UNIVERSITÉ DE SHERBROOKE

LAAS CNRS

PhD Opportunity: Human Biomechanics Digital Twin with AI for Ergonomic Collaboration

We are recruiting a PhD student to develop a real-time AI-enhanced digital twin of human biomechanics for collaborative robotics. The system will simulate the user's musculoskeletal condition using AI-driven models and allow cobots to optimize their assistance and minimize physical strain and improve ergonomics in both manufacturing and healthcare contexts.

Project Objectives

The following points are the main steps of the PhD project. These steps are also illustrated on the figure below.

- Create a biomechanical digital twin integrating wearable sensor data with real-time physics-based and AI-enhanced modeling.
- Use machine learning to predict human motion intent, joint load, and fatigue patterns based on sensor inputs and historical data.
- Develop adaptive robot controllers that utilize the AI-driven twin for ergonomically optimal collaboration in shared tasks.
- Deploy and evaluate the system in both industrial co-manipulation and rehabilitation settings with real users.

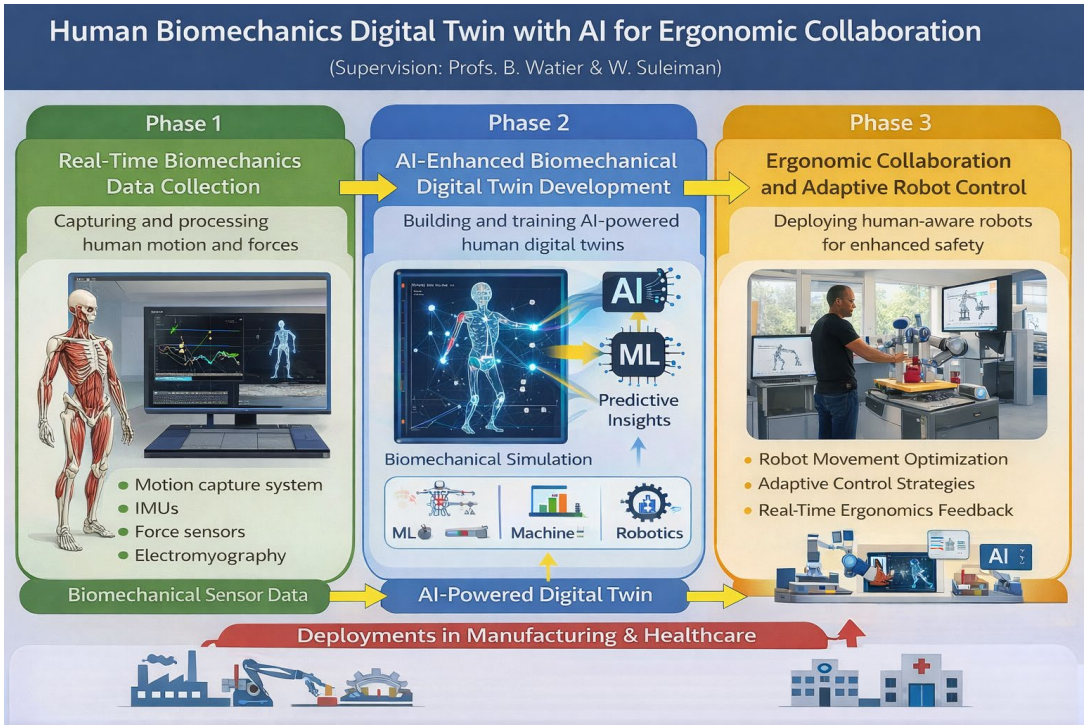

Figure : The main stages of the thesis project

Relevance and Application

In order to perform most of the complex tasks of future robotics, continuous physical interaction between humans and robots, commonly referred to as pHRI (physical Human-Robot Interaction) [1], [2], is necessary. This type of robotics can involve the co-manipulation of objects between humans and robots [3], [4], assistive and rehabilitation robotics [5], online learning robotics based on human gestures [6] or active exoskeletons [7].

Digital twins with AI enable predictive ergonomic assessment and smart co-adaptation in human-robot teaming. In manufacturing, this allows virtual testing and continuous ergonomic optimization of work tasks. In healthcare, AI-personalized twins help tailor assistive robotics and rehabilitation programs to individual patient profiles, enhancing recovery and usability.

Funding and Environment

The project is fully funded through NSERC's Canada Impact+ Research Training Awards and hosted in a dynamic research environment under the supervision of Prof. Bruno Watier (LAAS-CNRS, Toulouse, France) and Prof. Wael Suleiman (U. of Sherbrooke, Sherbrooke, Canada).

Thesis dates and duration:

- Thesis start date: October 2026
- Duration: 36 months
- Location: U. of Sherbrooke (Sherbrooke, Canada) and LAAS-CNRS (Toulouse, France) primarily

Thesis location:

The thesis will be carried out mainly in the University of Sherbrooke within Humanoid and Collaborative Robots research team, and Toulouse within the Gepetto team at LAAS-CNRS.

Humanoid and Collaborative Robots research team at the Interdisciplinary Institute for Technological Innovation (3IT), University of Sherbrooke, has recognized expertise in the design and implementation of real-time control systems for collaborative robotics. The team's research emphasizes seamless physical interaction between humans and robots, including the coordination and control of multiple humanoid platforms. 3IT also offers advanced experimental infrastructure ideally suited for developing AI-enhanced digital twins, featuring a range of collaborative robotic systems such as the Sawyer, UR5, and Gen3. This environment provides an exceptional foundation for cutting-edge research in human–robot collaboration.

GEPETTO is a team at LAAS-CNRS specializing in the study of anthropomorphic movements, with extensive experience in generating movements for humanoid robots. Based in Toulouse, the GEPETTO team develops control software suites for the HRP-2, Talos and H1Pyrène bipedal robots. The team is also interested in human movement and its simulation. It has a

complete technical platform for experimental movement analysis located at the CREPS in Toulouse Midi-Pyrénées.

Get Involved

Interested in shaping the future of safe, intelligent robots?

Candidates for the thesis must hold a Master's degree or be in the final stages of their engineering studies in robotics and/or, (bio)mechanics. They must have skills in Python programming. Knowledge of AI methodology for robotics and an interest in experimentation would be an advantage. Fluency in English is essential.

Email: Prof. Bruno Watier <bruno.watier@utoulouse.fr> and Prof. Suleiman <Wael.Suleiman@USherbrooke.ca> to express interest and learn more about the application process.

Bibliography

[1] A. De Santis, B. Siciliano, A. De Luca, et A. Bicchi, « An atlas of physical human – robot interaction », *Mechanism and Machine Theory*, vol. 43, p. 253-270, 2008, doi: 10.1016/j.mechmachtheory.2007.03.003.

[2] B. Navarro, A. Fonte, P. Fraisse, G. Poisson, et A. Cherubini, « In Pursuit of Safety: An Open-Source Library for Physical Human-Robot Interaction », *IEEE Robotics & Automation Magazine*, vol. 25, nº 2, p. 39-50, 2018, doi: 10.1109/MRA.2018.2810098.

[3] L. Peternel, N. Tsagarakis, et A. Ajoudani, « Towards multi-modal intention interfaces for human-robot co-manipulation », in *2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, oct. 2016, p. 2663-2669. doi: 10.1109/IROS.2016.7759414.

[4] M. Mujica, M. Crespo, M. Benoussaad, S. Junco, et J.-Y. Fourquet, « Robust variable admittance control for human–robot co-manipulation of objects with unknown load », *Robotics and Computer-Integrated Manufacturing*, vol. 79, p. 102408, 2023, doi: https://doi.org/10.1016/j.rcim.2022.102408.

[5] C. Lauretti, F. Cordella, E. Guglielmelli, et L. Zollo, « Learning by Demonstration for Planning Activities of Daily Living in Rehabilitation and Assistive Robotics », *IEEE ROBOTICS AND AUTOMATION LETTERS*, vol. 2, nº 3, p. 1375-1382, 2017.

[6] S. Ikemoto, H. Ben Amor, T. Minato, B. Jung, et H. Ishiguro, « Physical human-robot interaction: Mutual learning and adaptation », *IEEE Robotics and Automation Magazine*, vol. 19, nº 4, p. 24-35, 2012, doi: 10.1109/MRA.2011.2181676.

[7] H. D. Lee, B. K. Lee, W. S. Kim, J. S. Han, K. S. Shin, et C. S. Han, « Human-robot cooperation control based on a dynamic model of an upper limb exoskeleton for human power amplification », *Mechatronics*, vol. 24, nº 2, p. 168-176, 2014, doi: 10.1016/j.mechatronics.2014.01.007.

[8] I. Maroger, M. Silva, H. Pillet, N. Turpin, O. Stasse, et B. Watier, « Walking paths during collaborative carriages do not follow the simple rules observed in the locomotion of single walking subjects », *Scientific Reports*, vol. 12, nº 1, p. 15585, 2022, doi: 10.1038/s41598-022-19853-7.

[9] J. Xia, D. Huang, Y. Li, et N. Qin, « Iterative learning of human partner's desired trajectory for proactive human–robot collaboration », *International Journal of Intelligent Robotics and Applications*, vol. 4, nº 2, p. 229-242, 2020, doi: 10.1007/s41315-020-00132-5.