EUROPEAN COMMISSION

Community Research

PROJECT PERIODIC REPORT

Part 2 – Publishable Summary

Project acronym:	**CuPiD**
Project full title:	**Closed-loop system for personalized and at-home rehabilitation of people with Parkinson's Disease**
Grant agreement no:	**ICT–288516**
Project start date:	**1st October 2011**
Duration:	**36 months**
Project web site:	**http://www.cupid-project.eu/**

Date of latest version of Annex I against which the assessment will be made:	**2/08/2011**
Periodic report:	1st □ **2nd X** 3rd □ 4th □
Period covered:	**From 1/10/2012 to 30/09/2013**
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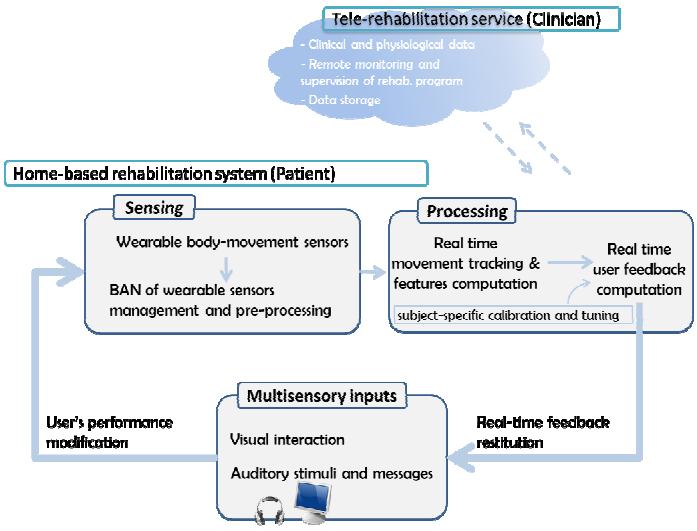
1 Publishable summary

CuPiD, i.e.: **Closed-loop system for personalised and at-home rehabilitation of people with Parkinson's Disease**, is EU-funded FP7 ICT Collaborative project started in October 2011 and that will finish at the end of 2014. It is part of the *eHealth* research and applications domain. Updated details on the project are available at the CuPiD webpage www.cupid-project.eu. The consortium includes 8 partners covering a wide spectrum of competences and interests, from industries, to academic, scientific and clinical institutions: University of Bologna (I), KU Leuven (BE), Tel-Aviv Sourasky Medical Center (IL), ETH Zurich (CH), Oxford Computer Consultants (UK), ST Microelectronics (I), EXEL (I), Fundació Illes Balears Innovació Tecnològia (ES). The project is coordinated by the University of Bologna

1.1 Project Summary

People with Parkinson's disease (PD) suffer from motor and cognitive impairments that severely impact mobility, may increase fall risk and deteriorate multiple key aspects of functional independence. Until recently, treatment goals focused almost exclusively on symptom relief but exciting recent work by the scientific community, including also CuPiD partners, has demonstrated that motor learning and rehabilitation principles can be effective even in the case of PD. It is crucial to make these rehab-like therapies accessible to patients in their **home-setting since they need continuous training**, as PD is a chronic neurodegenerative disease. In addition, optimal rehabilitation of a neurodegenerative as disease as PD, requires personalised training paradigms that patients can integrate into their everyday routine. Ongoing, long-term treatment in a clinical setting is not feasible, cost effective or something that patients are likely to comply with year after year. CuPiD is designed to meet this challenge. **The project partners are developing an ICT-enabled solution for motor learning in patients with PD in their home setting, tailoring the solution to target mobility, cognitive function and debilitating PD symptoms such as freezing of gait and gait impairments**. Key components of the CuPiD solution include **a home-based rehabilitation systems** (based on unobtrusive wearable sensors, on-board intelligence for real-time feedback to the user to correct the movements, exer-gaming and modular, multi-modal restitution interfaces) and a telemedicine infrastructure (tele-rehabilitation service) for remote monitoring and supervision of the rehabilitation program by a clinician.



General architecture of the CuPiD systems

Overall, CuPiD's objectives are summarized as follows:

- Produce clinical guidelines for developing tailored rehabilitation programs using technology;
- Create a home-based rehabilitation system (wearable sensors and local processing);
- Build a telemedicine infrastructure for remote supervision of the rehabilitation.

Keywords: Parkinson's Disease, Motor Learning, Neurological Diseases, Personalised Rehabilitation Exercises, Wearable/Portable systems for Health Monitoring Continuity of Care, Homecare and Telecare Services, Personal Health Systems, Clinical Guidelines

Target users : Patients, Health professionals, Caregivers: patients suffering from Parkinson's disease and healthcare professionals taking care of them.

1.2 Activities and main results (years 1-2)

The CuPiD consortium is involved in the design, development and test in the field of the systems, based on personal health system technology, for at home rehabilitation and training of major motor impairments caused by Parkinson's disease. The guiding principles for design and development are:

- sensory augmentation and substitution (i.e. the use of devices that assist a functional human sense and the use of one human sense to receive information normally received by another sense, respectively);
- unobtrusive and easy to use systems
- integration of motor and cognitive strategies to support motor learning or re-learning;
- delivering services in the patient's home environment.

1.2.1 Application scenarios

Three main scenarios of application were defined and developed:

1. **Gait: real time audio-feedback for gait rehabilitation (ABF)**

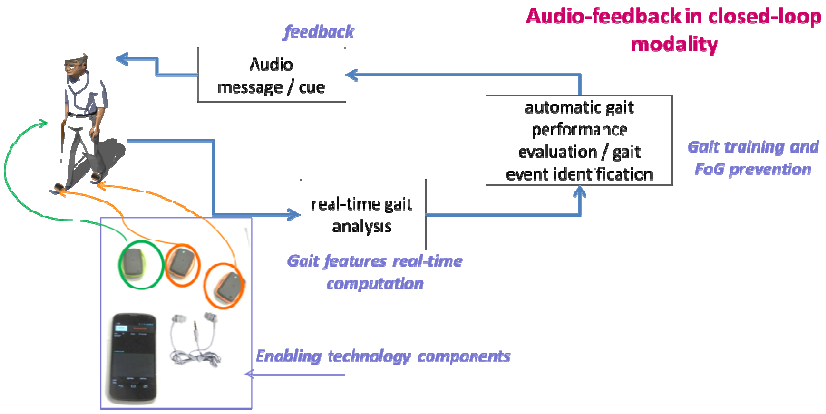
An example of an **audio feedback exercise for gait** rehabilitation would be walking. A person with Parkinson's disease would place inertial sensors on their shoes and then wear earphones attached to a smartphone. They walk for a short period to calibrate the system to their gait. They are then able to walk freely. If their gait falls outside of parameters configured for their exercise they receive audio feedback to prompt improvements.

2. **Gait: rehabilitation and detection of freezing of gait (FoG) episodes.**

FoG is a very disabling symptoms that may occur in some patients and may cause great problem with movement and even frequent falls.

In this case the person with Parkinson's disease would wear the same sensors on their legs. As with the previous example the user wears earphones attached to a smartphone. CuPiD software on the phone analyses accelerometry from the sensors and detects, or preferably predicts, an episode of "freezing" in which gait stops. Audio cueing is then provided which helps the user overcome freezing and walk normally.

The overall principles and architecture of the aforementioned **gait-rehab modules** (1 and 2) are summarized in the figure below



Principles and architecture of the ABF and FoG modules for gait training and rehab (year 2)

3. Exer-gaming training to improve reaching and transitional functions

A sample of **Exer-Gaming** is given by the task of reaching from a seated position to "touch" virtual balloons. The user views a human figure, an avatar, on the CuPiD Home system screen. The user wears CuPiD sensors on their arms and this enables the avatar to mirror their movements. By performing the correct movements the user can cause the avatar to reach, touch and burst balloons in the game.

Preliminary testing in all the three scenarios**,** for user acceptance was already done on 10 patients with PD, enhancing, overall, a very good acceptance and interest by patients. They also were able to give very good suggestions on still present limitations of the system that will be overcome in the next period

1.2.2 ICT-based solutions

CuPiD consortium is using customized and proprietary technology, being so able to supervise and to have specific control of the different elements, with the aim of meeting patient's needs and clinical guidelines. However the technology is intended to be easily integrated with existing technology using, for example, standard communication protocols or data sharing methods.

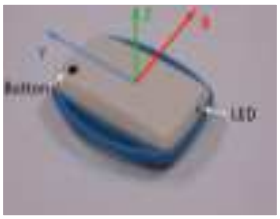
Technology choices were made on the basis of

1) Functionality: selecting technologies which supported functional user requirements. For example, the home system for people with Parkinson's must support a touch screen; the mobile systems must run on a smart phone.
2) Commercial viability: since CuPiD supports the large scale delivery of services to patient homes, the technologies used for the home systems should be low cost.
3) Commercial acceptability: since CuPiD supports clinicians to supervise patients remotely working in a hospital setting, the technology chosen for the hospital system must be familiar to hospital IT departments.
4) Flexibility: use of standards and open source software keeps open the possibilities of re-use of the technology in different contexts and minimises the perception that users are being locked into a system.

For gait rehabilitation modules the requirements are portability and ease of use. For example, a user should be able to put a sensor on their shoe, a smartphone in their pocket and get support for walking. Technology choices here are restricted. CuPiD has developed its own sensors (see below) and connected these to Android smartphones using Bluetooth standard protocols. Android was chosen since it meets the functional requirements, is low cost and widely acceptable. For Exer-Gaming, the exercises require an

Internet connection to a games server and a thick client at the patient home. The client runs on Linux (Kubuntu), which also allows deployment without licence fees. For CuPiD we are using standard webservices to achieve single sign-on and information sharing between the games server and the CuPiD clinical database.

As part of the project, custom inertial measurement sensors have been developed by EXEL using microchips provided by STMicroelectronics. The resulting sensors give performance and flexibility at a lower cost than their competitors.



EXLs1 (2012)

EXLs3 (2013) including also custom shoe-attachments

Regarding telemedicine, The CuPiD Home System provides a touch screen UI (whose language can be changed through configuration), authentication, user activity logging, error reporting and remote support. Transparent and reliable data exchange is achieved through a store & forward network. The CuPiD Clinical System is a secure database and browser-based application. fFor the integration, standard technologies have been used throughout including Bluetooth, SSL, and WebDav. The telemedicine infrastructure is released as open source to allow any project needing to deliver home-based patient services from a clinic (without live-patient connection) to benefit.

1.3 A look into the future: CuPiD 3rd year and expected outcomes

The overall outcome will be the establishment of feasibility and efficacy of a closed-loop based rehabilitation protocol to be performed at home by subjects with Parkinson's disease. CuPiD will develop innovative rehabilitation based on new technology and the patient's needs based on iteration during evaluation including patient with PD. **Expected outcomes will include the following:**

- Knowledge advancement about influence of training on PD patients. Provide evidence of efficacy of therapy by means of motor learning processes;
- Provision of an ICT-based tool to administer therapy in the home environment;
- Contribution to the use of standardisation in e-Health.
- Contribution to eHealth with innovative system and sub-systems (algorithms, smartphone apps, sensors, telemedicine..), preliminary validated and close to enter the market and the clinical practice.

One of the peculiarities of the project is the inclusion of an extended validation procedure that will be performed in the two clinical center involved in the study (KU Leuven, Tel Aviv Sourasky Medical Center). The **extended validation aims to include 40 patients**, it will be the core activity during the 3rd year of the project. The trials are designed to include **6 weeks** of continuous patient-specific training and a follow-up evaluation. The study aims at both validating the prototypes in terms of functionality, usability, effectiveness and reliability, but also at showing evidences of rehabilitative efficacy, toward a possible **clinical** validation, foreseen in a potential development of the CuPiD project.