

Démonstrateur du projet ROBOT@CWE

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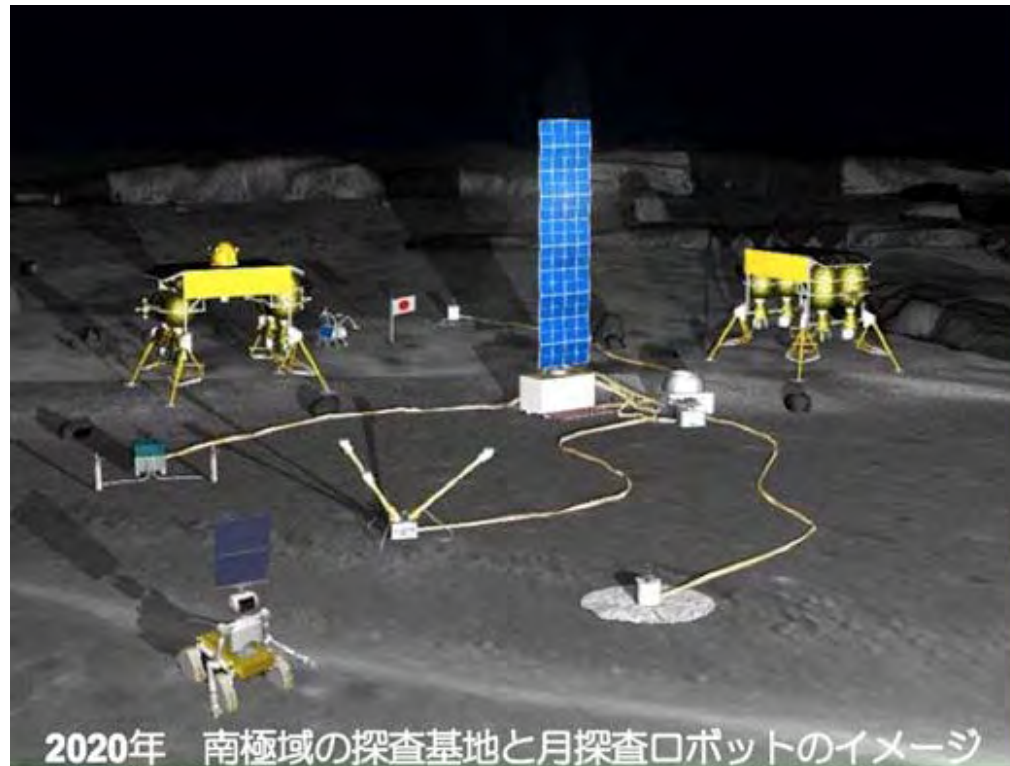
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Objectif

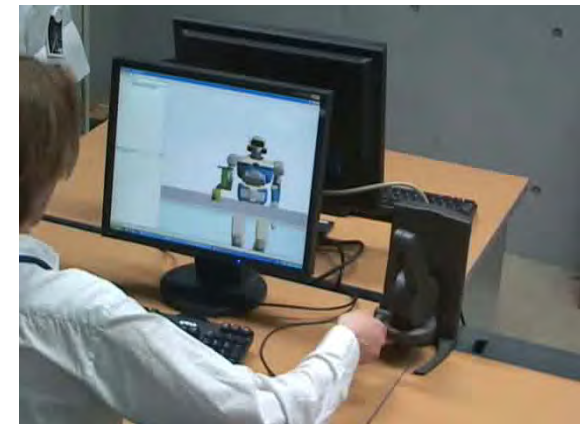
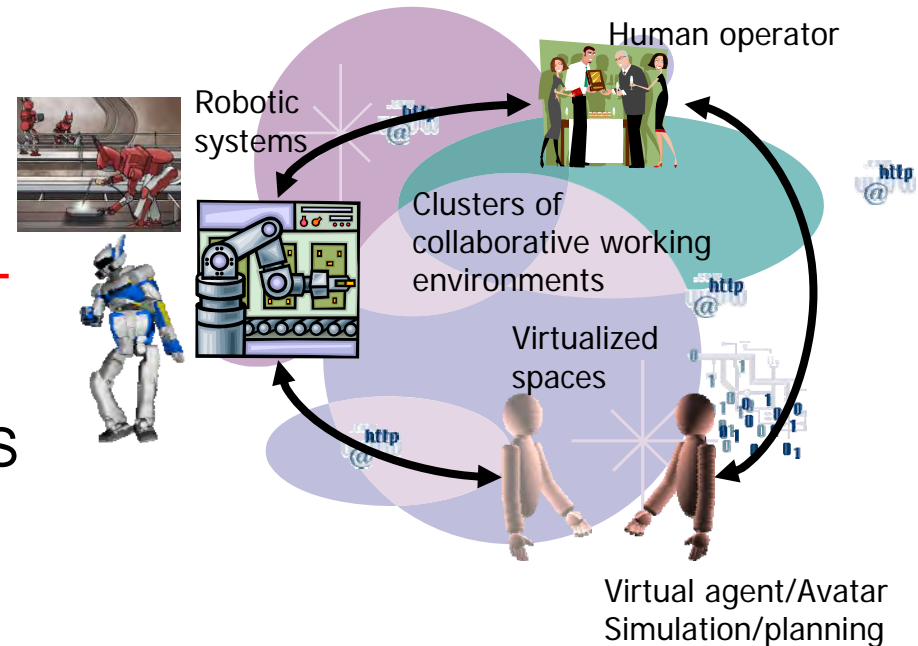
- Intégrer un robot comme un agent de travail dans un environnement de travail collaboratif

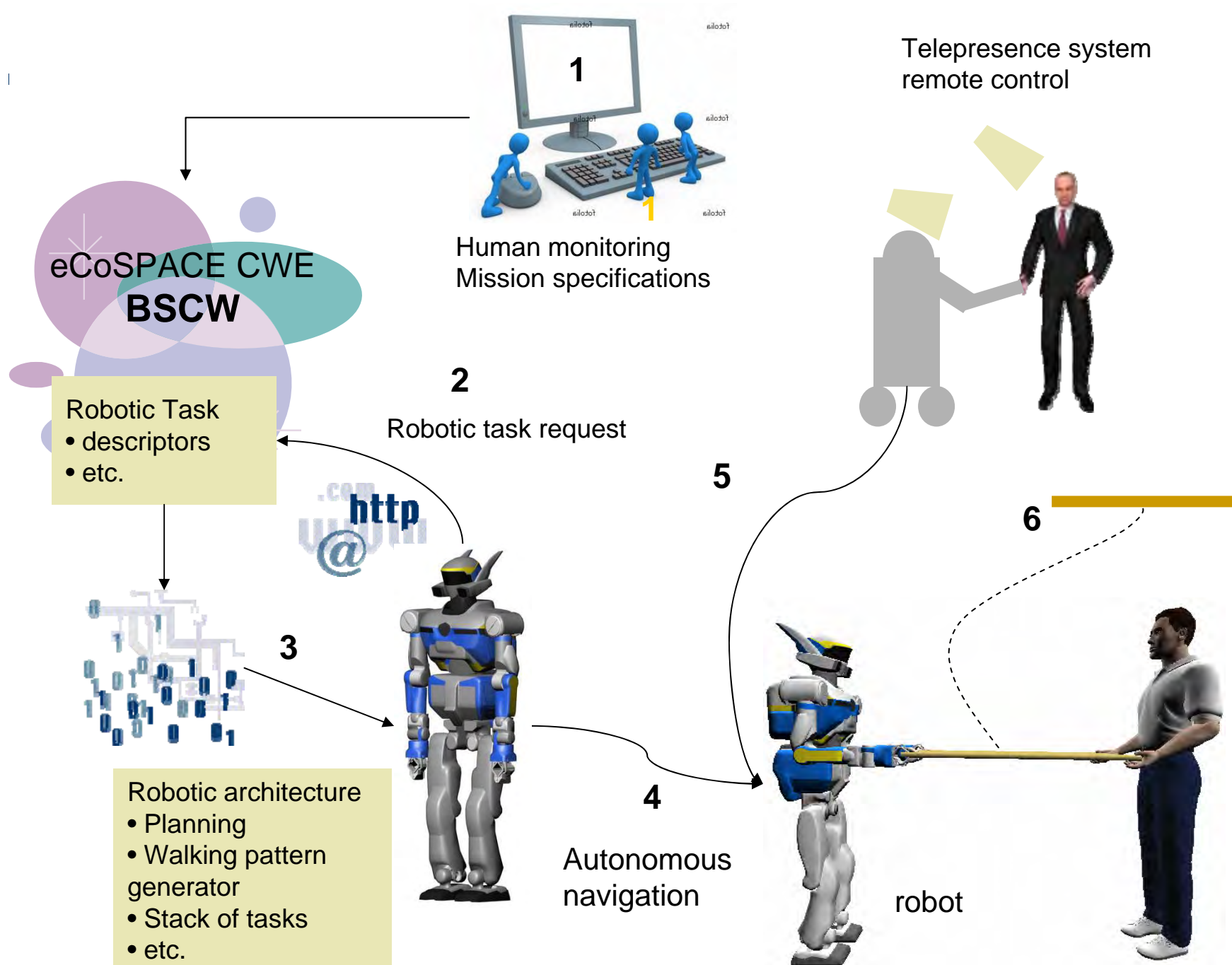


ROBOT@CWE

Projects

- Integrating robots in “collaborative working environment”
 - Members: **CNRS** and **AIST** (**JRL**), UC3M, TUM, UNISALZ, EPFL, DRAGADOS, HP EIC, SAS
 - www.robot-at-cwe.eu
- 4 operating modes





ROBOT@CWE demonstrator

1. The manager creates a task
2. The robot goes to inspect
3. The robot is tele-operated to reach the place of interaction
4. Autonomous Human-robot interaction to perform a collaborative task
5. Object assembly

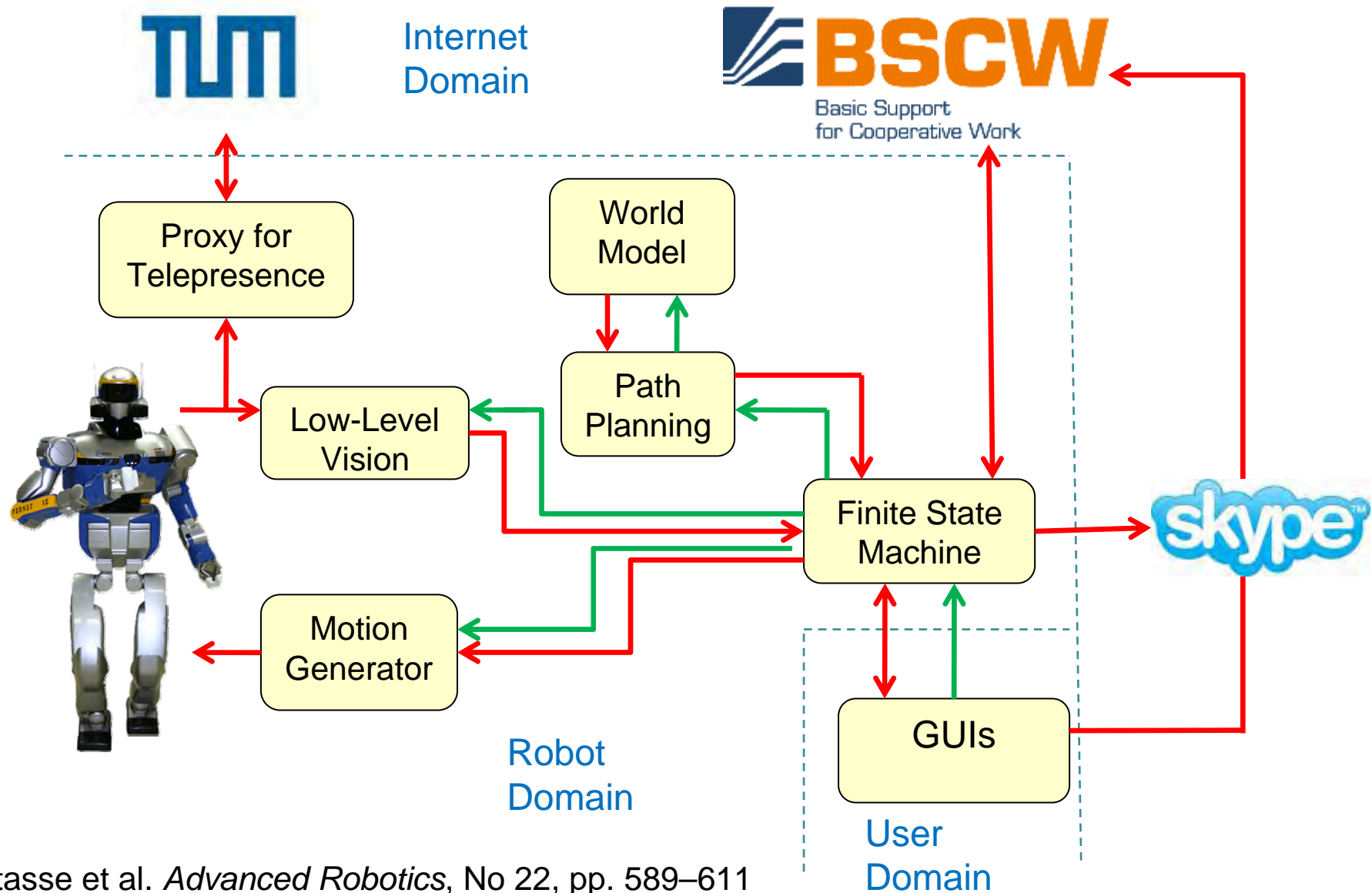


ROBOT@CWE video



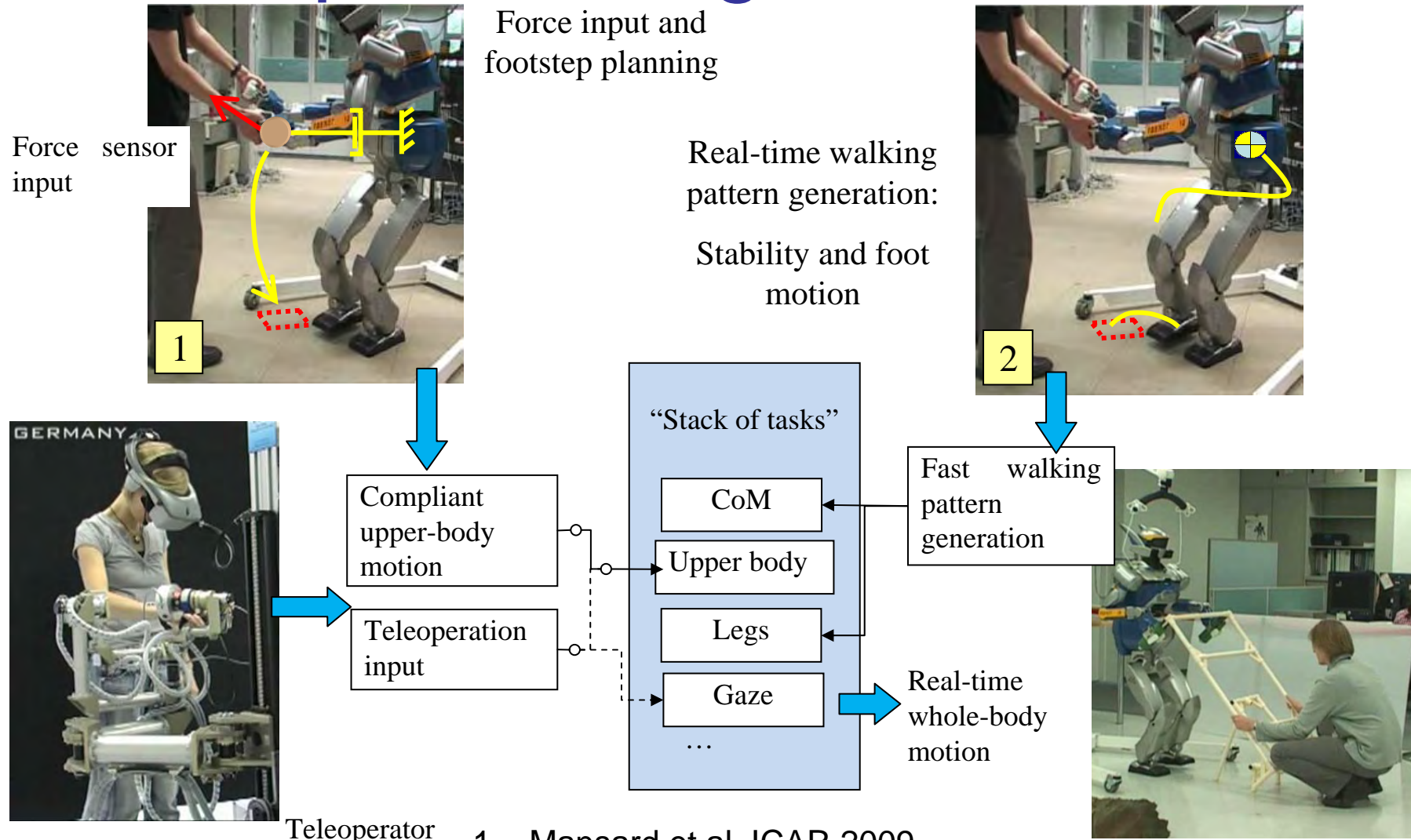
ROBOT@CWE video





1. Stasse et al. *Advanced Robotics*, No 22, pp. 589–611
2. Stasse et al. *Intelligent Service Robotics*, Vol. 2, No 3, pp. 1861-2276 2009

Example of integration



Human-humanoid Joint Action

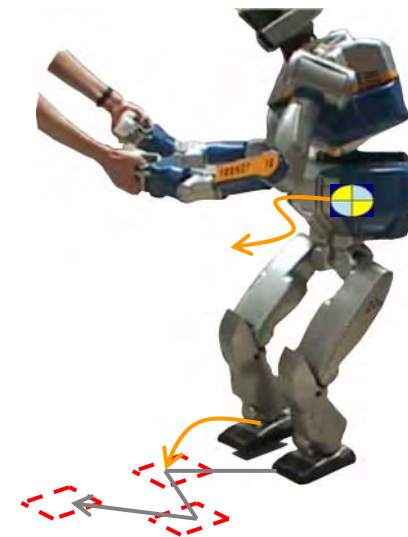
- Understanding human-human haptic joint actions
- Haptic language and semantics
- Mapping haptic interaction to whole-body motion
- Multi-modal interaction



Footprints



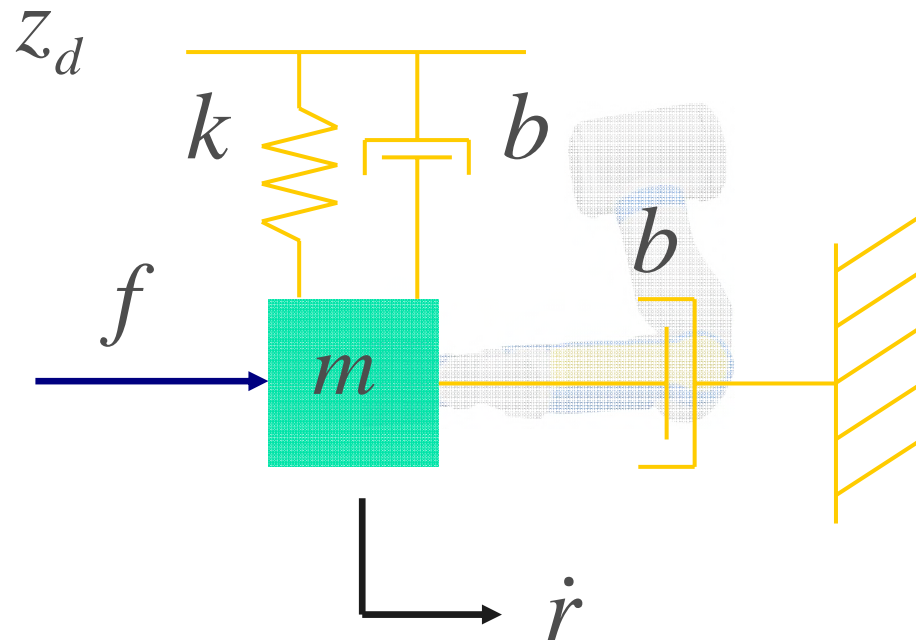
ZMP trajectory



CoM and feet trajectories

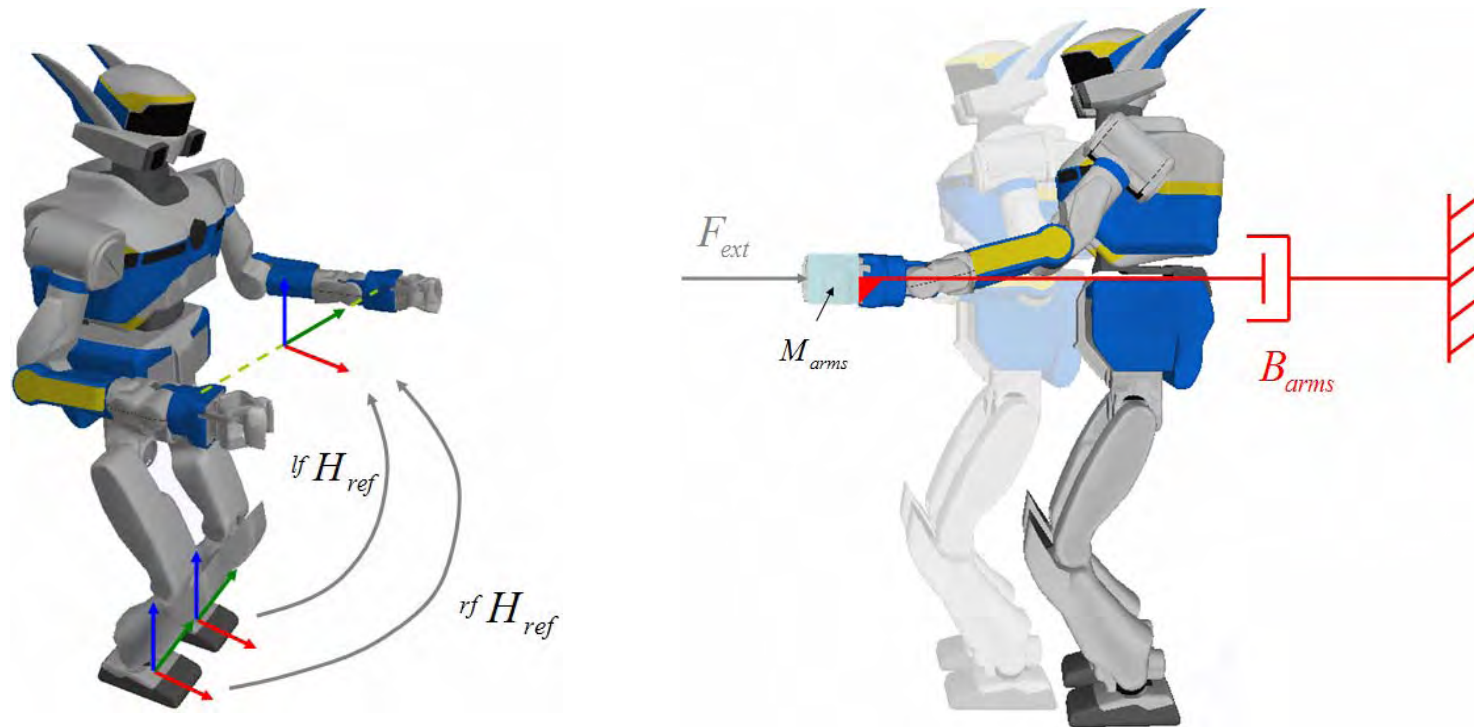
Admittance control

- Desired dynamic behavior of the end-effector



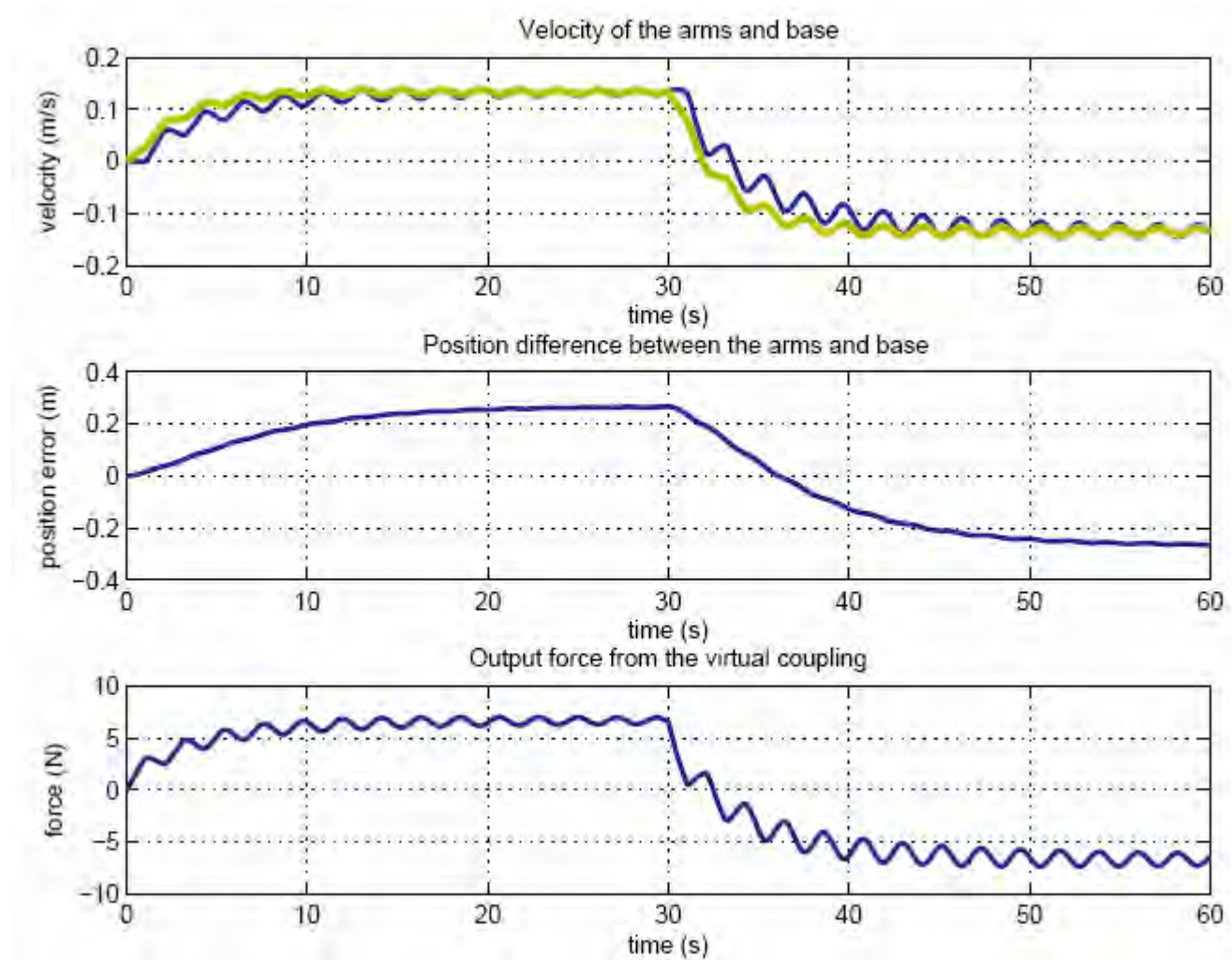
Haptic to footsteps planning

- Reference frame attached to the arms
- Tracking a desired relative position of reference frame with respect to the feet



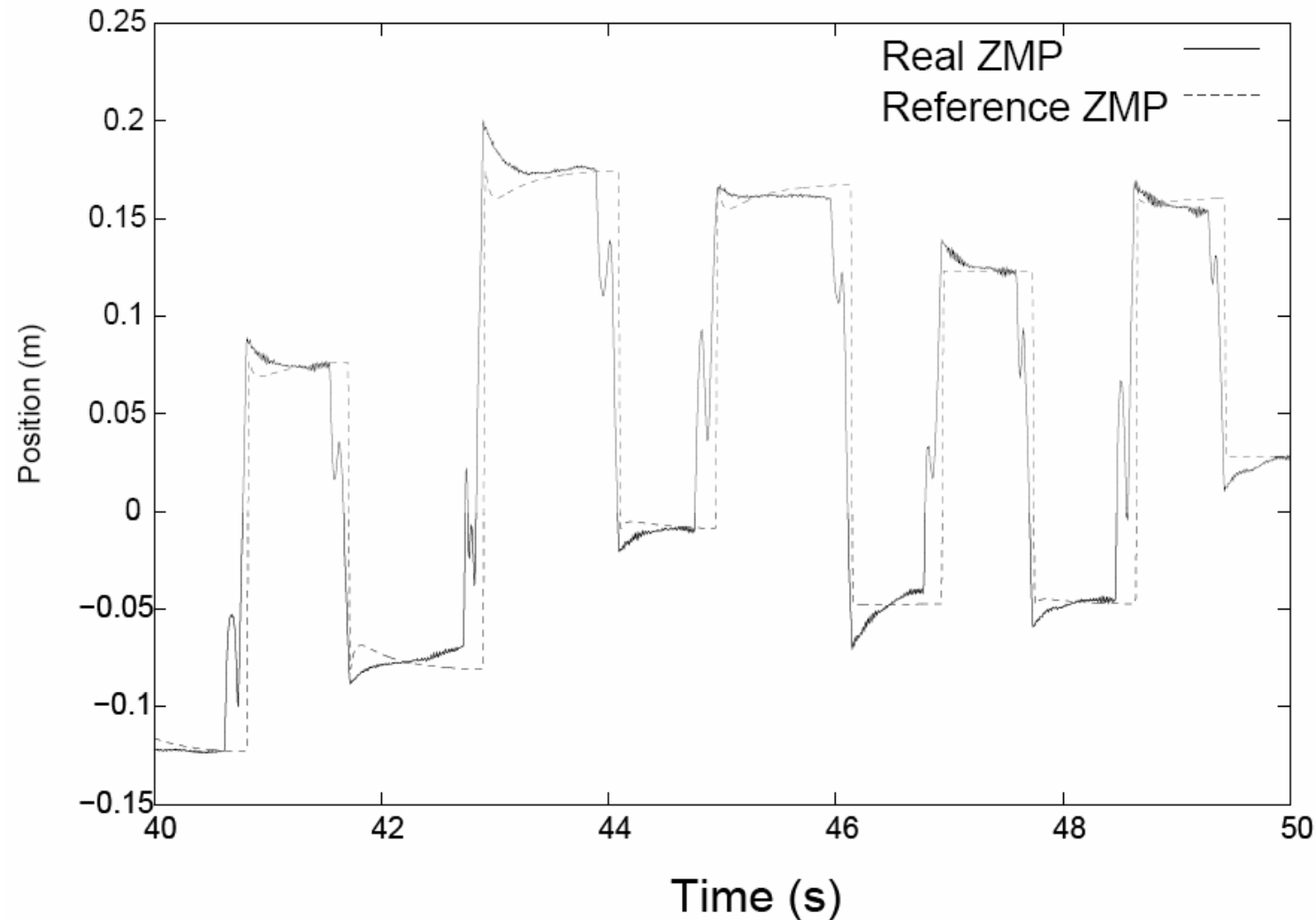
1. P. Evrard, Thèse UM2, 2009;
2. Evrard, Kheddar IEEE RO-MAN 2009, WorldHaptics 2009
3. Stasse, Evrard, Perrin, Mansard, Kheddar, *IEEE-RAS Humanoids*, 2009

Footsteps planning



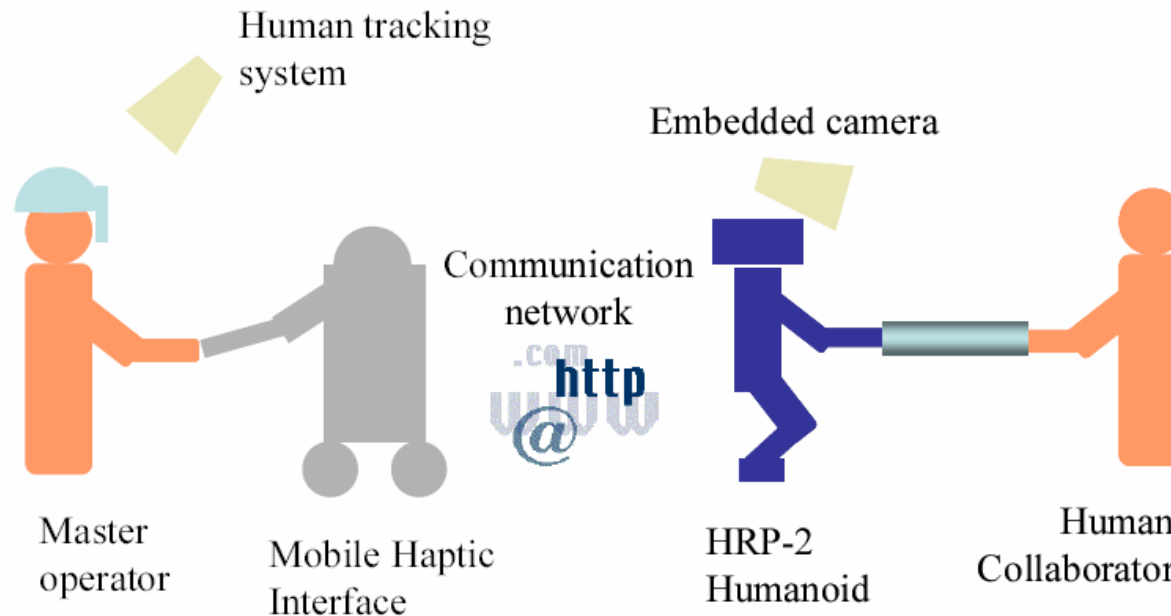
Experimental results

ZMP during experiment using 3d motion



Extension to tele-cooperation

Collaboration with TUM

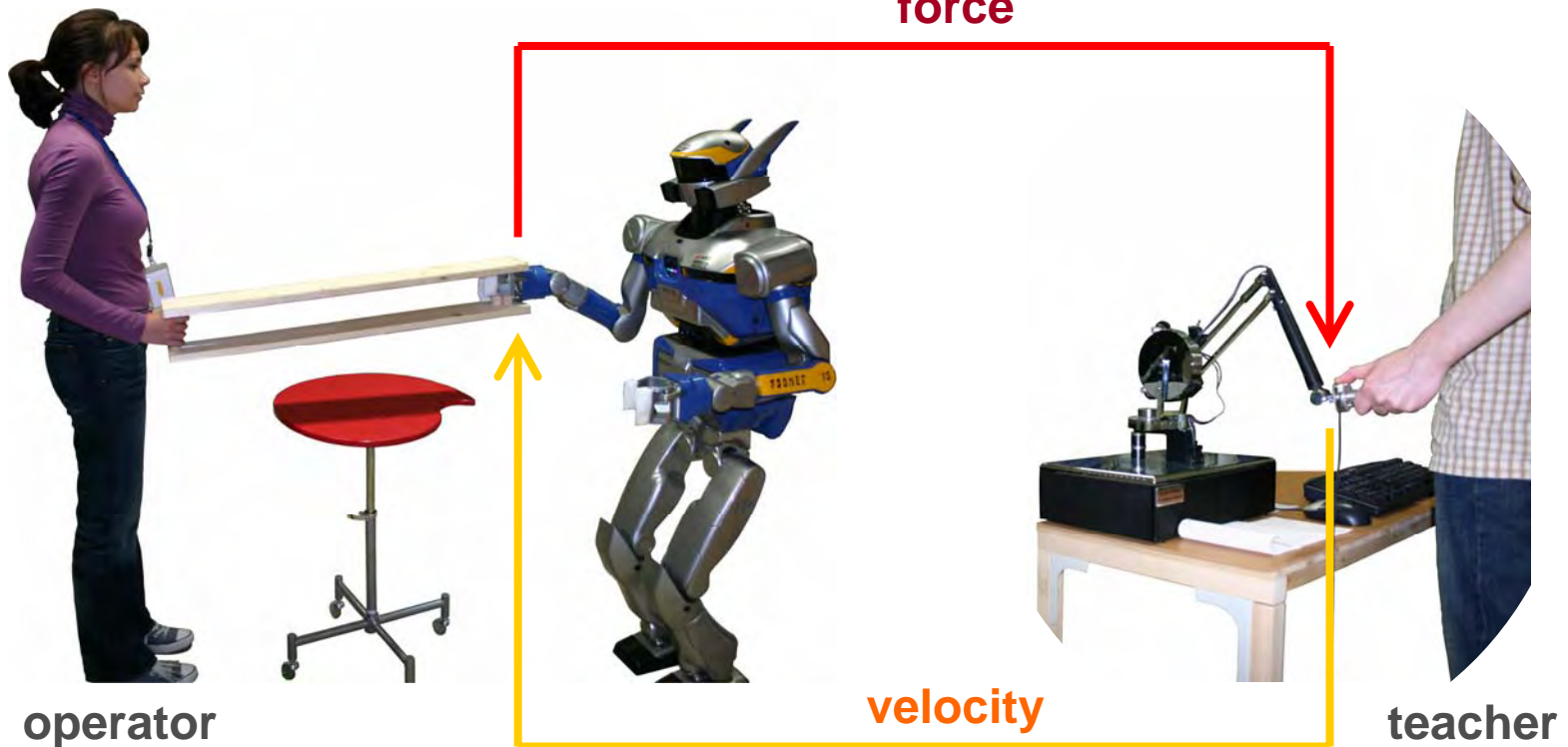


- Collaboration between two human operators through a telepresence system
- Teleoperation of a humanoid robot
- Coupling: gait vs. wheels

1. Peer et al. IEEE/RSJ IROS 2008
2. Evrard et al. IEEE/RSJ IROS 2009

Learning haptic joint actions

- Teleoperation system
- Velocity-force bilateral coupling



1. Calinon et al. ICAR 2009
2. Evrard et al. HUMANOIDS 2009

Demonstrations

- Scenario 1: teaching a follower behavior
 - Goal: reproduce the follower behavior of the teacher

Instructed to act
as a **leader**



Instructed to act
as a **follower**

- Scenario 2: teaching a leader behavior
 - Goal: reproduce the leader behavior of the teacher

Instructed to act
as a **follower**

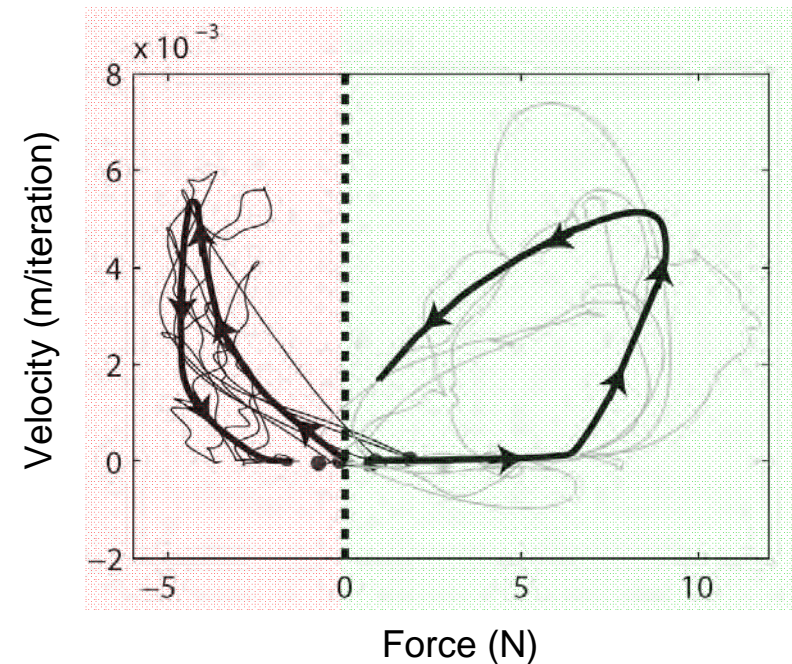


Instructed to act
as a **leader**

Leader and follower patterns

- Two teaching scenarios
 - Teacher leads
 - Teacher follows
- Two distinct patterns

Leader behavior Follower behavior



S. Calinon, P. Evrard, E. Gribovskaya, A. Billard, A. Kheddar, “*Learning collaborative manipulation tasks by demonstration using a haptic interface*”, ICAR 2009.

Conclusion

- Intégration
 - Travail ingrat mais nécessaire
- Plusieurs problèmes à résoudre
 - Comportement proactif du robot en mode collaboration physique
 - Augmenter la robustesse et les performances d'interaction
- Penser dès maintenant au 'outdoor'