

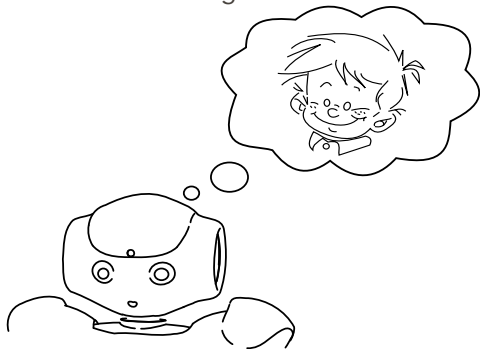
Non-Recursive Approach for Mutual Understanding

How to detect and repair misunderstanding between human and robots

Journée de travail sur la Robotique

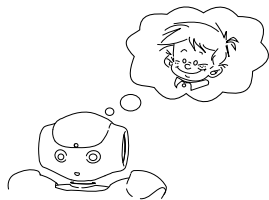
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INTRODUCTION

Mutual understanding requires 1st and 2nd order of theory of mind:



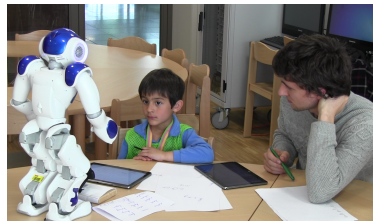
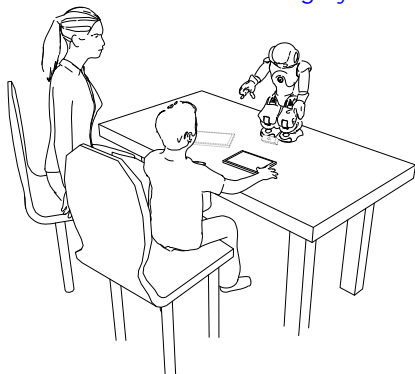
Do I understand you ?



Do you understand me ?

THE COWRITER INTERACTION

Learning by teaching approach:



- a **physical robot** to induce a "protégé" effect
- the robot is **autonomous**

Jacq, Lemaignan, Garcia, Dillenbourg & Paiva, **Building Successful Long-term Child-Robot Interactions in a Learning Context**, HRI 2016

Lemaignan, Jacq, Hood, Garcia, Paiva, & Dillenbourg, **Learning by Teaching a Robot: The Case of Handwriting**, RAM 2016

OBSERVED ISSUES

Situations of misunderstanding:

- When the child **press unexpected button**
- when the child is **disengaged**
- When the child **does not perceive the difficulty (or progresses)** of the robot
- Incoherent **visual behaviour** of the robot and the child

COLLECTING INFORMATION

Currently, the robot can perceive:

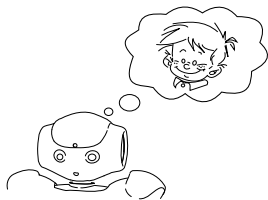
- The progress of the child/itself
- How the child evaluate the robot's progress
- The visual focus of attention (VFoA) of the child

IDEA

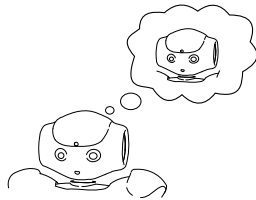
To develop a **cognitive architecture** that

- **takes as input** progress of the child, focus of attention, perception of robot's progress...
- builds **models of agents** (robot, child, robot perceived by child)
- **detects and repairs misunderstanding**

MUTUAL MODELLING



$M_R [C]$ (1st level)

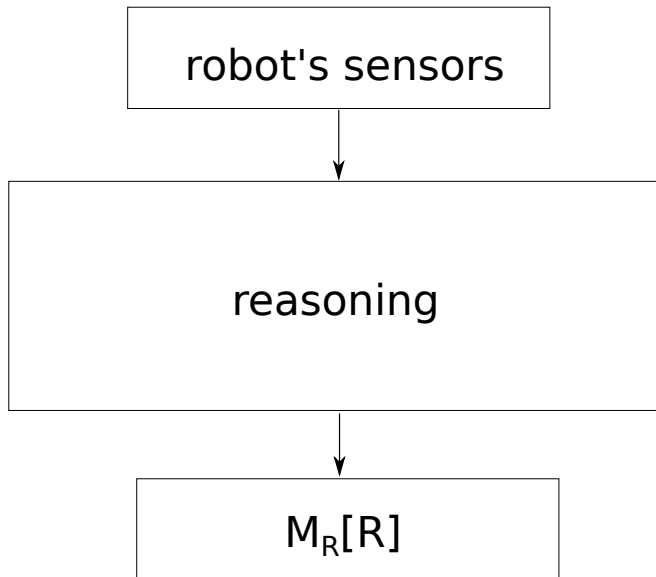


$M_R [R]$ (1st level)

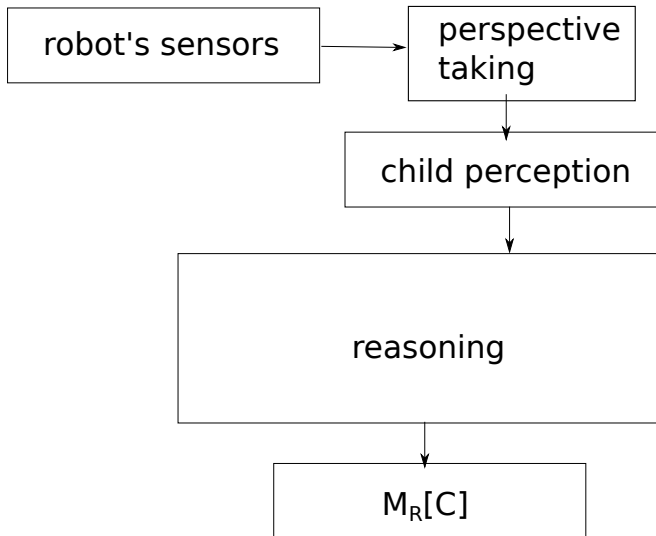


$M_R [C,R]$ (2nd level)

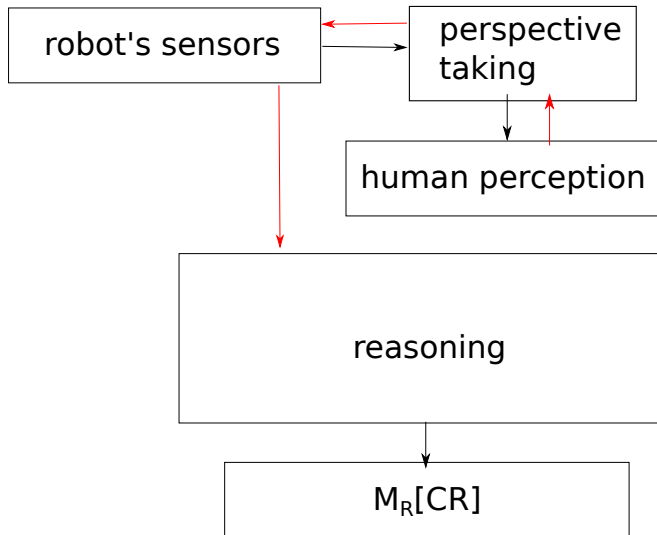
COGNITIVE ARCHITECTURE WITH NO MM



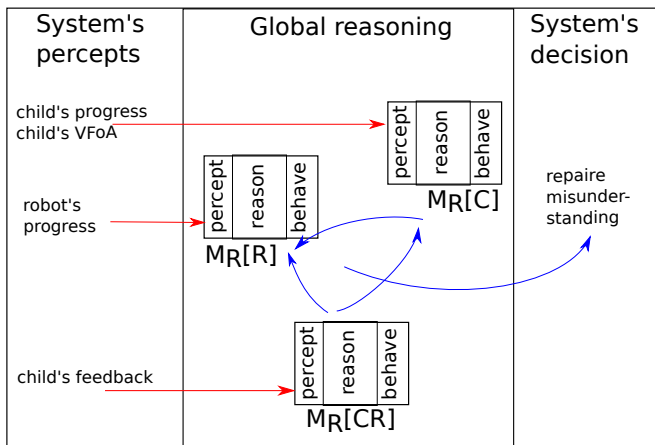
FIRST ORDER WITH RECURSIVE APPROACH



SECOND ORDER WITH RECURSIVE APPROACH

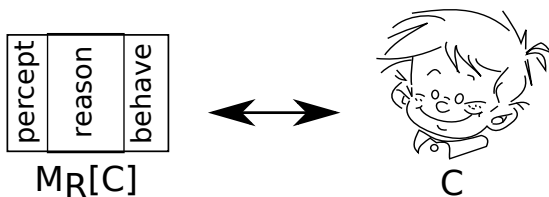


NON-RECURSIVE APPROACH



MISUNDERSTANDING (BY THE ROBOT)

When the robot misunderstands the human:

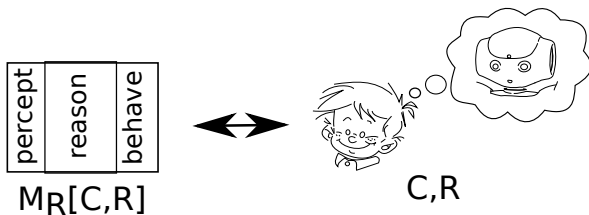


Prediction error:

$$\Delta \left(P_R^{t+1} [C] ; M_R^{t+1} [C] \right)$$

MISUNDERSTANDING (BY THE ROBOT)

When the robot misunderstands how the human perceives it:

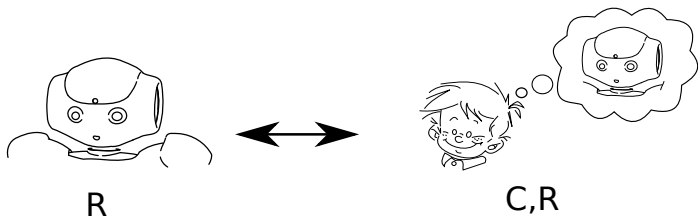


Prediction error:

$$\Delta \left(P_R^{t+1} [C,R] ; M_R^{t+1} [C,R] \right)$$

MISUNDERSTANDING (BY THE CHILD)

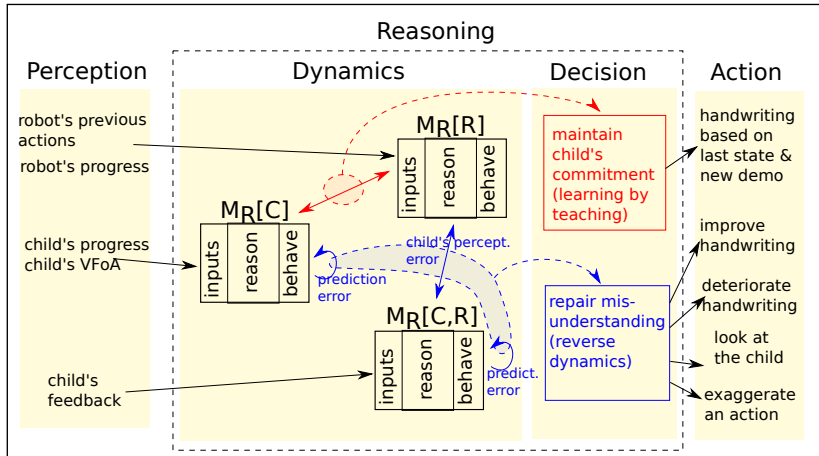
When the human misunderstands the robot:



Child's perception error:

$$\Delta \left(M_R^t [R] ; M_R^t [C,R] \right)$$

COGNITIVE ARCHITECTURE



TO SUMMARIZE

- **Mutual understanding** requires **1st** and **2nd** order of **ToM**
- A possible approach is **mutual modelling**: robot models **itself**, the **human, itself perceived by human**
- The robot needs to **update models in parallel** for reasoning
- Models must encode dynamics for **prediction**
- **Compare models** or **use predictions** to **detect and repair misunderstanding**