Adaptive Impedance Controller for Human-Robot Arbitration based on Cooperative Differential Game Theory

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Motivations

- When the human operator and the robot must execute a task together, the action of the one has immediate consequences on the other
- Humans and Robots have complementary capabilities, and the role of leader should be adapted

Background

- **Variable Impedance Control**: typically used in pHRI applications
- **Game Theory**: branch of applied mathematics that provides tools to analyze situations in which players make interdependent decisions
- **Role Arbitration**: the mechanism that assigns control of the task to either the human or the robot

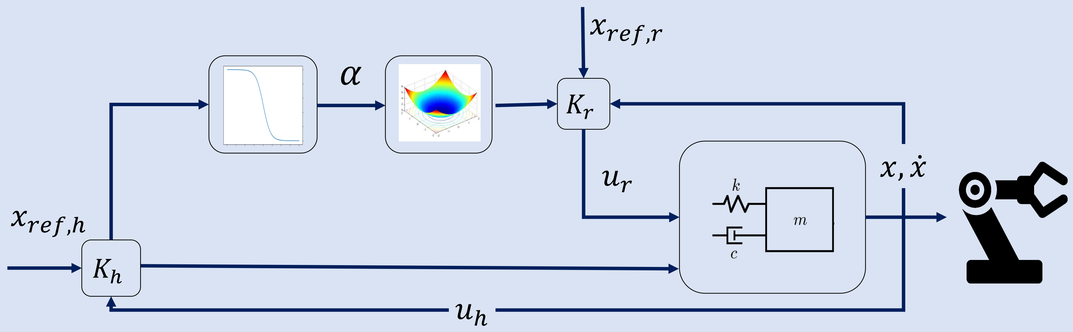
Method

The proposed method is composed of three main blocks:

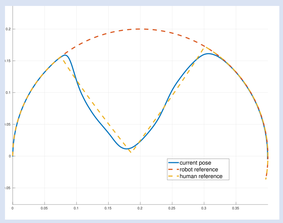
1. **Impedance Model** for the robot motion
2. **Differential Cooperative Game-Theoretic** modeling for the pHRI
3. Human-Robot **Role Arbitration** as a solution to the **Bargaining problem**

Each block has its function to make the robot's behavior adaptive:

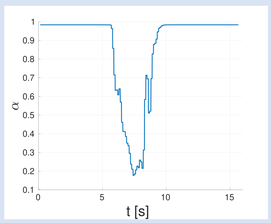
1. Allows smooth and compliant motions during interaction
2. Allows considering interaction in the computation of robot control gains
3. Move the leader role either to the human or the robot



Results

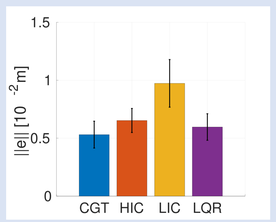


Trajectory following experiments in which humans can take the lead to modify the robot reference trajectory

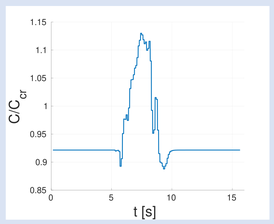


The arbitration parameter varies with force from 1, robot leading, to 0, human leading

The proposed controller is compared with other impedance controllers, showing overall better performances



Impedance parameters vary with arbitration. As a result, damping ratio spans values above and below 1



Conclusions

- **pHRI control scheme** based on Cooperative Game Theory is obtained and tested
- Results show potentialities of proposed control scheme for **Role Arbitration**, allowing for future developments

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