2018-00402 - Post-doctoral - Set modeling of humans and robots kinematics

Level of qualifications required: PhD or equivalent
Function: Post-Doctoral Research Visit

About the research centre or Inria department

This research project is part of the field of collaborative robotics. It is motivated by the following societal and economic issues:

- The preservation of know-how in the production and assembly companies
- The preservation of human in the industry: less hardship, musculoskeletal disorders (MSDs)
- Productivity Improvement: Synthesize a gesture of production; delegate manipulation tasks and dexterity constraints to an assistance system in order to focus the operator on cognitive tasks
- The factory of the future

The scientific issues addressed are:

- Identify and analyze the cognitive and physical fragilities of the operators
- Evaluate the cybernetic organism
- Design the cobotic system

The scientific objectives are:

- Measure, analyze and model the activity: model the knowledge, behaviors, interactions and uses; to better understand the place of the human within the production apparatus
- Model the operator's gesture: propose a modeling of the human that takes into account the uncertainties and variability of the parameters; to include in this model psychic and cognitive constraints
- Measure, analyze, synthesize the gesture: develop new evaluation indices that synthesize the properties of the gesture, its ergonomics and its influence on the task; identify the constraints leading to underperformance of the operator or the difficulty of the action; propose corrections learned or deduced from the model
- Design a robotic system: use existing cobotic architectures to design a collaborative production cell (tasks, sharing of authority)
- Understand the needs of the operator in terms of assessment and cognitive and physical assistance
- Design and control industrial robotized operator assistance systems
- Design of cobots coupling physiological, biomechanical evaluation and operator performance in physical and cognitive symbiosis with its robotic assistance system

Ultimately, the project must allow better penetration of cobots in our industries by demonstrating a quantifiable added value of the human / robot couple on the workstations.

Context

Scientific priorities: human-centered digital world / life long adaptive interaction with humans

Scientific Research context:

The Inria team Auctus focuses its research on the design of cobots (collaborative robots) under constraints coming from interactions with humans. The cobotic workplace is typically modeled using virtual reality. This approach makes it hard to model sets of operators with various physiologies.

On the other hand, Auctus members have participated in the advent of a new design approach named appropriate design. This method requires to model the considered systems using sets, but
allows to consider uncertainties and parameter variations within the same framework. The scientific challenge is to represent, in this same set-based formalism, the kinematic chains that model the human biomechanics, as well as the robots.

The key point is to develop the mathematical set-theory that allows modeling of this problem as well as the algebra of transformations of rigid bodies. This work will allow us to consider sets of humans and robots in order to analyze sets of possible interactions between the two.

**Assignment**

The biomechanics of humans as well as robots is based on the kinematic chain representation.

The main challenge of the set extension of the kinematic chain is the representation of sets of orientations using something like interval arithmetic. It is well known that naive use of interval arithmetic introduces overestimations due to forgotten correlations (wrapping effect). Improvements can be achieved using various interval analysis techniques, and challenging the numerous classical representations of movements of rigid bodies.

**Main activities**

The candidate will have to study the adaptability of different geometric and mechanical formalisms to interval methods, in order to find the most suitable in terms of sharpness and computational efficiency, and possibly come up with new approaches of his/her own.

**Keywords**: biomechanics, robotics, interval analysis, geometric modeling, kinematic chains

**References**:


**Skills**

Required knowledge and background: interval analysis, possibly robotics and geometric modeling, C++ programming

**Benefits package**

- Subsidised catering service
- Partially-reimbursed public transport

**Remuneration**

2653€ / month (before taxes)