Der Roboter ALIAS als eine Datenbank für Gesundheitsüberwachung für ältere Menschen

The Robot ALIAS as a Database for Health Monitoring for Elderly People

Tobias Rehrl, Jürgen Geiger, Maja Golcar, Stefan Gentsch, Jan Knobloch, Gerhard Rigoll
Lehrstuhl für Mensch-Maschine-Kommunikation, Technische Universität München, Germany
{rehrl,geiger, golcar, gentsch, knobloch, rigoll}@mmk.ei.tum.de

Katharina Scheibl, Wolfram Schneider, Susanne Ihsen
Gender Studies in Ingenieurwissenschaften, Technische Universität München, Germany
{katharina.scheibl, wolfram.schneider, ihsen}@tum.de

Frank Wallhoff
Jade University of Applied Sciences, Oldenburg, Germany
frank.wallhoff@jade-hs.de

Kurzfassung

Die Gesundheit bekommt mit zunehmendem Alter eine immer wichtigere Rolle, daher ist es, vor allem für ältere Menschen, wichtig einen Überblick über ihre gesundheitsbezogenen Daten haben zu können. Viele unterschiedliche technische Lösungen aus dem Bereich der Informations- und Kommunikationstechnologie sind entwickelt worden, um gesundheitsrelevante Daten zu messen. Wir haben ein System zur Gesundheitsüberwachung auf einer mobilen Roboterplattform integriert, dieser Roboter soll als eine Kommunikationsplattform für ältere Menschen dienen. Für die Realisierung dieses Gesundheitsüberwachungssystems wurde eine Nutzer/innenstudie durchgeführt, um die Bedürfnisse und Wünsche der älteren Menschen zu erfassen. Unter Berücksichtigung der Ergebnisse der Nutzer/innenstudie und bei Anwendung eines generischen Entwicklungskonzeptes wurde ein Gesundheitsüberwachungssystem entwickelt, welches sowohl sensorbasierte als manuelle Eingaben von gesundheitsbezogenen Daten ermöglicht. Die Eingabe und Darstellung der Daten erfolgt über einen Web-Browser, somit können autorisierte Personen auch von extern auf die lokal gespeicherten Daten zugreifen.

Abstract

Health plays an important role with increasing age, therefore keeping track of health data is a very essential task for elderly people. Many different Information and Communication Technology systems were developed to measure health data. We integrated a health monitoring system on a mobile robotic platform, which is designed as communication platform for elderly people. To realize this health monitoring system on a robotic platform for elderly people, it is important to address their needs and wishes, therefore, a user survey was conducted to figure out important issues relevant for elderly people. Taking the outcome of the user survey into account and following a generic design principle, a health monitoring system was realized, which features sensor-based and manual input for single or multiple users. The system interaction is browser-based and allows remote access to the health data stored on the robotic platform for authorized persons.

1 Introduction

The intended purpose of the AAL-Joint Programme project *Adaptable Ambient LIving ASsistant* (ALIAS) is the development of a mobile robotic platform (see Figure 1), which should be able to interact with elderly people and thus offer assistance in their everyday life situations [1, 2]. Consequently, the robotic platform aims to support people living alone at home or even in residential homes for the elderly and prevent them from becoming lonely. ALIAS shall interact with eldery users, monitor them and provide social inclusion and assistance in the daily routine.

One aspect of the project is health monitoring, thus, a database concept for health monitoring of vital functions was developed for the ALIAS robot. The ALIAS project has a user-centered design approach, therefore a user survey was conducted to determine important features of the database. The recorded vital functions were stored on the robotic platform, however, a remote access for the data is also possible, therefore a web-based approach for recording and visualizing the data was chosen.

In general, for elderly people, living and staying healthy

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is very important. Elderly people are more vulnerable to diseases and their quality of life is strongly affected by their health. Elderly people suffer from many diseases. Table 1 shows some of the most widespread diseases among elderly people according to a study performed by Hellström [3]. For this study, 448 persons (294 female, 152 male) who were dependent of help by others were questioned.

Diseases	%
Musculoskeletal disease	45.2
Other circulatory disease	38.8
Eye disease	34.5
Hypertension	20.8
Heart attack	20.7
Disease of the joints/arthritis	14.2
Bronchitis/emphysema/Asthma/other respiratory disease	13.7
Diabetes Mellitus	13.4
Urogenital disease	12.9
Infections	11.5
Hip fracture	10.3
Ear disease	9.7
Rheumatic disease	8.7
Dermatosis	9.0
Cerebrovascular disease	7.7
Metabolic disease	6.4
Dementia	5.0

Table 1: Most widespread diseases among elderly people (given in percentage) according to [3].

In this table, many different diseases are listed which affect elderly people. With the scope of the project, the ALIAS robot can assist elderly people whose quality of life is restricted by diseases by providing a wide spectrum of functionalities. Some of the diseases in Table 1 are not in the scope of the ALIAS project, for example everything that has to do with physical assistance. The main purpose of the ALIAS robot is to communicate and it has no physical manipulators. Thus, diseases like musculoskeletal diseases or hip fracture can not be addressed by the project. However, some of the diseases are dealt with in the ALIAS project. By providing a multimodal dialog system, the ALIAS robot can help people suffering from ear or eye diseases, for example. People suffering dementia can be assisted by providing reminder functions and cognitive assistance.

In this paper the development and realization of a health monitoring system for the ALIAS robot is described. Together with additional systems for recording health data, the ALIAS robot can impersonate a helpful assistant to record, monitor and store health data.

Important health data include vital signs like body temperature, pulse rate (or heart rate), blood pressure, and respiratory rate. By providing a system for monitoring of these data, the ALIAS robot can assist elderly people suffering from diseases like hypertension, Diabetes Mellitus, Cerebrovascular disease (which can be caused by hypertension) or diseases of the circulatory system. The recorded biosignals can be inspected by authorized persons from remote through the ALIAS system, e.g. a person's doctor or relatives. Additionally, the signals might be saved for later on-site inspection.

Figure 1: The ALIAS robot.

The remainder of this paper is organized as follows: Section 2 describes related work for health monitoring. In Section 3 relevant physiological parameters are introduced. The results of the user survey for creating a database concept for health monitoring are presented in Section 4. The system design is delineated in Section 5. In Section 6 the developed database concept is explained. The system interaction is topic of Section 7. Use cases for the health monitoring are presented in Section 8. The paper ends with a conclusion.

2 Related Work

According to the progressive prevalence of diseases with increasing age, there are many activities to apply Information and Communication Technologies (ICTs) for compensating age-related diseases or providing health care. These ICT-systems need to take special requirements like reduced cognitive capacities, sight loss, hearing loss and minor experience with interactive systems of elderly people into account.

There exist many solutions for health monitoring. An overview over different health monitoring systems is given in [4, 5]. This includes systems for remote monitoring, for example the system presented in [6] called MOMEDA, a personalized medical information system. In [7], a wireless PDA-based system is presented. It is designed for use during intrahospital transports of patients. Physiological data are recorded and visualized on a screen. In [8] ubiquitous wireless computing is considered, where different sensors measure various values of all kind of sorts. These sensors are combined to an *Infrastructure For Elderly Assistance* as the task for the future where the sensors serve as health indicators or full-time attendants. This approach is supported by [9] with the *Mobile Robot Peekee II* representing such a mobile infrastructure, here a mobile robot incorporates the sensors, thus no changes in the environment have to be conducted. *MobiSense* is another mobile health monitoring system for ambulatory patients in-

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troduced in [10]. This system is able to detect postures of people like lying, sitting and standing while it is also able to manage its' own resources like re-configuration of parts. Another health or activity monitoring system is shown in [11], this physical activity monitoring system has a built-in vital sign measurement and fall detection. Again, this system includes a wearable device collecting physical and activity data with various sensors, e.g. a 3-axial accelerometer. A similar approach has already been introduced in the year 2000 in [12] with presenting a *Home Telemonitoring Framework*, which is divided in two categories: the daily activity monitoring category for the elderly and the vital sign monitoring category for patients recovering at home. Thus, the home care needs were separated in different levels. The system itself was divided in the home monitoring unit mainly responsible for the data storage, a hospital monitoring center and a communication network connecting these components.
It can be seen, that the topic of health monitoring has a lot of different aspects, and, therefore many different technical systems providing different solutions were developed. One important factor is the type of health data, which is used for the health analysis.

3 Physiological Parameters Relevant for Elderly People

For health monitoring systems, there are many potential biosignals to record. The most important physiological parameters are the four standard vital signs: body temperature, blood pressure, heart rate (or pulse) and respiratory rate.
Several other biosignals have been proposed as fifth or sixth vital sign, but none of them has been officially universally adopted. Examples include the oxygen saturation, pupil size, equality and reactivity to light, perception of pain, blood glucose level, Body Mass Index (BMI) or galvanic skin response (GSR).

3.1 Vital Signs

The four standard vital signs are body temperature, blood pressure, pulse rate (or heart rate) and respiratory rate.
Body temperature [13] is measured with a thermometer and can be an indicator for several abnormalities. Average core body temperature is 37.0° C. Elevated body temperature can be a sign for a systemic infection or fever but can also be caused by hyperthermia. Temperature depression (hypothermia) can be caused by alcohol consumption or dehydration, for example. When measuring and interpreting body temperature, it is always important to review the trend of the patient's temperature. This makes the ability of a system like the ALIAS health monitoring system to record and store biosignals a very important feature.
Blood pressure is recorded as two values: a high systolic pressure and the lower diastolic pressure. The difference between these two values is called the pulse pressure. The blood pressure can be measured using an aneroid or electronic sphygmomanometer. Normal blood pressure values are 120 mmHg (millimeters of mercury) for the systolic and 80 mmHg for the diastolic. The systolic being constantly over 140-160 mmHg is defined as elevated blood pressure (hypertension), whereas low blood pressure (hypotension) is generally considered as systolic blood pressure less than 90 mmHg. Using a device like the ALIAS health monitoring system, thresholds can be set to supervise blood pressure. The pulse is the physical expansion of the artery. Its rate is recorded as beats per minute and can be measured at the radial artery at the wrist or at other places of the human body. Another way to measure it, is by directly listening to the heartbeat using a stethoscope. The normal reference range for an adult is 50-80 beats per minute. Respiratory rate [14] is the number of breaths per minute. A normal adult's rate is between 12 and 20 breaths per minute.

3.2 Physiological Data Processing With ALIAS

The health data can be transmitted to the robotic platform directly by a recording system or by a user who recorded the data on his own and stores it via the multimodal ALIAS user interface into the database. Examples are blood pressure and body weight. The ALIAS health monitoring system can then perform several tasks with these data. The system can store data in a short-term or long-term way, provide statistical analysis of the data, and visualize these data.

4 User Survey

For innovation processes it is essential to integrate the perspectives of the potential users into the development of the mobile platform [15]. Therefore, the relevant and heterogeneous target groups have to be considered. Only then it is possible to implement their needs and preferences to the robotic platform [16, 17]. The acceptance of health monitoring modules in general and the discussed database in particular have been investigated in a quantitative user survey with 79 senior students (35 women/44 men) in 2011. The mean age of the polled seniors was 70 years.
The seniors estimated the possibility of health monitoring as positive (50%), some are not sure (27%) and the rest (23%) are skeptical about modern health monitoring technologies. Among the skeptical persons, the reasons for this rejection were that they consider themselves as "too young" to use such a help and they want to test the database first to value the personal benefit. Unfortunately this was not possible in this setting.
Also the survey evaluates what kind of health data should be recorded and saved on the mobile robot platform (see Table 2). The results show that seniors are more open to

the measurement of the pulse (61%) and the blood pressure (63%) than to the measurement of the vital data such as breathing (47%), weight (46%) and body temperature (46%). It was striking that more than every fourth senior does not want the weight to be measured. Altogether the desired data can be summarized with the following statement of a senior "if it is important for a certain kind of illness". Some participants were so enthusiastic that they wish to store further data e.g. MRT/CT-picture files, important blood values etc.

	In any case	indifferent	In no case
Pulse	61.2%	28.4%	10.4%
Blood Pressure	63.4%	25.4%	11.3%
Blood sugar	54.7%	29.7%	15.6%
Weight	46.3%	26.9%	26.9%
Body temperature	45.5%	37.9%	16.7%
Breathing	47.0%	36.4%	16.7%

Table 2: Health data that should be recorded on the mobile robot platform.

The survey showed that seniors prefer a comfortable and safe way of using the health database. Almost half of the participants wants that the medical devices are directly connected to the robot so that the data can be saved automatically (44%). 23% are uncertain about this technology and the rest refuses the automatic data saving and transfer generally (23%). Nevertheless, the seniors are skeptical about a password-secured electronic health record. Only every third participant wants to save the health data on an external server. Reversely, more than 70% of the seniors would save the data on the hard drive of ALIAS at home. It remains to be seen if the seniors - as soon as they recognize the potential and the personal benefit of the electronic health record - give higher approval ratings.
For the interaction with the system, it is very important to the seniors that they can examine their data entry before it is saved (for 78% seniors this should be included in any case). Because of that when the robot is developed it should be paid attention to summarize the data in synopsis before it is actually saved, to announce the storage and to let this be confirmed by the user. Another point for the interaction is presentation of the stored data, 71% of the seniors wish a presentation in graph form and 74% a presentation in table form, respectively.
Altogether, it could be seen that seniors are open for health monitoring or concepts for physical monitoring of vital functions, but first they have to get familiar with a technical assistant system to save their health data. Some seniors pointed out that for this purpose ALIAS has to be "reliable". That is for the target groups a crucial point of view.

5 System Design

In order to properly design the health monitoring within ALIAS, it is necessary to identify what the system should realize from the users' point of view, therefore the user survey was conducted, see Section 4. The derived design decisions for the system are introduced in the following. The decisions concern the recorded health data (via sensors or manual entry) and how the user interacts with the system in a general way, therefore, different activity diagrams will be presented to explain the proceeding.

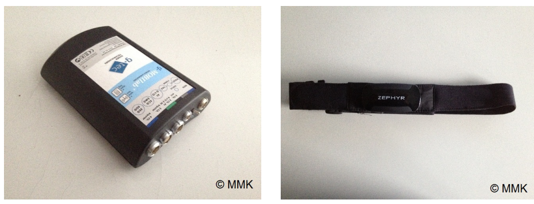
5.1 Recorded Physiological Data

The database for the ALIAS health monitoring comprises the following entries: 1) blood pressure with the systolic and diastolic value, 2) blood sugar, 3) heart rate, 4) respiration, 5) temperature, 6) weight.
For all these values minimum and maximum values for alarm triggering were defined. For the weight the body mass index (BMI) was chosen to provide the corresponding minimum and maximum values. In the following Table 3 the minimum and maximum values for the health data are shown.

Value Type	Maximum Value	Minimum Value
Systolic	140	105
Diastolic	90	60
Blood Sugar	110	70
Heartrate	100	60
Respiration	20	12
Temperature	37.5	35.8
Weight (BMI)	24.9	18.5

Table 3: Minimum/maximum values for the recorded health data according to [18].

The ALIAS health monitoring has two different sensor systems to obtain health data. The first system is the *g.tec g.MOBIlab* [19], the second system is the *Zephyr HxM BT* [20]. The first system is a professional medical device providing a lot of different features, whereas the second one is a consumer device, which is easier to handle. Both sensors are shown below in Figure 2.



(a) g.tec g.MOBIlab (b) Zephyr HxM BT

Figure 2: Integrated sensors.

The g.tec g.MOBIlab system records the following biosignals and physiological features: electrocardiograph (ECG) (with several corresponding values like heartrate (HR) heartratevariability (HRV) etc.), galvanic skin response (GSR) and respiration.
The Zephyr HxM BT system records the following biosignals and features: heart rate, speed and distance.

In addition to the sensors, the user can also enter health data manually into the database. The user is able to manipulate the following entries manually: blood pressure, blood sugar, heart rate, respiration, temperature and weight.
According to the results of the user survey (see Section 4) the recorded data is stored on the robotic platform and not on a remote server. However, a remote access for the data is also possible, since a web-based approach for recording and visualizing the data is chosen, thus authorized persons (doctors, relatives) are able to access the data if they have the permission.

5.2 Activity Diagrams

Activity diagrams are used to visualize the corresponding processes the system needs to perform in order to realize the interaction between system and user. In the following, the diagrams for entering health data will be shown and briefly explained. There are two ways of entering data into the database: sensor-based and manually.
For the sensor-based entering, the user initiates live data recording, therefore between the two sensor devices can be chosen: g.tec g.MOBIlab or Zephyr HxM BT, respectively. When a device received the user input, the data recording is started, the data is queued, until enough data are stored to start the monitoring and the corresponding visualization. After a dataset value has been displayed, the system stores it into the underlying database. When the user chooses to stop the recording and forwards his choice to the system by pushing a button on the screen, the logging, monitoring and storing of the data is stopped abruptly and thus the live visualization is finished. The corresponding activity diagram is shown in Figure 3.

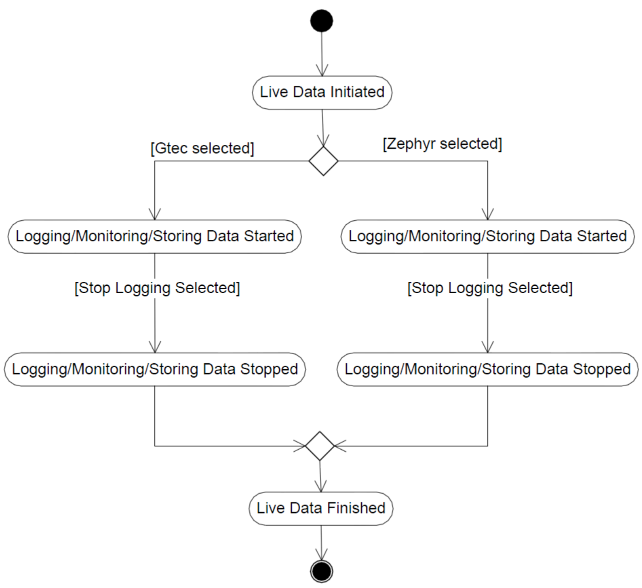


Figure 3: Live data entry.

For the manual data entry, there is one special case, since for blood pressure three values (systolic level, diastolic level, heart rate) have to be entered. For all other health data recorded with the proposed database, only one value has to be entered. According to the user survey (see Section 4), the user wants to check the data before they are finally stored in the database and additionally a warning message should be shown if critical values (see Table 3) are exceeded. In the following only the activity diagram for the blood pressure data entry is shown, since the proceeding for the single value health data follows that scheme.

When the blood pressure entry is initiated by the user, the system waits for the systolic and diastolic values as well as the heart rate to be entered. After the user has entered these values and pushes the confirm button, the system displays the entered values again to the user and offers him two options: The first option is to edit the data in case the entered values turn out to be wrong. In this case, the values are aborted and again the system waits for new values to be inserted. During this process, the underlying database is never touched, so the system makes sure that the database does never contain any false values. The second option for the user is to confirm the values he entered. Only if the values are confirmed by the user, the system stores the data into the database. At the same time, the system checks if the entered values are alarming, i.e. if one (or more) of the values are either lower than the minimum value stored in the database or higher than the corresponding maximum value (see Table 3). The corresponding activity diagram for the blood pressure entry is shown in Figure 4.

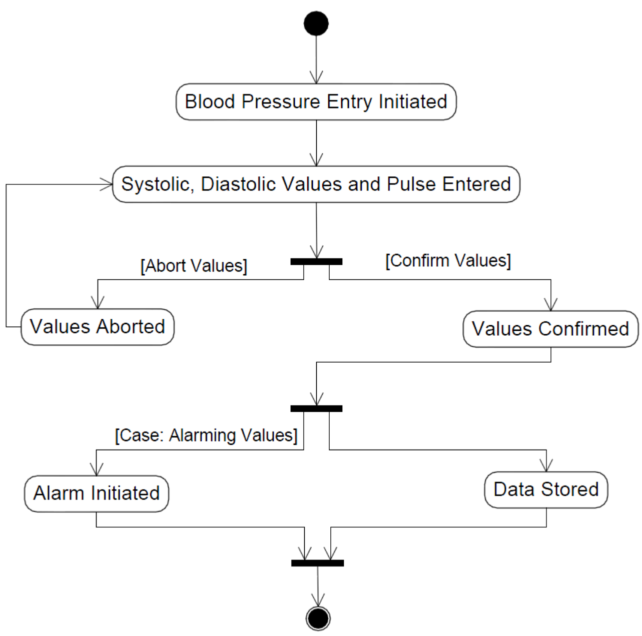


Figure 4: Manual data entry: blood pressure example.

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6 Database Concept

6.1 Basics

There are different types of databases available and they provide different kinds of features, more extensive information about databases can be found in [21, 22]. In general a database is a collection of data, which has a certain kind of interrelation and can be accessed via a specific set of functions or programs. For databases a specific architecture was defined comprising three different layers (see Figure 5): physical layer (containing the data file on physical disk drives), logical layer (first abstraction level: data is represented in a common abstract structure form) and the external layer (second abstraction level: the form of the data accessed by the users). Different database models (flat-files, Hierarchical Model, Network Model, Relational Model, Object-Relational Model, etc.) have evolved over time, the ALIAS health monitoring database follows an object-relational approach.

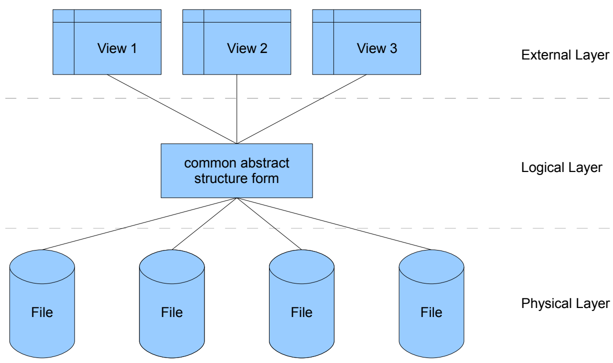

Figure 5: Abstract layers of databases.

6.2 Database Concept for the Health Monitoring

The database concept for the health monitoring system envisioned for the ALIAS project has to fulfill several properties, which are relevant for handling health data of elderly people. First, the data should be stored over longer time periods enabling to perceive changes in the course of the data (e.g. blood pressure). Second, the database should be able to handle different users and their related health data (this is relevant for the usage of the ALIAS system in care facilities). Third, the health data should be accessed either directly on the ALIAS system or via remote access, thus enabling doctors and the authorized health care providers to access the health data.
In order to achieve a generic, resource-efficient database, an elaborate database concept has to be developed. Figure 6 depicts the generated database concept consisting of the following entities: user, dataset, dataset value and dataset value type. These four entities will be described in the following.

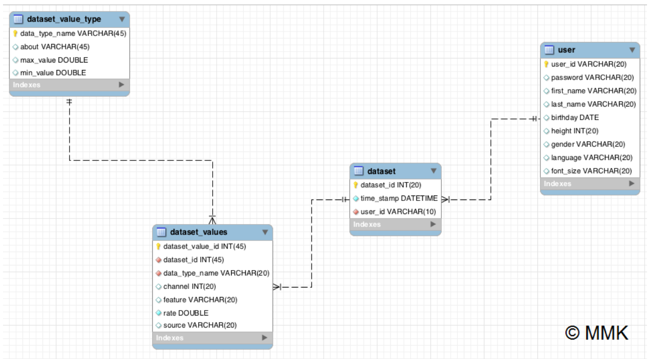

Figure 6: Database concept for the health monitoring.

User: In order to enable various users to share the same ALIAS robot, the table *user* was created. Here the user id, corresponding to the login name, is used as the primary key of the user. This ensures that each user can be uniquely identified by his chosen user id, at the cost that no two users can choose the same id. Furthermore, the user has to choose a password. The user id and the corresponding password are used to grant registered users access to the data base and into the system. In addition the following information about the user is provided by the user-entity: **First Name, Last Name, Birthday, Height, Gender, Language, Font size, Login and Password** (hashed). Finally, a user can be associated with various datasets. This is realized by a one-to-many relationship between a user and datasets.

Dataset: In order to uniquely identify a dataset, it contains an automatically generated *dataset id*. The timestamp enables to reconstruct, at which date and time a dataset was recorded. Furthermore, a dataset has a foreign key which assigns it to a specific user. A single dataset can contain multiple dataset values, which is realized by a one-to-many relationship between dataset and dataset values. The dataset relation is necessary, because a sensor may record multiple biosignals and extract many health features thereof at one time.

Dataset Value: The automatically generated field *dataset value id* allows to reference each dataset value in a unique way. In order to differentiate between multiple connected sensors, from which dataset values are transferred to the system, the field *channel* is invented. The field *feature* allows capturing further information of the sensor, if necessary. The dataset value itself is stored by the field *rate* and the sensor from which the dataset value is originated is captured by the field *source*. The dataset values table contains two foreign keys. The first assigns

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the current dataset-value to its corresponding data set. The second assigns a specific dataset-value-type to it.

Dataset Value Type: The *dataset value type*-table enables the resource-effective and generic framework to be realized: This table holds the various dataset value types that can be recorded, for example blood pressure, respiration or heart rate. These different types are recorded only once and are then assigned to the dataset values. It contains the field *data type name*, which also acts as a unique identifier for the dataset value type. Further information about the dataset value type can be stored in the field *about*, if necessary. The fields *minValue* and *maxValue* define the thresholds of the lower and upper alarm limits if any is set.

7 System Interaction

The ALIAS health monitoring module is provided as a web application, which means that it runs in a web browser. Thus, it is possible to allow remote access to the data, so that it can be inspected by authorized persons (i.e. a person's doctor, relatives etc.). The integration into the ALIAS dialog system is easily realizable, because a web browser is integrated into the graphical user interface (GUI) of the ALIAS system. For the manual data entry it is possible to use the touchscreen of the ALIAS robot or apply speech input.

In the following several system interaction steps will be described. The first step registration, is not intended to be done by the user, but in cooperation with either the nursing staff (in case the system is used in care homes), or together with a person of trust (relative, doctor) (in case the ALIAS system is used at home).

Registration: The registration is necessary to create an account for a user in the database, so that the data can be stored. The following data are required for the registration procedure: first name, last name, birthday, height, gender, language and font size. Additionally, the user has to choose a login, which serves as a unique identifier (i.e. user id) and a password, which is stored in hashed form. These two values serve in the future for logging into the system. When the user pushes the *Create-Button*, the system checks, if the login is already assigned (no two users can choose the same login). Therefore, if the login is already assigned, the user has to choose another one. Otherwise, the account is created and the user data are stored into the underlying database. The registration mask is shown in Figure 7.

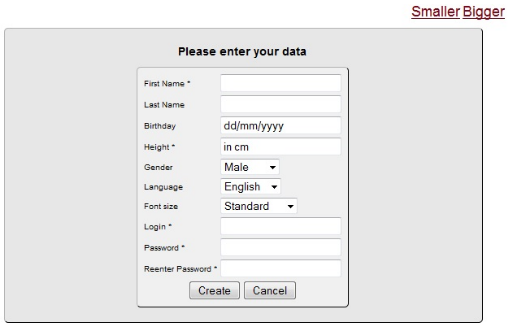

Figure 7: User Registration.

Login: Before any manipulation on the system can be performed by a user, he/she needs to log him/herself into the system by using his chosen login and password. The login procedure is only possible, if an account was already created by the user. When the user pushes the *Login-Button* after he/she inserted his/her id and corresponding password, the system checks, if the values are correct. If they are not, an error message is sent to the user. The user can repeat the login procedure or press the button *Forgot your password?* to recover the login. The login mask is shown in Figure 8.

Figure 8: User login.

After a successful login, the home display is shown in the web browser (see Figure 9). This home display consists of a menu bar, where health data entries are shown, within the field *Live Data*, the connected sensors can be started.

Figure 9: Home Display (larger on the actual screen).

Live Data Entry: For the live data recording the user has to selected one of the sensors first. After one of the sensors was selected, the live data recording starts. All recorded channels are shown, therefore the charting library *Highcharts* [23] is used. An example for visualization of a recording of health data from the g.tec g.MOBIlab sensor is shown in Figure 10.

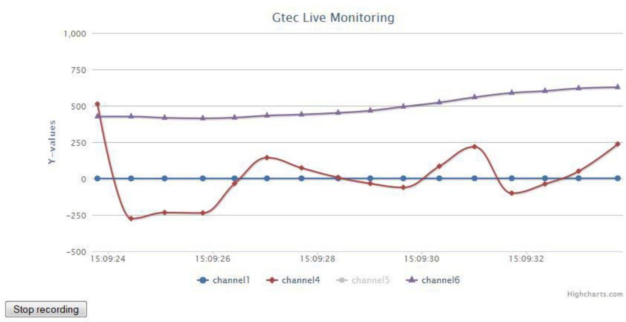

Figure 10: Live Data Recording: g.tec g.MOBIlab.

In general, Highcharts offers a good possibility to add interactive charts in a web application. Furthermore, Highcharts is compatible with all modern browsers like Chrome, Firefox, Opera etc. and it also supports the iPhone/iPad, besides it offers numerous chart types like line, spline, area, areaspline, etc. and allows multiple modifications.

The recording of the live data follows the *What You See Is What You Get (WYSIWYG)*-principle, since a recorded session is displayed in the same way as it was shown while the recording, because there were no additional points recorded or skipped during a live recording.

Manual Data Entry: The manual data entry consists of three steps: In the first step, the data values are entered by the user. Afterwards the user has the possibility to check his entered values. The final step consists of the data storage in the database. In the following these three steps are exemplary shown for blood pressure data entry. In the first step the user has to select blood pressure in the home display. Afterwards the overview for the blood pressure is presented (see Figure 11). This overview consists of three entries: adding data, displaying data for a specific time frame (week, month), display data since a specific date.

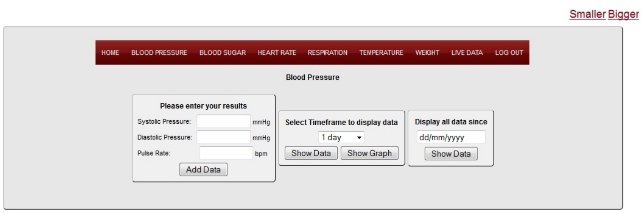

Figure 11: Manual data entry: entering blood pressure values.

For the blood pressure three values have to be entered: systolic pressure, diastolic pressure and heart rate. After all data entries were provided the user has to press the *Add Data*-button to proceed to the next step. In this step, all the entered data is displayed (see Figure 12) and the user has now two possibilities: Either he/she can edit the data once again, in case he/she made a mistake while the data entry, or he/she confirm the entered values.

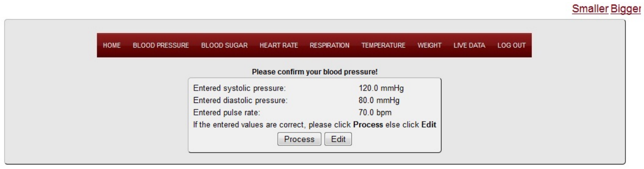

Figure 12: Manual data entry: confirmation of blood pressure values.

After the user confirmed the entered values, he/she gets a confirmation on the screen, see Figure 13, that the values are now stored in the database.

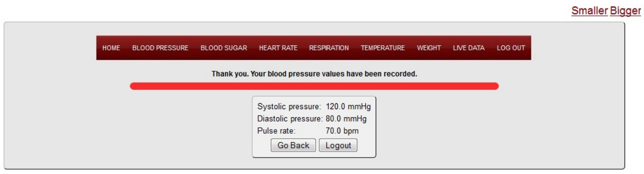

Figure 13: Manual data entry: blood pressure values storage.

Presentation of Stored Data: The user has two possibilities to view previous data, he/she can choose to display the data by selecting a timeframe or by inserting a specific date. In addition to time selection, there are two different presentation styles: presentation in table form (see Figure 14) and presentation in graph form (see Figure 15). This procedure for the visualization was wished by the users (see Section 4).

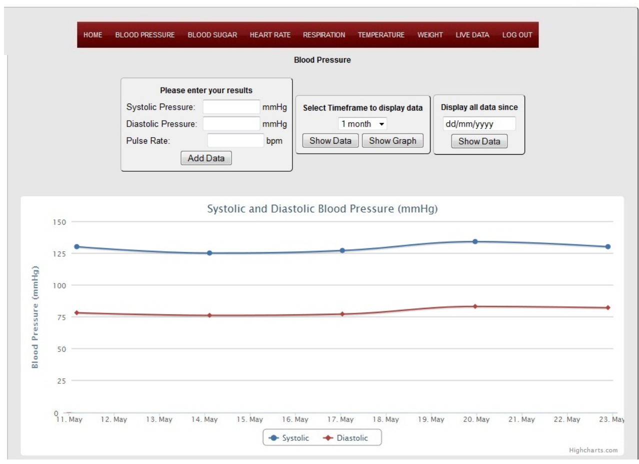

Figure 14: Data presentation via graph.

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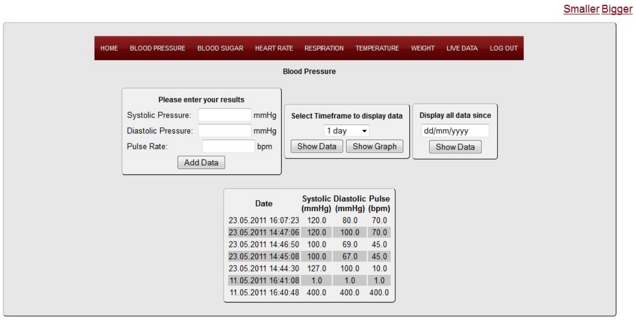

Figure 15: Data presentation via table.

The realization of the system interaction sticked to the user survey from Section 4. The system design and interaction followed the wishes and needs of the elderly users. In general, the health monitoring on the ALIAS robot is designed in a generic way, since the system is designed for usage by multiple users in nursing homes or for a single user.

8 Use Cases

Different kinds of use cases are thinkable depending on the task and the wishes of the user. In general, there are two kinds of categories of use cases. The first kind of case provides a direct feedback of the obtained data towards the user, whereas the second kind is more related to monitoring operations. These monitoring operations can be subdivided into a long-term monitoring, acquiring health data for a longer time period, to obtain data, where small irregularities can be more detectable, the second category is short-term monitoring, where the health data is recorded for a couple of minutes.

8.1 On-line Cases

Exercising with ALIAS The health data are directly provided as feedback for the user, while performing a physical exercise. The online feedback can help the user to rate his/her personal performance and might adjust his/her training according to the health data.

Gaming with ALIAS The health data can be shown while the user is playing with ALIAS, so either the level of physical effort can be estimated for instance by playing with the Nintendo Wii, or it is possible to extract the stress level as well as the state of the mental effort during gaming. If necessary and desired the data even can feed back to the games, for a closed loop control of the parameters defining the difficulty of the game levels, with the aim to optimize (maximize) the performance level of the user.

8.2 Monitoring Cases

Diary Monitoring of Vital Functions The diary monitoring of vital functions provides the possibility to create a profile of specific vital functions over time. This profile can be used to estimate the change of the vital functions of the user with external events. For instance, a cardio-training is set up for the user to enhance his/her fitness, thus a change of the resting pulse rate can be detected. Another possible example is to track the influence of different drugs on the vital functions.

Long-Term Monitoring The objective of long-term monitoring is to detect small irregularities in the health data of the user for a longer monitoring period (e.g. 24 hours).

9 Conclusion

In this paper a health monitoring system is presented, which is part of the robotic platform ALIAS. The design of the health monitoring system followed a user-centered approach, thus a survey was conducted to gain information about wishes and needs of elderly people with regard to: what kind of health data shall be recorded, where shall the data be stored, what are important steps for the system interaction. The outcome of the survey was considered in the realization and implementation of the database, additionally, the database was designed in a way that it can be applied to multiple user in nursing homes or a single user living alone.

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