A Framework for Service Robots in Smart Home: an Efficient Solution for Domestic Healthcare

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david
données et algorithmes
pour une ville intelligente et durable

Introduction

- **Context:**
  - Population is growing older…
  - Increasing need for domestic healthcare…
  - Two rising technologies:
    - Domestic robots (Buddy, iJINI, Zenbo, etc…)
    - Smart homes / IoT (Nest, Netatmo…)
- **Idea:**
  - Relies on strength of both technologies to efficiently help and monitor users in their everyday life
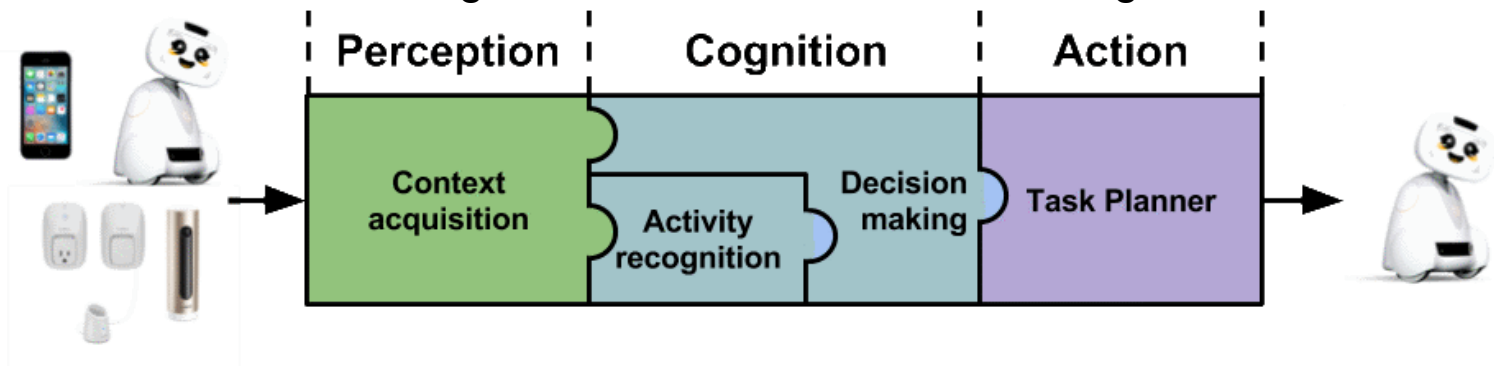 - Particularly for elderly and disabled people
- **Objective:**
  - Propose a complete framework for robot/smart home interaction
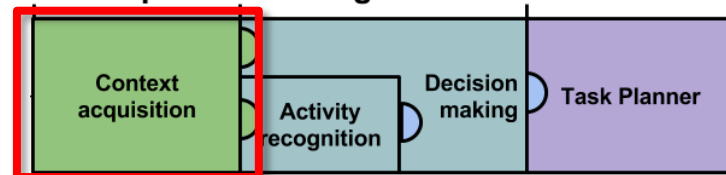
Problematic and challenges

- **Division of the framework in three steps:**
  - **Perception**: Acquiring context data from various sources
  - **Cognition**: Understand the context and act accordingly
  - **Action**: Acting on the environment to reach a goal

- **For each:**
  - Identification of challenges
  - Proposition of a solution
  - Implementation and experimentation

Perception: Challenges

- **Context data are likely to be uncertain:**
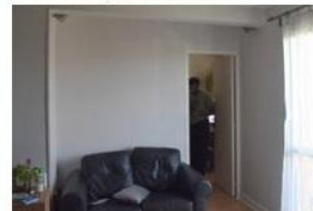

Freshness: Event is outdated

Example:

User leaves and is detected in the room while not inside anymore

Accuracy: Event is completely or partially wrong

Example:

User is seen from another room: detected in a room while being in an other

Imprecision: Event is correct, yet inexact

Example:

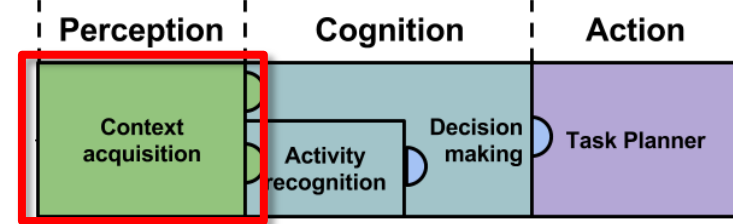A motion sensor detects a movement, not a position nor an identification

Contradiction: Two events provide a contradictory data

Example:

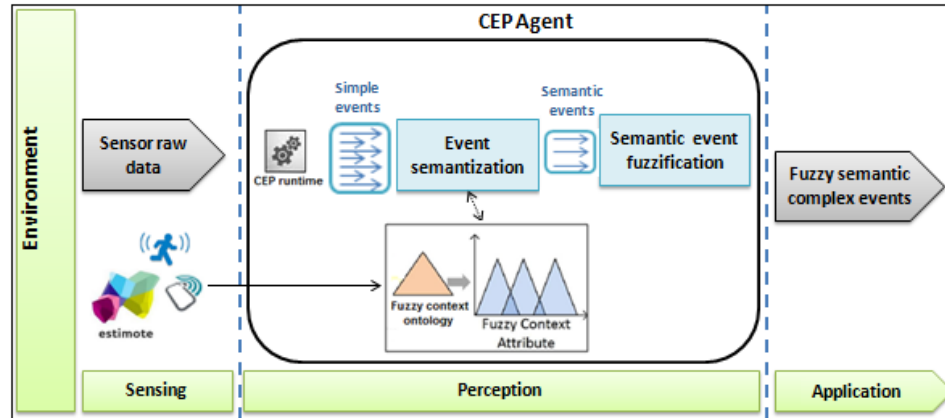User between two rooms and is detected in both: which value to keep ?

=> Tackling uncertainty is essential for a proper reaction !
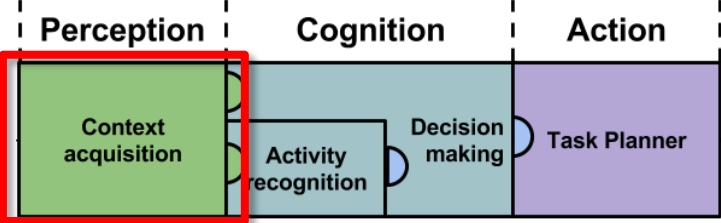
Perception: Solution

- **Proposition:**
  - Combination of:
    - Complex event processing
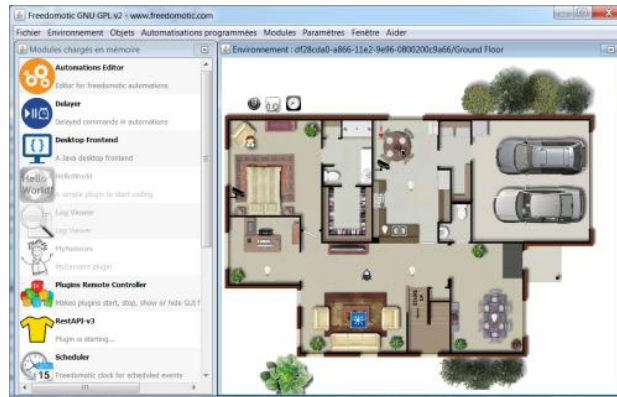   - Fuzzy logic
    - Semantic reasoning (ontologies)

- **Principle:**
  1. Gather, filter and batch events (**freshness**)
  2. Events are semantically enriched and formatted (**imprecision** and **accuracy**)
 3. Fuzzyfication (**contradiction**) and generation of one Fuzzy Semantic Complex Event

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Perception: Results

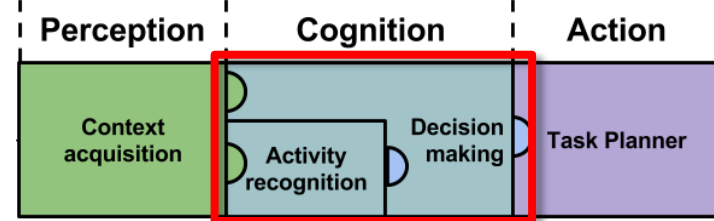■ **Evaluation through simulation using** *free*dom**ö**tic

■ **Results:**

- Comparison of activity recognition efficiency with and without our approach
- Improvement of activity recognition efficiency

Rate of succesful activity recognition

83% No FSCEP   93% FSCEP
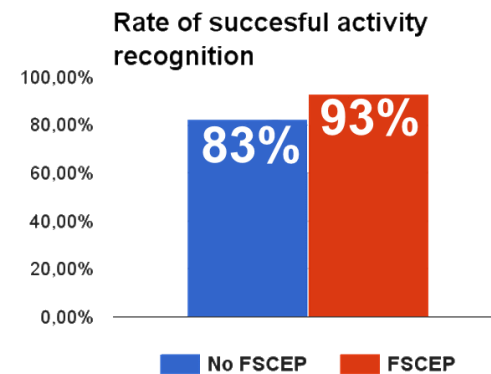
Cognition: Challenges
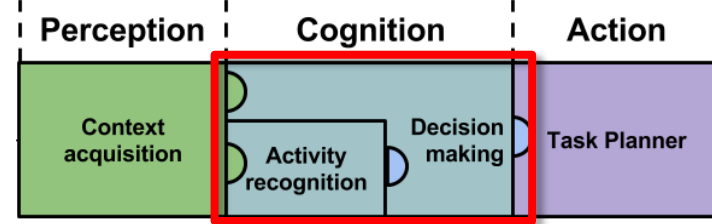
■ **Robot's activity recognition**
- Relies on its cameras
- Identify activities from user gesture

■ **Problem:**
- Solution prone to errors
- Risk of confusion
  - Ex: is the user phoning or taking medicine ?
- Limited set of possible recognized activities

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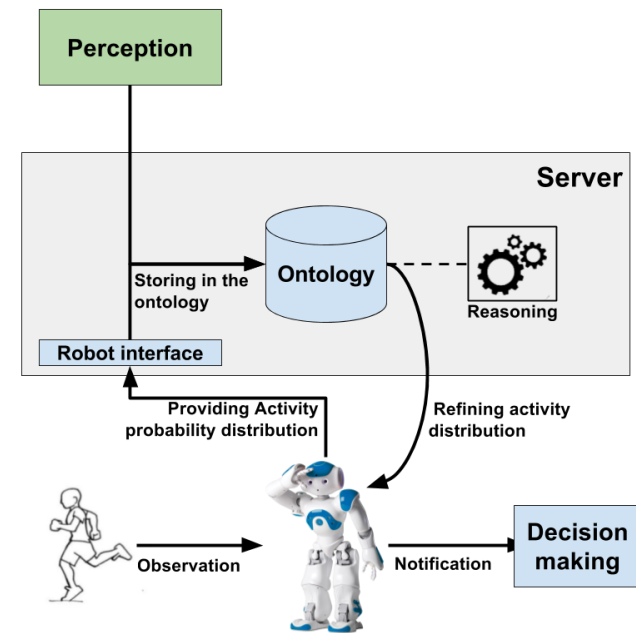# Cognition: Solution

- **Principle:**
  - Enhance the vision process with context data obtained in the perception layer and semantic reasoning

- **Activity recognition correction**
  - Adjust vision process output
  - Based on rules
    - *If the phone's inertial unit exceeds threshold -> increase "phoning's" probability*
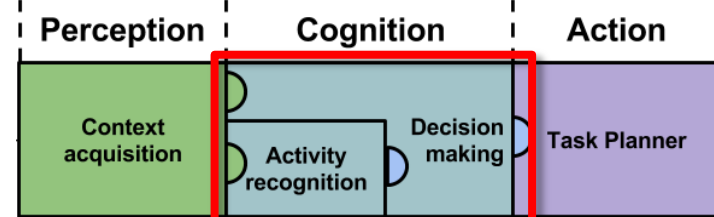
- **Activity recognition refinement**
  - Infer more precise activity
  - Based on semantic rules
    - *If user "sitting" at noon -> "lunching"*

Perception

Server

Storing in the ontology → Ontology ⟶ Reasoning

Robot interface

Providing Activity probability distribution

Refining activity distribution

Observation → Notification → Decision making

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Cognition: Results

- **Setup:**
  - 3 scenarios:
    - Phoning, Opening a door and remote controlling
    - 9 possible activities
  - 12 test subjects
  - Each subject repeated each scenario 10 times
    - Total: 120 run per scenario
  - Robot: Nao H25
  - Hadaptic platform (smart room)
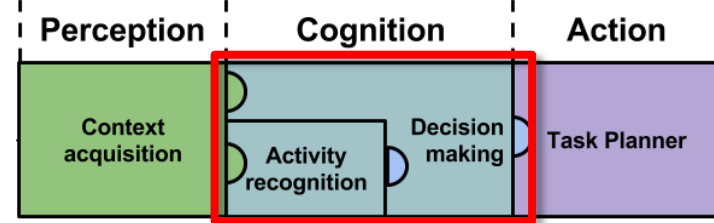

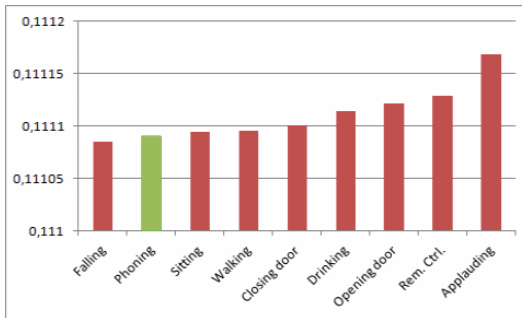Motion sensor   Opening sensor   Phone
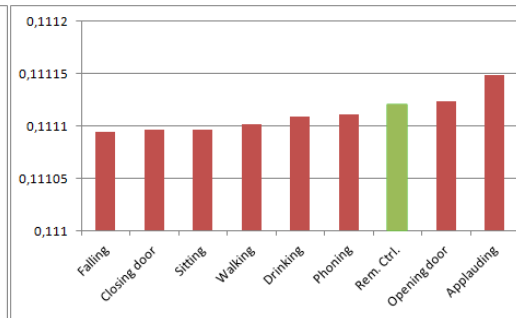
Wifi hotspot   Server   Zigbee antenna

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Cognition: Results

- ### ■ Results:

  - • Without refinement:
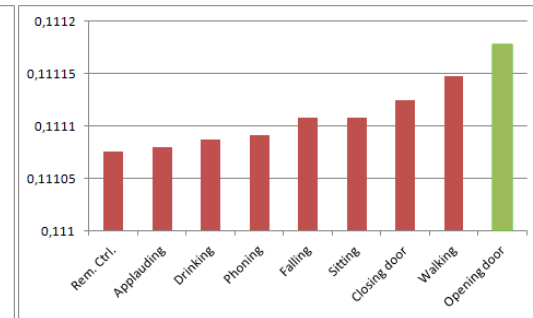
    Phoning | **Remote controlling** | **Opening door**
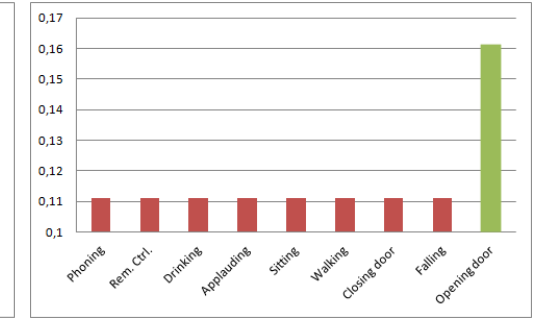
  - • With refinement:
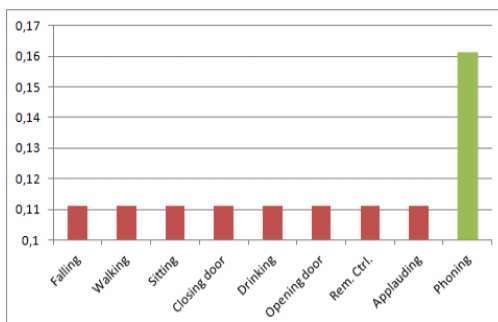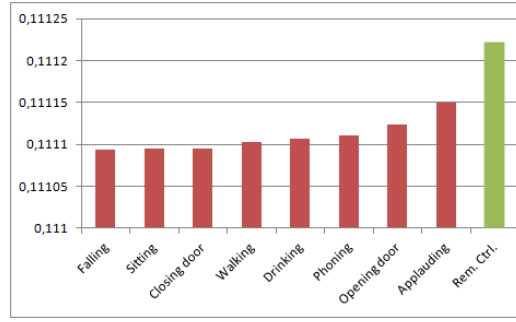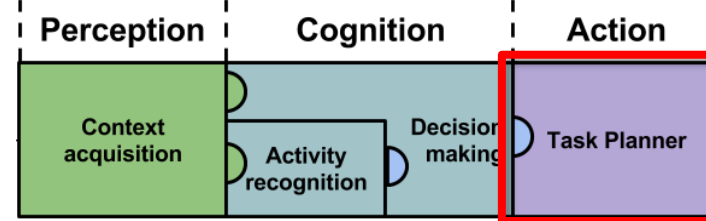
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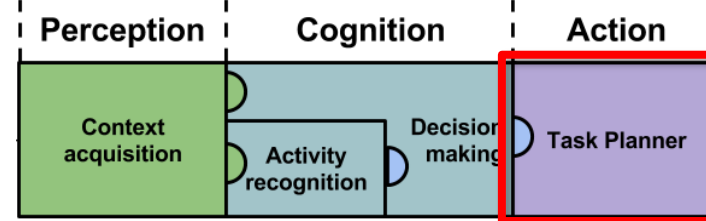
Action: Challenges

- **Task planner:**
  - Compute a sequence of task to reach a goal
  - Goal determined by decision making
  - Essential for properly helping the user
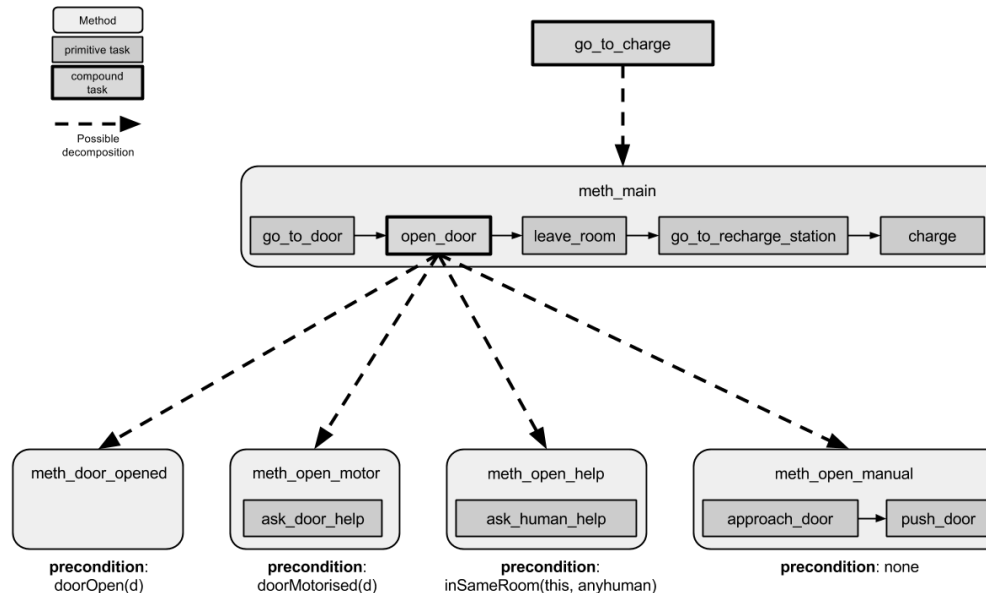- **Problems:**
  - Dynamic context (change during execution)
    - Plan may become obsolete
  - Context data non available when planning
    - Risk of incorrect plan
  - Multiple smart devices
    - Risk of data overflow
  - Limited smart devices
    - Useless usage of devices
    - Ex: waste of device's battery

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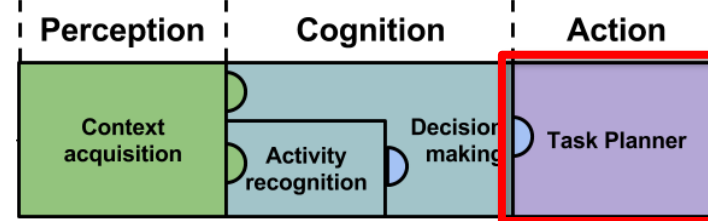
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Action: Solution

- **Dynamic HTN (DHTN)**
  - Improvement of Hierarchical Task Networks (HTN)
  - Principle: decompose compound task into subtasks by according to current context
  - Planning and executing at the same time
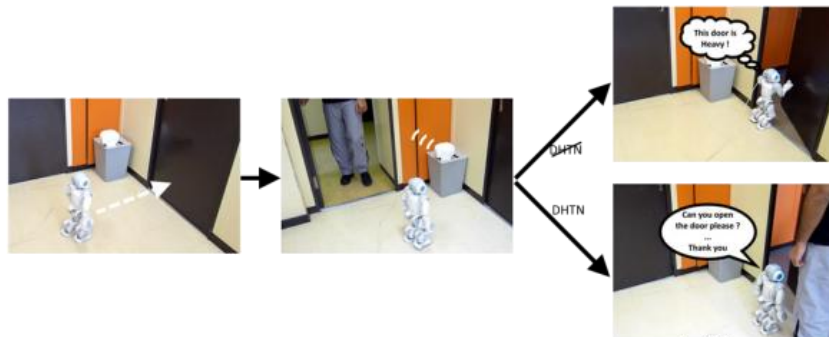 - Observation according to planning needs

Action: Results

- **Simulations through** *free*domotic

Number of replan needed to reach the objective

Average number of actions executed
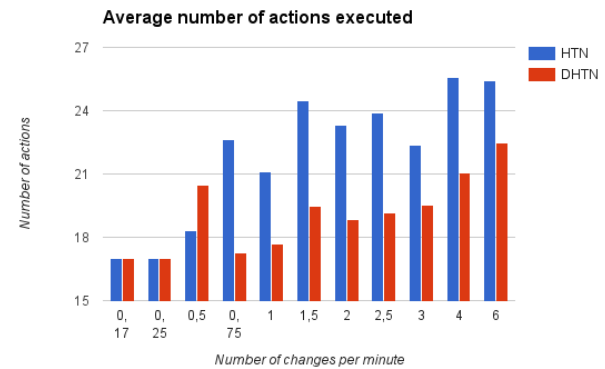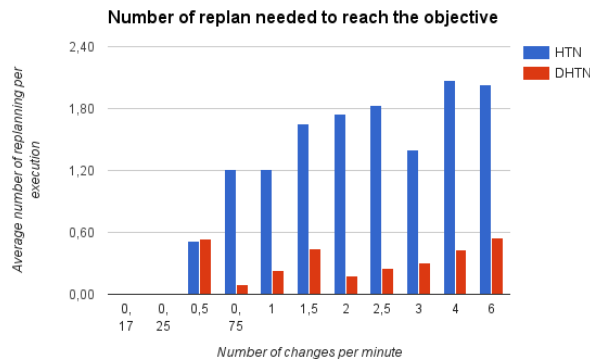
- **Integration with a real robot:**

Conclusion

- **All in all…**
  - We identified three layers for a framework for a robot operating in a smart home for domestic healthcare
  - For each layer, we identified challenges, proposed solution and implemented them
  - The framework is composed by all our solution
- **But actually, that's not all…**
  - More work ongoing
    - Decision making
    - Failure understanding and avoidance
  - More experiments
    - Evident platform
    - Complete real case scenarios

Voilà !

Thank you for your attention. :) Questions ?

For more info:

http://nara.wp.tem-tsp.eu/

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