A Smart Information Offering System by Mining Time Series Motion Logs

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Abstract—Nowadays, the robot system become an assistant role in human life. The continent of Smartphone also brings the possibility of offering information in anytime and everywhere. But, the way of offering human the most suitable data is still a subject.

In this paper, the authors present a smart information offering system by mining the Time series motion log. The system constructed by two parts: the server part and the client part. The server part includes web server, data server, service robot and other input devices. And the client part is Smartphone. First, the input devices collect data by cameras rather than sensors to get human actives to be the mining data. Then, the actions will be classed and analysis to get the active patterns and find the possible reasoning results. Finally, the result can be showed by the device or applied for other purpose. The system successfully offers smart information by human action through the mining technology and show the result to user.

I. INTRODUCTION

The progress of technology makes our life more convenient than ever. But the benefit is only helping for those people who know and are familiar with using application systems. For those people who are unfamiliar with system usages, the application systems are still hard to understand and difficult to use. The problem also shows the importance of developing a system that can understand human.

The robot system has changed in the recent years. The meaning of robotic technology is not just including visible robots, and the system or devices that help to collect, analyze and show useful information for supporting people. But the increase of data collection methods and the development of internet what exactly help find information easily, now has become the reason of making data complicated. For obtaining useful information, the way of obtaining the needed data for system becomes a subject.

In this paper the authors consider to offer user a smart information system. The system obtains the characteristic behaviors of human by processing the images which are captured by stereo cameras. The data what get by the stereo cameras include the human movement and the obtain time of the movement. The kind of data the authors call it “Time serious motion log”. By mining Time series motion logs and extraction of association rule, the authors acquire the knowledge to recognize the actions. And the results can be used as a human action forecast data to help the system distinguishes user’s situations and intentions, and then provides service appropriately.

II. RELATE WORK

A. Data Mining Technology

The technologies progress faster than human’s imaginations in the present day. As same as the speed of the progress of technologies, the data what can be collected by also increased. But the amount of the increased data what enrich the database day by day has become the reason of information overflow. The reason let researchers start to investigate the method of data mining. The data mining technology includes several methods. For example: association rule, clustering, classification and regression. But the way of achieving data mining is not only the way of how to apply these methods, but also include a series of technique as data collection, data processing, data cleansing, visualization technique, and decision making. Every step of the process is important. In the mining process, the first step is to collection the usable data, and preprocessing those data if need. Then those data will be analyzed by different methods. Humans will allow add their judgments at the visualization step for getting the most suitable data or decide to process data cleansing function for processing mining.

The amount of applications what involve data mining technology is large. Recently, data mining is also applied in the area of recognizing human actions. But these researches almost need to set the sensors on human body to obtain human movement data for getting the human action, or try to use sensors to get the frequency of use of object to find the possible activity of human. For example, Fukuda applies the mining technique in the cooking support system [1] [2] [3] [4]. The system infers the next human action by taking account of the past human behaviors by sensors. The system gives the advises of the next action which is gotten from those collected statistical data to user by monitor or voice. Morita, Sato and Doi [5] use wristwatch-type sensor to achieve human action recognition using acceleration and physiological data. For enable recognition of actions, they extracted features from the sensor data and constructed a decision tree using the features. Palafax and Hashimoto [6] also use the sensors what is settled on user’s body to obtain human movements, and use clustering with PSO optimization algorithm to read and classify user object activity.
B. Information Display

The mobile technology successfully make technology became a part of human’s daily life. Especially the development of Smartphone what the convenient and multipurpose of inspires developer to develop newer applications of mobile devices. One of the Smartphone’s advantages is what can achieve augmented reality (AR) easily by using the camera that involved in Smartphone. The ability offers a chip, simple and useful way to show information.

III. METHOD

A. Kukanchi

Recently, the word “robot” has been used for broader meaning than it used to be. Robot also means the intelligent system which applies the robot technology to support real world. ATR-centered group [7] that researches the networked robot technology separated the robot into 3 types. The ideal is very similar to the authors’ image of networked robot, but the concept maybe different [8]. The first type is virtual type robot which is included into Smartphone or etc., the second type is the unconscious type robot that focuses on information collection and situation recognition, and the third type is the visible type robot which is for handling the situation and directly communicating with human. The three type of robots work cooperation and exchange the information to each other. By sharing information with each other or the environment, the three type robots can cooperate and provide service. This way of thinking is called “Kukanchi” as figure1. The information which is collected from the Kukanchi system can also be thought of a useful data for utility, for example, the information can use in data mining to discover the valuable knowledge.

B. Action Recognition

For getting the information of human, and offer the suitable service. The first step is to recognize human actions. The authors use the motion capture equipment, which is named Vicon, to get images. Then, the authors use V-Space, which is developed by Yamaguchi Lab., as the image processing software to capture motion data.

V-Space uses the RGB(R: Red, G: Green, B: Blue) color space as the basic color space to process the images and it can trace the object by its color. The system analyzes the colors in the original images which are captured by the camera, and calculates the weight points and the coordinates by the color pixel, and then saves the point and coordinate data into database. By repeating the process of calculating the weight points and coordinates after a period of time, the system can use the data to trace the object, and the user can find the trajectory which he needs by the color data of the target. Moreover, the system also includes background subtraction technique to improve the capability of detecting moving objects or the object which is with complex background. After the image processing step, the coordination data of human body or object can be apply to judge the movement data. Then, the author can class and calculate those data to be the preprocessing data for mining. The figure 2 shows the experiment view of V-Space.

C. Data Mining Method

In the research area of data mining, association rule is a well-know method. Association rule shows attribute value conditions that occur frequently together in a given dataset. The method targets to find interesting association and correlation relationships among large set of data items. It provides information of this type in the form of “if-then” statements. The rules are computed from the data and, unlike the if-then rules of logic, association rules are probabilistic in nature. A widely-used and typical example of association rule is known as marketing basket analysis as illustrated in figure 3. Although the method is well-known in business, it still can be applied to find other knowledge. It is say that if the authors fix the attributes of class of the consequence, association rule still can be extracted from the factors of class [9].

IV. EXPERIMENT

The structure of the system includes two parts: the server part and the client part what is like the illustration in figure 4. The server part is for collection, calculation and translation all the data for finding usability information. So, the server part includes web server, data analysis server, database and other input devices like camera and assistant robot. The client part is
for showing information to user. The platform is a mobile device. Although the robot can offer services to human, it can also collect data whenever it is offering server or not, so the authors put the assistant robot as the part of input device.

**Server**

![Diagram of system structure](image)

**Fig.4. The system structure**

For putting in practice, the authors design a clothes store as the experiment environment. Figure 5 shows the image of the experiment environment. The system recognizes human actions by mining Time series motion logs from images which captured by stereo cameras, and provide the information to customers. The authors focus on the human actions of customers to construct the system. The system captures human movements by processing the images from stereo cameras. The human behaviors include taking, walking, stop and turning in front of the merchandise. The authors take the four human behaviors as the characteristic behaviors. The large data of human behaviors can be classed by the four characteristic behaviors and the class can also make the data become simple, especially when user wants to process data cleansing.

**A. Data of the environment**

For collection the data of the environment, the authors applied the pointing movement system which is development by E. Sato-Shimokawara [10] as the basis of the system. The original design of the pointing movement system is constructed based on networked robotics which networked two types of robots: two unconscious type robots and a visible type robot. The unconscious type robots are designed to detect object. It uses two cameras which are putted in the environment as the agent. And the visible type robot is for following the user’s instructions by the result what unconscious type robot obtained. For unconscious type robot to obtain the data what is for offering data to visible robot to recognize the trace route, the three-dimensional coordinate of the user’s head and hand position and the visible type robot position are calculated. The pointing movement system is also applied on automatic driving system which is developed by Yamaguchi Lab. The system uses the same ideal to get the environment data, and allow the vehicle automatically drives by different situation or user’s instruction. Because the system is for the vehicle, it’s designed for outdoor environment.

In the system, the authors did some change for involving the ideal of pointing movement system into the system, and applied the obtained data to other application. Because the authors don’t need the position data of the visual type robot, the authors use monitor camera and the camera of visual type robot to calculate the three-dimensional coordinate of human and extended the ability to obtain more data in the environment which like the position of furniture or appliances. The data of user position and object position can be used by other application like using in data mining to find more information. Moreover, because the original system is designed for getting indoor data, if the data can combine the outdoor data, what’s like the automatic driving system the authors describe above, and used for mining information, the usability of the system can be extended.

**B. Action recognition**

As describe in chapter 3, the author involve the V-Space which is developed by Yamaguchi Lab. as the image processing software to capture movement data. After capturing the human movement data from V-Space, the human actions analysis can be implemented for processing data mining.

For explaining about the mathematical expression of movement analysis, the authors make the definition of value as follows:

The coordination of production is $C_p = (x_p, y_p, z_p)$. The coordination of head is $C_h = (x_h, y_h, z_h)$, the coordination of left hand is $C_l = (x_l, y_l, z_l)$ and the coordination of right hand is $C_r = (x_r, y_r, z_r)$. The vector of head movement is showed as $V_h$.

$$V_h(t) = C_h(t) - C_h(t-1)$$

(1)

The difference between vectors of head movement is $D_h$.

$$D_h(t) = V_h(t) - V_h(t-1)$$

(2)

And the angle between vectors of head movement is $A_k$.

$$A_{km} = \tan^{-1} \left( \frac{V_{km} - V_{km-1}}{V_{km} - V_{km-1}} \right)$$

(3)

The rules of characteristic behavior recognition are as follow:

1) **Taking**:

If the coordination of right or left hand is at the position of merchandises every 0.1 second, it can be judged as “taking”.

- If $C_{l}(t)$ or $C_{r}(t) \approx C_{p}(t)$ than judge as Taking.

2) **Turning**:

If the variable of angle between parallel plane and the ground coordination of the head (the movement vector) is over the threshold value every 0.1 second, it will trigger off the condition judgment. And, if the next four angle values of the movement vector are under the threshold value, then it can be judged as “turning”. The following is the logic operation:

1. Trigger:

   - If $A_{km} > A_{threshold}$ than enter the condition judgment.

2. Condition judgment:

   ...
If \( \sum_{i=0}^{m} f(t-i) = m \)
\[
f(t-i) = \{x | (A_{h(t-i)} > A_{\text{threshold}}) \} = 1:0, t>i\]
then judge the movement is Turning.

3) Walking:
If the variable of vector-valued between parallel plane and the ground coordination of the head (the movement value) is over the threshold value every 0.1 second, it will trigger off the condition judgment. And if the next four movement vectors are over the threshold value, then it can be judged as “walking”. The logic operation is as follows:
1. Trigger:
   If \( D_{h(t)} > D_{\text{threshold of walk}} \) than enter the condition judgment.
2. Condition judgment
   If \( \sum_{i=0}^{m} d(t-i) = m \)
\[
d(t-i) = \{x | (D_{h(t-i)} > D_{\text{threshold of walk}}) \} = 1:0, t>i\]
then judge the movement is Walking.

4) Stop:
If the variable of vector-valued between parallel plane and the ground coordination of the head (the movement value) is under the threshold value every 0.1 second, it will trigger off the condition judgment. And if the next four movement vectors are under the threshold value, then it can be judged as “stop”. The logic operation is as follows:
1. Trigger:
   If \( D_{h(t)} < D_{\text{threshold of walk}} \) than enter the condition judgment.
2. Condition judgment
   If \( \sum_{i=0}^{m} d(t-i) = m \)
\[
d(t-i) = \{x | (D_{h(t-i)} < D_{\text{threshold of walk}}) \} = 1:0, t>i\]
then judge the movement is Stop.

In fact, the data what is not captured by Vicon but by other equipments which like stereo cameras may include noise. Because of the reason, the accuracy of data which is obtained from the stereo cameras is less than Vicon. The results of the rules, which are described before, may include noise which affects the movement what is gotten by, and even affect the behavior patterns that is created and used for recognizing human actions. So, the authors implement the visualization techniques on the human movements which are obtained from stereo cameras to reconstruct the rules of characteristic behavior recognition. The rule of characteristic behavior recognition is illustrated as figure 6.

For solving the area what is difficult to distinguish, the authors design a range of values to handle the problem. The condition is named “don’t care” (the authors use the mark * to represent). Before creating the result by the rule of characteristic behavior recognition, if the variable of vector-valued for judging the walking and stop states is under the threshold value, then the data will be processed by trigger. And then, the function which is for judging “stop” and “walking” will work on the four vectors that are created after the process of trigger.

After recognizing the characteristic behaviors by the rules, although the system can obtain a more stable motion from walking state, the two problem what are the accuracy problem of stereo cameras and the noises of the head shaking in stop state still arise the problem of false recognition. So, * which is the middle of walking and stop, or in other words, ambiguous operation which is like a noise, is applied to identify and separate the conditions, like “walking but nearly stop” and “exactly stop”.

C. The data mining and knowledge finding
For offering the usable information to user, through mining the data which obtained from the unconscious type robots, the authors can get more hidden information in the environment. In the system, the authors want to offer the service to human by human action. As describe in chapter 3, the association rule targets to find interesting association and correlation relationships among large set of data items. The method can help to extract human behavior patterns, so the authors apply the method and use the result into the system for recognizing human actions and offering services at the appropriate time.

For preceding the experiment, the authors invite seven university students, one female and six male, as the subjects to recode their movement.

The authors capture the images of the subjects by Vicon and use the function to judge and analyze the motions of subjects for collecting the data of characteristic behaviors, and then, use the data to create behavior patterns and recognize action. The data what get by the Vicon include the human movement and the obtain time of the movement. The kind of data the authors call it “Time serious motion log”.

Figure 7 shows the process of collecting characteristic behaviors and using the behavior patterns to process the extraction of association rule and knowledge discovery. Because extracting from all the items of Time series motion logs will cost large complexity. Before analyzing the data of behavior patterns, the characteristic behaviors will be classified by those feature actions, as described in figure 8.
The process of analyzing the behavior patterns will be easier by the classified data. After the process, the system can calculate the confidence and support by the formula of extraction of association rules to get the result. The Table I, Table II and Table III show the experiment results after classified by those feature actions and the statistics after judging and analyzing the data of behavior patterns.

In this research, the authors focused on the characteristic behaviors of “taking” as the main factor of behavior patterns, and using the behavior patterns to extract association rule. The result {stop, taking} × 3, which is shown in Table I, and the sum of taking action = 19, which is shown in Table III, present the discovered knowledge of (3) (Action of customer who is interesting to but don’t want to buy), which is described in Figure 8. The tables also show two results of knowledge discovery that (3) (Action of customer who is interesting to but don’t want to buy) is 100% confidence, and the confidence of (1) (Action of customer who has decided to buy) and (2) (Action of customer who is not interesting at all) are both 0%. The result which is shown in Figure 9 presents the knowledge which be found. And it also proposes the proof that knowledge discovery technique is a useful method.
D. Applying the fined knowledge and showing the information

The discovered knowledge of predicting the shopping behavior can be applied in the robot system which based on Kukanchi and experimented on the environment as authors described. The image is showed as figure.10. The visible type robot provides the services to the customer for encouraging his purchase only when the customer is detected the characteristic behaviors which point to the action of interesting to the merchandise but don’t want to buy.

V. CONCLUSION

The robotic system in nowadays is not only for supporting the visual type robot, but include more ability what can collect, analysis, transmission and display the information for human. In other words, the robotic system has to build by many kinds of technologies about data, transmission, and display object.

In this paper, the authors presented a system what is able to collect, process, analyze, and the most important, mining the data about human action by the movement. The mining method what included in the paper can operate without set any equipment on experimental subjects. And the collected data what is used in the system is target to get the human movement what is near the real experience of human. Furthermore, the experiment proves the possibility and utility of using the concept of Kukanchi to construct a system.

In the future work, for extending the ability of the system, the system can collect the data of three-dimensional space of the environment, and find the user patterns to build the space information or to find the relative between human active and the environment. Moreover, the system can conjecture the future event by processing the data of human daily life, the information of environment, and the relative between human and environment.

REFERENCES