SENSE-PARK

Deliverable D5.1.1:
Report on D5.1 Demonstration of sensor system prototypes regarding the levels 'being', 'belonging' and 'becoming'

SEVENTH FRAMEWORK PROGRAMME

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Executive Summary

This deliverable report D5.1.1 presents the prototypes of sensor system which is done inside WP5, Task 5.1, Task 5.4 and Task 5.7 of SENSE-PARK project. D5.1.1 is a report on the hardware development of the wearable sensor units and their docking station for the level ‘being’, on the integration of gaming hardware for the level ‘belonging’ and on the clinically approved and validated sensors for the level ‘becoming’.

History

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1. Introduction

This deliverable reports on task 5.1, Task 5.4 and Task 5.7 of WP5. Presented is the work done as part of the 'Supporting and Empowering Parkinson patients in their home environment using a Novel Sensory information system that monitors daily-life-relevant parameters of Parkinson disease and their' known as SENSE-PARK. It comprises the tasks Task 5.1: *Hardware and firmware development of wearable sensor system*, Task 5.4: *System development of virtual reality-based test and training system* and Task 5.7: *Integration of validated ambulatory and clinical devices of clinically approved and validated sensors*.

The aim of the SENSE-PARK project is to develop an information system for use in the home environment, which provides the patients with tools to monitor patterns in their conditions. The wearable sensor system presents an important tool for measuring and logging human activities in daily life. On the other hand, computer games can be used to measure leisure activities.

The aims of tasks as taken from the DoW (Description of Work) are:

(Wearable sensor system)
Task 5.1 (Hardware and firmware development):

- Development of the RFID reader (processor, antenna, energy management).
- Development of the hardware wrist device (microprocessor, sensors, RFID reader, interface to satellite sensors).
- Development of the docking station (data upload, battery charging)
- Development and implementation of the firmware of wrist device.

(Virtual reality-based test and training system)
Task 5.4 (System development):

- Setup of a virtual reality environment
- Incorporation of available gaming interaction hardware

(Clinically approved and validated sensors)
Task 5.7 (Integration of validated ambulatory and clinical devices):

- Selection of relevant devices and methods
- Interface development
- Data synchronisation

The WP5 was led by HSG-IMIT and was carried out together with partners EKUT and Hasomed, the discussion was carried by telephone, E-Mail or face-to-face meeting. There were also feedbacks related to the system enhancement from other partners in the consortium, these were carried out through all project partners meetings.

2. The System Concept

This section discusses the design process of the sensor system prototypes regarding the levels ‘being’, ‘belonging’ and ‘becoming’. It includes the specifications and descriptions of the system for each level.

Domains of interest

Based on the input from WP2, the project covers six domains of interest which are planned to be addressed within the SENSE-PARK project (see Table 1). The four domains (hand tremor, bradykinesia, gait and sleep) together with the sway domain have symptoms which are categorized under the motor aspects, while the cognition domain is categorized under the non-motor group.

Domain of interest	Description	Monitored by level
Hand Tremor	Unintentional rhythmical hand movement (shakiness)	‘being’
Bradykinesia	Slowness of movements	‘being’
Gait	Difficulty in starting movement, length of stride, freezing which can lead to falling	‘being’
Sleep	Problems during sleep	‘being’
Sway	Difficult maintaining postural instability	‘belonging’
Cognition	It is a non-motor symptom	‘belonging’

Table 1: It shows the six domains of interest to be monitored in SENSE-PARK project. The table shows also the level of monitoring for each domain.

The discussion between the SENSE-PARK partners highlighted that these six domains can be monitored by two levels, namely the ‘being’ level and the ‘becoming’ level. The four domains (hand tremor, bradykinesia, gait and sleep) are to be monitored by the system for level ‘being’. On the other hand, the two other domains (sway and cognition) are to be monitored by the system for level ‘becoming’.

System for level ‘being’

The level ‘being’ addresses the system which monitors movements and motions of a PwP’s during daily activities. One of the important questions related to the system is system modularity. In fact, the six domains of interest have symptoms which effect different segments of the patient’s body. Accordingly several sensors have to be worn on different body parts (see Figure 1 and Table 2).

The operational scenario of these units is started by wearing the units from the patients at the morning of every day. During the day, the units measure continuously the daily activities in which all the data will be buffered on the devices. When the patient goes to sleep at night, the units are placed on the docking station for uploading the data and charging. Here the CAT software system is obligated to acquire the data from the units by sending the corresponding commands.

During the development phase, each sensor unit saves the raw data to its own memory card. That means there is no connection between the different units. For reading simplicity, the following abbreviations for different units: PDInerUnit, PDInerRFIDUnit and PDDockingStation are considered in this report. PDInerUnit denotes the sensor unit where only inertial sensors (accelerometer and gyroscope) are built in, PDInerRFIDUnit is the unit which includes inertial sensors and RFID reader and PDDockingStation is the docking station for uploading the data and charging the units.

Domain of interest	Placement	Type of sensor	Unit abbreviation
Hand Tremor	Hand	Inertial sensors	PDInerUnit
Bradykinesia	Hand	Inertial sensor with RFID	PDInerRFIDUnit
Gait	Ankle or Back	Inertial sensors	PDInerUnit
Sleep	Back	Inertial sensors	PDInerUnit

Table 2: The table displays the distribution of units with respect to the four domains (tremor, bradykinesia, gait and sleep) and body's segments.

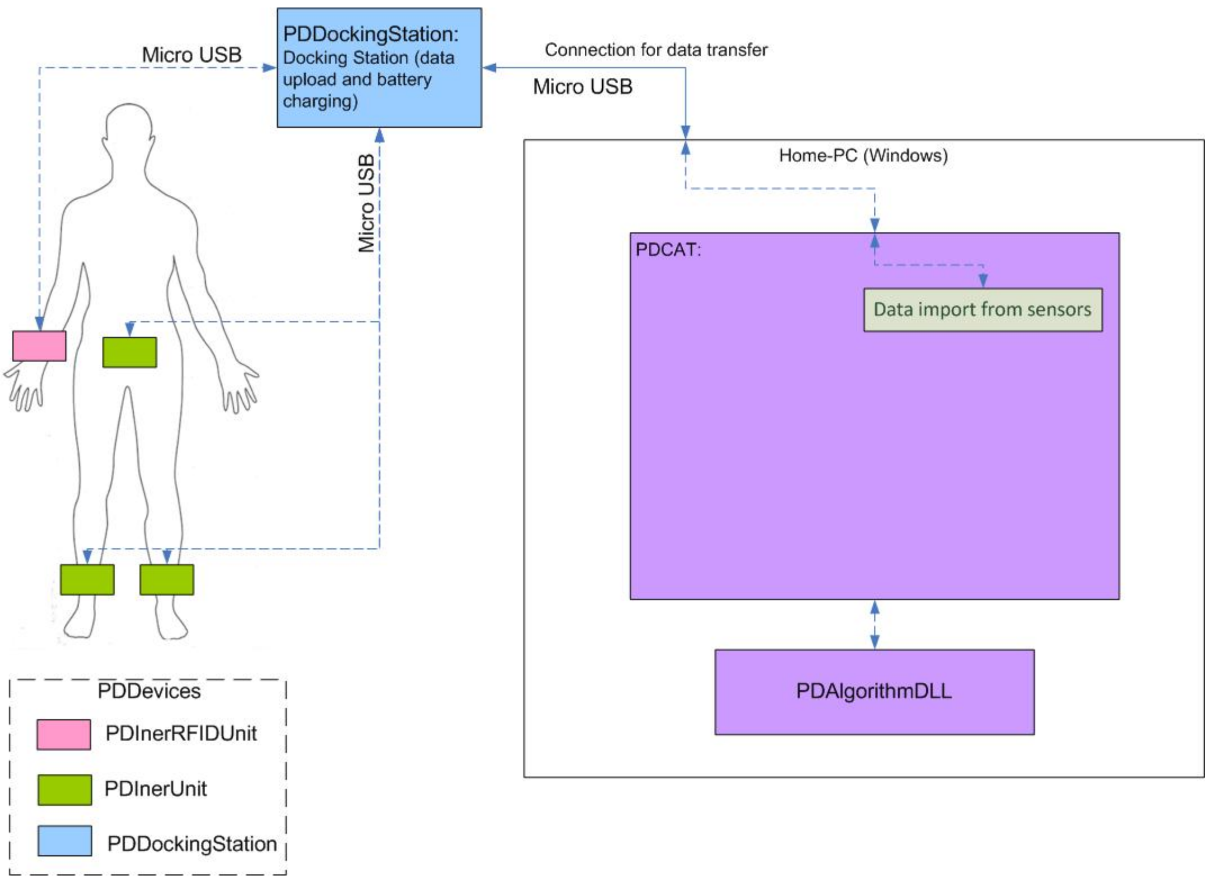

Figure 1: Assignment of sensor units on different segments of the body.

Based on the fact that the four domains (hand tremor, bradykinesia, gait and sleep) have symptoms which are categorised under motor aspects; inertial sensors (accelerometer and gyroscope) are used to measure the corresponding motions. The accelerometer measures the acceleration along the axis to which it is attached, while the gyroscope measures the angular velocity of the rigid body along a single axis. In the used approach, each unit (PDInerUnit and PDInerRFIDUnit) consists of 3-axis accelerometer and 3-axis gyroscope. By measuring two different physical quantities (angular velocity and acceleration) a more reliable analysis of the patient's motion (motion activity and/or symptom) is possible. A magnetometer is added also to the platform but it is treated as an optional sensor element.

System for level 'belonging'

The level 'belonging' addresses the system which collects data of leisure activities. Here the WBB (Nintendo Wii Balance Board) is employed as a standalone system to monitor the sway domain. Figure 2 shows the integration of WBB in the SENSE-PARK project, where a software module was developed which allows accessing the force sensors. The Center of Pressure (CoP) which can be calculated from the force values is also integrated in the interface in order to derive the sway domain related parameters.

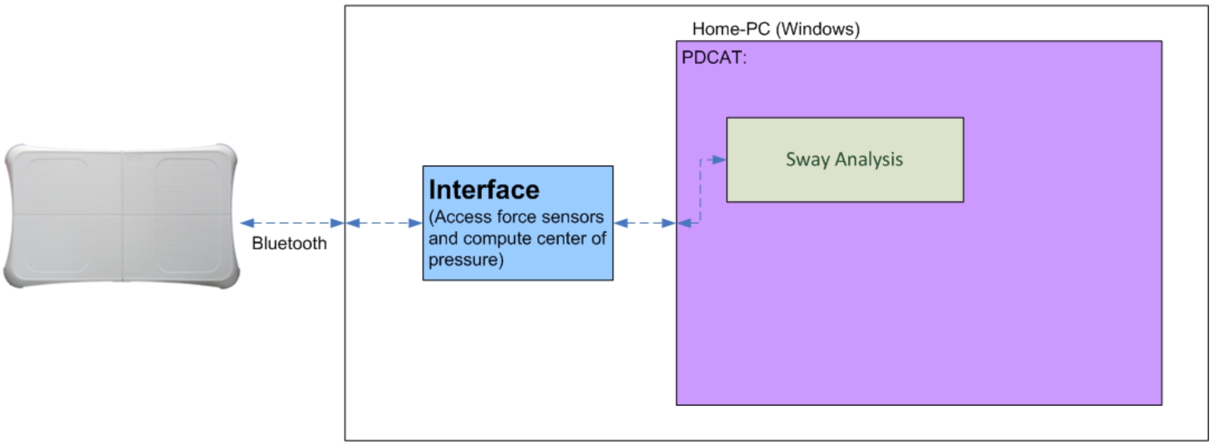

Figure 2: The integration of Wii Balance Board into SENSE-PARK project.

System for level 'becoming'

The level 'becoming' incorporates clinically approved and validated sensors. For the domains related to motor aspects, the discussion between EKUT and HSG-IMIT decided to use wearable inertial monitors (www.apdm.com) from APDM in the first stage in order to validate some parameters of the planned domains of interest.

Detailed Functional Description

Here the detailed explanation of the sensor units is presented. The hardware design concept of the system for level 'being' will be described briefly.

PDInerUnit

The PDInerUnit unit includes a 3-axis low power accelerometer (range: ±4g, resolution: ±0.002 g/digit) and 3-axis gyroscope (range: ±500 deg/s, resolution: ±0.017 deg/s/digit). A microcontroller reads out the accelerometer and gyroscope simultaneously with 100Hz and stores the measurement on the micro SD memory card. Figure 3 shows the PDInerUnit unit which is fixed on the arm by using an arm band. The same unit can be placed on back and foot with a suitable band. The unit is equipped with a battery to enable operation for around 8-10 hours in continuous measuring mode.

Figure 3: Top views of the wrist hand sensor unit (PDInerUnit). The left view shows the internal parts of the unit, namely: battery and PCB (printed circuit board). The right view shows the integrated unit which is supposed to be worn around the hand wrist.

Figure 4 shows the internal schematic diagram of the PDInerUnit unit. The communication interface between microcontroller and other components is SPI (Serial Peripheral Interface) in order to ensure fast enough data transfer between them.

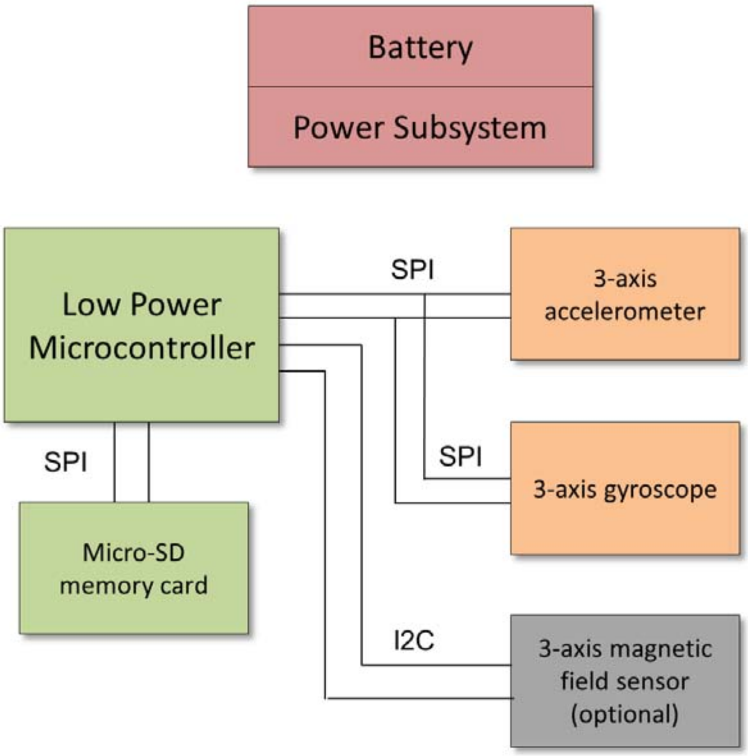

Figure 4: Schematic diagram of the internal structure of the PDInerUnit unit.

PDInerRFIDUnit

This unit is similar to the PDInerUnit, except for the integrated RFID reader which is used to associate the raw data with the corresponding activities, for example the marking of inertial data when the patient performs teeth brushing. Figure 5 shows the designed unit along with the RFID module. The integrated RFID module has a frequency range of 865-868 MHz. This band allows reading the RFID tag within 1 meter distance.

Figure 5: Top view of the PDInerRFIDUnit. It shows two PCB board, left part is inertial sensor unit and the right part is RFID reader with antenna.

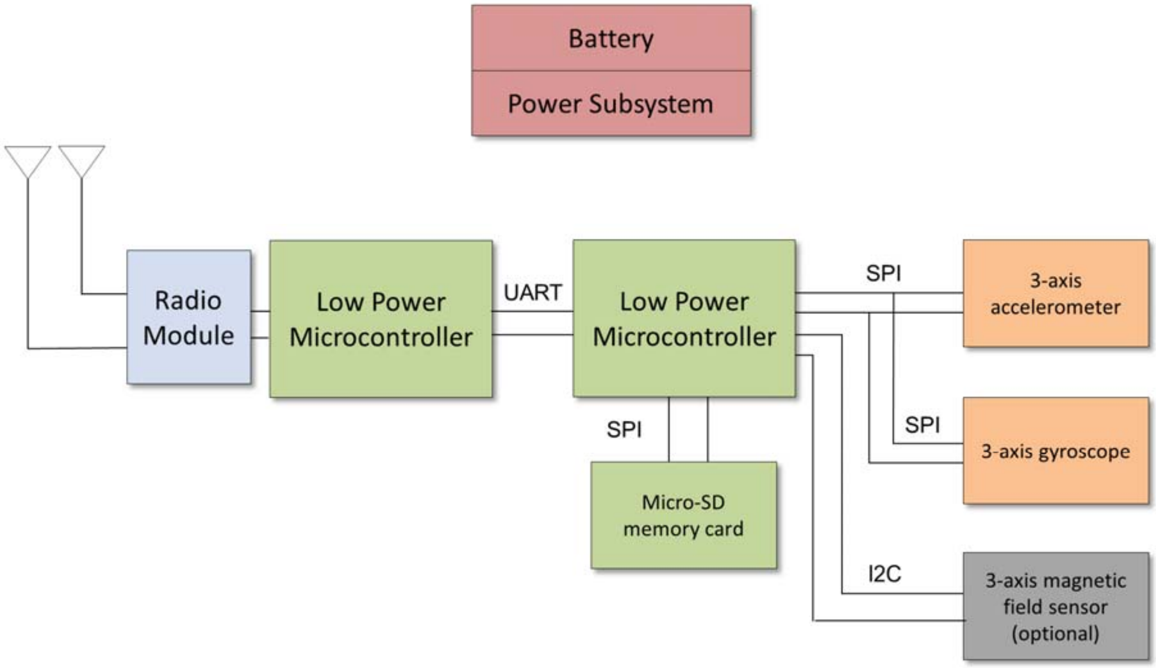

Figure 6: Schematic diagram of the internal structure for the PDInerRFIDUnit unit.

PDDockingStation

The docking station onto which the sensor units have to be placed every day has two purposes:

1. Upload the raw sensor data stored on the micro-SD card to the CAT software system on PC.
2. Recharging the units.

Figure 7: Top view of the PDDockingStation.