SENSE – PARK

<u>Deliverable D6.1.1:</u>
Report on D6.1 Demonstration of Central Administration Tool and user interface to the PWP's

SEVENTH FRAMEWORK PROGRAMME

SENSE-PARK
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Acronyms

WP	Work package
PwP	Person with Parkinson
PDCare	The entire system, containing all components
PDCAT	Parkinson Disease Central Administration Tool
PDDevices	Parkinson Disease Device Components
PDTelemed	Parkinson Disease Server Application

Summary

The deliverable report D6.1.1 describes the software prototype regarding management, storage, analysis and visualization of data and parameters collected and extracted through the wearable sensor system as well as through the gaming and VR environment. The report includes the description of the implementation of tasks 6.1, 6.2 and 6.3.

History

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Content

Introduction

Two of the main results of the SENSE-PARK project, are at first the home-based PC software application (Central Administration Tool, CAT) and secondly a web-based server application (PDTelemed). The PDCAT is the medium for the user, to manage, store, analyse and visualize data and parameters collected and extracted by the wearable sensor system. The next step in this chronology is the exchange of these objective and subjective information with friends, carers and experts. This functionality is realized by the PDTelemed component.

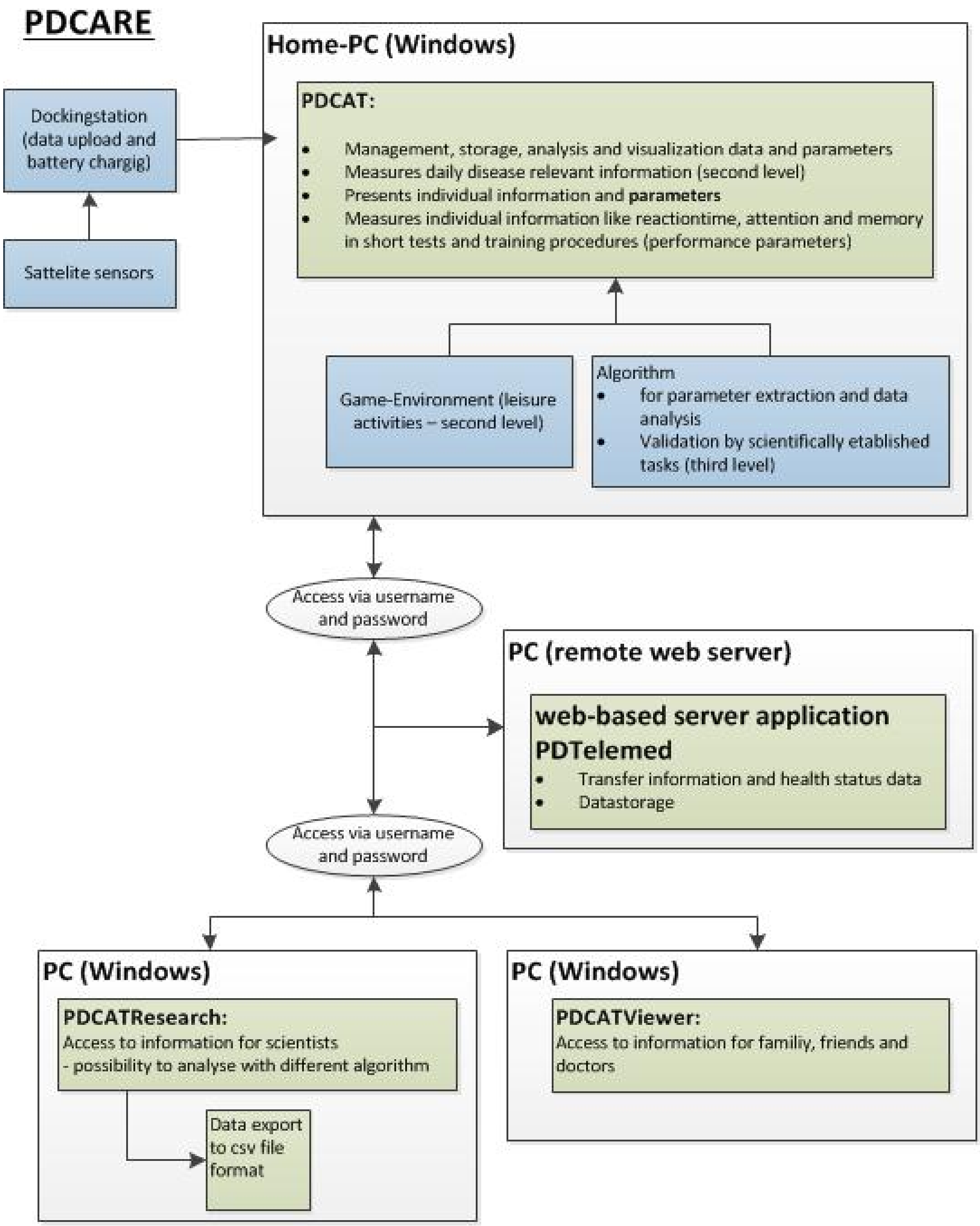

Figure 1: Overview of the system

The SENSE-PARK system called PDCare contains two main components. One of them is the hardware part, containing the PDInerUnit, PDInerRFIDUnit and the PDDockingStation (summarized in PDDevices), that's a part of the work package 5. The other component is the software part PDCAT (with different versions as PDMonitor (for the patient), PDViewer (for friends, care service and physicians) and PDCATResearch (for scientists) and the server part PDTelemed. Through a defined interface, a connection between the PDCAT and the PDTelemed will be established. PDCAT and PDTelemed are integrated in work package 6, led by Hasomed.

The content of this report is the conceptual work and implementation of the software application PDCAT and the interface to the hardware component PDDevices. The aim of PDCAT is the presentation of extracted parameters of interest, closely linked to the results of WP3.

The realization of the first part of the WP6 contains the following tasks:

Task 6.1.: Definition of universal interfaces
• Review of standardized interfaces and protocols for medical data communication
• Definition of interface sensor systems and CAT
• Definition of interface between the web-based server application and the CAT

Task 6.2.: Integration of sensor systems, data storage and analysis
• Integration of sensor systems
• Implementation of a database
• Integration of data analysis algorithms from WP 5
• Implementation of data analysis spanning all available parameters for later feedback

Task 6.3.: Development of the user interface
• Implementation of feedback methods to PwP's (e.g. charts, messages, scores)
• Implementation of navigation methods for overall system control by PwP's
• Usability tests involving PwP's in a lab environment

The concept

The conceptual work for the PDCAT application has started with first interface solutions based on the results gained from WP2 and WP3 (especially Deliverable 2.2 and 3.1). Afterwards a conceptual document the “Software Requirements Specification” was produced (document attached), following the laws and norms for development of medical devices. In this document possible GUI solutions, sensor coupling, database management and internet communication solutions are defined, even the required interface definitions from task 6.1.

The software application has to contain the connection to the sensor units and several input devices. So it is possible to measure parameters of the domain ‘cognition’ and individual information concerning the health status of the patient. The software manages, stores, analyses and visualizes all those collected data corresponding to the different domains. A management for medications is included too. The aim was the development of a system with good usability for PwP’s.

For computing the parameters of the collected raw data, a DLL-interface has to be integrated, which connects the PDCAT with the data analysis algorithm from HSG-IMIT. The raw data from the database are transferred to the algorithm. After the analysis, in preparation of the data exchange, the generated result data will be given back to the PDCAT and saved into a database. All generated disease-relevant data, will be combined in a result presentation for every domain to show up connections and coherences.

The domain ‘Cognition’

Depending on the results from WP 2 and linked to the three main levels, six domains were included; *Tremor*, *Bradykinesia*, *Sleep*, *Gait*, *Sway* and *Cognition*. Regarding to the domain *cognition*, we have integrated several test and game modules in the concept. After intensive discussions with the project partners, following modules were implemented into a prototype for the evaluation of cognitive functions:

1. **Alertness**: In this module three different skills are measured. The first one is the *tonic alertness*, which is measured as the response time to a visual stimulus.[1] The second skill is *phasic alertness*, which can be described as the improvement of the response time through an acoustic warning signal.[2] Under the aspects of Sturm et al.[3] there is a third attribute called *intrinsic alertness*. This skill describes the maintaining of reaction attendance during a longer period of time.

2. **Divided Attention**: Empirical studies have shown that attention is a non-uniform construct. In fact, the following four aspects are largely independent and can be distinguished as follows:[4,5,6]

   1. Periodic activation, Alertness
   2. Selective attention
   3. Divided attention
   4. Tonic activation

   Tasks requiring divided attention abilities have to include at least two different kinds of stimulus, which have be simultaneously looked out for. This aims to encourage the patient to be attentive to both stimuli and to respond to relevant stimuli. When there are many stimuli appearing and disappearing fast, they interfere with each other. Thus, mistakes are likely to be made, and the performance decreases.

3. **Response Control**: Examined is the ability to react in an appropriate way under time pressure and to control behavioural impulses simultaneously. It is essential to supress a triggered reaction by an external stimulus in favour of internally controlled behaviour. The focus of attention is directed to a predictable appearance of stimuli and the corresponding reaction, for example to react or not to react.[7,8,9]

4. **Visual Exploration**: In this application the basal cognitive performance and the selective attention will be tested. In addition the test can be used for the screening of a visual neglect.
   The basal cognitive performance is associated in the literature with the ability which is called perceptual speed. The term selective attention describes the ability to focus on the relevant stimuli of a stimuli constellation and ignore irrelevant stimuli of this constellation over a short time period. This application is modelled after the well-known “Digits-Connection-Test”, developed from Oswald und Roth 1987.[10,7,8,9]

5. **Working Memory**: In this application the visual-spatial memory span and the visual-spatial memory function are determined. The application is also used for testing the implicit visual-memory learning and the working memory. [7,8,9]

6. **Topological Memory**: The aim of the procedure is to test the spatial memory. The route through a labyrinth is shown to the patient as green dots. The fundamental idea of this test is the “Stylus-Labyrinth” from Milner[11, 12]. Milner has shown the correlation between the topological memory and different cognitive deficits in several studies. In the same way other researchers have used Milners “Stylus labyrinth” to detect the connections between special cognitive disorders and the ability to learn the way through a labyrinth.

7. **Refind**: This module tests the complex attention functions. It is an extension of the research method “Digits-Connection-Test”, developed from Oswald und Roth 1987.[10]
   It identifies the perceptual speed or cognitive speed.
   For this extension the task is to search for numbers and letters and mark those as fast as possible in a given order. The letters have to be found in an ascending order while the numbers are in a descending order (A-9, B-8, C7, etc.)

8. **Attention and Concentration:** The term attention sums up functions which put external and internal sequences of processes on an orderly basis regarding time and content.

Broadbent[13] based his "bottleneck- or filter theory" on the assumption of a *limited processing capacity* for incoming sensoric information meeting the organism, so that if reacting to *selected stimuli* other *stimuli simultaneously incoming are suppressed*. From nowadays´ point of view there are a range of input channels for every mode of perception filtering incoming information. Sternberg (cf. also Keller & Grömminger, 1993) differentiates in his *action orientated model of attention* between 4 phases[14]:

1. Perception,
2. Identification of relevant stimuli,
3. Choice of reaction and
4. Starting a motor program as reaction to the stimulus.

These processes partly happen automatically; if specific aspects of the situation are understood active analysis processes are started. Automated processes run parallel with little capacity, whereas all others want a serial processing which needs more attention capacity and time. The ability for *directed attention* is a basic precondition for a general capability *Disturbances of attention and concentration* can manifest themselves in a reduced *perception and processing capacity*, reduced *information processing capacity*, rapid signs of *fatigue* especially when strained, but also higher *delicateness to distraction;* all together intellectual and practical actions may be impaired to a high degree.

9. **Verbal memory:** An important result of research into memory is the current treatment of the memory as an integrative element of cognitive abilities. Memory functions are in this sense not just the process of recorded information, the long-term storage and procedures of re-call (in a sense a passive storage facility); but rather the means by which the content of memory has an effect on the future recording of information and the experience needed for the practical treatment of side effects (Hoffmann, 1983). And consequently modulate the emotional experiences of the individual.

10. **Divided Attention 2**: Similar to the *Divided Attention* module, this module detects the parameters to the topic divided attention. The attention to relevant environment stimuli depends on intern organism variables (psychological status, cognitive processes and emotions) and external factors (stimulus intensity, contrast, colour, delineation, spatial relationship, etc.). By especially intensive or new stimuli (with high information level) it can be automatically; meaning involuntary attention can be focused through an orientation reaction. In particular, the selectivity of attention is permanent controlled by emotional assessment and maintained or not by motivational processes.

11. **Sway:** The sway test is based on the Berg Balance scale (Berg et al. 1992) and the Romberg's test (Khasnis et al., 2003) and describes the common clinical experiment to reflect balancing ability.[16,17] The test is divided into different parts of physiological tasks and collects the balance information using an integrated connection to the balance board.

PDApp

PDApp is an application that was implemented for mobile Android based devices. The aim is to monitor a PwP's daily routine. The patient can set time marks, starting and ending events like special movement, drinking, feeding, ironing, cleaning teeth and more. In combination with SENSE-PARK's inertial sensors a more detailed view will be recorded this way. That is very important during the first test phase of the system, while validating the algorithm for movements sampled with the inertial sensors. Later we will see the need of time marks.

The app allows the user to control activities and medication during a whole day. Android was chosen as basic system, because it is widely used and as the most popular platform it supports many devices. The user can use his own Android based smartphone or tablet computer, so he doesn't has to wear a second device only for using SENSE-PARK. PDApp runs on every Bluetooth 2.1 capable device with Android version 4 or higher. The development was done in Java with Eclipse as development tool.

PDApp is split into two large parts. Part one is the user interface, which is optimized for persons with handicap (large buttons and labels, long-time touch for controls to avoid incorrect operation). The second part is a background service for sensor management and activity / medication reminder. The background service runs all the time, even if external software is running as main application.

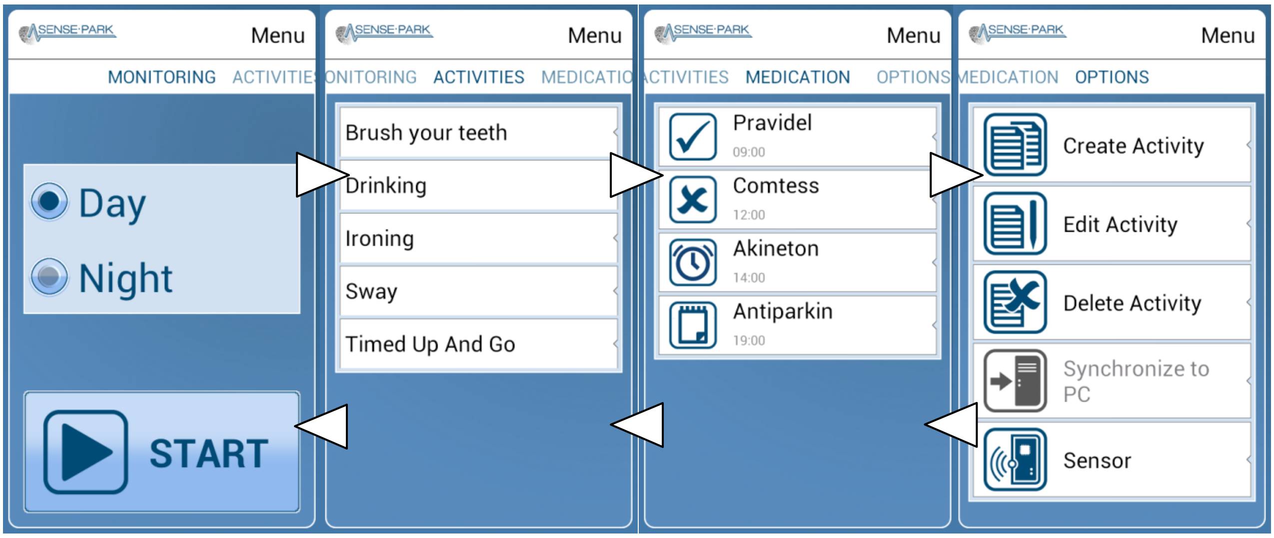

Figure 2: managing the monitoring; activity overview; medication overview; options overview

Activities

Activities are a technique to register separate tasks that occur during the day. PDApp includes predefined activities, like brushing teeth or drinking (see figure 1 left). Additionally the user can add own activities and edit or delete existing ones. During the test phase of SENSE-PARK the consortium has to decide which events will be recorded. Each activity has a short instruction. The recording is started and stopped manually by the user. It is also possible to start an activity at a specific time and to remind the user, when the time for an activity has come. All activity execution times will be synchronized with the PDCAT PC software and can be visualized together with the analysis results of the movement sensors.

Figure 3: starting an activity and stopping after a certain time manually.

Medication

Medication is a method to remind a PwP to take his medicine at certain time. If ingestion time has reached, an Android system notification is generated and the user is advised to take the medicine. Afterwards the user confirms or denies the ingestion or has the possibility to be reminded later (see Figure 3 right). The medicine schedule as well as the ingestion time is synchronized with the PDCAT PC software. The PDCAT is recording the answers of the PwP who is taking the meds.

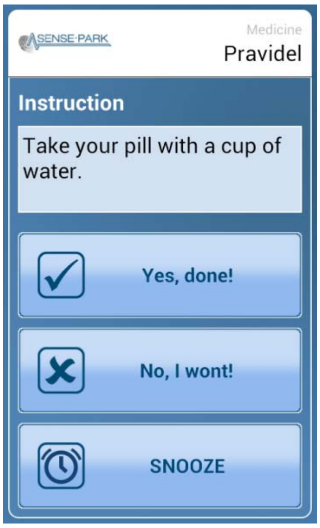

Figure 4: Medicine ingestion

Sensor management

PDApp is able to control sensors being used. This has been implemented for the Hasomed (Rehacom) sensors. The communication between application and sensors is done via Bluetooth. The user manually starts and stops the monitoring of movement with the inertial sensors. During the day a periodic check is performed to ensure that the measurement is still active. At startup an adjustment of sensor real time with the smart device is done. All sensor measurement data are stored within the sensor and will be synchronized vie USB-cable with the PDCAT PC software.

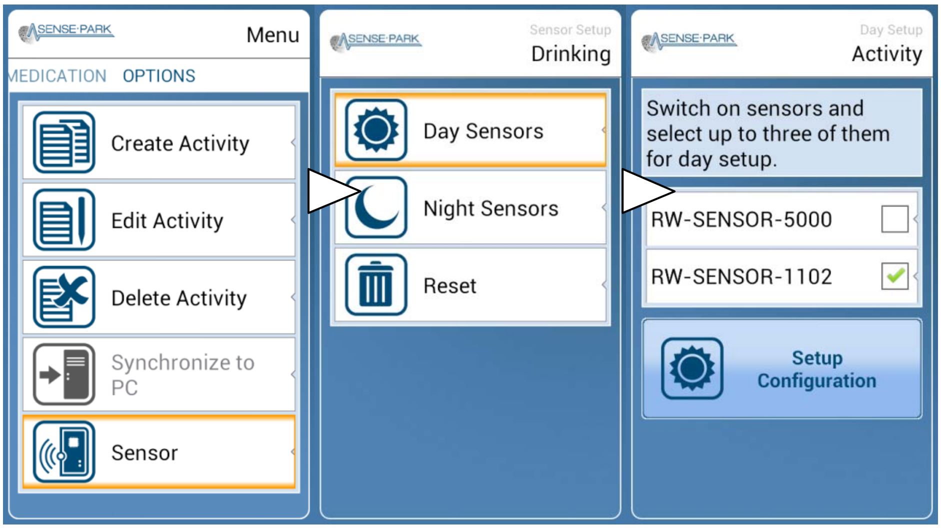

Figure 5: Configuration the sensors day and night setup.

The Prototype

Several steps were necessary to come out with a purposeful prototype. One of the most important things was the strong cooperation with the SENSE-PARK partner. As one of the first steps Hasomed designed possible solutions of the graphical user interface and delivered those solutions to the project partners. The user interface proposal has to be adapted to cognitive and movement abalities of PD patients. The aim is the acceptance of the software solution by PD patients through a high degree of usability.

Following the requirements, the description of the implementation specifies our solution strategies and their realisation in detail. This allows our project partners to apprehend the changes and the given priorities. In addition our document contains first ideas and examples for the realisation of the graphical user interface including concrete overview graphics of the setup from certain software parts.

The form of this document follows the requirements for developing medical devices defined in Europe in according to MDD 93/42 EWG and related regulations.

Necessary for the start of the implementation was the definition of single test-modules. Therefore, there were intensive discussions between Hasomed and IMM regarding this topic. During this discussion examples about the possible solutions were presented. As a result of these discussions were the described test modules, which were integrated into the software.

Simultaneously Hasomed planned together with AbilityNet the GUI-Design and concept of the workflow of the software. Depending on necessary adaptations for the PwP, Hasomed implemented a first software design.

One of the requirements to the software is to be motivating and handsome for the user. Regarding to this requirements we integrated the possibility to record the balance capabilities during executing the virtual game 'Divided Attention 2'. Additional to this none visible recording of the balance capabilities, we realized a standardized clinical sway test, defined by IMM. This test contains 5 different conditioned parts and finishes with a short sequence of driving a car, to raise the immersive level. To connect a wii Balance Board and record the data which were produced by the board, we integrated the DLL provided by HSG-IMIT. Depending on an extension in the graphical user interface of the PDCAT, it is possible to connect the Balance Board every time with the application. After collecting the data from the board, the PDCAT manages the data handling and imports all collected data into the database.

To integrate the analysis of the different domains, Hasomed defined an output interface for the exported result data. Regarding to this definitions, a data management for the result data of the domains were integrated. To make working ways shorter and optimize the development, Hasomed prepared a dummy-DLL definition, so HSG-IMIT has the possibility to test the developed DLL's. For optimization, a lot of Mail corresponding and telephone talks was necessary to integrate the parameter DLL's into the PDCAT. After the first integration, we realized the result presentation of the analysis results in the same kind like the result presentation of the domain cognition. These information were connected with the information from other parts of the application like the medication plan.

During the development of the prototype and all surrounding devices and applications, documents with descriptions of the realized functionalities were produced and delivered to all project partners. This was planned as a possibility to discuss and analyse functionalities through all partners. Even for further development we build a document of possible server and user management solutions. This document was send to EKUT and they decided which solution will be integrated depending on this document. The chosen option contains the storage of the raw data only on the user PC and the repeated analysis of the raw data after the update of the analysis algorithm.

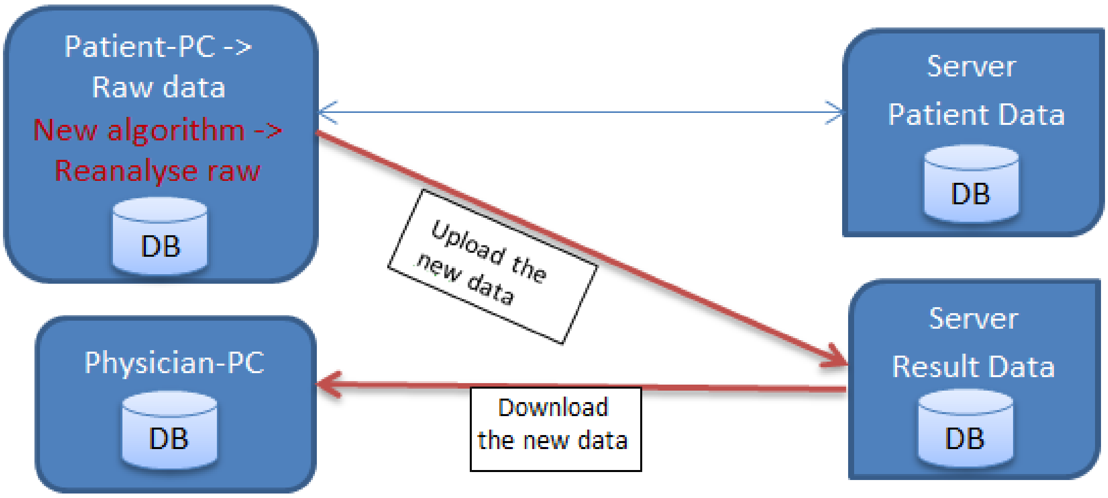

Figure 6: The concept of the data storage for the server.

With the first realization of the prototype regarding the task from 6.2., we proceed to collect the first user feedback with the help of the project partners (mainly CPT and AbilityNet).

One of the current works done by IMM is to get the first impressions from PwP's about the integrated test-modules. Regarding to this we give advice and support with the application to the partner IMM. For further feedback from other PwP's we wrote a description of the possible functionalities in the prototype and delivered this to our project partner CPT.

In the later state of develop the prototype, the collected feedback by CPT and AbilityNet were discussed for possible adaptations and the PDCAT software were further developed to the agreed solutions. Added are numerous telephone calls and meetings. The cooperation between the partners is very strong. Only in this kind we will reach the aim giving PwP's an instrument observing her daily life and activities.

The prototype has been realized by following conceptual definition. In the following chapter, the main features and internal structures of the PDCAT are described and explained.

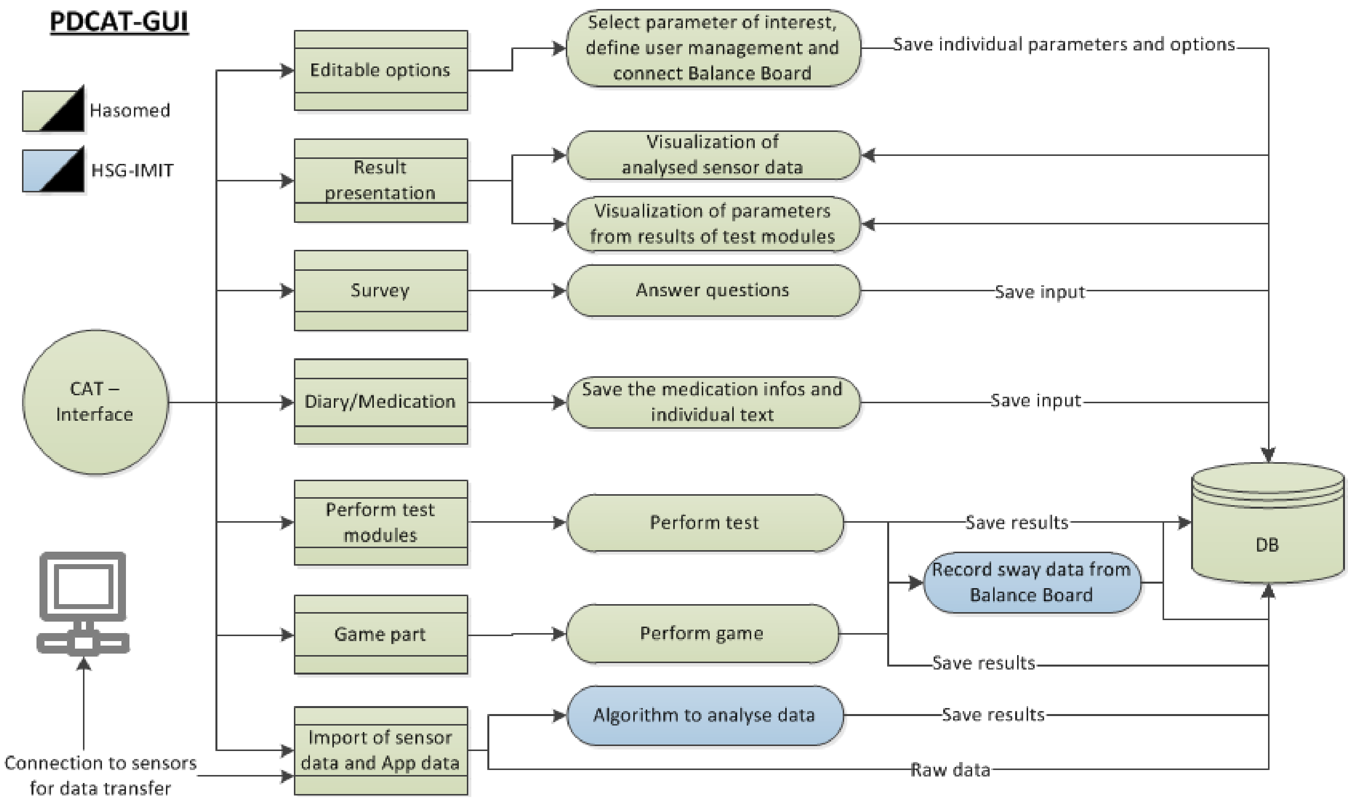

Figure 7: Overview about the interface structure of the PDCAT

The first points of contact for the user with the developed application are the interaction methods. Inside the PDCAT application the control by keyboard and mouse devices are integrated. Regarding the output of deliverable 3.1, the user interface is adapted to the requirements of PwP’s, by designing the interface components large and easy activatable with highlighted component selection. Also the use of consistent conventions by the usage of buttons with unique meaning, like getting back to the previous step, has been considered.

Figure 8: Main menu to navigate through all functionalities. Each option is reachable through big buttons. The selected buttons are highlighted by a different colour.

Because of the complexity of the parameter dimensions from the domain 'Cognition', inside PDCAT a wide range of measurable parameters is implemented. To motivate the user and to avoid a rapid boredom, these parameters are measured while performing different tests. This only takes a small amount of time and resources. We started with seven different tests and three games. After the validation phase of the tests made by our project partner IMM, we reduced their number to the top 3 of the most efficient tests regarding the results of the validation.

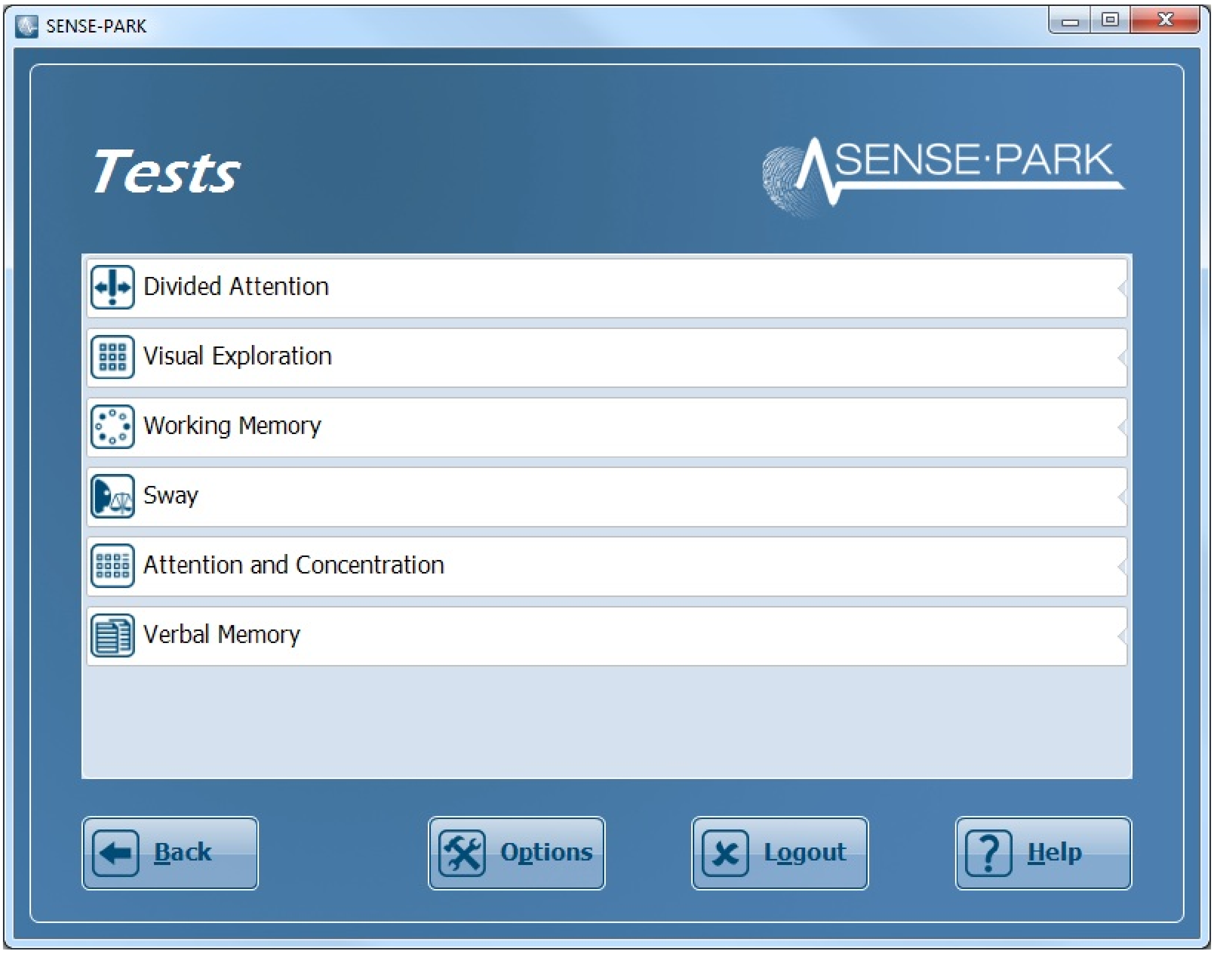

Figure 9: List of the final number of tests and games.

The parameters of the other domains will be recorded by the sensor units and the balance board, combined into PDDevices. For further processing of the collected data from the PDDevices, it is necessary to integrate a defined interface linking PDCAT and PDDevices. Through this interface, a connection will be established and the data will be transferred. Afterwards these raw data will be saved into the database and forwarded to the analysis algorithm. Therefor a specific defined interface definition to the DLL-implementation was integrated. Based on this interface, the computed result data will be imported and saved into the database.

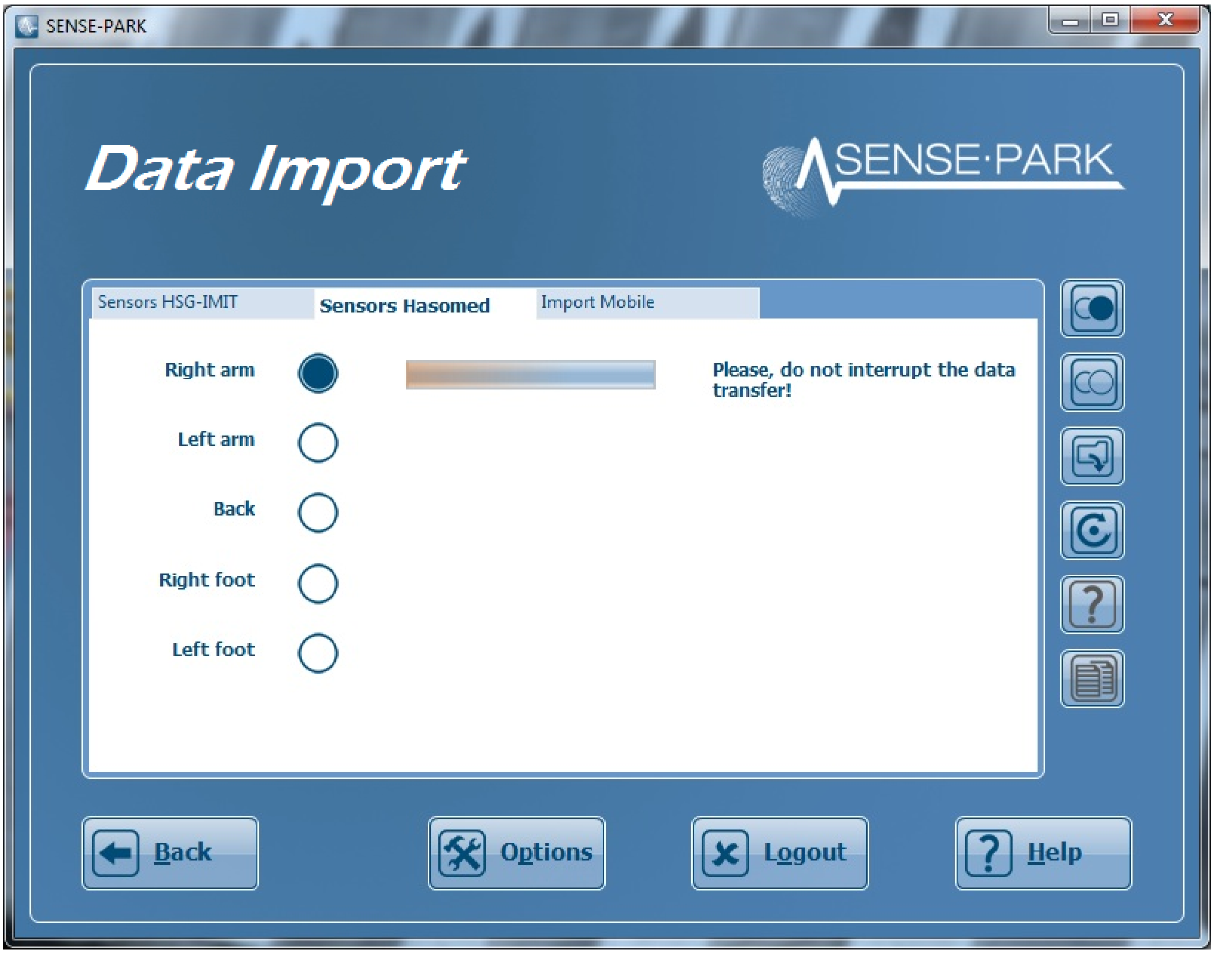

Figure 10: In this graphical interface the user has the possibility to connect the devices, transfer and analyse the data input. The transferred data are saved automatically into the database.

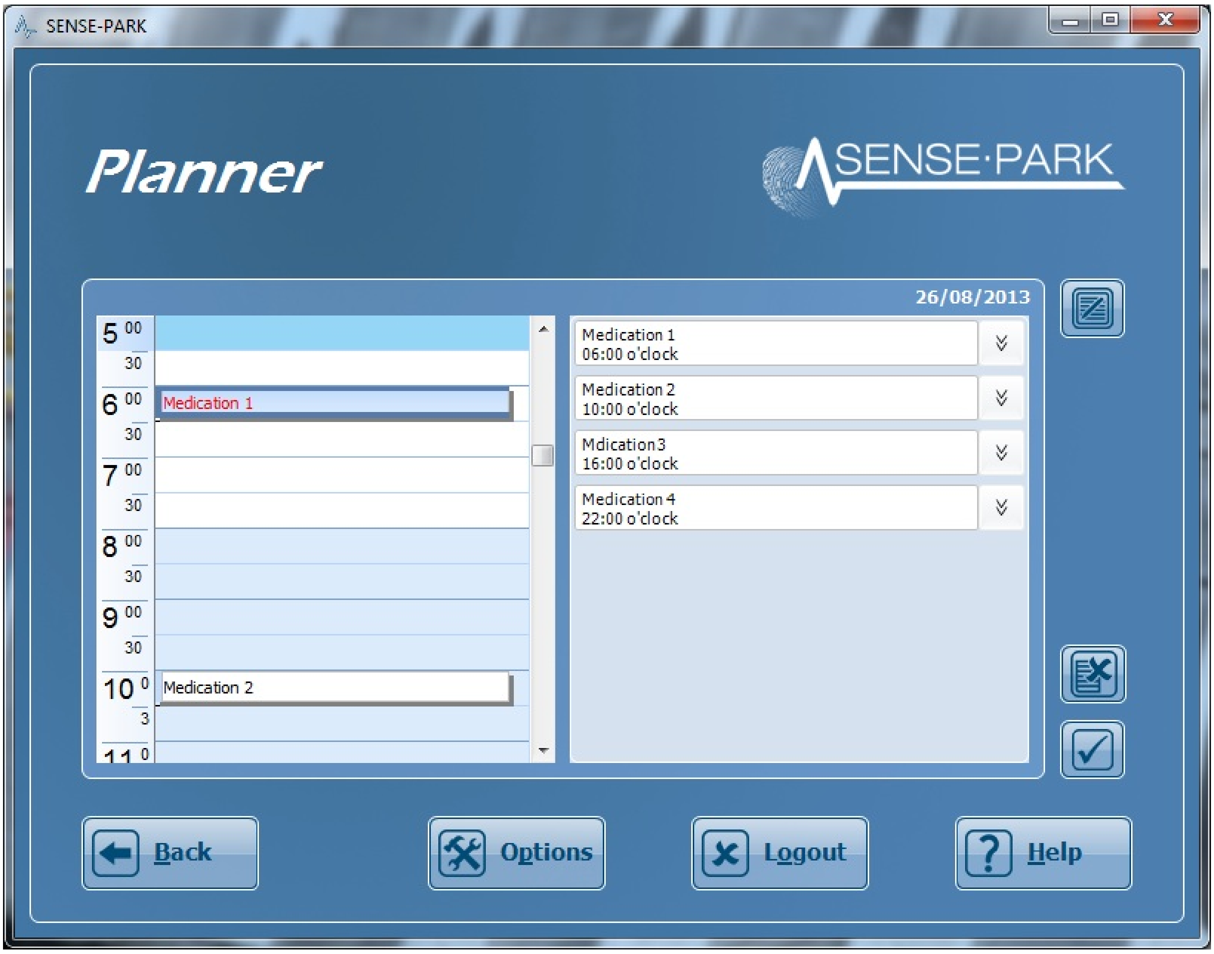

Figure 11: The user is able to enter his medication plan in this section. Together with the synchronization trough the PDApp, the medication times will be reminded to the PwP via the smartphone. Additional the individual information about the intake of medication can be recorded in the PDCAT and PDApp to be synchronized afterwards.

Besides the parameters coming from the domains, a set of subjective data as well as the medication plan can be recorded. In the menu section of recording the medication the user can enter the medication data into a timetable. With this table it is possible to record the intake of every medication. All additional information about the intake of medication imported from PDApp will be integrated into the list. The same way like the medication data are handled, the survey answer will be imported in the evaluation graphics. The answer is recorded on a scale (Figure 11) to the corresponding question and could be saved related to every hour a day. If there is any information that doesn't fit to one of the prepared categories, the user can add that information in the diary section. Here he can write his own comments and read past notes.

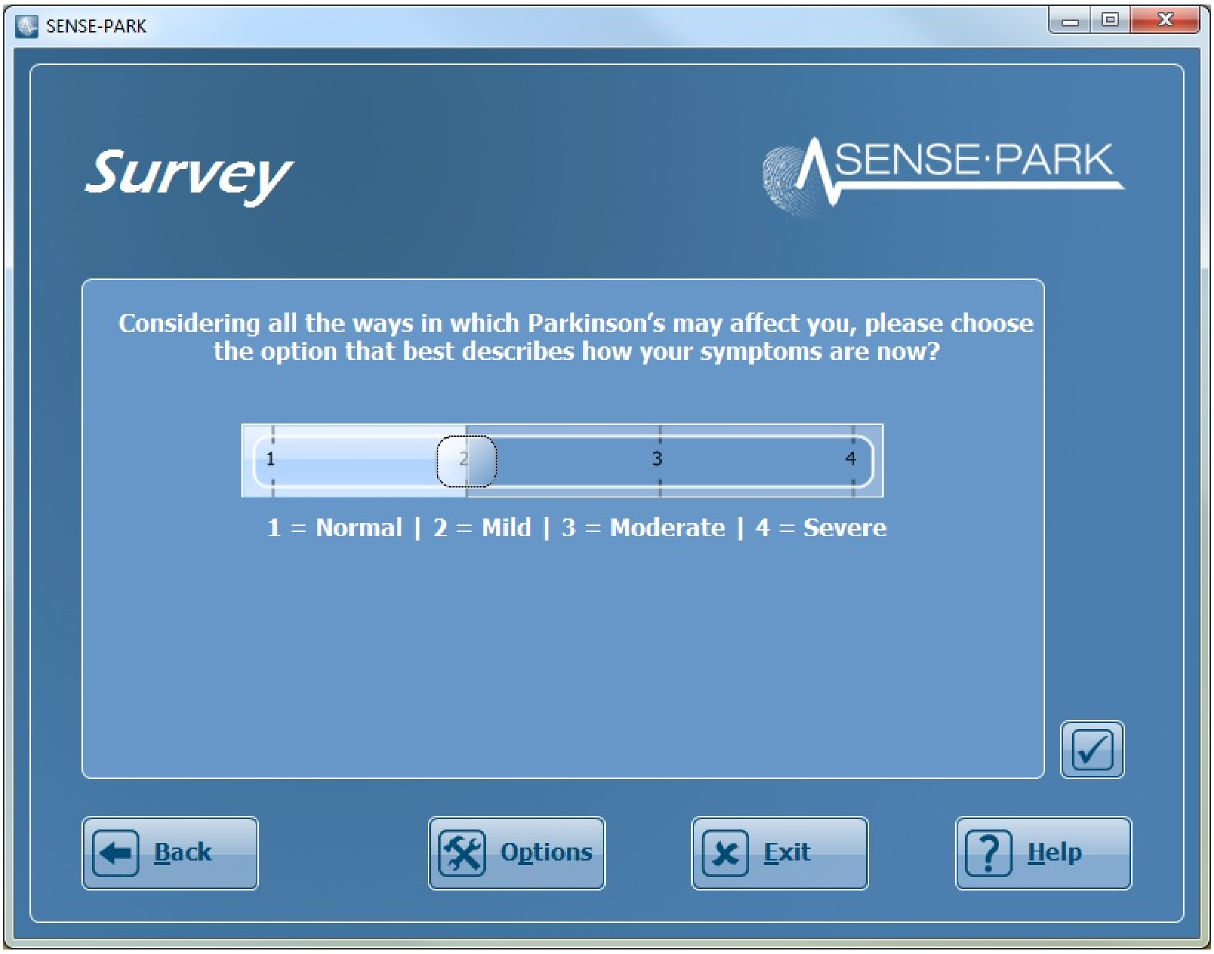

Figure 12: Additional to all objective information, subjective parameters selected by the user will be recorded. The survey question gives an individual estimation about the user conditions compared to the objective parameters in the result presentation.

In the result presentation all those information were brought together. For every recorded domain a single result presentation will be created. Every cognitive test has one evaluation. The information for those graphics was collected from the domain parameter, the medication planner, the survey answers and the activities from the app. Because of the identification of correlated various data types, the user will be able to detect coherences between the different topics.

To manage all those possibilities, it seems feasible to adapt the software to individual terms of interest. In the options section, the user can activate and deactivate domains and edit settings like the use of the Balance Board. In those settings also the management of external account data is integrated. Here the user can define external users and plus their user rights. It will be also possible to search for other registered physicians.

With the realized prototype and integration of the first and further user feedback, we finished the task 6.3. of the work description in WP6.

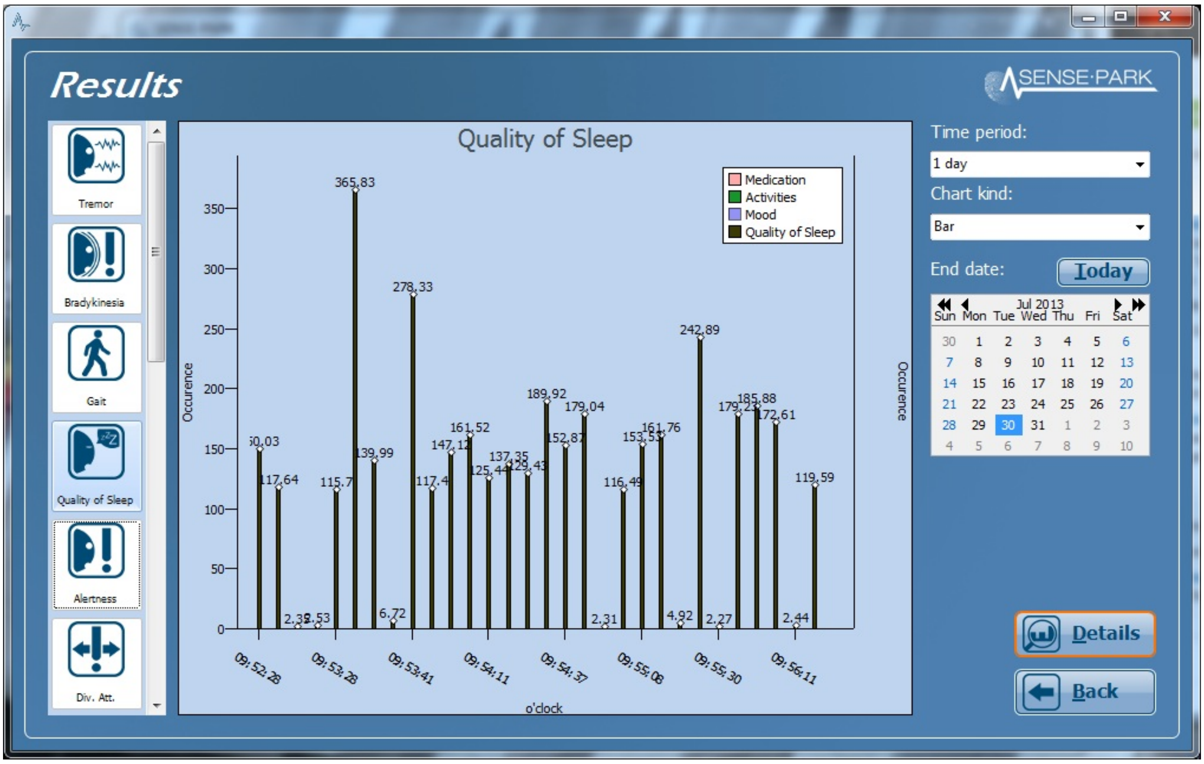

Figure 13: In the result presentation of the PDCAT every single parameter can be displayed with additional information received from the medication states, the recorded activities and the saved individual sense of mood.

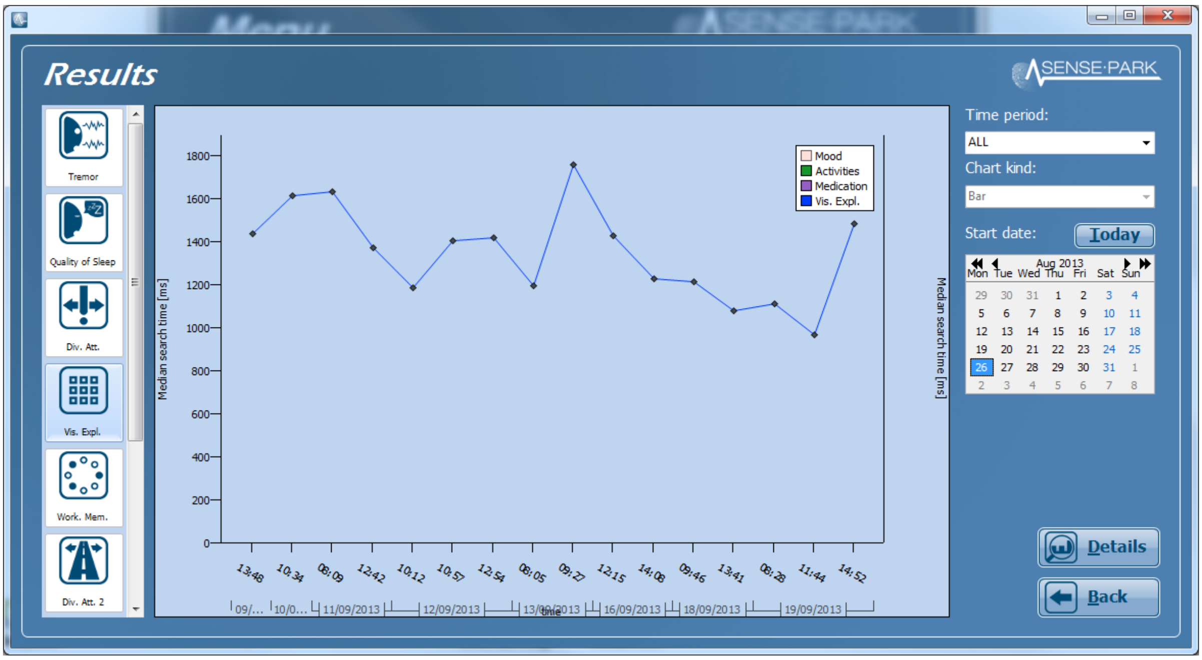

Figure 14: If the time period changes to a value greater than a day, the recorded values will be displayed as a graph over the certain time section.

During the progress of the project the partners have collected first experiences with the software PDCAT and with different kinds of sensors. The project partners concluded that although the RFID-Sensors are in principle able to detect specific events in the PwP's daily routine they will not pursued further because the size of the RFID-Sensors is currently too large and presents, thus, a obstacle for unobtrusive measurement. Also the need of current is too high, so a usual accumulator can give power for only 2 hours.

To be able to register distinct events, nevertheless, Hasomed developed the SENSE-PARK App, a software application for smartphones (PDApp) that allows the registration of distinct events. Also the App provides information about medication states.

Inclusion of Hasomed sensors as a back-up to the HSG-IMIT sensors

The PDApp can communicate with the Hasomed inertial sensors from the product RehaWatch as these sensors have a Bluetooth interface included.

These sensors are CE-certified as medical device. Additionally they are calibrated and are able to collect data for up to 11 hours without any interruption. After this time the accumulator has to be recharged by using a docking station and the data sets can be transferred to the computer with the PDCAT-program.

Thus, the SENSE-PARK system is now able to include two different sensors, first the sensors developed and customized through HSG-IMIT for SENSE-PARK and the older Hasomed sensors. Given the pace of the current sensor development we believe that this provides the SENSE-PARK system with the needed flexibility to adapt to this development.

Figure 15 : Hasomed's Rehawatch sensors

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