



ROS for Humanoid Robots



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Why Humanoid Robots?



[CMU robotics club]

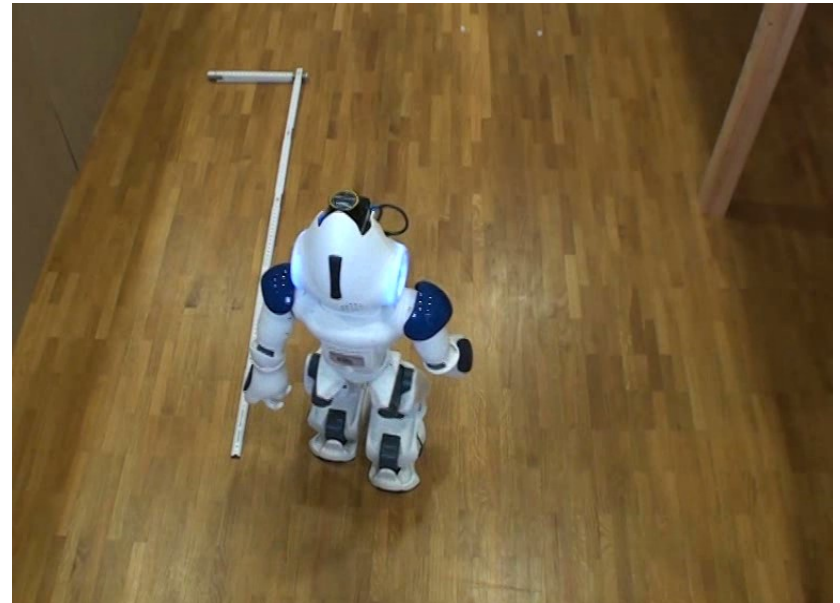
Why Humanoid Robots?



[DARPA Grand Challenge '12]

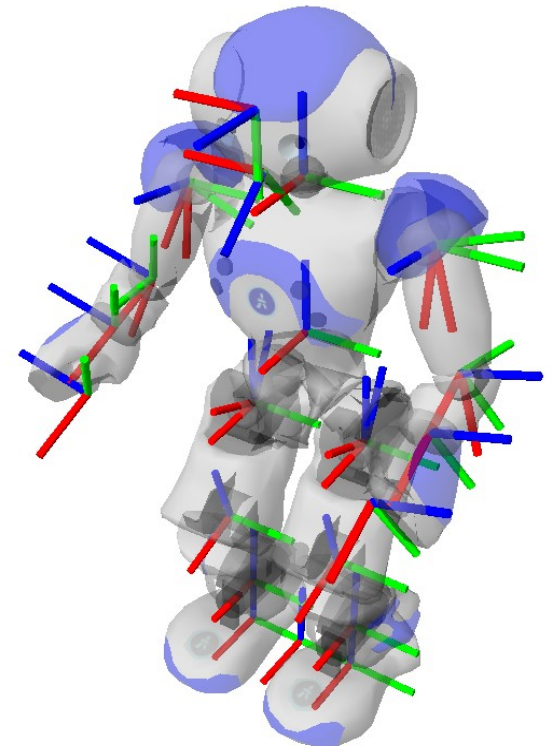
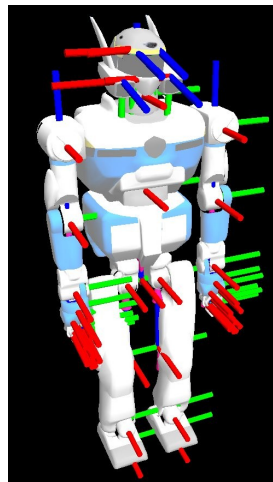
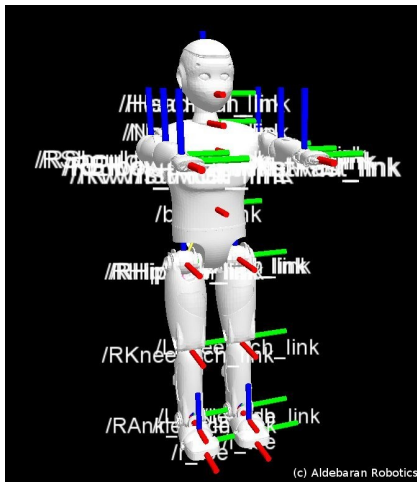
Challenges

- Many degrees of freedom
- Free-floating base
- Noisy observations from light-weight sensors
- Motion drift from foot slippage and joint backlash



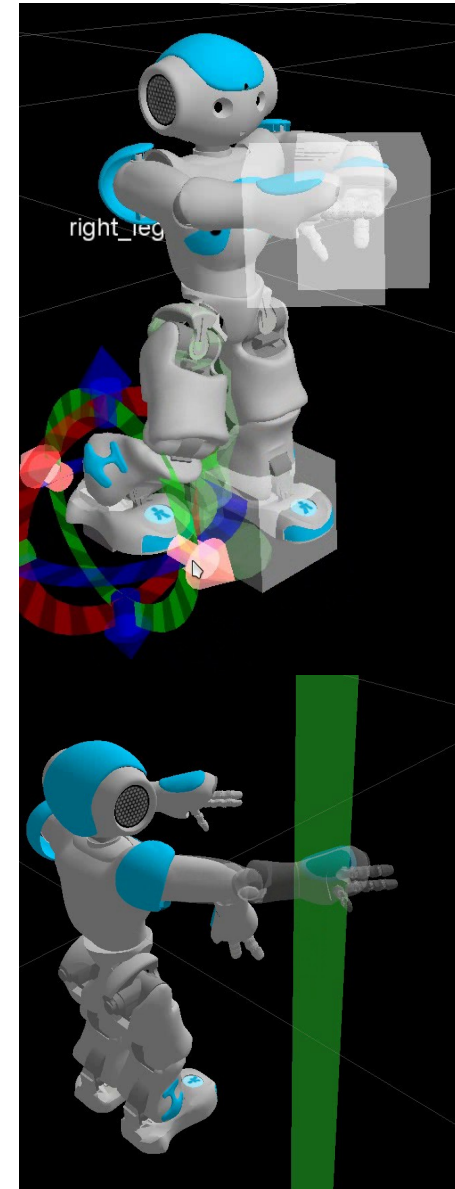
urdf and tf Standardization

- REP-105: Coordinate Frames for Mobile Platforms
 - `map` → `odom` → `base_link`
- REP-120: Coordinate Frames for Humanoid Robots
 - `base_footprint` as stable projection on the ground
 - `torso` link as root of the arms
 - `gaze` determines viewing direction
 - `[l/r]_gripper`: end-effectors of the arms
 - `[l/r]_sole`: end of the leg chains

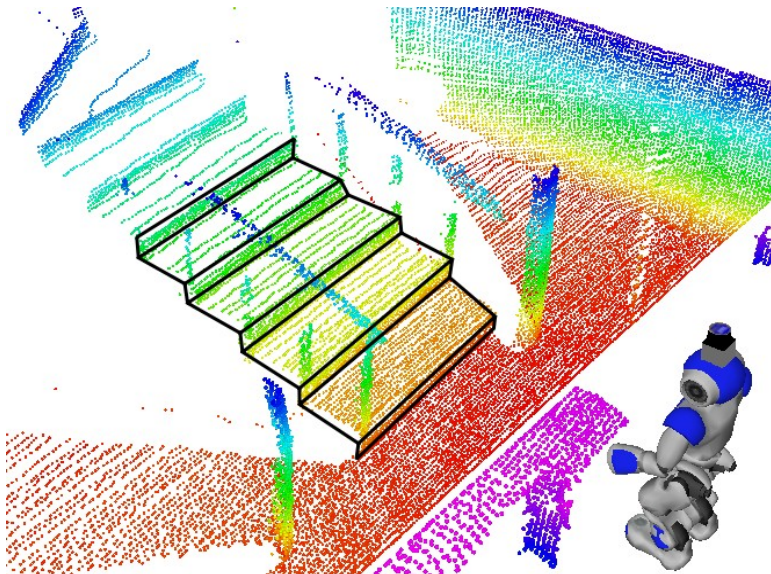


Manipulation and Kinematics

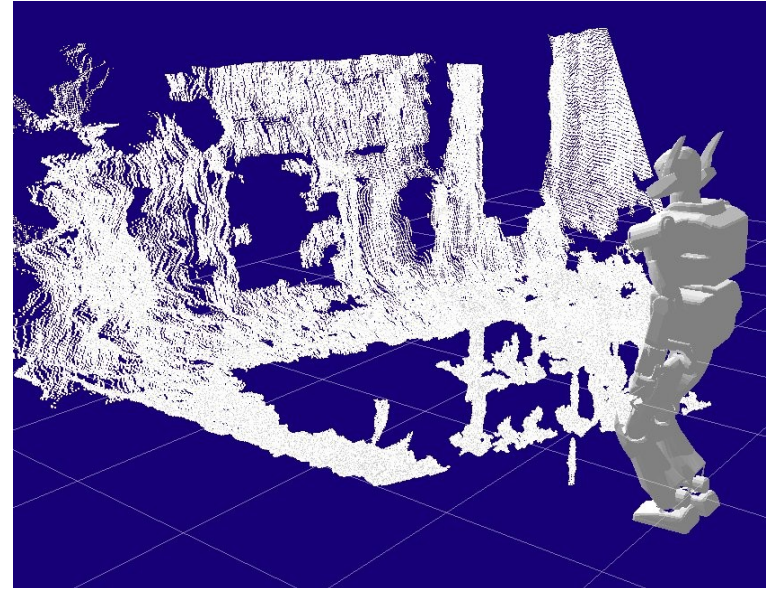
- **arm_navigation** wizard works well for single chains
 - Requires static base_link
- **kdl** for iterative IK on chains
- In the future: Whole-body planning in *MoveIt!*



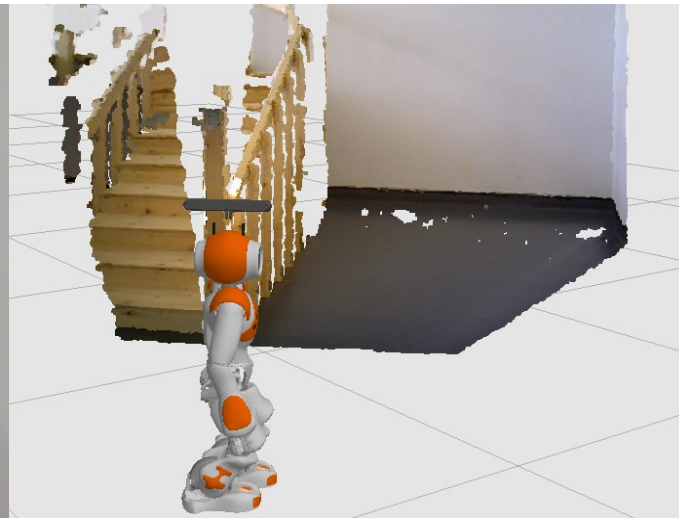
Sensing and Perception



[Osswald et al. '11]

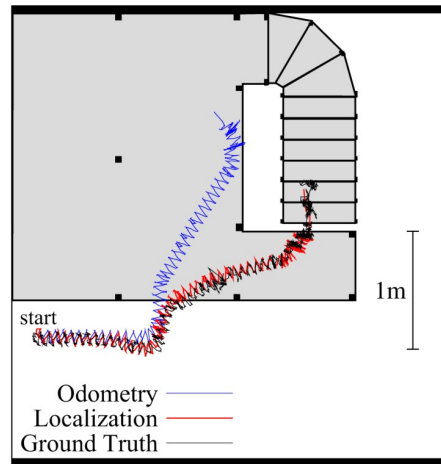


[Courtesy of T. Moulard, LAAS]

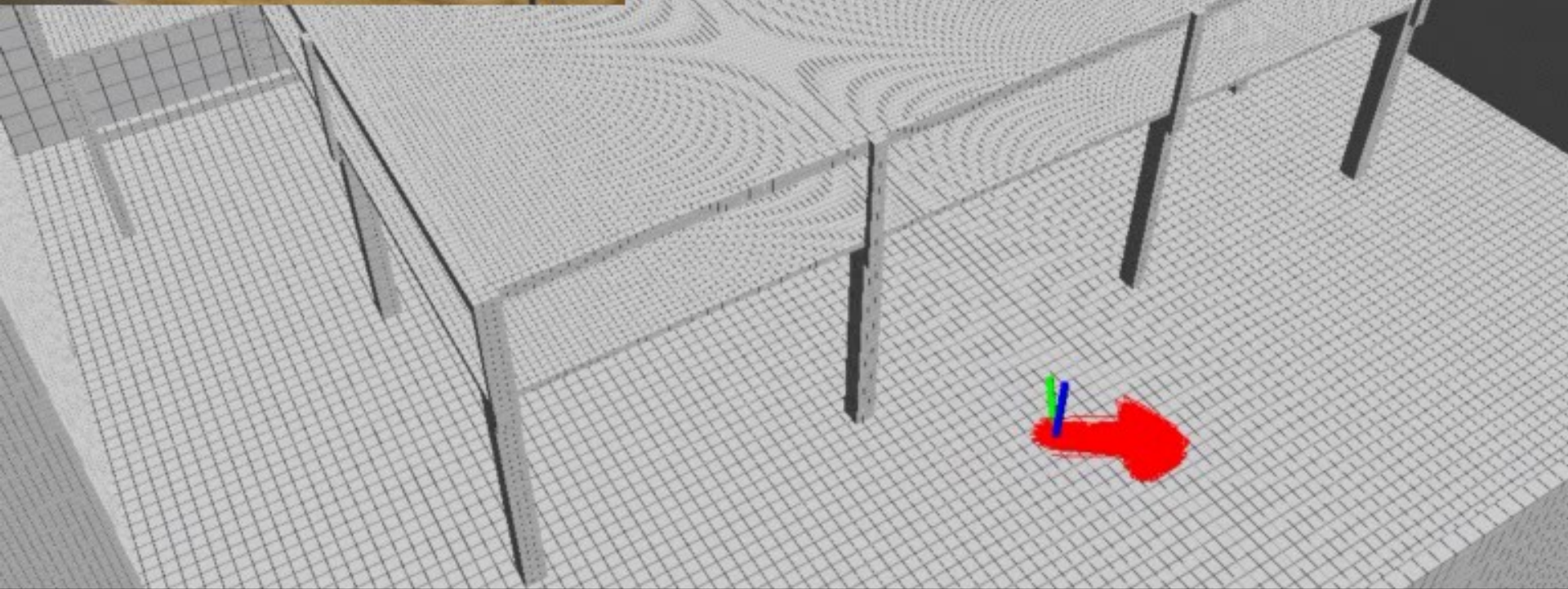


Localization

- Complex indoor environments and shaking movements require estimation of 6D torso pose
- 3D environment model in OctoMap
- Monte Carlo localization based on laser, IMU, and proprioception
- 3D environment model and ray-casting available in **octomap_mapping**



[Hornung et al. '10]



Localized 6D torso pose

Video: Climbing a Staircase



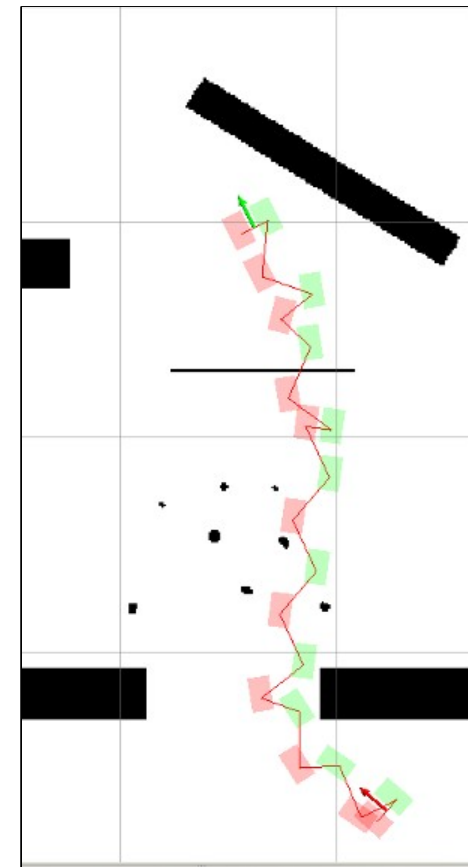
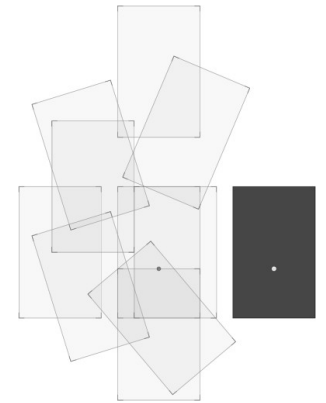
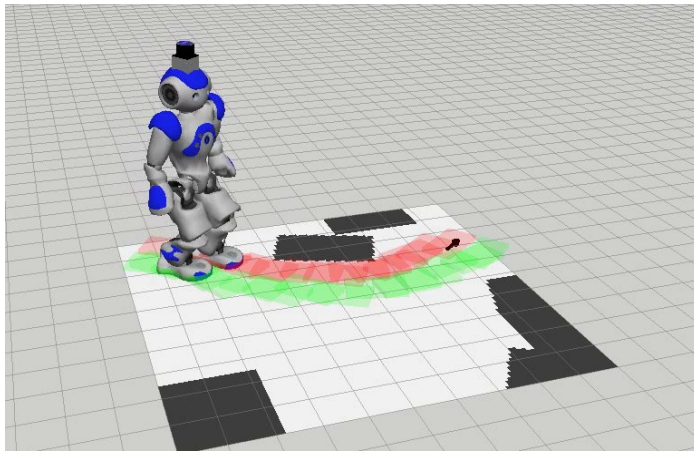
Video: Walking Down a Ramp



The center of mass is balanced over the support polygon

Footstep Planning

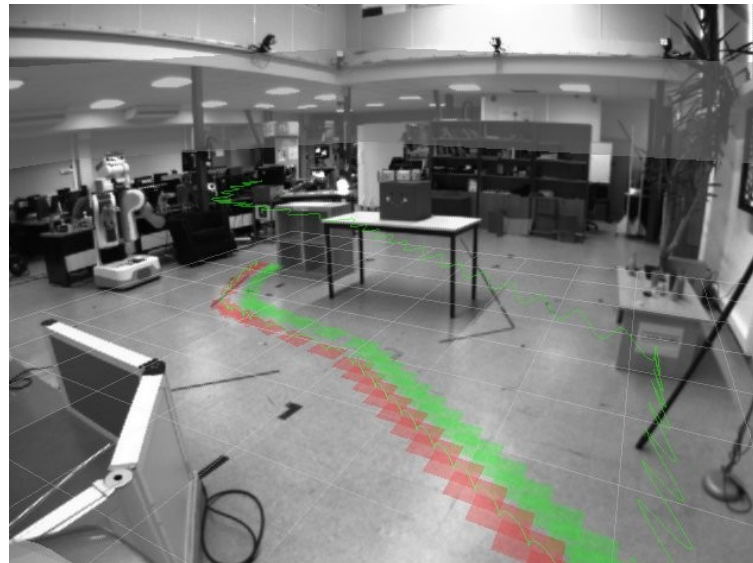
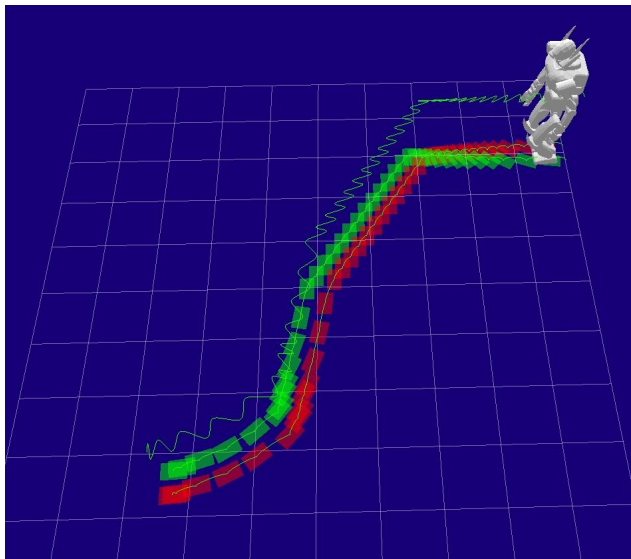
- Humanoids can avoid obstacles by stepping over them
- Plan with discrete set of footstep transitions in a heuristic search
- Available in ROS package **footstep_planner** using SBPL
 - Anytime capable (ARA*)
 - Efficient replanning (AD*)



[Garimort et al. '11]

Walking Motion Generation

- **Task:** Determine joint angle trajectory to walk on given footstep locations
- Provided walking controllers
 - For Nao: footsteps or omni-directional velocity
- **humanoid_walk** stack

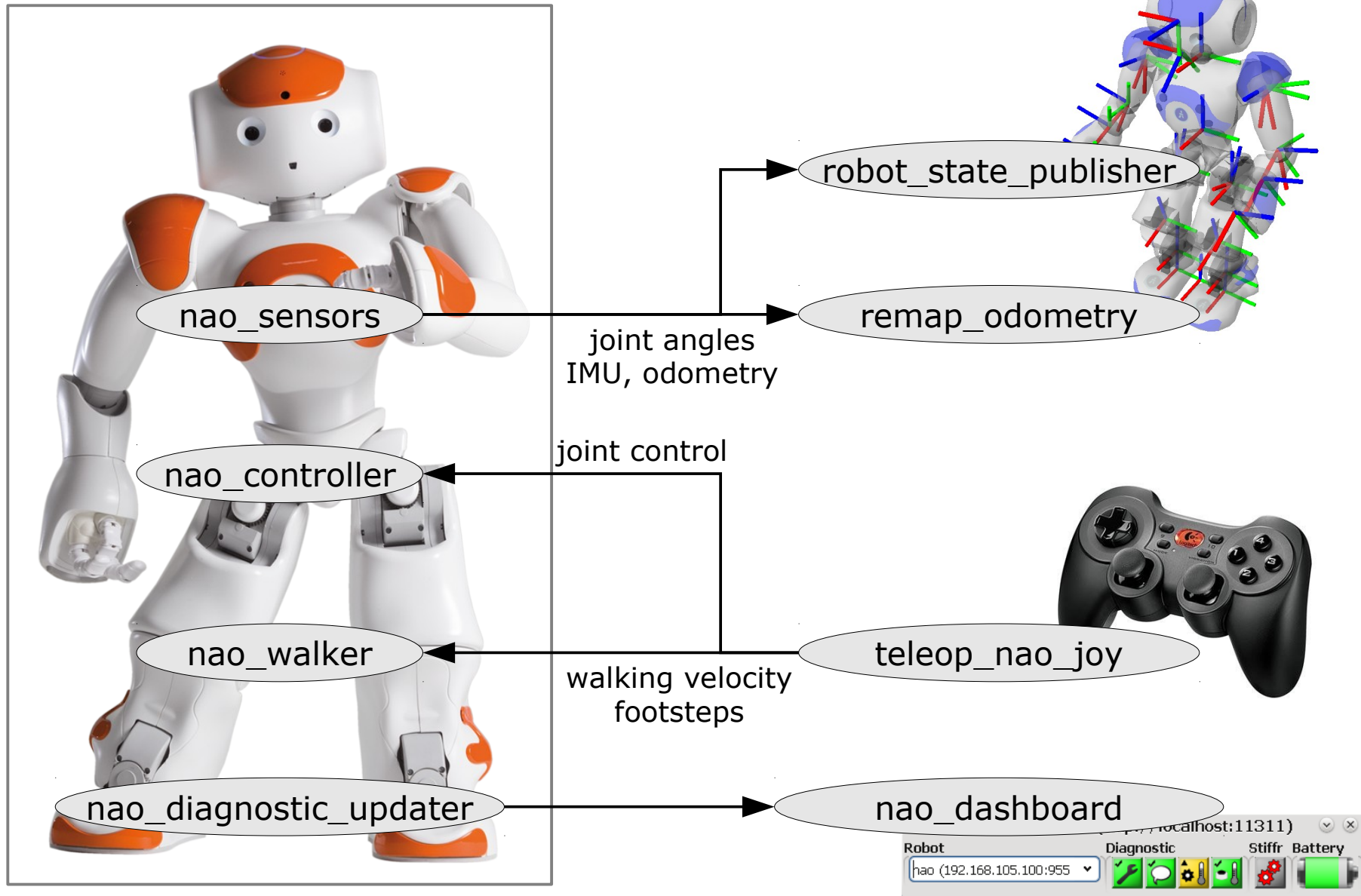


[Courtesy of T. Moulard, LAAS]

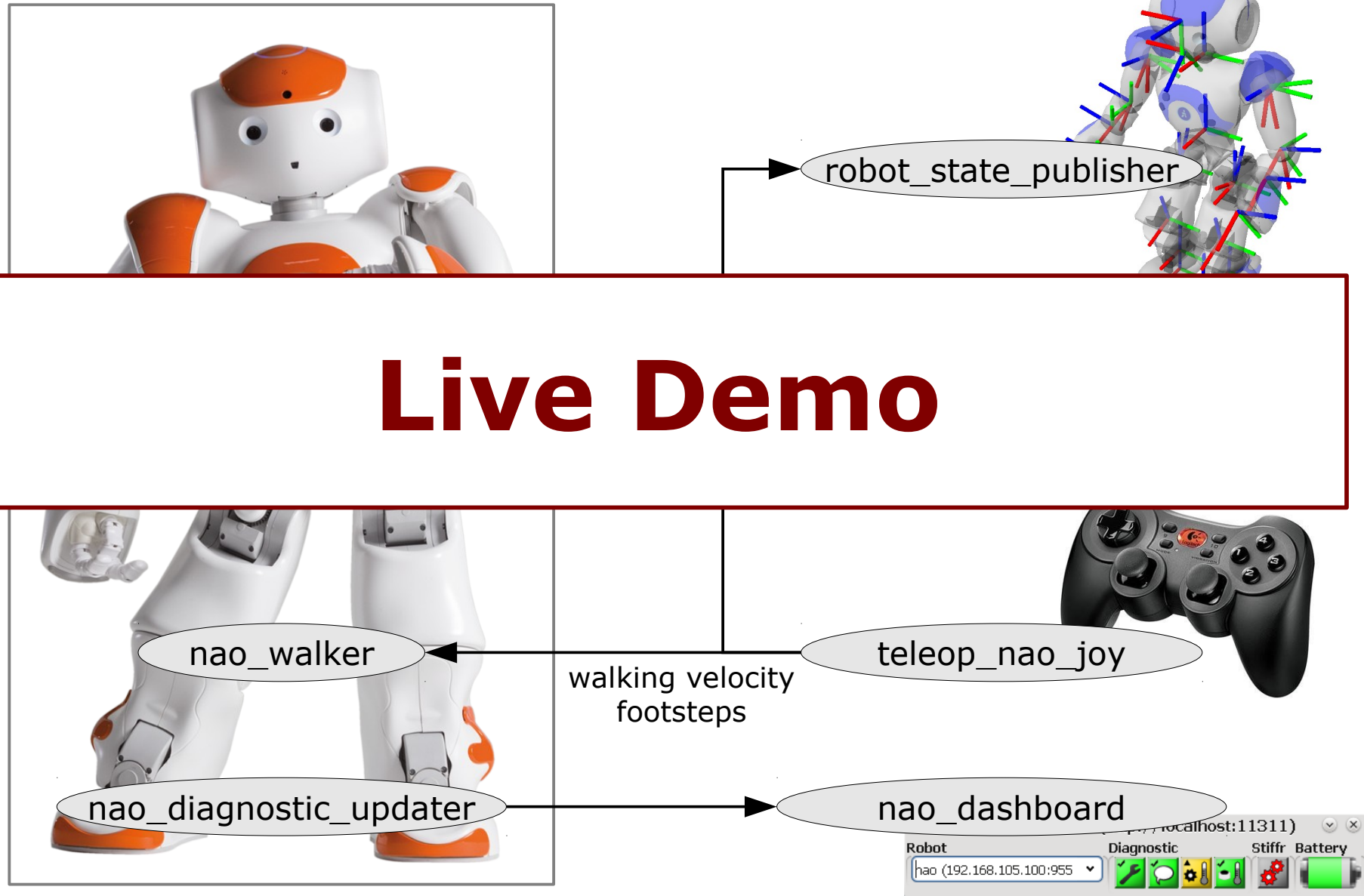
The NAO Humanoid in ROS

- Basic API in **nao_driver** (**nao_robot** stack)
 - Wraps NaoQI API (1.6 - 1.12) in Python
 - Runs remotely or directly on the robot (with cross-compilation)
- URDF and teleoperation in **nao_common** stack
- Odometry and projected base_footprint frame in **nao_remote**

NAO Nodes Overview



NAO Nodes Overview



Summary

- Review of suitable ROS packages for humanoid robots
- Manipulation and kinematics working for chains, may improve in the future
- Localization and path planning for a humanoid navigation stack
- Overview of ROS for the Nao humanoid

Thank you!

