A Study for Assistant Robotic System using Motion Capture Method for Adapting to Human-robot Interface

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***Abstract*—In this paper, the authors present a user-centered concept for the operation experience of human-robot interface. For showing a concrete concept of our research, we design an assistant robot system. There are several stages for developing this system. Firstly, it is to obtain user's data. The authors obtained static data from Internet, and activity data from capturing humans' a motion data. The authors adapt accelerator sensor and image data, to capture human motion. Secondly, the authors use association rule of data mining technique to find the hiding knowledge from user's data. The system can base on the found knowledge, which includes the relation about life patterns, psychological conditions and etc., to provide appropriate assistance. The system mainly includes the following steps: capture user's motion data by accelerator sensor and stereo camera in indoor environment, analysis captured motion data, found the hiding knowledge from user's data, recognize the environment through user's data, and based on these data and knowledge to provide service. In this paper, we design a human-centered assistant system for adapting to human-robot interface. The system not only uses static data, but also activity data using capture methods. We briefly describe the assistant robotic system's overall concept, and discuss the motion captures methods and knowledge finding. Simple experiment results will also be shown.**

Keywords—huamn motion; motion capture; human-robot interface; data mining

I. INTRODUCTION

Since the development of technology, human's daily life become more convenient. Many robotic systems are developed to provide service to people. However, these systems still have some limit, for example: although the system can collect a lot of information, but the most appropriate information still hardly to be obtain by system itself. It is said, when a person wants to obtain information he wants, he can just use personal computer or electronic devices to get information, but system is hardly to do the same thing. Moreover, when a human saw the other people's action, he will understand the meaning of the action because much direct information can be obtained from actions, but robotic system can't. Thus, how to let system obtain the information as human is one of the main topics in the field of robotic system development.

Human-robot interface is the research for connecting user and systems. However, the operation interface of system is not simple to use for most people. Users always have to spent a lot of time to learn how to operation. In fact, this problem occurs not only in the field of robotic systems, but also other types of systems. Because of this, the concept of human-friendly interface is presented. Human-friendly interface aims to provide an intuitive operation experience for users when they use a system. This concept is applicable in most of the system, which has to interact to people. In the field of robotic system, the developers even pay more attention to this topic, especially the way of providing an intuitive operation manner. However, for providing best operation experience, the system should not only focus on the way of operation, but also the user's thought, habit, etc. In other words, human-robot interface should be user-centered, which is according to the view of human to interact with users.

Moreover, because of the development of Internet and personal devices, the amounts of information increase faster; the ways of obtaining information are also easier, too. However, how to find the required information from big data becomes a problem. Data mining technique, which is developed recently, is for finding knowledge from big data. It includes not only data processing, but also a series of techniques like data process, data cleansing, visualization techniques and decision making. Every step of the process is important. Especially visualization techniques that help humans make their

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judgments. In the mining processing, humans add their judgments at the visualization step for getting the most suitable data or data cleansing function for processing mining. After visualization step, the next step is processed for finding the valuable knowledge. If the data or function is not help for discovering knowledge, the visualization step will be processed again, until useful knowledge is found. Moreover, there are some important things of discovering knowledge by data mining, like the appropriate judgments of human, the performance of processing interactive data mining and the step of keeping mining process is implemented until the appropriate knowledge is found. Data mining technique, which helps to find information and hiding knowledge, provides a possible way for us.

In this paper, the authors aim to develop an assistant system in accordance to the found knowledge from human's data to provide appropriate service. Our research includes several stages. Firstly, for obtaining user's data, we not only collect static data but also motion data, which are accelerator sensor and image data, to obtain the direct information from user. The two types of motion capture methods both have its advantage and disadvantage. Using sensors to capture data helps get precise motion data, but environment information will lose. Using image to capture data is able to collect more information, especially environment information than using sensor, but the privacy problem will occur. For keeping the advantage, we adapt both of these motion data in our system, and use them in different occasions for avoiding the disadvantage. Secondly, for finding useful information and hiding knowledge from amount of data, we adapt data mining technique. Data mining includes several methods, because we want to find the relation between life pattern and psychological condition, association rule of data mining as the method. The data mining results offer useful information to the robotic system for improving the operation way. Note that the content of this system is still a conceptual work, therefore we focus on describing the system's overall concepts, and discuss the motion capture method and knowledge finding, which is the first step of this system, with simple experiment results.

II. Related Work

There are several investigations about human-robot interface, Atyeo, M.'s research [1], which talk about the user interface architecture, provide the service using static data for adapting user interfaces to suit the different user's needs. Manhartsberger, M et al. [2] develop an object-based intuitive user interface approach, based on a real life conceptual user model. Murakami et al. [3] present an information recommendation system that supports elderly people by using users' schedule. Nakamura et al. [4] develop the recommend system that uses personal attributes and preference of each person. Moreover, there are several relate invetigations about capturing human's action for system, but most of these research are target to exercise support, such as MacEk, J. and Kleindienst, J [5] present an interactive system for physical exercise of older people and provide results of a usability study with target user group. The system monitors the users' heart rate and scans the users' movement patterns by statistical estimators. It wants to encourage older people to do regular physical activities without caregivers by providing in a monitored environment. Winward, C. et al. [6] presents an exercise support system for people with long-term neurological disability to enable them to use local gym facilities safely and effectively. Ikegami, Y. et al. [7] developed a support system that visually impaired can use alone at home. They want to encourage users to continue exercise by entertainment ways. Furthermore, there are some investigations utilize data mining technique to finding knowledge and provide service.

As described in above, there are researches for developing user-friendly interface for providing service, but it uses static data for user, what doesn't include the activity data. Moreover, the researches for capture human's action almost for exercise support. Our research focuses on not only static data but also activity data to provide service. The system adapts data mining for fining knowledge and information from user's daily life data, and these found information is not only to provide service, but also for provide a better operation experiment to user.

III. System Concept

In this research, the authors design an assistant robotic system using motion capture method to concert the presented user-cantered human-robot interface. The system is an extended system base on perverse research [8]. The robotic system can roughly divide into three parts as follows: input part, server part and output part. The system adapts accelerator sensor and stereo camera as input device. These devices are for capturing human motion data and the environment information. Users take the accelerator sensor. The stereo camera is sited in living room for user's privacy. Server part is a computer, which responds to save and analysis these collected data. The output part is for provide service, which could be a tablet, smartphone, robot, or etc. depending on the service contents. The system mainly includes the following steps: capture user's motion data by accelerator sensor and stereo camera in indoor environment, analysis captured motion data, found the hiding knowledge from user's data, recognize the environment through user's data, and based on these data and knowledge to provide service. However, because the system is still under development, here we only briefly described the system structure, and show simple experiment results of the research.

A. Motion Capture method

The assistant robotic system obtains user's motion data by capturing motions, here we based on perverse investigations [9]-[12] to obtain the accelerator sensors and image data from stereo camera.

For obtaining accelerator sensor data, we use accelerator sensor with Zigbee sensor network, which is that designed by System Craft Inc.,in this system. The sensor can recode the motion data using acceleration data 20 times per second in the valid range of Zigbee Network. The acceleration is able to get human's movement by coordination data type. The obtained acceleration data is a series coordination data, so the real time acceleration data can be shown as waveform. The coordination data is analysis for recognizing different motions. By the experience, we know that motion is from a series subtle movement, and difference motion composed of different series of movement. We applied the fuzzy inference to the motion recognition algorithm by considering the possibility and miss

risk of above. Moreover, although the fuzzy inference covers some difference of motion data, but the risk of ineffectiveness will increase when the amount of motion's difference become large. Thus we also make fuzzy membership function optimized for assisting the motion recognition algorithm.

For obtaining image data, we use stereo camera in this system. We use camera capture image, recode the time series coordination data of images and the capture time. These data are applied to calculate the movement speed and direction of human face and hands. Next, the movement speed and direction of human face and hands is converted into the range of member value (0~1) by the fuzzy membership function to recognize the motions.

According to the experiment, we choose 4 motions that often appear in our daily life as the recognized targets. It is lie, sit, stand and walk. We mainly applied fuzzy member ship function and fuzzy inference to recognize motions. The fuzzy set operations for motion recognition are shown in Equation (1)-(4). Subjects for the experiments are 3 male students, who are between 20-24 years old. The motions recognize rate is shown in Table. 1. As the result, we know that it is possible to capture motion using accelerator sensor and image data.

$$mLIE = MIN(mLIE) \tag{1}$$

$$mSIT = MIN(MAX(mSIT\_1, mSIT\_2), 1\text{-}mLIE) \tag{2}$$

$$mSTAND = MIN(mSTAND, 1\text{-}mSIT) \tag{3}$$

$$mWALK = MIN(mWALK, 1\text{-}mSTOP) \tag{4}$$

TABLE I. RESULT OF THE ITEM THAT RELATE TO SOCIETY SITUATION

Motion recognition rate	Accelerator sensor data	Image data
Lie	0.83	0.98
Sit	0.75	0.85
Stand	0.95	0.93
Walk	0.98	0.95
Total	0.88	0.93

B. Method of fining knowledge

In this research, the authors are trying to find the relation between the life patterns, psychological conditions and etc. The purpose approach to the association rules method. The association rule is known as market basket, but the attribute of class is not unable to be changed. That is say we can fix the attributes of class of consequence, and association rule still can be extracted from the factors of class [13]. The following mathematical expression is applied to calculate the confidence and support values for the method of association rule.

$$Support = \frac{T_{union}(X) \cap consequent(x)}{Number\ of\ transcation} \tag{5}$$

$$Confidence = \frac{T_{union}(X) and\ consequent\ (Y)}{Transaction\ number\ of\ antecedent\ (X)} \tag{6}$$

Because the research still underdeveloped, we applied questionnaire from people whose age is over 60 years old, and get 592 available questionnaire data for the research. The questionnaire has 71 title items that include 45 background situation items and 26 daily life situation items. The date are collected about 3 days from 2011, March 23 to March 25, which offered by the group that process the project:" The individual difference response auto-growing assistant robot system for elderly" that support by Japan Science and Technology Agency (JST) s-innovation. The background items include the data, such like living area, job type, annual income, marriage situation, license, insurance and etc. The daily life situation items include data, such like gender, age, the connect frequency with children and grand children, the frequency of interaction with other people, interesting, go out frequency, life rhythm and etc. In other words, these data include elderly people's data of background, life habits, interesting, emotion, society situation, and etc. The part context of questionnaire is shown in Table. 2.

TABLE II. THE PART CONTEXT OF THE QUESTIONNAIRE

Time of filling questionnaire		
No.	***Question***	***Answer***
1.	Your gender	Male or Female
2.	Your age	60~64 65~69 70~74 75~79 80~84 Over 85 years
3.	Living situation	Living along Living with spouse Living with children Living with other elder Other
4	Connect frequency with children or grade children	Every Day 2 or 3 times a week Once a week 2 or 3 times a month Once a month Ones per half years Once per a year Once per several years I have no children
…	…	…

We adapt a data mining tool, which is Weka (Waikato Environment for Knowledge Analysis) that are developed by Waikato University [14], to implement the data mining. We use all the data to process the association rule. Fig. 1 shows a part of results of using data mining tool. Here we have to notice that the amount of the results of association rule we found are too many that cannot be write in this paper, so we just show a part of them. Through the result, we can find some interesting rule that hiding in the data. For example: the knowledge of society situation of the elderly people is shown in Table. 3. In

accordance with this table, firstly, it shows people how is used to visit friends have 3 combinations. These combinations are independence to each other. It is said, people who is used to visit friends are not limit to the people who have same life habit. Furthermore, the next two kinds of people are able to find the comment place. People who can ask advice from family or friends are the people who is used to visit friends and don't have BS broadcast reviewer. People whom young people automatically talk to have the following life: These people are used to visit friends, don't have PC desktop, don't get information from news, go out every day, eating in 5-8 p.m., have a mobile number. Moreover, if we want to know the knowledge of the difference between people how living alone and all the other people, living situation data will be choose as the processing data. After get the results, as shown in Table. 4, we found the elders not living along have some common items, what they are often to go outside and have desktop PC. And for people who living along, they have the facsimile and the ideal of economy. The result shows an obviously difference between elderly people who living along and the others. These results show the possible of adapting data mining method to find hiding knowledge and information from human's static and activity data.

a7.type of job=14 17 ==> 1.sex=2 17 conf:(1)
4-1.children-contact frq.=9 12-1.intersting-watch movie=1 a15-3.PC_desktop=1 14 ==> 2.age=2 14 conf:(1)
11.range of active =3 12-3.do interesting frq.=1 13-1.time of eating=1 12 ==> 2.age=2 12 conf:(1)
12-1.intersting-watch movie=1 12-3.do interesting frq.=1 a15-3.PC_desktop=1 13 ==> 2.age=2 13 conf:(1)
12-1.intersting-watch movie=1 13-3.time of eating=1 15.intersting TV channel-politics=0 13 ==> 2.age=2 13 conf:(1)
12-1.intersting-watch movie=1 13-3.time of eating=1 a14-1.Car license=1 12 ==> 2.age=2 12 conf:(1)
12-1.intersting-watch movie=1 13-3.time of eating=1 a15-3.PC_desktop=1 12 ==> 2.age=2 12 conf:(1)
12-1.intersting-watch movie=1 26-7.not feel trouble to measure health situation and safety =1 a15-3.PC_desktop=1 17 ==> 2.age=2 17 conf:(1)
13-3.time of eating=1 15.intersting TV channel-Economy=0 a15-3.PC_desktop=1 13 ==> 2.age=2 13 conf:(1)
10. go out frq.=1 12-3.do interesting frq.=1 a19. TV number=2 8 ==> 3.household=1 8 conf:(1)
11.range of active =3 a15-3.PC_desktop=1 a19. TV number=2 8 ==> 3.household=1 8 conf:(1)
12-3.do interesting frq.=1 a15-3.PC_desktop=1 a19. TV number=2 8 ==> 3.household=1 8 conf:(1)
12-3.do interesting frq.=1 17.get region communication infor.-no=0 a14-1.Car license=1 a19. TV number=2 9 ==> 3.household=1 9 conf:(1)
12-3.do interesting frq.=1 17.get region communication infor.-no=0 a18. mobile number=2 a19. TV number=2 9 ==> 3.household=1 9 conf:(1)
12-3.do interesting frq.=1 a18. mobile number=2 a19. TV number=2 11 ==> 3.household=1 11 conf:(1)
13-2.time of eating=0 a38. living together situation=3 33 ==> 3.household=1 33 conf:(1)
13-5.time of watch news=1 a7.type of job=19 a43. Homeowner status =4 8 ==> 3.household=1 8 conf:(1)
a14-1.Car license=1 a19. TV number=2 a45. Annual income=2 8 ==> 3.household=1 8 conf:(1)
a19. TV number=2 a45. Annual income=2 10 ==> 3.household=1 10 conf:(1)
a36. Marriage=1 a38. living together situation=3 36 ==> 3.household=1 36 conf:(1)
a38. living together situation=3 38 ==> 3.household=1 38 conf:(1)
4-1.children-contact frq.=9 33 ==> 4-2.grandson-connect frq.=9 32 conf:(0.97)
4-1.children-contact frq.=9 5-1.children-contact time/once=0 33 ==> 4-2.grandson-connect frq.=9 32 conf:(0.97)
4-1.children-contact frq.=9 33 ==> 4-2.grandson-connect frq.=9 5-1.children-contact time/once=0 32 conf:(0.97)
5-1.children-contact time/once=0 36 ==> 4-2.grandson-connect frq.=9 35 conf:(0.97)
5-2.grandson-contact time/once=0 53 ==> 4-2.grandson-connect frq.=9 53 conf:(1)
5-2.grandson-contact time/once=0 16.shopping news-no =0 47 ==> 4-2.grandson-connect frq.=9 47 conf:(1)
4-1.children-contact frq.=9 33 ==> 5-1.children-contact time/once=0 33 conf:(1)
4-1.children-contact frq.=9 33 ==> 4-2.grandson-connect frq.=9 5-1.children-contact time/once=0 32 conf:(0.97)
4-1.children-contact frq.=9 4-2.grandson-connect frq.=9 32 ==> 5-1.children-contact time/once=0 32 conf:(1)
4-1.children-contact frq.=9 13-4.time of other=0 29 ==> 5-1.children-contact time/once=0 29 conf:(1)
8.travel frq./ last year=4 10. go out frq.=1 8 ==> 9-11.social activity=1 8 conf:(1)
13-3.time of eating=0 a7.type of job=19 a20-13.car insurance=0 9 ==> 9-11.social activity=2 9 conf:(1)
12-2.start to intersting-no=1 12-3.do interesting frq.=2 7 ==> 10. go out frq.=2 7 conf:(1)
1.sex=2 26-3. hope have more time to talk to family_children and grandson=2 34 ==> 9-12. young people automaticly talk to you=1 33 conf:(0.97)
1.sex=2 a31-12. _FOMA etc. support Broadband cellphone=0 33 ==> 9-12. young people automaticly talk to you=1 32 conf:(0.97)
12-2.start to intersting-no=1 12-3.do interesting frq.=2 7 ==> 10. go out frq.=2 7 conf:(1)
6.pets=3 7.go to hospital frq.=4 10. go out frq.=1 7 ==> 11.range of active =3 7 conf:(1)
6.pets=3 12-1.intersting-listening music =0 a20-13.car insurance=0 7 ==> 11.range of active =3 7 conf:(1)
6.pets=3 10. go out frq.=1 a20-13.car insurance=0 9 ==> 11.range of active =3 9 conf:(1)
7.go to hospital frq.=4 10. go out frq.=1 12-1.intersting-listening music =1 7 ==> 11.range of active =3 7 conf:(1)
12-1.intersting-PC=1 67 ==> 12-1.intersting-Mahjong=0 66 conf:(0.99)
12-1.intersting-play go=0 67 ==> 12-1.intersting-Mahjong=0 66 conf:(0.99)
13-2.time of connect to friends=0 67 ==> 12-1.intersting-Mahjong=0 66 conf:(0.99)
14.get infor.-ragional announcement=0 68 ==> 12-1.intersting-Mahjong=0 67 conf:(0.99)
14.get infor.-circular=0 67 ==> 12-1.intersting-Mahjong=0 66 conf:(0.99)
16.shopping news-commercial=0 67 ==> 12-1.intersting-Mahjong=0 66 conf:(0.99)
19.get disaster infor.-circular=0 67 ==> 12-1.intersting-Mahjong=0 66 conf:(0.99)
20.place of falling down-stairs=0 67 ==> 12-1.intersting-Mahjong=0 66 conf:(0.99)
21.place of get injury-stairs=0 68 ==> 12-1.intersting-Mahjong=0 67 conf:(0.99)
23.action of feel danger-when cooking=0 67 ==> 12-1.intersting-Mahjong=0 66 conf:(0.99)
a39-3. parent of spouse or self=0 68 ==> 12-1.intersting-Mahjong=0 67 conf:(0.99)
a21-4.SANKEI news paper=0 67 ==> 12-1.intersting-play go=0 66 conf:(0.99)
a15-16.analog vedio camera=0 a21-4.SANKEI news paper=0 63 ==> 12-1.intersting-play go=0 63 conf:(1)
12-2.start to intersting-watch movie=0 65 ==> 12-1.intersting-PC=1 64 conf:(0.98)
12-2.start to intersting-gardening =0 66 ==> 12-1.intersting-PC=1 65 conf:(0.98)
12-2.start to intersting-gardening =0 12-2.start to intersting-dressmaking=0 64 ==> 12-1.intersting-PC=1 63 conf:(0.98)
13-4.time of clean=0 64 ==> 12-1.intersting-PC=1 63 conf:(0.98)
13-4.time of clean=0 19.get disaster infor.-circular=0 63 ==> 12-1.intersting-PC=1 63 conf:(1)
13-4.time of clean=0 23.action of feel danger-when cooking=0 62 ==> 12-1.intersting-PC=1 62 conf:(1)
14.get infor.-internet=1 64 ==> 12-1.intersting-PC=1 63 conf:(0.98)
19.get disaster infor.-circular=0 67 ==> 12-1.intersting-PC=1 66 conf:(0.99)

Fig. 1. The part of the results of association rule of processing all the items using data mining tool "Weka".

TABLE III. RESULT OF THE ITEM THAT RELATE TO SOCIETY SITUATION

Result Item	Item	Conf.
People who is use to visit friends	-have far active range -watch news in 5-8 pm -don't get region communication infor.	1
	-do interesting 2~3/month -not eating in 5-8 am -intersting TV channel-politics	1
	-not intersting TV channel-Internetional -don't get infor. from news -don't get region communication - have 1 mobile number	1
People who can ask advice from family or friends	-is use to visit friends -don't have BS broadcast reveiwer	1
People whom young people automaticlly talk to	-is use to visit friends -don't have PC desktop -don't get infor. from news -go out every day -eating in 5-8pm - have 1 mobile number	1

TABLE IV. COMPARE THE LIVING SITUATION BETWWEN ELDERLY PEOPLE WHO ARE NOT LIVING ALONG AND WHO ARE LIVING ALONG

People not living along	Conf.	Peple who living along	Conf.
-offten go outside/travel -have PC_desktop -don't watch TV in 5-8 pm	1	-have facsimile -not intersting to music -eating in 11am-2pm -Annual income about 3millin~4millin en	1
-offten go outside/travel -have PC_desktop -have 2 TV	1	-have facsimile -intersting TV channel-Economy -look shopping news-flyer	1

The founding knowledge as above is helpful for the assistant robotic system. The system is able to base on the data, which include static data, activity and psychological conditions, to know the person's life for providing better operation way depending on the concept of user-centered.

IV. CONCLUSION AND FUTURE WORK

In this paper, the authors propose a human-robot interface adapting user-centered concept. We develop an assistant robotic system in this research for showing the concert concept. Although several works of this paper, which are the main part of designed assistant robot system, are still remaining at the conceptual stage. The experiment results, which motion capture method and finding knowledge using data mining, of the first step show the develop potential and power of the system.

There are several stages remaining in the future work. Firstly, the authors will increase the number of recognizable human motions, includes the subtle movements. Secondly, we plan to adapt camera, which include infrared sensors, to help increase the recognition rate of subtle movement. Thirdly, we plan to combine the series of motion data and environment information to detect the space around user to collect real time information for improvement the system.

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