TDDE05 AI Robotics
Human-Aware Robots

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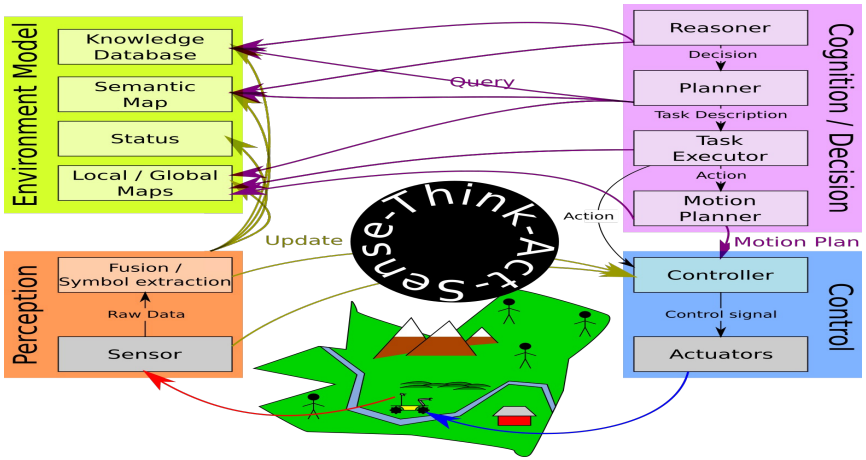
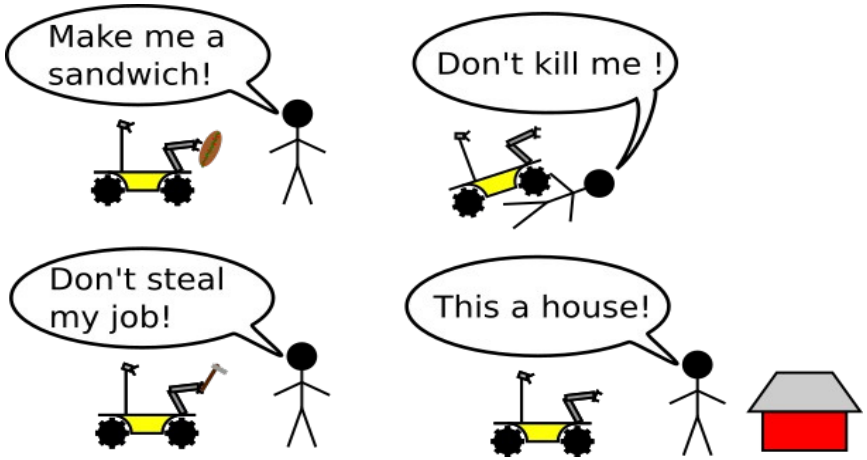
Lectures

1 Introduction to AI Robotics
2 Introduction to ROS
3 Foundation of Robotics: Control and State Machines
4 Foundation of Robotics: Perception
5 Robotic Architectures
6 Reactive Architecture
7 Deliberative Architecture
8 Decision Theory
9 Knowledgeable Robot
10 Machine Learning for Robots
11 **Human-Aware Robots**
12 Putting It All Together

Robot Architecture

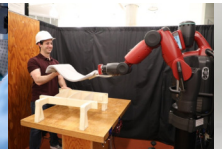


Human-Aware Robots

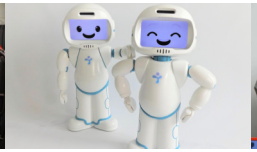


Mode of Cooperation

- Physical



- Social/emotional



- Cognitive

Modes of interractions

- Remote presence
  - Teleoperation, first-person view, visualisation of the environment
- Taskable agent
  - High degree of autonomy
  - Task delegation and planning
- Assistive agent
  - Model of human behaviour, intentions and expectations

Trust

- Reliability
- Compatibility
- Complexity
- Triability and adaptability
- Observability

Understanding

- Communication: human robot interface, natural language processing...
- Model of human behaviour, intentions and expectations
- Do human have a good model of robot behaviour, intentions and expectations?

Lecture content

- Human-Robot Interraction
  - Situation Awareness
  - Human Robot Communication
- Safety and Social Rules in Robotic
- Training Robots

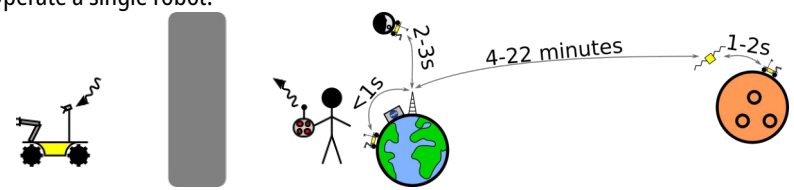
Human-Robot Interraction

Roles of Interaction

- Operator
- Supervisor
- Teammate
- Mechanic/Programmer
- Bystander

Operator

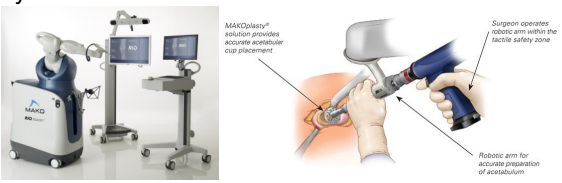
- Operate a single robot:



- Interactions depend on level of autonomy
- Need information on the status of the robot
- Challenges
  - How to maintain awareness despite communications limitations
  - How to control multiple robots
- A visualisation and user interface problem!

Application to surgery

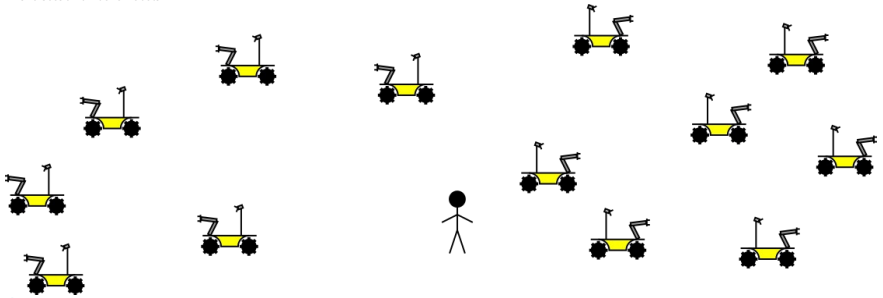
- Assisted surgery:



- Remote surgery:

Supervisor

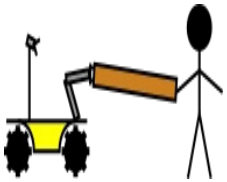
- Oversees a number of robots



- Needs global picture of all robots/mission
- Challenge: How many robots can a supervisor effectively monitor?
- A multi-agents problem!

Teammate

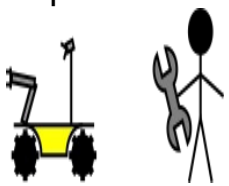
- Robot is a member of the



- Need to understand any limitations robot has in
- Challenges:
  - Can the robot understand the same interaction vocabulary as other team members?
  - Physical interractions

Mechanic/Programmer

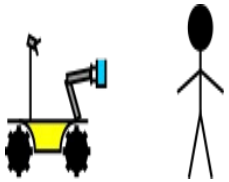
- Comes into play if the operator cannot resolve the issue



- Challenges:
  - How much self diagnosis can the robot do?
  - Have to determine when to move from operating in degraded capability to pulling robot off task and attempting to fix problem

Bystander

- No formal training using robot but must co-exist in environment with robot



- Challenges:
  - How can a bystander form a mental model of what the robot's capabilities are?
  - Should a bystander have a subset of interactions available?
  - What type of social interactions come into play?

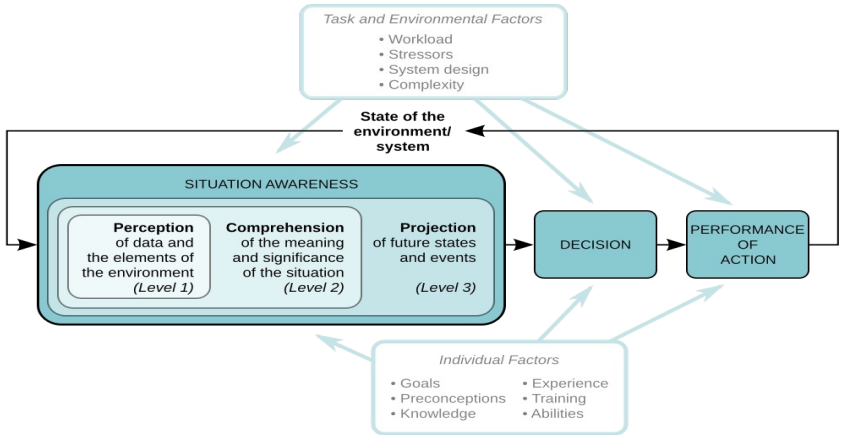
Situation Awareness

Situation Awareness

- Situation awareness is the spatial and timing knowledge of environment elements and events

- Robots need to know
  - Human position, intention and capabilities
- Humans need to know
  - Robots position, intention and capabilities

Situation Awareness Levels



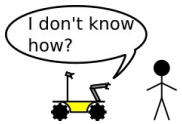
Control for a UAV predator

Human Robot Communication

Human Robot Communication

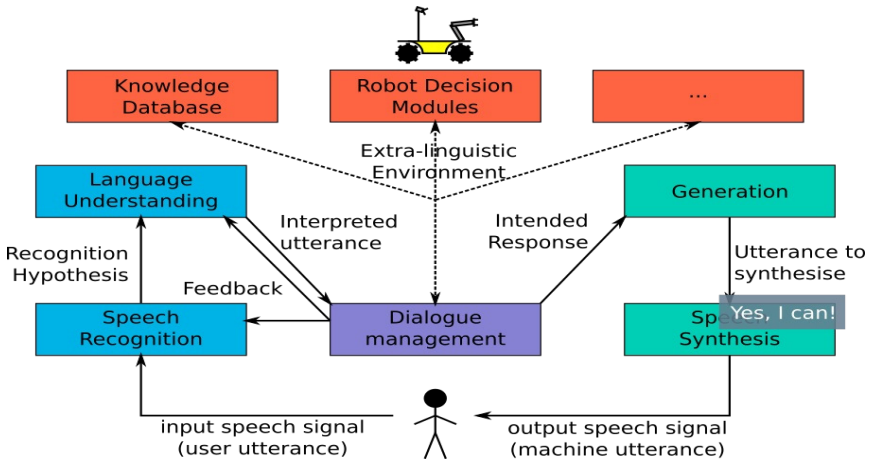
- To receive commands

- To raise situation awareness



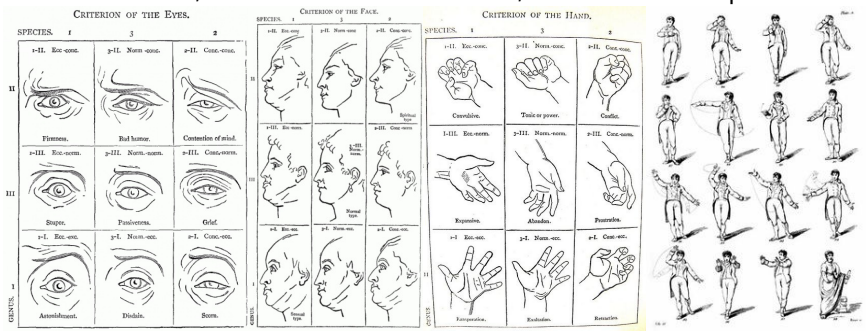
- Different ways:
  - Speach, gestures, emotions

Speach Recognition and Synthesis



Social Cues

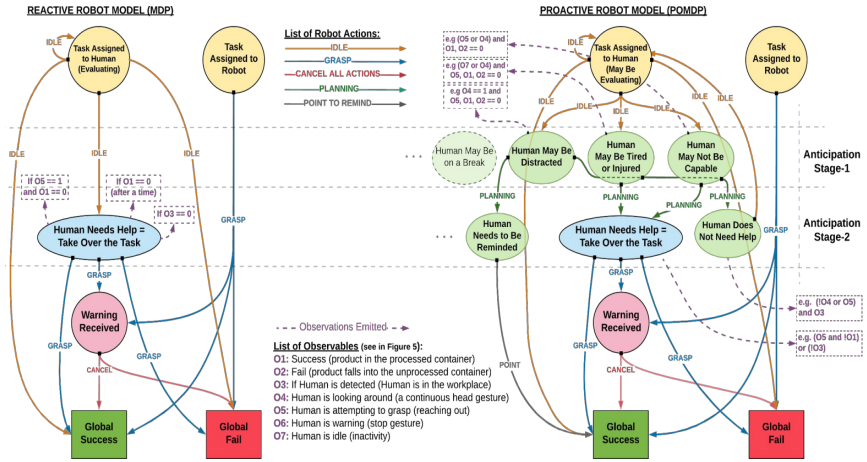
- Francois Delsartre, a French dramatist in the 1800's, defined a Code of Expressions:



Humanoid Robot

Social Cobots (1/2)

Social Cobots (2/2)



Safety and Social Rules in Robotic

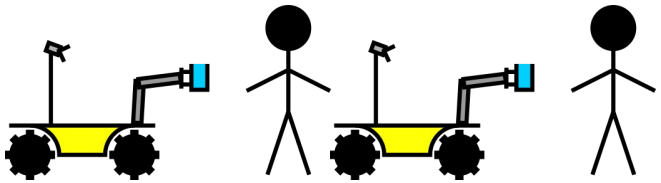
Industrial robot

- Humans and machines are sperated
- A couple of fatal injuries per year among several hundreds in manufacturing

High Speed Autonomous Crossing

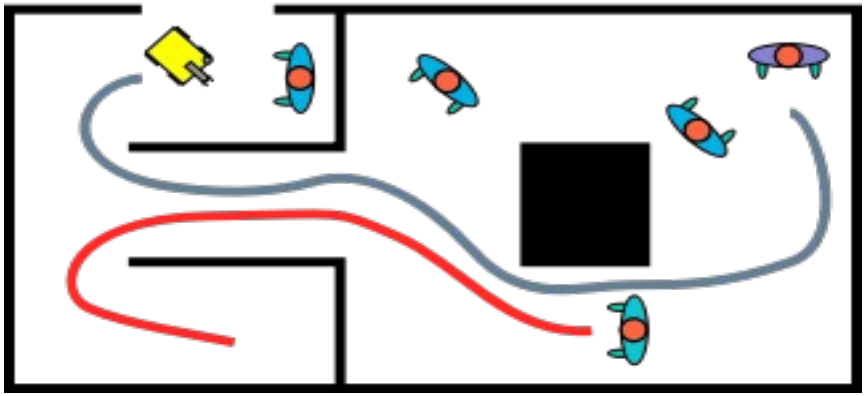
Human comfort

- Does it feel safe?

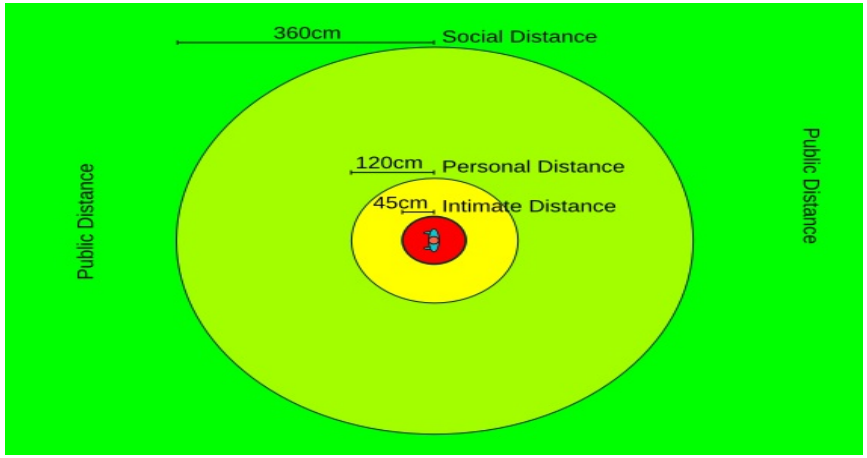


- Comfort
- Naturalness
- Sociability

Human Aware Robot Navigation



Human comfort



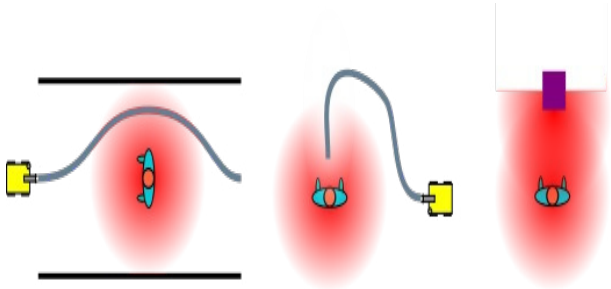
User studies of human comfort

- How should a robot approach a human?
  - Preference of hand over from the front, rather than diagonal or side
- How should a robot meet a human in a corridor?
  - About 40cm from hull to human center
- Which velocity should a robot approach a human?
  - 1m/s feels uncomfortable, while 0.5m/s was acceptable

Social Rules

- Motion speed
- Motion Smoothness
- Human motion awareness
  - ie weird hand over...
- Distances
  - Comfort zone
- Human gaze
- Possible objects hazard

Human-aware obstacle avoidance (1/2)



- How to define cost function?
  - Should also take into account sharp edges
- How to predict human motion?
  - Models, machine learning...

Human-aware obstacle avoidance (2/2)

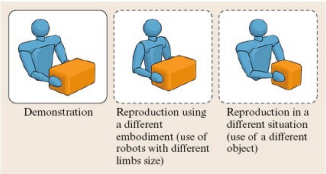
Physical safety

Training Robots

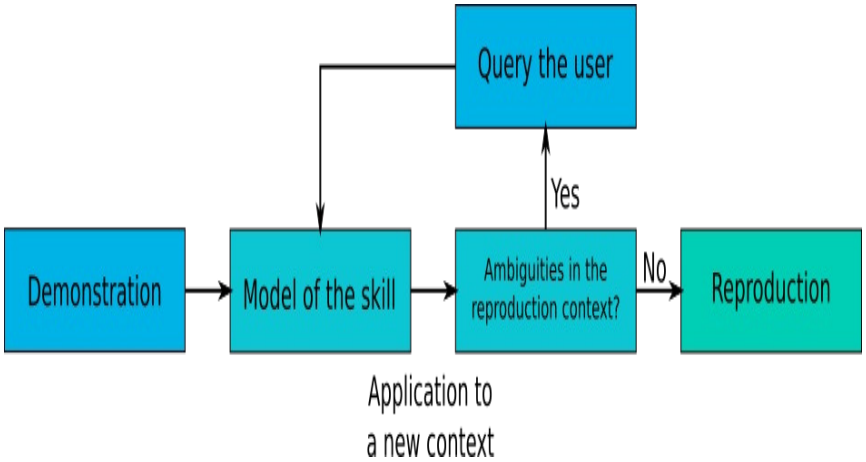
Teaching vs Programming

Training by observation

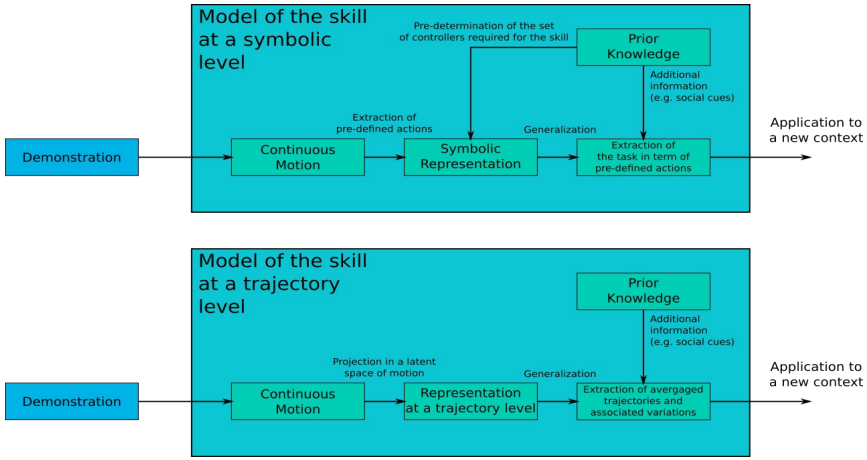
- Generalisation
- Immitation's key problem
  - What to immitate?
  - How to immitate?
  - Who to immitate?
  - When to immitate?
- Correspondance problem



Learning Skill Through Query Approach



Model of the skill

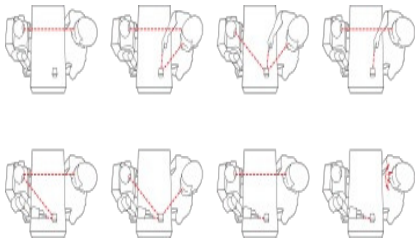


Symbolic Skill Model

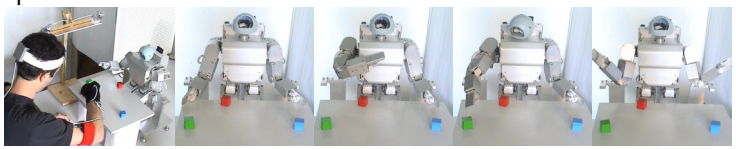
Trajectory Skill Model

Social Cues

- Human indications



- Robot poses



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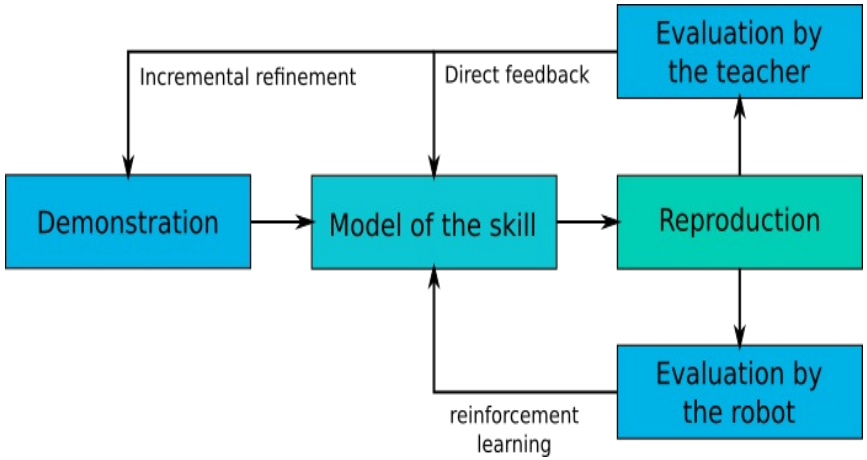
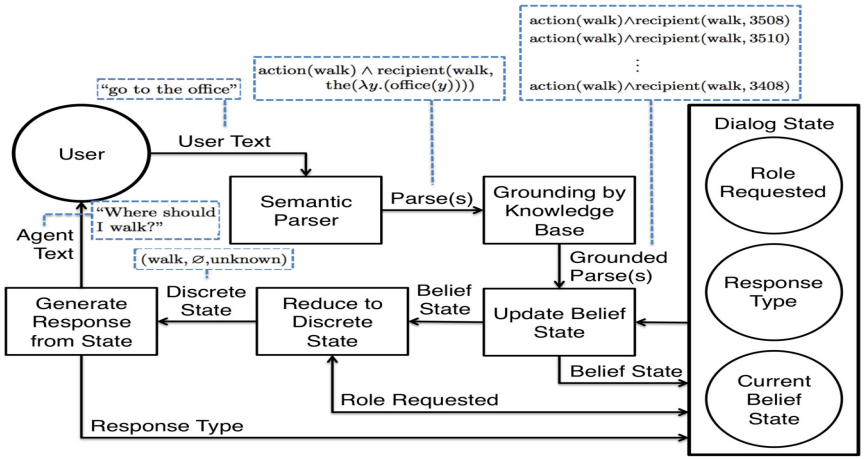


Open issues

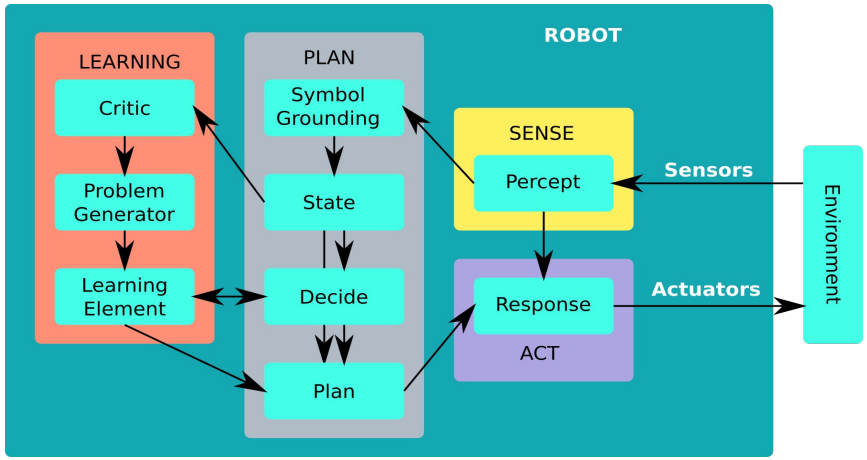
- Can we combine symbolic skill model and trajctory skill model?
- How can we reduce the need for prior-knowledge?

Learning to interpret natural language commands (1/2)

Learning to interpret natural language commands (2/2)



Sense-Plan-Learn-Act



Conclusion

- Being safe is not enough
- Interracting with robots
- Teaching a robot is hard