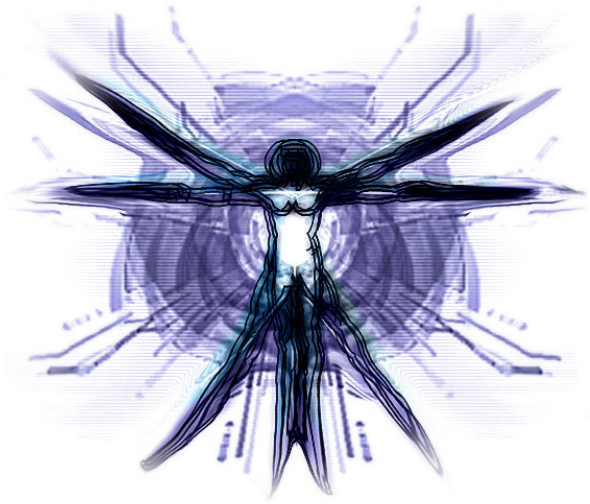

IS-ACTIVE

Inertial Sensing System for Advanced Chronic Condition Monitoring and Risk Prevention

D5.2 System integration in free-living environments

Document ID:	IS-ACTIVE - D5.2
Document title:	System integration in free-living environments
Document type:	Prototype
Contributors:	NOR, RRD, NST, ELS, UT

1 Introduction

The objective of IS-ACTIVE is to devise a person-centric healthcare solution for elderly with chronic conditions – especially people with COPD – based on the recent advances in wireless inertial sensing systems. The project emphasizes the role of the home as care environment, by providing real-time support to patients in order to monitor, self-manage and improve their physical condition according to their specific situation.

This document briefly describes the integration of the activity sensor node (ProMove-3D) with the feedback devices (Smartphone and Tablet), as well as with other sensors and technologies used in the IS-ACTIVE project (pulse oximeter sensors, Web portals, 3G network etc).

The IS-ACTIVE integrated system is available as prototype and is tested in field trials carried out in The Netherlands, Romania and Norway.

2 The Smartphone feedback device

The goal of the Smartphone feedback device is twofold: a) to give COPD patients insight into their daily levels of physical activity, and b) to motivate patients to increase their physical activity. In short, the smartphone application aims to achieve these goals by providing constant visual feedback on the patient's current activity level by displaying a real-time graph of activity, and to provide feedback messages to the patient if they deviate too much from a predetermined reference activity pattern. In the Dutch trials (see Section 2.2) the Smartphone is used in combination with only the ProMove-3D activity sensor (Section 2.1.1), while in the Romanian trials (Section 2.3) also a Nonin oxygen saturation sensor is employed (Section 2.1.2)

Figure 1 shows an example screenshot of the Smartphone as used in the IS-ACTIVE project. The figure shows an HTC Desire running Android version 2.2, the phone used in the Romanian trials. In the Dutch trials, the follow-up device (HTC Desire S) is used. The figure shows the home screen of the application: a graph, displaying the patient's current activity pattern (in blue) and the predefined target (or reference line) in green. The green 'Status' box shows the deviation of the patient from the reference line in the last 5 minutes. In the Romanian trials, this box is used to display the current oxygen saturation value of the patient if he/she is wearing the sensor.

Figure 1: The Smartphone (HTC Desire) showing the graph screen, with reference line (green) and current activity (blue). The status icon shows the activity trend from the past 5 minutes.

2.1 Sensor integration

The IS-ACTIVE system has integration with two different sensors: the ProMove-3D activity sensor node (Section 2.1.1) and the Nonin oxygen saturation sensor (Section 2.1.2).

2.1.1 ProMove-3D Activity Sensor Node

The activity input for the Smartphone application comes from an Inertia Technology ProMove-3D inertial sensor node. Figure 2 shows a rendering of the prototype ProMove-3D sensor node, which the patient has to wear on his/her hip. The sensor measures movement in the three axis of movement by sampling an internal 3D accelerometer. The samples are summed up over the three axis for 10 second intervals and stored as *activity counts*.

Each minute 6 of these 10-second activity count values are send over Bluetooth to the Smartphone.

Figure 2: The ProMove 3D wireless inertial sensor, pictured here as a 3D render with an attached belt clip for mounting on the patient's hip.

Each Smartphone is linked to one ProMove-3D node and the wireless connection between sensor and Smartphone is handled automatically.

When the patient switches on his Smartphone, the Activity Monitor application automatically launches, and the patient only has to press the 'Start' button to get going. If the sensor is within range and in its clip-holder (e.g. switched on), a wireless connection will automatically be established, and the sensor will start sending activity count values every minutes.

2.1.2 Nonin Oxygen Saturation Sensor

In order to measure the patient's current oxygen saturation levels during exercises or moderate/high intensity activities, the IS-ACTIVE system has integration with a Nonin WristOx2 3150 Pulse Oximeter saturation sensor (see Figure 3). This sensor consists of an infrared clip that the patient wears on his finger to measure the heart rate and oxygen saturation level, connected to a wristband that shows the current readings and contains a Bluetooth chip for wireless data transmission.

Figure 3: The WristOx2 3150 Pulse Oximeter from Nonin Medical Inc. The wristband contains a Bluetooth chip that connects to the Smartphone to transfer the measured oxygen saturation values.

The WristOx2 communicates with the Smartphone over Bluetooth to send its measured heart rate and oxygen saturation values. Both measures are then stored on the Smartphone, and the oxygen saturation values are displayed on the screen for the patient, as explained earlier in this section.

2.2 System integration in free-living environments (Netherlands)

The IS-ACTIVE patients in the Netherlands each receive a measurement kit containing (Figure 4):

- A ProMove-3D activity sensor.
- An HTC Desire S, Smartphone with the ActivitySensing software.
- A belt pouch for the Smartphone.
- A clip holder for the sensor (with belt and band clips).
- Chargers for the Smartphone and the sensor.

Figure 4: The contents of the measurement kit given to the IS-ACTIVE patients.

In their first week of measuring, while gathering the patient's baseline activity, the patient will not be able to see their activity levels on the Smartphone; instead they only see the messages "measurement in progress". This is to ensure that we are not influencing the patient's activity behavior during the baseline measurements.

After a week of measurement, the physiotherapist will look at the measured data, which is automatically synchronized to the server at Roessingh Research and Development. The

physiotherapist can log into a web portal to check up on all of his/her patients, and can now for each patient determine a suitable reference activity line based on the baseline values (see Figure 5).

Figure 5: Screenshot of the Dutch IS-Active web portal showing the interface for setting the reference line for a patient. The physiotherapist can set an activity target value for each hour of the day (between 08:00 and 22:00).

Once the physiotherapist has set a target (reference) line for the patient, this setting will be transmitted to the patient's Smartphone. The next time the patient uses the device, he will be able to see his activity values (see Figure 1) and receive regular feedback messages to motivate him to keep to his reference activity values. Also, when the intervention phase has started, the patient can log into the same web portal, and see his own daily (Figure 6), weekly, monthly (Figure 7), or yearly activity patterns online.

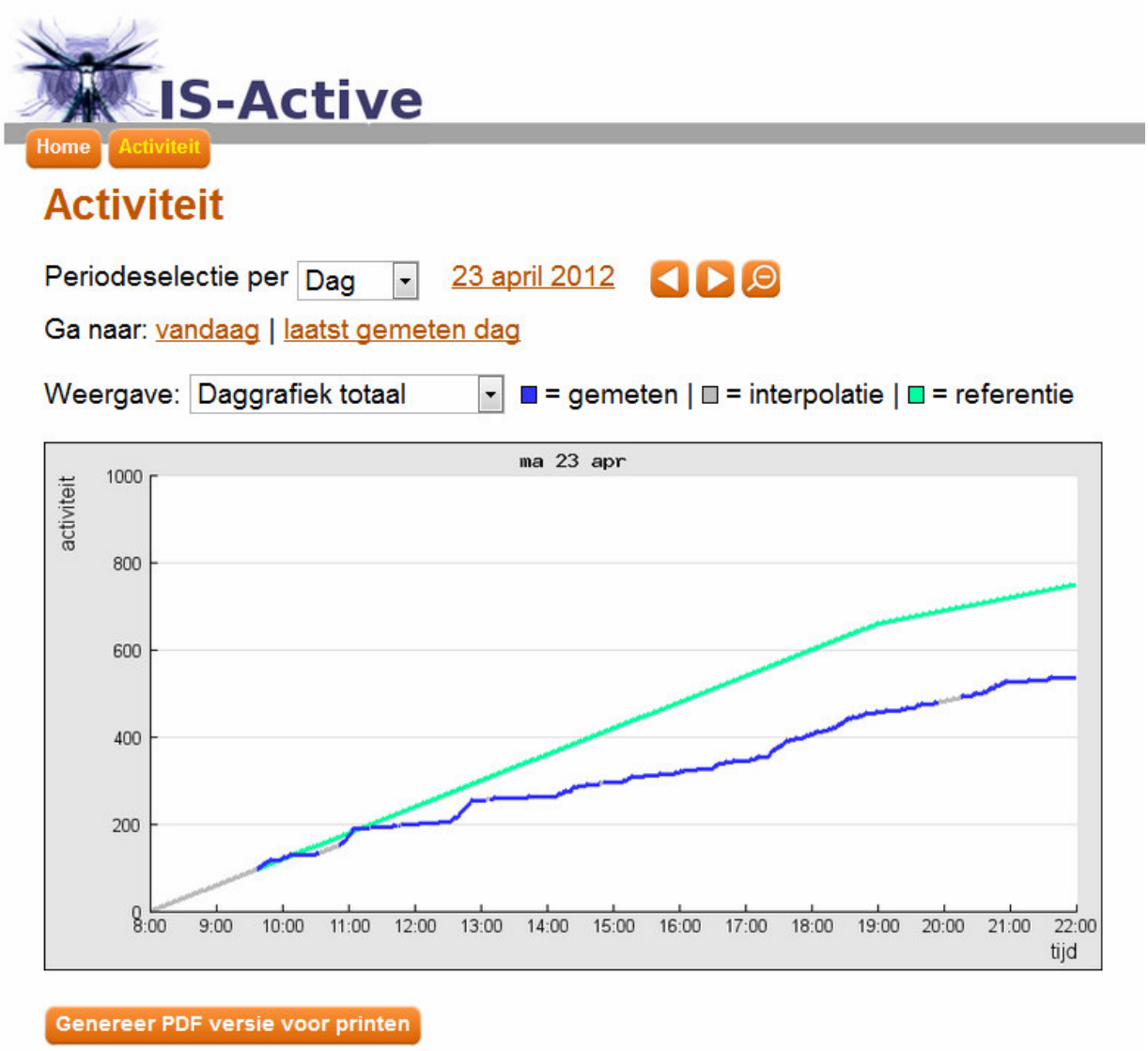

Figure 6: Patient view of his/her own daily activity line on the web portal.

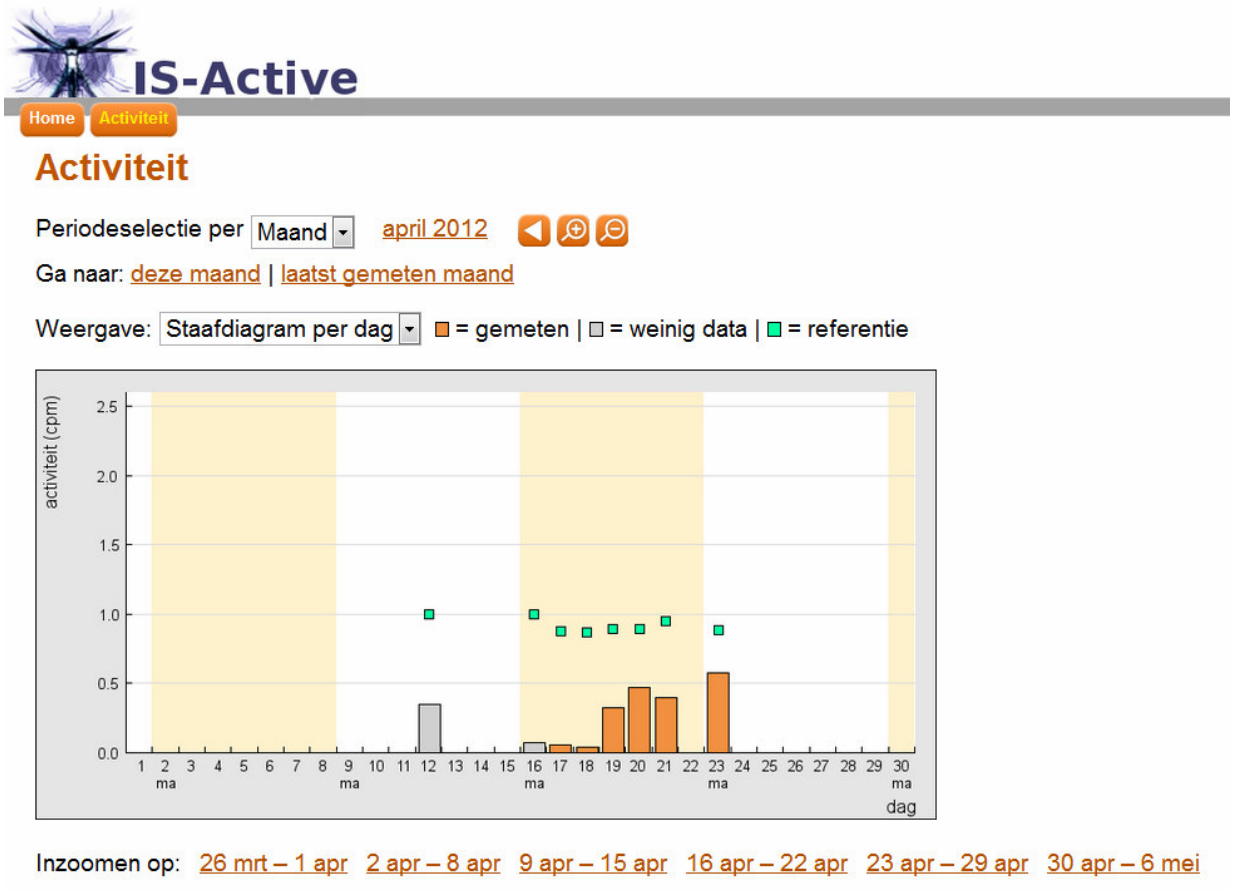

Figure 7: Monthly activity overview for a patient on the IS-ACTIVE portal.

2.3 System integration in free-living environments (Romania)

The IS-ACTIVE patients in Romania each receive a kit containing:

- A ProMove-3D activity sensor.
- A WristOx2 3150 Pulse Oximeter from Nonin Medical Inc.
- An HTC Desire, Smartphone with the ActivitySensing software.
- A belt pouch for the Smartphone.
- A clip holder for the sensor (with belt and band clips).
- Chargers for the Smartphone and the ProMove-3D activity sensor And alkaline AAA batteries for the WristOx2 3150 Pulse Oximeter.
- A textual description with all the steps needed for properly using the system and the specialist's contact information.

The user will have the system calibrated by the specialist in Physical and Rehabilitation Medicine, after 6Minute Walking Test and general and respiratory evaluation. The user will start the sensors (the ProMove-3D activity sensor the Pulse Oximeter) on the Smartphone, at 8 a.m. in the morning and will wear the components all day long (to 10 p.m.). During his daily activities and the physical exercises prescribed by the specialist in Physical and Rehabilitation Medicine, the user will check his/her physiological parameters (oxygen saturation and heart rate) and will adjust his/her labor in order to maintain in safe margins his energy expenditure,

while trying to respond to the suggestions on the Smartphone. The user will answer the questions on the Smartphone whenever needed. Periodically, the user will come to the specialist for evaluation of his/her condition, where the clinician will download and analyze the data recorded from the sensors and the answers of the patient. The next physical program of the user will be decided according to these data and the new clinical evaluation.

3 The Tablet feedback device

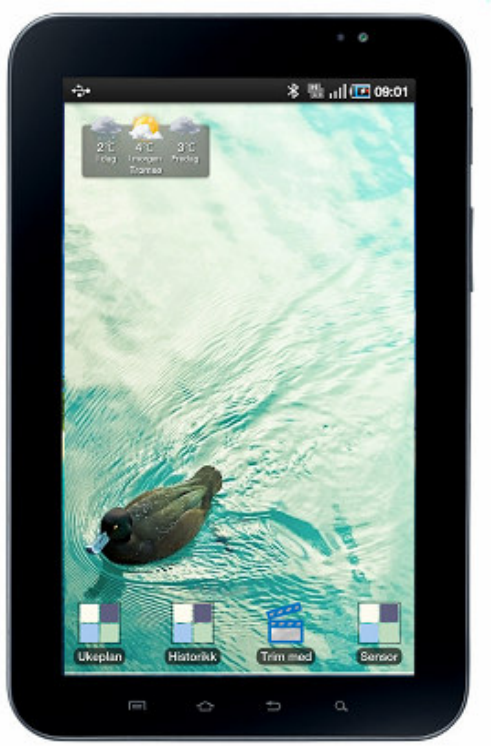

Figure 8 The Tablet device front page

The aim of the Tablet feedback device is to provide functions to motivate and support people with COPD in taking part in physical activity and exercising. People will follow a home-based program for a specific amount of weeks, where they will be divided in groups and take part in scheduled and unscheduled outdoor walking (common virtual walks) and exercising, and do exercising by a follow-along video.

The Tablet is easy movable and can be mounted on the wall or placed on a table in the living room, the kitchen, the hallway, or any place where it is easily visible. Using a docking station the tablet can easily be attached to a TV via HDMI and show the exercise video on the TV.

The prototype is running on a tablet computer that is dedicated for the needed IS-ACTIVE functionality, while other standard Android functionality is disabled or removed. The tablet we use in the prototype is a 7” Samsung Galaxy Tab running Android (Figure 8). The prototype also interacts with the Promove-3D sensor node in order to get the users activity data.

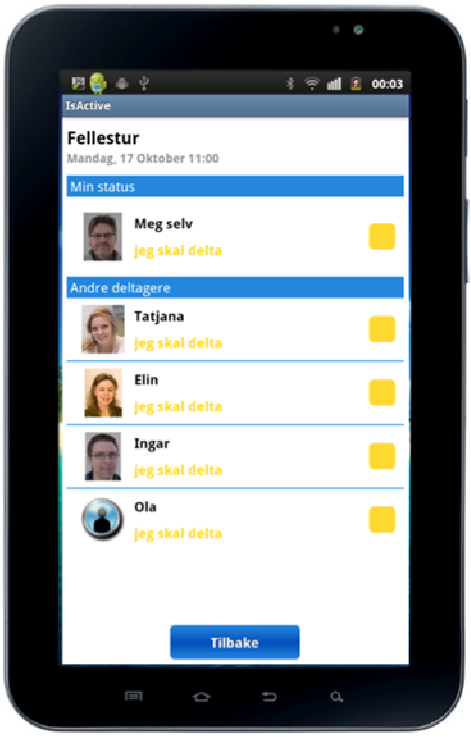

Figure 9 Common virtual walks

3.1 Sensor integration

The Tablet device is integrated with the ProMove-3D inertial sensor node, which monitors the patient's activity when it is worn on his/her hip. The wireless connection between the sensor node and the Tablet device is handled automatically through Bluetooth.

Similar to the Smartphone application, the sensor node measures movement in all the three axes by sampling an internal 3D-accelerometer. The samples are summed up over the three axes for 10-second intervals and stored as *activity counts*. However, the sensor is configured slightly different for the Tablet compared with the Smartphone application. The activity counts are continuously stored to the on-board local memory of the sensor node. The Tablet device will retrieve the the stored activity values from the sensor over Bluetooth when the user explicitly chooses to incorporate them in the Tablet activity diary.

3.2 System integration in free-living environments (Norway)

The IS-ACTIVE patients in Norway each receive a kit containing:

- A ProMove-3D activity sensor.
- A 7" Samsung Galaxy Tablet with the Tablet software.
- A desktop docking station for the Tablet.
- A clip holder for the sensor (with belt and band clips).
- Chargers for the Smartphone and the sensor.
- A user manual for the tablet and sensor.

Each Tablet device is equipped with a SIM-card enabling Internet access over a 3G mobile network. This connection is used for

1) Keeping the Tablet weather forecast widget updated, and for

2) Communicating with a Coordinating server.

The role of the Coordinating server is to keep the Tablet devices up-to-date on the status of each user regarding the common virtual walks and exercises. This is implemented based on a RESTful client-server model, and no personal identifiable data is stored or transmitted.

4 Conclusion

The IS-ACTIVE technologies have been proven to be easy to integrate and localise for the different user environments and setups, and are currently being evaluated with user in trials in three countries.