Robot Control for Nonprehensile Dynamic Manipulation Tasks

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Nonprehensile Manipulation **Prehensile Manipulation**

Expected outcomes

- Identification of classes of control frameworks solving appropriate nonprehensile tasks
- Implementation of the designed control actions on a physical prototype

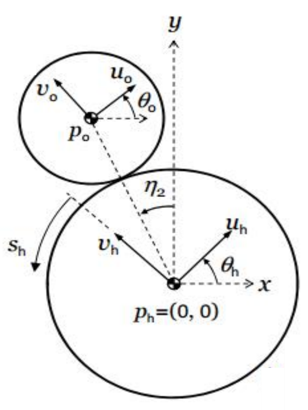
Fields of application

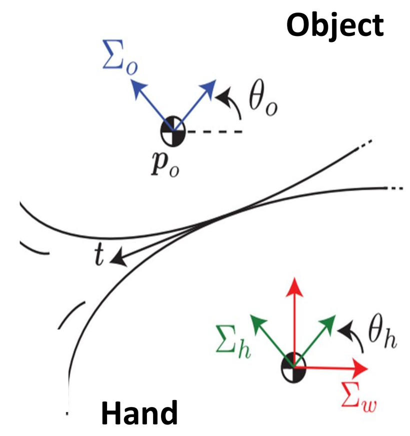
- Service and human assistance robotics
- Motion planning for mobile robots
- Industrial manufacturing processes

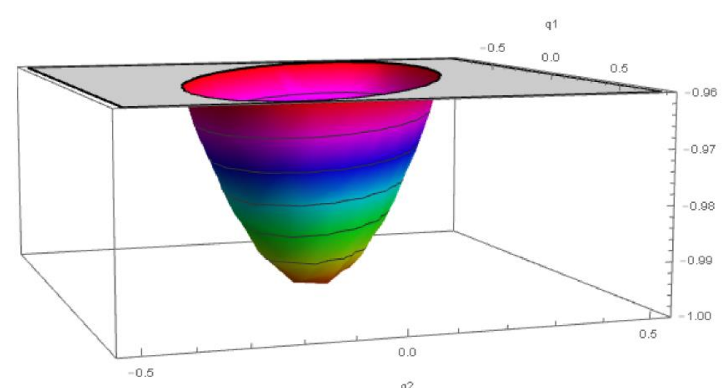
Potential benefits

- Increase of available robot actions
- Larger operative workspace
- Reduction of task execution time
- Enhanced dexterity in dynamic tasks

Stage of the research





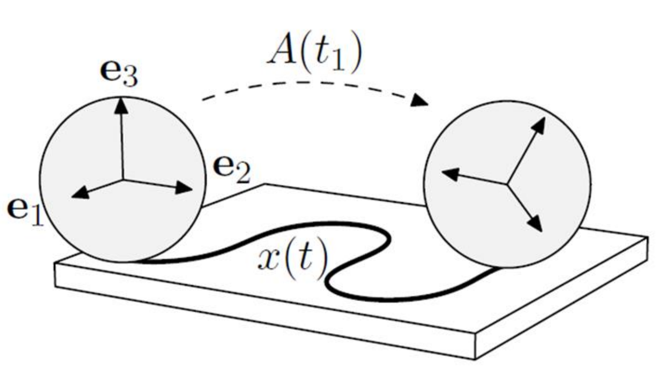


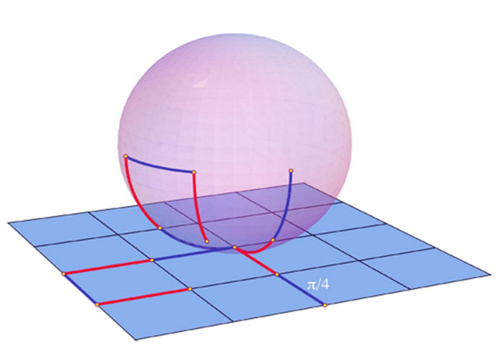
A general planar rolling model is considered for the class of rolling tasks. In this system one shape is actuated (hand), the other one is free to roll (object). The shapes of the object/hand are parameterized by charts.
A new method to derive an Interconnection and Damping Assignment Passivity Based Control (IDA-PBC), relevant to this kind of rolling system, is proposed. The approach employs a ***target potential energy matching equation***:

$$\partial_{q_2} V(q_1, q_2) - \alpha(q_1, q_2)\partial_{q_1} V_d(q_1, q_2) - \beta(q_1, q_2)\partial_{q_2} V_d(q_1, q_2) = 0$$

where $\alpha(q_1, q_2)$ and $\beta(q_1, q_2)$ are chosen to:

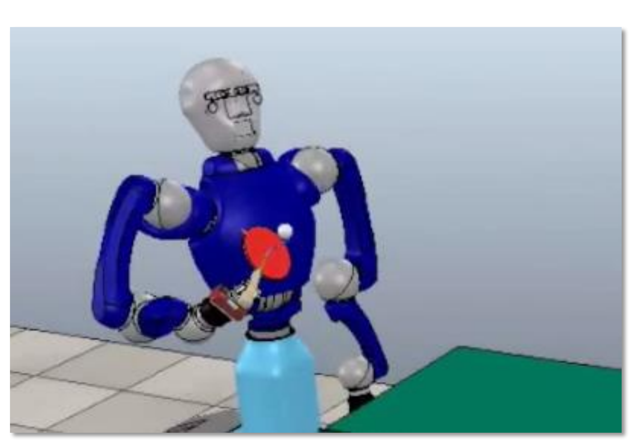
- select a desired energy function for the closed loop system,
- simplify the recognition of the desired closed loop inertia matrix.

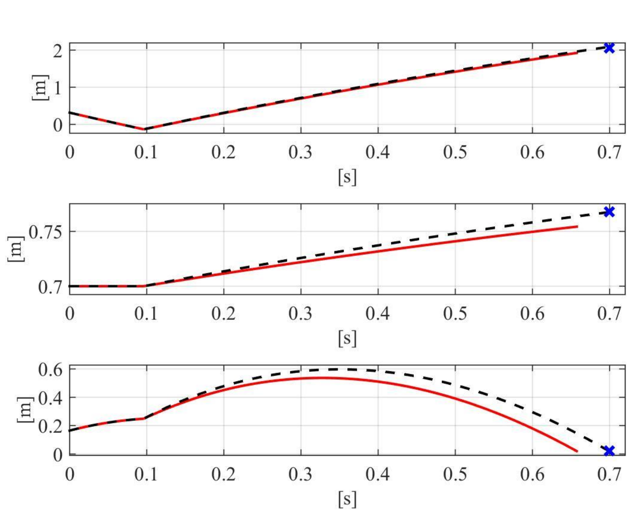




Manipulation of a sphere with a plane is a 3D rolling task which involves a nonholonomic constraint, induced by the non-twist and non-slipping conditions. It has been demonstrated that the sphere dynamics is always controllable, while the plane dynamics can be only bounded.
A ***geometric planning and control method*** is implemented to steer the rolling sphere between two arbitrary position and orientation configurations.

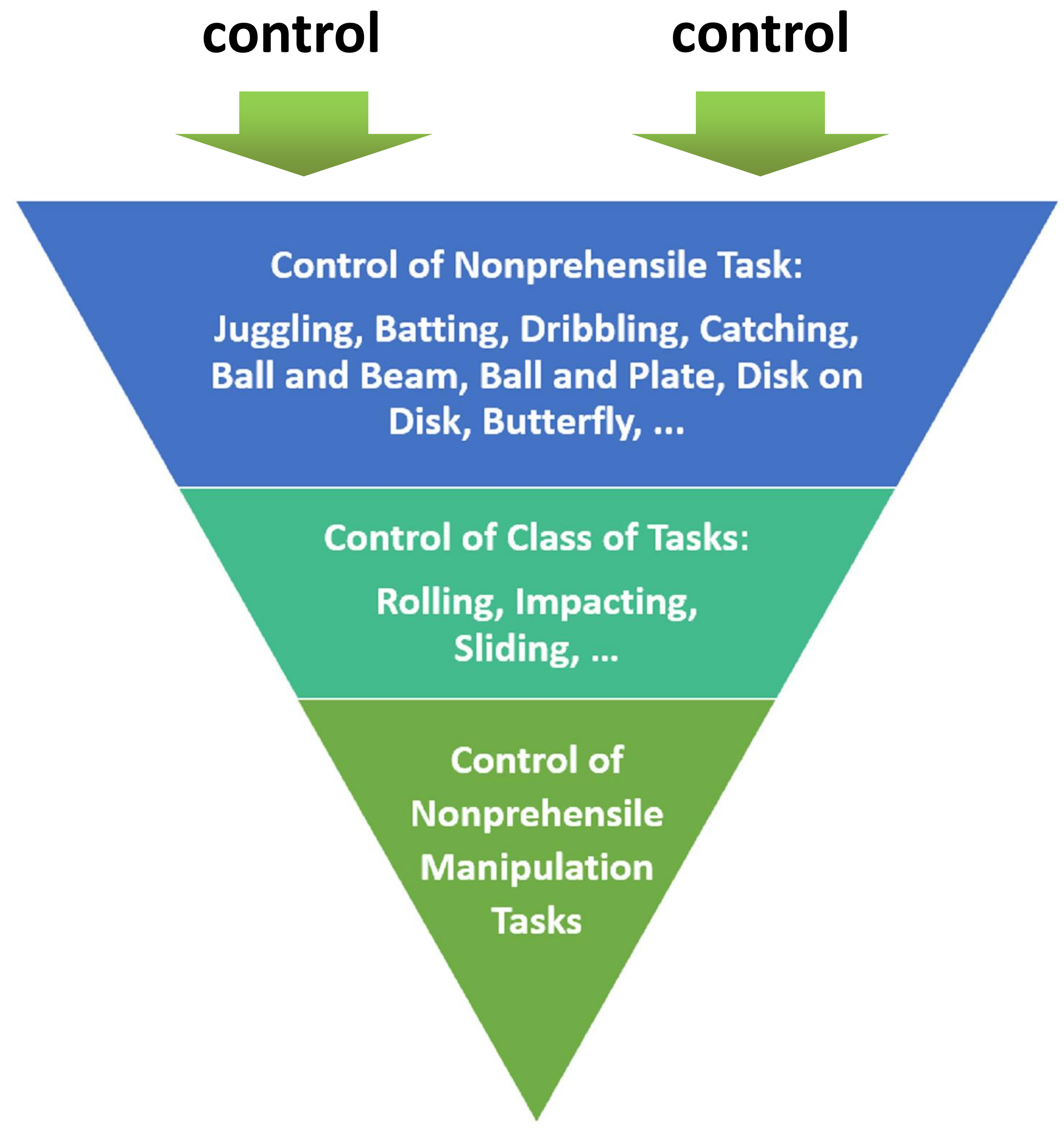
The batting task is a primitive that belongs to the class of impact tasks. As example the table tennis game is considered.
The paddle configuration (pose and velocity) is determined to return the ball at a desired position with a desired spin.
The problem of generating an ***optimal trajectory*** for the end-effector of the robot is tackled. The optimal trajectory minimizes the paddle acceleration functional, solving a two point boundary value problem on SE(3).





Methodology

Passivity-based control **Robust optimal control**

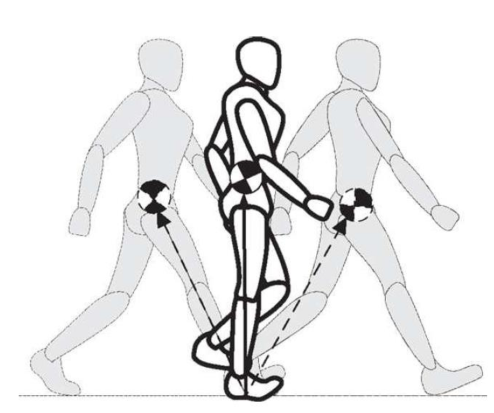


Future works

Experiments on physical robotic platforms like:

- ***RoDyMan***, a 21 DoFs humanoid robot, with a mobile base, two DoFs torso, a pan and tilt neck, two seven DoFs arms and two multifingered hands,
- the disk on disk, or the circular ball and beam prototypes.

Investigation of the Model Predictive Control (MPC) framework in the context of ***walking robots***. Establish connections between walking pattern generation and dynamic manipulation.



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