

On the Way to Automated Belief Repair for Autonomous Robots

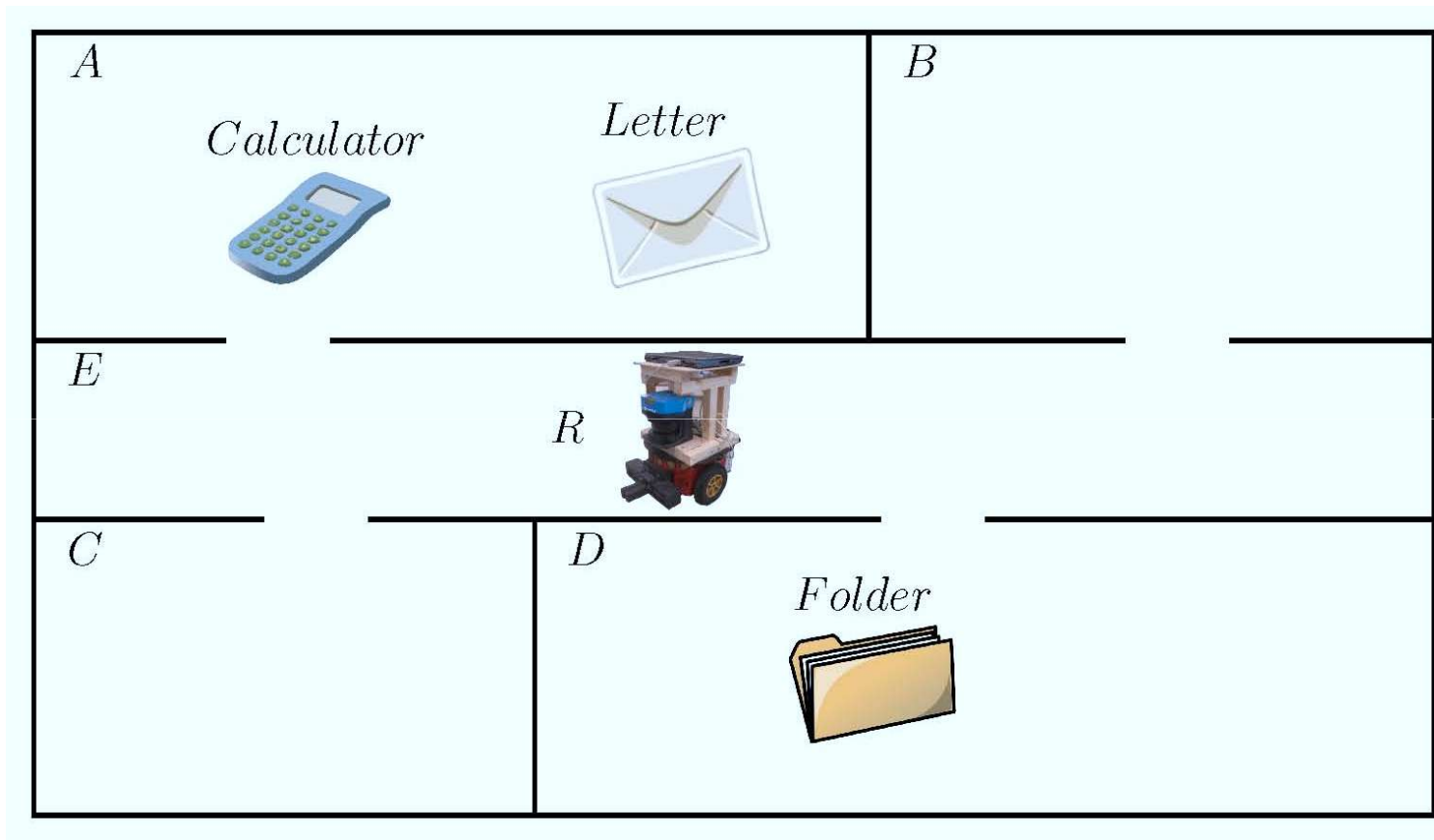
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Diagnosis & Repair of Beliefs

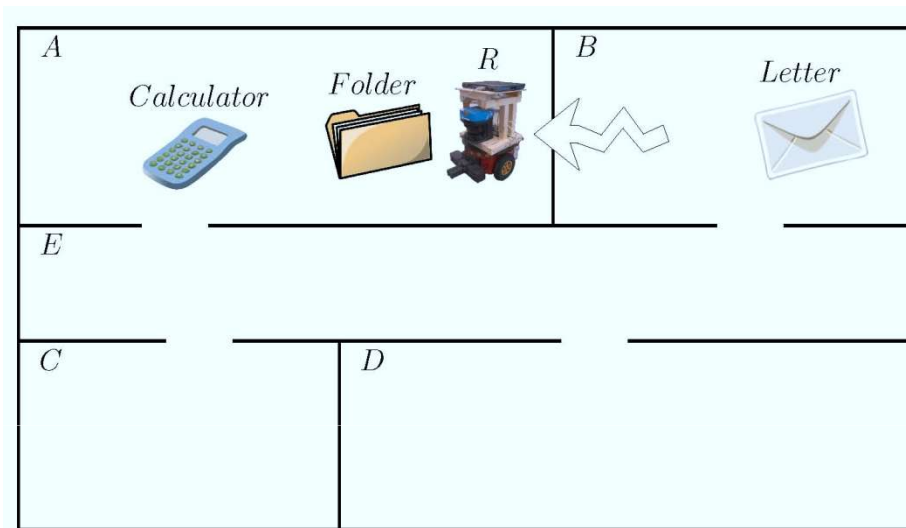
- most autonomous robots fail due to inconsistencies in their belief (world model)
- reasons for instance are
 - unreliable acting (e.g. move to a wrong room)
 - unreliable perception (e.g. perception of ghost objects)
 - exogenous events (e.g. external agent)
- belief of the robot = knowledge base
- Use of model-based diagnosis to detect and actively handle inconsistencies
- model the intended change of the world (background model - common sense)

Belief Diagnosis – A Simple Example

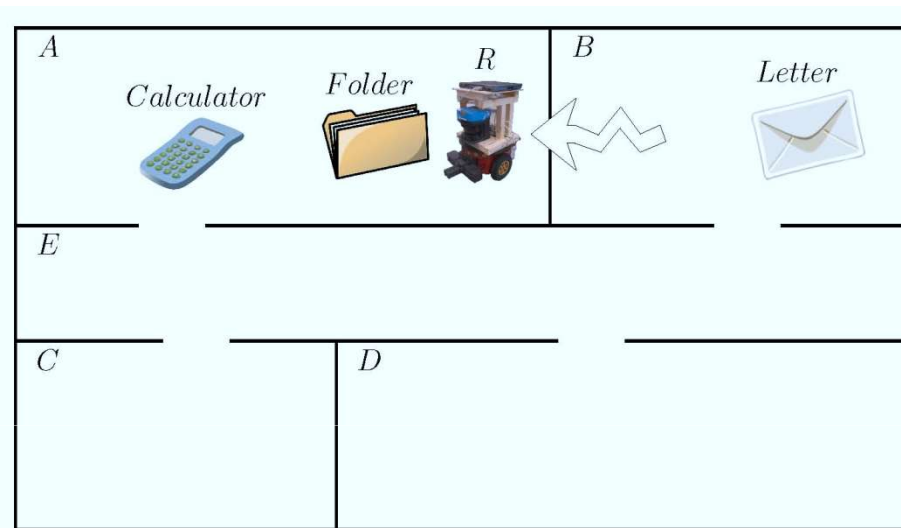


Task: bring the letter to room B and the folder to C
Actions: goto(l), grab(o), release(o)

Belief Diagnosis - A Simple Solution

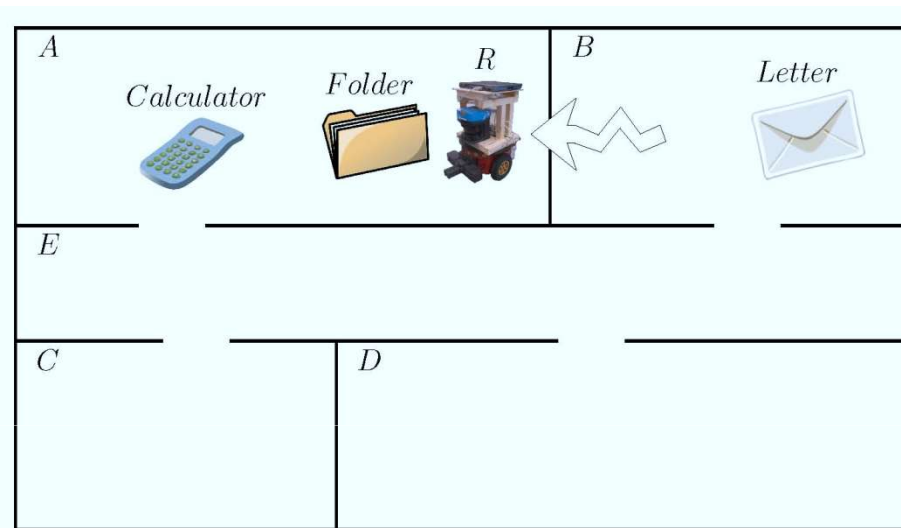


Belief Diagnosis - A Simple Solution



- Goal
- $isat(Calculator, B) \wedge isat(Folder, C)$

Belief Diagnosis - A Simple Solution



- Goal
- $isat(Calculator, B) \wedge isat(Folder, C)$

- Perception Robot
- $at(C) \wedge see(Calculator)$

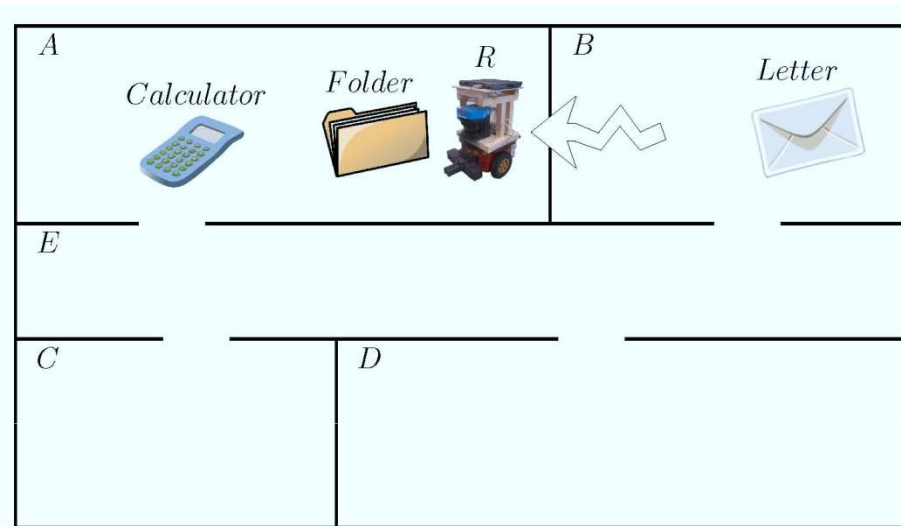
+

- Axioms + Previous Belief
- $isat(Letter, B) \wedge isat(Calculator, A)$

=

- Knowledge Base of Robot
- $at(C) \wedge isat(Letter, B) \wedge isat(Calculator, A)$

Belief Diagnosis - A Simple Solution



- Goal
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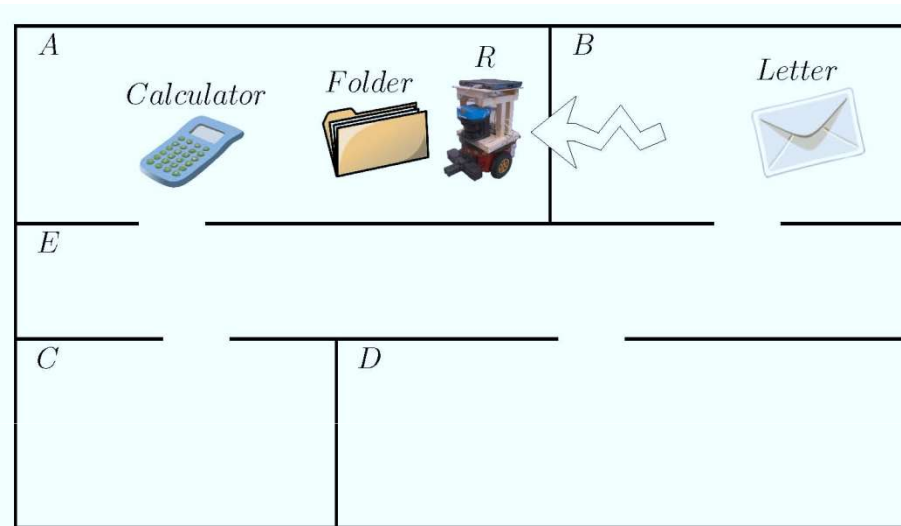
- Perception Robot
- $at(C) \wedge see(Calculator)$

Background Model
 $at(l) \wedge see(o) \rightarrow isat(o, l)$

- Axioms + Previous Belief
- $isat(Letter, B) \wedge isat(Calculator, A) \wedge isat(Calculator, C) =$

- Knowledge Base of Robot
- $at(C) \wedge isat(Letter, B) \wedge isat(Calculator, A) \wedge isat(Calculator, C)$

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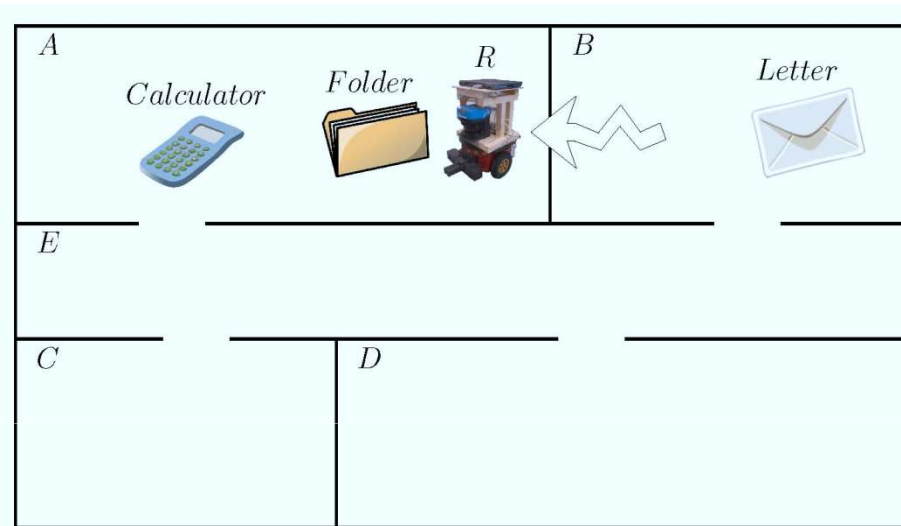
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- $isat(Letter, B) \wedge isat(Calculator, A) \wedge isat(Calculator, C) =$

Contradiction

- Knowledge Base of Robot
- $at(C) \wedge isat(Letter, B) \wedge isat(Calculator, A) \wedge isat(Calculator, C)$

Belief Diagnosis - A Simple Solution



- Goal
- $isat(Calculator, B) \wedge isat(Folder, C)$

Perception Robot

• $at(C) \wedge see(Calculator)$

Possible Conflicts

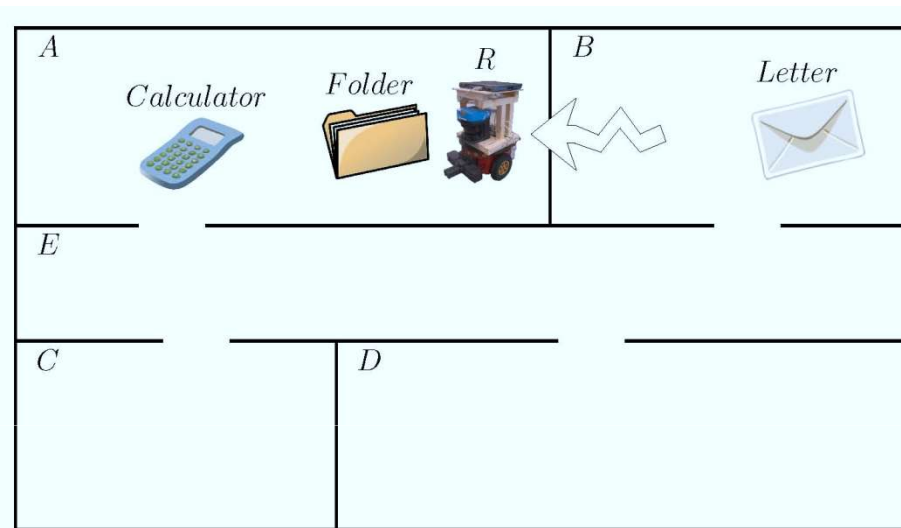
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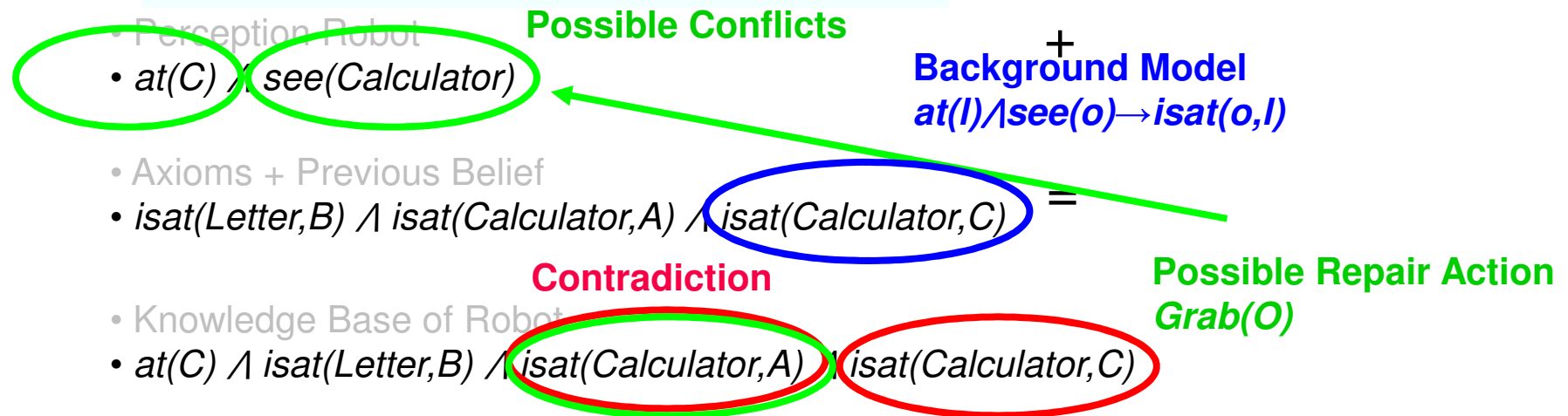
Contradiction

- Knowledge Base of Robot
- $at(C) \wedge isat(Letter, B) \wedge isat(Calculator, A) \wedge isat(Calculator, C)$

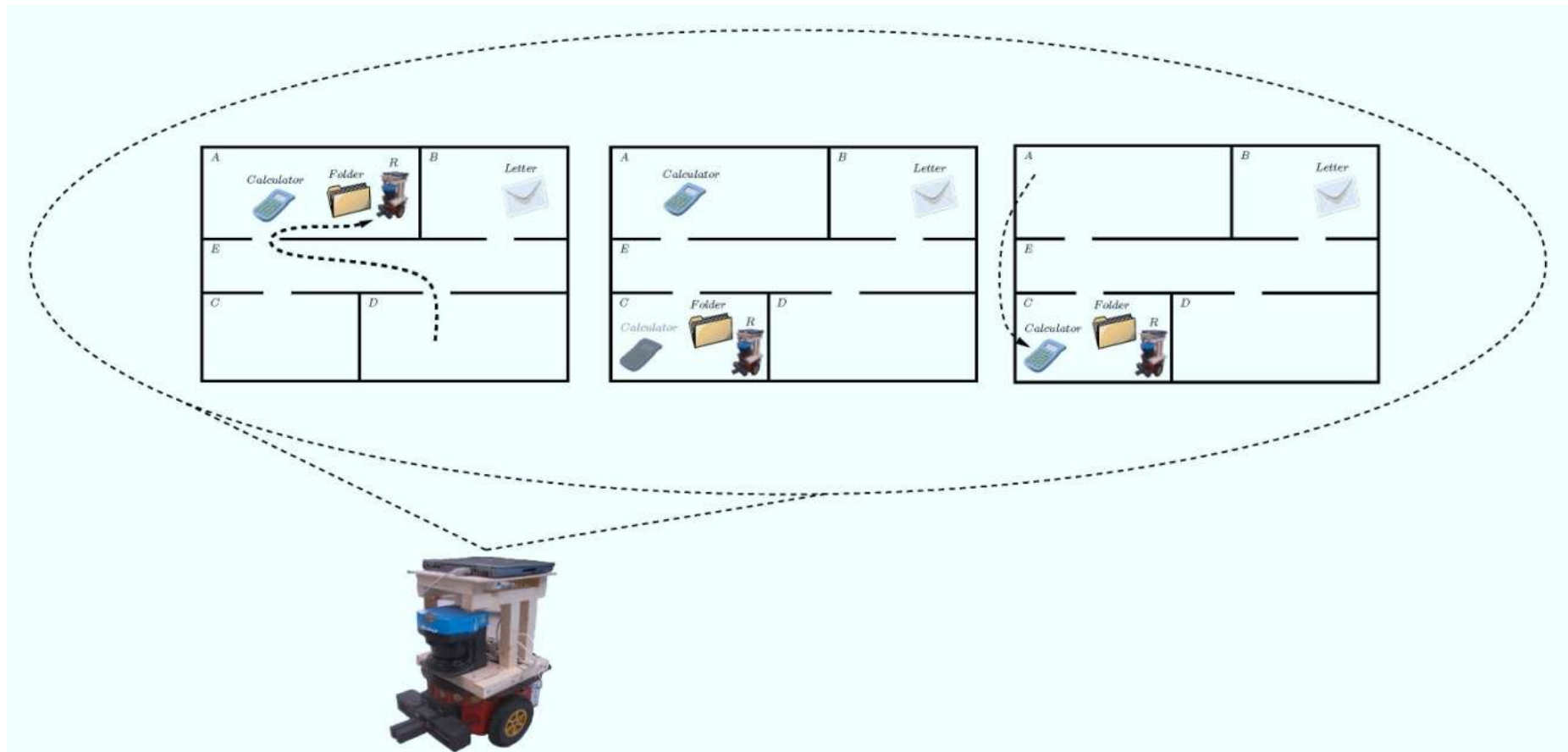
Belief Diagnosis - A Simple Solution



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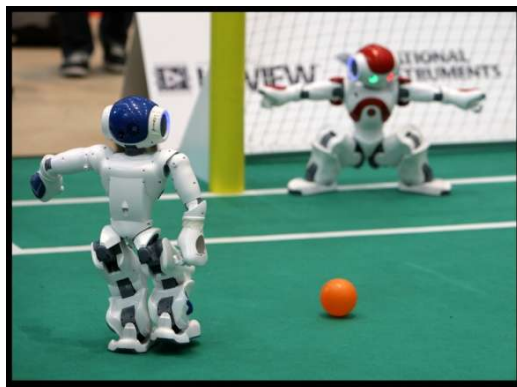
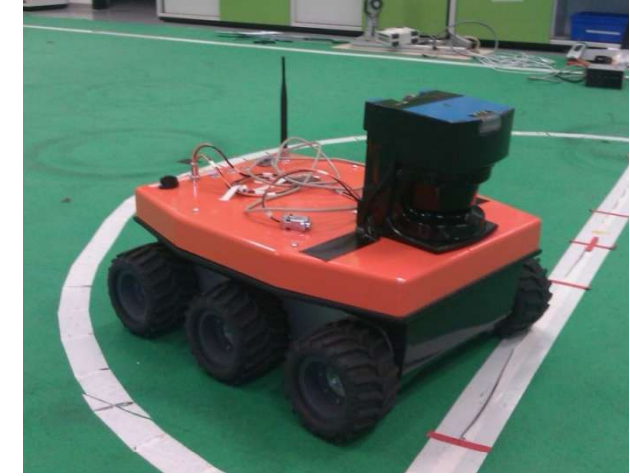
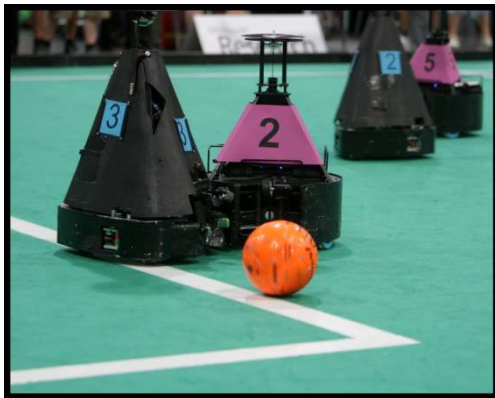


Dealing with Multiple Worlds

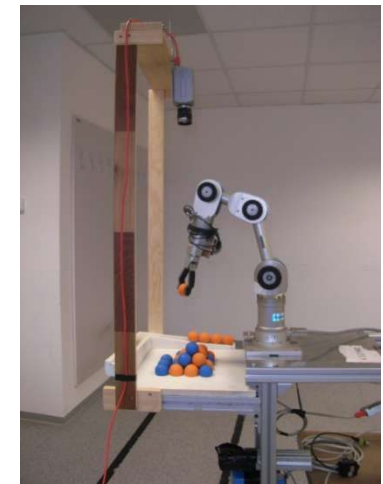


Conclusion

- robots might face inconsistencies in their internal belief of the world
- automated reaction is desired for truly autonomous systems
- model-based reasoning can help for fault localization
 - formalization of belief diagnosis
- robots have to deal with multiple worlds



RoboCup 2009
GRAZ · AUSTRIA

Thank you!