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2025 *Activity Report*

RESEARCH CENTRE: **Inria Centre at the University of Bordeaux**

IN PARTNERSHIP WITH: **Bordeaux INP**

Project-Team

AUCTUS

Robots for Humans at work

Project-Team AUCTUS

Creation of the Project-Team: 2020 April 01

Each year, Inria research teams publish an Activity Report presenting their work and results over the reporting period. These reports follow a common structure, with some optional sections depending on the specific team. They typically begin by outlining the overall objectives and research programme, including the main research themes, goals, and methodological approaches. They also describe the application domains targeted by the team, highlighting the scientific or societal contexts in which their work is situated. The reports then present the highlights of the year, covering major scientific achievements, software developments, or teaching contributions. When relevant, they include sections on software, platforms, and open data, detailing the tools developed and how they are shared. A substantial part is dedicated to new results, where scientific contributions are described in detail, often with subsections specifying participants and associated keywords. Finally, the Activity Report addresses funding, contracts, partnerships, and collaborations at various levels, from industrial agreements to international cooperations. It also covers dissemination and teaching activities, such as participation in scientific events, outreach, and supervision. The document concludes with a presentation of scientific production, including major publications and those produced during the year.

Keywords

Computer sciences and digital sciences

A5.1.1. – Engineering of interactive systems

A5.1.2. – Evaluation of interactive systems

A5.1.3. – Haptic interfaces

A5.1.5. – Body-based interfaces

A5.1.7. – Multimodal interfaces

A5.1.9. – User and perceptual studies

A5.5.1. – Geometrical modeling

A5.6.2. – Augmented reality

A5.10.1. – Design

A5.10.2. – Perception

A5.10.3. – Planning

A5.10.4. – Robot control

A5.10.5. – Robot interaction (with the environment, humans, other robots)

A5.10.8. – Cognitive robotics and systems

A6.2.5. – Numerical Linear Algebra

A6.2.6. – Optimization

A6.4.6. – Optimal control

A6.5.1. – Solid mechanics

A8.2.6. – Numerical methods for optimization

A9.5. – Robotics and AI

A9.8. – Reasoning

A9.12.2. – Activity recognition

A9.12.4. – 3D and spatio-temporal reconstruction

A9.12.5. – Object tracking and motion analysis

A9.12.6. – Object localization

A9.12.8. – Motion capture

Other research topics and application domains

B1.2.2. – Cognitive science

B1.2.3. – Computational neurosciences

B2.8. – Sports, performance, motor skills

B5.1. – Factory of the future

B5.2. – Design and manufacturing

B5.6. – Robotic systems

B9.5.5. – Mechanics

B9.6. – Humanities

B9.9. – Ethics

Contents

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2 Overall objectives

The project of the Auctus team is to design the collaborative robotics cells of the future.

The robotics community still tends to separate Human-Robot interaction's cognitive (HRI) and physical (pHRI). One of the main challenges is to characterize the task and biomechanical, physiological and cognitive capabilities of humans in the form of physical constraints or objectives for the design of cobotized workstations. This design must be understood in a large sense: the choice of the robots' architecture (cobot, exoskeleton, human-robot interface, etc.), the dimensional design (human/robot workspace, trajectory calculation, etc.), the coupling mode (comanipulation, teleoperation, etc.) and the control strategy. The approach then requires the contributions of the human and social sciences to be considered in the same way as those of exact sciences. The topics considered are broad, ranging from cognitive sciences, ergonomics, human factors, biomechanics and robotics.

The first challenge is to evaluate the hardship at work, the well-being of the operators and, further upstream, their cognitive state which impacts their sensorimotor strategy while performing a task. In the industry, the ergonomic analysis of the task is carried out by an ergonomist based on direct but often ad hoc observations. However, the context is changing: the digitization of factories, through the installation of on-site sensors, allows longitudinal observation of machines and humans. The available information can thus allow us to rethink how the evaluation of activities is carried out. Currently, an emerging subdomain, named *ergonomic robotics*, adapts available ergonomic criteria (RULA, REBA, etc.) to the evaluation of robotic cells. However, such criteria are related to the (quasi-static) posture of the operator, which limits the understanding of human motor strategies over a long period. Similarly, muskuloskeletal analyses may tend to see humans as high-performance machines to be optimized. This can make sense for a top-level athlete, but repeating actions in the industry over a day, months or years of work means that a temporary change of posture, possibly poorly rated according to usual ergonomic criteria, could be a good long-term strategy. These questions directly link motor and cognitive aspects that can be reflected in particular strategies such as fatigue or expertise (manual and cognitive). We aim to creat musculoskeletal metrics through extensive modeling of the human at work. This approach has not been widely explored in robotics but it could determine the right criteria to adapt to the behavior of a cobot.

The second challenge is to define a methodology to link the analysis of the task and the induced human movements to the robot design. Several of our industrial projects have shown that there is a significant conceptual distance between the ergonomist, an expert in task analysis and psychology, and the roboticist, an expert in mechanics, control and computer science, which makes it very difficult to analyze the needs and define the specifications of the technical solution. To fill these methodological gaps, it is necessary to better define the notion of tasks in the context of a human/robot coupling, based on case studies. We also have to establish a typology of human/robot interaction by taking into account the different physical and cognitive constraints, in a very detailed fashion, and their potential psychological, organizational or ethical impacts.

The third challenge addresses the need to think about the control laws of collaborative robots in terms of human/robot coupling. The effectiveness of this coupling requires an ability to predict future human actions. This prediction should make the interaction more intuitive, but also aims at optimizing the robot assistive behavior from the point of view of "slow" phenomena, such as fatigue. The major challenge is, therefore, to move from reactive to anticipatory control laws, by integrating a human prediction model, both in terms of movement strategies and decision strategies. Beyond the great computational complexity of predictive approaches, obtaining prediction models is an ambitious challenge. It is indeed necessary to learn models that are quite complex, due to the physical realities they can account for, and quite simple from a computational point of view.

3 Research program

3.1 Analysis and modeling of human behavior

3.1.1 Scientific Context

The purpose of this axis is to provide metrics to assess human behavior. Our human study specifically focuses on industrial operators. We assume the following working hypotheses: the operator's task and environmental conditions are known and circumscribed; the operator is trained in the task, production tools and safety instructions; the task is repeated with more or less frequent intervals. We aim to analyze the following:

- the physical and cognitive fragility of operators to meet assistance needs;
- cognitive biases and physical constraints leading to a loss of the operator safety;
- ergonomics, performance and acceptance of the production tool.

In the industrial context, these questions are tackled through the fields of work ergonomics and cognitive sciences. Four main axes are typically addressed: physiological/biomechanical, cognitive, psychological and sociological studies. We particularly focus on the biomechanical, cognitive and psychological aspects, as described by the ANACT [23, 27]. The aim is to translate these factors into metrics, optimality criteria or constraints to better analyze, design and control the collaborative robots.

A review of ergonomic workstation evaluation helps in positioning our desired contributions in robotics. Ergonomists evaluate the gesture through the observation of the workstations and, generally, through questionnaires. This requires long periods of field observation, followed by analyses based on ergonomic grids (e.g. RULA [40], REBA [31], LUBA [35], OWAS [34], ROSA [54],...). Until then, the use of more complex measurement systems was reserved for laboratories, particularly in biomechanical studies. The advent of cost-effective and minimally intrusive motion capture sensors (Inertial Measurement Units, RGB-D cameras), coupled with advancements in computer vision algorithms, now enables on-site data collection to assess workers' gestures, postures, movements, and physiological states. Some of these systems can be permanently integrated into production lines without disrupting workflow, while simultaneously evaluating worker well-being through biomechanical and physiological metrics. This facilitates longitudinal motion capture studies, similar to the evolution of maintenance practices from reactive to predictive.

Ergonomic robotics has recently taken an interest in this new evaluation paradigm to adapt the robot behavior to reduce ergonomic risks. This ergonomic adaptation complements the conventional approaches that only consider the performance of the action produced by the human in interaction with the robot. However, ergonomic criteria are usually based on the principle that the comfort positions are distant from the human joint limits. These notations are compatible with an observation of the human operator through the eye of the ergonomist. In practice, such evaluations are inaccurate and subjective [57]. Moreover, they only consider quasi-static human positions, without taking into account the evolution of the person's physical, physiological and psychological state. We aim to extend this approach to more reliable and comprehensive ergonomic metrics with musculoskeletal, fatigue, metabolic consumption modelling. The repetition of gestures, and the solicitation of muscles and joints, are questions that must complete these analyses. A method used by ergonomists to limit biomechanical exposures is to increase variations in motor stress by rotating tasks [55]. However, this type of extrinsic method is not always suitable in the industrial context [39] where we place our research efforts.

Through these human analyses, the Auctus team aims to revise the use of collaborative robots in the workplace to vary the operator's environment and encourage more appropriate motor strategies. Biomechanical studies of the intrinsic variability of the motor system allowed by the joint redundancy of the human body should result in the alternation of postures, movements and muscle activity observed in the individual to perform a requested task [55]. This variation leads to differences between the motor coordination used by each operator, and conveys the notion of motor strategy [32]. We aim to provide exhaustive studies of motor strategies in industrial setups.

The cognitive dimension of ergonomics must also be addressed in our approach to reduce the mental workload and foster the wellness of the worker. We believe that known sensorimotor strategies can be a physically quantifiable reflection of the operator's cognitive state. For example, human motion measurements can be used to predict fatigue [52] and, therefore, adjust the robot's assistance. A key challenge here is to better analyze human manual expertise (dexterous and cognitive) to adapt the human-robot interaction. The expertise embodies the operators' decision-making process while perceiving, understanding, and anticipating their gestures to preserve their safety, comfort, and performance in the task. We aim to adapt and refine known human cognitive models (multisensory perception [29], situation awareness [28]) to infer the influence of the task context and environment on operator behavior.

3.1.2 Methodology

How can we observe, understand and quantify human sensorimotor and cognitive strategies to better design and control the behavior of the cobotic assistant?

When we study systems of equations (kinematic, static, dynamic, musculoskeletal, etc.) to model human behavior, several problems appear and explain our methodological choices:

- the large dimension of the problems to be considered, due to the human body complexity (eg. joint, muscle redundancy);
- the distribution of anthropometries, force capacities, and fatigue resistance among workers, for example, size, the muscle mass, the possible geometric configurations on a workstation (set of possible trajectories, postures, and placements of the operator), and the forces needed to be produce to execute a task;
- the uncertainties in the measurement and the model approximations.

The idea is to start with a description of redundant workspaces (geometric, static, dynamic...). We use set-theory approaches, based on interval analysis [56], [45], which meet the variability requirement and cope with model and measurement uncertainties. Another advantage of such techniques is that they allow the results to be certified, which is essential to address safety issues. Some members of the team have already achieved success in mechanical design for performance certification and robot design [42]. By extending these set-theory approaches to our problem, a mapping of ergonomic, efficient, and safe movements can be obtained, in which we project the operators' motor strategies. Biomechanical, ergonomic, and cognitive metrics can, then, be defined and evaluated to quantify the human behavior in specific work situations.

It is therefore necessary to:

- model human capabilities, both at the musculoskeletal and the perceptive/cognitive levels, to allow for global, yet detailed, analyses as well as efficient integration of such knowledge in the control of the collaborative robots.
- contribute to accurate representations of the shoulder joint involved in most cobotic interactions and worker efforts. Its complex range of motion and the numerous muscles involved make proper shoulder modeling a significant challenge for musculoskeletal (MSK) models [8].
- propose new ergonomic, biomechanical, robotic, and cognitive indices that will link different types of performances while taking into account the influence of fatigue, stress, level of expertise, etc.;
- divide the task and the gesture into homogeneous phases: this process is complex and depends on the type of studied index and the techniques being used. We are exploring several methods: inverse optimal control, learning methods, techniques from signal processing;

- develop interval extensions of the proposed indices. The indices are not necessarily the result of a direct model, and algorithms must be developed or adapted to compute them (calculation of manipulability, Uncontrolled Manifold, etc.);

- Aggregate proposals into a dedicated interval-analysis library for human behavior studies (use of and contribution to the existing ALIAS-Inria and the open-source IBEX library).

The major contribution of the methodology is to embrace in the same model the measurement uncertainties (important for on-site use of measurement equipment), the variability of tasks and trajectories (proper to dexterous industrial operations), and the physiological characteristics of the operators (critical adaptability to every individual). The originality of the approach is to combine biomechanical, ergonomic and cognitive metrics with the usual performance indices to build a comprehensive and objective analysis of human behavior.

Other avenues of research are being explored, particularly around the inverse optimal control [46], to project human movements based on the performance or ergonomic indices. Such a projection would offer new interpretations and enhance the analysis of human behaviors.

Finally, the development of a population-scale musculoskeletal model database and the application of anthropometry-robust optimal control represents a new aera of research that the team will explore by 2025. This approach would further explore the inherent variability within human workforces. By constructing a diverse virtual population through statistical and biomechanical principles, we will be able to leverage predictive simulation to identify broadly applicable movement strategies and minimize potential strain across a spectrum of worker morphologies and capabilities. This dual approach moves beyond traditional, one-size-fits-all ergonomic assessments, enabling the development of personalized or, at minimum, broadly robust recommendations for safer and more efficient work practices.

3.2 Operator/robot coupling

This research axis is at the frontier between humans and robots and focuses on optimal methods to couple these two entities to perform joint activities. This raises questions that are directly related to human models and abilities (axis 1) and robot control (axis 3). Two main concerns must be addressed to form an effective human-robot dyad.

3.2.1 Human-Robot interaction

The first step to couple the operator and cobot together at work is to provide interaction modalities through which the agents can communicate and coordinate. The interaction can be direct, where the robot and operator act together in the same shared environment, or the operator can remotely perform the task with the robot through a teleoperation system (which reflects the remote interaction and potentially corrects for punctual weaknesses). The level and type of human-robot interactions are chosen with respect to the task, the context, or other human factors. The challenge is, then, to predict the joint human-robot behavior and capabilities for each interaction situation and collaborative context.

The formal computation of joint human-robot capabilities can be given thanks to the models and evaluation indices presented in Axis 1. We can focus on quantifying how the interaction with the robot will impact the human sensorimotor strategy (changes in the posture, positions, forces, etc., induced by the robot) and recomputing metrics such as human fatigue and motor variability[51] and the Mover project. We can further use the biomechanical and robotic models to consider a unified operator-robot entity and to compute their joint abilities (e.g. common human-robot force capabilities [53]).

Developing human cognitive and sensorimotor models to account for the effect of the human-robot interaction could provide a valuable tool to evaluate cobotic systems and collaborative works. However, the accuracy of these models must be addressed. We wish to understand how the robot influences the operator's work, and thus how his mental model of the task evolves according to the interactions with the robot. The challenge is, then, to predict the behavior of the operator that takes into account his cognition in the interaction situations. Preliminary literature results have shown that key cognitive mechanisms in human teaming may transfer to human-robot collaboration, such as joint human-robot action representation [25] or coordination mechanisms [44]. However, the situation awareness of the operator is modified by the interaction with the robot [49]. Developing a joint mental model that accurately captures the human-robot interaction can later guide the design of relevant interaction modalities to improve the team's understanding [26].

3.2.2 Cobot adaptive assistance

Taking into account the coupling between the operator and the robot at the control level is also central to the team's objectives. We wish to demonstrate how a collaborative robot can be used to mediate between a control objective that optimizes task performances, safety and comfort (what we consider as the *expertise trinity*), on one hand, and the action model of the human interacting with the robot (the inferred human intent), on the other hand. Such an arbitration in the control law adapts the robot's assistive behavior to better collaborate with the operator. This shared-autonomy concept is the focus of part of our research. It can range from a discrete task allocation between the agents to an effectively shared task [43].

We are strongly confident that the notion of expertise is central to adjusting the cobot behavior. The robot controller is designed to increase the level of expertise in the operator/robot team: it optimizes the human-centered metrics (safety criteria, biomechanical and cognitive comfort, etc.) and provides a gain in performances (joint human-robot capabilities). But it also aims at preserving the operator's particular expertise and know-how at the center of the activity. Manual expertise of highly skilled operators needs to be analyzed respectively on its dynamic aspects and on the ability to synchronize with other operators in the environment. Understanding better the expertise is envisioned as a way to alleviate the operators of repetitive and easy operations while maintaining their ability to perform expert gestures based on the complexity of the task.

Furthermore, this research axis raises the question of the modification of the work induced by collaborative robots for expert operators. While the overall goal is to make use of robots to punctually or continuously improve the work conditions of these operators (and not to replace them), the presence of these robots necessarily impacts the work referential and thus the expertise itself. One of the central questions, yet to be tackled, relates to the original and core part of the expertise that should remain unchanged. The proposed modeling of the operator/robot coupling and interaction is the first avenue to predict possible changes in the expertise. It can be input to the controller to constraint the robot to let the operator make the expert decisions naturally.

3.3 Design of cobotic systems

3.3.1 Architectural design

Is it necessary to cobotize, robotize or assist the human being? Which mechanical architecture meets the task challenges (a serial cobot, a specific mechanism, an exoskeleton)? What type of interaction (H/R cohabitation, comanipulation, teleoperation)? These questions are the first requests from our industrial partners. For the moment, we have few comprehensive methodological answers to these requests. Choosing a collaborative robot architecture is a difficult problem [36]. It becomes even more complex when the architectural design is approached from concurrent cognitive ergonomic, biomechanical and robotic perspectives. There are major methodological and conceptual differences in these areas. It is, therefore, necessary to bridge these representational gaps and to propose a global and generic approach that takes into consideration the expectations of the robotician to model and formalize the general properties of a cobotic system as well as those of the ergonomist to define the expectations in terms of an assistance tool.

To do this, we propose a user-centered design approach, with a particular focus on human-system interactions. From a methodological point of view, this requires to develop a structured experimental approach. It aims at characterizing the task to be carried out ("system" analysis) but also at capturing the physical markers of its realization (required movements and efforts, ergonomic stress, etc.). This specification must be done through the prism of a systematic study of the exchanged information (type and modality) needed by humans to perform the considered task. Based on these analyses, the main challenge is to define a decision support tool for the choice of the robotic architecture and the specifications of the role assigned to the robot and the operator as well as their interactions.

The evolution of the chosen methodology is for the moment empirical, based on the user cases regularly treated in the team (see sections on contracts and partnerships).

The process can be summarized through the following steps:

- identify expert or difficult jobs on industrial sites. This is done through visits and exchanges with our partners (manager, production manager, ergonomist...);
- select some challenging use cases to be studied and, then, observe the operator in its ecological environment. Our motion capture tools allow us to produce a force-motion analysis, based on previously defined ergonomic criteria, and a physical evaluation of the task in terms of expected performances, from both experiments and simulations. In parallel, an evaluation of the operator's expertise and cognitive strategy is throught questionnaires;
- synthesize these observatory results into design requirements to deduce: the robotic architectures to be initiated, the key points of human-robot interaction to be developed, and the difficulties in terms of human factors to be taken into account.

The different human and task analyses take advantage of the expertise available within the AUCTUS team. The team has already worked on the currently dominant approach: the use of human models to design the cobotic cell through virtual tools. We would like to gradually introduce the additional evaluation criteria presented above. However, the very large dimensions of the treated problems (modeling of the body's degrees of freedom and the constraints applied to it) makes it difficult to carry out a certified analysis. We choose to go through the calculation of the human workspace and performances, which is not yet done in this field. The idea here is to apply set theory approaches, using interval analysis as already discussed in section 3.1.2. The goal is, then, to extend the human constraints to intervals, which integrate the model variability, and to play them in virtual reality during simulations of the tasks. This would allow the operator to check his trajectories and scenarios not only for a single case study but also for sets of cases. For example, it can be verified that, regardless of the bounded sets of simulated operator physiological capabilities, the physical constraints of a simulated trajectory are not violated. Therefore, the assisted design tools certify cases of use as a whole. Moreover, the intersection between the human and robot workspaces/capabilities provides the necessary constraints to certify the feasibility of a task in the interaction situation. Overall, integrating human and task-related physical constraints in the design process brings to better cobotic systems. In the future, we will similarly develop tools to include human cognitive markers in the design approach.

This research line merges the contributions of the other axes, from the analysis of the human behavior and capabilities in its environment for an identified task, the prediction of the effects of the interaction/coupling strategy with the robot, to the choice of a mechanical architecture from the resulting design constraints. The proposed task-oriented and human-centered methodology is perfectly integrated into an Appropriate Design approach. It can be used for the dimensional design and optimization of robots, again based on interval analysis. The challenges are the change of scale in models that symbiotically consider the human-robot pair, the uncertain, flexible and uncontrollable nature of human behavior, and the many evaluation indices needed to describe them.

It is worth noting that we aim to develop a global mechatronic design approach, which would build upon the design constraints to specify the robot hardware and controller at once. The chosen set-theory computational methodology is particularly appropriate to meet this objective since the interval-based representation of the design constraints can be directly and equally used to set the control constraints.

3.3.2 Control design

The control laws of collaborative robots from the major robot manufacturers differ little or not at all from the existing control laws in the field of conventional industrial robotics. Security is managed a posteriori, as an exception, by a security PLC / PC. It is therefore not an intrinsic property of the controller. This strongly restricts possible physical interactions [1] and leads to suboptimal operation of the robotic system. It is difficult in this context to envision tangible human-robot collaboration. Collaborative operation requires, in this case, a control calculation that integrates safety and ergonomics as a priori constraints.

The control of truly collaborative robots in an industrial context is, from our point of view, underpinned by two main issues. The first one is related to the macroscopic adaptation of the robot's behavior according to the phases of the production process. The second one is related to the fine adaptation of the degree and/or nature of the robot's assistance according to the ergonomic state of the operator. If this second problem is

[1] In the ISO TS 15066 technical specification on collaborative robotics, human-robot physical interaction is allowed but perceived as a situation to be avoided.

part of a historical dynamics in robotics that consists in placing safety constraints, particularly those related to the presence of a human being, at the heart of the control problem [30] [41, 33], it is not approached from the more subtle point of view of ergonomics where the objective cannot be translated only in terms of human life or death, but rather in terms of long-term respect for their physical and mental integrity. Thus, the simple and progressive adoption by a human operator of the collaborative robot intended to assist him in his gesture requires a self-adaptation in the time of the command. This self-adaptation is a fairly new subject in the literature [47, 48].

At the macroscopic level, the task plan to be performed for a given industrial operation can be represented by a finite-state machine. To avoid increasing the human's cognitive load by explicitly asking him to manage transitions for the robot, we propose to develop a decision algorithm that would ensure discrete transitions from one task (and the associated assistance mode) to another based on an online estimate of the current state of the human-robot couple. The associated scientific challenge is to establish a link between the robot's involvement and a given working situation. We propose an incremental approach to learn this complex relationship. Its first stage will consist of identifying the general and relevant control variables to conduct this learning in an efficient and reusable way, regardless of the particular calculation method of the control action. Then, physically realistic simulations and real-world experiments will be used to feed this learning process.

To handle mode transitions, we propose to explore the richness of the multi-tasking control formalism under constraints [38]. It would ensure a continuous transition from one control mode to another while guaranteeing compliance with a certain number of robot control constraints. Some of these constraints convey the ergonomic specifications and are dependent on the state of the robot and of the human operator, which, by nature, is difficult to predict accurately. We propose, again, to exploit the interval-analysis paradigm to efficiently formulate ergonomic constraints robust to the various existing uncertainties.

Purely discrete or reactive adaptation of the control law would make no sense given the slow dynamics of certain physiological phenomena such as fatigue. Thus, we propose to formulate the control problem as a predictive problem where the impact of the control decision at a time t is anticipated at different time horizons. This requires a prediction of human movement and knowledge of the motor variability strategies it employs. This prediction is possible based on the supervision at all times of the operational objectives (task in progress) in the short term. However, it requires the use of a virtual human model and possibly a dynamic simulation to quantify the impact of these potential movements in terms of performances, including ergonomics. It is impractical to use a predictive command with simulation in the loop with an advanced virtual manikin model. We, therefore, suggest adapting the prediction horizon and the complexity of the corresponding model to guarantee a reasonable computational complexity.

4 Application domains

4.1 Factory 4.0

The 4th industrial revolution (factory 4.0) is characterized by the integration of digital technologies into the production process, to meet the challenge of customizing services and products. This agility requires making manufacturing and maintenance lines flexible and versatile. This adaptation capacity is a characteristic of the human being, which puts him at the center of the production apparatus. However, this can no longer be done at the expense of the human operators' health and well-being. How can we reconcile the enhancement of our manual and analytical expertise, the ever-desired increase in productivity and manufacturing quality, while reducing the hardship at work? Collaborative robotics, which we are seeking to build, is one of the key solutions to meet these societal challenges. By assisting humans while performing dangerous and painful tasks, the collaborative robot complements and helps them in their phases of physical and cognitive fragility.

More generally, we are interested in workstation cobotization, in the manufacturing and assembly industries but also the construction and craft industries. The application areas are related to regional needs in aeronautics, maintenance, water and waste treatment. In most of these cases, it is possible to define the tasks and to evaluate the stakes and added value of our work.

5 Social and environmental responsibility

The scientific positioning of Auctus has an explicit social objective: assisting industrial workers to improve their working conditions through the appropriate limitations of physical solicitations and the improvement of their cognitive comfort. This has a direct societal impact on the health of the population and regarding the preservation of industrial skills and expertise in the local and national industrial ecosystem. For this research to be effective, we need to bridge academic research with industrial practice. To do so, we have developed a multilevel ecosystem that brings together research and innovation and fosters the transfer of our activities and developed knowledge toward industry. Beyond the numerous conventional research partnerships with companies we are involved in (see section 7.5), two transfer actions particularly support knowledge dissemination. First, we participated in the **France Relance program** and its Inria instantiation through two "Plan de relance" projects: with the Gironde SME Aerospline, by focusing on industrial robot control methodologies; and with the startup FuzzyLogicRobotics, by exploring the possibilities offered by quadratic programming under constraints for rapid generation of robot trajectories. Second, we are involved in two **ANR Défi Transfert France 2030** projects: Grip4All (PI David Daney), in collaboration with Fives Syleps, aims to demonstrate the feasibility of dynamic robotic palletization of heterogeneous products in hard working conditions; Extender (PI Vincent Padois), in collaboration with Orthopus, seeks to demonstrate the benefits of advanced control methods in robotics for an assistive arm mounted on a wheelchair. All these knowledge-transfer projects provide proof-of-concepts of the applicability of our research developments, notably in advanced robotic system control, into concrete industrial applications with human assistance in mind.

Collaborations for social and cultural impact. Team members participate in a few projects and events with socio-cultural impact: Sylvie Michel, Vincent Padois, Pierre Puchaud, and Margot Vulliez recently joined the Inria HanditechLab, a network led by the CAMIN team (Inria Sophia Antipolis) and the SED of Inria Grenoble, to develop ad hoc assistance solutions on demand, based on simple and easily reproducible technologies, for people with disabilities. Lucas Joseph and David Daney are involved in the collaborative project ARTES, between the University Bordeaux Montaigne, the SCRIME and the University of Bordeaux, to perform motion capture analysis of expert dancer gestures. The Auctus team was involved in 2024 in the organization of the two-day conference RobNA on ethics and robotics in Bordeaux, and of the multidisciplinary school xiho to explore methodologies to combine Social Sciences and Humanities, Human-Robot-Interaction, and user experiments.

Ethics. The work on the emergence of **ethical questions in the robotics research process**, led by Sylvie Michel, Associate Professor at IRGO of the University of Bordeaux in delegation within the Auctus team, is central to supporting the consideration of ethical issues within our community and to providing organizational tools that aid in integrating this societal dimension within our research. Besides this specific research focus, the Auctus team validates all its developments through rigorous user studies, validated by the Coerle local ethical committee, and before which all involved students are made aware of scientific research ethics and good practices regarding data (GDPR).

Environmental impact. When climate change makes environmental resources scarcer, sustainability of robotic solutions can no longer be ignored and forces us to reconsider our developments in terms of environmental impacts. We recently started to question this challenge of **frugality in robotics**. Vincent Padois is a member of the steering committee, and Margot Vulliez participates in the discussions of the Priority Action AP1 "Robotique et Sobriété" of the GDR Robotique. Vincent Padois and Margot Vulliez have co-supervised Master internships about sustainable co-design of a robotic manipulator. Vincent Padois participated in ANF EcoInfo 2025 on "Digital Sustainability" and has a membership in the GDRS EcoInfo network. He will soon organize local and national trainings on "Robotic Sustainability" through this network and the URFIST Bordeaux. Antun Skuric and Vincent Padois received the IEEE/RAS Sustainability Award in 2025 for developing an open-source platform (pycapacity) to quantify robotic capabilities for measured and appropriate use.

5.1 Involvement in working groups

- Margot Vulliez is member of the Committee on Gender Equality and Equal Opportunities (GT Parité-Egalité) and of the local Committee for Mentoring at the Inria Bordeaux research center, since January 2024.

- Margot Vulliez participate in the activities of the working group on Gender Equality of the priority action AP3 of the GDR Robotique, since December 2025.
- Vincent Padois and Margot Vulliez respectively steer and participate in the activities of the priority action AP1 on Robotics and Sobriety of the GDR Robotique.
- Vincent Padois is a member of the GDRS EcoInfo.
- Sylvie Michel, Vincent Padois, Pierre Puchaud, and Margot Vulliez are members of the Inria HanditechLab.

6 Highlights of the year

6.1 Remarkable events

- The work of Antun Skuric, Nicolas Torres, Lucas Joseph, Vincent Padois and David Daney on the optimal use of robot motion capabilities for the online replanning of robot trajectories has been published in the prestigious IEEE Transactions on Robotics journal [10]. It provides a control methodology that better exploits the true robot capabilities while allowing for online trajectory adaptations. We consider it as a stepping stone towards a general reduction of the use of resources in Robotics.
- Sylvie Michel, Associate Professor at IRGO of the University of Bordeaux, has obtained a one year partial delegation within the Auctus team. Her role is central to supporting the consideration of ethical issues within our community and to providing organizational tools that aid in integrating this societal dimension within our research. This is a pioneering cross-disciplinary approach to research in robotics which is essential to a proper consideration of the societal and environmental challenges we are facing and we are proud to promote it.
- Five members of the Auctus team participated in May to the Festival Sciences Tout Court through 26 interventions in primary school classes all over Gironde, in preparation of the main projection day of the Festival. These interventions were initiated by Vincent Padois in collaboration with Caroline Baronnet from Academie de Bordeaux.

6.2 Working conditions

The Auctus team is currently hosted at the École Nationale Supérieure de Cognitique (ENSC) of Bordeaux INP, under conditions that have been inadequate for several years due to a severe lack of space. Permanent researchers share open-plan offices with students, which significantly impacts working conditions. The launch of two “ANR Défi Transfert” projects (Grip4All and Extender) required additional experimental space, leading the team to finance an agreement with Arts et Métiers to host part of its activities on their Bordeaux site. This transitional and fragmented setup has proven both organizationally costly and inefficient. Moreover, the hosting conditions at Arts et Métiers are unsatisfactory, and the division of the team across two sites is not viable in the long term.

7 Latest software developments, platforms, open data

During the year, the Auctus team focused on migrating its codebase from ROS1 to ROS2. All robots and haptic devices now operate under this middleware. This migration required a significant investment of time and effort. In parallel, several experimental platforms were developed, either for research purposes or within the framework of the various engineering contracts that started this year.

7.1 Latest software developments

7.1.1 Qontrol

Name: Quadratic Optimization coNTROL

Keywords: Robotics, Control, Optimisation

Scientific Description: Generic expression of a robot control problem using constrained optimization in a dynamic environment, applicable to robots that can be controlled in terms of torque, speed or position.

Functional Description: Qontrol is a tool for the generic formulation of robotic control problems in the form of constrained optimization problems. It is initially intended for fixed-base polyarticulated robots. It allows to easily create tasks and constraints in the control law.

News of the Year: Declaration to the Program protection office. Appears in "transfert challenge" kind of project (awaiting for finding) Appears in a european project (awaiting for finding)

URL: https://auctus-team.gitlabpages.inria.fr/components/control/qontrol/index.html

Contact: Lucas Joseph

Participants: Lucas Joseph, Vincent Padois

7.1.2 pin-actuation

Keywords: Biomechanics, Robotics, Python

Functional Description: Pin-actuation is a Python library for adding actuation models to Pinocchio multibody dynamics models. It extends Pinocchio's core capabilities by enabling the simulation of different types of actuators, including motors and muscles. It also provides tools for parsing OpenSim models (version 4) to integrate their actuation specifications into Pinocchio. This allows for the analysis and control of complex biomechanical and robotic systems with realistic actuation dynamics.

Release Contributions: Features Added Freeflyer joint option Added Universal Joint option Added passive actuators Added visual model creation Added model sub-module and vtp2stl support Added joint coordinate_names list Added joint position limits to parsed models

Improvements & Refactors Refactored custom_joint parsing Refactored cable wire handling General refactors and test maintenance Cleaned OpenSim scouting parser Improved child orientation handling for joint addition Multiple internal refactors (topic/refactor)

Fixes Fixed child orientation during joint addition

Chore / Maintenance Added Ruff line-length check to CI Updated README Improved .gitignore (PyCharm & cache files) Fancy .gitignore cleanup

Contributors Thanks to:

Pierre PUCHAUD Mégane MILLAN Alexandre SCHORTGEN Maël GALLOIS

URL: https://gitlab.inria.fr/biomeca/pin-actuation

Contact: Pierre Puchaud

7.1.3 moveit2_trajectory

Keyword: Robotics

Functional Description: This package provides trajectory processing and execution capabilities for robotic systems. It serves as a bridge between MoveIt2 motion planning and robot controllers, offering trajectory interpolation, Cartesian pose computation, and a ROS 2 action server interface.

URL: https://gitlab.inria.fr/auctus-team/components/motion-planning/moveit2_trajectory

Contact: Lucas Joseph

7.1.4 ik_qontrol

Keyword: Robotics

Functional Description: Implementation of a CLIK (Closed-Loop Inverse Kinematics) solution based on Pinocchio and Qontrol. Integration of this solution into a MoveIt plugin, enabling its use throughout the MoveIt framework.

URL: https://gitlab.inria.fr/auctus-team/people/erwannlandais/public/ros2_ws/command/ik_qontrol

Contact: Erwann Landais

7.1.5 Active Constraint

Keywords: Haptic guidance, Haptic, Telerobotics

Scientific Description: The implementation of haptic guidance in a teleoperation context with a haptic interface aims to encourage operators to follow a desired behaviour while allowing a certain freedom of action. This package includes the integration of a generic formula allowing continuous transition between different types of generic guidance model (potential fields, spring-damper and guide tube) as well as adaptable guidance models (ruling guidance, marble cart).

Functional Description: active_constraint defines the following parameters: stiffness and damping factors for five different types of guidance (potential fields, spring-damper, guide tube, ruling guidance, and marble cart), as well as threshold distances, parameters for changing models on the fly, and parameters specific to each guidance model. The integration of an RVIZ plugin allows you to switch between each guidance type on the fly and modify the above parameters. The package subscribes to the position and velocity topics of the robot and the haptic interface scaled in the robot's workspace. It also subscribes to a topic to retrieve the target position(s) of the guidance. These positions and velocities are used to generate a guidance force that is sent to the communication hub linked to the haptic interface.

Publications: hal-04776071, tel-05418923

Contact: Alexis Boulay

Participants: Alexis Boulay, Margot Vulliez, David Daney

7.2 New platforms

7.2.1 Grip4All

Participants: Erwann Landais, Loic Mazou, Alexis Boulay, Lucas Joseph, David Daney.

This platform consists of two KUKA LBR iiwa 14 robotic arms, a conveyor, and a monocular camera. It demonstrates an automated palletizing solution for fresh produce. Product spatial positions are estimated using monocular vision. Depending on the product characteristics, grasping is performed either by a single arm (asynchronous operation) or collaboratively by both arms (synchronous operation).

Advanced control techniques are employed to dynamically manage accessibility constraints, grasping and placement feasibility, grasp stability during transfer, and the overall manipulation capabilities of the robotic system. In particular:

- **Qontrol**: online generation of optimal motions in dynamic contexts using model predictive control and advanced performance optimization tools for robotic systems.
- **MegaPose**: object recognition and 6D pose estimation (position and orientation in space).

These tools are developed at Inria or within the Auctus team and contribute to showcasing and advancing Inria's expertise in robotics.

7.2.2 Explorer

Participants: Esteban Cosserat, Margot Vulliez, Vincent Padois, Lucas Joseph.

The Orthopus Explorer is a 6-DOF robotic arm used within the EXTENDER project. The goal of the EXTENDER project is to improve the daily lives of people with disabilities by developing new, adaptable control modes for robotic arms. The objective is to use the Qontrol control software to command the robotic arm developed by Orthopus and to evaluate different control modalities, which will subsequently be tested by users with disabilities.

7.2.3 Courrier

Participants: Raphael Gerin, Margot Vulliez, Vincent Padois, Lucas Joseph.

The objective of the Courrier project is to evaluate the relevance of communicating a robot's intention to a human operator working in the same workspace. In this context, an experimental platform has been developed involving a robot tasked with sorting colored objects. The operator and the robot share a common goal. The software component allows the selection of different communication modalities used by the robot in order to assess their impact on task efficiency and safety.

7.2.4 DMC (Dual Marble Cart)

Participants: Alexis Boulay, Margot Vulliez, David Daney.

Experimental simulation platform dedicated to the evaluation of a novel adaptive guidance model (dual adaptable) and its comparison with traditional guidance models through reaching scenarios in dynamic and changing environments. This platform combines a physical haptic device with a simulated robotic system and has already been used to conduct an experimental campaign, which is expected to lead to scientific publications.

7.2.5 DRPG (Deformable Robot Path Guidance)

Participants: Alexis Boulay, Margot Vulliez, David Daney.

Experimental simulation platform for assessing new adaptable virtual objects (elastic band and predictive guide) and comparing them with a fixed virtual object through reaching scenarios in changing environments. This platform relies on a physical haptic device coupled with a simulated robot and has been used to conduct an experimental campaign that is expected to lead to scientific publications.

7.2.6 OuiJa

Participants: Alicia Barsacq, Lucas Joseph, David Daney.

Development of an experimental platform for planar haptic communication between a human dyad, aimed at assessing the sense of agency and understanding force exchange mechanisms. This platform makes use of force/torque sensors available at Inria, as well as a motion capture system, to analyze participant behavior and identify key interaction features.

7.2.7 LePre Haptic

Participants: Benjamin Camblor, Hoang-Vy Nguyen, Alicia Barsacq, Lucas Joseph, Margot Vulliez.

Experimental platform designed to evaluate the impact of legibility and predictability of haptic guides on performance, sense of agency, and subjective measures during an assisted teleoperation grasping task.

7.2.8 Beta

Participants: Jacques Zhong, Lucas Joseph, Margot Vulliez.

Experimental simulation platform dedicated to the evaluation and comparison of different dynamic arbitration methods. The experimental setup consists in a simulated 7 DoF robot arm (Panda Franka) implemented in Gazebo with communication between the devices handled in ROS. The robot is teleoperated with a haptic interface (omega.7, Force Dimension) in rate control. The task is a shared-control pick-and-place, where the assistance estimate can be non-conflictual or conflictual with the human targets at each scenario.

7.2.9 VisuoHaptic

Participants: Remi Lafitte, Lucas Joseph, Margot Vulliez.

Experimental teleoperation platform to study how Human agents perceive visual and haptic information and to further characterize the rules of multisensory integration. Users are asked to perform a psychometric size-discrimination task. Visual, haptic, and visuo-haptic objects (rectangular 3D shapes) are presented by means of a simulated visual environment (computer screen, Chai3D simulation environment) and a haptic interface (Omega 7.0). Object width, cues reliabilities, and visuo-haptic conflicts can be manipulated.

7.2.10 Bipetto

Participants: Virgile Batto, Margot Vulliez.

Prototype of a kid-size humanoid robot, built as an open-source, parallel-actuated biped experimental platform to evaluate proposed co-design and multi-objective optimization methodologies.

7.3 Open data

All the project-team's publications are openly accessible and referenced through HAL. The software associated with our publications is hosted on public repositories on the Auctus GitLab server, ensuring transparency and reproducibility of our results.

Pierre Puchaud is involved in maintaining a biomechanics suite of software in the Pyomeca organization within the ACER associate team, notably the software Bioptim dedicated to human motion simulation. He is also contributing to the Pinocchio software, with Mégane Millan (Engineer in the Inria Willow team) and Lucas Joseph.

Regarding research data, the datasets generated by the team are not publicly released, as they often involve industrial collaborations or sensitive information. Nevertheless, all data are stored and managed according to the **FAIR** principles: they are **Findable** within our internal storage infrastructure, **Accessible** to authorized members, **Interoperable** through standardized formats (CSV, HDF5, ROS bags, etc.), and **Reusable** thanks to comprehensive metadata, versioning practices, and documentation. Access rights and protection measures are defined jointly with our partners to ensure compliance with confidentiality requirements while preserving long-term data integrity and traceability.

All practices related to open science, data handling, and ethical considerations follow the guidelines established by Inria's *Coerle*, ensuring that our research activities respect the institute's standards for scientific integrity, responsibility, and transparency.

8 New results

8.1 Human Factors and cognitive approaches in human/system interactions

8.1.1 Personalized Binary Emotion Classification Using Multimodal Smartphone and Wearable Sensor Data

Participants: Jean-Marc Salotti.

The results of Nicolas Simonazzi's PhD thesis, defended three years ago, were revisited, valorized and published in 2025. This study investigated the binary classification of emotional valence using data collected from motion sensors and keystroke dynamics on a smartphone, as well as from a connected wristband. To this end, we developed a mobile application designed to induce emotions through video stimuli while recording user interactions. A dedicated digital self-assessment tool, adapted from the Geneva Emotion Wheel, was created to help participants report their emotional states. Sensor recordings were labeled according to participants' self-reports and the experimental video conditions. We propose a method to process the resulting temporal data and to automatically classify the valence of reported emotions using machine learning techniques. Both a general valence classifier trained on all emotions from all participants and a personalized classifier trained on a subset of emotions from a single individual were evaluated. The most promising results were obtained with the personalized model, which achieved, on average across participants, approximately two-thirds accuracy in valence classification using multimodal data fusion. [9].

8.1.2 Modeling Human visuo-haptic perception in teleoperation

Participants: Rémi Lafitte, Margot Vulliez, Cécile Scotto.

Reliable visual and haptic feedback are known to improve teleoperation tasks. Better understanding human visuo-haptic perception could help to develop feedback strategies that better inform the human operator during human-robot interaction. The project is conducted in collaboration with the CeRCA-CNRS at the University of Poitiers.

Psychophysic experiments have suggested that the brain combines visual and haptic estimates of environmental properties (e.g., object size) in a statistically optimal fashion. Whether this sensory integration still holds in a more challenging environment, such as for teleoperation, remains unknown. We developed a psychophysic experiment, involving 10 young healthy adults (median age = 27 years old, 5 males) performing teleoperation size-estimation tasks, to assess the validity of established integration models in teleoperation conditions. We compared the experimental results to the predictions of the optimal integration (Maximum-Likelihood Estimate) and of best-cue switching models. The experimental findings indicate that the observed visuo-haptic judgments could not be fully accounted by the sensory integration or sensory segregation models. In this sense, sensory integration in this experiment could be said "ambiguous" [22].

We further extended the experimental protocol to test if integrating the perceptual estimates of an individual operator in the feedback process, specifically by modulating the haptic feedback, can help the latter to better perform discriminate objects in teleoperation.

8.1.3 Legibility and predictability of haptic guidance in teleoperation

Participants: Benjamin Camblor, Hoang-Vy Nguyen, Alicia Barsacq, Margot Vulliez.

Haptic guidance is a method to assist a human operator performing tasks in teleoperation through force feedback. Taking into account human factors and individual preferences is crucial when designing such haptic assistance. It can modify the perception and understanding that humans have of the robot's assistance behavior, i.e. the cognitive transparency of the robot. Specifically, making the robot actions more predictable and/or more legible can highly impact the understanding of the robot's behavior during human-robot interaction. The predictability of an action is linked to its similarity to the action that the human agent would expect for a given objective (action deduced from its goal). Conversely, an action is legible when it enables the human to predict the objective or intention it expresses (goal deduced from the action).

The project aims at evaluating the impact of different haptic guidance on the legibility and predictability of the robot's assistance in teleoperation. We designed an experimental protocol and platform to study how different haptic guidance, where we vary the guidance-path curvature, can be more or less legible and predictable during assisted reaching scenarios. We further investigate the effect of haptic guidance legibility/predictability on performance, user comfort, and agency.

8.1.4 Proximal Human-Robot Collaboration: Toward Human-Like Joint Agency

Participants: Alicia Barsacq, David Daney, Jean-Christophe Sarrazin.

When interacting with artificial agents in a joint task, human can experience a loss of feeling of control, or a loss of agency. The origin of this phenomenon is not well understood, but have a negative impact on the subjective and objective performance, awareness during the task and involvment. However, interacting with a human partner can prevent this loss of agency in collaborativ joint action.

Through a literature review of current evaluations of agency in collaborative human-robot interaction, we show that the embodiement of robots can prevent agency loss in joint tasks in the same way two humans interacting together do. Several barriers preventing the understanding of joint agency in human-robot collaboration were identified, and guidelines for roboticists were provided to overcome them.

This thesis is co-supervised with ONERA as part of the PEPR O2R program.

8.2 Human Behavior Analysis

8.2.1 Study of Motor Variability

Participants: David Daney, Vincent Padois, Pauline Maurice, Jonathan Savin.

This long term research project led to a main action in 2024: the analysis of the experimental results obtained during the experimental campaign of 2023 (MOVER). These results are encouraging as they demonstrate that motor variability depends on some features of the task, especially pace and direction of the movement. Moreover, the observed motor variability is high enough to induce changes in biomechanical risk factors as estimated through standard ergonomic scores [50]. The analysis of the results will be pursued in 2025, potentially within the framework of the INTRO project submitted to the ANR yearly call in collaboration with INRS and the LARSEN team in Nancy.

8.2.2 Searching for best-fitting musculoskeletal models approximating an individual's upper limb force capacities

Participants: Gautier Laisné, Jean-Marc Salotti, Nasser Rezzoug.

Upper-limb force feasible set: theoretical foundations and musculoskeletal model reconstruction. In biomechanics, human hand force capacities refer to the set of feasible forces exertable at the hand considering arm posture and muscle tensions. In physical Human-Robot Interaction (pHRI), knowing the operator's force capacities allows the robot to adjust its assistance to avoid exceeding force limits. Using a musculoskeletal model representing a human upper-limb, force capacities can be described as a 3D polytope called the force polytope. Following Gautier Laisné's PhD defense in December 2024, we further investigated the relationship between a wrench generated at the end-effector of a serial kinematic chain with n degrees of freedom and the set of cable tensions capable of producing it in cable-actuated systems. A set-theoretic framework is used to characterize feasible force and moment sets, showing that their shape and size depend on the modeling of cable activations and tend toward an ellipsoidal geometry when a sufficient number of cables is available. A computationally efficient method based on the projection constant is introduced to construct ellipsoidal approximations of force and moment polytopes. The framework is extended to describe the full set of cable activations generating a given feasible wrench, and it is shown that maximal wrenches correspond to unique activations under spherical activation constraints. The approach is applied to inverse dynamics in a musculoskeletal model of the human upper limb with seven degrees of freedom and fifty muscles, enabling solutions to be computed in milliseconds without optimization. A Python library supporting high-dimensional convex set operations is provided to facilitate practical applications in robotics and biomechanics. A paper on this topic has been submitted to a journal.

8.2.3 Parametric Identification of Metabolic Models of Fatigue

Participants: Pierre Puchaud, Simon Bernier, Jérémy Briand.

In the context of analyzing human physical capacity and fatigue. We developed a computational pipeline using **Bioptim** to identify individualized physiological parameters from mechanical power and oxygen consumption. This framework provides a robust method for extracting internal physiological characteristics and fatigue metrics, expanding the team's capabilities in human monitoring beyond pure kinematics and dynamics. The problem aims to identify time-independent parameters, specifically maximal oxygen uptake, maximal lactate production rate, and active muscle mass percentage, while simultaneously reconstructing hidden metabolic states such as glycogen depletion and muscle lactate accumulation. The formulation satisfy non-linear biochemical dynamics derived from equilibrium equations (e.g., creatine-phosphate reaction, Hill equations for oxidative phosphorylation). This work is a collaboration with Université de Montréal.

8.2.4 Modeling of human-human physical interaction

Participants: Alicia Barsacq, David Daney, Jean-Christophe Sarrazin.

Using control theory tools such as feeback control and MPC, a physical model of the OuiJa platform was developped. This model allow for a simulation of the behaviour of one or two humans collaborating via haptic information exchange. The model relies on traditionnal implementation of computationnal neuroscience, taking into account muscle dynamics, sensory delays and noise. It produces simulated data such as force, movement of the OuiJa platform (position, velocity). Those simulated data can be compared to the experimental one in different conditions. Finally, this model allow for a computationnal model of agency to be tested via simulated prediction error in different conditions.

This thesis is co-supervised with ONERA as part of the PEPR O2R program.

8.3 Human Robot Interaction

8.3.1 Re-expression of manual expertise through manual control of a teleoperated system

Participants: Erwann Landais, Vincent Padois, Nasser Rezzoug.

In the thesis of Erwann Landais which was defended in December [37], we studied how teleoperation can allow for the remote expression of technical gestures, with chemistry as a potential applicative domain. Indeed, teleoperation enables a task to be carried out remotely by a human expert. This remote control is often a guarantee of greater safety and comfort, or simply of feasibility in hazardous environments. However, it can also mean a loss of efficiency, or added complexity. To avoid these pitfalls, it is necessary to consider 1) what constitutes an operator's expertise for a given task, 2) the constraints encountered in carrying it out, and 3) the form of a teleoperation system adapted to it. An example of a task that could benefit from teleoperation is the task of finding solvents for chemical compounds, which is one of Syensqo's areas of expertise. This involves characterizing the solubility of a solute in a set of solvents, in order to determine the optimum solvent for that solute. This task, based on visual, cognitive and manual expertise, is performed by a small number of expert technicians. Performing this task relies on an empirical, tedious and sometimes dangerous process, motivating the distancing of technicians from the experimental environment through robotic assistance. Using this task as a case study, the thesis of Erwann Landais aimed at answering the following questions : on the one hand, how can an operator's expertise be preserved when performing a task using a teleoperated system ? And on the other hand, how can the suitability of a teleoperation solution for performing an expert task be assessed ? To answer these questions, a broad-spectrum literature review was carried out and two experimental studies were conducted. While the first study studied semi-automatic manipulation protocols, in the second study, which restults were analysed in 2024, a robot was designed to achieve a range of motion similar to that observed in technicians, and intuitive interfaces were used to define the desired movement of the vial in real time. The study shows that controlling the robot via these interfaces does not achieve an efficiency similar to that of the manual mode. However,the performance achieved is encouraging, and the study identifies several avenues of improvement for the efficient and reliable deporting of the technical gesture in chemistry. Finally, beyond the application framework, this work establishes a comprehensive methodology for evaluating the performance of teleoperation modalities.

8.3.2 Adaptive haptic guidance to assist human during teleoperation

Participants: Alexis Boulay, Margot Vulliez, David Daney.

This work is within the framework of the collaboration with the Farm3 company and addresses issues of remote vertical farming.Performing remote tasks through a teleoperation system can be assisted through haptic guidance, a force feedback computed based on a virtual geometric constraints to help the user to follow a given behavior (task trajectory, safety area,...).

A user study showed that the choice of guidance model depends on the interaction context: task complexity, environmental clutter, user preference, etc. [24]. This initial result motivated the development of a generic, adaptable online haptic guidance that follows the dynamics of the interaction to optimize human comfort.

Adaptive guidance force profile. We have developed a new adaptable haptic guidance model, the dual adaptable model, which aims to maximise user comfort by optimizing the force feedback in real-time with respect to the surrounding environement. A user study was conducted to evaluate this model and compare it to other conventional models in changing and partially known environments.

Adaptive virtual guidance path. Two new adaptive haptic guidance virtual objects have been developed: the elastic band and the predictive guide. Their purpose is to maximise user comfort by adapting to the user's actions, regardless of the knowledge of the environment. A user study was conducted to evaluate these virtual objects and compare them to a fixed virtual object in changing and dynamic environments.

The results are described in the thesis [14] and will be published in a journal soon.

8.3.3 Unified human-robot simulation for modulation of muscle activation

Participants: Pierre Schegg, Pierre Puchaud, François Bailly.

Current robot-assisted physiotherapy often lacks explicit biomechanical integration in control systems. To address this, we develope a unified framework co-simulating a musculoskeletal model of the upper limb and a collaborative robotic arm. Using Bioptim, we formulated a single optimal control problem encompassing both human and robot variables to define assistive torque trajectories. This approach allows for the modulation of specific muscle activations—specifically the Supraspinatus in a rotator cuff rehabilitation scenario—via a single hyperparameter. Preliminary results demonstrate that the formulation reliably adapts the robot's control law. Rather than uniformly scaling torques, the controller non-trivially redistributes the load across robot joints to achieve targeted reductions in muscle activation. This work validates the use of optimal control to integrate biomechanical constraints into human-robot interaction, paving the way for personalized movement assistance in cases such as muscle dystrophy or hemiplegia.

8.3.4 A Riemannian approach for Inverse Optimal Control

Participants: Ahmed-Manaf Dahamni, David Daney, François Charpillet.

The methods for solving Inverse Optimal Control that are currently available in the literature are either computationally slow like the commonly used Bilevel, or approximative methods that do not recovered the closest trajectory to the observation. To try and solve this problem a new approach called the Projected IOC has been created. However, this method has encountered solvability issues using modern solver. In our research, we have discovered that the solvability prolems stem from a violation of the Mangasarian–Fromovitz constraint qualification (MFCQ).

Following this discovery, we have developed a new method based on Riemannian optimization that has working principles similar to the Bilevel approach with a faster run time. This method can compute the jacobian of the Direct Optimal Control problem if proper conditions are met for the jacobian to exist. Gradient descent is then used to minimize a distance to the observation.

8.4 Robotics and control

8.4.1 Model Predictive Control blending and adaptive assistance for shared human-robot teleoperation

Participants: Elio Jabbour, Margot Vulliez, Vincent Padois, Célestin Préault.

Shared control aims at assisting human operators using robots in physically and cognitively demanding tasks which cannot be automated as they require human expertise and deliberative abilities. Sharing control for a given task typically involves blending algorithms that combine human control inputs and (pre)planed assistance trajectories. Over the last year, we proposed a shared control architecture that combines a predictive approach to blending and adaptation mechanisms to correct imperfect assistance inputs.

Model Predictive Control-based Blending (MPC-B) approach. Conventional blending techniques, such as Linear Blending, compute a combined output but neither guarantee the feasibility of the blended motion nor the optimality of the combined decision. We formulated the blending problem as a constrained optimal control problem. Model Predictive Control is used to determine a feasible blended trajectory through a receding horizon constrained optimization, ensuring compliance with task and safety limits while enabling smooth control transitions. This new blending framework was validated in a 13-participant user study comparing the proposed MPC method to Linear Blending and unassisted teleoperation. The results demonstrated significant improvements in safety (collision avoidance) and task performance, as well as reduced physical and cognitive workload for the operators with this new blending method.

Adaptive assistance based on human corrective actions. The assistance behavior is planned based on a given model of the task environement. Some errors in this model can induce conflicts between the assistance trajectory and the actual user goals. We developed a bi-level adaptive assistance mechanism that corrects for model inaccuracies by treating the operator's input as a corrective measurement. This framework integrates a real-time Adaptive Kalman Filter to compensate for local, transient errors and an online N-Point Procrustes Analysis module to learn and correct for global, systematic misalignments over time. The adaptive mechanism was validated in a 12-user study involving scenarios with erroneous assistance targets. Results showed that the adaptation mechanism successfully corrected the model errors in real-time. Compared to non-adaptive assistance, the new approach ensured zero collisions, significantly reduced physical effort, and improved task completion time.

8.4.2 Dynamic authority distribution in haptic shared control

Participants: Jacques Zhong, Margot Vulliez, Jee-Hwan Ryu.

An important challenge of shared control lies in how two agents (i.e. the human and the assistance) share the control of the teleoperated robot, set through the level of authority. However, there is currently no consensus on the most relevant metric to use to adjust this level of authority between the human and the robot, as this is mainly context-dependent. The arbitration is often set through an arbitrary criteria defined by-hand and no global arbitration method exists.

We proposed a novel optimization-based framework that dynamically arbitrates between different authorithy distibutions, with an online adaptation mechanism with respect to the user and the task. The arbitration policy is formulated as a Quadratic Progam (QP) to combine different metrics under constraints over the authority level evolution. Bayesian optimization is used as a sample-efficient global optimizer to adjust the policy parameters in a few evaluations. We evaluated the proposed method on a shared-controlled reaching task involving two typical situations: non-conflictual and conflictual assistance. Compared to existing methods, results show that the method yields significantly better interaction quality (from both objective and subjective measures) for non-conflictual scenarios, but not for conflictual scenarios where the assistance goal is not aligned with the actual human target.

8.4.3 Scenario-based Model Predictive Control for safe and effective human-robot collaboration

Participants: Vincent Padois, Sebastien Kleff, Kloe Bonnet, Tianyi Jin, Raphael Gerin.

Human-robot collaboration requires both safety and effectivness to be considered as viable solution in situtations where human working conditions could benefit from a robotic assistance. These two objectives are somewhat antinomic. Achieving both requires both an optimal control approach (i.e. one that considers the long term consquences of the control actions), online replanning (to constantly adapt to changing objectives), as well as a way to consider the variability (and associated uncertainties) in the human motion strategies. To combine these three characteristics, we have started to explore Scenario-based Model Predictive Control (SMPC) as a way to formulate the control problem faced when considering Human-Robot collaboration. This work has been initiated within the framework of Kloe Bonnet internship and is being pursued as part of the ANR COURRIER research program with the PhD work of Tianyi Jin, co-advised by Sebastien Kleff and Vincent Padois. Raphael Gerin provides support with the implementation of the proposed control approach within an experimental set-up shared by the partners of the ANR project. He is also in charge of implementing state-of-the art, lower-level, task-based control strategies allowing for the robust achievement of the task and motion planning strategy emerging from the higher level SMPC controller. With this architecture he has provided a ready-to-use simulation software to one of the COURRIER project partner (Onera) performing robot motion prediction tests with humans.

8.4.4 A Unified Tactile Servoing Framework based on Hybrid Force-Position Control

Participants: Sebastien Kleff, Vincent Padois, Lucas Joseph.

In robotics, traditional force control lacks local contact information. Tactile sensors provide rich feedback on physical interaction, but remain notably difficult to integrate into real-time control loops. The research we are initiating towards tactile based control and its application to human-robot collaboration requires a solid grounding and we have proposed a unified tactile servoing formulation that allows explicit control of contact pose and force at the Center of Pressure (CoP). Unlike conventional tactile servoing techniques, which are tightly coupled to a specific sensor and often treat the contact wrench as disturbance to be rejected, our approach relies on a generic and physically grounded feature space. We derive a hybrid force-position control law based on the Jacobian at the CoP that naturally decouples force and motion subspaces, ensuring geometric consistency during the contact interaction. Our framework, validated on a robotic manipulator with vision-based tactile sensing, demonstrates robust contact maintenance and force tracking capabilities, outperforming standard imagebased and pose-based controllers in tasks requiring precise regulation of the physical interaction. This work has been submitted to the IEEE Robotics and Automation Letters [16].

8.4.5 Extended Friction Models for the Physics Simulation of Servo Actuators

Participants: Marc Duclusaud, Grégoire Passault, Vincent Padois, Olivier Ly.

Accurate physical simulation is crucial for the development and validation of control algorithms in robotic systems. Recent works in Reinforcement Learning (RL) take notably advantage of extensive simulations to produce efficient robot control. State-of-the-art servo actuator models generally fail at capturing the complex friction dynamics of these systems. This limits the transferability of simulated behaviors to real-world applications. In this work, we present extended friction models that allow to more accurately simulate servo actuator dynamics. We propose a comprehensive analysis of various friction models, present a method for identifying model parameters using recorded trajectories from a pendulum test bench, and demonstrate how these models can be integrated into physics engines. The proposed friction models are validated on four distinct servo actuators and tested on 2R manipulators, showing significant improvements in accuracy over the standard Coulomb-Viscous model. Our results highlight the importance of considering advanced friction effects in the simulation of servo actuators to enhance the realism and reliability of robotic simulations. This work has been published at IEEE ICRA 2025 [11].

8.4.6 Simulation, Observability Analysis, and AI Methods for Tracking

Participants: Jimmy Étienne, David Daney, François Charpillet.

Over the past year, I developed and validated simulation and diagnostic tools for estimation, tracking, and decision-making. Key contributions include the FIM Observability Tool, an interactive simulator for analyzing Fisher Information Matrix observability under bearing-only measurements, and a Passive Hydrophone Array Simulator that synthesizes towed-array sonar scenes with multi-hydrophone time series, bearing measurements, and ground-truth metadata to accelerate acoustic tracking and localization prototyping. In parallel, I contributed to early work on a new platform for mobile robotics and delivered new results through POMmeDaPy (Python POMDP implementations including naive solvers, value functions, value iteration, and HSVI) and machine-learning experiments using diffusion processes for trajectory generation.

9 Bilateral contracts and grants with industry

9.1 Suez

Participants: Raphael Gerin, Margot Vulliez, Lucas Joseph, Vincent Padois.

A collaboration agreement has been signed with Suez to develop a robotic proof-of-concept for the secure diagnosis of electric vehicle batteries, where different teleoperation modalities will be tested and compared.

Project in a nutshell:

- Consortium: AUCTUS@Inria, Suez
- Funding: 50 keuros
- Duration: 2025-2026

9.2 ISP

Participants: Lucas Joseph, Vincent Padois.

Within the ACHEAS project, the Auctus team has provided its engineering and scientific expertise to support ISP in improving robotic motion planning for the automated disassembly of helicopter turbine brackets. The collaboration focuses on integrating vision-based perception with state-of-the-art, generic motion planning algorithms to generate collision-free robot trajectories online, despite variable bracket configurations and the absence of complete 3D models, while ensuring computational efficiency and guaranteed safety distances during screw removal operations.

Project in a nutshell:

- Consortium: AUCTUS@Inria, ISP, DIHNAMIC
- Funding: 2.3 keuros
- Duration: 2025

9.3 Farm3

Participants: Alexis Boulay, David Daney, Margot Vulliez.

We collaborate with Farm3, a start-up company specialized in vertical farming, since 2020. The company develops a robotized vertical farm, the Cube, to grow plants in a controlled environment through ultrasound-based techniques. Agronomists and farmers can remotely act on the plants through a teleoperation system, to perform expert tasks (seedlings, pollinating flowers, measuring data...) without polluting the sensitive growth environment.

After preleminary results of a master's internship in 2021, a contract was signed with Farm3 in 2022 to start a PhD project. This PhD thesis, defended in 2025, led to the development of haptic guidance for robotic teleoperation, aiming to assist humans through guiding forces. It proposes a generic, online-adaptable haptic guidance framework capable of adjusting to the complexity of the environment and the task. A new unified model, called ruling guidance, enables continuous combination and adaptation of the main existing guidance models, and was validated through a user study and objective metrics (performance, safety, comfort, and trust). The thesis also introduces an adaptive dual guidance model based on optimization, as well as real-time adaptable virtual objects (elastic guide and predictive guide). Altogether, these contributions form a comprehensive framework for dynamic haptic guidance in evolving environments.

Project in a nutshell:

- Consortium: AUCTUS@Inria, Farm3
- Funding: Farm3, ANRT (CIFRE)
- Duration: 2022-2025

10 Partnerships and cooperations

10.1 International initiatives

10.1.1 Inria associate team not involved in an IIL or an international program

SHAARE Inria-KAIST associate team

Participants: Huseyin Tugcan Dinc, Dong-Hyeon Kim, Kwang-Hyun Lee, Jee-Hwan Ryu, Alexis Boulay, Jacques Zhong, David Daney, Margot Vulliez.

Title: Shared Haptics for Augmented Assistive Robot Expertise

Duration: 2024 -> 2026

Coordinators: Margot Vulliez (Auctus) and Jee-Hwan Ryu (IRiS lab director @KAIST)

Partners:

- IRiS lab - Korea Advanced Institute of Science and Technology (Daejeon, South Korea)

Summary: Haptic teleoperation is a promising method to enable Humans and robots to jointly perform an activity. The human operator can safely and remotely control the robot while receiving feedback on the task interaction. Recent shared-autonomy concepts have been proposed in the literature to transfer part of the task from the human operator to the robotic agent to better assist him. Scientific challenges to tackle in such shared control support the need for a generic shared haptic framework. It will merge both haptic guidance (force feedback that assists the human to perform the task) and blending methods (control strategy that combines the human inputs and robot assistive skills). This global framework is the main research direction of the SHAARE associate team and will be our common baseline to share different developments and control techniques. The joint works specifically aimed at augmenting robot assistive behavior in haptic teleoperation by improving haptic guidance and by dynamically distributing the authority between the human-robot agents.

10.1.2 Visits to international teams

Research stays abroad

Participants: Jacques Zhong.

Visited institution: IRiS lab - KAIST

Country: South Korea

Dates: September to November 2025

Context of the visit: In shared-control approaches collaboration between humans and robots is done as combinations of their actions toward the goal, weighted through a level of authority (more assistance or more human control). The associate team is interested in how to distribute this authorithy level with respect to the interaction context, the task, or other human factors. The research visit focused on developing and experimentally evaluating a new approach for dynamic authority distribution, and was done in collaboration with Jee-Hwan Ryu (Full Professor @KAIST)

Mobility program/type of mobility: Collaborative research visit - SHAARE associate team

Participants: Sebastien Kleff.

Visited institution: NYU, Columbia University

Country: USA

Dates: 20th of April to 20th of May

Context of the visit: The aim of the visit was twofold: 1) pursue the collaboration with Ludovic Righetti on force-feedback MPC and the development of the associated software library 2) Discuss about the tactile servoing topic together wit the team of Matteo Ciocarlie.

Mobility program/type of mobility: On-going collaboration with Ludovic Righetti at NYU and initiation of a collaboration with Matteo Ciocarlie at Columbia.

10.2 European initiatives

10.2.1 Other european programs/initiatives

Assistance Generation Techniques for multipurpose robot

Participants: Vincent Padois, Margot Vulliez, Alexis Boulay, Elio Jabbour.

This collaborative work with the CEA LIST is part of the EUROfusion program, and explores robotic teleoperation solutions to help in the maintenance of the future DEMO fusion-energy power plant. In the context of unplanned tasks, this work intends to provide a set of assistive generic tools and robot control solutions to help the operator to overcome unexpected situations in maintenance operations with a multipurpose robotic manipulator. User-interactive tools should provide a way to the operator to program remote handling tasks on the fly according to the context, the type and geometry of the equipment needing maintenance. Given the user-specified task, predictive controllers aim at locally computing the robot motion with respect to both the task trajectory and the human input motion (from the teleoperation device). Haptic feedback is generated to guide the human on the planned trajectory.

Project in a nutshell:

- Consortium: CEA LIST, AUCTUS@Inria
- Funding: EUROfusion
- Budget : 50 keuros for Auctus over the 2024-2025 period
- Duration: 2024 -

10.3 National initiatives

10.3.1 PEPR O2R - AS2, Robot motion with physical interactions and social adaptation

Participants: David Daney, Vincent Padois, Margot Vulliez, Alicia Barsacq, Jean-Christophe Sarrazin.

The objective of this structuring action is to rethink the problem of motion generation of robotic systems by addressing it in its globality and by redefining the research objectives in connection with the Human and Social Sciences. It aims on the one hand to develop technological solutions, innovative methods and software to provide these new generation robots with advanced planning and control capabilities of their movements and on the other hand to guarantee that the motor actions produced by these systems will be well adapted to humans. These systems will have to be able to interact physically with their environment and with humans to perform a wide panel of tasks ranging from agile locomotion to dexterous manipulation through collaborative tasks. Among the key objectives linked to these developments, these robots will have to be able to anticipate their movements but also to adapt them to react to unforeseen events and to implement robust control strategies to guarantee the successful execution of tasks and safety for the human. The question of movement autonomy of the machine and sharing of control during collaborative tasks will also be essential with regard to applications and needs. In all cases, it will be necessary to ensure the sustainability of the approaches developed with regard to environmental and societal challenges.

Project in a nutshell:

- Consortium: AUCTUS@Inria, Rainbow@inria, willow@inria, Onera, Lirmm, univ. Picardie, Cerca, Pprime
- Funding: France 2030 (PEPR O2R)
- Duration: 2024-2032

10.3.2 PEPR Robotics : Dexterous Robotic Manipulation for Industry

Participants: David Daney, Vincent Padois, Margot Vulliez, Lucas Joseph.

The PEPR Robotics program aims to develop the foundations of high-performance, frugal, and responsible robotics to support societal and industrial transformations, by integrating energy and environmental challenges while improving the productivity and sustainability of human activities. By accelerating research from its earliest stages, the program seeks to develop a set of functional, software, and hardware building blocks, enabling the emergence of innovative robotic systems or functions capable of delivering pre-maturation results and fostering valorization within the strategic sectors targeted by France 2030.

Robotic manipulation capabilities are crucial for industry but remain limited when dealing with complex, fragile, deformable, or size-varying objects. The DRMI project aims to overcome these limitations by developing advanced manipulation solutions suited to constrained industrial environments. It relies on the design of new versatile grippers integrating intelligent perception and adaptive control, capable of continuously adjusting position, speed, force, and stiffness. The project revisits the entire design chain of robotic manipulation systems, from mechanical structures to control algorithms. Aligned with a circular and frugal economy approach, DRMI particularly targets recycling and remanufacturing applications, which require dexterous manipulation at multiple scales, from millimeter-sized components to large objects.

Project in a nutshell:

- Consortium: AUCTUS@Inria, Rainbow@Inria, LIRMM, PPRIME, CEA List, ENSAM, Marie et Louis Pasteur Univ., Icube IMT Atlantique, Institut Pascal,
- Funding: France 2030 (PEPR Robotique)
- Duration: 2025-2032

10.3.3 ANR COURRIER, COopération hUmain Robot - Rôle des Intentions Exprimées par le Robot

Participants: Vincent Padois, Margot Vulliez, Lucas Joseph, Raphael Gerin, Tianyi Jin, Kloe Bonnet, Sebastien Kleff.

The COURRIER project addresses the challenge of safe and efficient human-robot collaboration in industrial environments. While collaborative robots are increasingly deployed, their opacity and limited predictability remain major barriers to effective coordination and safety. Rather than relying solely on isolation or fully autonomous intelligence, COURRIER proposes a complementary approach that leverages the human operator's ability to anticipate and coordinate with robotic systems, provided that their behavior and intentions are intelligible. Grounded in cognitive science and theories of joint action, the project investigates how the readability of a robot's intentions—at strategic, task-specific, and motor levels—affects its predictability and, in turn, human performance, cognitive load, learning, and trust. COURRIER combines robotics, control, cognitive psychology, and neuroscience to identify the minimal information required for humans to build accurate mental models of robotic behavior. The project develops both methods for communicating robot intentions through motion and control strategies, and objective metrics to quantify the impact of predictability on coordination quality and cognitive cost. The methodology relies on controlled human-robot collaboration experiments, centered on a shared object-sorting task using a collaborative robotic arm. Performance, subjective measures (trust, perceived control, usability), and physiological indicators (EEG, eye tracking) are jointly analyzed. The project is structured around five work packages covering coordination, intention communication, expressive control, performance evaluation, and learning and trust. Inria, through the Auctus team, contributes core expertise in robot control, predictive and constrained motion generation, and human-robot interaction. Auctus is responsible for the design and implementation of control architectures enabling the expression and communication of robot intentions, as well as the experimental robotic platform and simulation tools. The team plays a central role in bridging control theory, experimental validation, and cognitive modeling, ensuring strong integration between robotics developments and human-centered evaluation.

Project in a nutshell:

- Consortium: ICNA/Onera (coordinator - Jean-Christophe Sarrazin), INCIA/CNRS, Mnemosyne/Inria, Auctus/Inria (PI: Vincent Padois)
- Funding: ANR (367 800 Euros for Inria)
- Duration: 2024-2028

10.3.4 Défi Transfert robotique, GRIP4ALL

Participants: David Daney, Vincent Padois, Margot Vulliez, Lucas Joseph, Alexis Boulay, Erwann Landais, Loic Mazou.

As companies adapt to changes in the Factory of the Future, they need to modernise their working environments, in particular to improve logistics and transform industrial sites into flexible spaces incorporating intelligent machines and shared with human operators. The aim of the Grip4All project is to make industry more competitive by developing a new palletising cell adapted to the severe constraints imposed on the logistics flow when handling mixed products (of varying dimensions and weight) and arranging them on a pallet, without having to sort them manually upstream. This new type of palletising meets a strong demand from a number of sectors, notably mass distribution and the food industry. It meets the demand for handling heterogeneous products without imposing constraints on their packaging, which significantly improves productivity and eliminates tedious human tasks. No similar solution currently exists on the market. The flexible robotics issues addressed will be transposable to other logistics processes in the factory of the future. Grip4All is proposing a logistics line design that breaks with the state of the art, where lines are usually built by aggregating specialised cells: by their very nature, these limit the possibilities for logistics to evolve and adapt to a wide variety of products, and therefore also their sustainability in a context of sustainable development. The Grip4All approach is based on the use of the technological building blocks of robotics and new technologies in gripping, dynamic movement planning, AI perception and scheduling. The palletising cell is made flexible by using one or more 'augmented' manipulator arms with adaptive grippers, and by arranging and controlling the manipulator arms collaboratively in a dynamic environment. The system is based on a reactive and predictive control mode, as well as perception and scheduling algorithms that detect heterogeneous products and calculate their positioning according to their nature. The aim is to be able to handle a wide variety of products on the same pallet in real time, with adaptive gripping capabilities compatible with a wide range of products (weight, shape, nature, packaging), including two-arm gripping, and with vision-based detection and perception capabilities coupled with dynamic generation of movements for gripping and depositing products on the pallet. To meet this challenge, the project brings together 4 complementary partners: 2 industrial partners and 2 academic partners. The Fives industrial group, through its subsidiary FIVES Syleps, world leader in computerised and robotised mixed palletising, is seeking to stay ahead of its competitors and open up new markets. Subcontracting industrial partner Kannon MSD specialises in vision-based perception. The INRIA teams will contribute their technological building blocks in the form of software dedicated to reactive control in dynamic and human environments by Auctus, and to product scheduling by the Edge team. RoBioSS, a leading team in the development of high dexterity robotic hands and grippers, will contribute its mechatronic design bricks to increase robot flexibility. To ensure that the solution is acceptable and that human factors are taken into account, the consortium will be supported by the CERCA laboratory, which is working closely with the RoBioSS team has been working on this subject for over ten years.

Project in a nutshell:

- Consortium: AUCTUS@Inria (coordinator - David Daney), RoBioSS@Pprime (CNRS), Syleps@Fives
- Funding: France 2030 (952 000 Euros for Auctus)
- Duration: 2024-2027

10.3.5 Défi Transfert robotique, Extender

Participants: Esteban Cosserat, Vincent Padois, Margot Vulliez, Lucas Joseph.

Project in a nutshell: The EXTENDER project aims to help wheelchair users perform daily tasks using a robotic arm by developing solutions that adapt to diverse sensory-motor, cognitive, and socio-economic profiles. The project follows a co-design approach involving robotics labs, the industrial partner ORTHOPUS, end users, medical teams, and socio-anthropology researchers. EXTENDER targets the growing assistive technology market, leveraging recent advances in robot control and human-robot interaction to improve safety, robustness, efficiency, and ease of use. The project integrates multimodal interfaces—joysticks, touch, motion, eye tracking, voice, and AR—and evaluates solutions through lab experiments, healthcare center trials, and international competitions (Cybathlon 2025-2026), complemented by socio-anthropological observations. Inria's Auctus team leads the adaptation of advanced control and interaction methods, ensuring safety, intuitiveness, and robustness in real-world use. They also contribute to evaluation, personalization, and technology transfer, bridging research and industrial deployment alongside ORTHOPUS and clinical partners.

- Consortium: ISIR/Sorbonne Université (coordinator: Guillaume Morel), Orthopus, AUCTUS@Inria (PI: Vincent Padois), LAAS/CNRS, ESEAN, Université de Clermont
- Funding: France 2030 (324 000 Euros for Auctus)
- Duration: 2024-2027

10.3.6 ANR ASAP-HRC, Autonomy for Shared Action and Perception in Human-Robot Collaboration

Participants: Vincent Padois, Margot Vulliez, Jacques Zhong, Elio Jabbour, Benjamin Camblor, Remi Lafitte, Célestin Préault, Cécile Scotto.

This collaborative ANR project started in 2021 between the AUCTUS team at Inria, the RoBioSS team at the Pprime Institute (CNRS), and the CeRCA laboratory (CNRS). It aims at rethinking autonomy for shared action and perception in Human-Robot Collaboration, through transverse studies in robotics and cognitive sciences. More particularly, three scientific axes must be addressed to develop a human-centered and generic shared-autonomy framework: 1) study key features of Human-Robot perception-action mechanisms and identify multisensory integration processes involved in Human-Robot interaction. These human studies should constitute the baseline of robotic developments and shape the shared-autonomy scheme; 2) develop a shared perception between the different actors (humans and collaborative robots),according to their sensory data and involvement in the task. This shared perception will be based on a multimodal (haptic, visual) feedback mixture conveying information about the task, the environment, and the collaborators; 3) combine Human-Robot commands into a joint action toward the task goal. The human inputs will first be used to infer the operator intent and adapt the robot behavior. Then, the shared action will combine robot skills and human commands into a unified and consistent control objective.

Project in a nutshell:

- Consortium: AUCTUS@Inria (coordinator - Margot Vulliez), RoBioSS@Pprime (CNRS), Interactions@CeRCA (CNRS)
- Funding: ANR Funding (287 840 Euros)
- Duration: 2021-2026

10.3.7 LAAS-AUCTUS collaborations

Participants: Thomas Flayols, , Nicolas Mansard, , Vincent Bonnet, , Virgile Batto, , Margot Vulliez, , David Daney.

We have built a close scientific relationship with the Gepetto team at LAAS CNRS (Toulouse) these past few years, through several collaborative projects:

Legged-robot codesign (2022-2025): This PhD project aimed at developing a generic codesign approach to cover the hardware specification and dimensioning and the control strategy and requirements at once. We proposed to leverage mastered AI-based methods (simulation, planning, optimization) to guide the mechatronic design cycles and to provide tools to assist designers. The transversal approach was applied to the design and prototyping of BIPETTO a new parallel-actuated kid-size legged robot. Inverse Optimal Control: A collaboration on Inverse Optimal Control problem has started in pursuit of the results obtained previously.

Project in a nutshell:

- Consortium: AUCTUS@Inria, GEPETTO@LAAS (CNRS)
- Funding: None
- Duration: 2021-Ongoing

10.3.8 National visits to the team

- Ludovic de Mattéis, LAAS-CNRS, PhD Student, Toulouse, gave on April 28th 2025 a presentation on "Optimal control of walkers with parallel actuation."

10.4 Regional initiatives

10.4.1 AAPR Perception-HRI, Improving perceptual information in human-robot interaction

Participants: Margot Vulliez, Benjamin Camblor, Remi Lafitte, Cécile Scotto.

This regional project completes the ASAP-HRC ANR objectives with additional cognitive studies to improve the exchange of perceptive information during Human-Robot interactions. Such an exchange of information between the agents is required to communicate and coordinate together. We particularly focus on visual and haptic feedbacks, related to the task, the context, or the robot assistance, and given through a teleoperation device to perform an industrial task. Only a fine analysis and modeling of the human multisensory perception and integration processes can provide practical guidelines to determine the optimal mixture of feedbacks to implement in the human-robot interface. The project therefore aims at developing personalized mathematical models of the perceptive and sensorimotor integration of visuo-haptic informations, in interaction scenarios with a robot. We additionally investigate how different haptic guidance can be perceived by a user, particularly studying the effect of legibility and predictability of a guidance path on performances, comfort or trust in the assistance.

Project in a nutshell:

- Consortium: AUCTUS@Inria (coordinator - Margot Vulliez), RoBioSS@Pprime (CNRS), Interactions@CeRCA (CNRS)
- Funding: Région Nouvelle Aquitaine
- Duration: 2022-2025

11 Dissemination

11.1 Promoting scientific activities

11.1.1 Scientific events: organisation

General chair, scientific chair

- Margot Vulliez was Studio chair for the ACM International Conference on Tangible, Embedded and Embodied Interaction, TEI 2025, Inria - CNRS - Université de Bordeaux
- Jean-Marc Salotti was the general chair of the European Mars Conference (EMC 2025), which was held in Paris on 28–29 November 2025.
- Pierre Puchaud led organization of the Webinar of R4-Robotique since September 2025, 7 webinars with high-quality national and international presenters, weekly-based online seminars. R4 site

Member of the organizing committees

- Margot Vulliez co-organized the thematic session "Mechanical Design and Deformable Robotics" at JNRR 2025

11.1.2 Scientific events: selection

Member of the conference program committees

- Vincent Padois is associate editor for the IEEE International Conference on Robotics and Automation ICRA.

Reviewer List of conferences for which Auctus members have review activities:

- 2025 IEEE International Conference on Robotics and Automation ICRA
- 2025 IEEE/RSJ International Conference on Intelligent Robots and Systems IROS
- 2025 Congrès annuel de la société de biomécanique

11.1.3 Journal

Reviewer - reviewing activities List of journals for which Auctus members have review activities:

- IEEE Transactions on Robotics
- IEEE Robotics and Automation Letters
- International Journal of Robotics Research

- Mechanism and Machine Theory
- IEEE Transcations on Haptics
- Journal of Mechanisms and Robotics
- International Journal of Social Robotics
- Journal of Field Robotics
- IEEE Transactions on Biomedical Engineering
- International Journal for Numerical Methods in Biomedical Engineering

11.1.4 Invited talks

- Margot Vulliez: Joint GDR day, GDR Robotique and GDR IHM, November. Toward human-centered haptic design.
- Marot Vulliez, Alexis Boulay, Elio Jabbour: GDR day on Shared Control, TS4 Humans and Robots, January. Unified methodologies for adaptive shared control and haptic guidance.
- Alicia Barsacq: JNRR, Rennes, 30 September, nvolvement of Predictive Mechanisms in Human-Robot Joint Action: the Lens of Agency.
- Sebastien Kleff: LAAS, Gepetto Team, Toulouse, May. From force-feedback MPC to tactile servoing.
- Sebastien Kleff: LIRMM, IDH Team, Montpellier, December. From force-feedback MPC to tactile servoing.
- Sebastien Kleff: CRISTAL, DEFROST Team, Lille, December. From force-feedback MPC to tactile servoing.
- Jacques Zhong: IRiS lab, KAIST, Daejeon (South Korea), October. Adapting robotic systems to humans through dynamic shared control and multi-morphological simulation of virtual humans.
- Vincent Padois : Nov 2025 Invited seminar at Longlab, Atlantic Technological University of Galway: Getting the Human in the control loop of the collaborative robot (and vice-versa). Organizer: Prof. Philip Long (ATU). Galway, Ireland
- Vincent Padois : Oct 2025 Invited seminar at the JNRR workshop session (Journées Nationales de la Recherche en Robotique): Getting the Human in the control loop of the collaborative robot (and vice-versa). Organizer: Dr. Claudio Pachierotti (CNRS). Rennes, France

11.1.5 Leadership within the scientific community

- Margot Vulliez is co-coordinator of the Support Action "Hardware" of the PEPR Robotics Acceleration together with Abderrahmane Kheddar (LIRMM) and Olivier Ly (Labri Rhoban).
- Pierre Puchaud is part of the biomechanics groups within INRIA, responsible for software
- Pierre Puchaud is in charge of the Bioptim library: Maintainer, conducting weekly development reviews to guarantee software robustness.
- Vincent Padois: Leader of the advisory committee for the creation of a University Hub for Advanced Robotics Sciences (PULSAR) under the SIN department of the University of Bordeaux.
- Vincent Padois member of the GDR Robotics thesis award committee.
- Vincent Padois Representative of the Inria program agency and member of the creation committee of the PEPR “Accélération Robotique”.

- Vincent Padois Co-leader of the Priority Axis 1 “Robotique et Sobriété” of the GDR Robotics.
- David Daney is a member of the Scientific Council of the GDR Robotics, the main organization for robotics researchers in France.
- David Daney David participates in the Inria Master Class.

11.1.6 Scientific expertise

- David Daney is a member of the executive board of the "Aquitaine robotics" cluster, which brings together robotics players in Nouvelle-Aquitaine.
- David Daney represents Inria on the board of directors the "Aquitaine robotics" cluster.
- David Daney is the coordinator of 2 working groups (GT) on the evaluation and on the creation of 2 Inria Projet-Teams for the Inria Evaluation Committee.
- Jean-Marc Salotti represents Ensc on the board of directors of the "Aquitaine robotics" cluster.
- Margot Vulliez was external reviewer for the evaluation of a research proposal at the Swiss National Science Foundation SNSF, 2025
- Vincent Padois was external reviewe for the UP-SQUARED research call, PIA4 ExcellenceS Univ. Poitiers.
- Jean-Marc Salotti was a scientific advisor for the Cap Sciences exhibition dedicated to the exploration of the Moon.

11.1.7 Research administration

- David Daney is the Head of Science at Inria centre at the University of Bordeaux
- David Daney is a member of of the Inria Evaluation Committee.
- David Daney is a member of the France 2030 Robotics Committee.
- David Daney is member of the "Commission des Emplois de Recherche" for the Inria centre at the University of Bordeaux.
- David Daney is member of the "Comité de Centre" of the Inria centre at the University of Bordeaux.
- David Daney is a member of the executive board of R4, a regional robotics network involving 12 research entities in the region of Nouvelle-Aquitaine, France.
- David Daney is the principal investigator of DTR Grip4All ANR/France 2030
- David Daney is the co-investigator of Topic Priority DRMI within the PEPR Robotics
- Margot Vulliez is member of the "Commission des Emplois de Recherche" for Inria centre at the University of Bordeaux, since January 2024.
- Pierre Puchaud is member of the CUMI (Communauté des Utilisateurs des Moyens Informatiques): Representative for the Auctus team at the INRIA Bordeaux center.
- Vincent Padois is president of the Technological Developments Commission (CDT) at Inria Bordeaux.

11.2 Teaching - Supervision - Juries - Educational and pedagogical outreach

- Licence: Margot Vulliez, Mechanical Design, 24h éqTD, L1, BUT GMP, IUT of Bordeaux, France.
- Licence: Margot Vulliez, Design Projects, 13h éqTD, L2, BUT GMP, IUT of Bordeaux, France
- Licence: Benjamin Camblor, Facteurs humains et Ergonomie, L3 Mathématiques et Informatiques Appliquées aux Sciences Humaines et Sociales (MIASHS), Université de Bordeaux
- Licence: Alicia Barsacq, Structures arborescentes, 46h eqTD, L3, Enseirb, Bordeaux INP
- Master: Benjamin Camblor, Facteurs humains et interactions homme/machine, M1 Sciences cognitives et Ergonomie, Université de Bordeaux
- Master: Alexis Boulay, ROS 2 Introduction 10heq TD, M2, Enseirb
- Master: Alexis Boulay, Robotic Introduction 14.25heq TD, M2, Bordeaux University
- Master: Lucas Joseph, ROS 2 Introduction 20heq TD, M2, Enseirb
- Master: Lucas Joseph, Projet robotique 16heq TD, M2, CESI
- Master: Jacques Zhong, Tutoring and jury member for IT projects, ENSC
- Master: Vincent Padois, INP Bordeaux, ENSEIRB-MATMECA (30 eqTD hours) — 3rd year robotics option: responsible for robotics project UE and bibliographic research course initiated at my arrival in Bordeaux.
- Master: Vincent Padois, INP Bordeaux, ENSPIMA (25 eqTD hours) — 3rd year: UE “Collaborative Robotics and Gesture Assistance”
- Master: Vincent Padois, University of Bordeaux, Master in Mechanical Engineering (3 eqTD hours) — Introduction to industrial robotics in a process engineering UE, M1.
- Master: David Daney , Interactions Humains Robots, 6h eqTD, M2, Ecole Nationale Supérieure de Cognitique / Bordeaux INP, France.
- Master: David Daney , Numerical Methods for Robotics, 22h eqTD, M2, Enseirb/Ensc, Bordeaux INP, France.
- Master: David Daney , oral expression, 6h eqTD, M2, Enseirb/Ensc, Bordeaux INP, France.

11.2.1 Supervision

PhD in progress

- Ahmed-Manaf Dahmani (Inria), "Robust inverse optimal control for human motion analysis", funding: Inria, December 2023-, David Daney, François Charpillet (Inria Nancy)
- Alicia Barsacq (Inria), "Etude des méthodes de feedback pour une interaction homme/robot agentive", funding: PEPR O2R, September 2024 - , David Daney, Jean-Christophe Sarrazin (Onera)
- Kevin Co, "Commande optimale pilotée par stimulation électrique fonctionnelle et modélisation de la fatigue.", , August 2022 -, Mickael Begon (Udem EKSAP), Florent Moissenet (a Kinesiology Laboratory and Biomechanics Laboratory, Geneva University Hospitals and University of Geneva, Geneva,Switzerland), Pierre Puchaud
- Tianyi Jin, "Modular Model Predictive Control Architecture for Human-Robot Collaboration", funding: ANR COURRIER, October 2025-, Vincent Padois, Sébastien Kleff. Modular Model Predictive Control Architecture for Human-Robot Collaboration. Tianyi joined the summer school on Robust Model Predictive Control with CasADi held by University Freiburg in Sept 2025 as a prior to his PhD.

PhD defended

- Alexis Boulay (Farm3, Cifre), "Assister l'humain par un guidage haptique adaptable, application à l'agriculture verticale téléopérée", September 2025, David Daney and Margot Vulliez
- Virgile Batto (CNRS), "Systematic optimization of bipedal leg architectures: from foot-centric performance metrics to automated design", October 2025, Nicolas Mansard (LAAS-CNRS), Thomas Flayols (LAAS-CNRS) and Margot Vulliez
- Elio Jabbour (Inria), "Shared-autonomy control for improving Human-Robot collaborarion in haptic teleoperation", funding: ANR ASAP-HRC, November 2025, Margot Vulliez, Célestin Préault (CESI) and Vincent Padois
- Marc Duclusaud (Université de Bordeaux, Rhoban), "Approches modélisatoires et apprentissage par renforcement pour la locomotion robuste et autonome des robots humanoïdes en contextes dynamiques", funding: RobSys, December 2025, Olivier Ly (Université de Bordeaux), Grégoire Passault (Université de Bordeaux), Vincent Padois

Masters and Final Year Projects

- Kloé Bonnet, 6 months Master 2 internship on scenario-based Model-Predictive Control for robust human-robot collaboration. Sebastien Kleff,Vincent Padois
- Khouloud Hamrouni, 6 months Master 2 internship on setting up a robotics experimentation platform. Lucas Joseph
- Hoang-Vy Nguyen, 2 months Master 1 internship in Cognitive Sciences on setting up a user experiment about haptic guidance legibility/predictibility. Benjamin Camblor
- In the context of the exchange program between Karunya University (India) and ENSC-Bordeaux INP, Jean-Marc Salotti supervised the 2 months Internship of 5 ENSC students, which were related to the robotics domain.

11.2.2 Juries

PhD

- Margot Vulliez: Sonia-Laure Hadj Sassi, Reviewer, Modèle Biomécanique pour l'amélioration et la sécurisation de l'intéraction humain-robot, Université de Toulouse, 2025/12/09
- David Daney: Verlein Radwin, Reviewer, Set-Membership Methods for the Registration Problem in Exploration Robotics, Université de Montpellier, 2025/12/11
- Vincent Padois: Pierre La Rocca, President of the jury, Modélisation conséquentielle et territoriale de l'empreinte carbone d'équipements numériques pour l'agriculture et du réseau mobile associé, Université de Bordeaux, 2025/12/15
- Vincent Padois: M. Manzano, President of the jury, Contributions à l'ergonomie et aux stratégies de commande des exosquelettes de suppléance du membre supérieur, Insa de Rennes, 2025/12/04
- Vincent Padois: M. Bamaarouf, President of the jury, Development of a robotic system for assisting with ultrasound examinations: Contact management, Université de Clermont, 2025/11/21

HDR

- Vincent Padois: V. Bonnet, Reviewer, Capturing, modeling and understanding human dynamics for assistive robotics, Université de Toulouse, 2025/06/10

Recruitment

- Margot Vulliez participated in recruitment jury MCF in Robotics, section 61, Université de Technologie de Tarbes UTTOP, LGP, 2025
- Margot Vulliez participated in recruitment jury MCF in Robotics, section 61, Université de Toulon SeaTech, COSMER, 2025
- Margot Vulliez participated in recruitment jury MCF in Robotics, section 60-61, Sorbonne Université, ISIR, 2025
- Vincent Padois: President of the selection committee for Associate Professor recruitment MCF61, position 250829 at UTTOP (Tarbes)
- Vincent Padois: Member of the jury for the Inria Research Scientist (CR) competitive recruitment, Bordeaux center
- David Daney: Vice-President of the jury for the Inria Research Scientist (CR) competitive recruitment, Bordeaux center
- David Daney: Member of the jury for the Senior Inria Research Scientist (DR) competitive recruitment, Bordeaux center

11.2.3 Educational and pedagogical outreach

- As part of the "Fête de la Science" week, Jean-Marc Salotti offered about thirty high school students a robotics game designed to help them better understand the degrees of freedom of a robotic arm.

11.3 Popularization

11.3.1 Specific official responsibilities in science outreach structures

- Vincent Padois: Assigned to scientific mediation for Inria Bordeaux and member of the steering committee of the Aquitaine external scientific circuit

11.3.2 Productions (articles, videos, podcasts, serious games, ...)

- Jean-Marc Salotti took part in a video on the Curieux YouTube channel as part of the presentation of the Cap Sciences exhibition dedicated to the exploration of the Moon. Youtube video
- Margot Vulliez was interviewed for the content of Cap.Sciences workshop "Les Femmes Scientifiques" on Sciences.live, September 2025
- Margot Vulliez was interviewed for the Inria portrait series « Elles font le numérique », June 2025
- Pierre Puchaud was speaker at the INRIA Diggest seminar, "Un parcours en Biomécanique pour rejoindre Auctus", July 2025

11.3.3 Participation in Live events

Festival sciences tout court(s) 26 interventions in 13 primary schools about robotics, in the context of a young-audience festival for scientific documentary films with the Bordeaux Academy, May 2025

- Vincent Padois, Ecole de Saint-Laurent-Médoc
- Vincent Padois, Ecole Mousset Pauillac
- Vincent Padois, Ecole Jean de La Fontaine Gujan Mestras
- Vincent Padois Ecole Le Delta Le Teich

- Jacques Zhong, Ecole Jules Ferry Pessac
- Sebastien Kleff, Ecole Ferdinand Buisson Bègles
- Sebastien Kleff, Ecole Pasteur Carbon Blanc
- Margot Vulliez, Ecole de Macau
- Margot Vulliez, Ecole Pablo Picasso Moulis-en-Médoc
- Margot Vulliez, Ecole de Saint-Savin
- Margot Vulliez, Ecole de Générac
- Lucas Joseph, Ecole l'Aygue Marine Ayguemorte les Graves
- Lucas Joseph, Ecole Jean de La Fontaine Martignas sur Jalles

Un scientifique une classe – Chiche ! Seminars to raise general awareness of science and research careers for high school student secondary students

- Margot Vulliez, Lycée Maine de Biran, Bergerac (24), February 2025
- Vincent Padois, Lycée de Parentis-en-Born (40), January 2025
- Alicia Barsacq, Lycée polyvalent Gustave Eiffel, Bordeaux (33), December 2025

Classe transplantée Robot - CapScience / Les petits aventuriers du Numérique Presentation of robotic research to primary school students

- Jacques Zhong, CapScience, Côté Sciences Air&Espace, Mérignac, February 2025
- Sebastien Kleff, CapScience, Côté Sciences Air&Espace, Mérignac, February 2025
- Lucas Joseph, CapScience, Côté Sciences Floirac, October 2025
- Vincent Padois, CapScience, Côté Sciences Floirac, Februrary and October 2025
- Margot Vulliez, Ecole Louise Michel, Bordeaux, November 2025
- Lucas Joseph, Ecole Albert Schweitzer, Bordeaux, November 2025

Fête de la Science

- Sebastien Kleff and Margot Vulliez, Hand-on workshop to discover robotics, High-school students, "Mouvement de robots, comment construire un robot pour faire une tâche ?", Circuit Sciences du Numérique en Nouvelle-Aquitaine, Aiguillon (47) and Terrasson (24), October 2025

Journée des enseignants et enseignantes de NSI-SNT

- Margot Vulliez, Talk about robotics research and possible applications in high-school teachings, Inria Bordeaux research center, February 2025.

12 Scientific production

12.1 Major publications

[1] B. Camblor, D. Daney, L. Joseph and J.-M. Salotti. 'Attention Sharing Handling Through Projection Capability Within Human-Robot Collaboration'. In: *International Journal of Social Robotics* (16th Feb. 2024). DOI: 10.1007/s12369-024-01101-9. URL: https://inria.hal.science/hal-04399124.

[2] M. Jorda, M. Vulliez and O. Khatib. 'Local Autonomy-Based Haptic-Robot Interaction With Dual-Proxy Model'. In: *IEEE Transactions on Robotics* 38.5 (2022), pp. 2943–2961. DOI: 10.1109/TRO.2022.3160053. URL: https://hal.science/hal-03830217.

[3] N. Rezzoug, A. Skuric, V. Padois and D. Daney. 'Simulation Study of the Upper-Limb Isometric Wrench Feasible Set With Glenohumeral Joint Constraints'. In: *Journal of Biomechanical Engineering* 147.2 (1st Feb. 2025), p. 024501. DOI: 10.1115/1.4067329. URL: https://hal.science/hal-04915107.

[4] A. Skuric, N. T. Alberto, L. Joseph, V. Padois and D. Daney. 'Online approach to near time-optimal task-space trajectory planning'. In: *IEEE Transactions on Robotics* (9th Dec. 2025), pp. 1–16. DOI: 10.1109/TRO.2025.3641869. URL: https://inria.hal.science/hal-04576076.

[5] A. Skuric, V. Padois and D. Daney. 'Pycapacity: a real-time task-space capacity calculation package for robotics and biomechanics'. In: *Journal of Open Source Software* 8.89 (12th Sept. 2023), p. 5670. DOI: 10.21105/joss.05670. URL: https://inria.hal.science/hal-04316801.

12.2 Publications of the year

International journals

[6] O. David, V. Dhédin, J. Dumora, V. Padois, A. Rebbouh and F. Milella. 'Using programming by demonstration tools for DEMO maintenance: a framework proposal with an experimental validation'. In: *Fusion Engineering and Design* 215 (2025), p. 114935. DOI: 10.1016/j.fusengdes.2025.114935. URL: https://inria.hal.science/hal-04990347.

[7] É. Fournier-Aubret, A. Landry, B. Piras, D. Pellier, H. Fiorino, D. Daney and C. Jeoffrion. 'Proof of concept of a cobotic system in a constrained work environment'. In: *Applied Ergonomics* 125 (May 2025), p. 104472. DOI: 10.1016/j.apergo.2025.104472. URL: https://hal.science/hal-04926592.

[8] N. Rezzoug, A. Skuric, V. Padois and D. Daney. 'Simulation Study of the Upper-Limb Isometric Wrench Feasible Set With Glenohumeral Joint Constraints'. In: *Journal of Biomechanical Engineering* 147.2 (1st Feb. 2025), p. 024501. DOI: 10.1115/1.4067329. URL: https://hal.science/hal-04915107 (cit. on p. 9).

[9] N. Simonazzi, J.-M. Salotti, C. Dubois and P. Le Goff. 'Automatic classification of emotions using motion sensors and keystroke dynamics on smartphones'. In: *Ingénierie cognitique* 8.1 (July 2025), pp. 1–23. DOI: 10.21494/ISTE.OP.2025.1328. URL: https://hal.science/hal-05185171 (cit. on p. 20).

[10] A. Skuric, N. T. Alberto, L. Joseph, V. Padois and D. Daney. 'Online approach to near time-optimal task-space trajectory planning'. In: *IEEE Transactions on Robotics* (9th Dec. 2025), pp. 1–16. DOI: 10.1109/TRO.2025.3641869. URL: https://inria.hal.science/hal-04576076 (cit. on p. 15).

International peer-reviewed conferences

[11] M. Duclusaud, G. Passault, V. Padois and O. Ly. 'Extended Friction Models for the Physics Simulation of Servo Actuators'. In: ICRA 2025 - IEEE/RAS International Conference on Robotics and Automation. Atlanta, United States, 2025. URL: https://hal.science/hal-04984665 (cit. on p. 26).

[12] J.-M. Salotti. 'Qualitative Analysis of Mars Entry and Descent Options for Manned Missions'. In: *Proceedings of the 11th European Conference for AeroSpace Sciences*. EUCASS 2025 - 11th European Conference for AeroSpace Sciences. Rome, Italy, 30th June 2025, pp. 2797–2804. URL: https://hal.science/hal-05282883.

Edition (books, proceedings, special issue of a journal)

[13] J.-M. Salotti, ed. *Proceedings of the 2025 European Mars Conference, EMC2025*. EMC 2025 - European Mars Conference. Paris, France, 29th Nov. 2025. URL: https://hal.science/hal-05390036.

Doctoral dissertations and habilitation theses

[14] A. Boulay. 'Assisting humans through adaptive haptic guidance, application to remote-controlled vertical farming'. Université de Bordeaux, 23rd Sept. 2025. URL: https://inria.hal.science/tel-05418923 (cit. on p. 23).

[15] E. Jabbour. 'Shared-autonomy control for improving Human-Robot collaboration in haptic teleoperation'. Université de Bordeaux, 26th Nov. 2025. URL: https://theses.hal.science/tel-05460108.

Reports & preprints

[16] S. Kleff, L. Joseph and V. Padois. *A Unified Tactile Servoing Framework based on Hybrid Force-Position Control*. 5th Jan. 2026. URL: https://hal.science/hal-05441031 (cit. on p. 26).

[17] G. de Mathelin de Papigny, F. Gassibe and V. Padois. *F-RRT: an Efficient Algorithm for Semi-Constrained Path Planning Problems*. 21st Nov. 2025. URL: https://hal.science/hal-04926299.

[18] T. D. V. Nguyen, V. Bonnet, P. Fernbach, D. Daney and F. Lamiraux. *Humanoid Robot Whole-body Geometric Calibration with Embedded Sensors and a Single Plane*. 21st July 2025. URL: https://laas.hal.science/hal-05169055.

[19] K. Wojciechowski, E. Gursoy, A. Haffemayer, S. Kleff, V. Bonnet, F. Lamiraux and N. Mansard. *Learning-Guided Force-Feedback Model Predictive Control with Obstacle Avoidance for Robotic Deburring*. 17th Oct. 2025. URL: https://hal.science/hal-05320433.

Other scientific publications

[20] A. Barsacq, D. Daney and J.-C. Sarrazin. 'Involvement of Predictive Mechanisms in Human-Robot Joint Action: the Lens of Agency'. In: JJCR 2025 - Journée des Jeunes Chercheuses et Jeunes Chercheurs en Robotique. Rennes, France, 29th Sept. 2025. URL: https://inria.hal.science/hal-05374482.

[21] A. Boulay and R. Schmitt. 'Toward a human-centered haptic guidance'. In: Journée TS4 du GdR Robotique. Ed. by D. Daney and M. Vulliez. Paris, France, 31st Jan. 2025. URL: https://inria.hal.science/hal-05128277.

[22] R. Lafitte, M. Vulliez and C. Scotto. 'Ambiguous visuo-haptic integration in a teleoperation environment'. In: IMRF 2025 - 23rd International Multisensory Research Forum. Durham (GB), United Kingdom, 15th July 2025. URL: https://hal.science/hal-05343415 (cit. on p. 20).

12.3 Cited publications

[23] J. Bernon, E. Escriva and J. M. Schweitzer. *Agir sur la prévention durable des TMS*. Anact, 2011 (cit. on p. 8).

[24] A. Boulay, B. Camblor, M. Vulliez and D. Daney. 'A new unified and adaptive haptic guidance method, an exploratory user study'. In: (2024) (cit. on p. 23).

[25] F. Bunlon, J.-P. Gazeau, F. Colloud, P. J. Marshall and C. A. Bouquet. 'Joint action with a virtual robotic vs. human agent'. In: *Cognitive Systems Research* 52 (2018), pp. 816–827 (cit. on p. 10).

[26] B. Camblor, N. Benhabib, D. Daney, V. Padois and J.-M. Salotti. 'Task-Consistent Signaling Motions for Improved Understanding in Human-Robot Interaction and Workspace Sharing'. In: *ACM/IEEE International Conference on Human-Robot Interaction*. 2022. URL: https://hal.inria.fr/hal-03513888 (cit. on p. 11).

[27] P. Douillet. *Agir sur Prévenir les risques psychosociaux*. Anact, 2013 (cit. on p. 8).

[28] M. R. Endsley. 'Measurement of situation awareness in dynamic systems'. In: *Human factors* 37.1 (1995), pp. 65–84 (cit. on p. 9).

[29] M. O. Ernst and M. S. Banks. 'Humans integrate visual and haptic information in a statistically optimal fashion'. In: *Nature* 415.6870 (2002), pp. 429–433 (cit. on p. 9).

[30] S. Haddadin and E. Croft. 'Physical Human-Robot Interaction'. In: *Handbook of Robotics*. Ed. by B. Siciliano and O. Khatib. Springer Verlag, 2016, pp. 1835–1874 (cit. on p. 13).

[31] S. Hignett and L. McAtamney. 'Rapid Entire Body Assessment (REBA)'. In: *Applied Ergonomics* 31.2 (Apr. 2000), pp. 201–205. DOI: 10.1016/S0003-6870(99)00039-3. URL: http://www.sciencedirect.com/science/article/pii/S0003687099000393 (visited on 02/11/2017) (cit. on p. 8).

[32] J. Jacquier-Bret, P. Gorce, G. Motti Lilian and N. Vigouroux. 'Biomechanical analysis of upper limb during the use of touch screen: motion strategies identification'. eng. In: *Ergonomics* 60.3 (Mar. 2017), pp. 358–365. DOI: 10.1080/00140139.2016.1175671. URL: http://dx.doi.org/10.1080/00140139.2016.1175671 (cit. on p. 9).

[33] L. Joseph, V. Padois and G. Morel. 'Towards X-ray medical imaging with robots in the open: safety without compromising performances'. In: *Proceedings of the IEEE International Conference on Robotics and Automation*. Brisbane, Australia, May 2018, pp. 6604–6610. DOI: 10.1109/ICRA.2018.8460794. URL: https://hal.archives-ouvertes.fr/hal-01614508/en (cit. on p. 13).

[34] O. Karhu, P. Kansi and I. Kuorinka. 'Correcting working postures in industry: A practical method for analysis'. In: *Applied Ergonomics* 8.4 (Dec. 1977), pp. 199–201. DOI: 10.1016/0003-6870(77)90164-8. URL: http://www.sciencedirect.com/science/article/pii/0003687077901648 (visited on 16/04/2018) (cit. on p. 8).

[35] D. Kee and W. Karwowski. 'LUBA: an assessment technique for postural loading on the upper body based on joint motion discomfort and maximum holding time'. In: *Applied Ergonomics* 32.4 (Aug. 2001), pp. 357–366. DOI: 10.1016/S0003-6870(01)00006-0. URL: http://www.sciencedirect.com/science/article/pii/S0003687001000060 (visited on 24/10/2017) (cit. on p. 8).

[36] X. Lamy. 'Conception d'une Interface de Pilotage d'un Cobot'. PhD thesis. Université Pierre et Marie Curie - Paris VI, Mar. 2011 (cit. on p. 11).

[37] E. Landais. 'La téléopération comme moyen d'expression à distance du geste technique : application à la formulation en chimie'. Theses. Université de Bordeaux, Dec. 2024. URL: https://theses.hal.science/tel-04876966 (cit. on p. 23).

[38] M. Liu, Y. Tan and V. Padois. 'Generalized hierarchical control'. In: *Autonomous Robots* 40.1 (2016), pp. 17–31 (cit. on p. 13).

[39] S. E. Mathiassen. 'Diversity and variation in biomechanical exposure: What is it, and why would we like to know?' In: *Applied Ergonomics* 37.4 (2006). Special Issue: Meeting Diversity in Ergonomics, pp. 419–427. DOI: https://doi.org/10.1016/j.apergo.2006.04.006. URL: http://www.sciencedirect.com/science/article/pii/S0003687006000482 (cit. on p. 8).

[40] L. McAtamney and E. N. Corlett. 'RULA: a survey method for the investigation of work-related upper limb disorders'. In: *Applied ergonomics* 24.2 (1993), pp. 91–99 (cit. on p. 8).

[41] A. Meguenani, V. Padois, J. Da Silva, A. Hoarau and P. Bidaud. 'Energy-based control for safe Human-robot physical interactions'. In: *Springer Proceedings in Advanced Robotics - The 2016 International Symposium on Experimental Robotics*. Ed. by D. Kulic, G. Venture, Y. Nakamura and O. Khatib. Springer International Publishing AG, 2017. DOI: 10.1007/978-3-319-50115-4_70. URL: http://hal.archives-ouvertes.fr/hal-01398790/en (cit. on p. 13).

[42] J.-P. Merlet and D. Daney. 'Appropriate Design of Parallel Manipulators'. In: *Smart Devices and Machines for Advanced Manufacturing*. Ed. by L. Wang and J. Xi. London: Springer London, 2008, pp. 1–25. DOI: 10.1007/978-1-84800-147-3_1. URL: https://doi.org/10.1007/978-1-84800-147-3_1 (cit. on p. 9).

[43] S. Musić and S. Hirche. 'Control sharing in human-robot team interaction'. In: *Annual Reviews in Control* 44 (2017), pp. 342–354 (cit. on p. 11).

[44] B. Mutlu, A. Terrell and C.-M. Huang. 'Coordination mechanisms in human-robot collaboration'. In: *Proceedings of the Workshop on Collaborative Manipulation, 8th ACM/IEEE International Conference on Human-Robot Interaction*. Citeseer. 2013, pp. 1–6 (cit. on p. 10).

[45] D. Oetomo, D. Daney and J. Merlet. 'Design Strategy of Serial Manipulators With Certified Constraint Satisfaction'. In: *IEEE Transactions on Robotics* 25.1 (Feb. 2009), pp. 1–11. DOI: 10.1109/TRO.2008.2006867. URL: http://dx.doi.org/10.1109/TRO.2008.2006867 (cit. on p. 9).

[46] A. Panchea. *Inverse optimal control for redundant systems of biological motion*. Orléans, Dec. 2015. URL: http://www.theses.fr/2015ORLE2050 (visited on 26/03/2018) (cit. on p. 10).

[47] L. Peternel, T. Petrič, E. Oztop and J. Babič. 'Teaching Robots to Cooperate with Humans in Dynamic Manipulation Tasks Based on Multi-modal Human-in-the-loop Approach'. In: *Autonomous Robots* 36.1-2 (Jan. 2014), pp. 123–136. DOI: 10.1007/s10514-013-9361-0. URL: http://dx.doi.org/10.1007/s10514-013-9361-0 (cit. on p. 13).

[48] L. Peternel, N. Tsagarakis, D. Caldwell and A. Ajoudani. 'Robot adaptation to human physical fatigue in human–robot co-manipulation'. In: *Autonomous Robots* 42.5 (June 2018), pp. 1011–1021. DOI: 10.1007/s10514-017-9678-1. URL: http://dx.doi.org/10.1007/s10514-017-9678-1 (cit. on p. 13).

[49] J. M. Riley, L. D. Strater, S. L. Chappell, E. S. Connors and M. R. Endsley. 'Situation awareness in human-robot interaction: Challenges and user interface requirements'. In: *Human-Robot Interactions in Future Military Operations* (2010), pp. 171–192 (cit. on p. 11).

[50] J. Savin, R. Bousigues, P. Maurice, V. Padois, N. Rezzoug and D. Daney. 'Motor variability in human-robot interaction during an assisted trajectory-tracking task: preliminary results from the MOVER experiment'. In: *Humanoids 2024 workshop - Human movement modeling for Human-Robot interaction*. Nancy, France, Nov. 2024. URL: https://hal.science/hal-04883474 (cit. on p. 21).

[51] J. Savin, C. Gaudez, M. A. A. Gilles, V. Padois and P. Bidaud. 'Evidence of movement variability patterns during a repetitive pointing task until exhaustion'. In: *Applied Ergonomics* 96 (2021), p. 103464. DOI: 10.1016/j.apergo.2021.103464. URL: https://hal.science/hal-03280696 (cit. on p. 10).

[52] J. Savin, M. Gilles, C. Gaudez, V. Padois and P. Bidaud. 'Movement Variability and Digital Human Models: Development of a Demonstrator Taking the Effects of Muscular Fatigue into Account'. In: *Advances in Applied Digital Human Modeling and Simulation*. Ed. by V. G. Duffy. Cham: Springer International Publishing, 2017, pp. 169–179 (cit. on p. 9).

[53] A. Skuric, N. Rezzoug, D. Daney and V. Padois. 'Common wrench capability evaluation of a human-robot collaborative system'. In: *46th Congrès de la Société de Biomécanique*. Saint Etienne, France, Oct. 2021. URL: https://hal.inria.fr/hal-03396009 (cit. on p. 10).

[54] M. Sonne, D. L. Villalta and D. M. Andrews. 'Development and evaluation of an office ergonomic risk checklist: ROSA - Rapid Office Strain Assessment'. In: *Applied Ergonomics* 43.1 (Jan. 2012), pp. 98–108. DOI: 10.1016/j.apergo.2011.03.008. URL: http://www.sciencedirect.com/science/article/pii/S0003687011000433 (cit. on p. 8).

[55] D. Srinivasan and S. E. Mathiassen. 'Motor variability in occupational health and performance'. In: *Clinical Biomechanics* 27.10 (2012), pp. 979–993. DOI: https://doi.org/10.1016/j.clinbiomech.2012.08.007. URL: http://www.sciencedirect.com/science/article/pii/S0268003312001817 (cit. on pp. 8, 9).

[56] C. Viegas, D. Daney, M. Tavakoli and A. T. de Almeida. ‘Performance analysis and design of parallel kinematic machines using interval analysis’. In: *Mechanism and Machine Theory* 115 (2017), pp. 218–236. DOI: https://doi.org/10.1016/j.mechmachtheory.2017.05.003. URL: http://www.sciencedirect.com/science/article/pii/S0094114X17305700 (cit. on p. 9).

[57] J. R. Wilson and S. Sharples. *Evaluation of Human Work, Fourth Edition*. en. Google-Books-ID: uXB3CAAAQBAJ. CRC Press, Apr. 2015 (cit. on p. 8).