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Research on Hybrid Information Evaluation Type Watching Technology for the Improvement of QOL of the Elderly

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Abstract

The increase in living alone and old households due to aging of the society has led to a decline in the quality of life (QOL) of elderly people. How to maintain and improve the quality of life for elderly people is a pressing issue of society. We watch over the elderly from both aspects of health-related QOL and subjective QOL and work on creating a social system that realizes a safe and secure life for the elderly. In this research, we promote the health information database which holds health related information in the shared database system such as the cloud by the will of the person him/herself, and develop a method for mining various kinds of life log information and medical/care related information in a hybrid manner. In this paper, we propose a remote watching method inferring resident's behavior related to the operation of electric appliances from the measurement of total load current of the household. We also attempt to perform hybrid data mining by combining subjective mood data and objective data with wearable sensors that can collect biological data. We aim to provide a system that brings a safe and secure life to the elderly by carrying out assessment and early detection of abnormal symptoms of them such as depression and dementia.

Keywords: Single Elderly Person, Watching System, Household Electric Appliances, Total Load Current, Life Log

1. Introduction

Sharing of patient information at hospitals, nursing care facilities, pharmacies, etc. has begun, and standardization of information is necessary for sharing of medical data and nursing care data in order to conduct regional inclusive care (cooperation among home medical care and nursing care). It is thought that the creation of a health information database will be promoted by the owner of health information and each service provider shares and utilizes information. Due to the recent aging of the population and the dilution of family relations, the number of people who are living alone has increased [1]. Because the cooperation among stakeholders is not well conducted, the quality of life of the elderly is deteriorated. We view issues to be addressed as follows.

Although watching over the elderly tends to emphasize only the physical condition and health of the vital data, it is important to evaluate and improve living conditions such as social participation and worthiness of living.

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A method is not sufficiently established for comprehensively analyzing digital data such as various life logs and vital data and various auxiliary mental information such as records and memos by medical and caring personnel.

It is necessary to establish a feedback system based on the comprehensive analysis result according to (2) above. Assessment in nursing care and application to precise prevention/prediction are conceivable.

Extraction of behavior patterns of elderly people using various sensors such as motion detectors and wearable sensors and research on risk avoidance by action prediction have been carried out for the purpose of avoiding danger for the elderly living alone [2][3]. Meanwhile, databases of visiting nursing care records, contact notes, etc. are made and research on risk mining systems from nursing care information, etc. are being conducted, but it is considered there is a shortage of approaches from the aspect of elderly QOL that utilizes both information in hybrids.

In this research, in order to solve the problem, we promote research as follows. We examine two kinds of methods for objective life log acquisition. The first is paying attention to the use of electric appliances in home, the residents' life logs obtained by estimating the presence or absence of operation of electric appliances by the residents. And the second is acquisition of detailed life log information obtained from a wearable sensor (in particular, a smart band having a low stress). Together with life log information from these sensors, we will make a database of living records such as visiting nursing care records and contact notes, and study methods of mining both information in a hybrid manner. We aim at unified structuring and utilization of subjective data such as notes and conversation and objective data from sensors etc. by hybrid mining of different types of information.

The rest of this paper is organized as follows: In section 2, we present hybrid information evaluation type watching technology in perspective. In section 3, life log by estimating usage of electric appliances and its application to watching system for elderly home is detailed. In section 4, experiment on correlation between mood states data and biological sensor data is reported. Finally, the paper is concluded in section 5.

2. Hybrid Information Evaluation Type Watching Technology

Research has been conducted on more structured mining techniques such as active mining [4], interactive data mining [5] and so on. We consider selecting multiple target data to be mined according to the problem to be solved, applying various mining methods suitable for it, and solving the problem with a combination of them. For example, consider applying the hybrid information evaluation system as shown in Figure 1 to the elderly watching.

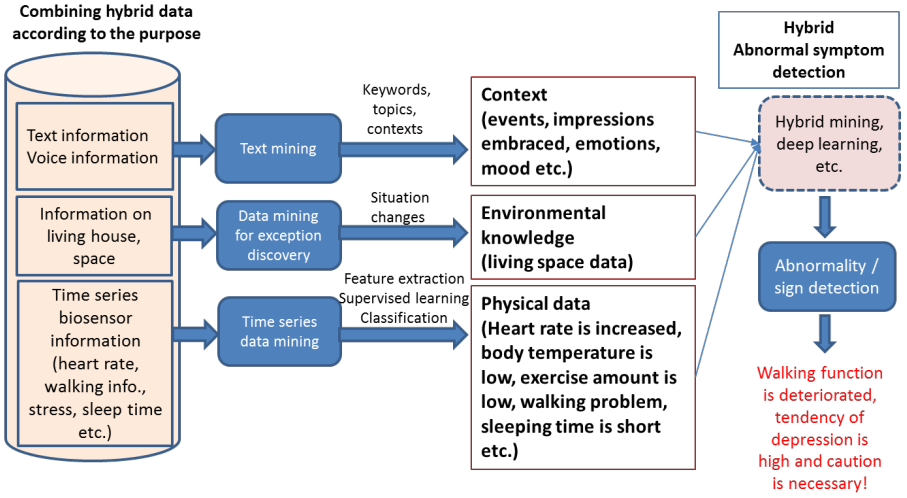


Figure 1. Overall schematic description of hybrid information evaluation type watching system for the elderly to improve QOL.

The hybrid information evaluation system will be constructed by combining the following technical elements (Figure 1).

Technology combining hybrid data according to the purpose

We develop techniques for collecting subjective information such as text information and voice information, information on living space, time series numerical information from biosensor etc. efficiently according to the purpose and interest of the user and performing preprocessing

Technology that selects and combines mining methods suited to the purpose for various forms and various information sources

We develop mining methods that can deal with diverse formats and various kinds of information sources and has flexibility to cope with versatility and changes in circumstances. In particular, we focus on mining method of semi-structured data represented

by text information and structured data represented by sensor data, and powerful exception discovery technology for detecting situation changes.

Technology to evaluate and interpret multiple mining results according to purpose

We develop a mining system for specific problem areas and technologies (display method of knowledge, evaluation method, effective feedback method to users) for making the excavated knowledge useful for users.

In this paper, we report experimental results using subjective information of daily mood data (digitized), electric power usage data as living space data, and SmartBand 2 (Sony) as a biosensor.

3. Life Log by Estimating Usage of Electric Appliances

The remote watching system in the isolated household which grasps something unusual early and handles in preventive way is a pressing requirement [6]. It is necessary to plan to combine both existing caring services by human care persons and a remote watching system utilizing ICT. In this research, our objective is to combine an active watching system by human network with passive sensor based watching system to detect unusual and emergent statuses and verify effective practical usage of the combined watching system in the real field.

To keep burden to the resident as small as possible, we just install a simple measuring device of electric load current at home distribution switchboard [7]. Then, we propose a remote watching method inferring resident's behavior related to the operation of electric appliances from the change in total load current of the household and acquire life log of the resident. Preliminary verification is performed whether it's possible to grasp the general living condition of the resident by screening out standby base power usage and inferring use conditions of electrical appliances (television, PC, air conditioner, microwave, rice cooker, refrigerator and washing machine) from the measured value of electric current. We asked two residents who live alone for cooperation to keep a living record table for confirmation of whether the life log of the resident could be obtained properly, and verification is carried out by contrasting with the life log information obtained from the electric usage data.

3.1. Measurement of Total Electric Load Current [7]

Figure 2 shows the measuring device installed at the home distribution switchboard in the house of the elderly resident. Figure 3 shows a display example of the viewer used by the members of a care support center who are in charge of caring elderly people.

Figure 2. Measuring device installed at the home distribution switchboard.

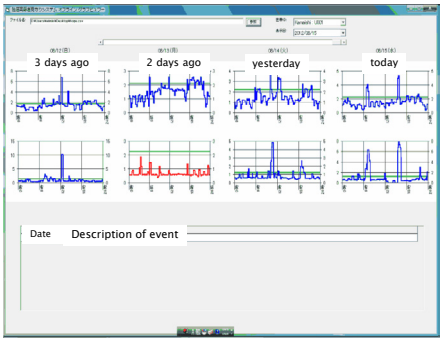


Figure 3. A display example of the viewer.

The inferred results by two methods, an integration method and a cumulative frequency distribution of change method, are shown as a daily chart in the viewer. The upper side shows the result by the integration method and the underside shows the result of the cumulative frequency distribution of change method. The former method calculates average value of total load

electric current for 15 to 30 minutes as the electric power consumption of the house. The latter method first obtains fluctuation value of electric current in 1 minute in absolute value and then calculates cumulative frequency distribution of the fluctuation during 30 minutes to get the 50% middle value of the fluctuation in 30 minutes time to infer whether home electric appliances are operated or not. Red chart shows unusual states like low electric power usage or no use of electric appliances. Blue chart shows normal state of living.

So far, by this method, low or no use of electric appliances are detected, but living condition or living pattern is not analyzed yet. In the next section, we investigate the possibility of identifying more specific living pattern from the electric load current.

3.2. Analysis of Total Electric Load Current

Living condition such as sleep, meal, housework, entertainment and bathing which are basic living activities is being presumed and the living pattern of one day is being generated from the obtained usage state of home electric appliances of the resident.

We assume that it is possible to detect some living pattern which is a little unordinary rather early and link to the preventing action on the care staff side. For example, detection of the following living patterns at early stage is considered,

Disorder in wakeup time, meal time and bedtime,

Inactive living behavior,

Grasp of going-out behavior.

We expect that worst situation such as lonely death overlooked so far can be evaded by the preventing action of care staff utilizing this system.

Here, we try to plot total electric load current with the amount of operation of home electric appliances for one day (24 hours). The sampling value of every 1 minute obtained from the measuring device was used as the plot of the total amount of electric load current. As the plot of the amount of electric appliances' operation, fluctuation value of electric current in 1 minute in absolute value is used.

A computation process was performed using programming language R for statistical analysis. We try to plot the total amount of electric load current (as time series variable ts) and the amount of electric appliances' operation (as variable dif) as shown in Figure 4. If we pick the area where both the total amount of electric current (plotted as ts) and the amount of electric appliances' operation (plotted as dif) (inside yellow limits covering roughly a quarter area on the upper right), we assume we can identify the area where the use of electric appliances is active and the operation of home electric appliances is also frequent. We estimate we might be able to make this range relate to some living activities.

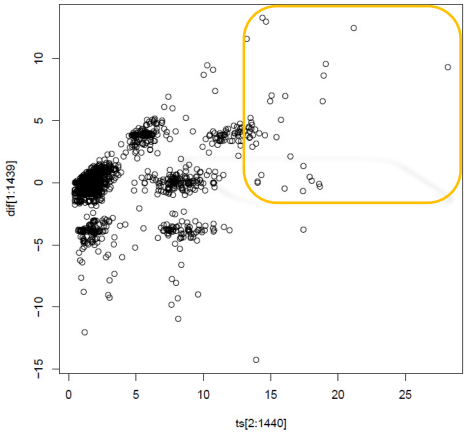


Figure 4. Total electric load current per minute (horizontal axis ts) and the amount of electric appliances' operation (vertical axis dif) for one day.

Based on these predictions, we analyze the actual data of the volunteered experiment collaborator's home while comparing it with the life record table. For example, Figure 5 shows plots of this sample on two days. On the left side, the integration method by the viewer and the display by the cumulative frequency distribution method are plotted. On the right side with the regions where both the total current amount and the home appliance operation amount are large on the time axis. Comparing the trends in the two schemes, it can be seen that the figure on the right shows well extracted trends on the left side.

3.3. Preliminary Experiment

We installed measuring devices at the home distribution switchboard in the house of the elderly people who volunteered to cooperate with the experiment (total 7 houses in this experiment).

In our experiment, we asked two subjects to keep daily living record for about six weeks on February 1-March 14. The relation between the living activities and the electric usage is being analyzed by checking the correspondence between them. The record about daily living such as getting up from the bed, having a meal, taking a bath, going-out and going to bed and the usage record of electric appliances such as television, rice cooker, electric pot, microwave, washing machine, cleaner, air conditioner and electric heater are put into daily living record table.

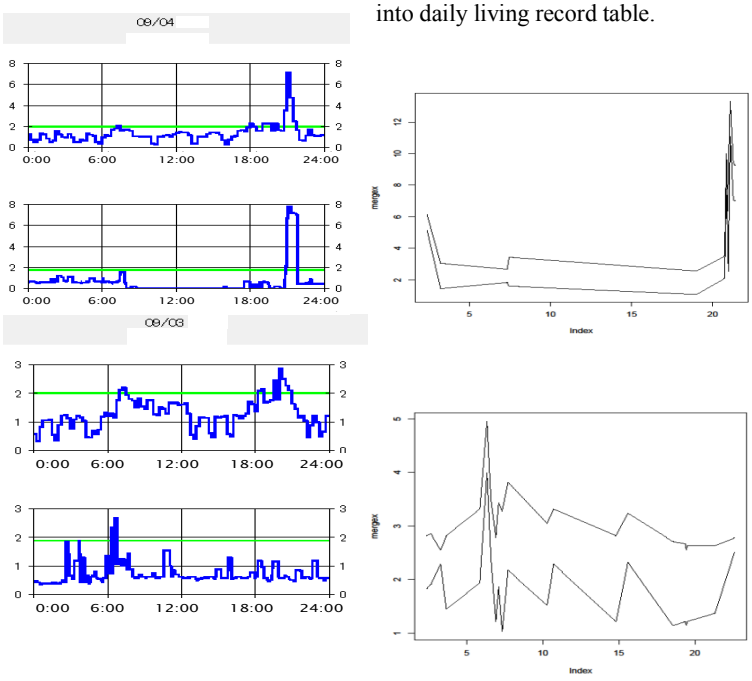


Figure 5. Regions in which both the total current amount and the home appliance operation amount are large are extracted and plotted on the time axis

Here, we compare the actual data of one of the two subjects with the daily records as summarized below and analyze the relationship between daily behavior and electricity usage. Based on the data obtained from the total load current measuring device, we will see how much life pattern estimation is possible.

The Subject lives a regular life. Often go out in the afternoon, but time varies from day to day. Bathing is done at the time of going out. On February 9 th, she went out from 12:00 to 16:00, but on February 19 th, didn't go out. Almost the same time for breakfast and dinner, lunch comes before 12:00 on February 9 th because she goes out. On this day, from 9:00 to 16:00, we can see that there is no use of home appliances. Meanwhile, On February 19th, she stayed home all day, use of home appliances is seen at 11:00-12:00. On this day, she used the electric heater for a long time. Both days, after 20:00 we cannot see the use of evident home appliances. The bedtime at 22:00 cannot be specified from the usage of electric power.

In this case, if it is almost clear that the daily plot pattern is known by being in a regular life, it could be said that the life pattern can be estimated even if specific usage of the home electronics cannot be specified. As a result, it seems that it is possible to grasp to some extent about the event which is the initial purpose as follows.

Disorder in wakeup time, meal time and bedtime,

Inactive living behavior,

Grasp of going-out behavior.

(1) Data of February 9 th data (Figure 6)
Getting up at 6:00 am
- Electric stove from around 5:00
- From 6:00 TV
- Microwave oven from 7:00
- Breakfast 7:00-8:00 am
- 11:00 – 12:00 Lunch
- Going out from 12:00 to 16:00
- After returning home, TV, electric stoves, microwave oven
- 17:00 – 18:00 dinner

22:00 Go to bed

(2) Data of February 19 th (Figure 7)
Getting up at 6:00 am
- Microwave oven from 6:00
- From 7:00 TV
- 8:00-13:00, 17:00-21:00 Electric stove
- Breakfast 7:00-8:00 am
- 13:00-14:00 lunch
- 17:00 – 18:00 dinner
- All day at home

22:00 Go to bed

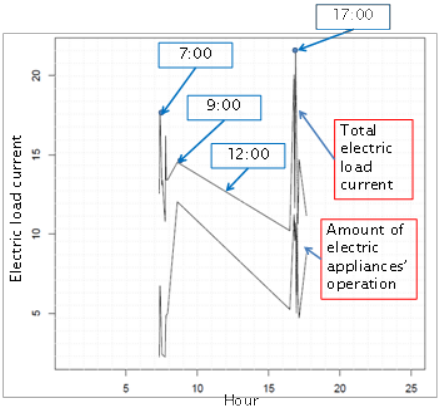


Figure 6. Plot of February 9 th

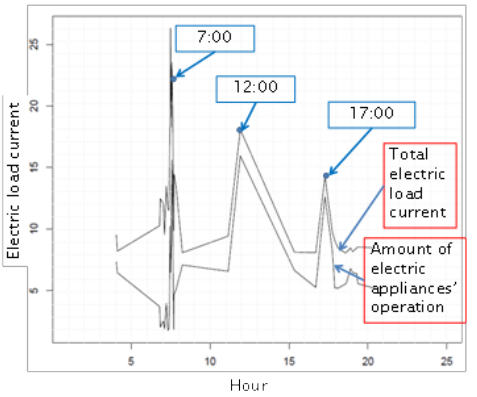


Figure 7. Plot of February 19 th

3.4. Considerations

We tried grasping the living behavior using the total load current of the household by experiment. Watching over people living alone using total load current and provided viewer [7] is effectively used in temporary houses. Furthermore, In addition, experiments were conducted based on the hypothesis that the characteristics of the life pattern of each individual appear in the use situation of electricity. As a result, if we look at individuals continuously (taking into account the seasonal change, for example), we can see the outline of daily behavior, and we can proactively respond by grasping the abnormality as soon as possible For example, disorder such as wake-up time, mealtime, and bedtime, inactivity of living behavior, grasping outing behavior, etc. However, in order to improve accuracy and completeness as a system, further study on data acquisition method and data analysis method are necessary.

4. Experiment on Correlation Between Mood States Data and Biological Sensor Data

For early detection and early treatment before the condition of the elderly becomes worse, it is necessary to adopt a method to encourage awareness of patients, for example, for suffering from depression. By using objective data and bringing them to patient's own awareness and leading to early detection, we expect that early treatment could be possible as a result.

Therefore, in this study, we try to discover regularity and relation between data obtained by data mining by combining quantitative data such as biological data and mood states data that is deeply related to depression in order to use to encourage awareness of patients.

4.1. Collected data

(1) Mood states data

We introduce a self-report method to measure multiple mood states [8] that can measure subjective mood of the day by answering a questionnaire of 24 items at the end of the day. The user answer the degree of these 24 items (8 × 3; the first 8 are for "positive feeling", the next 8 are "negative feeling", the last 8 are "resting state") into 4 scales (I do not feel it at all (1) - I do not feel it much (2) - I feel somewhat (3) - I feel very much (4)). These 24 items are "Lively, fun, fulfilling, cheerful, pleasant, energetic, smooth, motivated/ upset, scared, frightening, horrible, uneasy, tense, surprised, nervous/ slow, relaxed, tranquil, peaceful, carefree, comfortable, calm, quiet". The mood scales are converted into numerical values i.e., 1 through 4 and handled.

(2) Biological sensor data

We collect biological data of the subject using a wearable life logging wristband SmartBand 2 (Sony). By this device, we can monitor pulse (minimum pulse, average pulse, maximum pulse), stress (recovery, low, medium, high) by HRV, quality of sleep (time, deep, shallow), amount of physical exercise (walking (time, distance, step count, calorie consumption), running (distance, time, calorie consumption)). Using the application "lifelog", it is possible to accumulate the collected data and freely browse on the smart phone.

(3) Daily short memo

The subject makes a short memo mainly about events, impressions embraced at that time, emotions, etc. that occurred during the day. This is used to check the situation against changes of the mood states and biological data used for analysis.

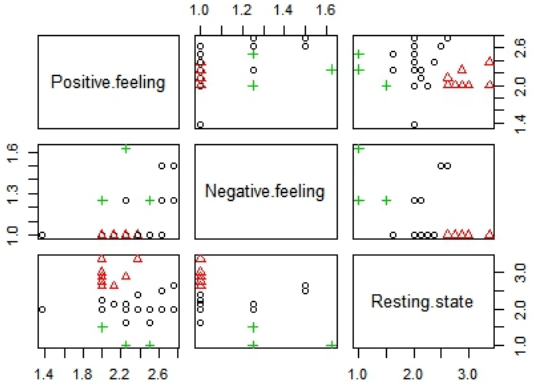
4.2. Preliminary data analysis

We conducted a preliminary data analysis for about one and half months data (17th January. - 5th March) by a subject to see the rough relation between subjective mood state data and objective biological data. In this experiment, the subject is a very average person who is living a healthy and regular life while working and not having much troubles in work or at home. In this analysis, data of only one subject is used and it is a preliminary demonstration in a very limited range.

(1) Clustering of daily data by mood states

First, we clustered obtained daily data by the mood states scales applying k-means clustering with k=3. Scales of each 8 items are averaged for the analysis. Then checked the specific events and living condition which characterize each group.

This is to ascertain to what extent the daily life is characterized by subjective data such as feeling and physical condition recognized by the subject.



○Middle-Higher Positive, Middle Resting
△Middle Positive, Lower Negative, Higher Resting
＋Middle-Higher Positive, Middle –Higher Negative, Lower Resting

Figure 8. Result of clustering based on mood data

Figure 8 shows the result of clustering based on mood data. When summarizing the results of daily living records (daily memos), it is estimated to be as shown in the Table 1. It can be divided into three patterns largely: rest days (holidays, etc.), normal working days, and days of event occurrences. As a result, subjective data such as the mood that the subject feels can confirm that the daily life is almost correctly color-coded.

Table 1. Summary of the result of daily living records according to the result of clustering based on mood data.

Cluster	Description of mood states of the day	Specific events and living condition
1st group (○)	Middle-Higher Positive, Middle Resting	Normal working day
2nd group (△)	Middle Positive, Lower Negative, Higher Resting	Rest days such as weekends and holidays
3rd group (＋)	Middle-Higher Positive, Middle – Higher Negative, Lower Resting	From the daily short memo, this group shows that some special events are occurring with higher Positive and Negative mood at the same time. Some excerpts follows. • I joined AI 's workshop one day and I am a bit nervous. • Preparation and implementation of the PBL achievement presentation, setting up desks. Stay at the hall in the afternoon. • Host a university laboratory tour afternoon. Many people participated. And it seems that the evaluation of the participants was also good.

(2) Relation between subjective mood state data and objective sensor data

In this section, regression analysis and correspondence analysis with the objective sensor data are performed on the mood data group shown in (1) to confirm the relevance among them.

• Regression analysis

Here, we tried multiple linear regression analysis to estimate "positive feeling" of mood states data of the subject from the data of walking (distance, time, calorie consumption) of biological sensor data as an example.

The analysis result and the state of residual evaluation are shown in Figure 9. In this analysis, the coverage of explanation parameters is as low as 28.5%. Risk value is lower than 1% confidence. It is understood that the walking time has the largest influence among the parameters.

Fit statistics	
MCC R	0.533916
R2	0.285066
Adjusted R2	0.236321
SE	0.230167
Observations	48

Analysis of variance

	DF	Sum of squares	Mean squares	F	Pr>F
Model	3	0.929435	0.309812	5.848053	0.001881
Error	44	2.330982	0.052977		
Corrected Total	47	3.260417			

Model parameters

	Value	SE	t	P-value	Lower 95%	Upper 95%
Intercept	2.020586	0.071698	28.1821	8.53E-30	1.87609	2.165083
Distance	0.00023	0.000357	0.644362	0.522686	-0.00049	0.00095
Time(Minutes)	0.031201	0.013366	2.334337	0.024207	0.004263	0.058138
Kcal	-0.0175	0.012829	-1.36394	0.179522	-0.04335	0.008357

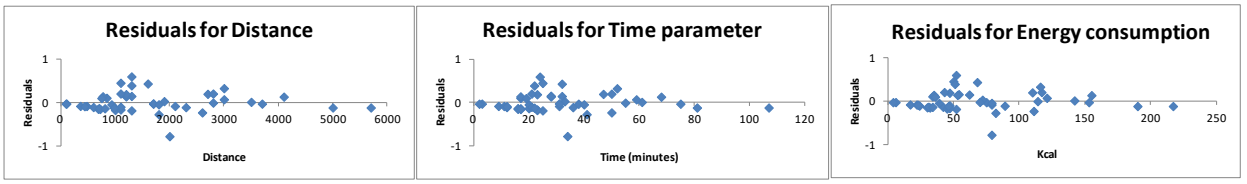


Figure 9. The result of regression analysis and the state of residual evaluation

• Correspondence analysis

The results of correlation analysis by performing cross tabulation of groups in Table 1 and Walking time and the plotting of the correspondence analysis is shown in Figure 10.

The correspondence can be clearly seen as shown in Table 2.

Table 2. Correspondence between groups and Walking time.

	Walking Time (minutes)
Group1	30=<.<60
Group2	<30
Group3	>=60

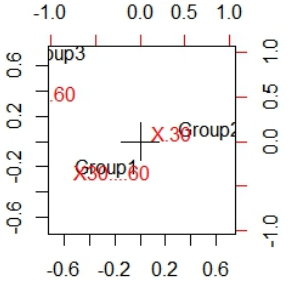


Figure 10. Plot of correspondence between groups and walking time (minutes)

4.3. Consideration

Subjective mood data was grouped, and walking was taken as a parameter to explain it, and it was analyzed. This time, we analyzed based on limited data, so we confirmed that it is possible to estimate subjective event to some extent with objective sensor data though its reliability is still low. In addition, it is necessary to collect and confirm the data of many elderly people.

By establishing this method, it is possible to estimate the mental state, mood, etc. of elderly people by acquiring biometric sensor data which are easy to measure in the future. We will improve the watching function, aiming to improve the quality of life (QOL) of elderly people.

5. Conclusion

We explained the concept of the health information database which holds health related information in the shared database system, and development of hybrid mining methods for various kinds of life log information and medical/care related information. We proposed a remote watching method inferring resident's behavior related to the operation of electric appliances from the measurement of total load current of the household. We also tried to perform hybrid data mining by combining subjective mood data and objective data with wearable sensors that can collect biometric data.

Although, examination and ingenuity are necessary for handling data with different types such as context, environmental knowledge, and physical data, if the context, environmental knowledge, and physical data can be acquired and somewhat analyzed, it can be considered that we can bring a safe and secure life to the elderly by carrying out assessment and early detection of abnormal symptoms of them.

Acknowledgement

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