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# Bottom up development of a robot's basic socio-cognitive abilities for joint action

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Inspired from Child Development and Human Behavioral Psychology  
 Identified *key Challenges* from Human-Robot Interaction (HRI) and Social Robotics perspectives  
 Discovered *basic blocks* for socio-cognitive capabilities for Joint action

Developed generic frameworks to elevate the robot's reasoning capabilities of:

**Perspective Taking**

Visible regions by different levels of effort

Mightability (*Might be able to*) Analysis: Effort-based visuo-spatial perspective taking [1]

Reachable regions by different levels of effort

**Effort Analysis**

Effort to Reach: No\_Effort, Arm\_Effort, Arm\_Torso\_Effort, Whole\_Body\_Effort, Displacement\_Effort, No\_Possible\_Known\_Effort

Effort to See: No\_Effort, Head\_Effort, Head\_Torso\_Effort, Whole\_Body\_Effort, Displacement\_Effort, No\_Possible\_Known\_Effort

Elevating socio-cognitive capabilities by combining perspective taking, effort and affordances [2]

**Affordance Analysis**

Inter-Agent affordances: what an agent might be able to do for other agent

Agent-Agent Affordance [3]

Agent-Object affordances: what an agent might be able to do with objects

Affordance Graph: Combining inter-agent and agent-object affordances [4]

**State Analysis**

Verifying the affordance estimated by the robot from the human's perspective to take the object, which is currently hidden from the human.

Which further facilitates developing frameworks for planning joint tasks:

**- for day-to-day interactive manipulation**

To give: PR2 robot is giving the object by estimating effort, visibility, reachability and graspability

To hide: PR2 robot hiding the object from human's perspective

Planning day-to-day HRI tasks [5]

To show: PR2 robot is showing the object by analyzing from the human's perspective

**- for behaving**

The robot estimates the comfortable hand-over position and proactively reaches out to take the object from the human. Reduces human effort and confusion in the joint task.

Proactive robot [6]

**- for shared planning**

Shared plan generated by the robot to clean the table, reducing each individual's effort

[1] Amit Kumar Pandey and Rachid Alami, "Mightability Maps: A Perceptual Level Decisional Framework for Co-operative and Competitive Human-Robot Interaction", IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2010)  
 [2] Amit Kumar Pandey and Rachid Alami, "Visuo-Spatial Ability, Effort and Affordance Analyses: Towards Practical Realization of Building Blocks for Robot's Complex Socio-Cognitive Behaviors", Cognitive Robotics in conjunction with AAAI-2012 (CogRob-AAAI 2012)  
 [3] Amit Kumar Pandey, Jean-Philippe Saut, Daniel Sidobre, Rachid Alami, "Towards Planning Human-Robot Interactive Manipulation Tasks: Task Dependent and Human Oriented Autonomous Selection of Grasp and Placement", IEEE/RAS-EMBS International Conference on Biomedical Robotics and Biomechanics (BioRob 2012)  
 [4] Amit Kumar Pandey and Rachid Alami, "Taskability Graph: Towards Analyzing Effort based Agent-Agent Affordances", 21st IEEE International Symposium on Robot and Human Interactive Communication (Ro-Man 2012)  
 [5] Amit Kumar Pandey and Rachid Alami, "Affordance Graph: A Framework to Encode Effort-based Affordances for day-to-day HRI", IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2013)  
 [6] Amit Kumar Pandey, Muhammad Ali and Rachid Alami, "Towards Task-Aware Proactive-Social Robot based on Multi-State Perspective-Taking", International Journal of Social Robotics, Volume 5, Issue 2 (2013), Page 215-236 (USR-2013)