A Personalized Service Recommendation System In a Home-care Environment

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Abstract

Many bio-signals of the chronic patients could be measured by various bio-devices and transferred to back-end system over the wireless network through the homebox. In a home-care environment, it becomes more complex to reliably process transmitting and receiving these bio-signals by the homebox. While the bio-devices increasing, the process is even much more complex. In addition, the chronic patients always hope to be served correctly and suitably by the service system in the house. Therefore, we have to provide services such as adjusting room temperature and lighting etc to make those patients' daily lives easy. In this paper, we propose a personalized service recommendation system (PSRS) based on users' preferences and habits. The PSRS has capability of providing suitable services. Furthermore, we construct personal models to record the patients' daily activities and habits. Through the models, the system will be able to automatically launch to safety alert, recommendable services and healthcare services in the house. In the future, the proposed system and models could even carry out the mobile health monitor and promotion in a home-care environment.

Keywords: personalized service, home-care system, service-oriented architecture

1. Introduction

Many bio-signals of the chronic patients could be measured and transferred over the wireless network through the homebox [1], [18]. However, bio-devices are gradually increasing recently. To manage the devices is thus becoming much more complex. Due to this situation, performance level is seen to decrease when a large number of data change occurs. In addition, the chronic patients always hope to be served correctly and suitably by the service system in their houses. Therefore, we have to provide services such as adjusting room temperature and lighting etc to make those patients' daily lives easy. If the system could actively predict the patient's preferences or habits, the system will be able to serve the person in advance with high quality of service.

In this paper, we developed a personalized service recommendation system based on patient's preferences in a home-care environment. For the recommendation services, we first explored the process of generating the recommendable service. We then constructed personal models by analyzing the patient's activity patterns. Through the personal models, the system will be able to automatically launch to safety alert, recommendable services and healthcare services in the house. The proposed system and models could even carry out the mobile health monitor and promotion. The rest of this paper is organized as follows. In Section 2, we are going to introduce the recommendation and personalization services. In Section 3, the proposed system and service groups are described. The processes of generating recommendable services are also mentioned. In Section 4, the personal models are carefully explained. The experiments and test cases are discussed in Section 5. The conclusion of the study is summarized in Section 6.

2. Related Work

2.1 Recommendation Service

The recommendable services are popularly applied on the Internet, such as the on-line recommended services (amazon.com), customized services (mywashington post.com), personalized advertisements (yesmail.com, yahoo.com) and other similar services [2]. By retrieving and analyzing the interactions between the users and the systems, recommendations services could be precisely delivered. The recommendable services are sometimes generalized to match the personal preferences [3]. In order to fit in with the user's demands, services are personalized and recommended based on the user's preferences and the contexts. Studies in applied systems showed that recommendations based on the user's habits can friendly get user's responses [4]-[6]. These results fit in with the studies in human-computer interaction and e-learning domains.

The Recommendation system could even provide custom-oriented services which differ from traditional service system. The services of the system could be personalized according to personal profiles. In order to achieve this goal, the primary step is to collect various information sources. These sources could be approximately classified into two types. The first one is user-relevant information, such as name birthday, health status, habits, and behavior patterns. The second type comes from the environment, such as the statuses of the devices, interactions between users and devices, the weather, the time, temperature, brightness and the others. The two kinds of these sources are primary foundations to build personalization services. Unfortunately, some sources are dynamically changed by the external factors. Furthermore, the user's demands are even too diverse to be monitored effectively. As a result, it is a challenge to recommend suitable services to a user.

2.2 Personalization Service

If we wish to properly recommend the services to a user, we should not only pay attention on the data sources. We also have to concentrate on personalization. For the service personalization, the key factors are to sensing the user's preferences and habits. Through these personal patterns, the existed services could be possibly adapted to match the user's needs. A recommendable service system could be inquired by the following viewpoints: user modeling, context modeling, semantic interoperability and service composition, self-service management, and so on. Using user models to predict user's needs is one of the most popular methods. An excellent user model would be able to select the proper attributes for exploring the user's behavior patterns [7]. The recommendable services could be dynamically composed and properly provided based on the users' patterns in specific environments.

The overlay model is a modeling technique based on collecting user's behaviors [8]. The primary idea of the overlay model is that a user's behavior is a subset of all users' behaviors. Therefore, a common model could be built by generalizing all users' behaviors. Individual model could then be established by comparing it with the common model.

The stereotype users' model is a speedy modeling technique. The model could be fundamentally built up, even when it lacks the user's behaviors component [9] - [10]. Although the model is built by the approximate value, it could perform effectively in many applications [11]. In order to build the stereotype model, the following elements are needed: user subgroup identification (USI), identification of users' key features (IUF), and representation template (RT). The first element is used to identify the subgroups' features. Users in a subgroup have application-relevant features on their behavior models. The second element is used to define the users' key features, which differ from the other subgroups. Furthermore, the presence and absence features should be clearly identified for decision support. The third element is hierarchically represented. The representations should be distributed in different systems. The representation templates in subgroups are named as stereotypes. The hierarchical style could precisely describe the user's behaviors when it goes down to low hierarchical nodes.

2.3 Interface Management and Query

Interface management is a mechanism for managing and providing various services to others. Web service is one of the most popular techniques nowadays. Through web services, various services are distributed in different systems and managed by individuals. The World Wide Web Consortium proposed three major roles for web services. (1) Service provider is defined to provide remote services. (2) Service registry is defined to provide registration and publication. (3) Service consumer is a role which requests to serve and receive the services. First, the service provider generates service descriptions and registers them into the service registry. The service consumer then requests the service registry and receives the interface descriptions. The relevant techniques are Web Services Description Language (WSDL) [13], Simple Object Access Protocol (SOAP; [14]), Universal Description, Discovery, and Integration (UDDI) [15], and Extensible Markup Language (XML) [12].

In business applications, web services are proven to be composed in a complex manner [16]-[17]. Moreover, IBM WebSphere could support standardized web services and cooperate with the Microsoft workflow tool. The BEA WebLogic server not only supports web services and XML, but also composes new services. Web services are extendable techniques, especially on developing a large system.

3. System Architecture

Service Oriented Architecture (SOA) is an emerging architectural style. The major ideas of SOA are that service elements are granularly defined and constructed, service interfaces are clearly standardized for composing new services, and the services built by following SOA are reusable. By composing services iteratively, a new system could be formatted for serving a specific domain. A SOA-based system usually includes three key features: software components, services elements and business processes. Web service is one of the most important ways to implement SOA. Web service requires XML-based techniques, such as XML, WSDL, SOAP, and UDDI.

The proposed personalized service recommendation system (PSRS) was built by following the SOA principles. The service elements in PSRS are distributed in different sub-systems. In PSRS, web services are evolved by three generations. First, a number of simple web services are implemented and usually used for query and response. Second, composite web services are derived from the simple ones to form more complex applications. Third, collaborative web services are continually emerging. These dynamic services could automatically support business agility. The architecture of PSRS would be flexible and extendable.

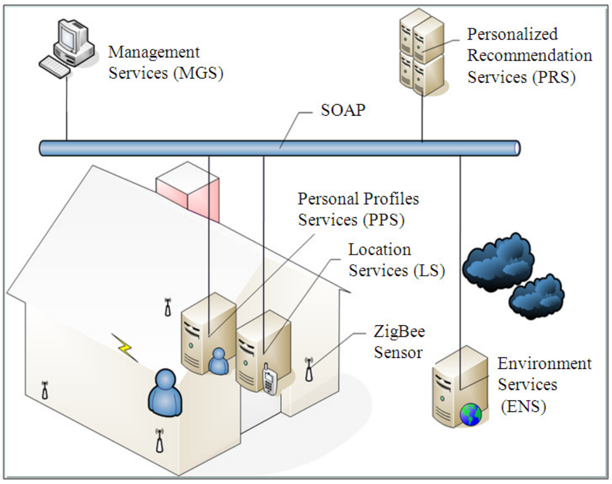

Fig. 1 The distributed Services in PSRS

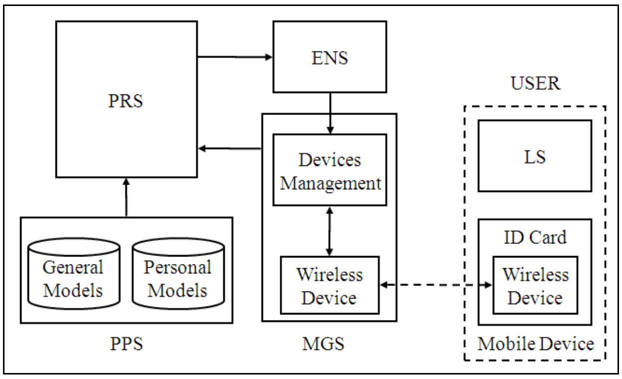

Fig. 2 System Architecture

The services in PSRS are developed according to SOA principles, too. There are three key benefits. By upgrading service components, the system performance could be improved at pace and the faults could be gradually reduced. Second, the system services could be enriched by increasing the number of service components. The system would become progressively better and friendly. Third, users' demands could be fitted in with the dynamic services composition. We could model user's preferences and compose new services for further recommendation. In order to keep the flexibility and extensibility, the services in PSRS are distributed in different service groups. They are explained in the following sub-section and shown in Fig. 1.

3.1 Grouping Services

(1) Personal Profiles Services (PPS): Personal profiles are key factors when recommending services to the person. Data stored in personal profiles could be classified into static data and dynamic data. A person's name, ID, sex, and blood type are categorized as static data. Dynamic data is composed of personal information which is possibly variable, such as age, habit, health status, behavior feature, service level and authority. The dynamic data should be automatically collected and analyzed by the information systems.

(2) Location Services (LS): The person's locations are usually key factors in judging the person's behavior models. For example, when a person moves close to certain facilities, this represents the possibility of use of the facilities. A person who moves from one position to another also represents specific activities, such as entering or exiting a room. Even a person who keeps motionless for a period of time would possibly represent some meanings. Furthermore, moving speed, pattern, and displacement are also key factors for modeling the person's behaviors.

(3) Environment Services (ENS): The environmental services could publish the contexts statuses and provide query services for the other services. Through the ENS, the others services could get the contextual statuses for further recommendable control. For example, the contexts are date, time, temperature, brightness, weather, noise and so on. The environmental devices would also be able to be controlled by ENS since the devices conditions could be simply queried. Furthermore, the services could thus be recommended to automatically control the devices for fitting users' preferences.

(4) Management Services (MGS): The services are responsible for managing the other services and some functionality. The other services would be registered and published in UDDI server and managed by MGS. The user's authority in PSRS would be managed by MGS as well.

(5) Personalized Recommendation Services (PRS): The models of personal activities are analyzed and built by PRS. Personalized services are recommended according to the personalized models, which are tuned by the pre-defined general model and personal behaviors. Personal services in the digital home could be automatically triggered before the user manually controls them. For instance, we could preset control the status of air conditioner, lighting, television, exercise devices among other devices.

For the user's scenarios of this paper, the user takes a mobile measurable device with wireless ID card. The fixed homebox in the house could receive the user's bio-signals and locations from the wireless sensor. At the same time, the MGS could acquire these data and those contexts from the environment. Then, the PSRS could actively select the adaptive services by the previous contexts and the personal models. The PSRS architecture is shown in Fig. 2.

3.2 Generating Recommendable services

The recommendable services are reasoned out by the contexts, personal models and the user's locations in the PSRS. The static factors and rules are pre-defined by the web-based editor and stored in the knowledge base. The dynamic factors used for triggering rules are dispatched from the PPS, LS and ENS. The services would thus be recommended by following the actions of the triggered rules. In addition, the dynamic rules are formulated by the tuned personal models and the factors. If no personal models exist, the general model would be selected. The personal models are carefully described in Section 4. The ruling outputs might be automatically used for passing messages or controlling devices in the digital home. Its outputs could even call on a series of others services. The decision process is shown in Fig. 3.

4. Personalization Models

In PSRS, the primary contexts used to personalize services are the personal models, locations and his/her health statuses. The user could select service modes, such as manually setting devices or automatically recommendation services. If the user enters in the service scope, his/her ID will be sensed. The user's locations will also be identified to trigger recommendable services.

The interoperability of service providing is shown in Fig. 4. If there are existing personal models, the models will be loaded to bind the activity patterns and to select the proper items. The parameters of the devices could be set by the quantitative items. For example, the values of air conditioner and lamplights would be automatically set by following the user's preference. The device usage progress of the user will be recorded to update the personal models, which are built and analyzed through personal modeling.

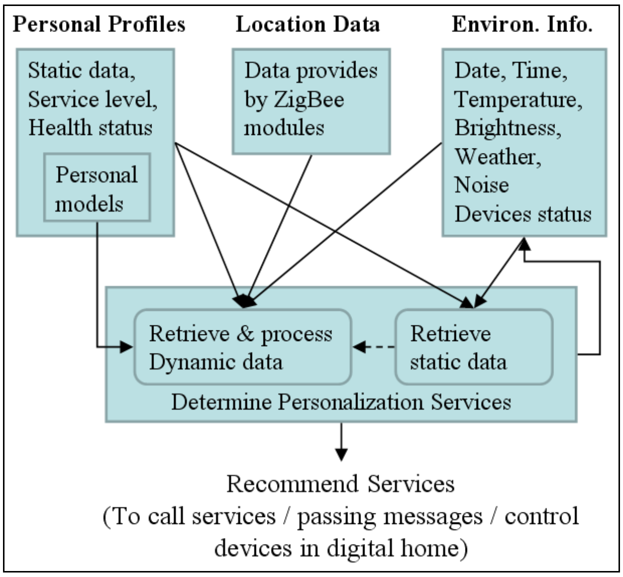

Fig. 3 Recommendable services Generation

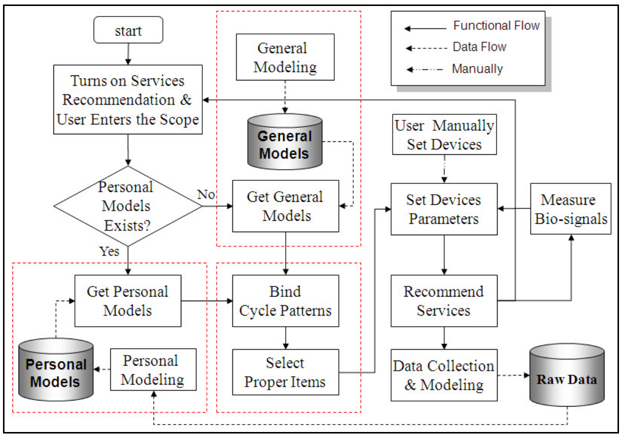

Fig. 4 Interoperability of service providing

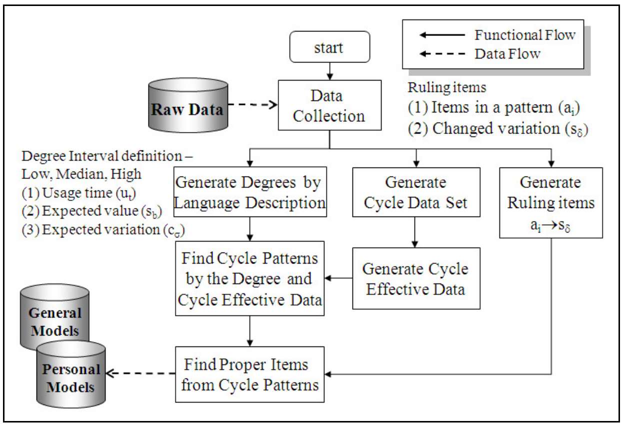

Fig. 5 Personal models Generation

If there are no existing personal models, the general models will be recommended to bind the user's patterns. General parameters will also be set in those devices. If the user manually set the devises during the progress of usage, the user's intension will be recorded for tuning and building new personal models. Personal models of the user would be available for use next time. Undoubtedly, the user could manually set the devices anytime. He/she could manually set the music volume or TV channel for instance.

4.1 Personal Modeling

The user's raw data is collected from recording the interactions between the individual and the devices. Through analyzing the raw data, personal models could be generated. A user's activity patterns will cyclically occur in the same conditions. The cycle effective data are collected by mining the raw data. By discretion the effective data and incorporating them into distinct degrees, the cycle patterns could be found. A cycle pattern is combined with the ruling items, which are mapped to the functions on the devices. Therefore, the cycle patterns could be bound to serve the user. The flow of personal models generation is shown in Fig. 5. The personal models are stored in data repositories. As mentioned in the previous section, personal models could also be updated by the new raw data. Likewise, the general models can be generated by the same process in Fig. 5. However, the differences are that all uses' activities are selected for analyzing.

4.2 Ruling Items and Cycle Patterns

Personal models are stored in a rule-based database. The rules combined with factors and formulas. There are three kinds of factors: 1. Event – dynamic factors; 2. Status – static factors; 3. Compound – composite factors. Each factor has its own identified number. The static factors are represented by negative numbers, while the dynamic factors are represented by positive numbers. The formulas are combined by factors, and are stored with IF-ELSE format in a database. In order to edit the formulas, these are represented as mathematical equations on the website. For instance, the formula could be represented as "2 + 3 + 7 + -8 = 10". The numbers of the formula are factor identifications. The symbol "+" refers to the sequences of the occurred factors. Each launched formula corresponds to an active service. Formulas could be iteratively launched by the dynamic factors during the recommendation. The composite services will be appeared by the iterations.

5. Experiments and Verification

5.1 Experiment Environment

The PSRS was implemented by the C#.NET programming language. We integrated many types of devices to verify our PSRS. A computer server was remotely installed for serving web service techniques. A laptop was included to connect the ZigBee coordinator for receiving the user's locations. The ZigBee modules contain six CC2430 reference nodes, two CC2431 blind nodes and one CC2430 coordinator. The ZigBee modules were purchased from Texas Instruments. One programmable logic controller (PLC) was linked to the laptop by the RS232 interface. The PLC was used for controlling home devices, such as three color lights (red, green, white), one electric fan and one doorbell. The homebox and bio-server are provided by the Institute for Information Industry (III). These facilities are used for measuring the use's bio-signals.

5.2 Test Cases 1 — *The user activity patterns*

The cycle patterns are pre-defined in the web-based editor. These patterns are shown in the following:

(1) Pass through POS1: Turn off green light
(2) Pass through POS2: Turn on green light
(3) Pass through POS3: ring doorbell
(4) Pass through POS5: ring doorbell
(5) Clockwise (POS3+POS2+POS1+POS5+POS3): flash red light
(6) Counter-clockwise (POS1+POS2+POS3+POS5+POS1): flash white light

A user would launch the services if his/her activities matched the pre-defined patterns. The scenario is shown in Fig. 6. The blue arrows display the counter-clockwise pattern. The yellow arrows display the clockwise pattern. The experimental results showed that the PSRS could correctly execute distinct services based on the user's activity patterns.

5.3 Test Cases 2 — *Multiple users login service*

In this scenario, two users will enter the sensing scope of the homebox. The first user's profile will be pre-loaded into the homebox if he/she enters the scope. He/she could automatically login and then measure his/her bio-signals. If he/she finishes and leaves the sensing scope, he/she would also automatically logout. The second user could then automatically login and use the homebox. The users don't need to manually operate the login process. The login service could automatically work in a multi-user environment. The sequences of the occurred activities are shown in Fig. 7. The yellow arrows are the first user's activities. The blue arrows are the second user's activities. The cycle patterns are shown in the following:

(1) Enter POS4 + none user: ring doorbell
(2) Enter POS4 + not login: automatically login
(3) Login + Leave POS4 = login out

5.4 Test Cases 3 — *Flexible services composition*

For services recommendation, the services could query contexts statuses through web services. In order to show the flexible services composition, the system operator will modify the defined cycle patterns and ruling items. The flexible cycle patterns will then provide different services. The scenarios are shown in Fig. 8. The blue arrows are the first activities. The yellow arrows are the second activities. The green arrows are the third activities. The cycle patterns are shown in the following:

(1) Enter POS5 + Leave POS5: Leave POS5 (Ring doorbell)
(2) Enter POS5 + Evening = Turn on light
(3) Turn on light manually + Leave POS5: Turn off the light automatically

After modifying the cycle pattern:

(4) Enter POS5+Not Evening: Power on a electric fan
(5) Power on the electric fan + Leave POS5: Power off the electric fan

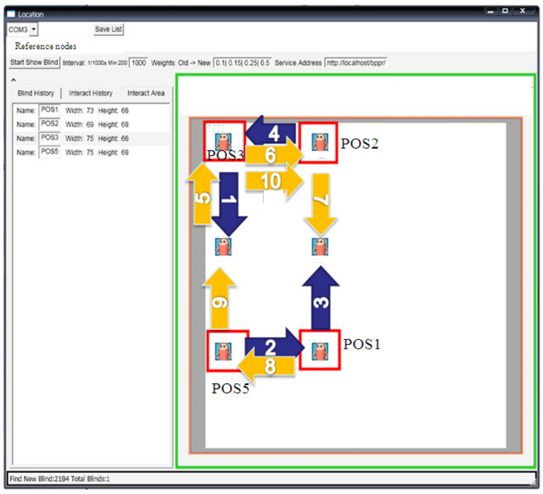

Fig. 6 User Activity Patterns (ZigBee Localization Interface)

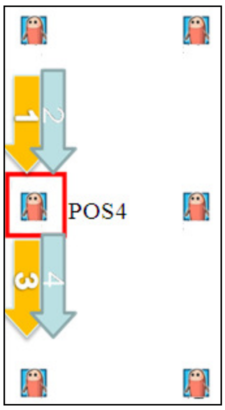

Fig. 7
Multiple Users

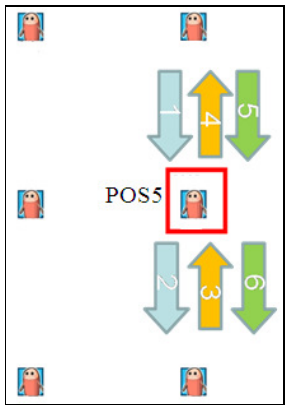

Fig. 8
Flexible Services

6. Conclusion and Future Work

In this paper, we developed a personalized service recommendation system (PSRS) in a home-care environment. The PSRS has capability of providing proper services based on the user's preferences. For the recommendable services, we explored the processes and data sources of generating the recommendable service. Furthermore, we construct personal models to record the user's activities and habits. Through the personal models, the system will be able to automatically launch to safety alert, recommendable services and healthcare services in the house. In the future, the proposed system and models could even carry out the mobile health monitor and promotion in a home-care environment.

7. Acknowledgements

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