# *Developing an Robotic System for Healthcare from the Aspect of Lifestyle*

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***Abstract*—Nowadays, there are more and more people start to notice their health in daily life that makes this topic become a popular topic. Many health care systems or applications are developed, but these systems only depend on calculating the amount of exercise by devices, but don't involve other situations, such as life rhythm, social condition, etc. In this paper, the authors discuss and improve these existence problems. The paper puts emphasis on current health history and the different career's life rhythm. Active mining is utilized to analyze and construct user models. This research presents a new way for exercise support; it also shows the ability and potential for robotic system to offer personalized service.**

***Keywords—intelligent systems; human-machine interface; data mining; user model***

## I. Introduction

According to the statistical data of Japanese government in 2014[1], people's average life span of Japanese are increase. Male's average life span are 80.5 years and female's average life span are 86.83 years that updated previous recodes. The data shows that people's health situation are better than last century. Thus, people maybe have more time to do things they do like to, especailly after retire, they have more time to enjoy their retired life. Therefore, the way to improve people's life quality is discussion topic. And the methods of stay healthy are the most important point of all. Moreover, accordence to data of Japanese govement [2], average value of Japanese people, whos ages are over 65 years old, cause of death, are as following: Malignant neoplasm is 19.01%, Heart disease is 17.23%, Cerebrovascular disease is 9.28%, Pneumonia is 12.74% and other is 41.75%. The death probability at 65 years old are low by Malignant neoplasm, but high by Heart disease, Cerebrovascular disease and Pneumonia, the trade is stronger when 75 years old. Thus, the prevent of these disearse have the priority, which start from health preservation of daily life.

Existent robotic systems to serve people had shown their powerful and usability. But still that many users confuse the operation way and complex functions of these systems, a lot of the user interfaces were designed as passivity. These system requires people to input commands into a system's connected device\input to generate output results. These system processes are intuitive at the beginning, but along with the development of system, the input commands also became more complex. Therefore, development of an intuitive and simple operation user interface for a powerful robotic system is also a topic.

Moreover, there are many systems focus on supporting people's healthy life. But these systems depends on calculating the amount of exercise to detect user's health situation. And most of them have to collect enough data before start to provide service. Thus, when a new user starts the system, he/her has to wait the system collect data.

This paper present a system concept that considers both the amount of exercise and user's life rhythm. This system depends on people's knowledge to him/herself as a base personal data, and according to his/her daily activity data to adjust. The data of analyzed step of this system includes amount of exercise and life habit. The characteristic is a useful data for personal service system, which increases usability of a system's user interface.

This paper includes following section: Section 2 described related works to this paper. The proposed system's architecture are shown ins Section 3. Section 4 explains the theory of constructing user model. And the experiments are descriped in Section 5. The final section summarizes the research and discusses the future works.

## II. Related Work

The concept of User-frendly inferface are developed for years. However, because there are a huge space between existence interface and ideal interface, thus developers still work hard on development of user-frendly interface. For example: Minagawa A. et al. [3] present a system by detecting human motions to interact with user. They integrated multiple sensing technologies as intermediary, which let users feel more naturally and effectively. Schmeil, A. and Broll, W. [4] presented a functionality of a location-aware digital information system, which combined a familiar interface with andiropomorphic, for porivide intuitive user interface. Proença, R. [5] et al. based on recognition of static gestures of human hands to exploit novel human-machine interfaces.

There are several previous works, which provide service by human pattern recognition without disturb human [6], and an exercise support system by motion detection [7]. The systems are also focus on depending personal data to provide service. However, these system still have to collect data before providing service. Instead collecting data before start service, the presented system adapts user's knowledge to him/herself as the basic data. This research depends on users' life rhythm data to build users' basic life style data, and adapts knowledge discovery technique to find recommend information for system. The obtained information possible helps improve a system's service contents and operation way of user interface.

## III. System Architecture

The presented system is based on previous researches[6][7] that adapted vision-based motion recognition to collect human's activity data. These research use several different devices, one is Stereo camera and another one is Kinect[8]. It is a multifunctional motion detection device includes RGB camera, depth sensor and multi-array microphone. These input devices is easily to capture motion data and extra data, such like environments information. Because of this paper focus on daily activity data of user's all day life, the authors puts the portability and privacy protection as prority. Thus 3D accelerator sensor is choosing.

The architecture illustrated according to the function of different part. At input part, the 3D accelerator sensor captures use's activity data, and includes a device for user to input knowledge that user knows his/herself. The collected data is analyzed and saved in analysis parts, which is a computer with data mining software and database. Service provide part includes a tablet or robot for interaction with user. Moreover, tablet and robot also collect user data, the user's interact data and feedback are returned by service provide part. All of these devices are connected to each other by network.

The system process as follows: first, users input their information, and carry 3D accelerator sensor to capture their motion data. The system starts provide service depend on input information. A database saves these captured data from 3D accelerator sensor to prepare analysis human activity. The saved data are analyzed to construct the personal information. Service part adjusts the concept of provide service, and provides service according to the constructed personal information. Users' interactive data and feedback are collect and return to the system. The simple concept of presented system is illustrated in Fig. 1.

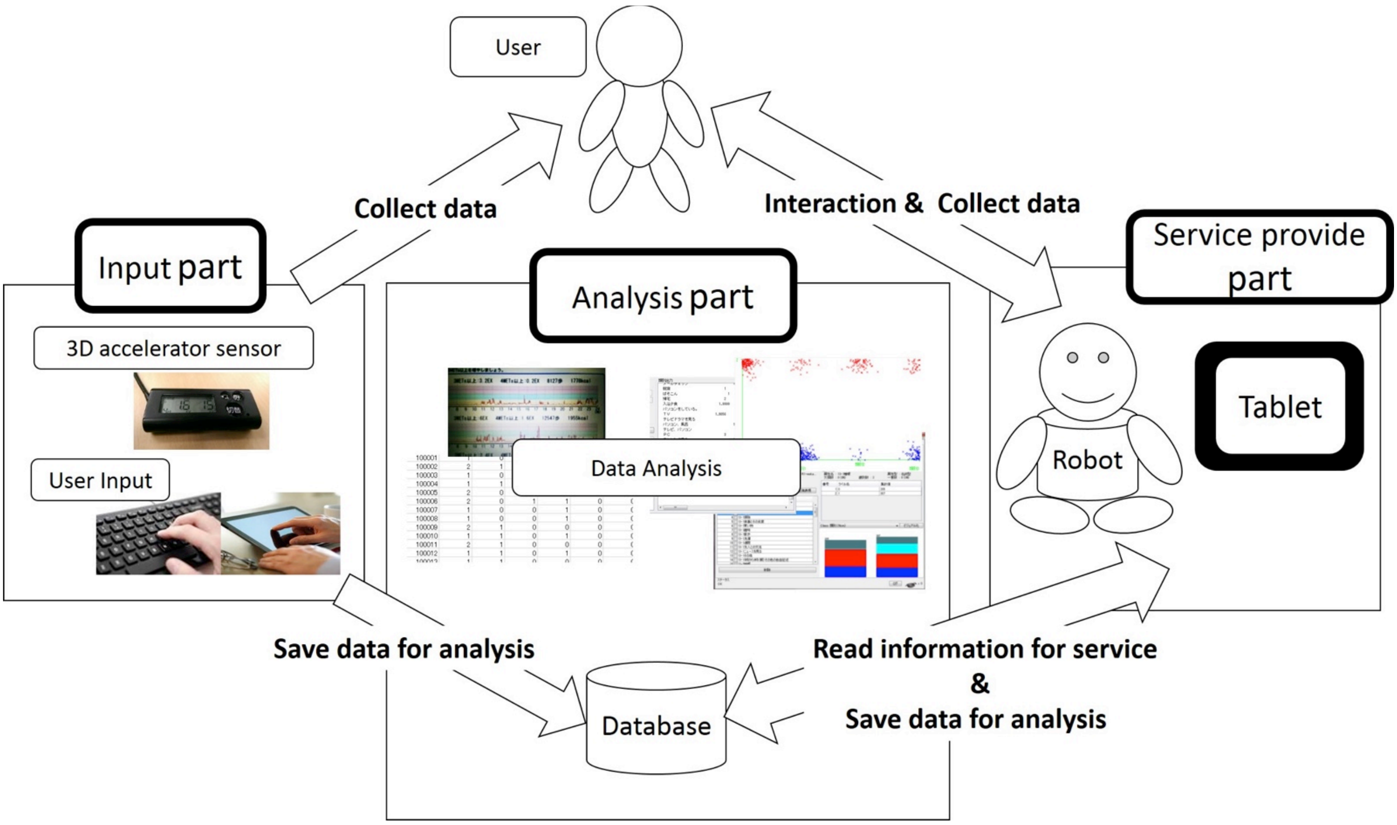


Fig. 1. The concept of system architecture.

## IV. Method for User Information Construction

This section describes the methods to construct user information for the presented system. This research focuses on the knowledge of user knows him/herself.

### A. *Personal data collection*

Most of personal service systems have to collect enough data before start providing service. This is an unavoidable problem. This paper constructs basic models as basis to judge the input data that user knows him/herself. The data for construction model collected by questionnaires, which is a direct data collection way. The data collected by the project:

The individual difference response auto-growing assistant robot system for elderly supported by Japan Science and Technology Agency (JST) s-innovation. These data are collected from 2011, March 23 to March 25. 592 available data are obtained. Participants are people whose age are over 60 years old. The questionnaire contains 71 items, which includes 45 background data and 26 daily life data such as habit, interest, society situation, etc. The background data include living area, job type, annual income, marriage, license, insurance, etc. The daily life data include gender, age, frequency of connecting with children and grandchildren, frequency of interaction with people, interest, go out frequency, life rhythm, etc.

### B. Basic life style information model

Knowledge finding is adapted to construct basic model, what usually adapts visualization methods to help human add judgments for finding hiding knowledge. In this case, different visualization methods are implemented until useful knowledge is found. The technique combines conventional data mining with human judgments is called active mining [9].

EM algorithm [10] is useful in finding a probabilistic model and depends upon unobserved latent variables, what is choosing as the mining method to construct basic model. Using the constructed model provides different services, such as recommendation or useful information. Weka (Waikato Environment for Knowledge Analysis) [11] developed by The University of Waikato Hamilton, New Zealand, is applied to construct the model of life style information.

Life rhythm data is extracted from the collected data of the questionnaire. User's main activity data in each period time are utilized. The contents are shown in Table I. The collected life rhythm data include 6 periods, which are 5 to 8 o'clock, 8 to 11 o'clock, 11 to 14 o'clock, 14 to 17 o'clock, 17 to 20 o'clock, and 20 to 23 o'clock.

TABLE I. THE SAMPLE OF LIFE RHYTHM FROM QUESTIONNAIRE

| ***User No.*** | User Identify Number |
|---|---|
| ***Question*** | ***Answer*** |
| ***Gander*** | Male or Female |
| ***5 to 8 o'clock*** | Sleeping<br>Cleaning house<br>Cooking/Eating<br>Shopping<br>Doing things that interest myself<br>Exercise<br>Doing Laundry<br>Go to hospital<br>Having fun with family/friends<br>Watch TV<br>Working<br>……. |
| ***8 to 11 o'clock*** | Same as above |
| ***11 to 14 o'clock*** | Same as above |
| ***14 to 17 o'clock*** | Same as above |
| ***17 to 20 o'clock*** | Same as above |
| ***20 to 23 o'clock*** | Same as above |

## V. EXPERIMENT OF CONTRUCTING USER MODELING

Clustering method using EM algorithm of Weka is choosing to perform, and 4 clusters are found. The experiment result is shown as Fig.2. There are 4 kinds of model of life style information. In Cluster 0, there are 153 persons includes 3 male and 150 female that takes 26% from the number of participates. In Cluster 1, there are 239 persons includes 208 male and 31 female that takes 40% from the number of participates. In Cluster 2, there are 81 persons includes 13 male and 68 female that takes 14% from the number of participates. In Cluster 3, there are 119 persons includes 84 male and 35 female that takes 20% from the number of participates.

Cluster 0 includes 3 male and 150 female, who usually spend 47% times in a day on doing housework that includes cleaning house (8%), cooking/eating (21%), doing laundry (9%) and shopping (9%); and spending 35% time in a day on doing things that interest him/herself (13%), exercise (3%) and watching TV (19%). The concept details are shown in Fig.3. They usually wake up early (5~8 o'clock) for cooking/eating, doing housework in the morning, shopping or have fun in the afternoon, and watching TV at night. According to our experiment, this kind of life rhythm comes from housewives/househusbands or people who take care their family's daily life.

Cluster 1 contains 208 male and 31 female, who usually spend 53% times in a day on entertainments that includes doing things interest him/herself (23%), exercise (7%) and watching TV (23%); and spending 28% times in a day on cleaning house (3%), cooking/eating (16%), shopping (7%), and doing laundry (2%). Fig.4 shows the concept details. The activities in their daily life are simple. Most of them spend several hours on one activity he/she interest. According to our experiment, the kind of life rhythm comes from retirees who don't have much life stress, aren't busy on housework and have time to enjoy his/her own life.

Cluster 2 includes the data of 13 male and 68 female, who spend 42% times in a day on housework that include cleaning house (7%), cooking/eating (19%), doing laundry (8%) and shopping (8%); and spending 36% times in a day on doing things that interest him/herself (14%), exercise (5%) and watching TV (18%). The concept details are shown in Fig. 5. Their life rhythm data look like Cluster 0 that includes the data of a housewives/househusbands or people who take care the family's daily life. But the proportion of housework is decrease and entertainment increase in Cluster 2. These people wake up after 8 o'clock, doing housework, shopping or have fun in the afternoon, and watching TV at night. According to our experiment, this kind of life rhythm usually comes from a housewife/househusband who wake up later and have more time to enjoy him/herself, although they still are the main person who take care his/her family' daily life, but they don't have to spend so much time as those people of Cluster 0. Thus the time of preparing breakfast and doing housework decreases, the time of entertainment increases.

Cluster 3 contains 84 male and 35 female. They spend 44% times in a day on working. The times for cooking/eating are 15%. The times for entertainment in a day are 23%, which include 6% on doing things that interest him/herself and 15% on watching TV. Fig. 6 shows the concept details. According to our experiment, the kind of life rhythm usually belongs to workers.

In order to verify the accuracy of the found model, the predict career results from the experiments are compared with the career data and family information from the questionnaires. The accuracy of Cluster 0 is 73%; the accuracy of Cluster 1 for extraction is 59%; the accuracy of Cluster 2 is 59%; the accuracy of Cluster 3 is 76%. The total accuracy is 66%.

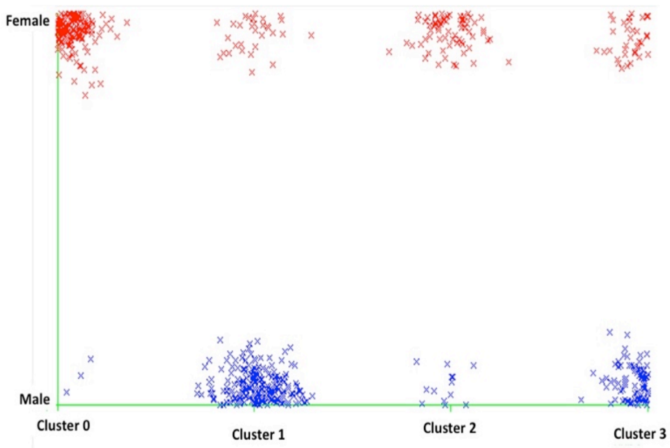


Fig. 2. The experiment result of constructing model usinf life style data.

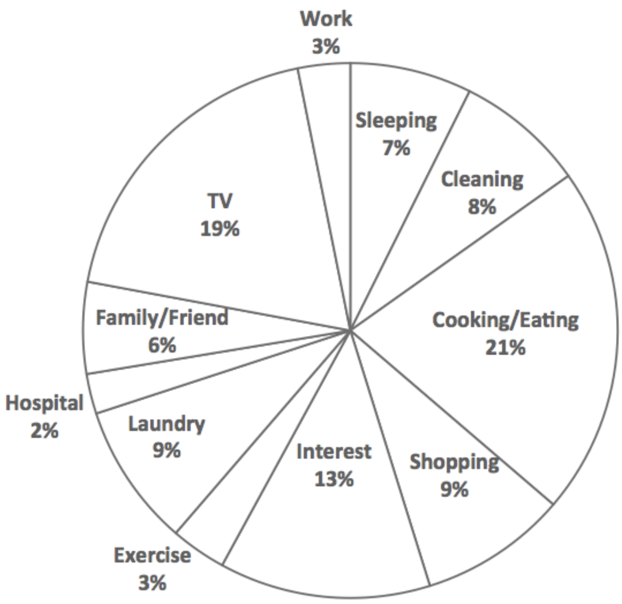


Fig. 3. Concept detail of Cluster 0 of experiment result from life style information.

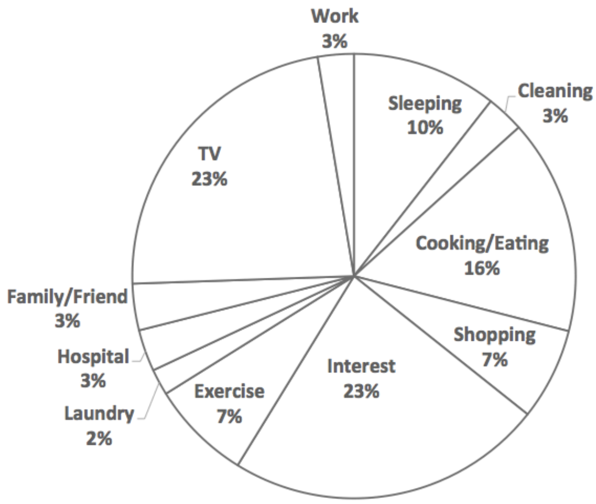


Fig. 4. Concept detail of Cluster 1 of experiment result from life style information.

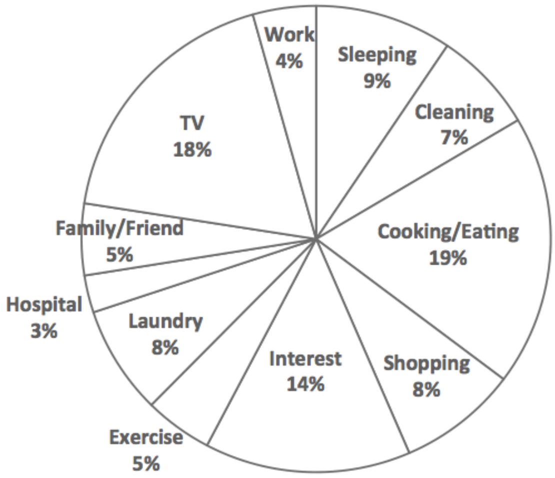


Fig. 5. Concept detail of Cluster 2 of experiment result from life style information..

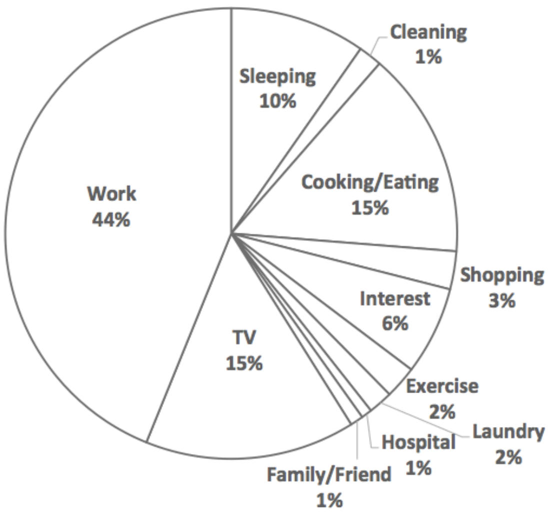


Fig. 6. Concept detail of Cluster 3 of experiment result from life style information..

Moreover, the current health state information of participates also be added for approach user's real health conditions. The frequency of participates go to hospital is used. Fig. 7 shows the result from data mining tool, and 3 Clusters are found. In Cluster 0, there are 127 persons includes 86 male and 41 female that takes 21% from the number of participates. In Cluster 1, there are 302 persons includes 188 male and 114 female that takes 51% from the number of participates. In Cluster 2, there are 163 persons includes 34 male and 129 female that takes 28% from the number of participates.

From the new clusters, 3 models are found. Cluster 0, as illustrated in Fig.8, include most of participates who spend 43% times in a day on work, 23% for things they interest, 15% on cooking/eating, and rest 7% on housework. The cluster is judged by experiment as workers. Cluster 1 that is shown in Fig. 9 include participates who spend 50% day time on doing things he/she interest, 17% times in a day on cooking/eating, and rest 15% day time for housework. The cluster is judged by experiment as retirees. Cluster 2 include participates who spend 19% day times on cooking/eating, 22% times on a day for housework, and rest 36% on doing things he/she interest. The concept details are shown in Fig. 10. The cluster is judged by experiment as housewives/househusbands.

The results from Fig.7 help to sum information which worth to notice. In results of Fig.7, Cluster 0 (workers) spends less time to hospital then Cluster 1 and 2. The daily life for Cluster 1 (retirees) and Cluster 2 (housewives/househusbands) are contrary: people of Cluster 1 spend most of times on enjoy life and take care of him/herself, people of Cluster 2 spend most of times to take care every day's daily life. According to the clustering results, a compare is made. Participates' average ages and health states are described in Table II. Cluster 0 is 64.4 years old, 41.7% people go to hospital 1~3 times a month and 8% go to hospital 1~7 times a week; Cluster 1 is 66.3 years old, 57% people go to hospital 1~3 times a month and 6.3% go to hospital 1~7 times a week; Cluster 2 is 64.9 years old, 52.1% people go to hospital 1~3 times a month and 4.3% go to hospital 1~7 times a week. It is said that although trade of going to hospital will increase along with age, but these people who have more time to take care daily life (housewives/househusband) have better health situation. It also remain again that health care system should not only put the points on exercise, but also extend the area to every aspect of daily life.

TABLE II. PARTICEIPATES' AVERAGE AGES AND HEALTH STATES IN THE 3 CLUSTERS

| | Cluster 0 | Cluster 1 | Cluster 2 |
|---|---|---|---|
| *Average ages* | 64.4 | 66.3 | 64.9 |
| *Go to hospital 1~3 times/month* | 41.7% | 57% | 52.1% |
| *Go to hospital 1~7 times/week* | 8% | 6.3% | 4.3% |

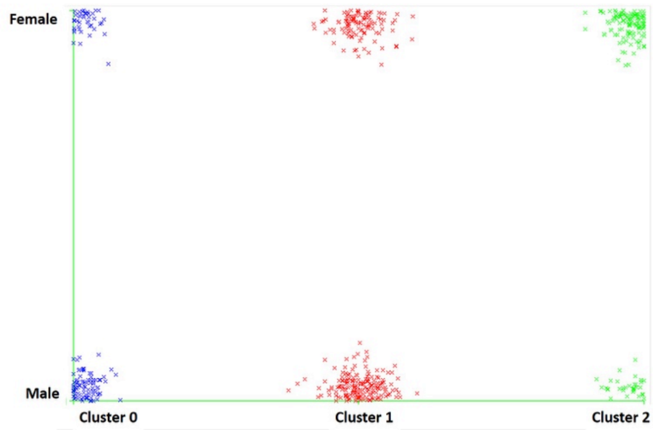


Fig. 7. The experiment result of constructing model using life style and currect health state data.

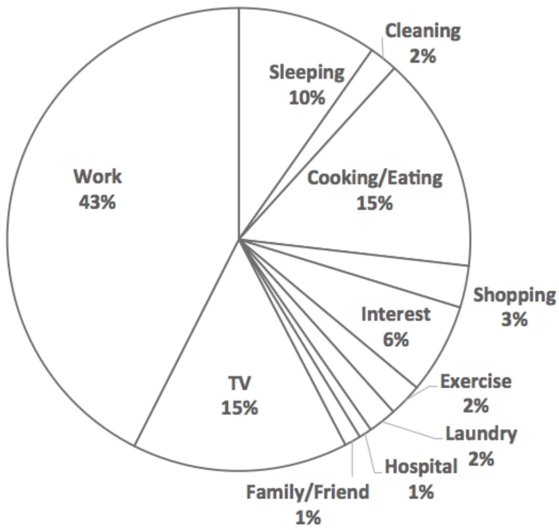


Fig. 8. Concept detail of Cluster 0 constracted by mining life style data and currect health state data.

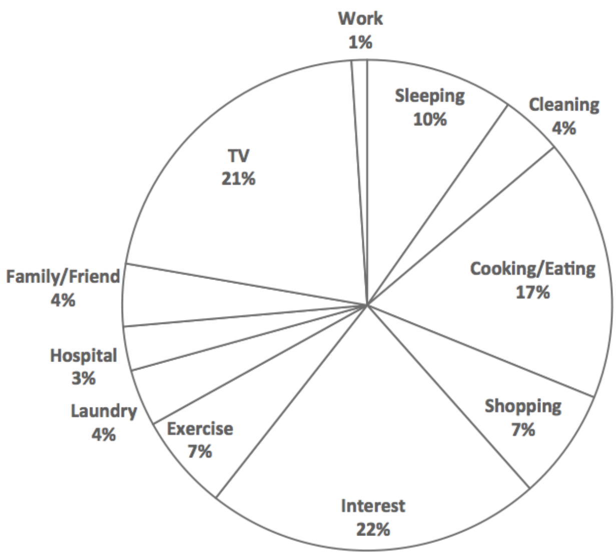


Fig. 9. Concept detail of Cluster 1 constracted by mining life style data and currect health state data.

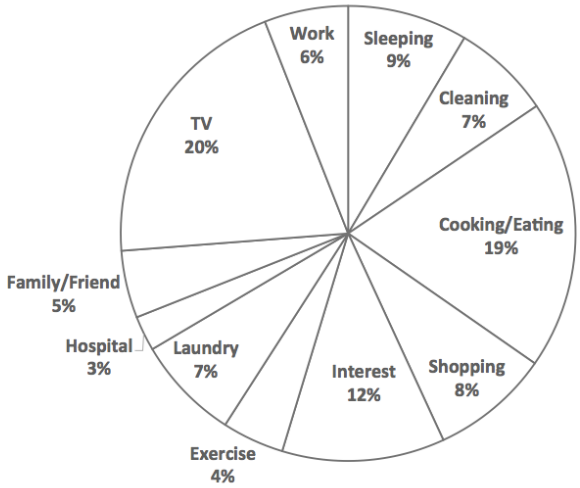


Fig. 10. Concept detail of Cluster 2 constracted by mining life style data and currect health state data.

### *A. Application*

In the previous research, an exercise support robotic system has been developed [7]. The system detects user's motion for calculation the amount of exercise, adapts a robot to interact with users. When the system detects the user less of exercise, the robot will invite user to do exercise by playing video game using virtual keyboard or virtual mouse. The research has considered user's weariness, but ignore user's life rhythm and the amount of exercise of daily activity. This research makes up this weakness by increasing the users' life rhythm data.

## VI. CONCLUTION AND FUTURE WORKS

This research presented a concept of using life rhythm to construct basic models for suppoet the presented health care system. Through the experiment results, several different kinds of model are found. The results show the possible of adapting life rhythm data, as the basic data to distinguish different life style. And the important of currect health states. The system bases on the results to support different user's exercise needs. The research is prodictable that it will improve better user experience effectively. In the future works, there are several targets that have to accomplish, such as improvement the way of collect data information, improvement the prediction accuracy, development the data collection interface, development different model construction way, and extending the support aspect of health care system.

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