WIS : A Well-being Index based Health Care System in Smart home

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***Abstract*— In this paper, we present a health care system which can diagnose chronic diseases such as metabolic syndrome. In case of chronic invalids health information has to be check periodically, causing major inconvenience to the patient. In this paper, we propose an automatic diagnostic method for detecting metabolic syndrome, by utilizing a collaborative community computing approach in conjunction with a well-being index.**

Keywords-component; Well-being index; pervasive health care; metabolic syndrome; automatic diagnosis.

I. INTRODUCTION

The subject of personal health care has been given considerable attention in recent years by both medical and computer engineering areas. Many medical research institutes are attempting to gather the personal health information by utilizing questionnaires or tele-consultation as forms participative inquiry [1]. However, there has been substantial evidence indicating the discomfort that such traditional information gathering methods produce [2]. For example, if the patient has metabolic syndrome, she or he needs to provide a large amount of personal information related to the disease [5]. Furthermore, she or he is forced to answer complicated questionnaires which can be difficult to answer for a lay person. Only after a long drawn process involving significant patient participation required for successful diagnosis of the disease, the attending physician is able to prescribe the required medication or physical therapy for the patient.

Unfortunately, the feasibility of this process is not limited to patient discomfort as the expense of gathering this information is also becoming prohibitive. For example, the cost of medical treatment has increased 11.4 % in South Korea [3]. And five other countries, USA, UK, France, Germany and Japan have also seen average increase in their national cost for medical service of more than 5% over the same period [3].

To provide a better system which addresses the concerns of the traditional approach, we encounter the following challenges:

- What information is considered most critical for diagnosing the metabolic syndrome?
- How can our proposed system automatically acquire the user and environment information without active user participation?
- How can the system make a reliable decision with respect to the result of diagnosis?
- What service should the system have for management of metabolic syndrome?

To solve those challengeable questions, we attempted to research numerous approaches with respect to the diagnosis and treatment of metabolic syndrome with the Ajou University Hospital. As a result of this research, we developed a specialized '*Well-being index model*' for treatments of metabolic syndrome, and also designed a context-aware system to deploy the index model in the real-world by utilizing community computing technology [4].

This paper is organized as follows: Section 2 describes the metabolic syndrome. Section 3, 4 explains the proposed system and algorithm for automatic diagnosis. The conclusion is given at Section 5. Finally the demonstration scenario and environment are introduced at Section 6.

II. METABOLIC SYNDROME

A. Etiology

The metabolic syndrome is a particularly complicated disease whose cause is still not exactly known. However, a number of expert groups such as the WHO, the EGIR, and the NCEP ATP, have determined the core components of the metabolic syndrome: obesity, insulin resistance and hypertension [5]. Since lifestyle is closely related to many of these core components, lifestyle management system is considered significant component in the prevention of metabolic syndrome.

TABLE I. ATP III CLINICAL IDENTIFICATION O F THE METABOLIC SYNDROME.

Risk Factor	Defining Level
Abdominal obesity, given as waist circumference	
Men	> 102 cm (>40 in)
Women	> 88 cm (>35 in)
Triglycerides	≥ 150 mg/dL
HDL cholesterol	
Men	< 40 mg/dL
Women	<50 mg/dL
Blood pressure	≥ 130/≥85 mm Hg
Fasting	≥ 100 mg/ dL

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B. *Existing Diagnosis Method*

Four major diagnosis methods for metabolic syndrome have been widely used by various health associations such as the WHO and the EGIR. The Table I shows an existing diagnosis method by using the National Cholesterol Education Program (NCEP)'s ATP III report [6].

III. Design of Well-being Index System

To support information gathering and automatic diagnosis, we designed a well-being index system that has the capability to process a lot of context data such as vital signs, human activity, environment information and expert data. The system is divided into three parts: context acquisition, context processing and providing proper services. In this project, '*community*' means a set of devices and services that cooperate to achieve common goals [7].

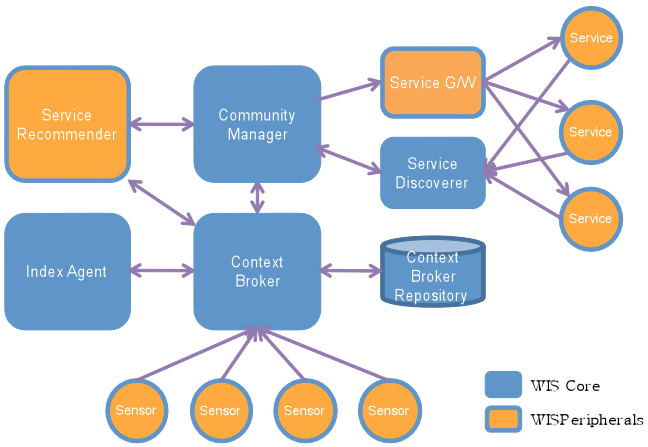

Figure 1. Overall Architecture of WIS

The goal of community computing, which is the core technology behind our system, is to accomplish the goals through collaboration among different communities. Each component is based on a Java software application that operates on a server platform. Fig. 1 shows overall architecture of the well-being index system.

A. *Community Manager*

The main function of community manager is to detect a situation from diverse sensor and environment data, make a service goal, and manage collaboration among different communities [8]. With the support of community manager, we can describe easily a new health care service through defining a community.

B. *Context Broker*

A context broker is a software part that provides a processed data from numerous sensor and expert sensor to community manager. To make a reasonable decision, previous collected data is accumulated at the context broker repository as domain knowledge.

C. *Service Recommender*

After our system finishes the diagnosis, the system is able to figure out user's well-being index. And then service recommender retrieved one or more appropriate services to be improved user's status as a steady state. Services that can be provided by service recommenders are as follows: aroma, mood, art and music therapy as well as exercise recommendation service and environmental care.

D. *Index Agent*

Index agent is one of the most important components in entire system as its role is to figure out a well-being index. Generally, the community computing is deployed to resolve ordinary goals such as temperature management and home automation.

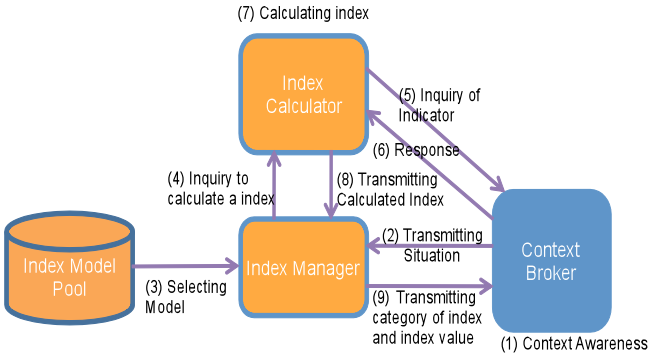

Figure 2. The Procedure of Index Computation

Therefore we design an index agent as an expert system to support a particular goal with the Ajou University Hospital. Fig. 2 shows the procedure of index computation. We describe the details of the well-being index in next section.

For the residue, the service G/W is used to execute a particular service and the Service Discoverer is used to search usable service in space. Context Broker Repository is saved context information.

IV. Well-Being Index for Metabolic Syndrome

As we discussed at section II, a diagnosis method for the well-being index system is required that automates the decision making process and reduces the involvement of a physician by utilizing expert systems. To make the well-being index, we have conducted a lot of clinical trials with respect to disease of living habit during two years. Based on the experiments, we divided the diagnosis basis into five categories. We have given weight-factor to each category based on questionnaires given by medical professionals to participants. Table II shows part of a well-being index table that utilizes to diagnose the metabolic syndrome.

TABLE II. Well-being Index Table

Classification	Weight (%)	Indicators	Measurement cycle	Measurement methods
Health Index (H)	20	Nutrition	At meals	SmartDiningTable
		BMI	Everyday	SmartFloor
Emotion Index (E)	10	Sleep satisfaction	Everyday	SmartMirror + SmartBed
Exercise Index (X)	20	Exercise	Everyday	SmartTreadmill
		Activity	Everyday	SmartShoes

Vital Index (V)	20	Blood pressure	Twice a day	HealthWatch
		Blood sugar	Every year	Connecting EMR
		Triglyceride	Every year	
		Total Cholesterol	Every year	
Preference Index (P)	30	Eating out	At eating	SmartDiningTable

For evaluation of proposed model, we have invented measurement devices such as Smart Floor, Smart Mirror and Smart Shoes and deployed at the CUS smart home [9]. Fig. 3 shows the experimental environment with smart devices.

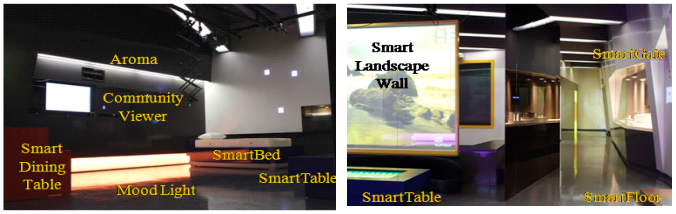

Figure 3. Smart home based on WIS

V. Conclusion

We have developed a well-being index based health care system by utilizing community computing within an innovative diagnosis method for metabolic syndrome. We have also attempted to reduce patient participation during measurement of patients' vital and health status by utilizing context awareness and community computing. In case periodic measurements are required for medical treatment, our health care system can provide an alternate and more convenient approach where the presence of an attending physician is not always required. Finally, this project lays the foundation for future work on a personal health care system and we are actively pursuing further experimentation with the well-being index system with the aim of fine-tuning the approach described in this paper.

VI. Demonstration for PERCOM 2009

For the conference demonstration, we have developed a context awareness simulator that can replace actual measurement devices in the CUS smart home. Additionally, using this simulator, we can simulate and test community computing services like service discovery, context brokering and service invocation before real services are deployed in real space. It is impossible to move our entire system for demonstration because the system is embedded at the daily object such as dining table, bed, watch, shoes and door. However we will still be able to bring some of the devices like SmartTable, SmartShoes, HealthWatch, and Music Therapy. Conference participants can make use of well-being index system, and evaluate our well-being index model by using some actual devices and the simulator. The possible scenario for the conference is as follow.

Figure 4. Main User Interface for Demonstration – Controller mode: The icon indicates available service (Left), Monitor mode: The index presents a result of diagonosis (Right).

Demonstration Scenario - After user finished measuring their vital index and typing their health information through the simulator, health care system calculated with respect to the collected data. User may have their well-being index which is related to metabolic syndrome. Then, the system will have to recommend appropriate services to manage user's index. The user will be able to enjoy well-being life care service such as music therapy and aroma therapy through user-friendly interface as Fig.4

Technical requirements – three laptops, four environment sensors, one HealthWatch, one activity sensor and one access point.

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