Title: *Collaborative robots as a tool for optimizing skill acquisition through the appropriate use of motor variability: Quantification of human motor variability in a constrained task*

Context

One of the major challenges of the so-called "Factory of the Future" is the improvement of workers' occupational health, and specifically the reduction of work-related musculoskeletal disorders (WMSDs). WMSDs, indeed, have both an immediate and a long term impact on the quality of life of workers, as well as a significant economic cost [1,2].

The development of WMSDs is caused by the repetition of physically demanding tasks which generate fatigue and, in the long term, damage body tissues (e.g., muscles, tendons, ligaments). Thus, physical fatigue and WMSDs are tightly coupled [3]. On the other hand, human motor variability appears to be a positive factor for delaying the onset of fatigue and/or for counteracting its effects [4]. Exploiting motor variability corresponds to using different motor strategies, at joint and/or at muscle level, to perform a given task. One can thereby reduce muscle/joint prolonged overloading by switching between different motor strategies, giving the fatigued muscle/joint time to recover. Enabling and encouraging industrial workers to positively exploit the intrinsic variability of the task (not all degrees of freedom of the tasks are constrained) [5], combined with their own motor variability (due to the kinematic and actuation redundancy of the human body) [6], could therefore help reduce WMSDs. Such exploitation of motor variability is, ideally, the natural result achieved by an expert. Such optimum is, however, not always reached, or requires a very long practice time. Methodologies to help the acquisition of motor habits exploiting at best the overall variability therefore need to be developed. In this respect, collaborative robots are a possible tool that could enable an individualized acquisition of such good practices at the motor level [7].

Objectives and Work Plan

Within the context described above, the internship focuses on the quantification of human motor variability in a partially constrained task. The methods and tools developed during the internship will be applied to the case of a trajectory tracking task, representative of industrial tasks typically observed on assembly lines.

The main objectives of the internship are:

- Identify approaches in the literature which allow to quantify both the variability associated with a given task, and the motor variability of a human operator subjected to task-related kinematic constraints.
- Develop and conduct an experiment to compare the motor variability observed in humans during a partially constrained trajectory tracking task, to the theoretical variability computed using a digital human model. The goal of this experiment is to estimate how much humans, possibly with different levels of expertise, exploit the available variability.
- Analyze the relation between the level of constraints imposed by the task and the motor variability exhibited by human operators.

Advising and Organization

The internship will be co-supervised by:

- Pauline Maurice (CNRS Researcher in Larsen team at LORIA, Nancy): pauline.maurice@loria.fr,
- Jonathan Savin (Research Engineer at INRS, Nancy): jonathan.savin@inrs.fr,
- Vincent Padois (Research scientist in Auctus team at INRIA Bordeaux Sud-Ouest): vincent.padois@inria.fr,
- David Daney (INRIA researcher in Auctus team at INRIA Bordeaux Sud-Ouest): david.daney@inria.fr.

The internship is for a duration of 6 months, in the interval between January and September 2020. The intern will be mainly located in LORIA/INRIA research center in Nancy.

This internship is preliminary to a potential PhD thesis continuing the same topic (collaborative robot as a tool for optimizing skill acquisition through the appropriate use of motor variability).

Requirements
Technical skills: Robotics, signal theory, statistical analysis, Matlab/Python/C++ programming. Experience with human subject experiment and/or motion capture is a plus.

General Skills: Team player, autonomous, proactive, creative, enthusiastic, organized, serious and rigorous (this list is not exhaustive).

Language: English or French

Application
Applicants should send their CV, motivation letter describing their specific interest for the topic, and their Master's grades to the aforementioned advising team.

References
[1] Punnett, L., & Wegman, D.H. (2004). Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *Journal of electromyography and kinesiology*, *14*(1), 13-23.
[2] Schneider, E., Irastorza, X., & Copsey S. (2010). OSH in figures: Work-related musculoskeletal disorders in the EU – Facts and figures. *European Agency for Safety and Health at Work*.
[3] Luttmann, A., Jäger, M., Griefahn, B., Caffier, G., & Liebers, F. (2003). Preventing musculoskeletal disorders in the workplace. *World Health Organization*.
[4] Srinivasan, D., & Mathiassen, S. E. (2012). Motor variability in occupational health and performance. *Clinical biomechanics*, *27*(10), 979-993.
[5] Sternad, D. (2018). It's not (only) the mean that matters: variability, noise and exploration in skill learning. *Current opinion in behavioral sciences*, *20*, 183-195.
[6] Bernstein, N. (1967). *The co-ordination and regulation of movements*. Pergamon Press, Oxford.
[7] Peternel, L., Fang, C., Tsagarakis, N., & Ajoudani, A. (2019). A selective muscle fatigue management approach to ergonomic human-robot co-manipulation. *Robotics and Computer-Integrated Manufacturing*, *58*, 69-79.