Data-based Human Motion Learning and Optimal Monitoring of Assistive Robots

PhD offer in the Laboratory of Automatic control, Mechanics, Industrial and Human computer science (LAMIH) | UMR 8201

PhD candidate in	Automatic control
Affectation	Automatic control department
Duration	3 years
Salary	Around 1500 € net/month
Starting date	01/10/2022
Location	Valenciennes, 59300 (France)

Research context

Considering human interactions with assistive robots is a highly challenging and still open problem. This thesis will focus mainly on modelling, monitoring and controlling human assistive robots, in particular robotic orthoses (e.g. Figure 1). It aims at applying data-based methods from advanced control theory and learning approaches towards a personalized assistance. The consideration of human interactions for such systems being crucial, the main objectives of this thesis are :

> To propose a generic methodology for human motion learning : by merging different types of data (kinematic, EEG, EMG), in order to design a complete and representative motion model.

> To achieve a personalized assistance by properly monitoring assistive robots and fitting the techniques to the specific measured reality.

> To consider the unavoidable uncertain nature and variability of the dynamics involved in such systems, in order to increase safety and to improve patient performance.

A central issue for most assistive robots is related to the generation of healthy reference trajectories [2]. Physiotherapists also share the necessity of reference determination for applying correct torque profiles on the impaired limbs and, more generally, for evaluating the subjects movements. Learning sensorimotor patterns from healthy subjects allows to set up adaptive motion models and thereby to design controllers that yield safe interaction with the user [3]. Furthermore, the considerable advances of Artificial Intelligence (AI) offer a wide variety of algorithms that can be applied to learn motion models from healthy persons data in order to identify the ideal human motion [5].

FIGURE 1 – An example of a robotic orthosis available at the LAMIH laboratory (MotoBOTTE) for ankle rehabilitation [1]

One of the challenging problems for controlling assistive robotic systems is the presence of several types of uncertainties. There are many patient specific parameters that can affect the outcome of the treatment, and which need to be taken into consideration [4]. For example, EMG measurements vary between individuals and can also vary on the same person due to offsets in electrode placement. There are other factors such as fatigue, mechanical properties of muscles, severity of impairments and most importantly, the inter- and intra-user variability. This makes the problem more challenging and open to innovative solutions.

Finally, the aim of this thesis is to provide a response to the limitations of the current studies and to develop systematic and generic methods allowing to generate the required and personalized rehabilitation treatment protocols, guiding thereby the physiotherapists.

Main requirements

> Master degree or equivalent in Automatic Control or Mechatronics
> Excellent background in automatic control
> A knowledge in machine learning techniques is highly appreciated
> Good programming skills (Matlab and C or Python)
> Professional English (French in not necessary)

How to apply

> Send your CV with 2 academic referees, a cover letter (explaining why you are interested in this offer and how you can contribute to this project) and your transcript of records for the last 3 years.
> Contacts : Kaouther Moussa {kaouther.moussa@uphf.fr} and Jimmy Lauber {jimmy.lauber@uphf.fr}
> Deadline : 30/04/2022

References

[1] J.-C. Arceo Luzanilla, "Assistive Motor Reeducation via Brain Computer Interface for Neurological Deficiencies," Polytechnic University of Hauts-de-France, 2021. https://tel.archives-ouvertes.fr/tel-03346043/

[2] T. Proietti, . V. Crocher, A. Roby-Bram and N. Jarrassé, "Upper-Limb Robotic Exoskeletons for Neurorehabilitation : A Review on Control Strategies," IEEE Reviews in Biomedical Engineering, pp. 4-14, 2016.

[3] P. Maciejasz, J. Eschweiler, K. Gerlach-Hah, A. Jansen-Troy and S. Leonhardt , "A survey on robotic devices for upper limb rehabilitation," Journal of NeuroEngineering and Rehabilitation, 2014.

[4] L. Ho Shing and X. Sheng Quan, "Exoskeleton robots for upper-limb rehabilitation : State of the art and future prospects," Medical Engineering Physics, pp. 261-268, 2012.

[5] M.A. Vélez-Guerrero, M. Callejas-Cuervo and S. Mazzoleni, Artificial Intelligence-Based Wearable Robotic Exoskeletons for Upper Limb Rehabilitation : A Review, Sensors2021, 21(6), 2146.