H.F.R.I.
Hellenic Foundation for Research & Innovation

Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment

Title of the research project: *Implementation of an Integrated System for the Support and Rehabilitation of Motor Functions Through a Hybrid Brain-Computer Interface*

Principal Investigator: *Panteleimon Asvestas*

Reader-friendly title: *INSPiRE*

Scientific Area: *Engineering and Technology*

Institution and Country: *University of West Attica - Greece*

Host Institution: *University of West Attica (UNIWA)*

Collaborating Institution(s):

- *Institute of Communication and Computer Systems (ICCS), School of Electrical and Computer Engineering (ECE), National Technical University of Athens (NTUA)*
- *2nd Department of Physical and Rehabilitation Medicine, National Rehabilitation Center*

Budget: *190.000,00 €*

Duration: *36 Months*

Research Project Synopsis

INSPiRE targets the design and implementation of a novel **integrated Hybrid Brain-Computer Interface (HBCI)** system to support and restore motor functions of people with limited mobility (due to conditions such as stroke or spinal cord injury) by utilizing real-time multi-channel electroencephalography (EEG) and electromyography (EMG) recordings.

The main idea behind the project is to create an **artificial communication pathway between the brain and the muscles or an external device**, pursuing the following goals:

- Provide simultaneous motor function assistance and rehabilitation capabilities by stimulating muscle fibers through external electrical stimulation (Motion Support and Rehabilitation System)
- Provide kinetic independence for the disabled through an automated system that uses brain and muscle signals to control a modified wheelchair (Wheelchair Motion Substitution System)

A number of common neurological disorders have the ability to affect motor functions by disrupting any stage of the neuromuscular motor pathway, that mainly consists of the brain (motor signal generator), the spinal cord with its connected nerves (signal transmission bus) and the muscle groups (signal receptors and movement actuators). In some cases, muscular potential remains mostly unaffected, the issue being a flawed “control signal” delivered to the muscle groups either due to the brain not generating the appropriate signal or due to transmission problems.

In this context, INSPiRE seeks to utilize **non-invasive EEG and EMG modalities** combined with cutting-edge technologies and task-oriented training to facilitate motor rehabilitation and motion independence within a closed-loop control framework.

Project originality

The scientific field of INSPiRE lacks extensive work on the development of portable systems for everyday life application that offer support and rehabilitation capabilities via employing multiple recording modalities. This research gap has been a key motivation for INSPiRE, which aims to expand the current state-of-the-art by combining:

- Integration of EEG, EMG, and FES (Functional Electrical Stimulation) technologies for the development of a brain-to-muscles signal pathway substitution that offers **simultaneous motion support and rehabilitation capabilities**
- **Simulation protocols** to ensure safety before real-world testing on patients
- Maximum **patient independence** through the use of HBCI
- Maximum **portability** by minimizing equipment size

Most previous studies either highlight BCI application prospects, or employ large-scale devices in laboratory environments or do not fully combine the technologies utilized in this project. The holistic approach of INSPiRE considers decoding the human motion by studying **corticomuscular interactions** within a multimodal framework (EEG/EMG), aiming to implement this knowledge for the development of portable user-friendly systems that can both fulfill patients' everyday needs and implement gradual rehabilitation.

Expected results & Research Project Impact

The **main results** of INSPiRE include:

- Neurokinetic models describing specific aspects of human motion
- Advanced computational tools for automated real-time motion recognition
- Simulation protocols for system design and virtual testing
- Non-invasive HBCI system for the adaptive control of a wheelchair
- Portable non-invasive HBCI system employing functional electrical stimulation (FES) for the support and rehabilitation of motor functions

The expected results and the related work offer the opportunity for advances in the existing field, constituting a progressive step towards the development of affordable next-generation systems for everyday use by people with impaired mobility. **Associated impacts** are extended to multiple domains, with the potential benefits including the following:

- **Social Benefits**: Kinetic independence and social inclusion of people with motor impairments
- **Economic benefits**: Lower manpower and support costs for people with reduced mobility by developing affordable devices
- **Healthcare benefits**: Personalized rehabilitation protocols, introduction of state-of-the-art devices into the Greek clinical practice and system integration in subject-specific level
- **Scientific Benefits**: Analysis and evaluation of motor activities, modeling of the brain mechanisms concerning human locomotion and combinational system simulation

The importance of this funding

The H.R.F.I. funding has granted the INSPiRE Scientific Team with the opportunity to materialize their vision regarding the development and implementation of a user-friendly system that can be applied in the everyday life of patients.

With the backing of H.F.R.I. we aim to showcase that tools which have mostly been used for laboratory research can be brought into play for serving real needs of motor-impaired patients within everyday settings.

As such, the H.F.R.I. supports both experienced and young researchers working in the project throughout its duration towards these goals, while its contribution is also invaluable regarding the availability of advanced equipment that will be used both for research / development purposes as well as for **acquiring and distributing new knowledge** on state-of-the-art equipment and techniques across national institutions.

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