3 Publishable summary

3.1 MINDWALKER in a nutshell

A lack of mobility often leads to limited participation in social life. The purpose of MINDWALKER (https://mindwalker-project.eu/) is to conceive a system empowering lower limbs disabled people with walking abilities that let them perform their usual daily activities in the most autonomous and natural manner.

The project addresses 3 main different fields of expertise:

- BNCI technologies
- Virtual Reality
- Exoskeleton Mechatronics and Control

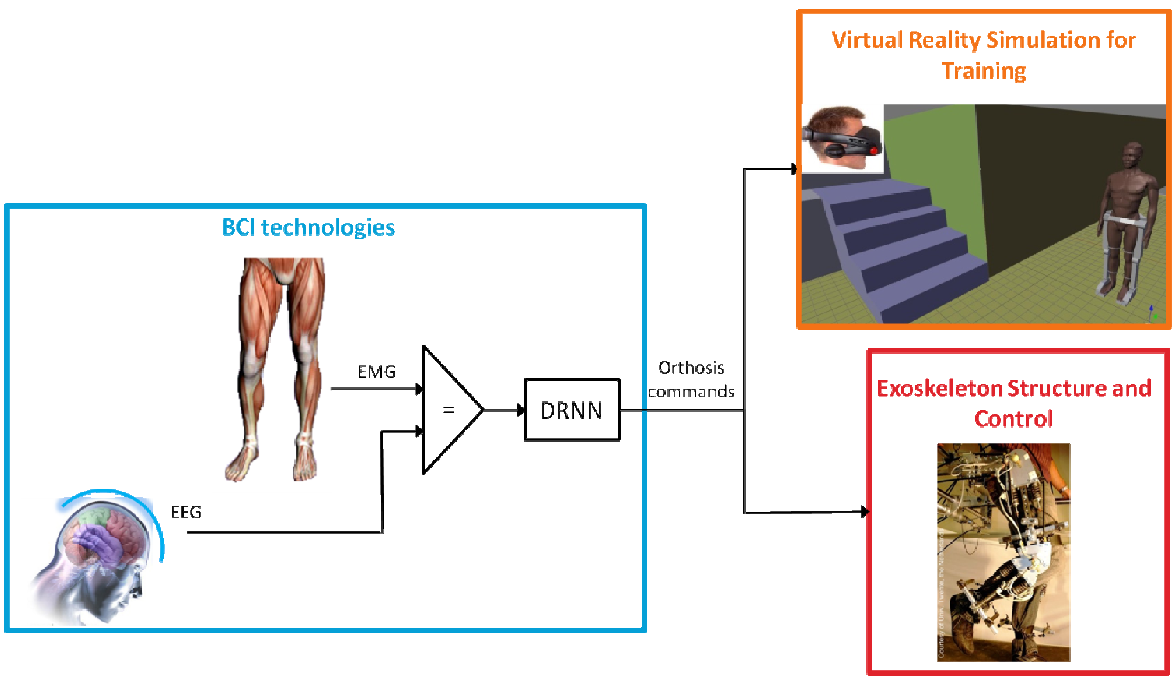

Figure 1: MINDWALKER 3 main areas

The project top level objective is to combine these expertises to develop an integrated MINDWALKER system. In addition the system shall undergo a clinical evaluation process.

3.1.1 Approach and expected results

- New smart dry EEG bio-sensors will be applied to enable lightweight wearable EEG caps for everyday use. (WP4)
- Novel approaches to non-invasive BNCI will be experimented in order to control a purpose-designed lower limbs orthosis enabling different types of gaits. Complementary research on

EMG processing will strengthen the approach. The main BCI approach relies on Dynamic Recurrent Neural Network (DRNN) technology. (WP5)

- A Virtual Reality (VR) training environment will assist the patients in generating the correct brain control signals and in properly using the orthosis. The VR training environment will comprise both a set of components for the progressive patient training in a safe and controlled medical environment, and a lightweight portable set using immersive VR solutions for self-training at home. (WP6)
- Novel exoskeleton orthosis will be designed to support the weight of an adult, to address the dynamic stability of a body-exoskeleton combined system, and to enable different walking modalities. (WP2, WP3)

3.1.2 Evaluation

The developed technologies will be assessed and validated with the support of a clinical evaluation procedure (WP8). This will allow measuring the strengths and weaknesses of the chosen approach and to identify improvements required to build a future commercial system. In addition the resulting system is expected to be progressively tested in everyday life environments and situations, ranging from simple activities at home to ultimately shopping and interacting with people in the street.

3.2 Activities and work done since the beginning of the project

The 6 first months (M1 to M6) of the project essentially consisted in setting up a solid collaboration ground and performing initial activities related to user requirements elicitation, system architecture definition and system requirements specification.

One of the essential activities during the six first months of the project has been the early system specification phase (WP1), dealing with (i) the collection of user & system requirements, (ii) the preliminary technical specification of the MINDWALKER system, and (iii) the preliminary specification of the interfaces between major subsystems. These activities resulted in a set of deliverables supporting the overall system specification at an early stage. Iteration has then been carried out in the next 6 months, in order to further refine and detail the overall specification.

Besides this essential specification phase, review of the state of the art has been performed in a number of MINDWALKER major scientific areas, resulting in state of the art surveys deliverables (WP2, WP4, WP5, WP6).

Additionally, as a central concern during for the MINDWALKER project, WP5 partners investigated and defined the baseline approaches and experimental protocols required for the BNCI side (WP5), in order to validate the “ideation” concept (i.e. the ability to link the EEG signals obtained from a subject imagining walking, to the legs kinematics). Work has been done to identify the promising setups for a proper parameterization of the DRNN processing chain, that may prove to be reliable enough for generating a walking gait signal.

Ethical considerations have been tackled WP8, with activities aiming at setting up and maintaining a release of an “ethical package”, that shall support the preparation of an ethical review after 2 years, that will then allow the clinical evaluation with Spinal Cords Injured patients.

Dissemination material, including the MINDWALKER website and a MINDWALKER leaflet, have been prepared in the frame of WP9. Initial dissemination and exploitation plan have been worked out and reported.

Finally, contacts have been established and interactions occurred within the Future-BNCI cluster, and project partners attended a couple of specific Future-BNCI cluster round-table discussions during 2010 (in particular at the TOBI workshop). Potential collaboration modalities between Future-BNCI projects have been investigated. Initiative for BNCI technologies standardisation has been supported by project's partners.

The second half of the year (M7 to M12) has been critical in confirming work hypothesis and methodology, strengthening the collaboration between partners, and ensuring the convergence of partners' vision for the whole project. The following activities, in particular, have been carried out in this timeframe:

- BNCI experimentations to address fundamental research questions (WP5).
- Subsystems technology trade-offs analysis (WP2, WP3, WP4, WP5, WP6).
- Review, refinement and consolidation of initiated system technical specification and interfaces definition (WP1).
- Development of V0 preliminary versions of each subsystems, (WP3, WP4, WP5, WP6)
- Step 0 integration preparation (integration dry-run), Step 0 integration sessions performance, debriefing with end-users (WP7).
- Producing Year 1 due deliverables.

An important activity in this period has been to investigate, and figure out if (and in which extent) the BNCI "ideation" concept feasibility could be confirmed. Experiments carried out in this timeframe helped better understanding the related stakes and issues, though did not allow giving a definite answer to the complex question.

Due to the rather fundamental characteristics of the related research, the consortium approach is to develop solutions that do not only rely on the success of the "ideation" approach: though the consortium aims at providing the MINDWALKER system with such an ideation capable BNCI (which is a major research objective of the project), multiple complementary means are being investigated in parallel, that could improve, complement and/or substitute to the baseline approach, should it reveal unfeasible or ineffective in the project time frame. This complementary means are for instance: EMG-supported BNCI with measures of arm's EMG (FSL performed a number of experiments with this approach), and gait pattern generators (CPG) to mix BNCI signals with well formed gait pattern signals. Additionally, back-up control approaches based on voice, joystick / buttons, etc. are also scrutinized (will anyway be used for subsystem level testing of e.g. the lower limbs exoskeleton).

An important milestone has been the Step 0 integration that gave partners an opportunity to setup a V0 version of the different subsystems, and allowed partners facing actual integration issues for the first time. It helped ensuring that data formalisms and communication protocols were making sense. The development of a common communication library dramatically eased the integration process, reducing the burden, and allowing the partners to focus their efforts on understanding the subsystems connection architectures, testing various data types transfer, and testing various failure cases (e.g. manually un-plugging/re-plugging communication cables and ensuring overall robustness).

A number of publications have already been submitted and for some of them accepted to different types of peer reviewed symposium (both workshops and conferences).

3.3 Main results and achievements since the beginning of the project

Noticeable results after one year include:

- The development of a common understanding of the project's challenges by all partners through the specification phase (WP1) to which all partners contributed, and going toward a common vision of the approach, identification of potential (sometimes unforeseen) problems to solve, and possible strategies to overcome these problems.
- Technologies trade-offs have been performed, with early technologies tested in different areas, such as the electrodes concept testing for the SWEEBS (WP4), and the VRTE visual feedback and human body tracking technologies (with e.g. head-mounted displays, 3D screens, kinect based tracking, etc.).
- An important milestone has been the Step 0 integration that gave partners an opportunity to setup the V0 version of the different subsystems, and allowed them to face the actual integration issues for the first time. It helped ensuring that data formalisms and communication protocols were making sense. The development of a common communication library dramatically eased the integration process, reducing the burden, and allowing the partners to focus their efforts on understanding the subsystems connection architectures, testing various data types transfer, and testing various failure cases (e.g. manually un-plugging/re-plugging communication cables and ensuring overall robustness).
- As far as ethical issues are concerned, both FSL and ULB obtained the agreement from their respective ethical board committee (EBC) to carry out BNCI related experimental protocols in the frame of WP5.
- Attendance to a number of dissemination events (including e.g. the EU ICT event in September 2010), and preliminary publications of early results in peer-reviewed symposium proceedings.

The first year of the project allowed taking the consortium to full power in preparation to Year 2, which will require all the consortium energy for implementing and integrating most MINDWALKER components before the resulting prototype technologies can go through a clinical evaluation cycle during Year 3.

As an essential milestone and major challenge, a MINDWALKER advanced integrated solution should be made ready by the end of year 2 (M24).