Post Doctoral proposition 2023 - 2026

Research laboratories : LIRMM (Montpellier) & LAAS-CNRS (Toulouse)

Keywords ***: Biomechanics, behavioral neuroscience, robotics, bifurcation***

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Post Doct: 18 months

Title: Understanding and modelling bifurcations in human behaviors near robots

Scientific context
To efficiently interact with humans, robots need to predict human intentions and movements. However, prediction of human behavior is complex. Our recent studies with human behaviors while working in collaboration with humanoid robots as well as human manipulators sometimes show implicit 'bifurcations' in movement trajectories: after maintaining a unique stereotypical trajectory up till a certain spatio-temporal inflexion points, humans randomly choose one of two movement trajectories leading to a bimodal distribution in their trajectory population. When, and why these bifurcations occur and what trajectories they lead to, still remains largely unclear, making human movement prediction around these inflexion points very difficult.

This inter disciplinary Post Doctorate project will last 1.5 years and use biomechanics, human-robot interaction and behavioral neuroscience to explore bifurcations in human behaviors while working with robots. Starting from human-robot physical interaction tasks already explored by our labs, the project will try to understand the cause behind these bifurcations and ways to control them.

Methodology
This project will be divided in different main tasks including dynamic analysis of musculoskelettal system of a human when collaborating with other human or robot, modelization of the behaviors of the systems and extraction of invariants to better predict spatio temporal bifurcation. The results of the project should lead to better and more efficient human-robot interaction with the development of new controller classes for the generation of movements of robotic systems in collaboration with humans. It will also explain bifurcations for the neuroscience field, where this is still an unresolved feature of the human behavior.

Location
The Post doctorate will be carried out at LAAS-CNRS in Toulouse within the Gepetto team and at LIRMM in Montpellier within the IDH team. The GEPETTO team at LAAS-CNRS is specialized in the study of anthropomorphic movements, and has a large experience on the generation of movements for humanoid robots. Based in Toulouse, the GEPETTO group deals with the HRP-2 and Pyrene robots which are among the most successful humanoid 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 of Toulouse Midi-Pyrénées.

The IDH team at LIRMM specializes in human machine interactions, and the integration of Neuroscience and Robotics to improve machine behavior near humans. The team is based in Montpellier and predominantly works with KUKA and FRANKA robot manipulators, as well as the HRP2 robot.

Skills prerequisite:
- Demonstrated skills in Python and/or Matlab programming
- Dynamics of rigid solids
- English level C1 is required
- Knowledge in biomechanics, neuroscience and/or robotics is a plus
- Previous publications in peer reviewed conferences and/or journals required
- A phD in motor control, biomechanics or robotics is expected

Please send your CV and letter of motivation to:
Ganesh (https://www.lirmm.fr/ganesh-gowrishankar/) at ganesh.gowrishankar@lirmm.fr
And
Bruno (https://gepettoweb.laas.fr/index.php/Members/BrunoWatier) at bruno.watier@laas.fr

Reference:
Maroger, I., Silva, M., Pillet, H. et al. Walking paths during collaborative carriages do not follow the simple rules observed in the locomotion of single walking subjects. Sci Rep 12, 15585 (2022). https://doi.org/10.1038/s41598-022-19853-7
Kodl J, Ganesh G, Burdet E (2011) The CNS Stochastically Selects Motor Plan Utilizing Extrinsic and Intrinsic Representations. PLoS ONE 6(9): e24229. https://doi.org/10.1371/journal.pone.0024229

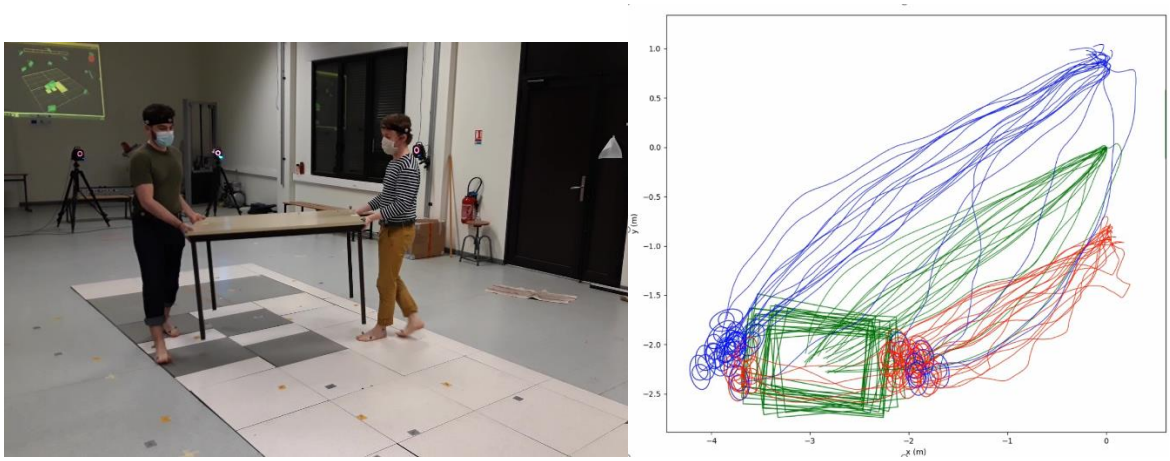
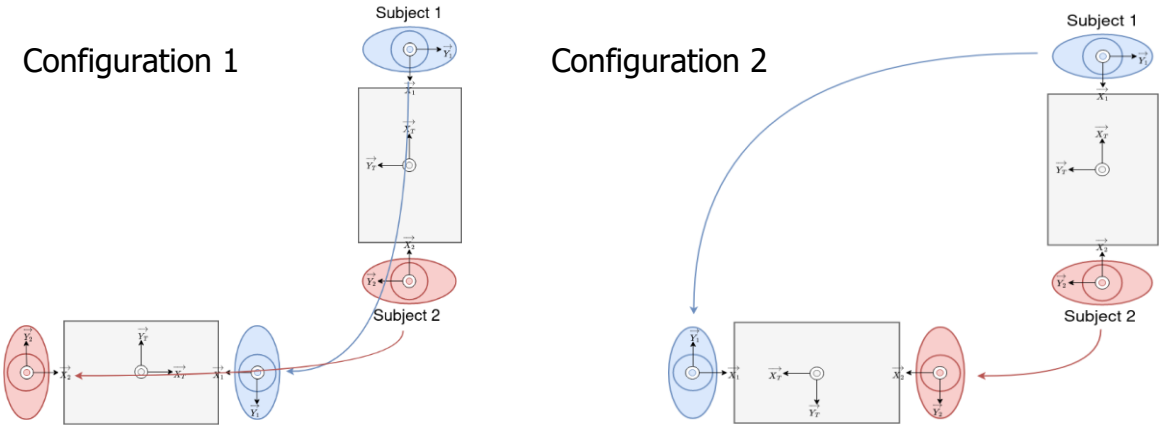


Figure 1: Example of bifurcation during co-transportation of a table (2 possible configurations)



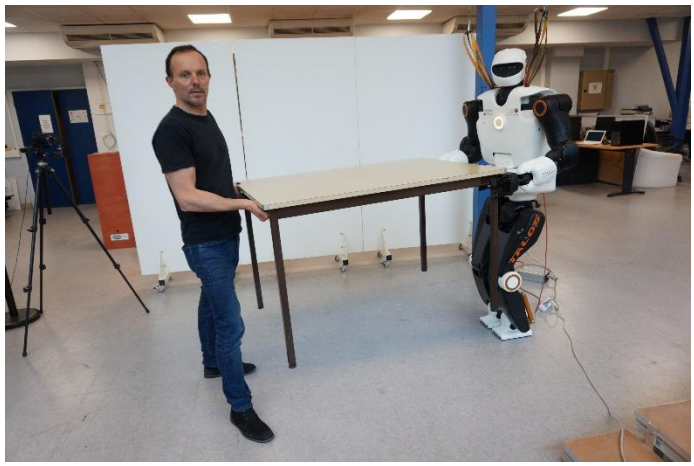


Figure 2: Application to human-robot interaction