Automatic Dish Recommendation System for People Dining Together: The Group FDT

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Abstract

A tabletop dish recommendation system for multiple participants dining together in response to their dining status, which is named the Group FDT (Future Dining Table) is presented. The system always recognizes the dining status of the users and recommends dishes timely. The recommendation and its displayed position on the table are based on the investigation of real dining, literature, and the experimental result. The system is expected to be useful in filling the staff shortage in the food services such as a Japanese pub which often receive additional dish orders.

1. Introduction

Dining is clearly indispensable for our life and closely connected to the feeling of happiness and the life quality. Recently, as the significance of eating activity to our life has been noticed, more attention has been paid to the dining field. Now the information and communication technologies have been positively applied and promoted in almost all fields, however, its contribution to the pursuit of happy dining has not been made enough; dining environment is one of the few that has not changed much.

In this paper, we propose a tabletop dish recommendation system for multiple participants dining together, called the Group FDT (the acronym for Future Dining Table). Considering the recent and future shortage of labor supply, it will become more difficult to keep good employees who are capable of recommending another dish which matches the dining status of the customers. This system is expected to be useful as a substitute of a food server in such situation. A good example of the type of restaurant we think is a Japanese pub. There the staff is often busy in responding many additional dish orders from the floor because ordering additional dishes in the middle of dining is the normal dining manner in this type of restaurant. At the same time, there the number of the staff is often not enough to take care of all the customers, sometimes resulting in making the customers waiting for a while.

The chapters are composed in the following way. Proposal and design of the system is described in Chapter 2. The system implementation is proposed in Chapter 3. The dishes recommendation rule is introduced in Chapter 4. The related research is described in Chapter 5, and the conclusion is given in Chapter 6.

2. System proposal and design

2.1. System proposal

Compared with ordinary restaurants, those higher class ones offer services considering the customers' demands. The staffs in those restaurants are so trained that can recommend dishes and drinks properly according to the customers' conversation atmosphere, facial expression, their dining status and many other elements. The recommendation made by experienced staffs usually makes customers be satisfied because the dining situation and eating habits of the customers are taken into consideration carefully [1]. The service provided during dining is often called midway service. To not cause customers' dissatisfaction, the timing of giving service is essential [2][3][4]. Taking the recommendation service for instance, it is significant to recommend the desert for promotion in a restaurant as soon as the dining finishes [3][5]. However, recent labor shortage makes it difficult to provide such a fine recommendation that would be supported by the customers and that would contribute to the sales at the same time. We thus propose a tabletop dish recommendation system for multiple participants dining together, which is named the Group FDT (Future Dining Table). It should be capable of substituting for a serving staff in a restaurant.

2.2. System design

The system needs to fulfill the following requirements to fulfill the goal of substituting for a serving staff.

1) The system is capable of making a recommendation.

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Figure 1. Appearance of the system in use

2) The system is capable of making a recommendation effectively.

To achieve 1), the system should always recognize the dining status of the users. To estimate dining status accurately, user's dining activity is recognized and dining status history is stored. The history includes the information such as who ate the dish, what dish was eaten, and when the dish was eaten. To confirm the dining progress, the amount of food left in each dish is measured. Since the dining activity is recognized from a USB camera placed over the dining table, it is not necessary for user to wear any sensors, which would make them feel much more comfortable when dining.

Another important factor for effective recommendation is how the recommendation is shown to the users. To achieve 2), the displayed positions of the recommendation on the table are based on the investigation of real dining, literature, and the experimental result.

The appearance of the Group FDT system in use is shown in Figure 1. The recommendations are shown on the table. The system is assumed to be useful in a restaurant where additional dishes are usually ordered. It is assumed to replace or to help waiters when human resource becomes more precious.

3. System implementation

To recognize the dining status of multiple users, 4 USB cameras (resolution 640*480 pix) are set 125cm above from the dining table. In this way, the USB camera recognizes the dishes without taking the image of user's face, which protects user's privacy. The data collected by the 4 cameras are handled by each client PC and then sent to the server PC as the dining information. A projector of XGA resolution is set up 165cm high from the dining table and is connected to the server PC, which is used for showing recommended dish images on the table.

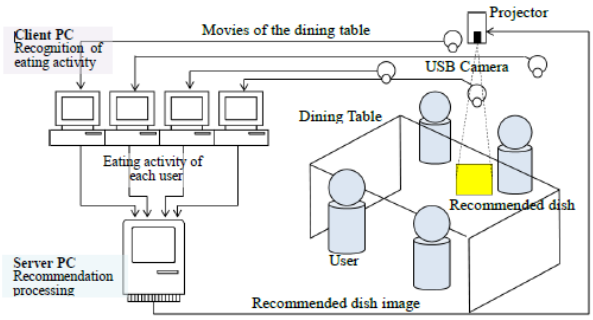

Figure 2. System architecture

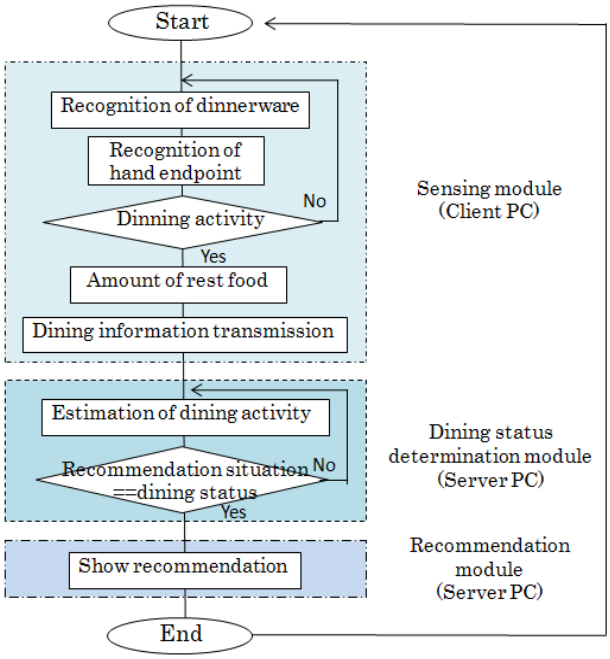

Figure 3. Software procedures

The system software includes 3 modules, sensing module (client PC), dining status determination module (server PC) and recommendation module (server PC). Figure 2 is the system architecture. Figure 3 is system software procedures.

3.1. Sensing module

Sensing module is about the sensing of user's dining data taken by each camera. Regarding the center of dining table as the origin, the table is divided into 4 areas, and each camera covers one quartile of the dining table and takes one user's data. The resolution of each camera is 640*480 pix, and the dining table is sensed by resolution

1280*960 pix. The size of the table is 120*90cm, so that every pixel covers the area about 0.094cm on the table.

After camera capturing the image of the table, the tableware and user's hand are recognized, and then the distance between dishes and chopsticks is calculated. This is suggested as the sensing module procedure. As the dining activity is considered to be done by the recognition, the rest amount of food is going to be computed, the data, including dining status and rest food amount, will be sent to server PC. The real time image processing is implemented by OpenCV.

OpenCV is an open source computer vision library originally developed by Intel. Each processing in sensing module is composed in detail as follows.

3.1.1. Recognition of dishes. Dishes are equipped with different colors by the rim to be recognized in this system [6] [7] [8] as Figure 4 shows. The system extracts the color of each dish rim, which is labeled. The labeling is used for picking the area which is bigger than a certain value to reduce the image noise. The maximum minus minimum values in X axis and the maximum minus minimum values in Y axis of the extracted area are used to calculate the midpoint of the dish. Also a cup is recognized by the color equipped in the cup handle. Other recognition technique, such as the shape of the dishes and the markers of the dishes can also be applied, but not implemented in this system.

3.1.2. Recognition of chopsticks. During dining, user's chopsticks are moving towards to the dishes. So that, in this Group FDT system, the distance between dish and chopsticks becomes the basis to confirm dining activity [6].

The endpoint of chopsticks is processed by OpenCV background extraction. The image of the table is captured first as the background. To cope with the gradual change of the shooting condition, every frame is combined at the rate of 0.01 with the background. To cope with the change of the dish location and the change of the recommendation image, the background is updated. It is replaced by the foreground image when the foreground remains the same in 25 consecutive frames. The background is subtracted from the current frame by this, and the changed region would be gained. After the opening to reduce minor noise, the region with certain area (more than 2000pixel) is extracted by the labeling and regarded as user's hand area. In this area, the furthest point from user's body is supposed to be the endpoint of chopsticks, and the coordinate of it is figured. This is the recognition process of chopsticks. Recognition of other cutleries and according dining behavior can be used to expand the applied area of dining of the system in the future.

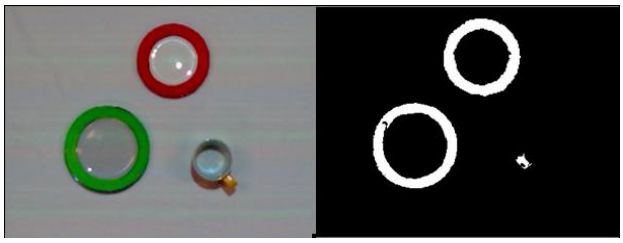

Figure 4. The color is given to each dish (left) and extraction of the color (right)

3.1.3. Recognition of dining behavior. The system recognizes the close distance between dish and endpoint of chopsticks, and the lasting time, as the judgment of one dining behavior [6]. When the distance is shorter than the dish radius, the user is considered to be taking the food. However, sometimes the endpoint of chopsticks could not be recognized because the angle or the thickness of the chopsticks is changeable. To solve this problem, if the distance is as less than (dish radius+ 20pix) (about 2cm), and this situation lasts for at least 3 frames (about 0.3s), then the user is regarded doing one eating behavior.

The recognition of drinking behavior is almost the same, if the distance between the finger endpoint and the cup handle is close enough, and lasts for at least 3 frames (about 0.3s), then the user is regarded drinking.

3.1.4. Calculation of rest amount of food and drink. The rest food amount left in the dish could be known by calculating the food area in the plate [6]. The radius and midpoint of the dish are learnt from the recognition of dishes step. Count the total pixel numbers of the dish area first. The area not white is regarded as food area. Calculate the pixel numbers of food area in the plate by HSV model, then how much user eats is possible to be calculated. The food area in the first captured image is considered as 100%, and the percentage of food left is calculated all the dining time.

It is difficult to recognize how much the beverage left in the cup by camera. However, if the number of drinking to finish a cup of beverage is known, how much remains in the cup can be easily estimated. Set the total drinking times of one beverage, the system recognizes how many times user have drunk from it, then the left times will be considered as rest drink amount.

3.1.5. Transmission of dining activity information. User's dining information is transmitted to server PC. Socket communication (Winsock) is used for transmission. The information sent to server PC includes the user ID, eating time, eaten dish NO., rest food amount, and the coordinate of dishes. User ID is the IP address of the PC, so that each user could be recognized because of the different IP addresses. Eating time is the timing dining behavior determined. It has been discussed in recognition

of dining behavior step.

All these information is stored for the dining status determination module. The coordinates of dishes are used when showing recommendation in the recommendation module.

3.2. Dining status determination module

Dining status determination module is about determining the dining status on the basis of dining activity information, and storing the dining history from sensing module.

The determination of dining status is estimated according to the following 7 situations. The dish recommending is based on both this and the recommendation rule in Chapter 4.

1. rest amount of total dishes is less than 25%
2. rest amount of total dishes is less than 5%
3. rest amount of sharing dish is less than 25%
4. rest amount of personal dish is less than 25%
5. rest amount of drink is less than 25%
6. have one dish· drink three times in a row
7. have one dish· drink more than 7 times among 10 times

The recommendation timings of rest amount less than 25% and 5% situations are made according to the investigation about acceptable recommendation timing [9], which tries to make user be more willing to accept the recommended dishes. The estimation of consecutive eaten dishes (6), and dishes be eaten in high frequency (7), are figured out from the dining status history.

3.3. Recommendation module

What kind of dishes and drinks are recommended during dining is described in this chapter.

3.3.1. Dish recommendation rule. Table 1 is the rule for food recommendation. It shows that the recommended dishes and objects under different dining status. The recommendation target, even is all the participants here, just occupies part of all the diners in daily life. As for the recommended dishes, the recommendation algorithm itself is not the focus of this research, so we have applied the investigation results of the orders in Japanese restaurants. Based on this investigation, what is ordered as an additional dish, soupy rice or desert, could be come out. The reason for choosing fried potato or dumplings as recommended dishes, is also depend on the investigation, that often be ordered after fried chicken and Caesar salad. Young soybean is recommended for people drinking beer frequently, because beer and young soybean are ordered at the same time generally.

3.3.2. Drink recommendation rule. Table 2 is the rule for the drink recommendation. This rule is not only made from the initial investigations but also made from the ordinary order sequence [11]. Beer is often ordered at first, the second order usually is Chūhai, and wine, sake or cocktail is ordered as the third order. As a result, the drink from the first to the third is recommended following this rule. As to the recommendation from the fourth drink, those not be drunk too much will be recommended in terms of dining status history. As to the soft drink recommendation when dining finished, the Oolong tea is known as the frequently ordered soft drink after drinking alcoholic drink.

TABLE 1. Rules For The Food Recommendation

Condition	Recommendation target	Dish of recommendation
All dishes are less than 25%	All	Soupy Rice
All dishes are less than 5%	All	Vanilla ice cream
Caesar salad in big dish is less than 25%	Part	Dumplings
Caesar salad in individual dish is less than 25%	Individual	Dumplings
More than 3 consecutive bites of fried chicken	Individual	Fried potato
More than 7 swallows of beer in the recent 10 bites	Individual	Young soybean
Others	None	None

TABLE 2. Rules For The Drink Recommendation

Condition	Number of cups drunk	Dish of recommendation
Dining begins	1st cup	Beer
Drink is less than 25%	2nd cup	Chūhai
Drink is less than 25%	3rd cup	Wine, Sake
More than 2 orders of beer	After 4th cup	Chūhai
More than 2 orders of cocktail	After 4th cup	Shōchū, Sake
All dishes are less than 5%	None	Soft drink

3.3.3. Displayed position of recommended dishes. Here is about the location of recommended dish image, thus the dishes coordinates are necessary here. This system is able to change the image location automatically according to the real time dishes location on the table. With the dish location information learnt from the sensing module, the blank space without dishes and where users feel comfortable is searched for showing recommended dishes images. Furthermore, a promotional dish might be ordered if the location of real dish is taken into consideration. The user could see the dish location intuitively. The location of recommendation is determined by the distance between dishes and the location of the tableware [10].

During multiple participants dining, usually, every customer has his own personal dish near his hands while also sharing big dishes in the centre of the table with other people. So the personal dish is supposed to be shown beside use's hands, and big sharing dishes is supposed to be shown in the centre of the table.

4. Related research

The Another Dish Recommender system, the first FDT, recognized dining activity by the visual markers attached to a user's hand and the bottom of dishes [7][8]. This made it difficult for the user to perfectly focus on the dining itself. Furthermore, a hand in using may change the angle of the visual marker attached, which was sometimes resulted in inaccurate recognition. The acrylic dining table was so transparent that the dining activity could be easily recognized from the bottom surface. This made the user see his/her own feet and the facilities installed there, which might cause his/her unhappiness while having dinner. The rest food amount was estimated from the eating counts, which was not very accurate.

Then the recognition method including the rest food amount was changed to image processing by the camera placed above the dining table [6]. This system was however for single participant. The system proposed in this paper is the same in that it recommends dishes based on the recognition of dining status, but is different in that it is for multiple users dining together and in that the recommendation is better designed.

Chang's eating monitoring system uses the dishes with RFID tags and the food tray with an RFID reader, a load meter and pressure sensors [12]. It can measure every step of weight reduction of food. What and how much has been eaten can be recognized. But the cost is expensive and it does not concern about the behavior of the user. The proposed system in this paper recognizes dining activity only by USB camera.

Recognition of video-recorded dining behavior has been proposed by Qing [13]. Hand movement is detected and eating is recognized from the video of a dining room by using Conditional Random Field. Qing's research recognizes only drinking activity, while this system recognizes both dining and drinking.

To recognize the consecutive the dining activity, from getting food by chopsticks to putting food into mouth, Miyawaki installs an acceleration sensor to user's wrist to detect his/her wrist wrench and elbow twist[14]. Since user needs to wear the acceleration sensor, it is giving burden to user during dining, while the recognition of dining activity in our system is made by cameras only. There is not any burden or pressure for users.

In welfare and medical care, such as Takeda's research [15], meal has been recorded for management of health. This record is typically a written memorandum showing the given menu or sometimes the remains after meal. Because making a written meal record is time consuming and is not easy when there are many clients, automatic recording of meal has been researched in welfare information technology.

A lot of researches concerned about dining activity supported, including interpersonal communication, have been worked. Mori develops a system for cooking optical decorations and storytelling [16]. The decorations and stories given by the cooker are changeable according to user's dining status. To recognize the dining activity in Mori's research, dish recognition, dish location detection, and the rest amount of food, are implemented by image processing. Our system not only recognizes these elements, but also detects other dining status, as who ate the dish, what dish is eaten, and when the dish is eaten, and then recommend dishes according to dining status history.

"Sixth dish" by Amano is a system to help interpersonal communication during dining [17]. It projects pictures on vacant dishes from above so that pictures give clues to start conversation. This research supports meal times in terms of communication but it does not use dining status or a user's behavior.

An agent to support interpersonal communication during dining was developed [18], while the Group FDT presented in this paper is for dining support.

5. Conclusion

The Group FDT has been proposed, designed and developed. The system recognizes multiple users' real-time dining activity, stores it as the dining history, and gives dish recommendation in response to the dining status obtained from this information.

The system applies image processing for dining recognition by simple and inexpensive equipment such as cameras installed over the dining table. The dish recommendation is shown on the table by a projector. The image location of recommended dish is changeable depending on whether it is a personal dish or a shared dish.

The current system uses redundant devices, namely four cameras and five PCs, because it is based on its predecessor system of individual use. This will be restructured in the future. The important point to mention is that the each element of the system is not the focus of this research, but the combination of these elements into a new system that provides original service to the coming society.

The system is expected to be useful as a substitute of a food server in a restaurant where additional dishes are often ordered. The system will be extended to better support dining activity including interpersonal communication in the future.

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