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Cooking Support System Utilizing Built-in Cameras and Projectors

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Abstract

This paper proposes a new cooking support system. Cameras and projectors are installed above the kitchen counter. Information such as size, position and direction of the ingredient are measured by analyzing the camera image. The projector displays necessary information onto the ingredient in the overlay by using the information. The idea of research for a novel cooking support system utilizing this new method achieves is discussed in this paper and the effectiveness of the system is shown by a prototype.

1. Introduction

Research of cooking support system is becoming more active[1][2]. In some cooking support systems, multiple cameras are set up above the kitchen counter to recognize the sort of the ingredient, position of the ingredient, and the process of cooking[3]. We propose to add projectors and to support the user's cooking by overlaying cooking instructions based on the result of recognized information by cameras. As a result, the cooking method can be displayed in the free space of the table smartly. Moreover, it becomes possible to superimpose information for cooking (ex. how to cut) upon the ingredient when it is necessary. Another feature of the present study is the conversation robot. This is a very big advantage. For instance, it is assumed that the user is embarrassed because it is necessary to mix the seasoning with the ingredient but he or she doesn't understand how to mix it concretely. In such a case, the user looks to the robot and asks "Let me know how to mix it". Then the robot answers "Do it like this" projecting animation to empty space of the kitchen counter. When the user is wandering which, part should be cut. The robot can teach the user where and how to cut by drawing a line on the ingredient.

2. System design

2.1. Kitchen counter

Figure 1 shows the overview of the kitchen counter of this cooking support system. Figure 2 shows the installation of cameras and projectors. Figure 2(a) shows the lens windows of cameras and projectors above the kitchen counter. To cover the whole of kitchen counters except the gas stove, three cameras and two projectors are arranged as shown in Figure 2(b). The appearance of cameras and projectors on the ceiling is shown in Figure 2(c).

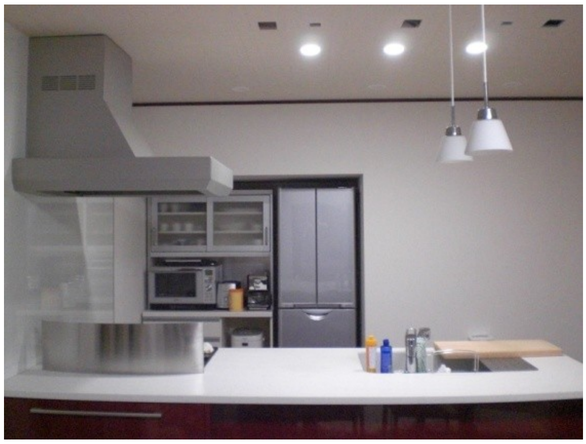


Figure 1. Image of the entire kitchen counter

2.2. Outline of cooking support system

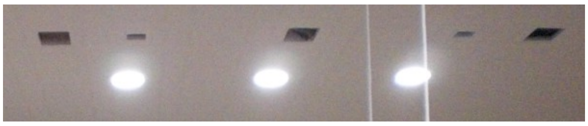
Using an example of cutting fish in three fillets, the outline of the cooking support system is described here.

1. The user boots up a system without ingredient on the cutting board.
2. The system takes a picture on the cutting board, and records it as a background image.
3. When the user puts the fish, the system recognizes the fish by the background subtraction and shape matching.
4. Based on fish's recognized position the system displays the speech balloon as a cooking instruction on the fish.
5. The system recognizes the progress of cooking by the movement of user's hand using the background subtraction.
6. The system directs the place where the fish should be cut according to the cooking method by displaying the line.

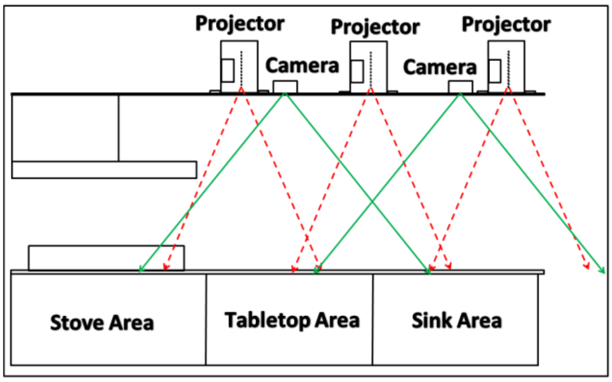
Thus, the user advances cooking following to the instruction of the system, and can easily cut the fish in three fillets.

2.3. Method of the fish recognition

Fish's position, the size, and information of direction are necessary to display the procedure of cooking in the overlay. To do so, the object that exists first on the cutting board is recognized. And, it is recognized that it is a



(a)Lens windows of cameras and projectors



(b)Layout of cameras and projectors

(c)Installation of cameras and projectors on the ceiling

Figure 2 built-in cameras and projectors

fish in the next step. The background subtraction is used for the object recognition on the cutting board. The MatchShapes (match of shape by the Hu moment invariant) function of OpenCV, Open Computer Vision Library [4], is used to recognize that the extracted object is a fish. In the background difference, to respond to the fact that brightness changes while cooking because of the outside light, the background image has been updated[5]. Moreover, in the shape recognition of the fish, aiming to raise the recognition rate of fish's position and posture, shape was matched by dividing shape into the part of fish's head and the part of the tail. This division type match method enables the recognition of fish's shape to be continued even when cooking person's hand gets on on the fish.

2.4. Display of the cooking instruction

Information is displayed on the fish that recognized it with a projector installed above the kitchen counter and the overlay was displayed is shown in Figure 3. The cooking method is presented by projecting the speech balloon such as "Please take the scale". It directs by drawing in the speech balloon and the line in the place where the fish should be cut. It is judged where to be cut from the position, the direction, and size about the fish. When it is necessary to turn around the fish, it devises of directing the user by displaying the arrow and the balloon of the meaning of rotating or reversing.

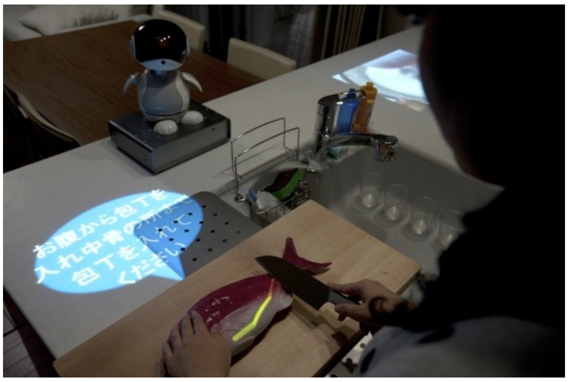


Figure 3. Projection of speech balloon and cutting line

The operation of user's hand is used to advance the step in this cooking support system. A method of using coming in succession of user's hand area and the area of the ingredient as a judgment whether the user added the processing operation to the ingredient is proposed[6]. This method is used as a trigger that advances the step also in the present study. However, in the case of image recognition errors it is necessary to confirm it by talking with the conversation robot.

The speech balloon displayed with the projector interferes with the background subtraction. Therefore, when the image is acquired for the background subtraction processing, a black image is temporarily output from the projector.

3. Implementation

3.1. Experimental environment

Equipment of the following specs is used for the experiment, and OpenCV is used for add the picture processing.

PC: Dell Precision M6400 Intel(R) Core(TM) Duo CPU T9600 2.80GHz, 3.48GB RAM, Microsoft Windows XP Professional version 2002 Service Pack 3

Projector: Panasonic PT-FW300, resolution 1400 × 1050, horizontal scanning frequency 65.49kHz, vertical scanning frequency 60.19Hz

Camera: ViewPLUS Dragonfly2 DR2-HICOL, resolution 1024 × 768, frame rate 15fps

2.13. Detail of implementation

This chapter describes the results of an experiment as an example of fish fillets using a fish's model. Figure 4(a) is an input image when beginning to cook, and Figure 4(b) is a background image used for the background difference processing. Figure 5 shows the background subtraction result. Objects which have the size more than the threshold value in the result of the background difference are left. The result of extracting the outline to those objects is shown in Figure 6. Next, obtained outline images are collated with a template outline image of the fish (Figure 7) prepared beforehand. The shape matching by the Hu moment invariant is used for this collation. As a result of the shape matching, the object that satisfies the threshold is left as a fish candidate.

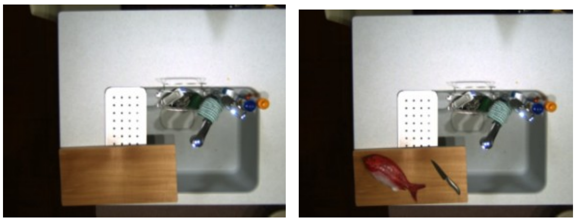


Figure 4 Input Image (a) and (b)

Figure 5.. Result of background subtraction

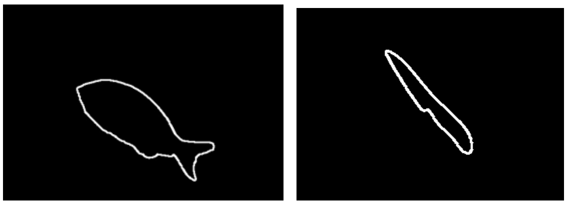


Figure 6 Pulled out outline images

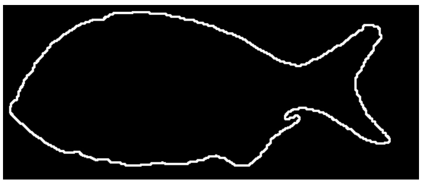


Figure 7 Fish's template image

Whether it is really a fish can be checked more in detail by using fish candidate's size and posture. Here, the minimum rectangle circumscribed for fish candidate's outline image is first drawn (Figure 8). Because fish candidate's posture is understood from this rectangle, it is corrected to become the horizontal (Figure 9).

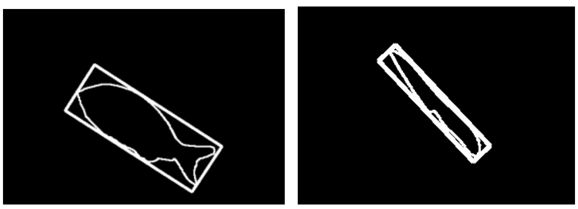


Figure 8. Minimum rectangles that enclose contours

Figure 9. Rotated images on minimum rectangle

Here, we have to recognize which side is the head to decide the direction. Outline images on the fish candidate's right half and left half are collated with an outline of fish's tail template image. When the fish candidate's direction is detected, an outline image of fish candidate's head and tail is collated with an outline image of the head and the tail of fish's template (Figure 10) again more precisely. The fish candidate who satisfied the threshold is a fish.

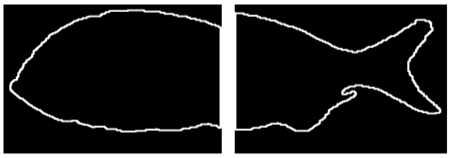


Figure 10 Template image of shape of fish's head and tail

After the fish's position, posture and size are recognized, the cooking method is directed by projecting the balloon. When the fish is cut, it is directed by projecting the line of cutting plane and the picture of the kitchen knife onto the fish (Figure 11). Therefore, it is comprehensible how to move the kitchen knife when the fish is cut. After fish's belly is cut, it is necessary to turn around the fish to cut the back. In this case, it is directed to rotate to parallel respect to the cutting board by projecting the balloon and the arrow (Figure 12).

Figure11 Projection thing when fish is cut

When the opposite side is cut, the fish should be reversed based on the line where fish's head and tail were connected by instructing the balloon and the arrow (Figure 13). At this time, it is necessary to recognize the inside and outside besides the back and forth in the direction of the fish. Therefore, the inside and outside was recognized by referring to the history of fish's posture recognized in the past and the user's operation (rotated and reversed).

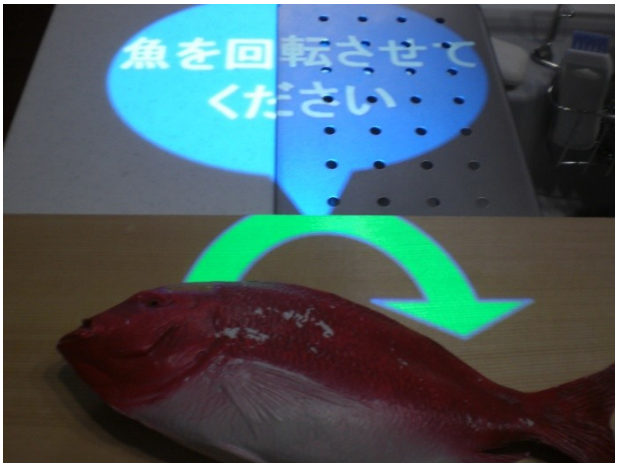


Figure 12 Image that draws in rotation instruction

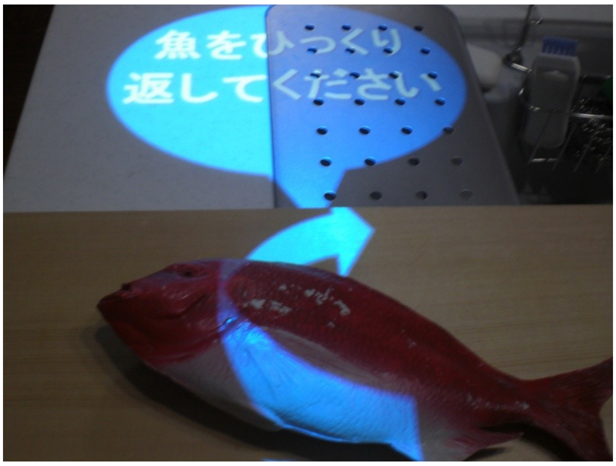


Figure 13 Image that draws in reversing instruction

2.14. Results

A simple evaluation of this system was conducted using a few test users. The cameras and the projectors above the kitchen counter worked well as expected. The system could plainly teach the users the cooking method. However, it was found that the critical usage of the kitchen knife along the bone is not shown under the present situation by the overlay display. The current system is made to understand how to cut it showing the user the sample video about this. This system is judging the progress of the step of cooking by using only movement information of the hand and the ingredient obtained by the background difference method. It was found that this judging method is not enough and all the step-by-step recipes cannot be covered only by this method.

4. Conclusion

A cooking support system that set up cameras and projectors above the kitchen counter is proposed. This system overlay the step-by-step cooking instructions onto the ingredient, using the information recognized by the cameras (size, position, and inclination of the ingredient). A cooking support system to cut a fish in three fillets was made for trial purposes, and the effectiveness of the system was confirmed. The proposal method showed that a considerably complex cooking procedure was able to be shown the user very correctly. However it was understood that the step progress control only by the judgment of the hand movement is insufficient. It was also understood that another strategy is necessary to tell an advanced usage of the kitchen knife. These are future tasks.

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