A Context-aware Information in Smart Home for Health Recommendation Service based on CARE Architecture

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Abstract

Nowadays, providing a health service to home users presents a number of challenging tasks. Several researches attempt to provide health services to home users. Apart of health service, health recommendation service is proposed as a term of recommendation health service for preventing the disease. However, the existing research works suffer to provide the appropriate health recommendation service because most of researches analyze the disease based on only user’s health condition. In this paper, we aim to help the physician to analyze the health recommendation service by providing the human behavior information and context-aware information in smart home. The healthcare system and physician can analyze the cause of disease through provided information. To obtain there relevant information, context-aware activity recognition engine (CARE) architecture is proposed for providing the context-aware information and also human activity information. Human behavior analysis system is also established in this research for summarization the outputs from the CARE architecture. Through experiment studies, the results of questionnaire express the importance of the provided information. The human behavior information can be used to analyze the appropriate health recommendation service for the home user.

Keywords: Healthcare system, Health recommendation service, Human behavior, Context-aware information, CARE architecture

1 Introduction

In the 21 century, concern about healthcare has become an essential aspect in daily life, not only just for the elderly but also for young people. People are more concerned about their health and desire healthy. Recently, healthcare systems have become more popular, especially in the smart home domain. The smart home [1] has emerged as one of the mainstream approaches to support technology-driven independent living for elderly and disabled persons. The smart home concept is gathered with several technologies i.e. wireless sensor network (WSN), data communication, and security to produce the ambient intelligence in home. Hence, several healthcare systems have proposed belonging to the smart home concept, e.g. a home healthcare (HHC) system [2].

According to the HHC system, there are many companies have released the products, which use for monitoring daily health conditions. Panasonic has released EW-NK63 device for measuring the calories consumed in each day. OMRON has presented HeartScan device for monitoring and recording the ECG information. Based on current technologies, users can maintain the health condition by themselves, and physician can utilize these data for diagnosis the diseases. Nonetheless, only basic health condition might not enough for analyzing the patient’s health in some cases. It is difficult to accurately assess an individual’s health condition because each person has a different lifestyle. Moreover, the existing healthcare system cannot find the real cause of the disease because only health signals are used to diagnose the disease. The cause of the disease does not directly appear in the health signals. Therefore, there are several types of data available which have to be considered such as user location, or user action. Consequently, human behavior information plays an important role to help the healthcare system to diagnose and prognoses the disease.

To address this shortcoming, E-health is proposed to manage the user’s health information. It removes the need to process paper-based, and allows healthcare system or physician to record the the user’s health condition electronically. Thus, in this paper, we aim to provide the human be-
behavior information to help the physician to analyze the health recommendation service for the home user. Consequently, context-aware activity recognition engine (CARE) architecture is introduced for obtaining the human behavior and context-aware information in smart home. Human behavior analysis system, demonstrated as the E-health, is also implemented on top of the CARE architecture for summarization the human behavior information. The results of this system can aid in physician diagnoses, enabling them to make more accurate recommendation on how to prevent disease. Through this studies, the questionnaire’s results express the effectiveness of our proposed system.

2 CARE Architecture

To carry out the goal of this paper, CARE architecture is designed as human activity framework. The application that requires the human activity information can build on top of the CARE architecture. The proposed CARE architecture has principal task to improve the ability of activity recognition system and provide the results that are more accurate, more reasonable, and more reliable in the real environment. Several techniques are applied in the CARE architecture. For example, BSN and HSN techniques are developed to collect the human information and surrounding information in smart home. To classify the human activity, this proposed architecture focuses on 14 target activities that users often perform at home, such as “Watching TV,” “Working on a computer,” or “Cooking” activities. The CARE architecture consists of six layers, which combine several technologies and techniques inside as shown in Figure 1.

![Figure 1. A layered architecture of the CARE architecture](image.png)

2.1 Physical Layer

Physical layer consists of physical hardware such as sensors, home appliances, or network components. This layer provides the context-aware information in smart home, including the human information. To obtain the relevant information in a real environment, Context Sensor Network (CSN) with a diversity of sensors and network protocols is proposed. The CSN is a sensor network that typically collects the context-aware data in the smart home. There are three kinds of sensor networks in the CSN: a home appliance sensor network, a home furniture sensor network, and a human sensor network. The goal of first two sensor networks is to capture the object usage in smart home. The variety of sensors are built-in the home facilities such as “Sofa,” “Outlet,” or “TV”. Whereas the human sensor network is proposed for observing the human information, such as human location in smart home. Moreover, several communication networks are also developed in these three sensor networks: UPnP, ECHONET, and Zigbee.

Nevertheless, using information concerning object activation and human location still has limitations because sometimes, human location does not hint at any specific activity if several objects are being used. In this layer, posture classification is proposed to improve the ability of activity recognition. A novel algorithm, called range-based algorithm [3], is used for classifying the human posture. The concept of this algorithm is to use the relation of body parts to extract the postures from the range between body parts.

2.2 Data Layer

Organizing the huge amount of data in a smart home is a complicated task because there are several information components for the system to consider. The system cannot always obtain absolutely perfect data from the sensor. There can be missing data and noise problems associated with hardware. Therefore, the data layer has the responsibility of storing and organizing the data obtained from the physical layer. A data manager and system repository are proposed to organize the data in the smart home. The data manager is proposed to normalize and transform the data before sending it to the system repository. There are two main functions to normalize raw data: supply missing data function and eliminate...
data function.

Meanwhile, the system repository plays a vital role in controlling data flow in the system. There are two modules in the system repository: a repository and a context controller. The repository is used as the database in the CARE architecture. It collects the data that is normalized by the data manager and also retains the temporal reasoning of the system. The context controller performs three main data-processing tasks: “Mapping Data,” “Composing Data,” and “Reprocessing Data”. This context controller will synchronize the data between data layer and semantic layer.

2.3 Semantic Layer

In semantic layer, three ontologies namely context-aware infrastructure ontology, functional activity ontology, and activity log ontology, are designed for creating smart home knowledge-based for recognizing human activities.

The proposed semantic layer makes CARE architecture scalable because it describes at the abstract level, so it does not need a training process. It differs from the existing researches, which use the probabilistic method to recognize the human activities. They require a large amount of data for training set. Furthermore, it also gains the benefit from the semantic web technology – standards for distributed data sharing and processing. Based on these three ontology models, two pieces of information are introduced for improving the ability of activity recognition: the new user’s context and Activity’s Location in the Activity Log (AL²). For the new user’s context, we add the human posture information, which is obtained from the posture classification, to reduce the “ambiguous activity problem”. Meanwhile, the AL² is introduced to find the relationship between activities that occur at the same location. The history of activities at the current user’s location is investigated with the current activity for classification [4].

2.4 Platform Infrastructure Layer

To translate from the data to the knowledge, ontology application manager management (OAM) framework [5] is developed. The OAM framework has a duty to link between a unified conceptual backbone for data modeling and representation and an application layer. Resource description framework (RDF), a standard model for data interchange on the web, is created via the OAM framework. The RDF will collect the data modeling, which is mapped between the data in the repository and the ontology model. After that, all of data modeling will be stored in the smart home knowledge-based. Moreover, the OAM framework also provide the engine to access the knowledge through SPARQL. The SPARQL is a language query that used to query the knowledge from the RDF (refers to the ontology model and database) in a smart home knowledge-based.

2.5 Processing Layer

The intelligent technique is built in the processing layer for recognizing human activity based on the smart home knowledge-based, which is created in the platform infrastructure layer. Normally, ontological models do not have the ability to recognize human activity. The popular ontological language, OWL (Web Ontology Language), has been used to build activity ontologies, and to recognize activities based on context data. Naturally, ontology uses Description Logic (DL) to express domain knowledge. To infer the human activity, DL rules are created by modeling and linking between an activity instances and inferred activity instance. DL rules in this research describe relationships among object activation, human location, human posture, and activity log. The following example indicates a DL rule for the “Washing dishes” activity:

\[
\text{Washing dishes} \sqsubseteq \text{Functional Activity} \\
\sqsubseteq \text{Kitchen Activity} \\
\sqcap \text{use}(\text{Object.Furniture}(\text{Sink})) \\
\sqcap \text{Object.Human.Current\_location}(\text{kitchen}) \\
\sqcap \text{HumanPosture(Stand)} \\
\sqcap \text{LastActivity.Kitchen\_Activity}(\text{Eating or drinking})
\]

2.6 Application Layer

For the application layer, several applications, which require the human activity information and semantic context-aware information in smart home, can be implemented on top of the CARE architecture, such as activity recognition system, healthcare system, or human behavior analysis system. To evaluate the performance of activity recognition based on the CARE architecture, the proposed architecture is installed in iHouse [6],
an experimental smart home environment. The experiment was performed by six actors (three males and three females) whose ages ranged from 24 to 31. They were asked to perform any activities in iHouse without instruction. The results of the activity recognition based on the CARE architecture are shown in Table 1.

Table 1. Accuracy of activity recognition based on CARE architecture

<table>
<thead>
<tr>
<th>Activity</th>
<th>Accuracy (%)</th>
<th>Other possible resultant activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = Sitting on the toilet</td>
<td>97.75</td>
<td>A1 (2.08%), A11 (14.75%)</td>
</tr>
<tr>
<td>A = Taking a bath</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>A = Lying down &amp; Relaxing</td>
<td>97.69</td>
<td>A11 (3.49%), A14 (4.65%)</td>
</tr>
<tr>
<td>A = Showering</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>A = Making coffee</td>
<td>98.21</td>
<td>A11 (13.59%)</td>
</tr>
<tr>
<td>A = Eating or drinking</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>A = Washing dishes</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>A = Working on a computer</td>
<td>95.59</td>
<td>A11 (3.89%), A14 (3.95%)</td>
</tr>
<tr>
<td>A = Watching TV</td>
<td>95.58</td>
<td>A11 (2.95%)</td>
</tr>
<tr>
<td>A = Reading a book</td>
<td>99.59</td>
<td></td>
</tr>
<tr>
<td>A = Scrubbing the floor</td>
<td>93.75</td>
<td>A11 (6.25%)</td>
</tr>
<tr>
<td>A = Sweeping the floor</td>
<td>96.67</td>
<td>A11 (3.33%)</td>
</tr>
<tr>
<td>A = Others</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Average accuracy:</td>
<td>96.60 %</td>
<td></td>
</tr>
</tbody>
</table>

Based on the goal of this research, we are going to use the human activity information, which obtain from the CARE architectue, by implementing the human behavior analysis system for analyzing the disease.

3 Actualization of a Health Recommendation Service

Until now, providing the appropriate health recommendation services in home is a challenging task. The system has to decide which health services are suitable for the home user. There are several proposed systems that attempt to provide the health recommendation service to the home user. Nonetheless, most of the existing researches tend to collect only user health condition through intelligent wearable devices based on various kind of techniques, and diagnose the disease based on only the user health condition. SapoFitness [7] has been established to monitor the health information, especially user’s weight information, to control the user’s weight. For monitoring the heart rate, mobile health monitoring system (MHMS) architecture has been designed to monitor the heart rate from RFID ring-type pulse sensor and display the heart rate through smart phone [8].

Nevertheless, existing healthcare systems cannot find the real cause of the disease because they use only health signals, while other information must be also taken into account, notably human behavior information. Hence, the outputs of the CARE architecture will be used for analyzing and presenting to the home user and the physician for diagnosis the disease through the human behavior analysis system. Both activity information and context-aware information in the home are presented in the human behavior analysis system. Four kinds of information are analyzed in this system. Figure 2 illustrates the example interface of activity information in the human behavior analysis system.

![Figure 2. The activity information in the human behavior analysis system](image)

3.1 Activity Analysis

Normally, to diagnose the disease, the health information is the main information that the physician or the healthcare system uses. However, the real cause of the disease may not show off in the health information. Therefore, the activity information plays an important role in recognizing the cause. Based on the summarization of the activity information in this system, three types of information are provided. Activity of daily living (ADL) information is presented to the home user. The home user, physician, or healthcare system can monitor the ADL information to perceive what a home users does in each day for analyzing the cause of disease. Moreover, the activity information is also shown in term of percentage and time.

These kinds of information are very useful for ascertaining the cause of disease. For example, the existing healthcare systems cannot diagnose “Diarrhea disease” because the symptom of “Diarrhea disease” does not appear in the basic health information. Nevertheless, the human behavior analysis system can predict this illness from the “Sitting on the toilet” activity. If the
home user tends to perform the “Sitting on the toilet” often, the healthcare system might predict that the user has some problems with “Diarrhea disease”. Consequently, the system can provide a health recommendation service to the user for checking and preventing the “Diarrhea disease”.

Consider to the famous disease as “Obesity”, it is considered a serious disease since it is one of the main causes of diseases such as “Diabetes”, “Heart disease”, and “Cancer”. Of course, it is easily to diagnose “Obesity” from body weight, but the reason for “Obesity” is not dependent only on body weight. The daily habit of the user can also affect “Obesity” problem. In this research, the human behavior analysis system also provides energy expenditure information based on the activities that user performed in each day. Energy expenditure is calculated based on Metabolic Equivalents (METS) values. The METS value is most frequently used in calorie count to compute energy consumed during each activity. The formula for energy expenditure in this research is defined by the American College of Sports Medicine (ACSM), illustrated in equation below.

\[
\text{Energy Expenditure (kcal)} = 1.05 \times \text{METS} \times \text{Duration (hour)} \times \text{Weight (kg)}
\]

Based on the provided energy expenditure, the system can perceive how many calorie burn in one day based on the activities that user performed. Thus, if home user tends to perform low calories activities often, system might serve the health service, such as exercise service to the home user for preventing the “Obesity” problem.

3.2 Object Interaction Analysis

Normally, the usage of objects information is used to recognize the human activity. However, in this research, the human behavior analysis system provides the object interaction information for analyzing in the healthcare domain. The object interaction information can be analyzed in several directions. The system can perceive how long user spend for sleep from detecting the duration of “Bed” usage. The sleeping time is important to know that home user has adequate sleep or not. Monitoring the use of “Sugar container” can help the home user, who has “Diabetes” problem, control the user’s blood sugar.

However, analyzing only the object interaction information for healthcare domain might not enough because some objects in home, user turns on the home appliance, but does not use. For example, user might turn on “TV” in the living room while cooking in the kitchen. Thus, the object interaction information might useful when combining with other information such as activity information, or location information. Normally, the object interaction information is linked with the activity information because the object interaction information can be used for classifying the human activity. Thus, combination between the object interaction information and activity information will improve the ability of analyzing the disease.

3.3 Location Analysis

The location information is also provided in the human behavior analysis system. The location information is very useful for a patient who lives alone in home and has Alzheimer’s disease. Sometimes there can be a situation where their person has regular lapses in memory and forgets what/where the activity is that they were supposed to be doing. Caring for a person with Alzheimer’s at home can be difficult. The location information can help people in the early Alzheimer’s disease. The system can give the health service as “Quiz exercise” for asking when the patient moves from one place to another. For instance, the system might ask or remind the patient for checking the gas system when patient leaves the kitchen.

3.4 Health Information Analysis

Based on the existing healthcare system, the health information is the most relevant to diagnose the disease. Thus, several companies, e.g. Panasonic, OMRON, or Hitachi, have released products for obtaining the health information in home, and also provide the software to monitor the daily health information.

In the same direction, the human behavior analysis system also provides the health information to the users. For example, the weight information is summarized and displayed in line graph for helping the home user perceives the change of weight. Blood pressure information is the basic information that is used to diagnose “Hypertension” disease. Threshold value can be set for detecting the abnormal of the blood pressure information. Based on this graph, the sys-
tem can detect the tendency of the health information. Thus, this system can provide the health service if the abnormal information is detected.

4 Questionnaire

To evaluate this research, questionnaire technique is chosen to decide the performance of the proposed researches. Questions in questionnaire cover all of proposed, CARE architecture, activity recognition, and human behavior analysis system. The questionnaire about the effectiveness of this research is answered by six actors who demonstrate all experiments in this research. The questionnaire consists of three parts, which are following.

4.1 User’s Opinion in Information in Healthcare System

First part of this questionnaire asks the user’s opinion in information of existing healthcare system and information in our research. Questions in the first part were measured under each statement on Yes-no question and 5-point Likert scales. Mean and standard deviation (SD) values of the responses were calculated according to the 1-5 scores in difference indicator. Table 2 summarizes the response of three questions in the first part of a questionnaire.

The results from Table 2 illustrates that using only the basic health information might not enough. The respondents agreed with the first statement (with a mean score of 2.67) that the basic health information is insufficient for diagnosis the disease. A mean score is lower than half of level Likert scales (3). Therefore, using the basic health information in the healthcare system might not enough for diagnosis in some circumstances. Although, the basic health information can be used for finding the end result, it cannot perceive the cause of disease.

According to the purpose of this research, the knowledge regarding the human activity will be used for diagnosis the disease. The question of the usefulness of the activity information is asked the respondents. The respondents agreed with the statement (with a mean score of 4.67) that the knowledge regarding to the activity information is useful for providing the health recommendation services. The activity information can be used for diagnosis and prognosis the disease.

Meanwhile, the last question in this part mentions about the usefulness of the human behavior summarization. All respondents gave the positive answer with 100% agreed that the human behavior summarization is useful for the home user to recognize what user does in each day. Moreover, this information is also useful when using for analyzing the cause of the disease.

4.2 User’s Opinion in Relationship between Providing Information and Diseases

For the second part of questionnaire focuses on the relationship between the proposed context-aware information, which consists of three kinds of information (activity information, object interaction information, and human location information), and the diseases. The question asks the respondents about “Please answer in which you believe that the $X_i$ can be used to diagnose, treat, or prevent the following diseases.” where $X_i$ denotes the activity information, object interaction information, and human location. Ten diseases, which are common happened in Thailand, are observed in this research by asked the relationship between these ten diseases and the context-aware information. The questions are measured based on the Yes-no question. In addition, the results were calculated in percentage.

4.2.1 Recognize Diseases base on Activity Information

From the results in Table 3, we can conclude that all respondents believe that the activity information can be used to diagnose, treat, or prevent the given diseases. For example, recommendation the health service for the “Cystitis” and “Diarrhea” diseases is not an easy task because the healthcare system cannot get the health information that relates to the “Cystitis” and “Diarrhea” diseases. However, the proposed system can predict the “Cystitis” and “Diarrhea” diseases if system detects the home user tends to perform “Sitting on the toilet” activity often.

In addition, the ADL information in this system also helps the healthcare system not only to provide the appropriate health recommendation service, but also to analyze the cause of disease. The result in “Obesity” is a good outstanding example that activity information is useful for the healthcare system. Since the main cause of “Obesity” is that the home user has physical inactivity, so the physical activity on free time are
Table 2. User’s opinion in Information in Healthcare System

<table>
<thead>
<tr>
<th>Statement</th>
<th>Indicator</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard deviation (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think the basic health information such as weight, blood pressure, or step count is enough for diagnosis, treatment, and prevention of diseases?</td>
<td>1 (Insufficient) - 5 (Sufficient)</td>
<td>2</td>
<td>5</td>
<td>2.67</td>
<td>1.105</td>
</tr>
<tr>
<td>Do you think that knowledge regarding the human activity is useful for providing health recommendation services?</td>
<td>1 (Useless) - 5 (Useful)</td>
<td>4</td>
<td>5</td>
<td>4.67</td>
<td>0.471</td>
</tr>
<tr>
<td>Is human behavior summarization useful for the home user?</td>
<td>0 (No), 5 (Yes)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3. Summarization of the relationship between three kinds of information and the diseases

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Activity Information</th>
<th>Object Interaction Information</th>
<th>Human Location Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Migraine</td>
<td>50 %</td>
<td>50 %</td>
<td>67 %</td>
</tr>
<tr>
<td>Tension-type headache</td>
<td>83 %</td>
<td>17 %</td>
<td>100 %</td>
</tr>
<tr>
<td>Cystitis</td>
<td>83 %</td>
<td>17 %</td>
<td>50 %</td>
</tr>
<tr>
<td>Chronic Fatigue Syndrome</td>
<td>50 %</td>
<td>50 %</td>
<td>50 %</td>
</tr>
<tr>
<td>Hypertension</td>
<td>50 %</td>
<td>50 %</td>
<td>17 %</td>
</tr>
<tr>
<td>Obesity</td>
<td>100 %</td>
<td>0 %</td>
<td>50 %</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>50 %</td>
<td>50 %</td>
<td>33 %</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>50 %</td>
<td>50 %</td>
<td>33 %</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>83 %</td>
<td>17 %</td>
<td>83 %</td>
</tr>
<tr>
<td>Alzheimer</td>
<td>67 %</td>
<td>33 %</td>
<td>50 %</td>
</tr>
</tbody>
</table>

insufficient or too irregular to control the target body weight. In this sense, when the healthcare system detects that the home user tends to perform physical inactivity, the healthcare system might serve the health recommendation service as “Body-weight control service” to the user.

4.2.2 Recognize Diseases based on Object Interaction Information

From the results, the respondents believe that the object interaction information is not important for diagnosis the diseases. For example, there is no home facility that can infer to the “Hypercholesterolemia”, or the “Hypertension” disease cannot detect from the home facility usage. Nevertheless, not all of home facility do not have a link to the diseases. There are some diseases the respondents believe that it might infer to the diseases. For instance, using “Lavatory” often can infer that the user might have some “Diarrhea” problem, or “Tension-type headache” disease might happen because home user uses the “Computer” for a long time.

4.2.3 Recognize Diseases based on Human Location

The average results of human location got the lowest score when compare with the activity information and the object interaction information. The main reason is the human location does not hint any information that related to the diseases. It means that to diagnose the disease, it does not need the human location as the main information for analyzing the disease. However, consider in detail of disease, the respondents believe that there is a location that can infer to disease, especially “Toilet”. Absolutely, the human location might infer the disease, but it does not do the important information when diagnose the disease. It might be worked when using with other information such as the activity information or object interaction information.

4.3 Effectiveness

In the last part, the questionnaire is focused on the qualitative on the effectiveness of the information. The question mentions about how influential in different information for the provision of health recommendation service. Likert scales is used from 1 (No, not influential at all) - 5 (Yes, it is critical). The result of this question is shown in Table 4. From the result of the first question, the respondents believe that the basic health information plays a vital role for diagnosis. Although the healthcare system can diagnose the disease with specific health information, the basic health information cannot find the cause of the disease.

Even tough the activity information obtained score in the second rank. It does not mean the activity information is not important. The SD value of the activity information is lower than the SD
of the basic health information. Thus, the importance of the activity information is closely to the basic health information because the activity information is used to analyze the cause of disease. It is useful for preventing or prognosis part in the healthcare system. The healthcare system can provide the health recommendation service for preventing or prognosis the disease to the home user based on the activity information analyzing. The object interaction information and the human location information are in the third and last rank respectively. The respondents believe that these two information is hard to infer to the disease. However, if this information is integrated with other information such as activity information. It can improve the accuracy for selecting the appropriate service for the home user. For example, the “Computer” is turned on for a long time. The healthcare system cannot used this object interaction information to link with the “Tension-type headache” because the system cannot guarantee that home user is currently using the “Computer”. Thus, the activity information can help to perceive this kind of knowledge.

5 Conclusion

In this paper, we introduced the CARE architecture that can provide the context-aware information in smart home. It is useful for analyzing the health recommendation service. The CARE architecture was designed as a human activity framework, and expressed the high accuracy of recognition when add two pieces of information: human posture information and AL. Based on the outputs of CARE architecture, the human behavior analysis system was built for summarization the human behavior information and the context-aware information in smart home. Four kinds of information were summarized and displayed to the home user and the physician. Moreover, the questionnaire was designed to evaluate the information, which was provided from the proposed system. The results of questionnaire showed that the respondents believe the activity information was relevant for diagnosis the disease. Although it was not the most important information, it was useful for the healthcare system. Since it can be used to find the cause of the problem and also can make the health recommendation service for prognosis.

Since the CARE architecture was designed based on the ontology concept, the advantage of ontology concept can be expressed in the future research. For example, the semantic web technology can be implemented for data sharing and processing in the area of healthcare.

References