JOURNAL OF INFORMATION PROCESSING SYSTEMS JIPS

A Health Management Service with Beacon-Based Identification for Preventive Elderly Care

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Abstract

Bluetooth low energy (BLE) beacon is an actively push-to-broadcast electronic signal and can be used for object identification. This paper uses such beacon-based identification and Internet of Things (IoT) technologies for the elder health management service system to simplify the user interfaces and steps for preventive elder care. In the proposed system, an elder's family member, caregiver, or medical worker can conveniently and quickly record daily health management information. Besides, through the statistics and analysis of the data on the back end of the system, it is helpful for the elderly to refer to the data of daily care management and future management trends. Similarly, it is also an essential reference data for system maintenance and the new preventive health care services development.

Keywords

Beacon-Based Identification, Health Management Service, Preventive Elderly Care

1. Introduction

For a long time, elderly care has been more focused on medicine than wellness. In Taiwan, more than 80% of healthy elder has the right to enjoy life and well-being, but they are disregard. The elderly citizens who do not receive adequate preventive care services will confront elderly depression, disability, dementia, or bedridden dilemma prematurely. However, due to the increase in the elderly population, senile diseases have received widespread attention in many countries. For example, the prevention and cure of elderly depression have incorporated in nations' public policies. Aging is not one or only pathogenic factors of disability, dementia, or melancholy. Overall conditions in society, culture, environment, and economy as well as individual factors such as an elder's age, social support, life quality, genetic factor, and dwelling environment, all of which are probably correlated with senile melancholia as disclosed in the literature [1].

The rapid population aging was worse than that of the European or American continent. Taiwan will go into an aging society according to the population projection of the National Development Council (2013). 14% of the population are elders older than 65 years old, and even the hyper-aged civilization with only seven more years.

Fortunately, not all the elders in statistics were bedridden, disable, or helpless patients, but over 80%

were health or suboptimal health senior citizens. Some researchers have proposed eldercare services as the primary strategy to address the aging issue [2]. These innovative and value-created services for high acceptability, entertainment, and persistence of elderly citizens, thereby overcoming the bottleneck of the elderly's willingness to participate, thereby improving the quality of care for the elderly. In other words, if the elderly services only focus on 13% to 19% of the elderly population, it is easy to be biased towards medical treatment and lose health care. Since the elderly with self-care ability still maintain the life self-care ability, social ability, and social support system, they should also have appropriate health care services to delay disability, recover and continue to enjoy happy time [3-6]. Furthermore, the concepts of "healthy aging" and "active aging" advocated by the World Health Organization (WHO) aims to promote the independent communal participation of senior citizens in leisure life. Autonomy and independence for elders also are essential goals of WHO. Elders can interact with other fellows and hold a healthy attitude in the aging course for fewest family care burdens.

During an activity sponsored in a community care center or a daily senile center, a senior citizen's health events should be listed in a communication book through a family member or a hospital frequently. These individual health events include blood pressure, heartbeat, body temperature, and so on. As written records for the elderly, these communication books do not meet the requirements for integration and analysis of health management. On the other hand, no other applications or software programs are for the elderly, such as the tool of healthy management or medication reminder designed for elders over 65 years old. Besides, lots of elders are unwilling to be disconnected from today's society, and still, actively participate in today's social activities, and accept the use of online social applications, such as Facebook and Line, to learn knowledge through the community. The elders are quite looking forward to learning new experiences.

Currently, long-term caring services are labor-intensive, through the Internet of Things (IoT) technologies to solve the bottleneck of traditional care quality and service user participation and promote an effective care service model [7-9]. The design concept of the proposed system is to make the management interface easy to be operated by the elderly. Through beacon identification technology to better realize health management and communicate with the hospital. The proposed system can extend to social welfare organizations in Taichung City (such as community nursing centers or elderly entertainment schools) for experiments/corrections and development/maturity. Services in the proposed system are compatible with the 10-year Long-term Care Program 2.0 upheld by the Ministry of Health and Welfare. Therefore, the proposed system can be an application system favorable to the elderly and our society on the occasion of an upcoming aging society in Taiwan.

The organization for this paper includes: Section 2 presents the procedure of system design and requirements for the proposed management service; Section 3 describes the system test with system requirements taken into account; Section 4 demonstrates the prototype system; and Section 5 concludes the whole.

2. System Design

Traditionally, the records of essential health management refer to activity status, weight, and mood recorded in a communication book by handwriting mostly. In this paper, we take the records of preventive health care services for applications to intervention, program design, and platform establishment. The

requirements to design proposed services based on the design procedure and the use case diagram are presented in Subsection 2.1 and Subsection 2.2, respectively.

2.1 Design Procedure

The proposed system should correspond with the following steps to design the application software satisfying elderly health management on demand. As shown in Table 1, the steps include:

Step 1 (Planning and design): The requirements take account of the demand-oriented concept, interviews with elders, healthcare workers, and practical cases. In Step 1, the proposed system is designed and assessed by collecting, analyzing, checking, and evaluating senior citizens. In this regard, the requirements refer to the system architecture and specific functions, which are presented in the use case diagram, as shown in Subsection 2.2.

Step 2 (Development): According to the use case diagram confirmed in Step 1, the proposed system is developed and created as the health management service for senior citizens. The use case diagram presents a function or a requirement available for a user through an interface in an oval textbox. In Step 2, all functions are designed and indicated in the use case diagram.

Step 3 (Test): Each function completed in Step 2 needs to be verified for its correctness. The test cases for the function in the use case diagram are listed and proved for its effectiveness, as shown in Section 3. The application software and the database developed in Step 3, including records of elderly health management and knowledge created in a social community, are applied to test the system's stability and accessibility.

Step 4 (Maintenance): The data collected in Step 3 can be references for an elder's family members or a hospital. Through data statistics and analysis, such recorded data provides applications to intervention, program design, and platform establishment of preventive health care services of the elderly in a community. The elderly care health management database is available for an elderly family member and a hospital frequently visited by the elderly to understand health management information.

Table 1. Steps to develop application software satisfying elderly health management

	Indicators	Method or tool for data collection (how)
Step 1: Planning and design	Plan and access the design for the application software	Do interviews with elders and health-care workers and understand the requirements of the elderly for evaluating and designing the program architecture and detailed functions.
Step 2: Development	Follow the results planned and designed in Step 1 to develop the application software as required and create an elder care management database.	Improve the user interface design for more intentions of using the app.
Step 3: Test	Apply the application software and the database developed in Step 3 to elderly health management records and social community's knowledge	Demonstrate data and software functions on a tablet computer or a mobile phone.
Step 4: Maintenance	Provide an elder's family members or a hospital with data and analyzed information health	Access the elderly health management information from the database anytime to understand an elder's correct physical and mental health status.

According to the requirement in Table 1, Fig. 1 shows the system architecture. In the proposed system, an elder wears a Bluetooth low energy (BLE) beacon device. BLE beacon is an actively push-to-broadcast electronic signal and can be used for object identification. Therefore, a user identifies an elder with the registered BLE beacon device by the proposed system in which a user can be an elder's family member, caregiver, or medical worker. An institution that is either a community care center (daily senile center) or a hospital operates the function of the proposed system for a user. The institution is responsible for managing the elders' profile information and the materials. The materials are some published video clips for health information learning; profile information includes (1) an elder's personal information, (2) records of an elder browsing the materials, (3) records of an elder's activity, participation, and compatibility, and (4) the Study of Osteoporotic Fractures (SOF) criteria record. An administrator operates the functions of the proposed system for a user and an institution and manages tags describing elders' diseases, elders' profiles, materials, equipment, and institutions.
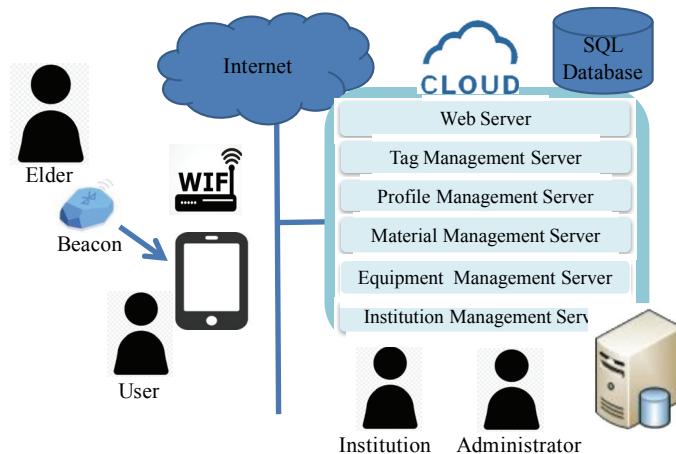

Fig. 1. System environment.

2.2 Use Case

According to the requirements as mentioned above, Fig. 2 presents the functions for three identities: user, institution, and administrator:

2.2.1 User

A user who can be an elder's family member, a caregiver, or a medical worker can browse and edit a profile of a beacon device. In the proposed system, a beacon device represents an elder, binding the personal profile of the elder. The content of health management necessary to an elder contains blood pressure, heartbeat, body temperature, overnight sleep state, today's mood, and so on. The SOF criteria for frailty pays close attention to weight loss, inability, and feeling full of energy. Most of which are written in a communication book by hand currently and taken as reference materials of family members or a community care center (daily senile center) holding an activity for the elderly. However, the communication book not present the elder's daily physical and mental changes statistically. Hence, the proposed system considers the following factors:
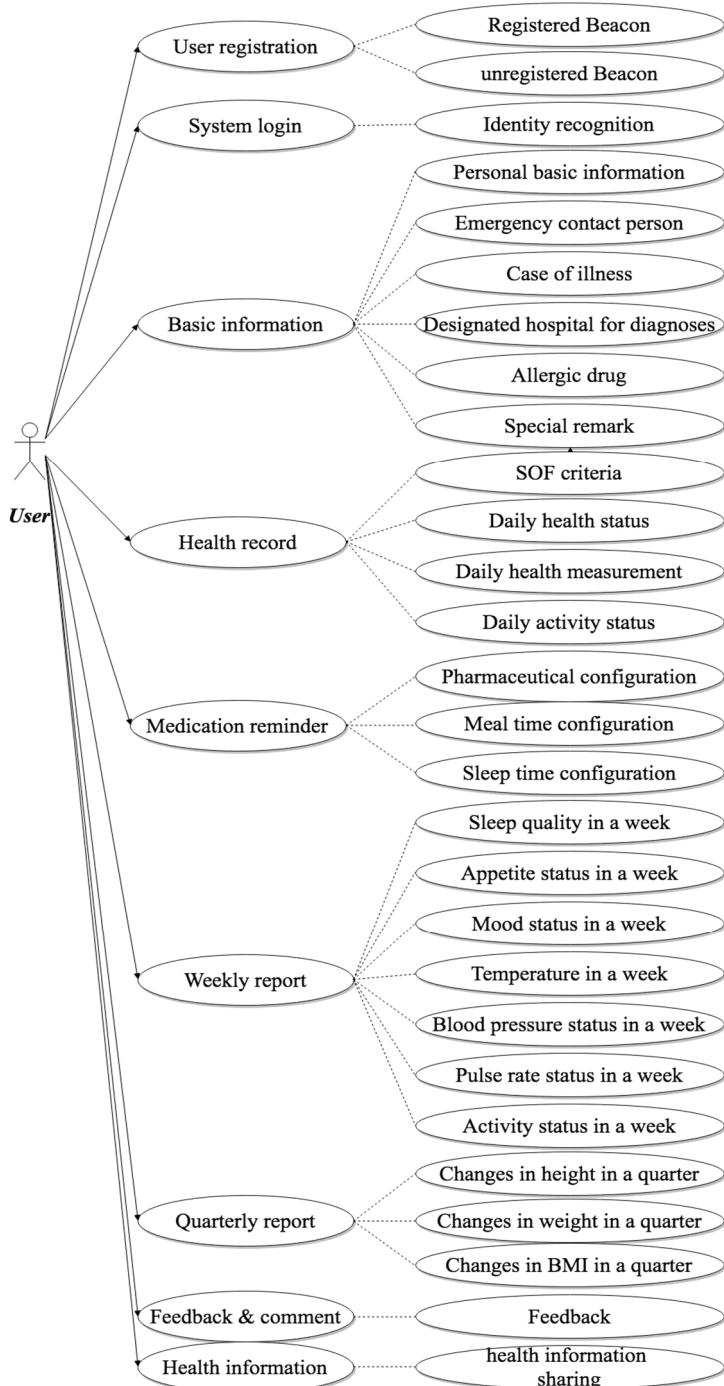
Fig. 2. Use case diagram.

- User (beacon device) registration: In a community care center (daily senile center), an elder needs to wear a beacon device for identification. An unregistered beacon device represents a new elder to be incorporated, identified in the proposed system, and created for a legal account.

- System login: A user logs in the system by entering his/her username and password for granting the system authority.
- Basic (personal) information: A user logs in the system for browsing and editing an elder's personal information, such as contact information.
- Health record: The health information includes health status, self-reported health conditions, basic health measurements, and today's activity status.
  (1) SOF criteria, which are for identifying a frail patient based on the following conditions:
      (i)   Weight loss ≥5% over three years
      (ii)   An elder sitting in a chair (not using arms) or raising them five times
      (iii) An elder's answer to the question, "Do you have feeling full of energy?" for an answer "yes" or "no".
  (2) Health status: daily sleep quality, etc., as editable information
  (3) Self-reported health conditions: another individual physiological status is recorded by a user except for sleep quality and appetite
  (4) Basic health measurements: data such as body temperature, blood pressure, and pulse rate to alert the user to any abnormal health conditions that should be checked.
  (5) Today's activity status: records of an elder's activity level, participation, and compatibility
- Medication reminder: The medication reminder, which activates with an alarm clock set for morning, afternoon, or evening, is to remind a user of the medication time before or after a meal.
- Weekly report: The weekly report is a report printed weekly to present all daily health records.
- Quarterly report: The weekly report is a report printed every quarter to present all daily health records.
- Feedback: A system administrator can reply to the feedback or comment from the App user.
- Health information message: The pages of health information available to an elder indicate at least one health message every day in the preliminary stage.
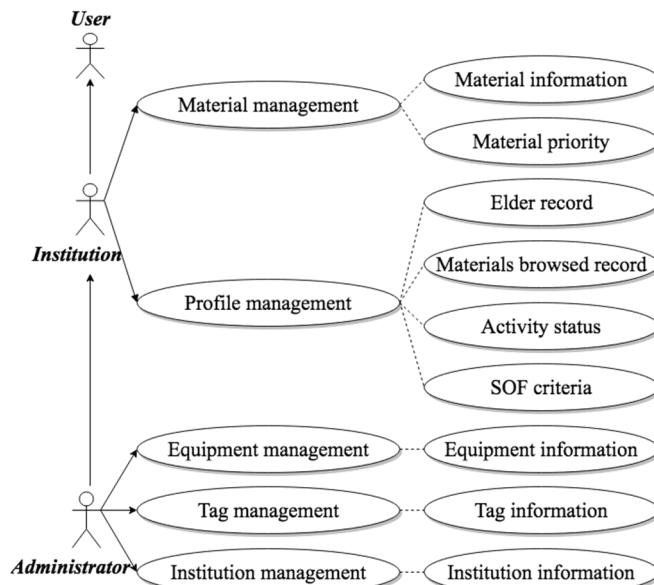

Fig. 3. Use case diagram for an institution and an administrator.

2.2.2 Institution

As shown in Fig. 3, an institution can manage materials and profiles, which can be a user's identity for operating the functions. In this regard, materials include some published video clips for health information learning; profile information refers to (1) an elder's personal information, (2) records of an elder who browsed materials, (3) records of an elder's activity, participation and compatibility, and (4) the SOF criteria record.

2.2.3 Administrator

As shown in Fig. 3, an administrator is responsible for managing information of equipment, tags for labeling material information, and an institution/an institution identity for operating the functions.

3. System Test

This section presents the required in Subsection 2.2 for the proposed system and the vital points for different identities as follows.

- A user can search the registered beacon and an unregistered beacon, each of which represents an elder. In this regard, an unregistered beacon represents a new elder to be incorporated and identified in the proposed service.
- An institution can add and modify the profile and the information of an elder for regular information maintenance related to an elder incorporated.
- An institution can check and edit an elder's profile and even information of all elders in the institution.
- An administrator can check and edit an elder's profile and even information of all institutions.
- An administrator checks an elder's health status and information records.

3.1 User Function Test

Table 2 lists the critical functions in the test and the expected test results for user registration and identity recognition as follows:

- (1) Test a registered or unregistered beacon is searchable.
- (2) Test that SOF criteria, basic information, health status, health measurement, or feedback of an elder can be displayed correctly.
- (3) Test SOF criteria, basic information, health status, health measurement, or feedback to add, revise, or delete correctly.
- (4) Test a user's editing, reading the records, or inquiring for SOF criteria, basic information, health status, health measurement, feedback, and the weekly/quarterly report.
- (5) Test a user configures the medication reminder for the medication time before/after a meal.

Table 3 presents the essential functions for the test and expected test results in the weekly/quarterly report in that the daily health record in a week/quarter is displayed correctly.

3.2 Institution and Administrator Function Test

Tables 4 and 5 list the essential functions in the test and expected test results for an institution and an administrator as follows:

(1) Test the material information and its priority displays correctly.
(2) Test the material information and its priority adds, revises, or deletes correctly.
(3) Test an elder's personal information edits and presents correctly.
(4) Test the record of an elder browsing material presents correctly.
(5) Test the records of an elder's activity, participation, and compatibility present correctly.
(6) Test the questionnaire record displays correctly.
(7) Test the information of equipment, tags, and an institution present correctly.
(8) Test the equipment, tags, and an institution edit correctly.
(9) Test the information of equipment, tags, and an institution operate correctly.

Table 2. Essential functions and expected test results for a user's personal basic information and daily health records

Function test	Strictness level	Expected result
Beacon registration	Strict	A registered or unregistered beacon is searchable and lists correctly.
System login	Strict	The login process performs successfully. The user's identity can be recognized.
Basic personal information	Strict	The necessary personal information enters and displays correctly. The emergency contact person enters and displays correctly. An elder's cases of illness write and display correctly. The designated hospital for diagnoses enters and presents correctly. Allergic drugs write and display correctly. The special remarks labels and displays correctly.
Health record	Strict	Health status writes and displays correctly. Health measurements write and present correctly. Activity status writes and presents correctly.
Medication reminder	Strict	The medication time configures correctly. The mealtime configures correctly. The sleep time configures correctly.

Table 3. Essential functions and expected test results for the weekly/quarterly report of a user

Function test	Strictness level	Expected result
Weekly report	Strict	The sleep quality in a week presents correctly. The appetite in a week displays correctly. The mood in a week shows correctly. The changes in body temperature in a week layout correctly. The blood pressure status in a week presents correctly. The pulse rate status in a week exhibits correctly. The activity status in a week shows correctly.
Quarterly report	Strict	The changes in height in a quarter perform correctly. The changes in weight in a quarter present correctly. The changes in BMI in a quarter exhibit correctly.

Table 4. Essential functions and expected test results for institution identity recognition

Function test	Strictness level	Expected result
Material management	Strict	The material information and its priority enter and display correctly.
		The material information adds, revises, or deletes correctly.
		The priority of material edits correctly.
Profile management	Strict	An elder's personal information shows and edits correctly.
		The record for an elder browsing material view correctly.
		The records of an elder's activity, participation, and compatibility present correctly.
		The questionnaire record performs correctly.

Table 5. Essential functions and expected test results for administrator identity recognition

Function test	Strictness level	Expected result
Equipment management	Strict	The information about equipment displays correctly.
		The equipment adds, revises, or deletes correctly.
		The information about equipment edits correctly.
		The priority of material edits correctly.
Tag management	Strict	The information about tags exhibits correctly.
		The tag adds, revises, or deletes correctly.
		The information about tags and an institution edits correctly.
		The record for questionnaire views correctly.
Institution management	Strict	The information on an institution displays correctly.
		The institution adds, revises, or deletes correctly.

4. Demonstration

This section presents the interfaces of the proposed system. First is the user identity function. Fig. 4 presents the result of searching for a registered or unregistered beacon. Fig. 4(a) shows the registered


(a)   (b)
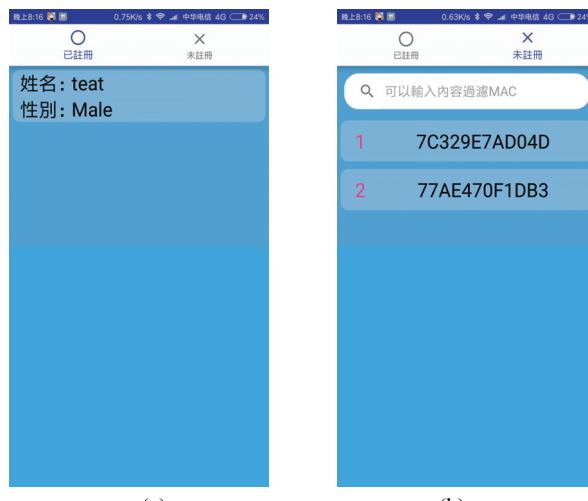
Fig. 4. Interface for searching for (a) the registered or (b) unregistered beacon in the user identity function.

beacon, which including name and sex. Fig. 4(b) shows that a unregister beacon for beacon ID. Fig. 5 is the interface for browsing and updating an elder's information, which includes health status, self-reported health conditions, basic health measurements, and today's activity status. Fig. 6 shows the interface for evaluating SOF criteria frailty, which includes frailty, falling, or depression of an elder. Fig. 7 shows the interface for simulated images in the quarterly (weekly) report, which exhibits data processed every quarter (week).

**Fig. 5.** Interface for updating information of an elder in the user identity function.
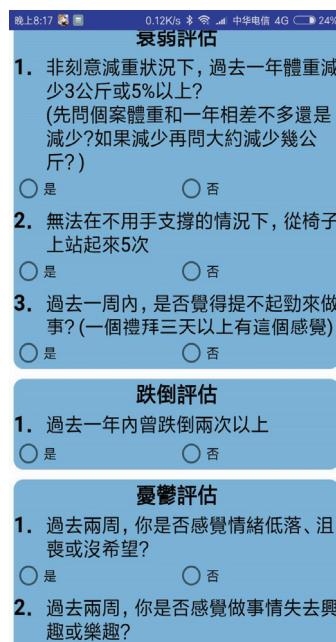
Fig. 6. Interface for SOF criteria for evaluating an elder's frailty in the user identity function from which frailty, falling or depression of an elder.
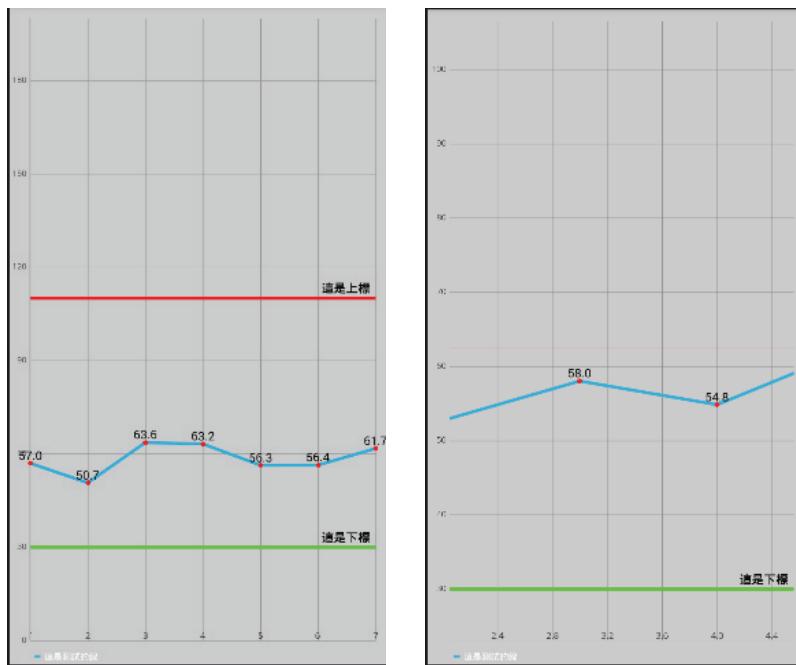
Fig. 7. Quarterly (weekly) report for data processed every quarter (week).

Fig. 8 shows the interface for material management in the institution identity function. The content of the material management refers to "name," "link," and "authority for browsing," a material (public or private). Fig. 9 shows the interface for updating the material information in the institution identity function, from which attributes such as "name," "browsing authority," and "tag" of the material can be changed.

Fig. 8. Interface for the material management in the institution identity function, involving "name", "link", "authority for browsing (public or private)", "update", and "delete".
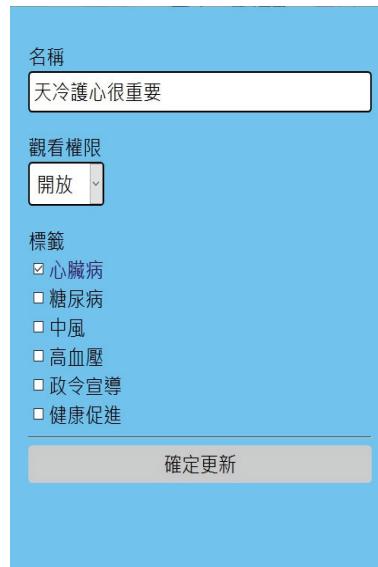
Fig. 9. Interface for updating the material information in the institution identity function, from which attributes such as "name", "browsing authority", and "tag" of the material can be changed.

Figs. 10 and 11 show the interfaces for managing and updating the profile of an elder in the institution identity function, from which you can change the ID, name, sex, participation, beacon information, and tag for the elder. Moreover, Fig. 10 displays the interface for the tag management in the administrator identity function. Fig. 12 shows the interface for the institution management in the administrator identity function wherein the institution management regulates attributes such as the ID, password, location, and authority (of an administrator or an institution) to access an institution.

Fig. 10. Interface for the profile management of elders in the institution identification function which relates to an ID number, name, sex, participation, beacon information, tag, the record of browsing a material, activity status, and questionnaire record for elders.

Fig. 11. Interface for updating the profile of an elder in the institution identity function which relates to an ID number, name, sex, participation, beacon identification, and tag for the elder.

Fig. 12. Interface for the institution management in the administrator identity function which relates to identification, password, location, and authority (of an administrator or an institution) to access an institution.

5. Conclusions

The proposed system provides the health management service with beacon-based identification for a caregiver or a physician to record the elder's daily health care. The user can check and control the elder's health conditions quickly and give appropriate medical care. The proposed system can keep the elder's

daily health management on track and accumulate these records into big data. The analyzed results can help the elder's family members or a hospital understands the elder's correct physical and psychological health status. Besides, the health management information concerns lots of research teams, the academic circle, elderly long-term care organizations, and caregivers, which can be a reference for further establishing preventive health care services.

Acknowledgement

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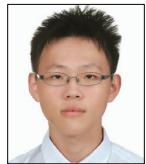
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