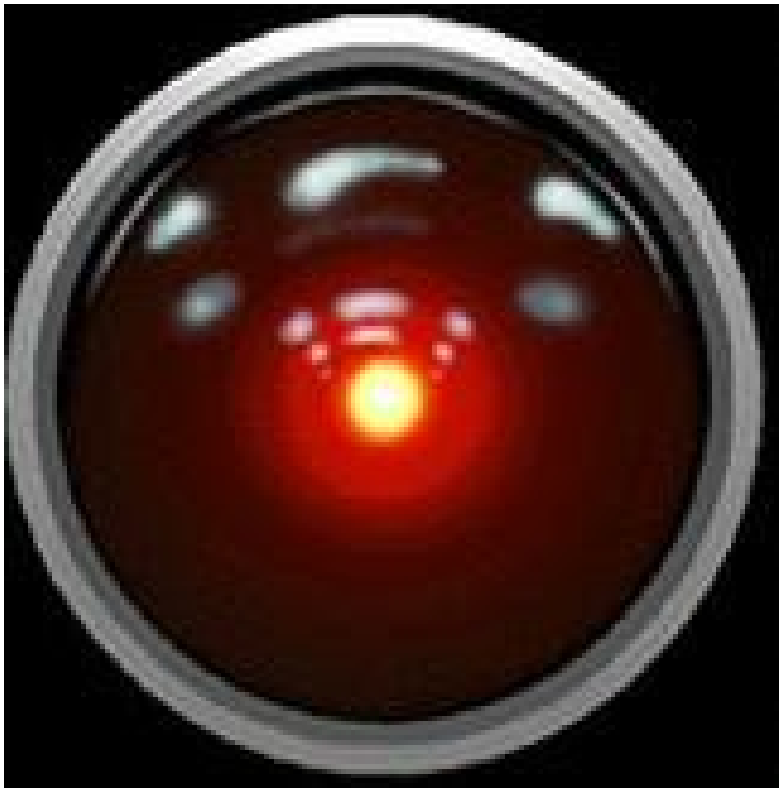


CS 309: Autonomous Intelligent Robotics

Instructor: Jivko Sinapov

http://www.cs.utexas.edu/~jsinapov/teaching/cs309_spring2017/

Announcements

Homework 4 is out – Q & A

Final Project Timeline

- Project Proposal due: Apr. 3rd
- Project Presentations / Demos: Finals Period assigned for this class
- Final Report due: May 11th

Project Proposal Guidelines

- Work in groups of 2-3
- Preferably, team up with people with different skills than yours
- Purpose of the proposal is to give you an outline / roadmap

Project Proposal Guidelines

- Each proposal should be about 3-4 pages

- Each proposal should include:
  - What is the application / task / problem?
  - Any previous experience you may have in that area
  - What do you expect to achieve by the end of the semester?
  - How do you plan to evaluate whether it works or not?
  - Related work in robotics
  - A timeline / schedule of progress and milestones

Project Proposal Guidelines

- Organization: your proposal should have sections and headings (don't just submit one long essay)
- For example:
  - Introduction / problem formulation
  - Related Work in Robotics
  - Proposed approach / software
  - Proposed evaluation
  - Summary of anticipated end result

Project Ideas

Help the robot “see” something it currently cannot

Help the robot “hear” something (e.g., the elevator sound)

Help the robot “do” something (e.g., follow a person)

Final Project Timeline

The most important thing is to start early, and discuss your ideas with the TAs, mentors and myself. We'll point you to a starting point, describe functionality that already exists, and help refine your ideas.

Readings Discussion

Artificial Intelligence: A Modern Approach. Chapter 11: Planning

R. Brooks (1986). ``A Robust Layered Control System for a Mobile Robot", MIT Al Memo 864, Vol RA-2, No. 1. p. 14-23

R. Brooks (1991). "Intelligence Without Representation", Artificial Intelligence, Volume 47 , Issue 1-3

“Would it be feasible to create a version of STRIPS where the cost of each action depends on the difficulty that action?”

“What are some of the planning algorithms that the segbot v2 and v3 take?”

- Jeremy

“Now that I know about various planning techniques-- progression planning, regression planning, partial order planning, planning graphs, and propositional logic representations-- I would like to know more about how these are used to solve actual problems.”

- Mayuri

“Brooks mentioned that “insect level thinking” was the goal as of now, I understand that he means instincts, but what would that actually be? A robot that “survives” on its own for the most part?”

- Raychel

“Has the author considered the near infinite possibilities of events that could happen to the robot? I fear the first thing to happen will be to have the autonomous robot be struck by a car. What exactly is the end goal of such an autonomous robot? The author talks about having goals but does not seem to list any.”

- Ye

“Even humans have some type of central system (the brain) that controls the processes that occur in the human body. How would the robot administer control on a "collection of competing layers?"”

- Yuanhui

“I believe that humans cannot give instructions to a robot for each situation in life before the creation of the system. This would take immense man hours and be implausible. How can we do this if we have to tackle all of the small mundane tasks in preparing a robot? “

- Shivam

“I believe that humans cannot give instructions to a robot for each situation in life before the creation of the system. This would take immense man hours and be implausible. How can we do this if we have to tackle all of the small mundane tasks in preparing a robot? “

- Shivam

“However, in most experiments with these robots and the "real world", they are confined to one building, like the four robots at MIT Brooks mentioned. Couldn't one argue that the building is merely an expanded test environment?”

- Christian

“This article is written back in 1980’s and the significant amount of time has passed. Is Brook’s view of incremental approach gained support and acceptance by the others? Or, are researches still mainly use central system approach? “

- Jamin

Rodney Brooks

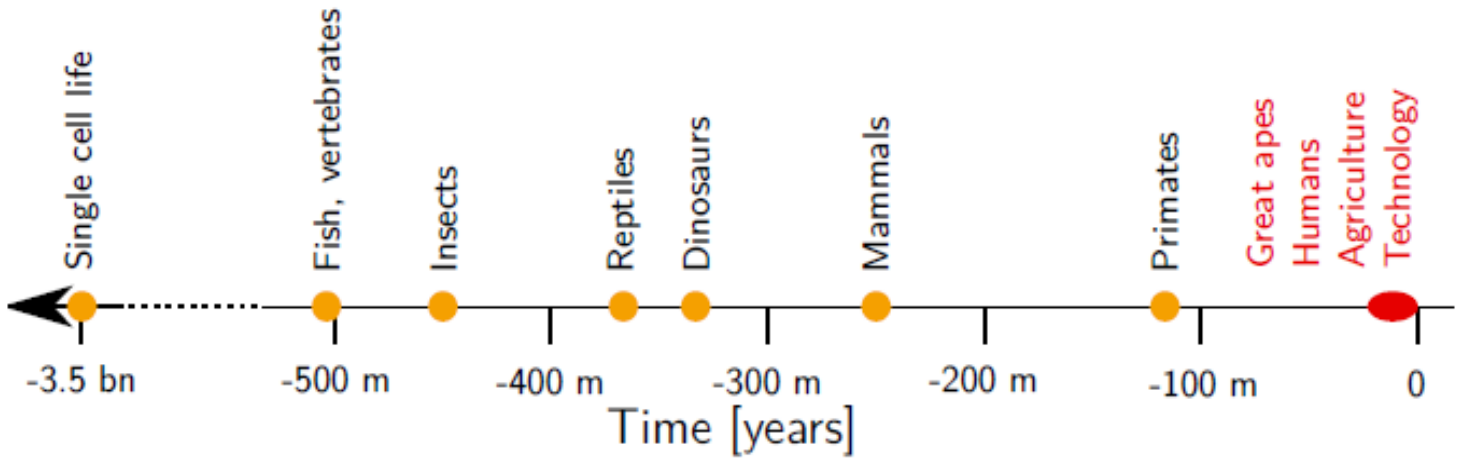
- $\star$ 1954 in Adelaide (Australia)
- Degree in mathematics and computer science
- Positions: CMU, MIT, Stanford
- Professorship: MIT, head of AI Lab
- Companies: iRobot, Heartland robotics, ...
- Contributions: Behavior-based AI, robotics, ...
- Several awards
- Tons of papers

[I1]

GOFAI

- **GOFAI**: good old-fashioned artificial intelligence
- Typically implemented as a central planner operating on a set of symbols (predicates)
- **Tools**: logic, predicate logic, PROLOG, Search algorithms, etc.
- **Solution:** sense → model → plan → act

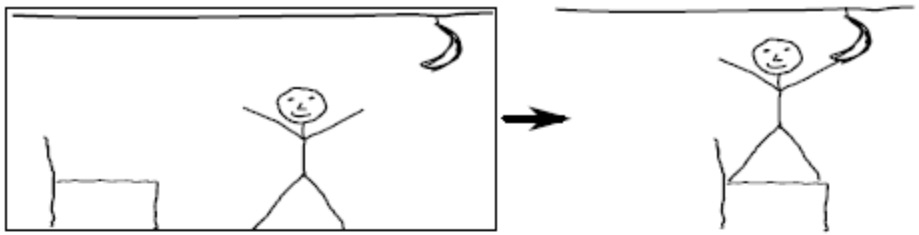
Brooks' opinion: GOFAI failed



Conclusion:

- Complex/intelligent skills appear simple, once the prerequisites are available
- Skills: problem-solving behavior, language, expert knowledge, reasoning
- Prerequisites: mobility, acute sensing, survival and reproduction in dynamic environments

Abstraction is a dangerous weapon



GOFAI:

- Requires abstraction
- Handcrafted decomposition: PERSON, CHAIR, BANANA
- Basic concepts / representation
- Planner (search algorithm)

Reality:

- Intuitive interpretation & solution

Conclusion:

- Over-simplification of GOFAI
- Intelligence includes interpretation & abstraction

Toy worlds vs. Real worlds

GOFAI:

- Use of toy worlds
- Human interpreter for abstraction/simplification
- Static (prepared) environments
- Planning/perception with limited "field of view"

Behavior-based AI:

- Real worlds
- No human assistance, robot should operate on its own
- Dynamic environments without simplifications
- Full bandwidth of intelligent behavior

Conclusion:

Autonomous mobile robots in real-world
$\Rightarrow$ artificial intelligent systems

Toy worlds vs. Real worlds

GOFAI:

- Limited applicability
  small subset of real-world
- Top-down approach
- Engineering decomposition:
  solution $\rightarrow$ decomposition
- Central locus of control

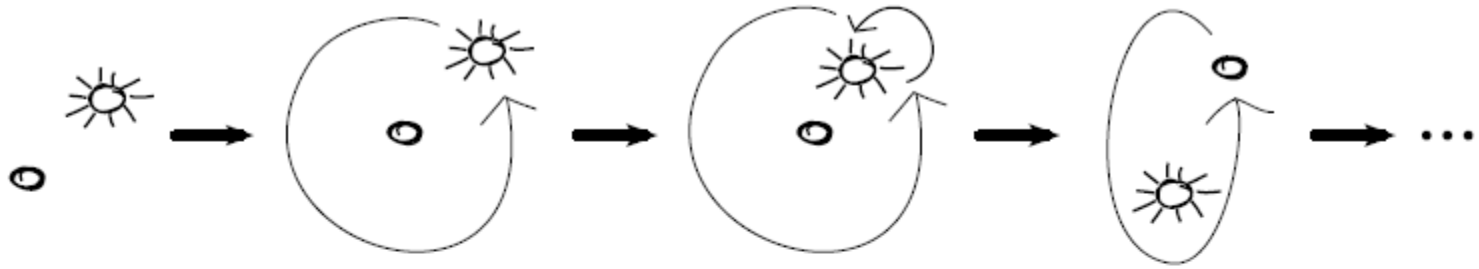
Behavior-based AI:

- Vast repertoire of capabilities, experience, and knowledge
- Bottom-up approach
- Incremental decomposition:
  decomposition $\rightsquigarrow$ solution
- No central control instance

Conclusions:

Intelligent systems as composition of independent sub-systems

Brook's opinion: GOFAI failed



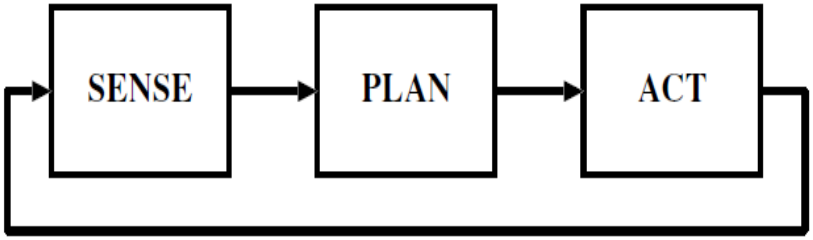
Conclusion:

This cycle will also happen to AI

Overall conclusions:

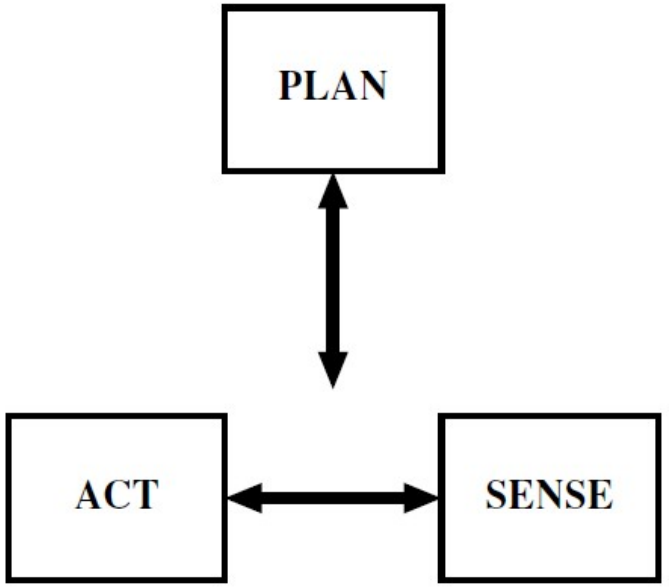
- GOFAI: Not sufficient to explain intelligent behavior
- Hindsight: current (1986) AI work will appear useless
- Change of paradigm: *"towards process, away from state"*

Alternatives to Sense-Plan-Act



Sense-Plan-Act

Reactive



Hybrid

Reactive Paradigm

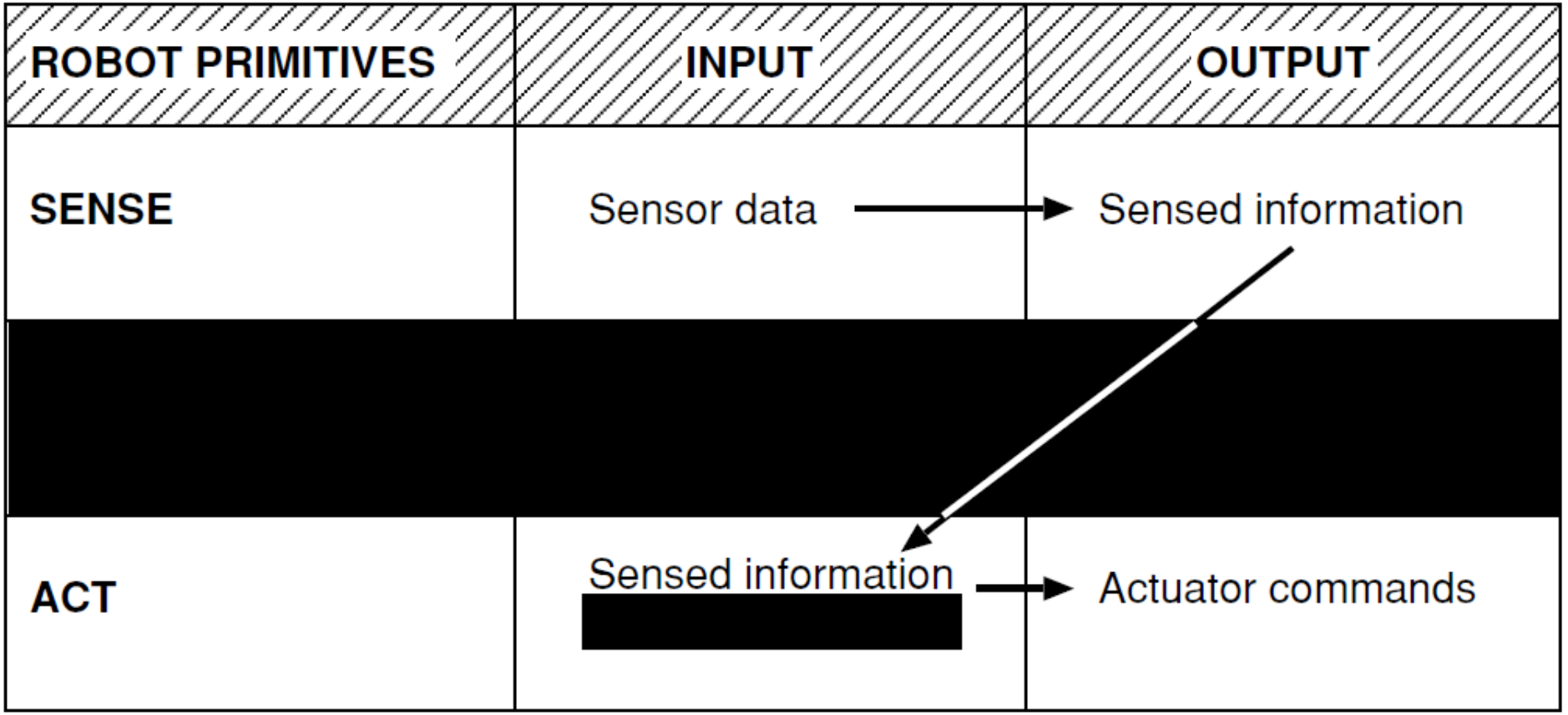


Figure I.5 The reactive paradigm.

The Hybrid Paradigm

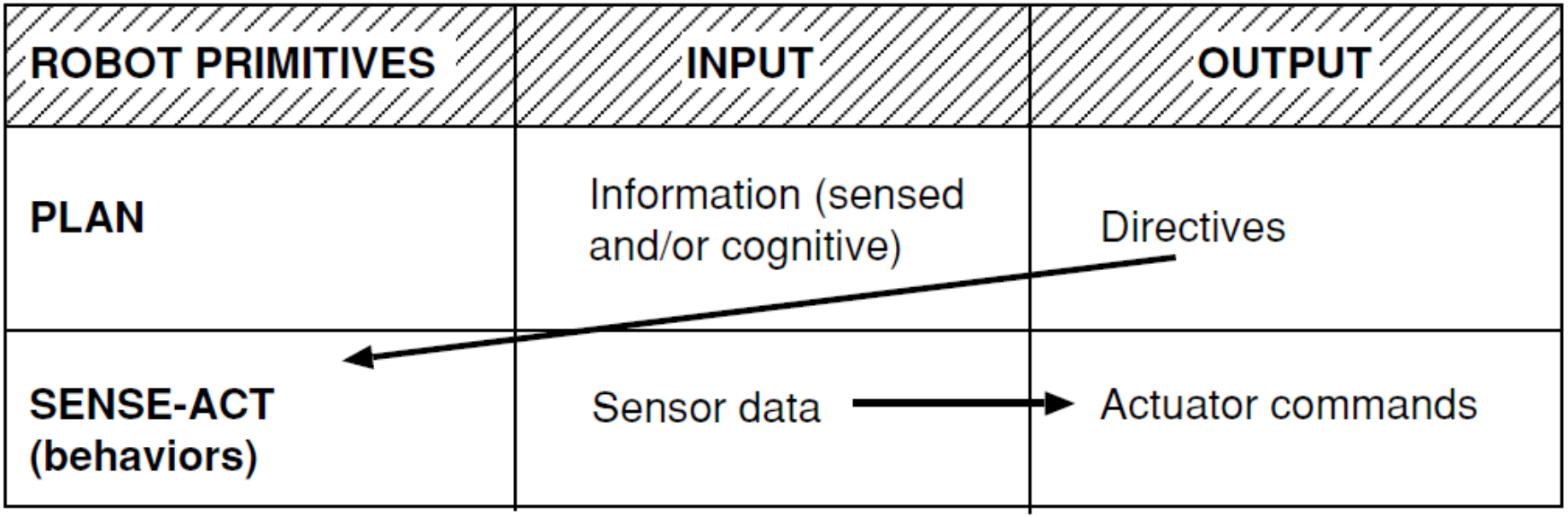
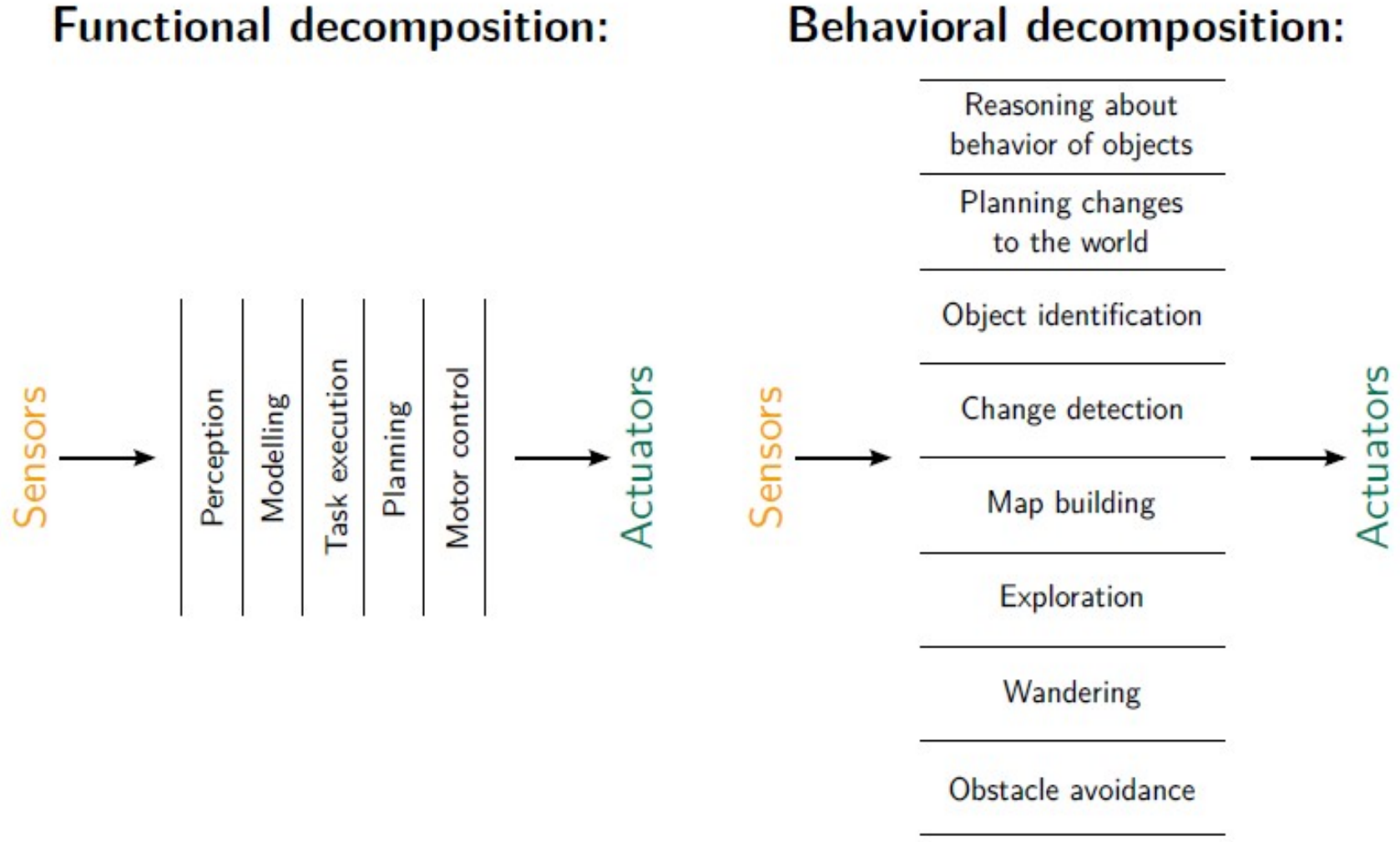


Figure I.6 The hybrid deliberative/reactive paradigm.

Functional vs. Behavioral Decomposition



Words of Wisdom

"When we examine very simple level intelligence, we find that explicit representations and models of the world get in the way."

"It turns out to be better to use the world as its own model."

"Representation is the wrong unit of abstaction in building the bulkiest parts of intelligent systems."

Where is Brooks now?

Credits

- “Introduction to AI Robotics” by Robin Murphy

- Slides by Lorenz Hillen from Universität Bielefeld

Robot Tutorials: How to Move the Robot from Code

THE END