Artificial Intelligence Chapter 25 Agent Architectures

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Outline

- Three-Level Architectures
- Goal Arbitration
- The Triple-Tower Architecture
- Bootstrapping
- Additional Readings and Discussion

25.1 Three-Level Architecture

- Shakey [Nilsson]
  - One of the first integrated intelligent agent systems
  - Hardware
    - Mobile cart with touch-sensitive "feelers"
    - Television camera, optical range-finder
  - Software
    - Push the boxes from one place to another
    - Visual analysis : recognize boxes, doorways, room corners
    - Planning : use STRIPS (plan sequences of actions)
    - Convert plans into intermediate-level and low-level

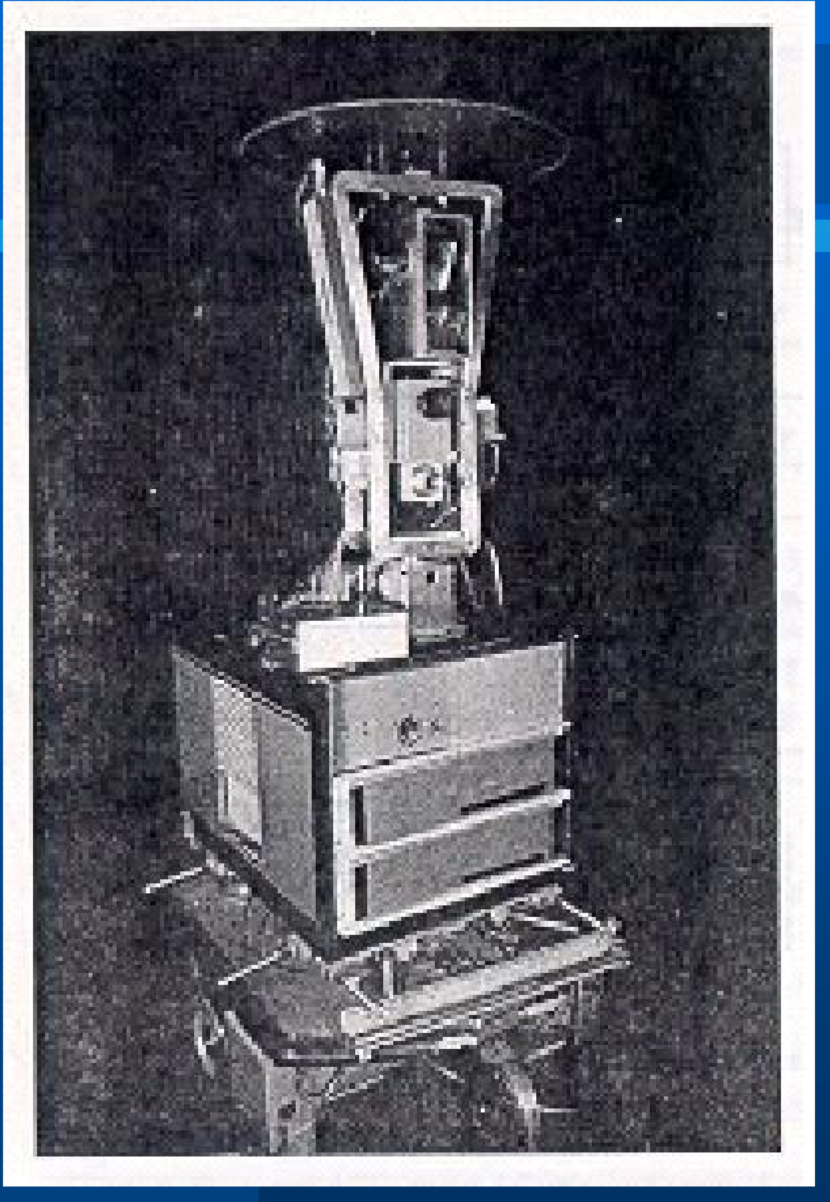

Figure 25.1 Shakey the Robot

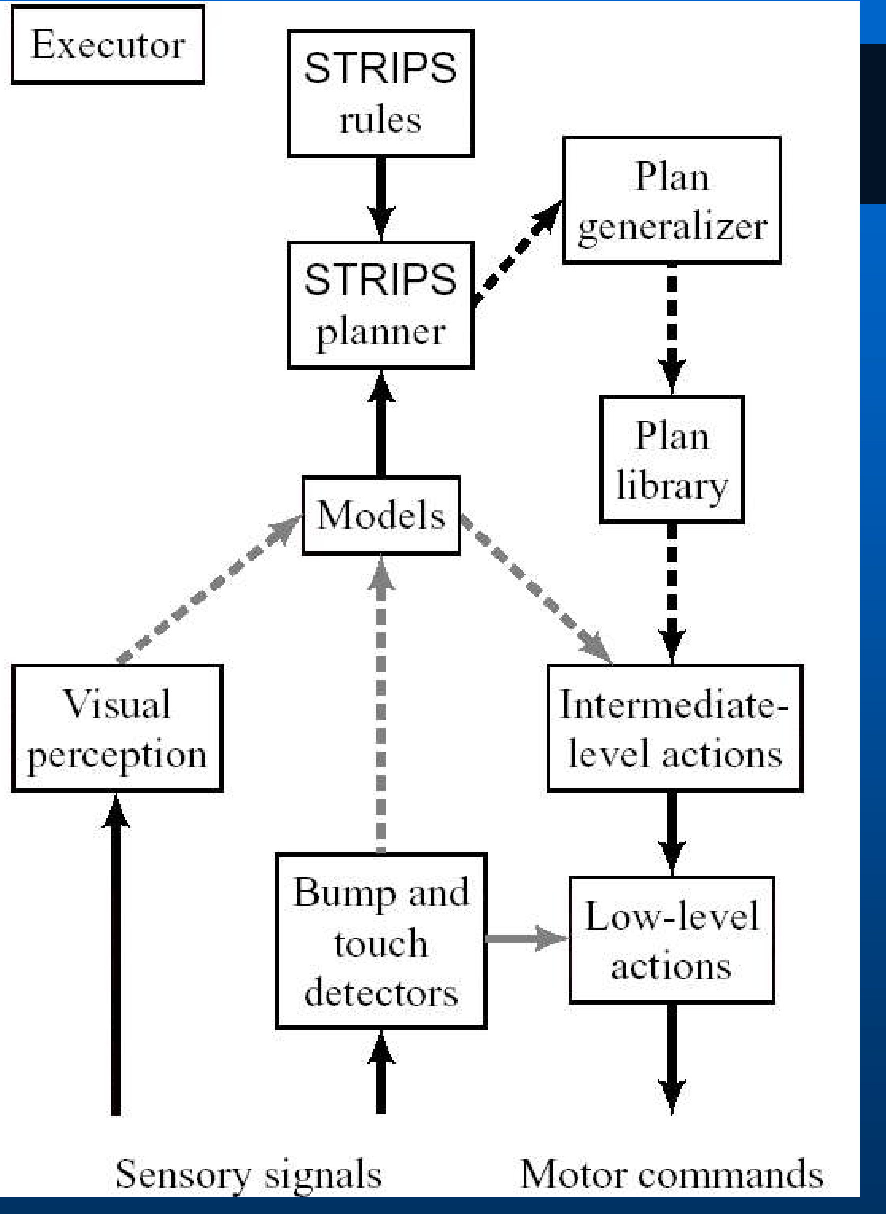

Figure 25.2 Shakey Architecture

25.1 Three-Level Architecture (Cont'd)

- Figure 25.2
  - Low level : Gray arrow
    - The low-level actions (LLAs) use a short and fast path from sensory signals to effectors.
    - Important reflexes are handled by this pathway.
    - Stop, Servo control of motors and so on
  - Intermediate level : Broken gray arrow
    - Combine the LLAs into more complex behaviors
    - Intermediate-level action (ILA)
    - Ex: A routine that gets Shakey through a named doorway.
  - High level : Broken dark arrows
    - Plan is expressed as a sequence of ILAs along with their preconditions and effects.

25.1 Three-Level Architecture (Cont'd)

- More Recently, the three-level architecture has been used in a variety of robot systems
  - AI subsystems are used at the intermediate and high levels
    - Blackboard systems
    - Dynamic Bayes belief networks
    - Fuzzy logic
    - Plan-space planners

25.2 Goal Arbitration

- Need of Arbitration
  - Agents will often have several goals that they are attempting to achieve.
  - Goal urgency will change as the agent acts and finds itself in new, unexpected situations.
  - The agent architecture must be able to arbitrate among competing ILAs and planning.
- Urgency
  - Depend on the priority of the goal at that time and on the relative cost of achieving goal from the present situation.

25.2 Goal Arbitration (Cont'd)

- Figure 25.3
  - Goals and their priorities are given to the system and remain active until rescinded by the user.
  - ILAs stored as T-R programs and matched to specific goals stored in its Plan library.
  - If any of the active goals can be accomplished by the T-R programs already stored in the Plan library, those T-R programs become Active ILAs.
  - The actions actually performed by the agent are actions called for by one of Active ILAs.

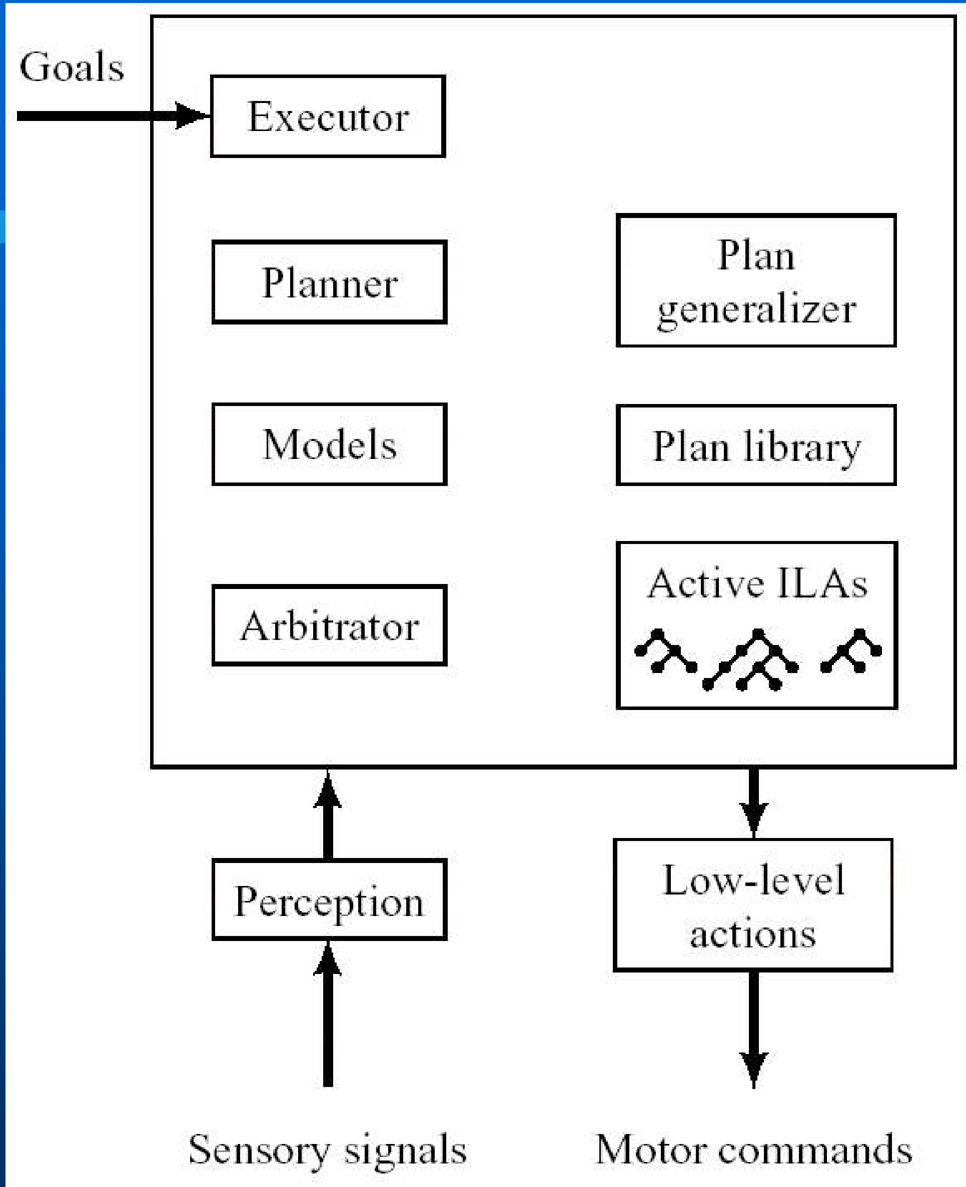

Figure 25.3 Combining Planning and Reacting

25.2 Goal Arbitration (Cont'd)

- The task of the Arbitrator
  - Select at each moment which T-R program is currently in charge of the agent.
  - Calculate cost-benefit that takes into account the priority of the goals and the estimated cost of achieving them.
  - Works concurrently with the Planner so that the agent can act while planning.

25.3 The Triple-Tower Architecture

- The perceptual processing tower
  - Start with the primitive sensory signals and proceed layer by layer to more refined abstract representations of what is being sensed.
- The action tower
  - Compose more and more complex sequences of primitive actions.
- Connections between the perceptual tower and the action tower
  - Can occur at all levels of the hierarchies.
  - The lowest-level : correspond to simple reflexes
  - The higher level : correspond to the evocation of complex actions

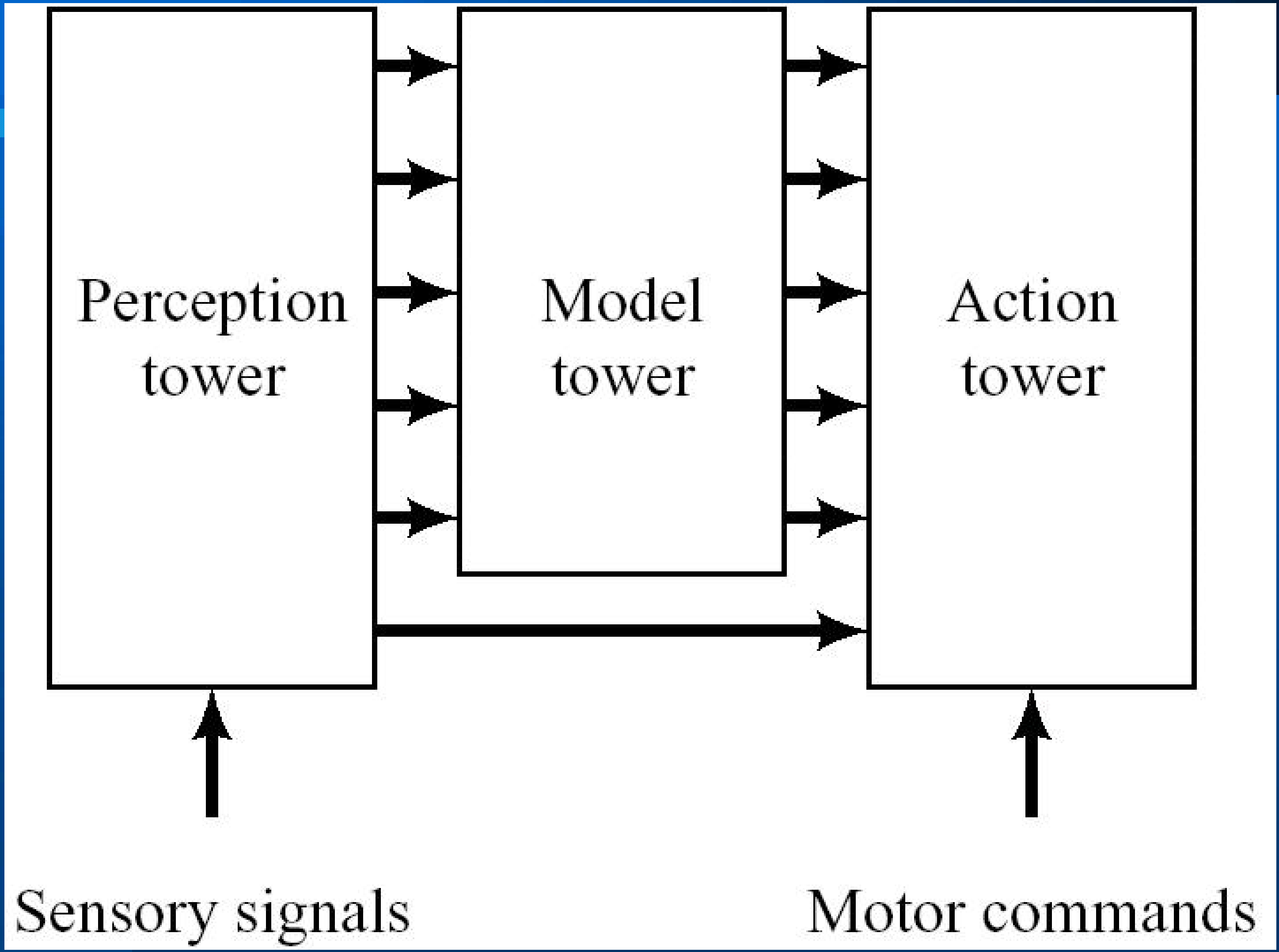

Figure 25.4 The Triple-Tower Architecture

25.3 The Triple-Tower Architecture (Cont'd)

- The model tower
  - Internal representations required by agents.
  - At intermediate levels
    - There are might be models appropriate for route planning.
  - At higher levels
    - Logical reasoning, planning and communication would require declarative representations such as those based on logic or semantic networks.

25.4 Bootstrapping

- The limit of contemporary robots and agents
  - The Lack of commonsense knowledge.
  - No "bootstrapping"
    - Bootstrapping is to learn much of the knowledge from previously obtained knowledge.
    - Humans can bootsrap knowledge from previously acquired skills and concepts through practice, reading and communicating.
- Bootstrapping process will be required by AI agent to be similar to human-level intelligence.

25.5 Discussion

- A critical question is whether to refine a plan or to act on the plan in hand.
  - Metalevel architectures can be used to make such a decision.
  - Computational time-space tradeoff : Agent actions ought to be reactive with planning and learning used to extend the fringes of what an agent already knows how to do.

Additional Readings

- Whitehead, S., Karlsson, J., and Tenenberg, J., "Learning Multiple Goal Behavior via Task Decomposition and Dynamic Policy Merging," *Robot Learning*, Ch. 3, Boston: Kluwer Academic Publishers, 1993
- Laird, J., Yager, E., Hucka, M., and Tuck, C., "Robo-Soar: An Integration of External Interaction, Planning, and Learning Using SOAR," *Robotics and Autonomous Systems*, 8:113-129,1991.
- Russell, S., and Wefald, E., *Do the Right Thing*, Cambridge, MA: MIT Press, 1991.