Is symbolic AI still relevant?

A view from the automated planning trenches

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Current Trends in Artificial Intelligence 2

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HERIOT WATT UNIVERSITY

EDINBURGH CENTRE FOR ROBOTICS

We live in interesting times…

"The rise of powerful AI will be either the best or the worst thing ever to happen to humanity. We do not know which."

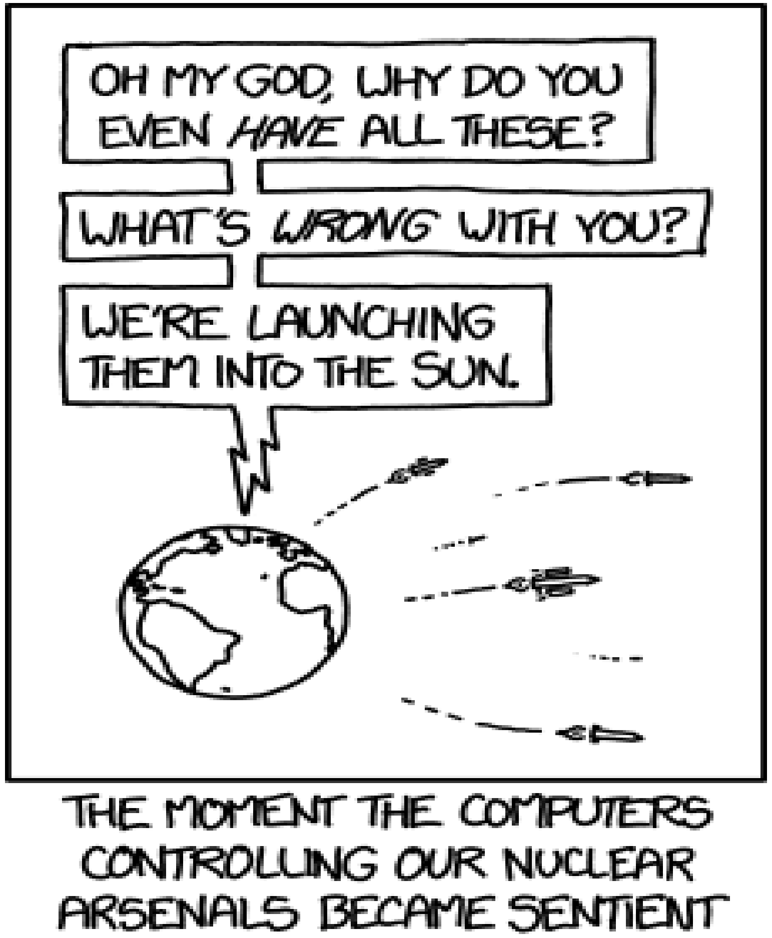
Stephen Hawking

"With artificial intelligence we are summoning the demon. In all those stories where there's the guy with the pentagram and the holy water, its like – yeah, he's sure he can control the demon. Doesn't work out."

Elon Musk

"AI watchdog needed to regulate automated decision-making, say experts: Algorithms can make bad decisions that have serious impacts on people's lives, leading to calls for a third party body to ensure transparency and fairness."

The Guardian, 2017-01-27



Judgment Day - https://xkcd.com/1626/

Automated planning

Automated planning

A technology for autonomous **decision making**.

Heavily based on **symbolic reasoning**.

Automated planning

What is it?

Why is it useful?

Where is it going?

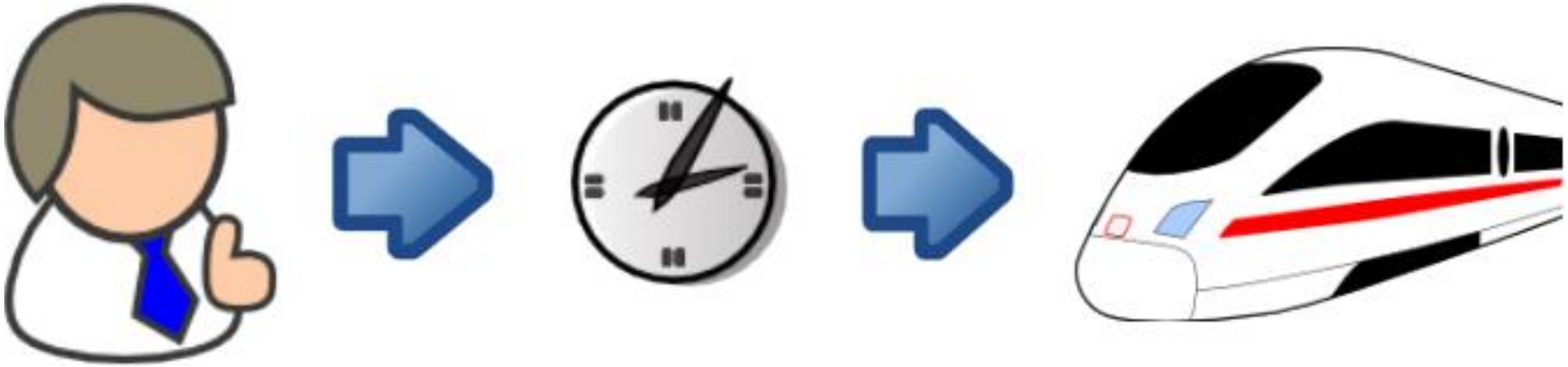
Is it still relevant?

Case study: the JAMES robot bartender – http://james-project.eu/

R. Petrick and M.E. Foster. Planning for social interaction in a robot bartender domain, ICAPS 2013

What is planning?

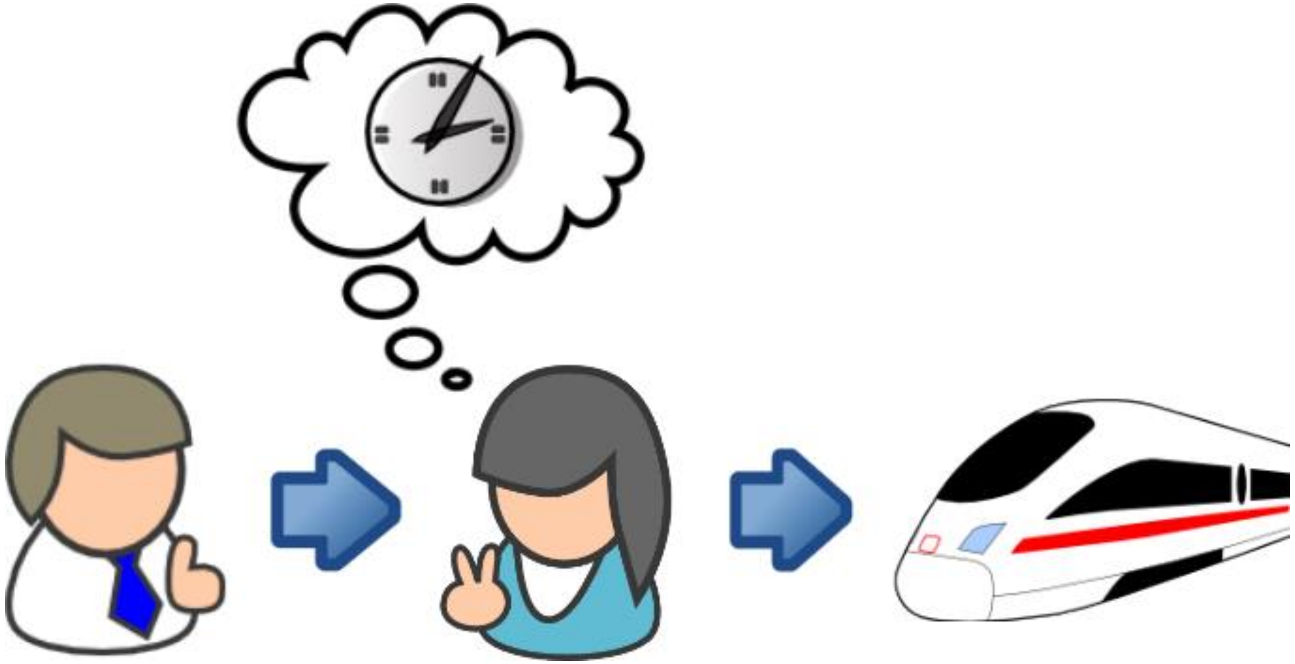
“I want to take the train from Copenhagen to Hamburg.”



Go to the station, buy a ticket, check the departure board for track information, go to the track, board the train, . . .

What is planning?

"I want to take the train from Copenhagen to Hamburg."



Go to the station, buy a ticket, ask someone for track information, go to the track, board the train, . . .

What is planning?

Photo: Universität Bielefeld / JAMES project

What is planning?

Two people, A and B, each individually approach the system.

System (to A): How can I help you?

Person A: A pint of cider, please.

Person C approaches and attracts the attention of the system by gesturing.

System (to C): Just a moment please.

System: (Serves A)

System (to B): What will you have?

Person B: A glass of red wine.

System: (Serves B)

System (to C): Thanks for waiting. How can I help you?

Person C: I'd like a pint of bitter.

System: (Serves C)

What is planning?

What should I do? When should I do it?

Humans are pretty good at this task.

Can an AI system make these decisions?
It’s a tough problem computationally...

What is automated planning?

What is automated planning?

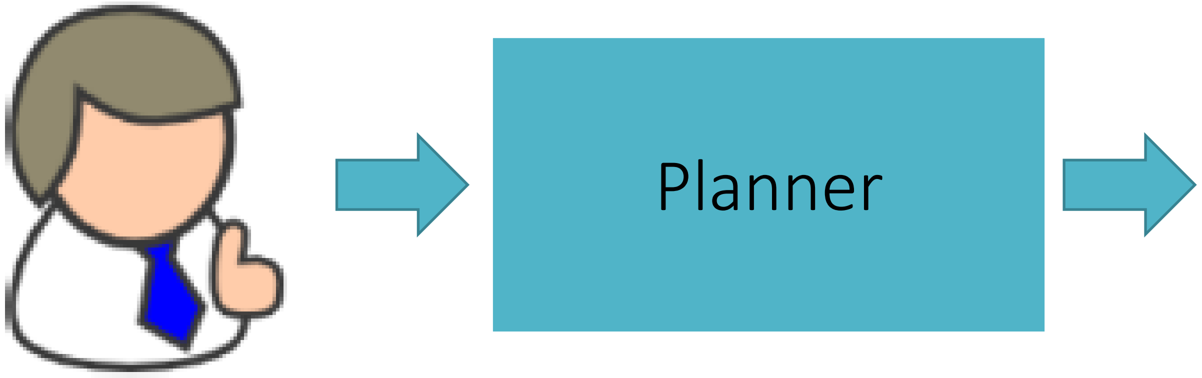
What can the system do?

What does the world look like?

What are the goals?

What steps are needed to achieve the goals?

What is automated planning?



1. Go to the station
2. Buy a ticket
3. Check the departure board for track information
4. Go to the track
5. Board the train
6. …

What is automated planning?

Photo: Universitaet Bielefeld / JAMES project

→ Planner →

1. Greet the customer
2. Ask the customer for a drink
3. Acknowledge the drink order
4. Pick up the correct bottle
5. Serve the customer
6. End the transaction

How can we represent a planning problem?

Photo: fortiss GmbH / JAMES project

Planning problems

- A planning problem consists of:
  1. A representation of the properties and objects in the world and/or the agent's knowledge, usually described in a logical language,
  2. A set of state transforming actions,
  3. A description of the initial world/knowledge state,
  4. A set of goal conditions to be achieved.

- A **plan** is a sequence of actions that when applied to the initial state transforms the state in such a way that the resulting state satisfies the goal conditions.

Representation

- Actions

`greet(?a)`	greet agent ?a
`ask-drink(?a)`	ask agent ?a for a drink order
`ask-drink-next(?a)`	ask the next agent ?a for a drink order
`serve(?a,?d)`	serve drink ?d to agent ?a
`bye(?a)`	end an interaction with agent ?a
`wait(?a)`	tell agent ?a to wait
`ack-order(?a)`	acknowledge the order of agent ?a
`ack-wait(?a)`	thank agent ?a for waiting
`ack-thanks(?a)`	acknowledge agent ?a's thanks
`inform-drinklist(?a,?t)`	inform agent ?a of the available drinks of type ?t

- Properties

`seeksAttn(?a)`	agent ?a seeks attention
`visible(?a)`	agent ?a is visible
`inGroup(?a) = ?g`	agent ?a is in group ?g
`inTrans = ?a`	the robot is interacting with ?a
`request(?a) = ?d`	agent ?a has requested drink
...	

Representation

```
action greet(?a : agent)
    preconds:
        K(inTrans = nil) &
        K(!ordered(?a))
    effects:
        add(Kf, inTrans = ?a)
```

```
action ask-drink(?a : agent)
    preconds:
        K(inTrans = ?a) &
        K(!ordered(?a))
    effects:
        add(Kf, ordered(?a)),
        add(Kv, request(?a))
```

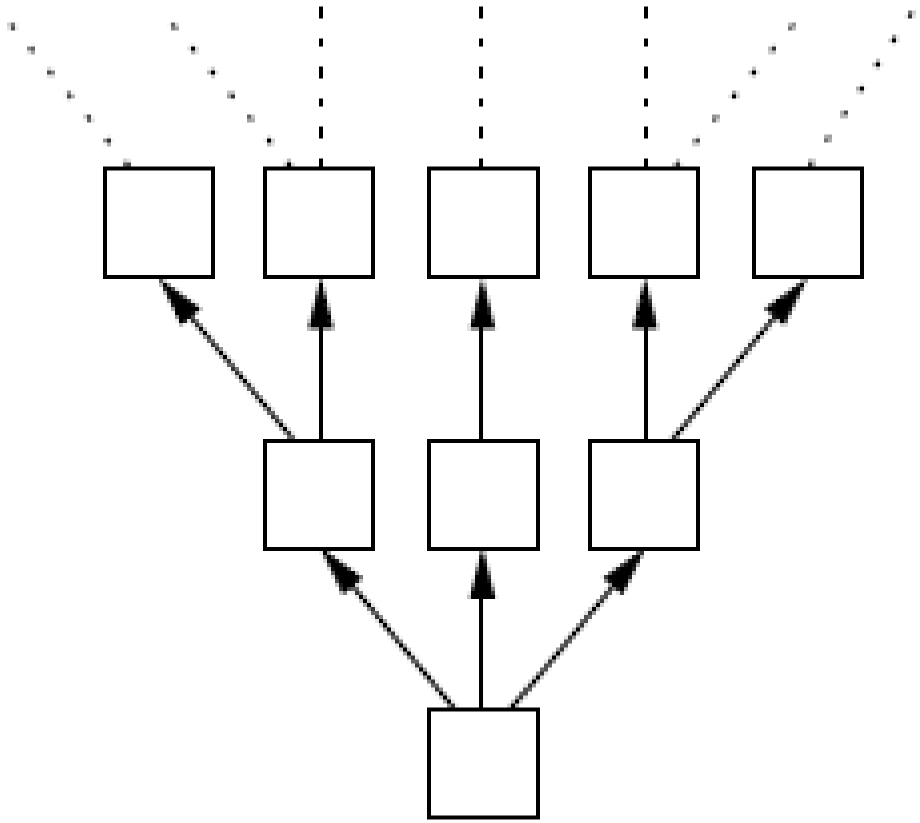
```
action serve-drink(?a : agent, ?d)
    preconds:
        K(inTrans = ?a) &
        K(ordered(?a)) &
        Kv(request(?a)) &
        K(request(?a) = ?d)
    effects:
        add(Kf, served(?a))
```

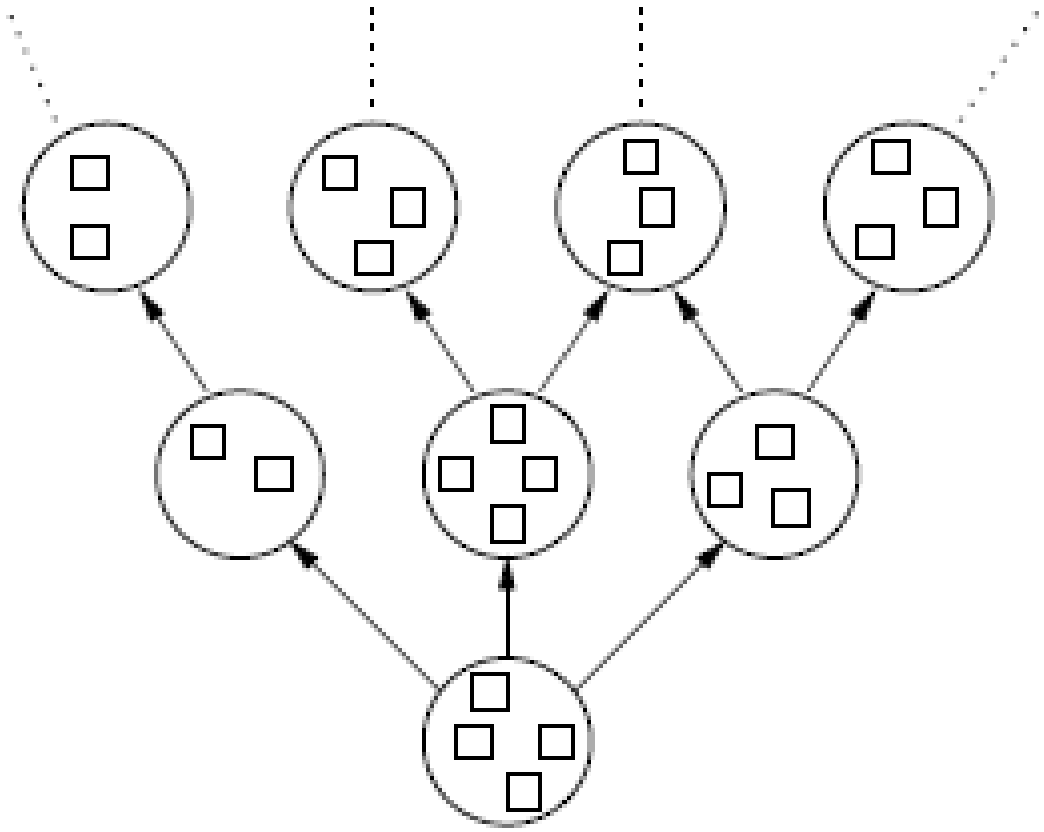
```
action bye(?a : agent)
    preconds:
        K(inTrans = ?a) &
        K(served(?a))
    effects:
        add(Kf, inTrans = nil)
```

Reasoning about action

```
    Kf: handEmpty, onTable(bottle1), onTable(bottle2),
        !empty(bottle1)
    Kw: empty(bottle2)

Action: grasp(bottle1)

    Kf: inHand(bottle1), onTable(bottle2),
        !handEmpty, !onTable(bottle1), !empty(bottle1)
    Kw: empty(bottle2)

Action: senseWeight(bottle1)

    Kf: inHand(bottle1), onTable(bottle2),
        !handEmpty, !onTable(bottle1), !empty(bottle1)
    Kw: empty(bottle2)
    Kv: weight(bottle1)
```

Planning





Planning

`greet(a1),`	[Greet agent a1]
`ask-drink(a1),`	[Ask a1 for drink order]
`ack-order(a1),`	[Acknowledge a1's order]
`serve(a1,request(a1)),`	[Give the drink to a1]
`bye(a1).`	[End the transaction]

`wait(a2),`	[Tell a2 to wait]
`greet(a1),`	[Greet a1]
`ask-drink(a1),`	[Ask a1 for drink order]
`ack-order(a1),`	[Acknowledge a1's order]
`serve(a1,request(a1)),`	[Give the drink to a1]
`bye(a1),`	[End a1's transaction]
`ack-wait(a2),`	[Thank a2 for waiting]
`ask-drink(a2),`	[Ask a2 for drink order]
`ack-order(a2),`	[Acknowledge a2's order]
`serve(a2,request(a2)),`	[Give the drink to a2]
`bye(a2).`	[End a2's transaction]

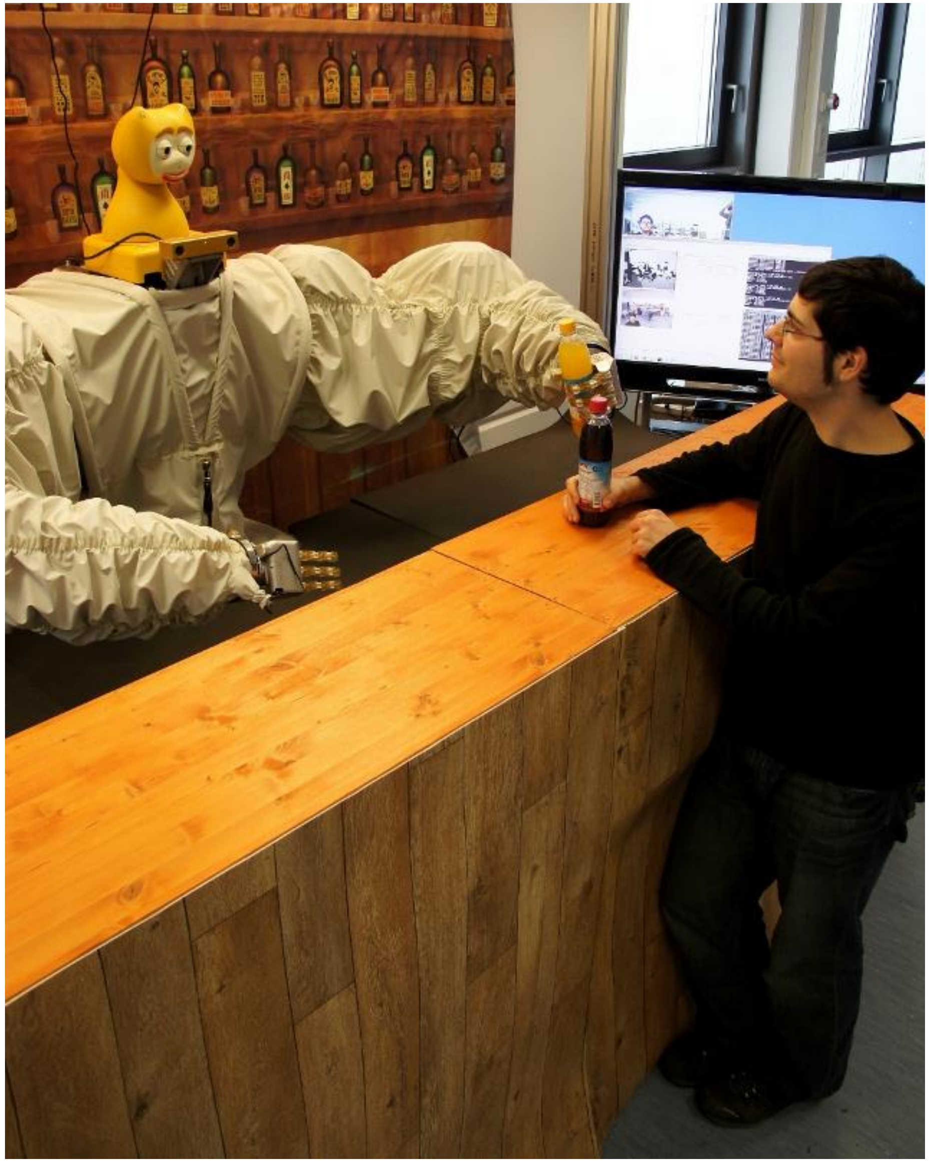


Photo: fortiss GmbH / JAMES project

Planning

Three customers:

A1 and A2 in group G1

A3 is alone (singleton group G2)

Bartender serves members of G1 in sequence, then deals with G2.

Other social behaviour:

- First-come/first-served ordering
- All orders are acknowledged immediately
- If a new customer arrives while the bartender is occupied, it nods at them and serves them later

Social behaviour is based on the observation of bartenders in real bars (Huth et al., 2012); see Foster et al. (2013) for details on the planning domain.

wait(A3, G1)	Tell G2 to wait (with a nod)
greet(A1, G1)	Greet group G1
ask-drink(A1, G1)	Ask A1 for drink order
ack-order(A1, G1)	Acknowledge A1's order
ask-drink(A2, G1)	Ask A2 for drink order
ack-order(A2, G1)	Acknowledge A2's order
serve(A1, request(A1), G1)	Give the drink to A1
serve(A2, request(A2), G2)	Give the drink to A2
bye(A2, G1)	End G1's transaction
ack-wait(A3, G2)	Acknowledge G2's wait
ask-drink(A3, G2)	Ask A3 for drink order
ack-order(A3, G2)	Acknowledge A3's order
serve(A3, request(A3), G3)	Give the drink to A3
bye(A3, G2)	End G2's transaction

Photo: fortiss GmbH / JAMES project

Automated planning research

How do we model problems?
How do we generate plans efficiently?
How do we apply planning to (real-world) problems?

Trend 1: inside the box

An explosion of new planners, new algorithms, new modelling languages

International Planning Competitions

1^{st} **International Planning Competition** held in 1998

- 5 competitors
- Deterministic track
- Many plans 30-40 steps long, some over 100 steps

http://www.icaps-conference.org/index.php/Main/Competitions

International Planning Competitions

8th International Planning Competition held in 2014

- Deterministic track: over 60 planners competed across 5 subtracks
- Learning track: 11 planners competed
- Probabilistic track: 8 planners competed

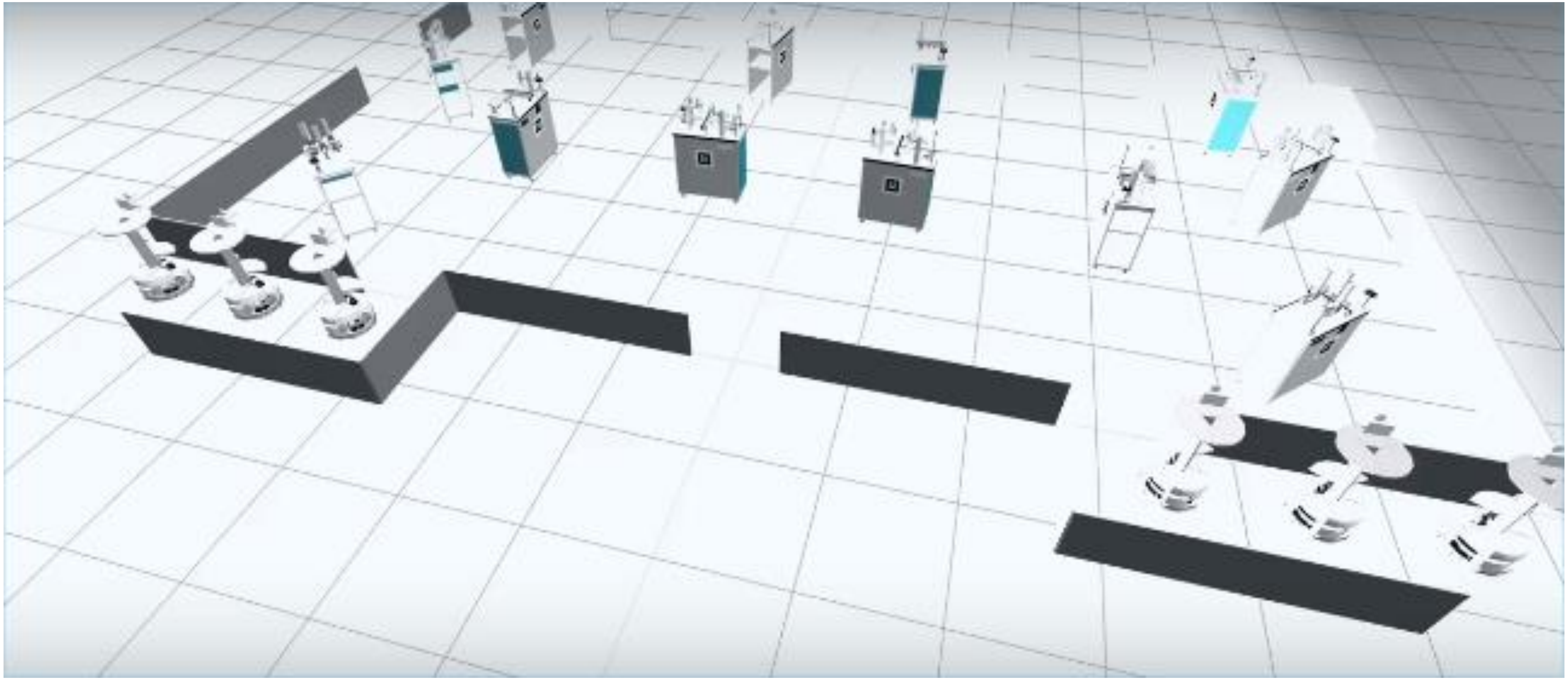
Distributed and Multiagent planning competition: 8 competitors

Unsolvability planning competition: 11 planners

RoboCup Logistics League Planning Competition: 5 teams

http://www.icaps-conference.org/index.php/Main/Competitions

Logistics League Planning Competition



http://www.robocup-logistics.org/sim-comp

Trend 2: outside the box

Domain/problem acquisition + applications

ICAPS 2012

Wordcloud of the title words from accepted papers at the 2012 International Conference on Automated Planning and Scheduling (ICAPS)

ICAPS 2017

Wordcloud of the title words from accepted papers at the 2017 International Conference on Automated Planning and Scheduling (ICAPS)

Machine learning + planning

Learning planning actions

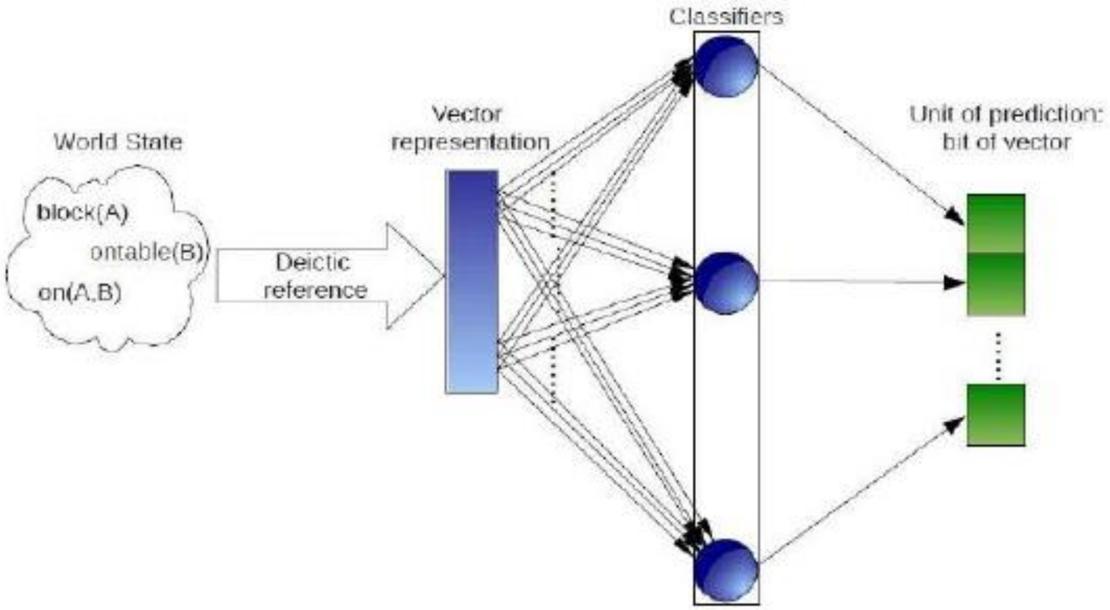
Can we learn the symbolic structure of actions?

Learning domain knowledge

Can we learn how the world is structured?

Learning control knowledge

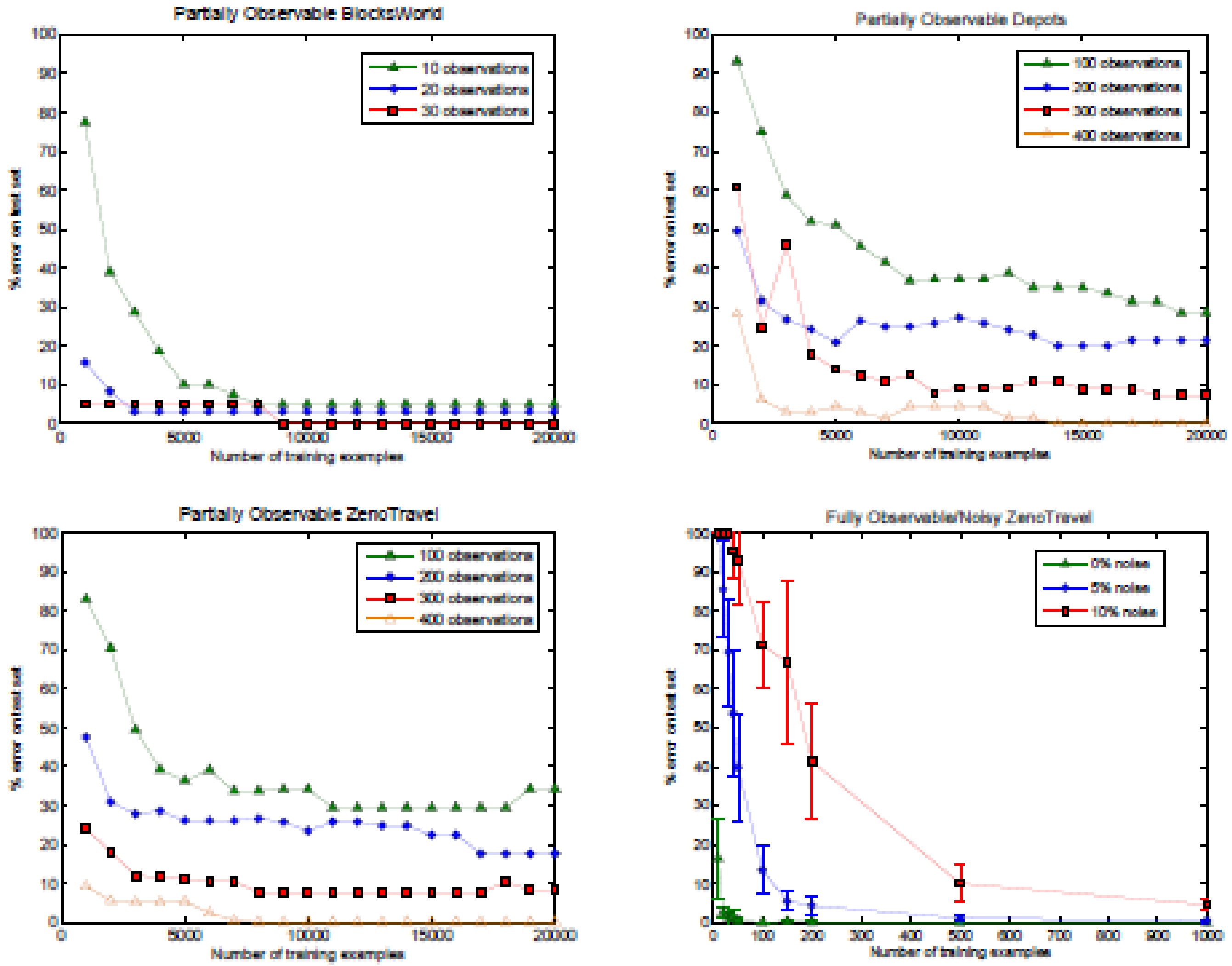
Can we improve the quality/efficiency of generated plans?

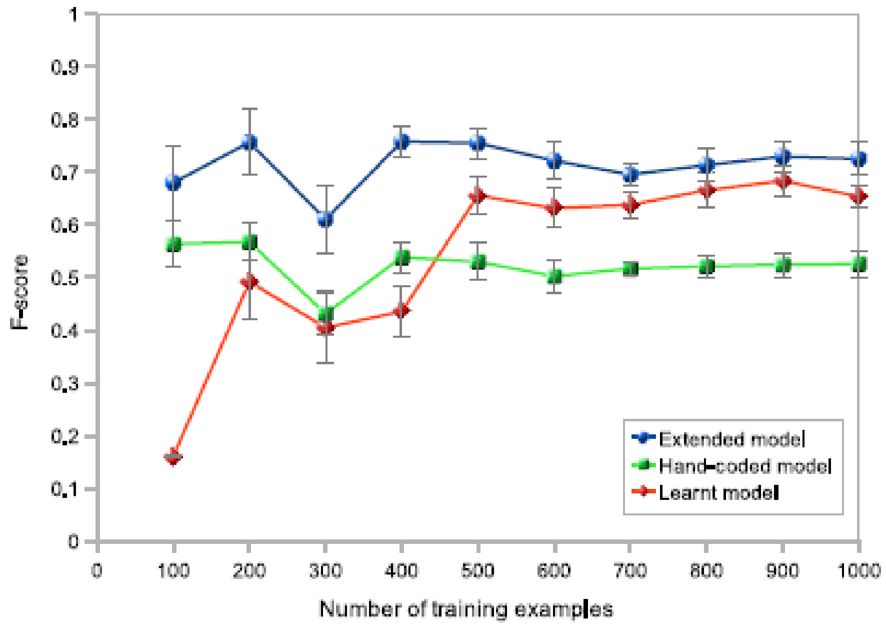



```
(:action move
  :parameters (?m ?l - location)
  :precondition  (is_at ?m)
  :effect (and (is_at ?l) (not (is_at ?m))          (0.9)
    (forall (?x - portable) (when (in ?x)
      (and (at ?x ?l) (not (at ?x ?m))))))
        no change                                   (0.09)
        noise                                       (0.01).
```

K. Mourão, L. Zettlemoyer, R. Petrick, and M. Steedman. Learning STRIPS Operators from Noisy and Incomplete Observations, UAI 2012

Machine learning + planning

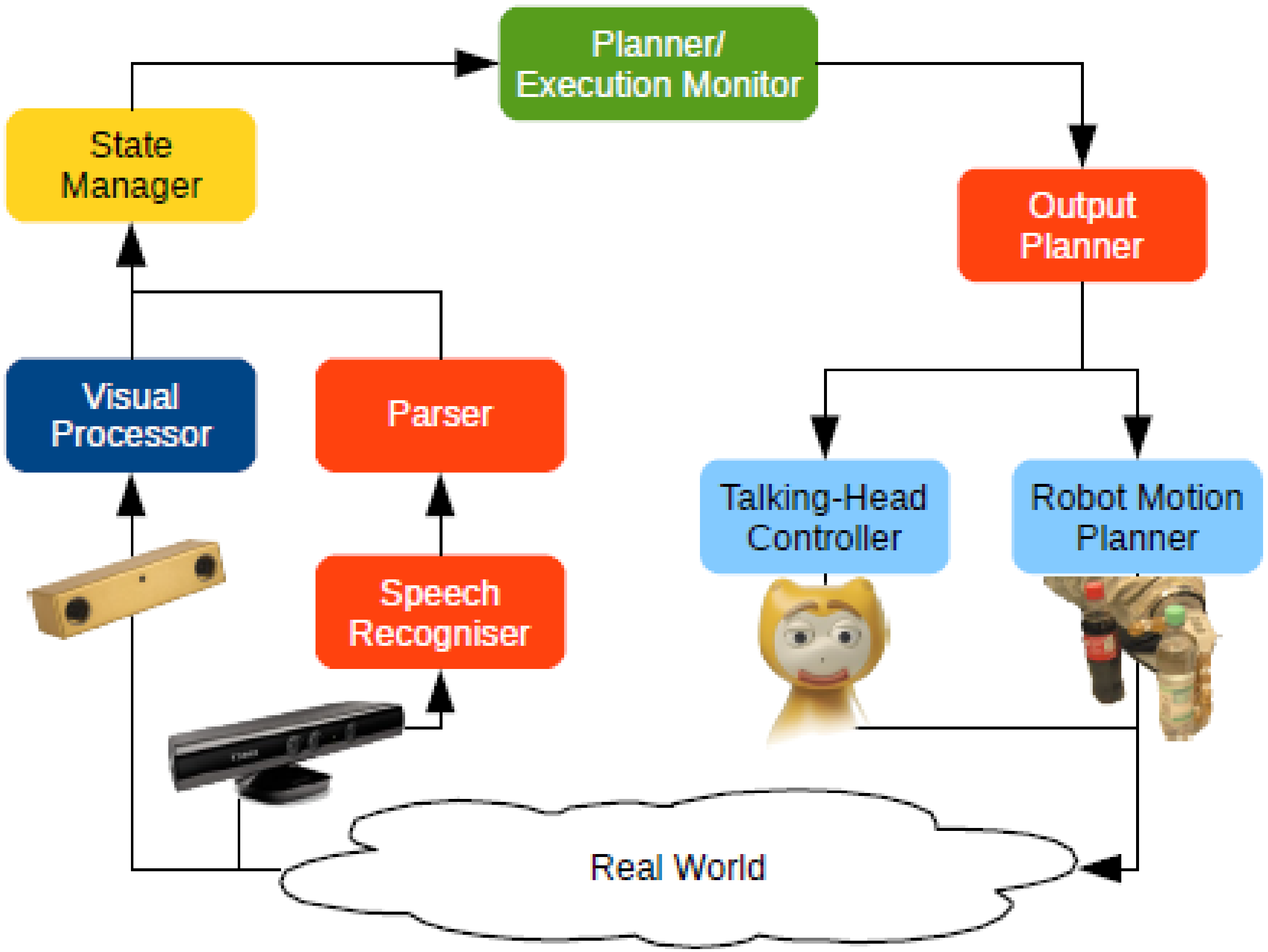




K. Mourão, R. Petrick, and M. Steedman. Learning Action Effects in Partially Observable Domains, ICAPS Workshop on Planning and Learning, 2009

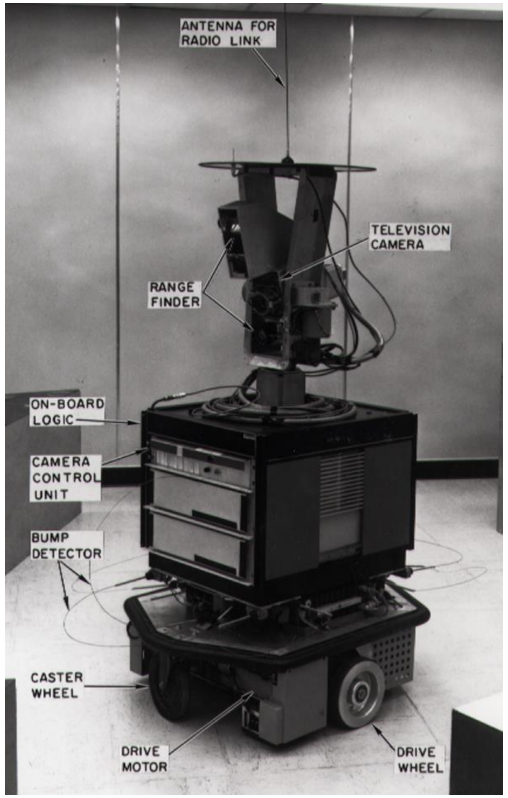
K. Mourão, L. Zettlemoyer, R. Petrick, and M. Steedman. Learning STRIPS Operators from Noisy and Incomplete Observations, UAI 2012

Applications



R. Petrick and M.E. Foster. Planning for social interaction in a robot bartender domain, ICAPS 2013

Robotics



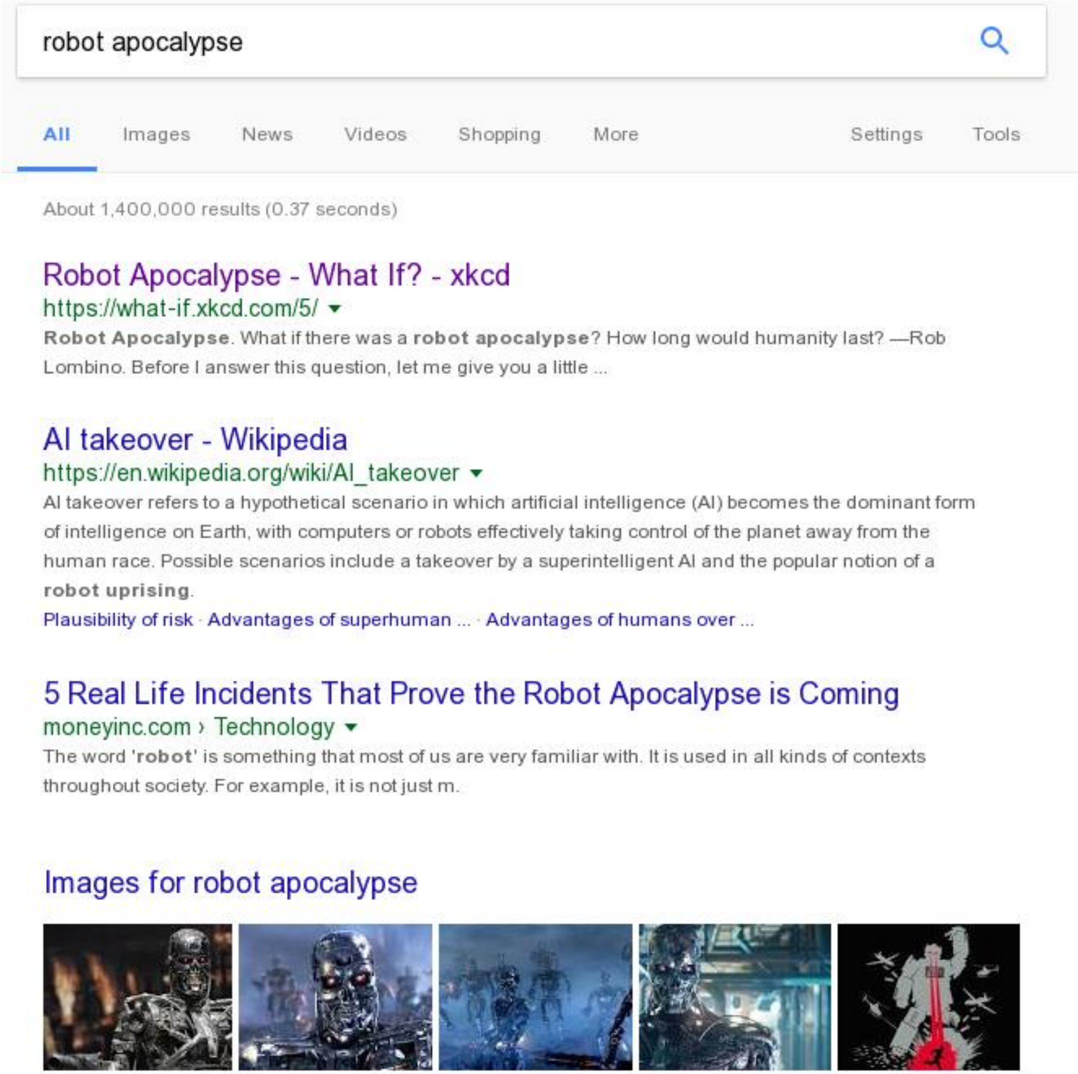
Shakey - Photo: SRI International


Valkyrie - Photo: NASA

Pepper - Photo: Softbank Robotics

AI doesn't necessarily mean robots! Robots don't necessarily mean AI!

Robotics and AI



JAMES robot bartender

JAMES video – For more information about JAMES, visit the project website at http://james-project.eu/

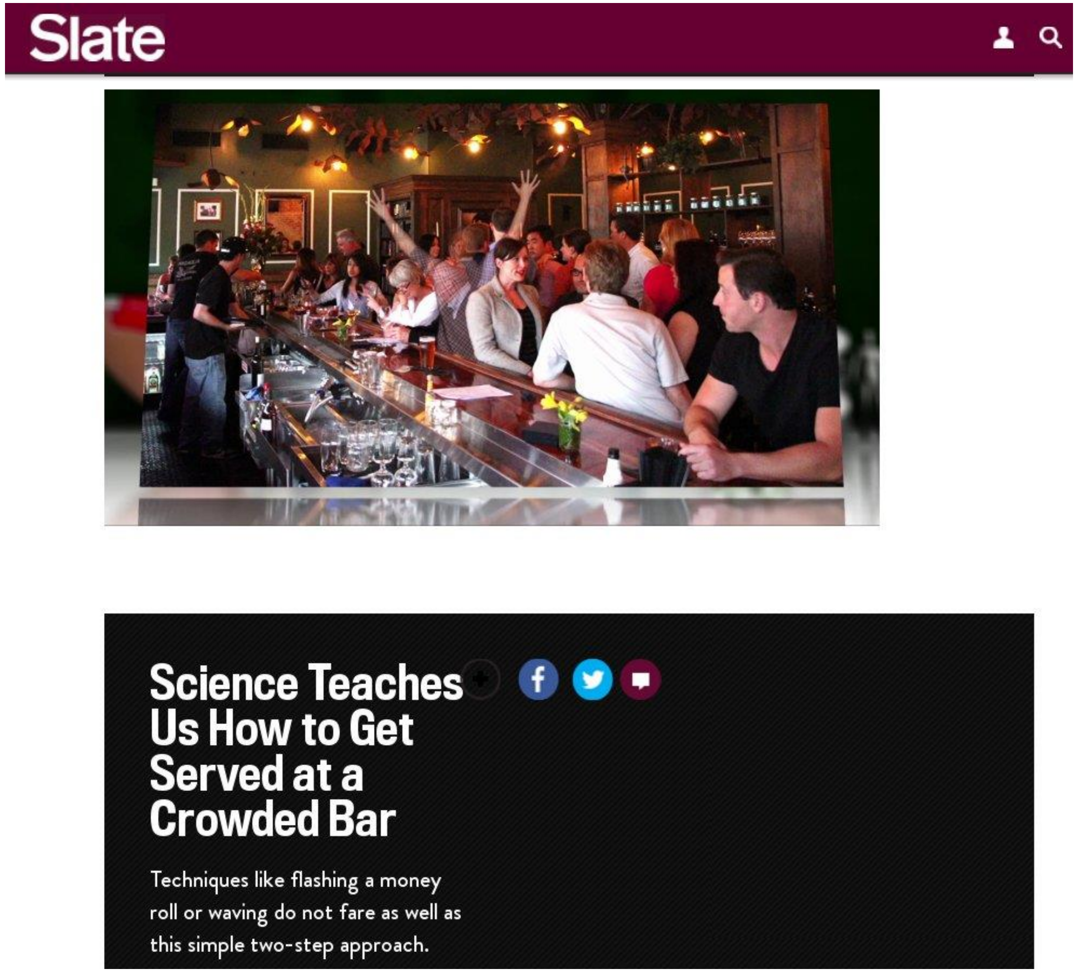
STAMINA robot

STAMINA video – For more information about STAMINA, visit the project website at http://stamina-robot.eu/

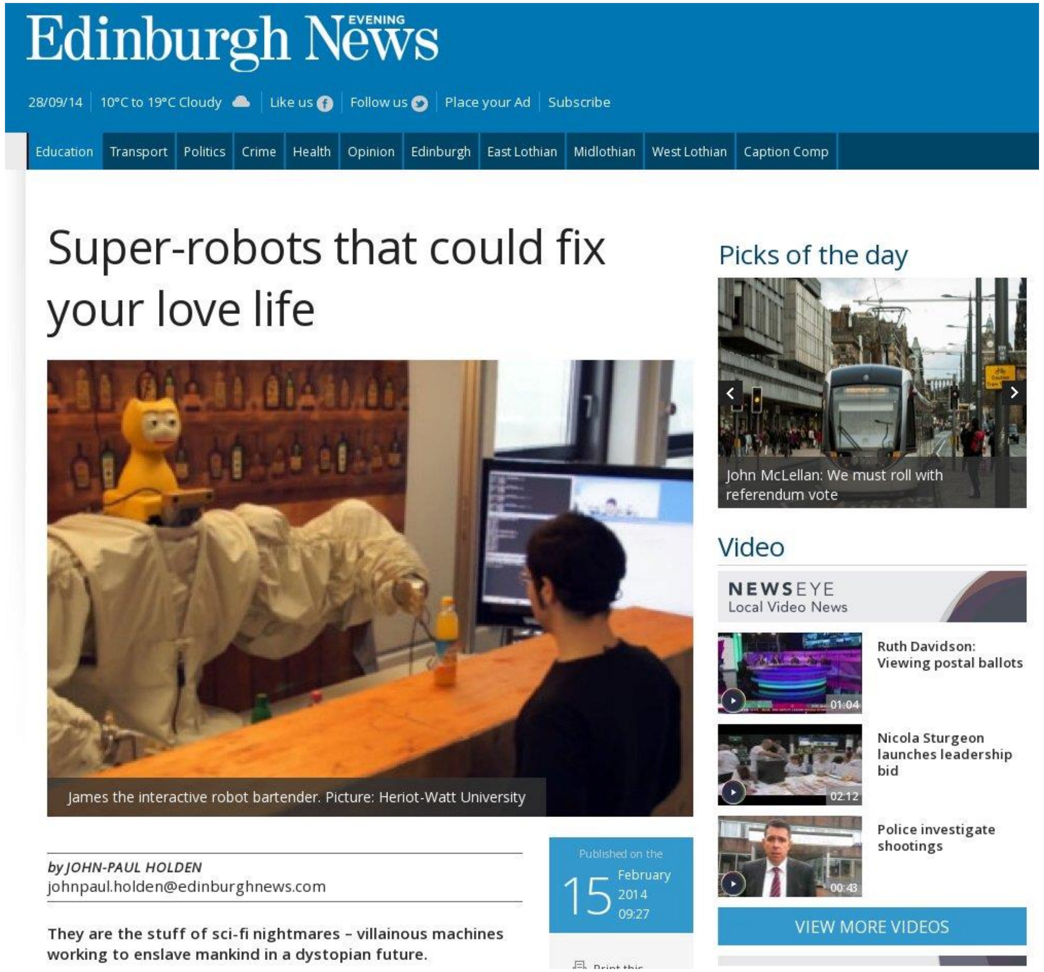
JAMES robot bartender "Version 2"

JAMES V2 video – For more information about JAMES, visit the project website at http://james-project.eu/

Interesting times…



Slate video - How to Get Served at a Crowded Bar



Edinburgh Evening News - 2014-02-15

Applications

Robotics consortium in offshore technology funding boost

8 November 2017 | Scotland business

f Share

A consortium of five universities is to spend up to £36m in developing robotic and artificial intelligence (AI) technologies for use in harsh offshore environments.

[BBC News - 2017-11-08]

ORCA: Offshore Robotics for Certification of Assets

ORCA HUB
Offshore Robotics for Certification of Assets
Remote Safety and Integrity

Photo: Ocean Systems Lab, Heriot-Watt University

Trend 3: explaining the box

Explainable planning: why is the system doing what it's doing?

Explainable planning

```
action grasp(?o : object)
    preconds:
        K(handEmpty) &
        K(onTable(?o))
    effects:
        add(Kf, !handEmpty),
        add(Kf, !onTable(?o)),
        add(Kf, inHand(?o))
```

```
   Kf: handEmpty, onTable(bottle1), onTable(bottle2),
       !empty(bottle1)
   Kw: empty(bottle2)

Action: grasp(bottle1)

   Kf: inHand(bottle1), onTable(bottle2),
       !handEmpty, !onTable(bottle1), !empty(bottle1)
   Kw: empty(bottle2)
```

Why was an action chosen?
What would happen if another action was applied?
What is the system trying to achieve?
What does the system believe about the world?
…

EPSRC project: Start Making Sense
Cognitive and affective confidence measures for explanation generation using epistemic planning

Summary

Symbolic AI + automated planning still have an important role to play as a technology for decision making

Trends

1. Better tools
2. More connections with machine learning
3. Focus on real-world applications
4. Contributions to explainable systems