Humanoid Path Planner

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Outline

Path Planning

Given

- A robot (kinematic chain),
- obstacles,
- constraints,
- an initial configuration and
- goal configurations,

Compute a collision-free path satisfying the constraints from the initial configuration to a goal configuration.

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Historical perspective

- 1998: Move3D,
- 2001: Creation of Kineo-CAM, transfer of Move3D,
- 2006: Release of KineoWorks-2, development of HPP based on KineoWorks-2,
- 2013: kineo-CAM is bought by Siemens,
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Overview of the architecture

Modular: collection of packages

- package dependencies tracked by `pkg-config`,
- installation managed by `cmake` and a `git` submodule: `git://github.com/jrl-umi3218/jrl-cmakemodules.git`,
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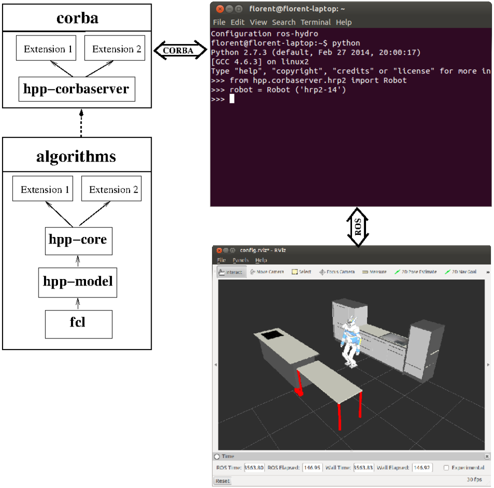

Software Development Kit

Packages implementing the core infrastructure

- Kinematic chain with geometry
  - `hpp-model`: implementation of kinematic chain with geometry,
    - tree of joints (Rotation, Translation, SO3: unit-quaternions),
    - moving fcl::CollisionObjects,
    - forward kinematics,
    - joint Jacobians,
    - center of mass and Jacobian.
- Path planning
  - `hpp-core`: definition of basic classes,
    - path planning problems,
    - path planning solvers (RRT),
    - constraints (locked dofs, numerical constraints)
    - path optimizers (random shortcut),
    - steering methods (straight interpolation)

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Extensions

Packages implementing other algorithms

- `hpp-model-urdf`: construction of robots and objects by parsing urdf/srdf files.
- `hpp-wholebody-step`: whole-body and walk planning using sliding path approximation,
- `hpp-manipulation`: manipulation planning (see next section)

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Python control

`hpp-corbaserver`: python scripting through CORBA

- embed `hpp-core` into a CORBA server and expose services through 3 `idl` interfaces:
  - `Robot` load and initializes robot,
  - `Obstacle` load and build obstacles,
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- Implement python classes to help user call CORBA services
  - `Robot` automatize robot loading,
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- `hpp-wholebody-step-corba`: control of humanoid specific constraints and algorithms,
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Visualization through ROS/rviz

Implemented by package `hpp_ros`.

Demonstration

Outline

Manipulation

Class of problem containing:

- A robot: actuated DOFs
- Objects: unactuated DOFs

A solution will be a succession of motion of two types:

- The robot moves without constraints. Objects do not move.
- The robot moves while grasping the object.

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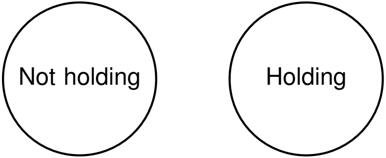
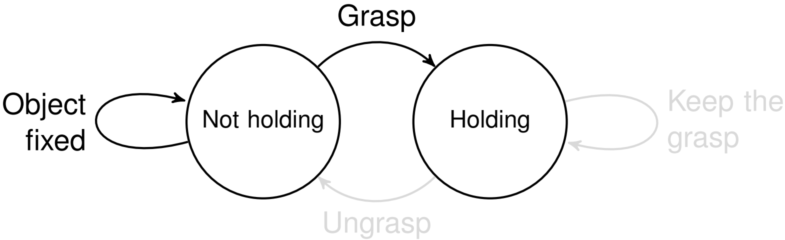
Manipulation

2 states:



Manipulation

4 transitions:



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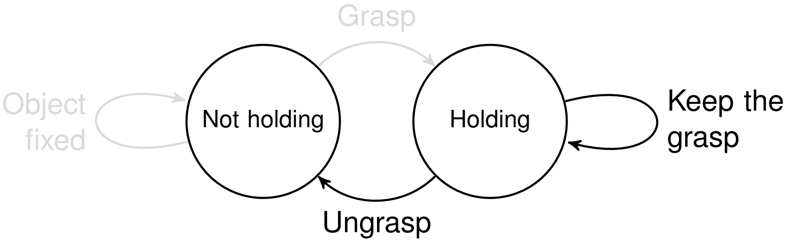

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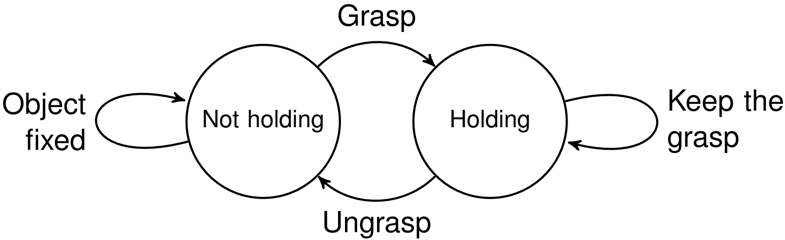

Constraint

Definition

A function $f \in D^1(\mathcal{C}, \mathbb{R}^m)$.

Level set

A level set of a constraint f is:

$$L_{f_0}(f) = \{q \in \mathcal{C} | f(q) = f_0\}$$

Projection

Using a Newton Descent algorithm:

$$q_{rand} | f(q_{rand}) \neq f_0 \Rightarrow q_{proj} | f(q_{proj}) = f_0$$

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Constraint

Two types of constraints:

Configuration

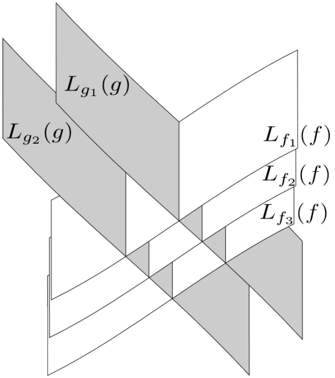
Only one level set is interesting: $L_0(f)$.

Motion

A level set also represents reachability space.

Foliation

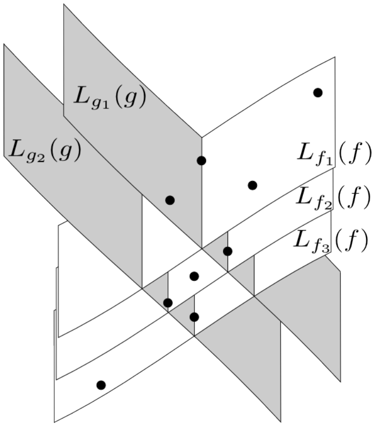
In the configuration space:

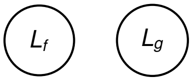


2 constraints on motion

- f: position of the object.
- g: grasp of the object.

Constraint graph





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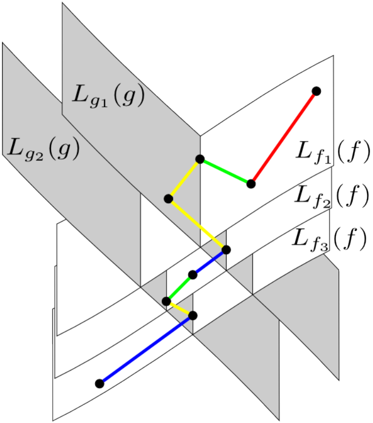
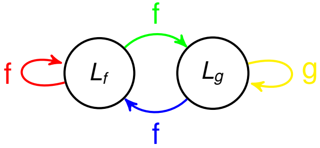
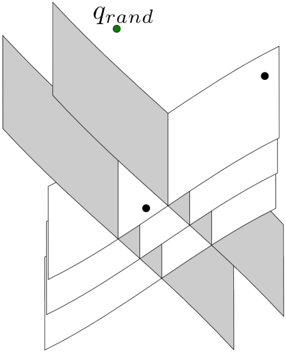




Rapidly exploring Random Tree



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q_{near} = nearest_neighbor(q_{rand}, *tree*)
f_e, f_p = select_next_state(q_{near})
q_{proj} = project(q_{rand}, f_e)
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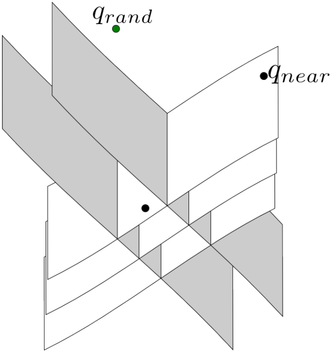

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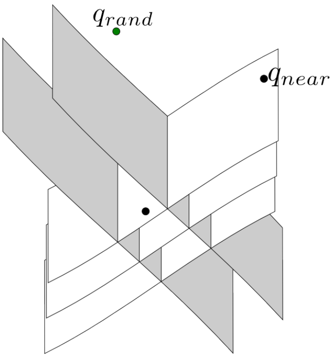

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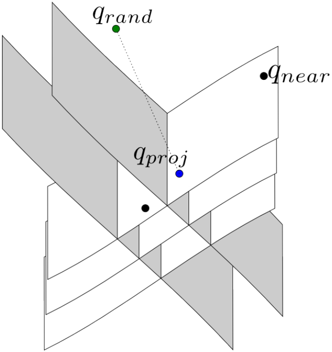

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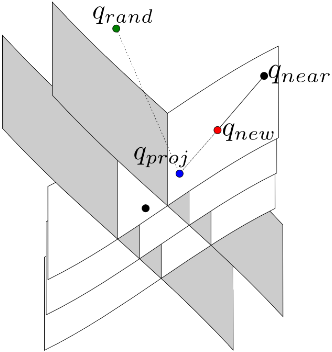

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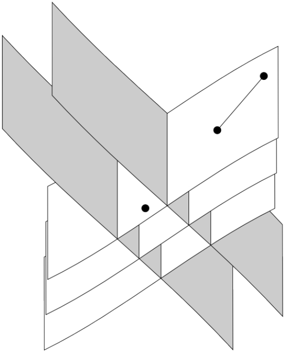

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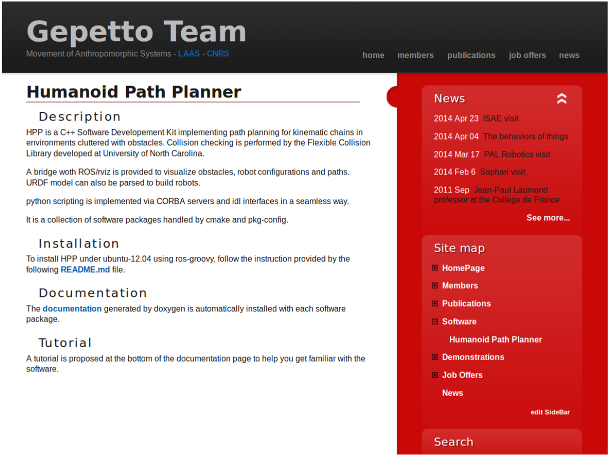
Documentation

Entry point on Gepetto home page:



Installation

Go to
`https://github.com/humanoid-path-planner/hpp-doc`
and follow the installation instructions.

Keep informed

- Mailing list `hpp@laas.fr` to discuss issues related to the software,
- github notifications for issues related to individual packages