IMT Mines Alès
École Mines-Télécom

Thesis topic: optimizing manufacturing processes in the presence of human factors

Establishment: IMT Mines Alès - Laboratory: EuroMov Digital Health in Motion

Institution: IMT Mines Alès
Location: Alès
Start date: September/October 2023

1. THESIS DESCRIPTION

1.1 KEY WORDS

Artificial intelligence, Motion capture, Combinatorial optimization, Industry 5.0, Musculoskeletal disorders.

1.2 MANAGERS

Thesis supervisor: Prof. Pierre Slangen
Co-director: Prof. Jacky Montmain
Co-supervisor: Dr. Oussama Ben-Ammar

1.3 PURPOSE OF THE THESIS

The Occitanie region's "Plan Régional Santé Travail 2022-2025" mentions a few figures to illustrate the need to put health and prevention at the heart of work in the region: musculoskeletal disorders (MSD) account for 80% of recognized occupational illnesses; 71% of employees are exposed to postural and joint constraints; 32% of employees are exposed to one or more chemical products, whatever their sector of activity. As for the statistical service in charge of labor, employment and vocational training within the public statistical system (DARES), it lists in its analysis n°031 of August 2022 the thresholds above which exposure can be qualified as "arduous" (according to the 2017 survey Surveillance médicale des expositions des salariés aux risques professionnels (SUMER)). However, she points out that most quantification methods are based on the expertise of survey physicians and the feelings of employees.

In this context, the development of a solution that integrates the identification and automatic calculation of arduousness factors when optimizing a manufacturing process is essential, and presents a number of challenges: (i) the definition and capture of all the movements of interest, i.e. motion capture, (e.g. holding arms up, kneeling position, fixed head and neck position, crouching posture, pushing, lifting, vibrations, repetitive gestures, etc.), (ii) the implementation of a data acquisition protocol compatible with the aforementioned movements, (iii) the development of an approach based on automatic learning (e.g., deep-learning, computer-aided control, etc.), (iv) the development of a data acquisition protocol compatible with the aforementioned movements.), (ii) the implementation of a data acquisition protocol compatible with the aforementioned movements, (iii) the development of an approach based on automatic learning (e.g., deep-learning, reinforcement learning,

etc.) to characterize gestures and quantify the arduousness of a given activity, (iv) and the proposal of a temporal scheduling of tasks that minimizes arduousness while maximizing productivity (combinatorial optimization). This issue is fully in line with Industry 5.0, where human factors play a central role.

The starting point of this thesis is the simulation of a manufacturing process defined by a set of data: tasks, precedence rules, assembly capacity, demand for finished product, technical and environmental constraints, operators, etc. This simulation provides a set of indicators such as the manufacturing time for a finished product, the load/capacity ratio, the need for skilled and/or unskilled operators, and so on. This simulation provides a set of indicators such as manufacturing time for a finished product, load/capacity ratio, skilled and/or unskilled operator requirements, etc.

The first task will be to couple this simulation with combinatorial optimization methods to propose a task scheduling and load distribution between operators. This first solution will not take into account the work arduousness.

Secondly, the PhD student will analyze the industrial environment and operators' movements to propose a detailed characterization and automatic calculation of the factors of arduousness. He will draw on technologies available at the Alès Imaging and Human Metrology (AIHM) platform at IMT Mines Alès. In particular, motion capture systems (optical or inertial) are perfectly complementary and compatible with the industrial environment. The candidate will be able to draw on existing work at EuroMov Digital Health in Motion, focusing on motion capture and the quantification of arduousness.

Finally, the PhD student will integrate the automatic calculation of these factors into the optimization of manufacturing processes.

1.4 EXPECTED RESULTS

Several deliverables are expected:

- A study of the quantification of arduousness in relation to regulations on arduousness at work in France, the industrial environment, workstations and associated tasks;
- The study of motion capture technologies.

The proposed approaches will be evaluated experimentally at a partner company. The work will be promoted through the publication of scientific articles in journals and conferences.

1.5 CANDIDATE PROFILE

Engineer and/or Master 2 with a focus on Data Science, Artificial Intelligence and Operations Research.

The person recruited must have the following skills:

- Machine Learning ;
- Data analysis ;
- Problem modeling ;
- Algorithms and programming.

Additional knowledge in one of the following areas would be appreciated:

- Modeling and analysis of human movement ;
- Combinatorial optimization methods.

The candidate must be motivated by the healthcare applications aspect and IT development.

1.6 APPLICATION

The application must include :

- A **detailed** CV ;
- A cover letter ;
- Transcripts from the last two years of training ;
- Letters of recommendation.

Applications should be sent by e-mail to: pierre.slangen@mines-ales.fr ; oussama.ben-ammar@mines-ales.fr ; jacky.montmain@mines-ales.fr