working on processing lines. In this regard, process automation has become a crucial factor in industries [Narendra, 2010] [Gumus, 2011] [Yachida, 1980].

Many researches have been conducted with computer vision systems in order to automate processes in field of foodstuffs. In [Arnarson, 1994] a shape classification technique in computer vision called PDL-HM is proposed. It combines the selection of morphological structuring elements from contour description languages and the extraction of shape characteristics to fish species classification in an industrial environment. In [Misimi, 2007] and [Misimi, 2008] computer vision methods are proposed to evaluate the color of Atlantic salmon fillets. In [Rodriguez, 2011] a method is developed to classify the Argopecten Purpuratus based on determination of weights by conversion and adjustment factors.

Similarly, researches about manipulator arms have achieved new progress in conjunction with computer vision systems, which allows controlling the movements with visual feedback [Li, 1996]. A robotic apparatus is presented in [Lefebvre, 1993], it aims to automate pulp sampling of potatoes in order to detect viral diseases using two computer vision approaches. In [Martinez-de Dios, 2003] is presented a robotic system for fish feeding and an underwater robot for autonomous pond cleaning.

The rest of this paper is organized as follows. Section 2 describes the method to determinate of movement direction of a finger mechatronic. Section 3 shows the results of the method. Finally, Section 4 presents conclusions.

Approach

This paper proposes a technique to determinate the movement direction of a finger mechatronic in order to improve the visibility of the *Argopecten Purpuratus*'s kidney. It will facilitate the full removal of the kidney, automating overall process of shucking of the *Argopecten Purpuratus* (Scallop).

The *Argopecten Purpuratus*'s stem covers the kidney avoiding the kidney extraction by automated methods. Due to it the whole shucking process fails. In this context the aim of finger mechatronic moves the *Argopecten Purpuratus*'s stem in the opposite direction to the localization of kidney through a digital images analysis using computer vision techniques. The Fig. 1 shows Stem and Coral of *Argopecten Purpuratus*.

The difficulty of this problem increases due to the high variability of scallops, such as their shape, colour or size. To achieve the objective proposed in this paper, it is necessary to perform various processes, which are described in detail below.

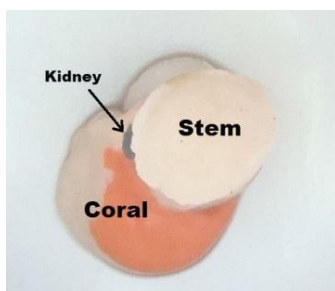


Figure 1. Scallop (original image): Stem, Coral and Kidney

Segmentation of the Region of Interest (ROI)

The ROI includes the area of the image where Scallop is presented. The segmentation process starts by converting the image from RGB to YCrCb color space. Then, the Cb channel is used to segment the images, with a dynamic threshold based on color histogram for binarization. The threshold is computed using the average of the color histogram. This value will be different in each image because each image is affected by external factors such as luminosity, which cause changes in the color and tonality.

Then, the noise from image is deleted by discarding of areas. Small areas which are outside or inside the ROI (Scallop) are deleted. Finally, an AND operation was applied between the original and segmented image. Thus, subsequent processes will work with the ROI of original image, as shown in figure 2 on the right.

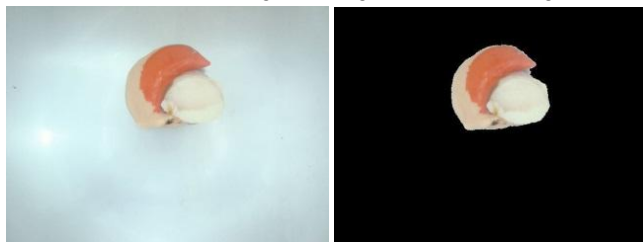


Figure 2. Original and segmented Image (Scallop)

Segmentation of the Stem and Red Coral

Segmentation of the Stem is important because the finger mechatronic shall be positioned over the Stem. The Stem was segmented using the B channel of RGB color space. Then, it is binarized with an experimental threshold, which was calculated by measuring the brightness in the background original image. Finally, a discarding of areas is performed, due to it is possible to detect areas which do not correspond to the Stem. The figure 3 on the right showed a stem segmented.

The images of database shows that the kidney is always located at one end of Red Coral (RC). In addition, segmentation of the Red Coral will help us later to find the region closest to kidney. Segmentation of the Red Coral was performed using the Cb channel of YCrCb color space. Then, it is binarized with experimental threshold of 56 and finally a discarding of areas is performed. The figure 4 on the right showed a segmented Red Coral.

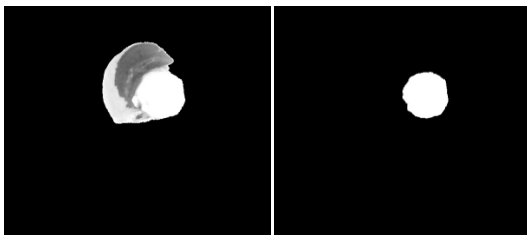


Figure 3. Segmentation of Stem

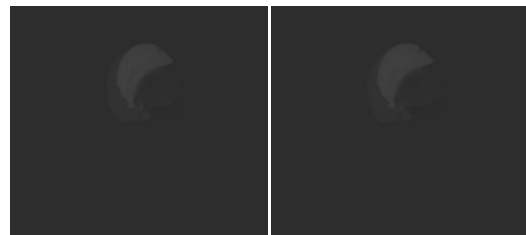


Figure 4. Segmentation of Red Coral

Determination of the movement direction of finger mechatronic

To determine the movement direction, it is necessary to determine the location of two specific points. The first point will be the center of mass of the Stem, and the second point will be a point on Red Coral's surface that is closest to the kidney.

Obtaining center area of the Stem: To obtain the location of this point is used the image of stem segmented. It is computed calculating the vertical and horizontal average of segmented image, which will represent x , y coordinates of the center of the Stem.

Obtaining Red Coral Point nearest to kidney: As it can be seen in the image database, the position and shape of the scallop are not always the same one. So, it is important to take into account the location of the Stem with respect to the Red Coral, since the position of scallop in the picture is not always the same.

One of the four extreme points of Red Coral (top, bottom, right and left) will be identified as the nearest point to the kidney, as shown in figure 5 (blues points). In order to determinate this position, the center point of scallop (red point in figure 5) and the center point of Red Coral (brown point in figure 5) will be attached to trace a straight line R1, as shown in figure 6.

Then a Cartesian plane is projected on the center point of Red Coral as it is shown in figure 6. According to the location of line R1 in the Cartesian plane, the position of the Stem with respect to Red Coral on the image can be determined. In the figure 6, the line R1 is localized in the fourth quadrant of the Cartesian plane.

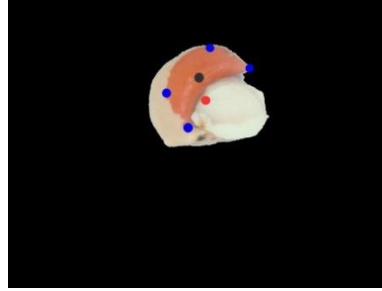


Figure 5. Highlights: Extreme points of RC (blue), center point of the Scallop (red) and center point of the RC (brown).

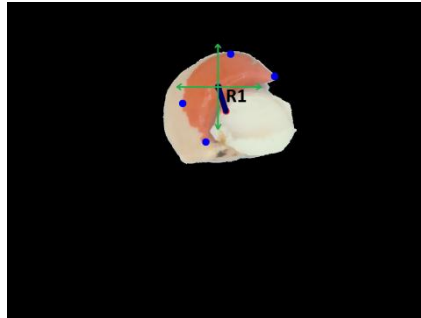


Figure 6. Localization of the straight line R1 in the Cartesian plane.

After that we determine a quadrant of the Cartesian plane, which contains the straight line. Then the two extreme points being the closest to this quadrant are chosen. After these operations we draw other three straight lines: the first straight line $D1$ (equation 1) is formed by the two points chosen above, the second straight line $D2$ (equation 2) and the third straight line $D3$ (equation 3) are formed together with each point (points chosen above) having the closest neighboring extreme points of the Red Coral as it is shown in figure 7.

$$D1: m_{slc} = \frac{y2 - y1}{x2 - x1} \quad (1)$$

where m_{slc} represents the slope of the straight line $D1$, and (x, y) represents the location of points in the image on the x -axis and y -axis respectively.

$$D2: m_{slc1} = \frac{y2 - y3}{x2 - x3} \quad (2)$$

where m_{slc1} represents the slope of the straight line $D2$, and (x, y) represents the location of points in the image on the x -axis and y -axis respectively.

$$D3: m_{slc2} = \frac{y2 - y4}{x2 - x4} \quad (3)$$

where m_{slc2} represents the slope of the straight line $D3$, and (x, y) represents the location of points in the image on the x -axis and y -axis respectively.

Then we calculate the distances of these three straight lines $D1$, $D2$ and $D3$, and the straight line with the greatest distance is chosen as it is shown in figure 8. One of two endpoints of this chosen line could be selected as the point of Red Coral being the nearest one to the kidney.

Having obtained these two extreme points (blue and green points in figure 8) the distance of each extreme point towards the center point of the scallop (brown point in figure 8), is calculated. Finally, the closest point (less distance) to the center of the coral is chosen. It is considered as the point being the nearest one to the kidney as it is shown in figure 9.

The geometric and mathematical calculations have been done because the position of the scallop in the image is not always the same one. The additional circumstance is irregular shapes of the scallop.

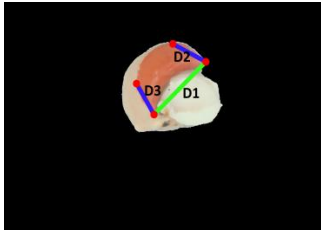


Figure 7. Trace of lines D1, D2 and D3

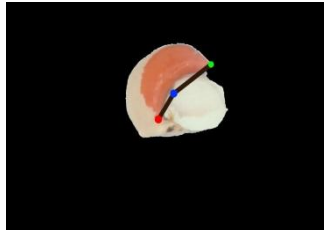


Figure 8. Two extreme points of Red Coral

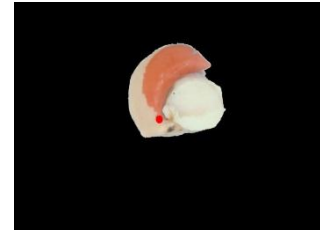


Figure 9. Point on Red Coral's surface that is closest to the Kidney

Movement direction of finger mechatronic. We obtain the two points: the center point of the Stem (green point in figure 10) and the point on Red Coral's surface that is the closest one to the kidney (red point in figure 10). With these two points we can determine the movement direction of the finger mechatronic. For this we draw a straight line $R2$ containing these two points as it is shown in figure 10.

Then we project the straight line $R2$, which will have: a) the center of Stem as the starting point and b) the distance being equivalent to the length of the straight line to segment $R2$.

Thus, the movement of the finger mechatronic starts in the center of the Stem Area in opposite directions to the localization of the nearest point to the kidney. It follows the path of the projected straight line $R2$, as it is shown in figure 11.

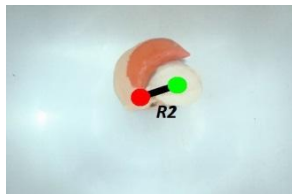


Figure 10. Trace of the straight line $R2$

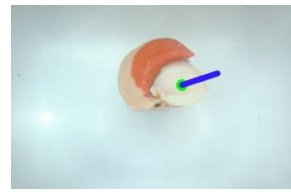


Figure 11. Movement direction

Results

The images used for the experiments were taken from the SSCCA-5 image database of the Research and Software Development Center of the San Agustín National University in Peru. This image database was developed in order to test the Shucking and Codification Process of the *Argopecten Purpuratus*. For these experiments a total number of 969 images were used: 693 images with a dark blue background, 176 dark lead background, and 100 of a light background. A sample of each image can be seen in figure 12. The dimension of the images is 1920x1080 pixels.



(a) Light background



(b) Dark Blue(DB) background



(c) Dark Lead(DL) background

Figure 12. Image Database according to the background

Tests to evaluate the efficiency. A result is considered as the “Good” one when the direction taken by the finger mechatronic is contrary to the position of the kidney. It makes the kidney to be visible. On the other hand, a result is “Bad” if the finger movement is directed towards any other direction.

The quantitative results of experiments are summarized in tables 1 and 2. The results show the level of efficiency achieved according to the background image. Thus, an overall performance of 99.38 % was achieved on the test set.

Table 1. Results of experiments with light background, Dark Blue(DB) background, Dark Lead(DL) background.

CODE	light background		Total	Accuracy (%)	DB background		Total	Accuracy (%)	DL background		Total	Accuracy (%)
	Good	Bad			Good	Bad			Good	Bad		
Code 1	26	0	26	100	104	2	106	98.11	0	0	0	100
Code 2	64	0	64	100	336	0	336	100	99	0	99	100
Code 3	9	0	9	100	156	0	156	100	71	0	71	100
Code 4	1	0	1	100	88	4	92	95.65	6	0	6	100
Code 5	0	0	0	100	3	0	3	100	0	0	0	100
Total	100	0	100	100	687	6	693	99.13	176	0	176	100

Table 2. Efficiency in groups according to the background

BACKGROUND	Efficiency in Established Groups			
	Total Images	Good	Bad	Efficiency (%)
Light	100	100	0	100
Dark Blue(DB)	693	687	6	99.13
Dark Lead(DL)	176	176	0	100
Total	969	963	6	99.38

Conclusion

In this work we propose a method that allows to determine the movement direction of a finger mechatronic and therefore to improve the visibility of the *Argopecten Purpuratus*'s kidney. This method is based on location of the point on Red Coral's surface being the closest one to the kidney even if this point is not observed in the image. The results show the efficiency 99.38% for removing *Argopecten Purpuratus*'s kidney.

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