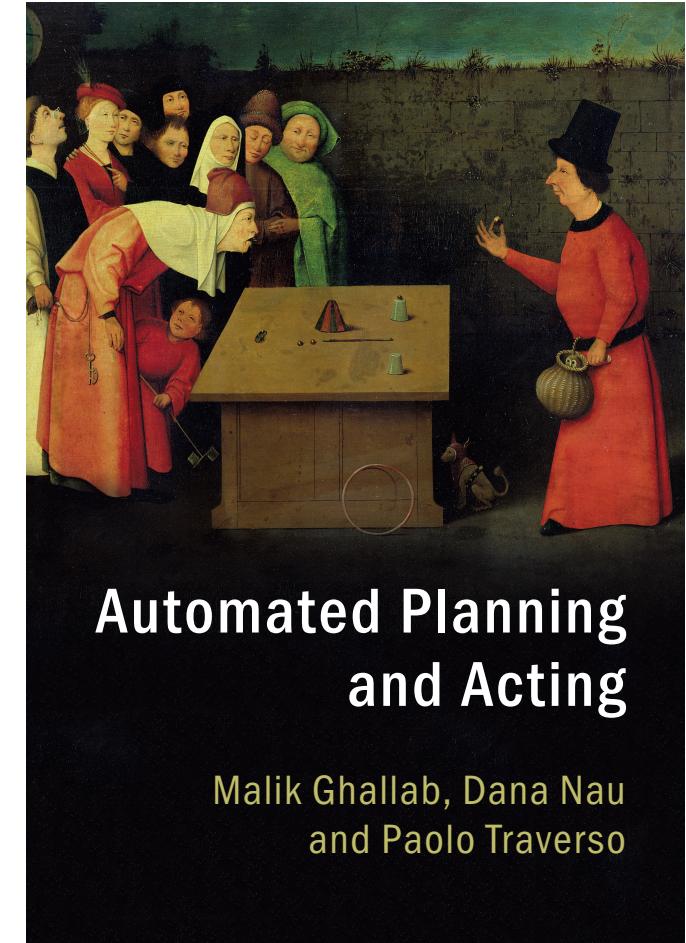


# Chapter 1

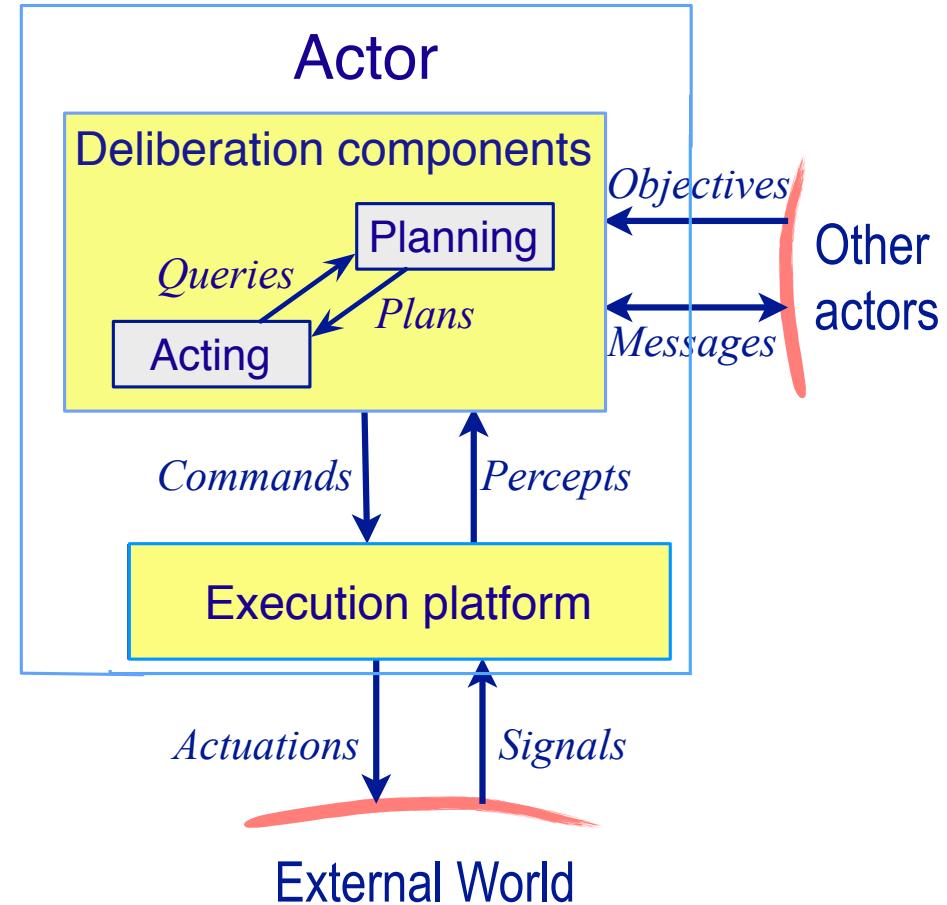
## Introduction

Dana S. Nau  
University of Maryland



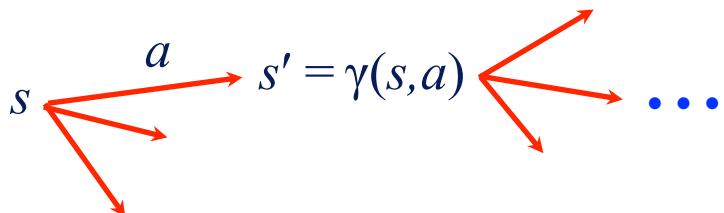
# Motivation

- *Actor*: agent that performs actions
- Deliberation functions
  - ▶ Planning  
*What actions to perform*
  - ▶ Acting  
*How to perform them*



# Planning

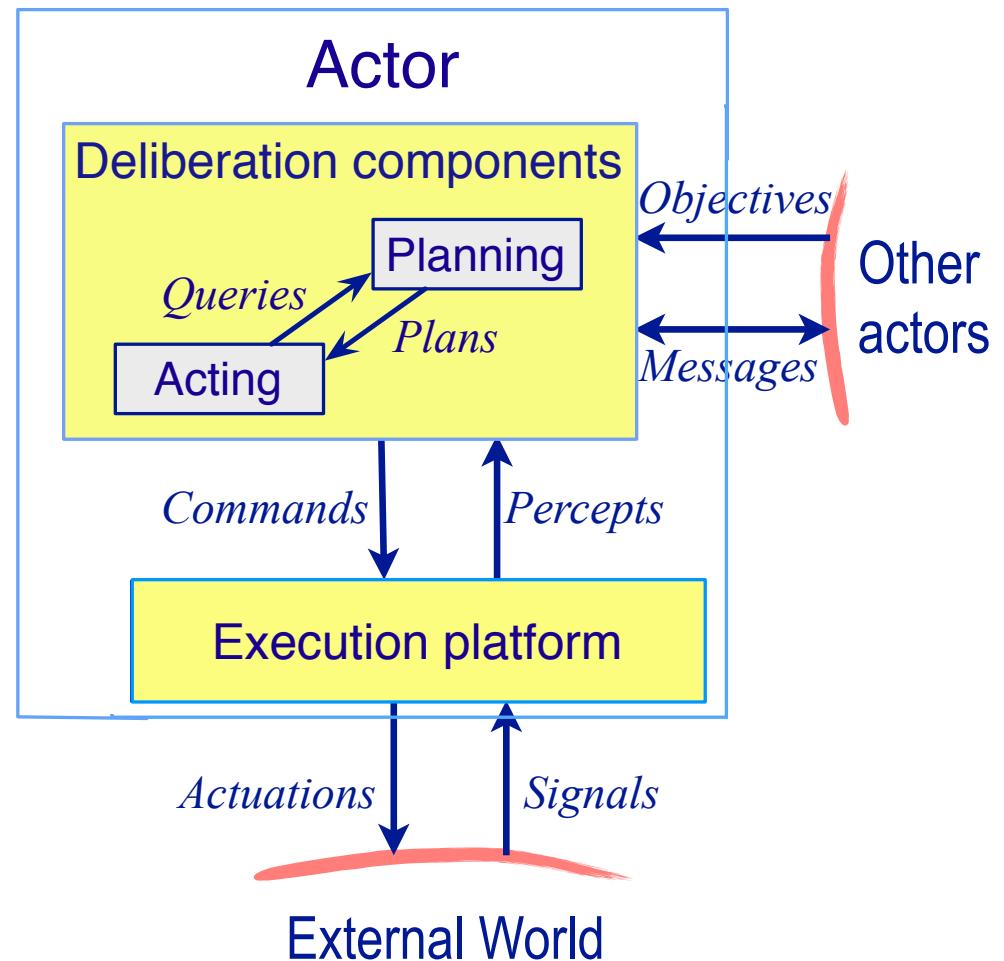
- Relies on *prediction + search*
- Uses *descriptive models* of the actions
  - ▶ Predict *what* the actions will do
  - ▶ Don't tell *how* to do them
- Search over *predicted states* and possible organizations of feasible actions
- Different types of actions ⇒
  - ▶ Different predictive models
  - ▶ Different planning problems and techniques
    - ▶ Motion and manipulation planning
    - ▶ Perception planning
    - ▶ Navigation planning
    - ▶ Communication planning
    - ▶ **Task planning**



*Most AI planning*

# Acting

- Traditional “AI planning” view:
  - ▶ Carrying out an action is just execution
  - ▶ Can ignore how it’s done
- *Sometimes* that’s OK
  - ▶ If the environment has been engineered to make actions predictable
  - ▶ Example on next slide
- Usually acting is more complicated
  - ▶ Example later



# Acting as Execution



Video: <https://www.cs.umd.edu/~nau/apa/kiva.mp4>

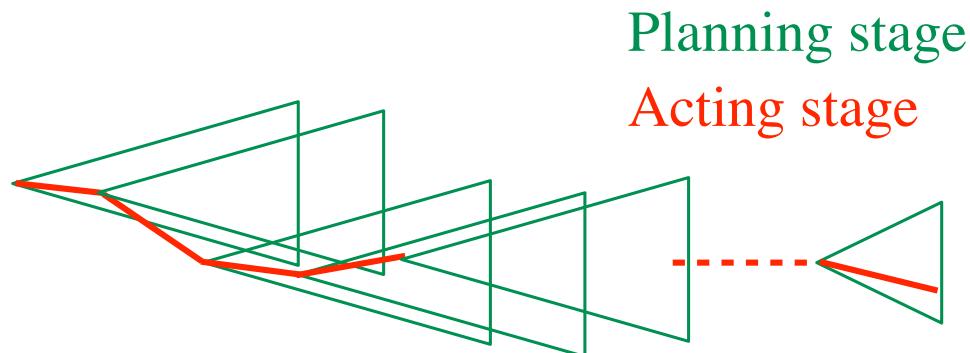
# Deliberative Acting



Video: <https://www.cs.umd.edu/~nau/apa/crow.mov>

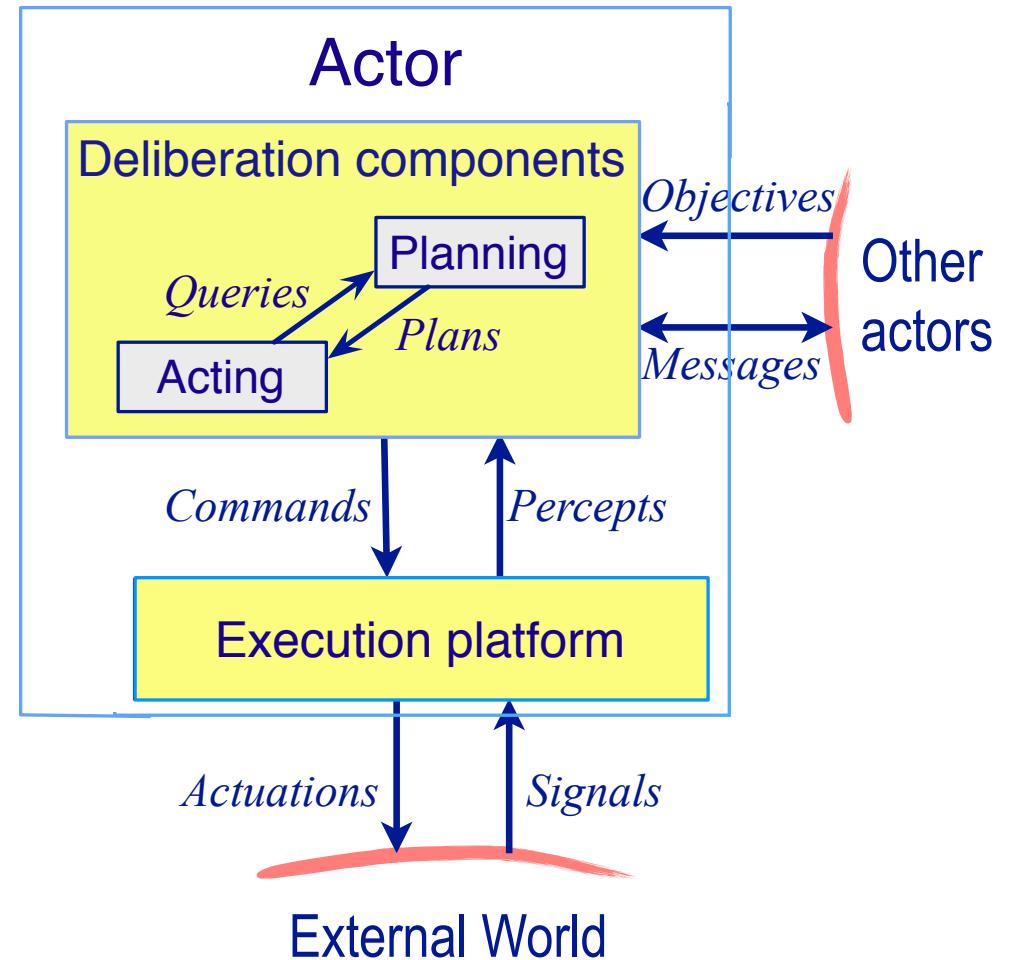
# Deliberative Acting

- Actor is in a dynamic unpredictable environment
  - Adapt actions to current context
  - React to events
- Relies on
  - *Operational models* telling *how* to perform the actions
  - Observations of *current state*



# Planning and Acting

- *Multiple levels of abstraction*
  - ▶ Actors are organized into physical subsystems
  - ▶ Deliberation reflects this
- *Heterogeneous reasoning*
  - ▶ Different techniques
    - at different levels
    - different subsystems at same level
- *Continual online planning*
  - ▶ Can't plan everything in advance
  - ▶ Plans are abstract and partial until more detail is needed

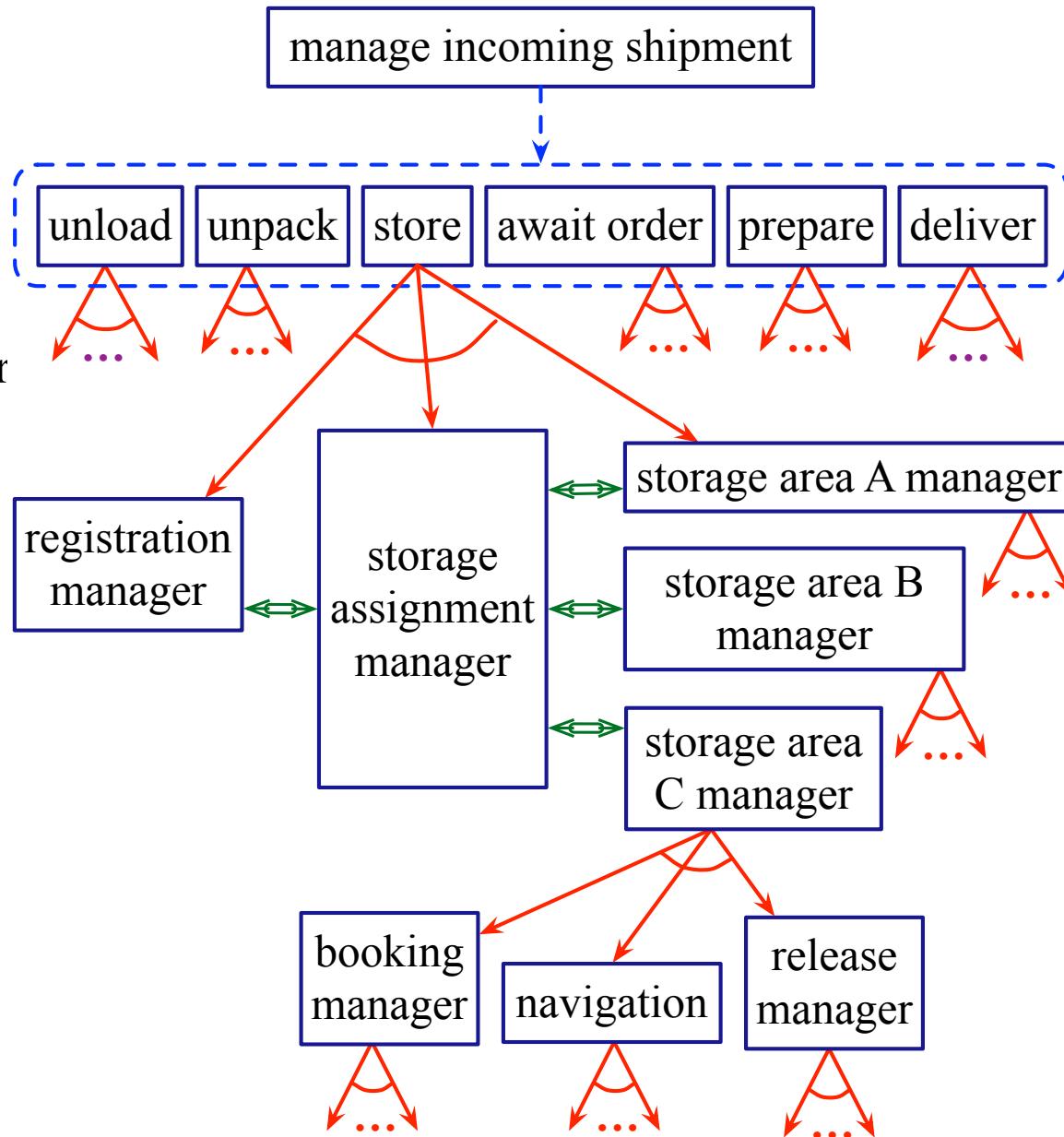


# Bremen Harbor



# Example: Harbor Management

- Importing/exporting cars
  - ▶ Based on Bremen Harbor
- *Multiple levels of abstraction*
  - ▶ Reflect physical organization of harbor
- *Continual online planning*
  - ▶ Top level can be planned offline
  - ▶ The rest is online, based on current conditions
- *Heterogeneous reasoning*
  - ▶ Different components work in different ways
  - ▶ Online synthesis of automata to control their interactions

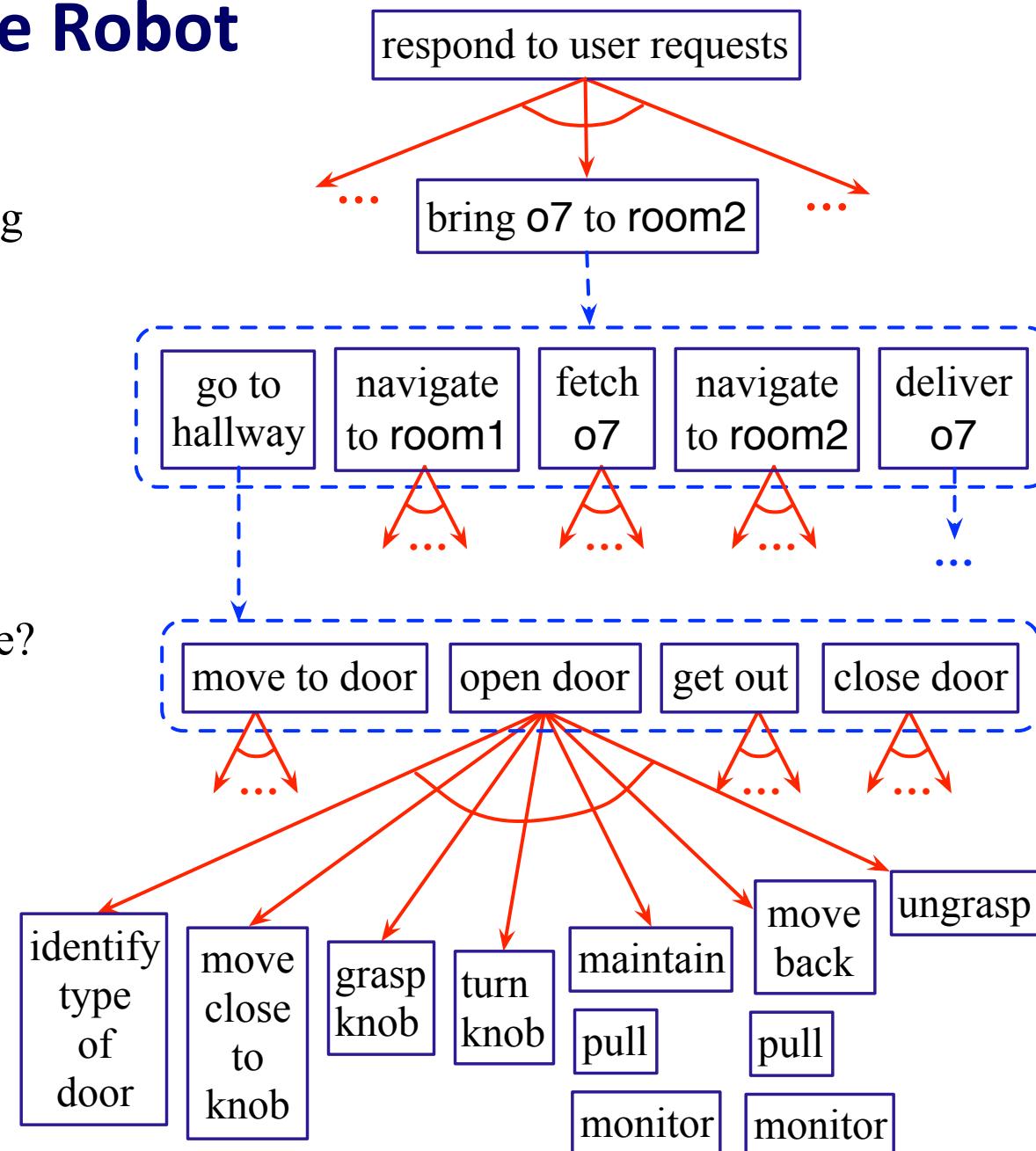


Planning

Acting

# Example: Service Robot

- *Multiple levels of abstraction*
  - Higher levels: more planning
  - Lower levels: more acting
- *Continual online planning*
  - What room is o7 in?
  - What route?
  - What kind of door?
  - Close enough to door handle?
- *Heterogeneous reasoning*
  - planning abstract tasks
  - path planning
  - reactive (e.g., open door)



Planning

Acting

# Outline of Book

1: *Introduction* (this lecture)

2: *Deterministic models*

- ▶ Conventional (*classical*) AI planning
- ▶ Integrating it with acting

3: *Refinement methods*

- ▶ Acting and planning by refining abstract activities into less-abstract activities

4: *Temporal models*

- ▶ Reasoning about time constraints

5: *Nondeterministic models*

- ▶ Actions with multiple possible outcomes

6: *Probabilistic models*

- ▶ Multiple possible outcomes, with probabilities

7: *Other:*

- ▶ perceiving, monitoring, goal reasoning, learning, hybrid models, ontologies



## Automated Planning and Acting

Malik Ghallab, Dana Nau  
and Paolo Traverso

Any questions?



Cover image: *The Conjuror*. Hieronymus Bosch (c.1450–1516)