The Common Edible Shellfish Recognition System Applying Laser Measurement

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Abstract
Image recognition has been widely applied to sorts of fields. Nevertheless, the most common characteristics of image recognition, such as color, contour and texture, are liable to affected by illumination and the light of background leading to bias the recognized consequences. In recent years the technology of three-dimensional scanning has developed increasingly mature which could precisely measure the contour of fixed-shape objects. We take the three-dimensional contour as characteristics in the project. The comparative sample which will be used as for recognition was scanned every one mille meter from the leftmost to the rightmost in order to establish the three-dimensional object database, besides we sampled 540 dots for each scanning line. In order to shorten the testing time, we merely scanned two scanning lines while doing testing. The edible shellfish was taken as example in the research so we examined the characteristic for recognition feasibility. There were nine edible shellfishes used for experiment. Each category has individual thirty samples. We take leave-one-out for recognition mechanism that the rate of recognition could reach 89.70 and the average of recognition time was 5 second. The three-dimensional scanning is a new option for characteristic capturing. Furthermore, we will do our best to continue increasing the rate and speed of recognition to improve the practicality in the future.

Keywords: edible shellfish, laser, three-dimensional scanning

Introduction

Taiwan is an island country surrounding by oceans. Nevertheless, the marine bio-industry was well-known by the people. Although the marine bio-industry is one key branch of the Taiwan's economy. The Marine affairs and Marine education of Taiwan still need to be strengthened. At the beginning, we were trying to bring the life diet of delicious seafood of the shellfish and fishes to arouse people's interest in marine knowledge. Then the issues of marine resources, environmental protection, sustainable operations will be introduced gradually. The edible seafood was the start for most people to know anything about the oceans [1][2]. It provided the learning channel of edible seafood to help people trying to recognize the oceans. The shellfish occupies an important position in sorts of seafood in Taiwan. Besides of the delicacy, the beautiful contours and unique shapes of outer shells of many shell fishes which attract people's attentions and collections.

It is not easy for ono-professional to rapidly and exactly find the relating data of edible shellfish that there are tones of edible shellfishes and similar characteristics. Normally people will go to libraries or go surfing on internet to searching for related knowledge of the shellfish [3][4]. The shellfish has sorts of categories, complex shapes and colors. The general inquiry method would apply key words and representative graphs to search for shellfish. There is no way to get started with for those who were not expertise of this area. At present, the technology of image recognition in searching and probing which has been widely applied in sorts of inquiries [5][6][7]. On the other hand, practical teaching could increase the learning performance according to literature reviews [8][9]. The visitors could touch the physical shell by the practical teaching of shell demonstration and guidance. It could show the visitors the knowledge of three-dimensional shells under the circumstance of directly commentary. The comprehensive understanding of ecosystem, characteristics and related environmental protection knowledge of the shells which the visiting learners could touch, view from all angles, and listen to multimedia lectures. Such way of knowledge propagation is relatively effective and attractive. It is quite unfavorable for practical teaching that would consume much laboring commentary. The automatic recognition mechanism must be established before developing the automatic commentary system for practical shell knowledge. In general, such recognition mechanism could be accomplished by radio frequency recognition technology such as RFID and NFC. There different sizes of shell that for small-size shells were not impropriate for recognition tag. It is no way for this system to recognize whether the audience brought their own test bodies or untagged ones.

Another way is applying image recognition algorithm to recognize shells which system had got good results already. Image recognition usually applying the characteristics of colors, shapes and textures of the shell's test body to proceed recognition. The characteristic distortion would happen during the process of image recognition while came across different environments and the changes of lighting. For example the shadows of shells will affect the judgment of characteristic of contours demonstrated as the figure 1 [15][16]. Whether the lighting differences or using different lens while capturing images which also could affect the determination of the characteristics of colors and textures. The test body put on different locations while filming using the same lens which could lead to offsets of capturing angles. It demonstrated as figure 2 which A stands for shell put in front of the front edge of recognition box, B stands for shell put in front of the center of recognition box, and C stands for shell put in rear of the front edge of recognition box. The height of the object would lead to the variation of image characteristics [19].

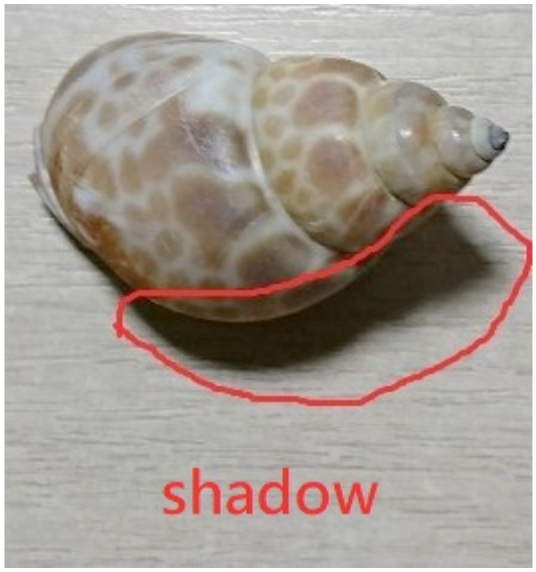

Figure 1: The misjudgment of the characteristic of contours caused by the shadows of the shell

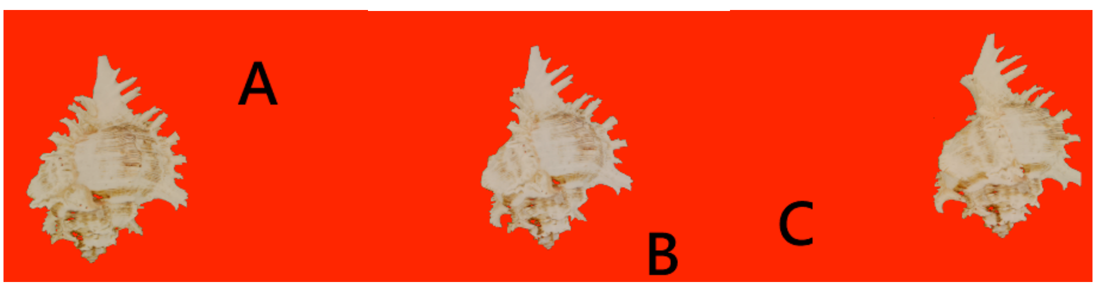

Figure 2: The distortions of the same shell putting in different locations

Besides the problems encountered of image recognition system above, shell image recognition still has to deal with the color differences of the dead shell and the live shell [19]. Once the shells exposed in the natural environments would fade away which could result to the losing exactness of recognition gradually while we took colors and textures as characteristics for recognition mechanism.

We build up a shell recognition system to solve up the problems above. The system is based on a closed recognition box to deal with the disturbs of outer lighting. The inside of the recognition box using four-sides of LED lightening board to provide sufficient light sources to resolve shadow issue and color differences caused by the variations of lights. The system could reach better recognition rate owing to overcome the environmental problems. The recognition box of practical recognition box demonstrated as figure 3.

Figure 3: Four-sided LED lightening boarded recognition box

The price of these four lightening boards were expensive which dramatically increasing the cost of system establishment. In order to assure the quality of lighting environment while proceeding recognition that the system needed to have the doors of recognition box kept shut. It isolated the lines of observer's sight from the shell which waited to be recognized. It led to poor perception of the observer while the shell was out of sight of the observer. It also resulted in poor recognition throughput for having doors shut while doing recognition.

The technology of three-dimensional scanning has developed increasingly mature and the high-quality optical environment was needed to cope with image recognition system which led to another issue of higher cost can be removed by using this technique. The three-dimensional contour was taken as characteristics of recognition in this paper. At first the contour datum of shells was saved as database. As for the shells needed to be recognized, we measured a couple of three-dimensional contour lines used to compare with the contours in database. The 3D contours of test body were taken as the characteristics of recognition. It could avoid the recognition system from the environmental lighting affects which the contour capturing errors caused by shadows. We took three-dimensional contours was characteristics which could prevent errors of recognition from gradual fade and blur of the colors and textures of shells.

System Architecture

The system consists of two hardware: one is for database, the other is for recognition. The hardware for database has to capture the complete three-dimensional contour of shells. While the hardware for recognition has merely to capture one or two lines of the contour.

The system for database was built up with a Raspberry Pi 3 Model B as the computing platform which connected a linear laser beam. The GPIO pin of Raspberry used to control 5-volt relay in order to determine whether the negative electrode was connected to the power supply for switching on and off this linear laser. While establishing the database we placed the edible shell on the scanning recognition platform or beneath the capturing system to recognize. We measured the height and thickness of the whole shell from the leftmost to the rightmost area by a linear sliding rail to drive with. We used the pins of RxTx via Raspberry to control the pre-coded Arduino Nano and the baud rate 115200 was applied to drive the stepping motor into operation by our in-house-protocol. Follow up was the image capturing system above the shell to capture the images of linear laser beams. And the system will calculate height and thickness of every area via laser spot to be part of the three- dimensional data of the shell. The linear sliding rail carried the measuring system running through the whole shell to get the complete thickness data of the whole shell and save them into database. The hardware system architecture used for database depicted as figure 4 and the practical outlook demonstrated as figure 5.

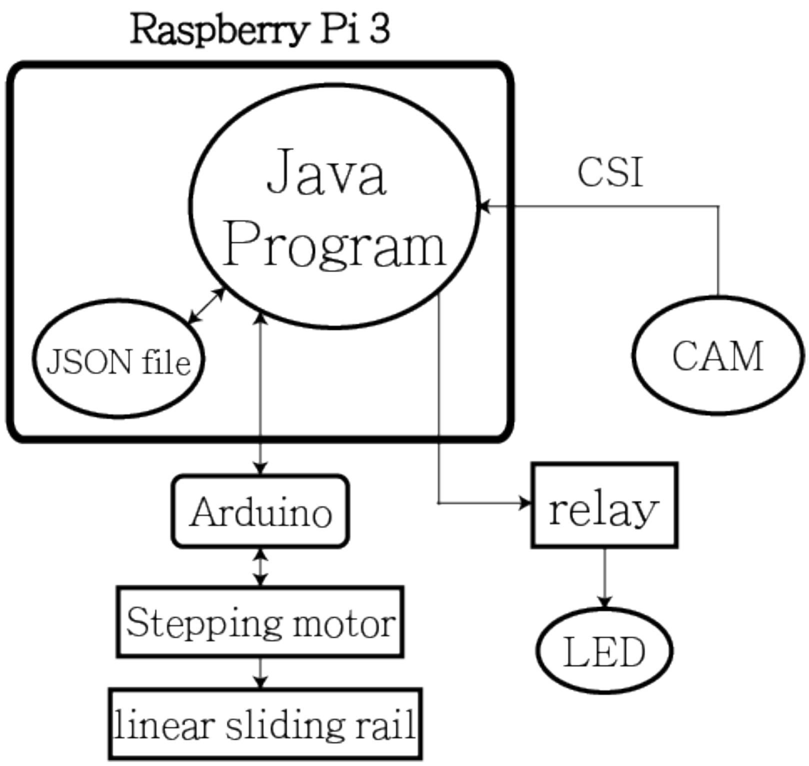

Figure 4: The hardware system architecture used for database

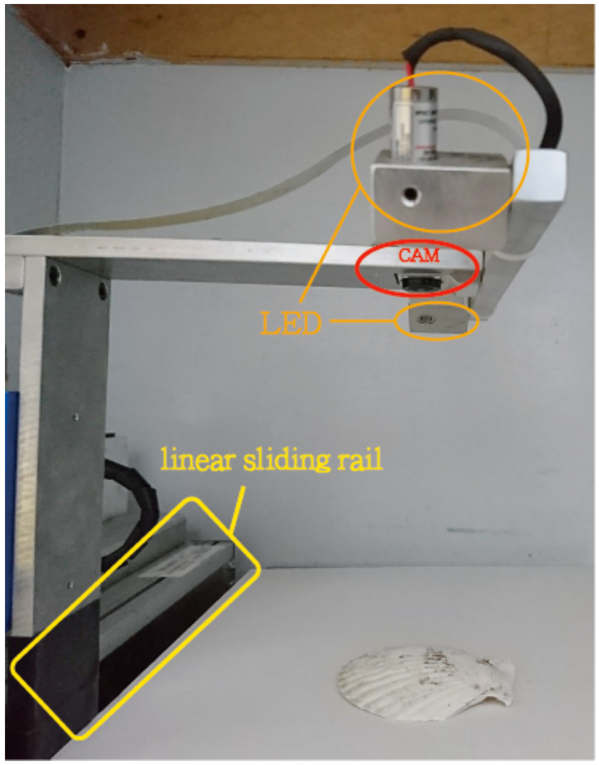

Figure 5: The practical hardware used for database

The recognition system mainly applying Raspberry Pi 3 Model B as its computing platform associated with two linear lasers to perform thickness measurements. In order to capture the images by system the users could place the edible shell on the recognition platform or beneath the capturing system which allows two linear laser's beams to project on the shell. Then the recognition process proceeded by two captured lines of thickness of the shell's contour, and the hardware architecture used for recognition demonstrated as figure 6. We applied two fixed-distance laser beam to sample measurements for recognition instead of sliding rail to speed up the calculation and reducing the cost as well.

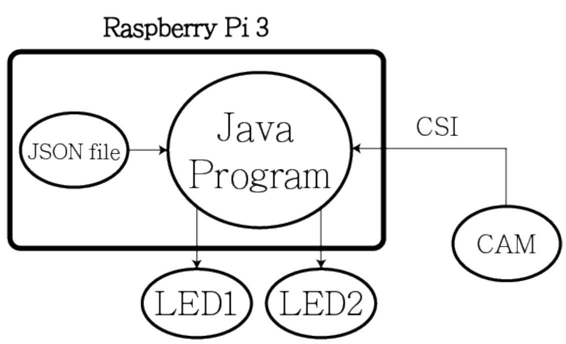

Figure 6**:** The hardware architecture used for recognition

The measurement theory

The measurement theory of the system is to employ linear laser beam projecting on different thickness of the object will reflect on different positions for users to measure with depicted as figure 7. To convert to the thickness of the edible shell by the reflection positions of laser beams via image capturing system. The linear laser was adopted by the system to measure the thickness of the straight line at a time for saving time. We could measure the three-dimensional data of the whole edible shell via shifting the sliding rail to alter the reflection position of the laser beams afterwards.

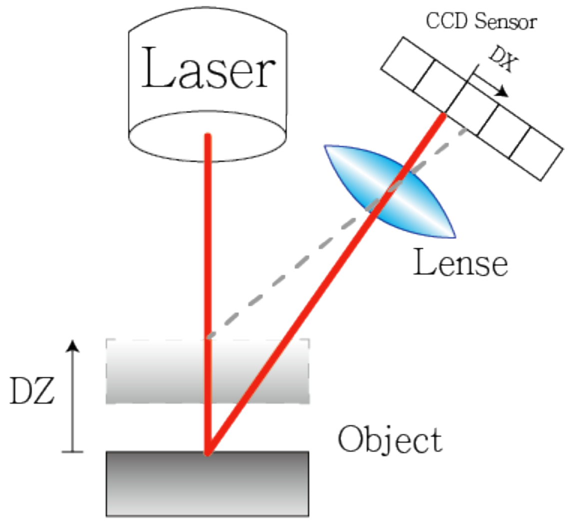

Figure 7: The schematic diagram of the projecting shifts of the linear laser beams

The measurement system

It cost a lot to build up a recognition box to isolate the disturbs by the outer lighting sources in the pass. We built up the system by laser measuring technology to bring down the production cost of recognition equipment. Even though the recognition rate was low which still met the standards of the exhibition hall.

Under considerations of decreasing the volume of the product, speed and recognition rate, the CSI interface of Raspberry Pi 3 Model B was connected onto the lens of 160 wide-angle Raspberry Pi Fisheye camera to capture images which both were used for database production and recognition system in this study. The system applied a Java programming to control image acquirement and proceed image analysis. The wavelength of the laser beam is 650 nm in the recognition system. In order to reduce noises that every lens was pasted 625-665 nm bandpass filter to adjust focal length till the picture was crystal clear demonstrated as figure 8.

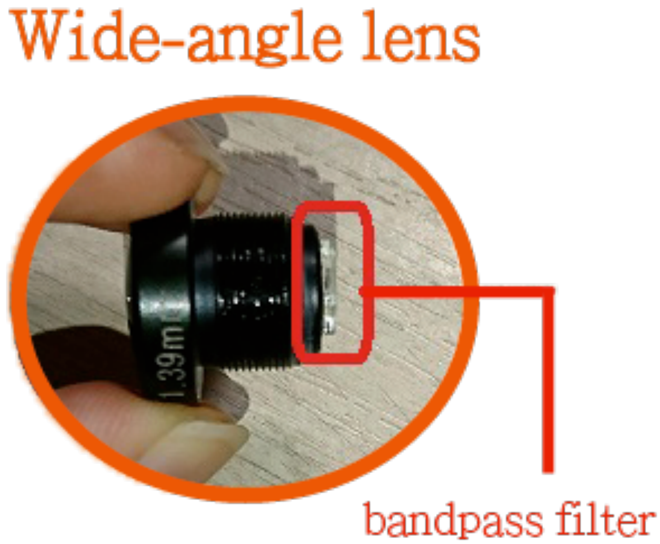

Figure 8: Wide-angle lens pasted with bandpass filter

The photographic parameters, such as focal length and area rate of lens, of low-price lens are unstable. Although there existed some descriptions of calculation in literature review. It was hard for us to neither directly and stably calculate the size of each image dot by our system, nor calculate the thickness of shell's contour by the amount of offset pixels. Moreover, it was too exactness to recognition. A lot of fixed-thickness' acrylics were used in which image calibration was applied to obtain the laser track's offset of each fixed thickness' acrylic. The related parameters in CSV format were stored in the text files of the system. Whenever the system gets started to operate the digital value of text file was accessed to be the measurement standards. While the image system obtained the laser offset image then compare with the closest record in the text files to be the thickness measuring data. Same as the length measuring data was gained through the image calibration.

The measurement algorithm

While building up the database the shells were proceeding completely precisely measurements. So it consumed much longer time to measure with. We used simple measurement for shell recognition. The measurement algorithm for database establishment was described in detail as follows.

The outer shapes of some shells were close to circular one demonstrated as the figure 9: the lateral view of Areola Babylon. If we only applied one-side laser beams, then some parts of shell would be masked which resulted to no way to precisely measure. Therefore, in this study the database for the system would use left and right individual linear laser beams. At first the system started up the left-side laser till the laser beams was found out projecting on the left contour of the shell, began to scan scan shell's contour of each area until image capturing no sight of laser beams. Follow up we turn off the left-side laser beams and turn on the right-side laser beams to scan the last of shell's contour until the right contour of the shell was discovered demonstrated as schematic figure 10 steps of shell's contour scanning.

Figure 9: The lateral view of Areola Babylon

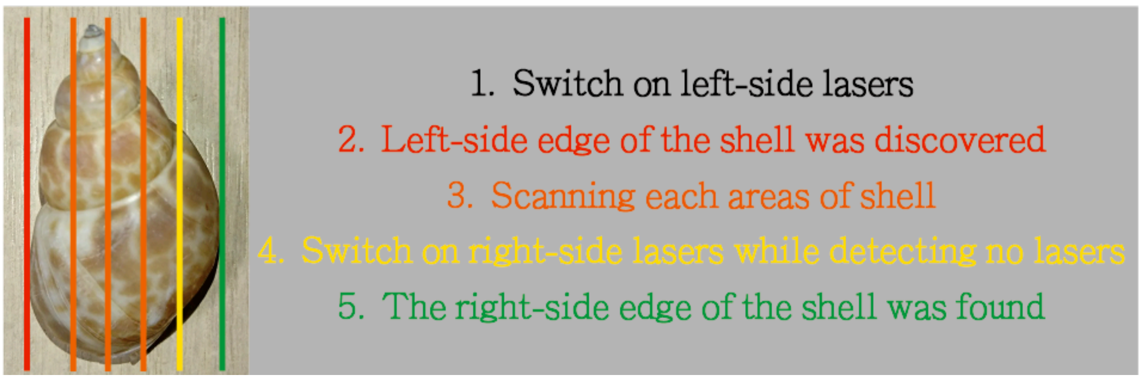

Figure 10: Steps of shell's contour scanning

While beginning measuring the system commanded the sliding rail return to reset, then it captured images via the upright capturing system. Each time the sliding rail marching on one centimeter to probe whether in the measuring range of object. When the system was in the measuring range, bisection method was applied by the system to control the sliding rail moving backwards and reducing the marching shifting distance. Every time the sliding rail will move on the half distance of last one until the left-edge of shell was located demonstrated as schematic figure 11: the marching way of sliding rail-left-edge of the shell.

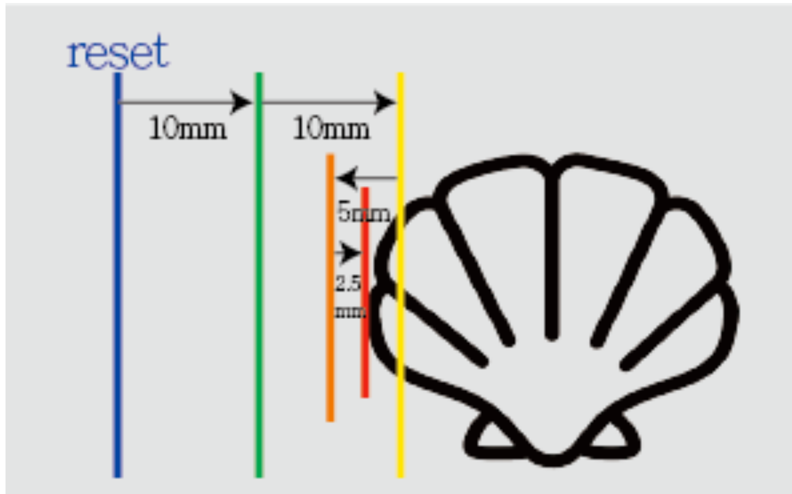

Figure 11: The marching way of sliding rail-left-edge of the shell

Once the left-edge of shell was located, the linear sliding rail moving forward 1mm to precisely measure each value of shell's contour's line. Till the system could not capture the values when left-side laser beams project on the shell, then the left-sine laser beams were shut down immediately. In the mean time, the right-side laser beams were turned on and moving in 1mm at a time to measure. While the system discovered the right-side laser moving beyond the right-edge of the shell, it would move backwards and reduce the sliding distance till the right-edge of the shell was found. It is the same of searching for the left-edge of the shell demonstrated as schematic figure 12 the way of linear sliding rail moving - right-edge of the shell.

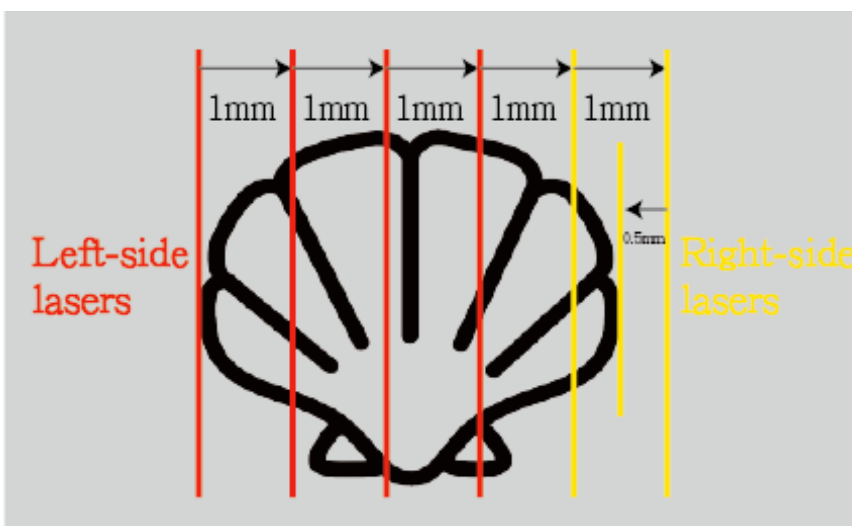

Figure 12: The way of linear sliding rail moving - right-edge of the shell

The same way will be applied in recognition measuring. There is neither no need to look for the edge of shells, nor having linear sliding rail for complete measurements. There were only data of two line captured by two fixed distance lasers to compare the data of the database.

Characteristics captured and normalization

All lenses were pasted 625-655nm bandpass filter to reduce noises while the system using image system to capture images. The 625-655nm bandpass only allows those lengths of this range to passing through, therefore which lights out of the range would show in dark grey demonstrated as figure 13: the image of half-shell scallop captured by image capturing system, and the red lights are linear laser beams.

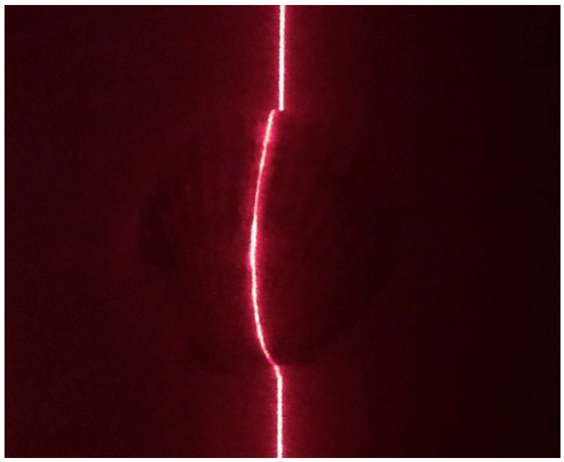

Figure 13: The image captured by image capturing system

Once images were captured the system would determine whether the dots of images were laser reflection or not. The length of laser beams was 650 nm belong to the range of red light, so we apply RGB as the way of judgment. The default is R is greater than 10 as a range to determine whether is laser reflection and probe the distance between center of red light and laser to be laser offset.

Shells were placing in different locations when measuring. We moving all data of shells to the top of Y-axis in order to reduce errors. The system scanned from the top of Y-axis while establishing database. If there were more than four consecutive Y-axis measured points belong to highly data, then they could be taken as the top of Y-axis. The system took this top of Y-axis as origin and moved all the scanning records to the corresponding positions. This is Y-axis normalization of the system demonstrated as schematic Figure 14.

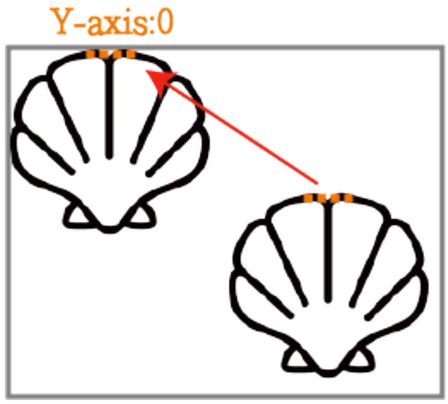

Figure 14: Y-axis normalization

Characteristics comparison mechanism

We took these two measuring results of shell to be measured which compared respectively with all three-dimensional measured data with same distance within the database. Then the KNN[19] were be applied as characteristics comparison mechanism.

The experimental steps and discussions

The experimental environment

In this experiments we captured images under the indoors light of resolution of 960X540. There were nine common edible shellfishes used to measure in these experiments. There were thirty pieces of each species of shellfishes to build up database system. The specimen of shells depicted as table 1.

Short-Necked Clam	Clam
	
Chlamys Madreporarum	Half Shell Scallop
	
Shelled Abalone	Corbicula Fluminea Formosa
	
Solen Strictus	Areola Babylon
	
Half Shell Oyster	
	

Table 1: Nine common edible shellfishes

The Experimental Process

In order to speed up the recognition rate that we initially scanned all the shells in completely three-dimensional way to build up database. Then the way called Leave one out [21] was applied where one shell was taken out of database to be recognition target, and the others to be the testing database. The certain line data of shell of database was chosen to test its correct rate. In experimental process, the distance of two line was measured 11mm were chosen to compare with database. In the way of KNN, and K=1 to compare.

Experimental results

The time for building up one single shell's data into database along with the size of the shells and how many time it measured. The average time is about three minute-ish to establish one piece of database.

The experimental results demonstrated as table 2. The correct rate reached 89.70% the highest one while we took the eleventh line as measured data (the distance with the edge was 1.1 centimeter).

Distance (mm)	Baseline	Recognition Rate
3	15	80.91%
5	14	83.03%
7	15	86.36%
9	12	86.36%
11	11	89.70%
13	8&12	86.67%
15	4	87.88%
17	4	88.48%

Table 2: Correct rate of recognition

Discussions

From the experimental results, only taking two three-dimensional thickness' data to recognition was worse than the performance of traditional image recognition. However, the recognition rate of the system has reached 89.70%. If we listed the most similar top three as other users to apply other ways to recognition, then the correct rate could reach 100%. Furthermore, the placing locations by users could affect system recognition. In general, the recognition rate is high while the laser beams projecting on the center of shell (more effective measured points). On the contrary, it is lower. In the future, either associated with other characteristics to reinforce integral recognition, or detect the measuring amount of measuring point where locations users placing shells avoid from recognition failures, both are ways to strengthen this system.

Conclusions

This study has achieved that one set of laser equipment to measure three-dimensional contour of shells to be recognition characteristics which could avoid taken image characteristics as recognition required highly stable light sources environment. Under the circumstance of applying Raspberry Pi associated with linear red line laser, thirty pieces of nine species of shellfishes to reach the recognition rate of 89.70%. If all the first three recognition results were correct, the recognition rate might reach 100%. In the future we will carry on either reinforce integrating other characteristics or warning for too less measured points, so that the system could be strengthen enough to demonstrate in exhibition hall.

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