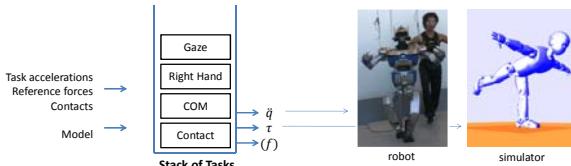


A Dedicated Solver For Fast Operational-Space Inverse Dynamics

Nicolas Mansard – nmansard@laas.fr

Objectives

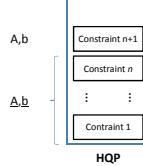


Hierarchical QP Solver

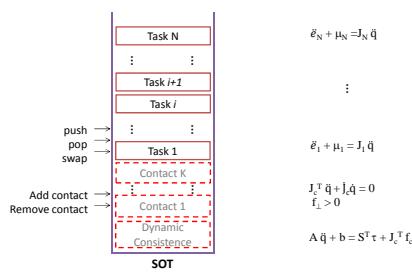
- ✓ At each level of the hierarchy:

$$\min_{x,w} \|w\|^2$$

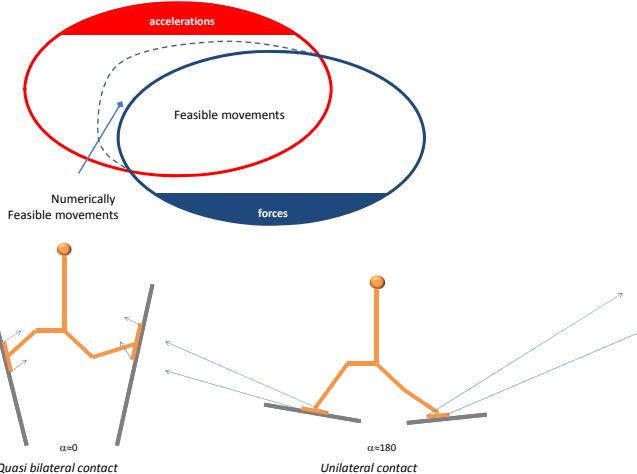
subject to $\begin{array}{l} Ax \leq b+w \\ Aw = 0 \end{array}$



- ✓ Implementation for inverse dynamics



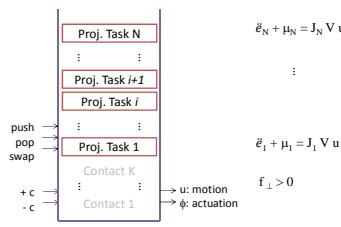
III-conditioned Dynamics



$$\begin{aligned} A\ddot{q} + b + J^T f &= S^T \tau \\ B^{-1}\ddot{q} + B^T b + G^T f &= (SB)^T \tau \\ GG^T f + \delta &= (SBG)^T \tau \\ (SBG)^T \tau &= G^T f + Vu + \delta \end{aligned}$$

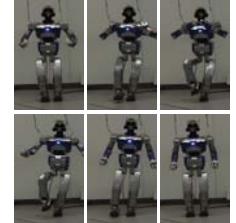
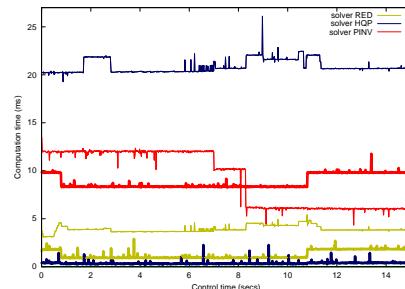


feasible movement

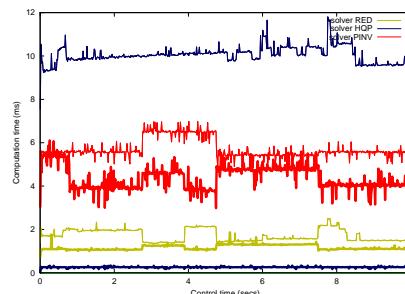


Time Scores

- ✓ Yoga movement "Standing Lotus"



- ✓ Waist movement with fixed hands



Robot Motions

- ✓ Novela festival: "Dance with HRP2"



References and Acknowledgments

1. B. Siciliano and J.-J. Slotine, "A general framework for managing multiple tasks in highly redundant robotic systems". In *IEEE Int. Conf. on Advanced Robotics (ICAR'91)*, Pisa, Italy, June 1991.
 2. C. Collette, A. Micellaci, C. Andriot, and P. Lemerle, "Dynamic balance control of humans for multiple grasps and non coplanar frictional contacts". In *2007 IEEE-RAS International Conference on Humanoid Robots (Humanoid'07)*, December 2007.
 3. A. Escande, N. Mansard, P.-B. Wieber, "Fast resolution of hierarchized inverse kinematics with inequality constraints". In *IEEE Int. Conf. on Robotics and Automation, ICRA'10*, Anchorage, USA, May 2010.
 4. L. Saab, N. Mansard, F. Keith, J. Fourques, and P. Soueres, "Generation of dynamic motion for anthropomorphic systems under prioritized equality and inequality constraints". In *IEEE Int. Conf. on Robot. & Automation (ICRA'11)*, May 2011.
 5. O. Ramos, L. Saab, S. Hak, and N. Mansard, "Dynamic motion capture and edition". In *IEEE-RAS International Conference on Humanoid Robots (Humanoid'11)*, Ried, Slovenia, Nov. 2011.

Acknowledgments

Acknowledgments
ANR JCJC R-BLINK (O. Stasse) & FP7 ECHORD GOP (K. Mombaur)
O. Stasse, A. Kheddar, O. Ramos, P. Souères, P-B. Wieber, T. Moulard