Using Human Knowledge Awareness for Human Robot collaboration

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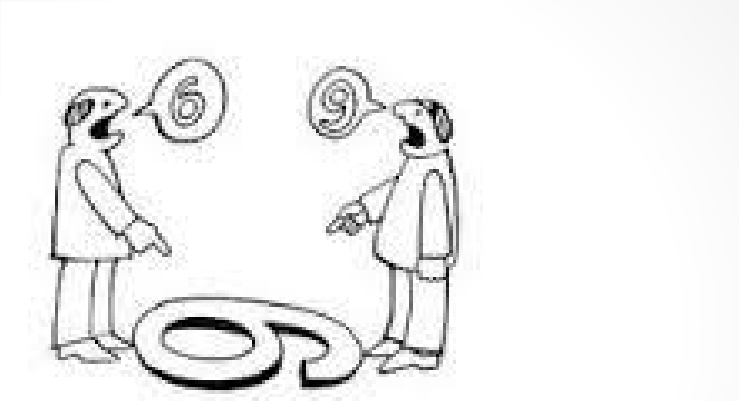
Introduction

Statement: reasonning on **other's mental state** is a key feature for **Joint Action**!

Does the chimpanzee have a theory of mind? (Premack 1978)

Does the autistic child have a 'theory of mind'? (Baron Cohen 1985)



Issue: how to **model** and **properly use awareness** of the **human knowledge** on how to perform a task?

e.g.: We want to bake a pie. Does the human know how to prepare the dough?
How to represent this knowledge? How to use it?

Motivation: **efficient** and **socialy adapted** human-robot collaboration

Outline

1. Human Knowledge Representation
2. Human Adaptive HTN Planner
3. Shared Plan Presentation and Negotiation
4. Adaptive Plan Execution

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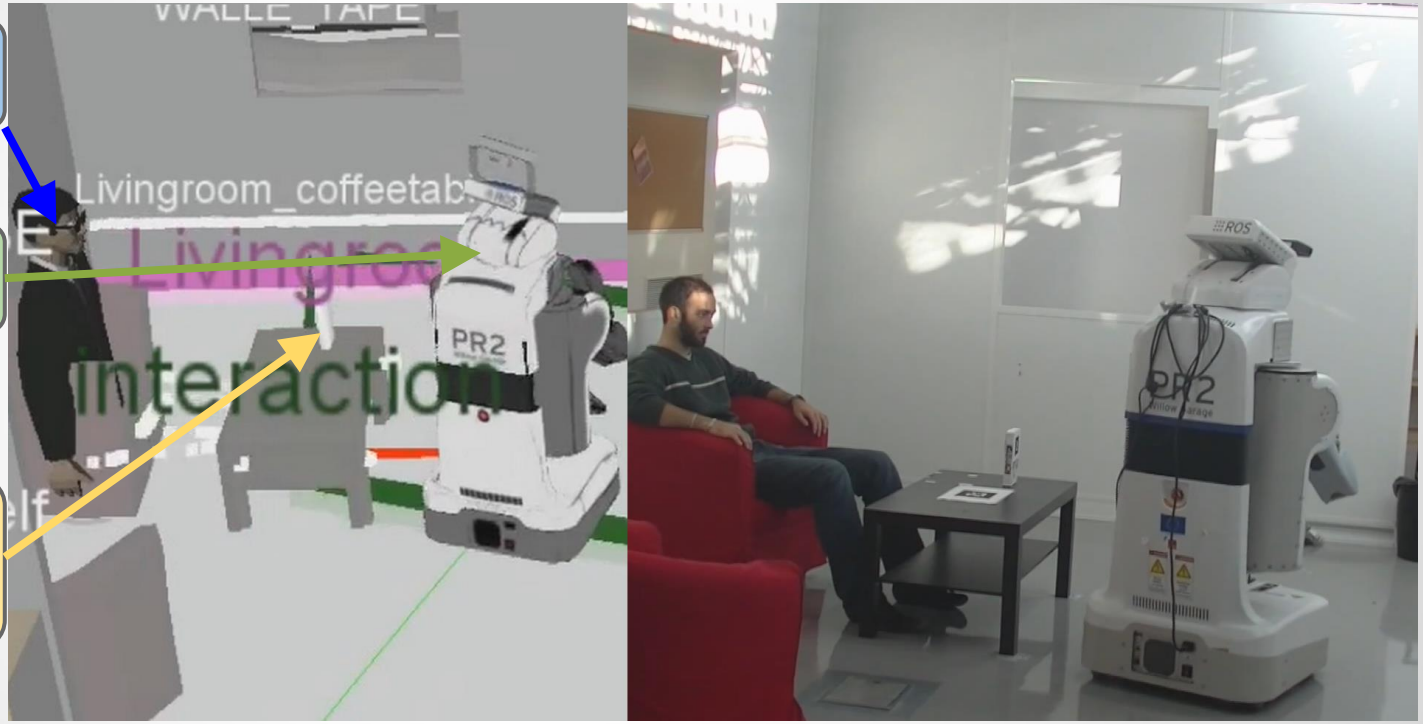
Human Knowledge Tracking

Knowledge tracking from situation assessment, using TOASTER

human tracker

proprioception

Object recognition



TOASTER: An Open-Source Situation Assessment Framework for HRI (RO-MAN 2016, *in review*)

https://github.com/Greg8978/toaster

Human Knowledge Tracking

Human Knowledge Modeling

In this work, we focus on the human's **knowledge on how to perform tasks**. This knowledge is represented as a vector

<HUMAN, TASK, PARAMETERS, VALUE>

e.g.: human1 has an expert knowledge on assembling a furniture piece A with a piece B:

<human1, assemble, [A,B], EXPERT>

HUMAN: human having this knowledge
TASK: name of the task
PARAMETERS: list of relevant parameters to describe the task knowledge
VALUE: value (or level) of knowledge

Human Knowledge Tracking

Human Knowledge Modeling

Knowledge Levels

1 NEW: human has no knowledge on how to perform the task

2 BEGINNER: human may know how to perform the task

3 INTERMEDIATE: human knows how to perform the task

4 EXPERT: human knows how to perform the task and is able to teach it

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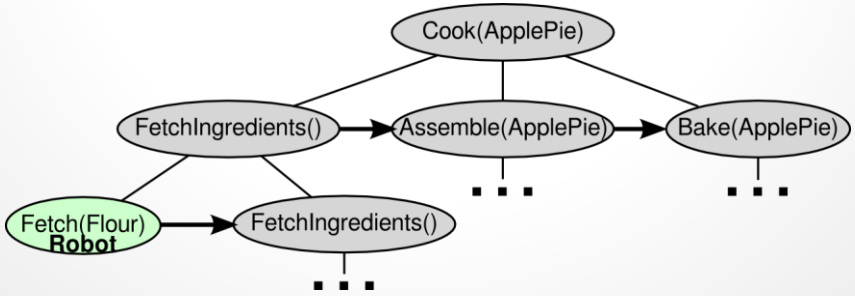
Human Adaptive HTN Planner

Hierarchical planner for better context

HATP: Hierarchical Agent-based Task Planner:
=> **Agents based:** computes multi-agent plans with humans and robots acting.
=> **Cost driven**: the best plan is found sooner (using plan pruning).
=> **Social rules**: refines the plans according to a set of rules designed to promote more socially acceptable plans (e.g. effort balancing depending on human preferences and context, social conventions).



Human Adaptive HTN Planner

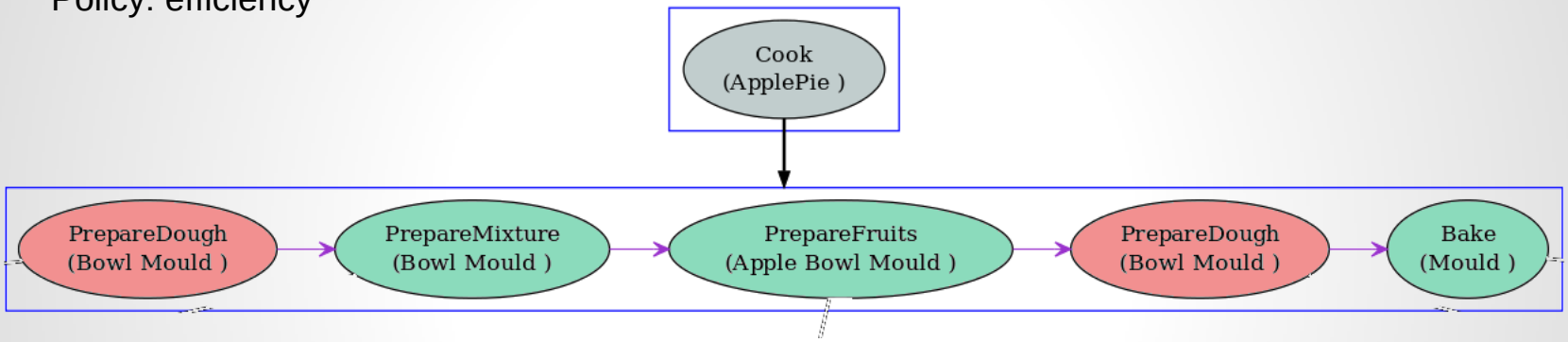
Human knowledge:

<*human1*, *PrepareDough*, *[ ]*, *EXPERT*>

Human request:

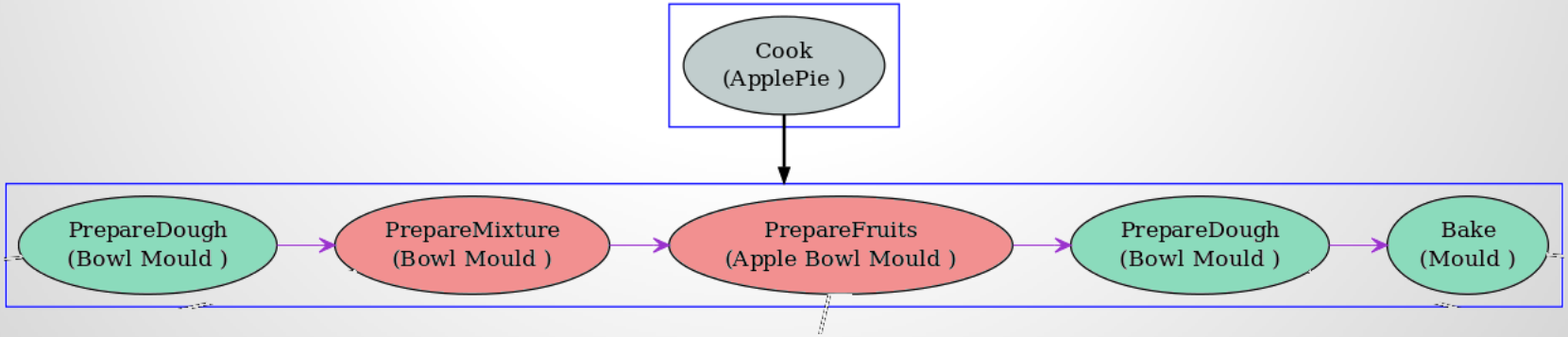
<*human1*, *Bake*, *[Mould]*, *Don' t want*>

Policy: efficiency



Robot Human

Policy: teaching



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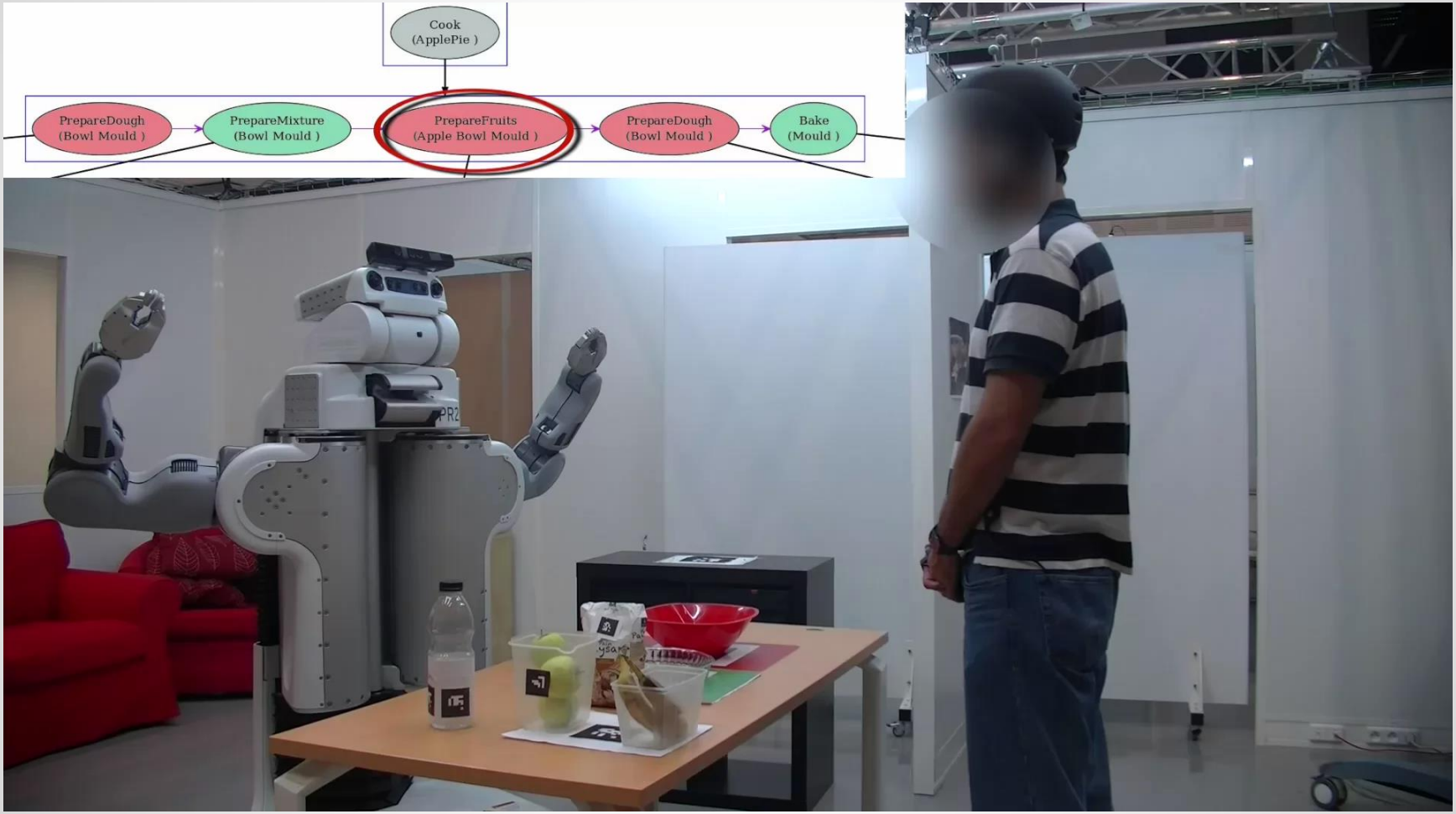
Shared Plan Presentation and Negotiation

Plan presentation

Shared Plan Presentation and Negotiation

Plan negotiation



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Adaptive Plan Execution

beginner <*human1*, *PrepareDough*, *[ ]*, *BEGINNER*>

expert <*human1*, *PrepareDough*, *[ ]*, *EXPERT*>

```
1:  for n:=nodes.start to n:=nodes.end do
2:      if agents(n) = {robot} then
3:          if children(n) ≠ ∅ ∧ user_kn(n) = NEW
              ∧ teachPolicy then
4:              execute_tree(children(n))
5:              user_kn(n) := BEGINNER
6:          else
7:              execute(n)
8:          end if
9:      else if user_kn(n) = NEW then
10:         explain(n)
11:         if children(n) ≠ ∅ then
12:             execute_tree(children(n))
13:             user_kn(n) := BEGINNER
14:         else
15:             monitor(n)
16:         end if
17:     else if user_kn(n) = BEGINNER then
18:         if propose_explain(n) then
19:             user_kn(n) := NEW
20:             (...)                ▷ Same process as NEW
21:         else
22:             monitor(n)
23:         end if
24:     else if user_kn(n) = INTERMEDIATE
              ∨ user_kn(n) = EXPERT then
25:         monitor(n)
26:     end if
27: end for
```

Conclusion

⇒ How to assess and represent human knowledge on tasks
⇒ Use human knowledge awareness for plan generation, explanation and monitoring
⇒ 1st user study to show the improvement from our system

⇒ User study in real
⇒ Negotiating the decomposition? / teach the robot

Thank you!

Questions?