Brooks' Subsumption Architecture

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Introduction

- What is intelligence?
- Is a house fly intelligent?
  - A house fly is much simpler than most of our attempts at artificial intelligence
  - For example…

Introduction

- It is unlikely that a house fly:
  - Forms 3D surface descriptions of objects
  - Reasons about the threat of a human with a fly swatter, in particular about the human's beliefs, goals, or plans
  - Makes analogies concerning the suitability for egg laying between dead pigs
  - Constructs naïve physics theories of how to land on the ceiling

Introduction

- It is much more likely that a house fly:
  - Has close connection of sensors to actuators
  - Has pre-wired patterns of behavior
  - Has simple navigation techniques
  - Functions almost as a deterministic machine
- And yet a house fly is much more successful in the real world than our attempts at AI

Introduction

- Are humans intelligent?
  - If a fly is intelligent, than we *must* be
  - Brooks believes human behavior only appears rational but is actually the "external expression of a seething mass of rather independent behaviors without any central control…"[1]

Introduction

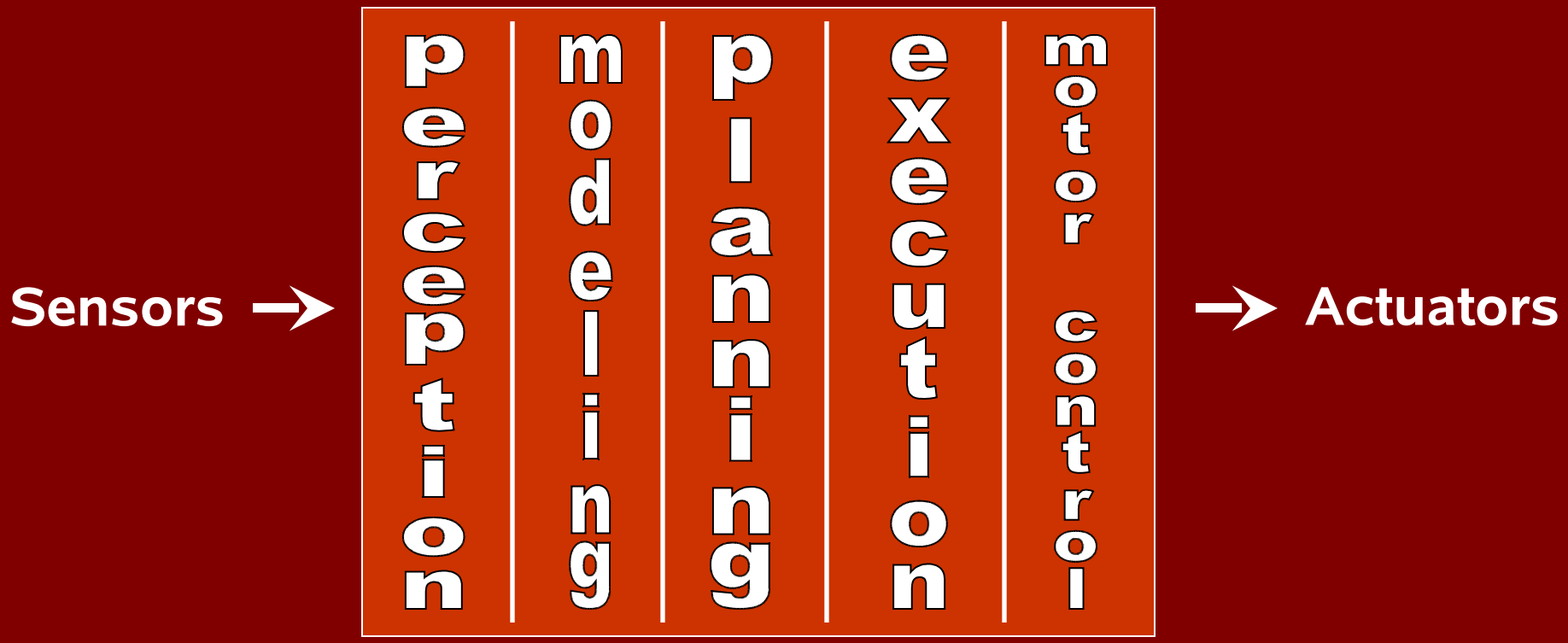
- Rodney A. Brooks
  - M.I.T professor
  - Member of M.I.T.'s Artificial Intelligence Lab
  - Developed the Subsumption Architecture for robot control in 1986
  - His goal was to develop artificial, complete creatures capable of inhabiting our world, not a simplified world

Outline

- Previous Robot Control Methods
- Brooks' Reasoning for a New Architecture
- The Subsumption Architecture
- An Example: Allen
- Programming Characteristics of Subsumption
- References

Previous Robot Control Methods

- The goal was human level intelligence
- Used a divide and conquer approach



Previous Robot Control Methods

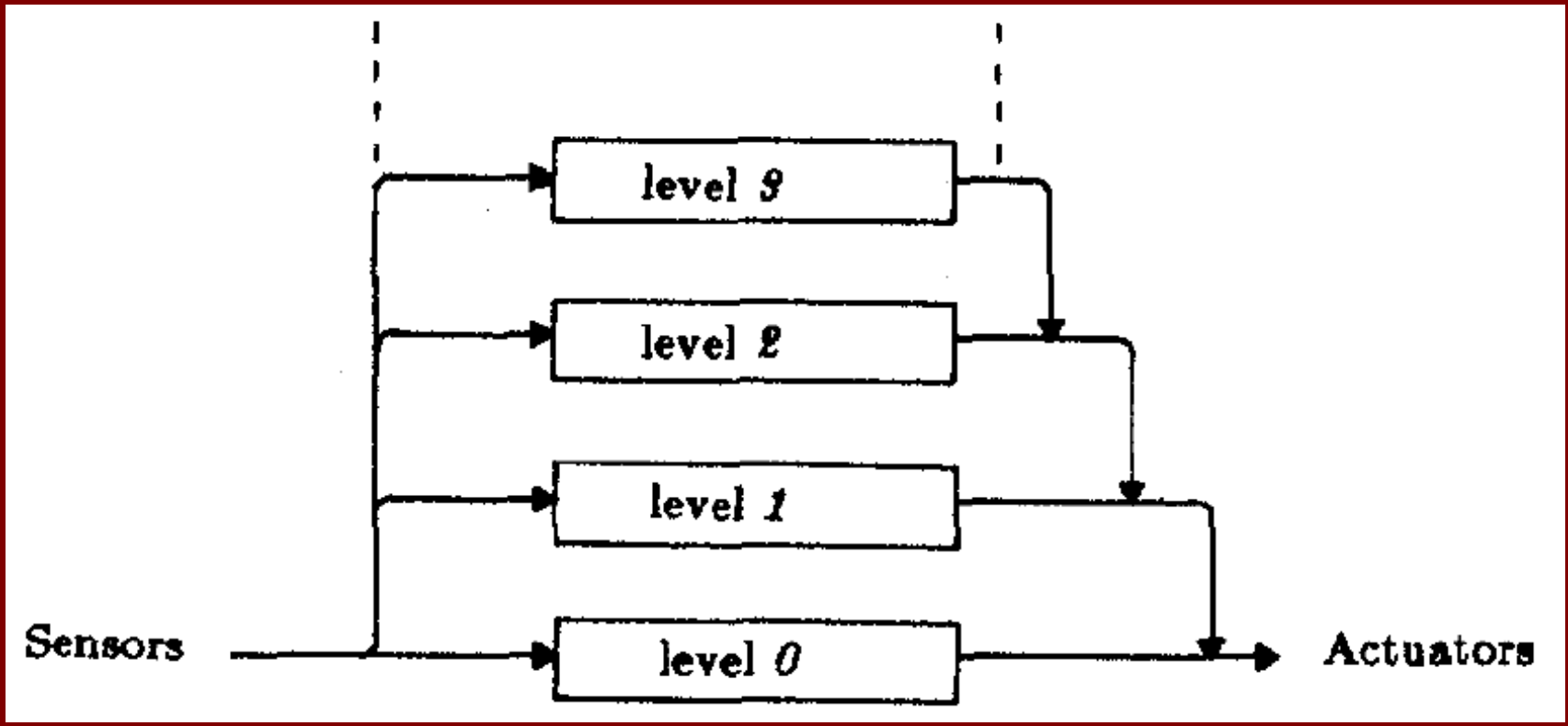
- Brooks' views of these methods:
  - Human level intelligence is clearly very difficult to implement and is not the only type of intelligence
  - Divide and conquer causes AI researchers to get bogged down in irrelevant sub-problems
  - The resulting design lacks robustness
    - Each sub-system is required for the robot to function

Brooks' Reasoning for a New Architecture

- Follow the evolutionary path of intelligence
  - Start with simple intelligence
    - Easier to implement than human intelligence
  - After a successful design, extend to higher levels of intelligence
    - Reminder of Brooks' view of human intelligence
    - Robust design as higher intelligence levels can fail but the lower levels will still work
- After all, there are plenty of examples of successful intelligence in nature that are much simpler than many AI research areas (the house fly example)

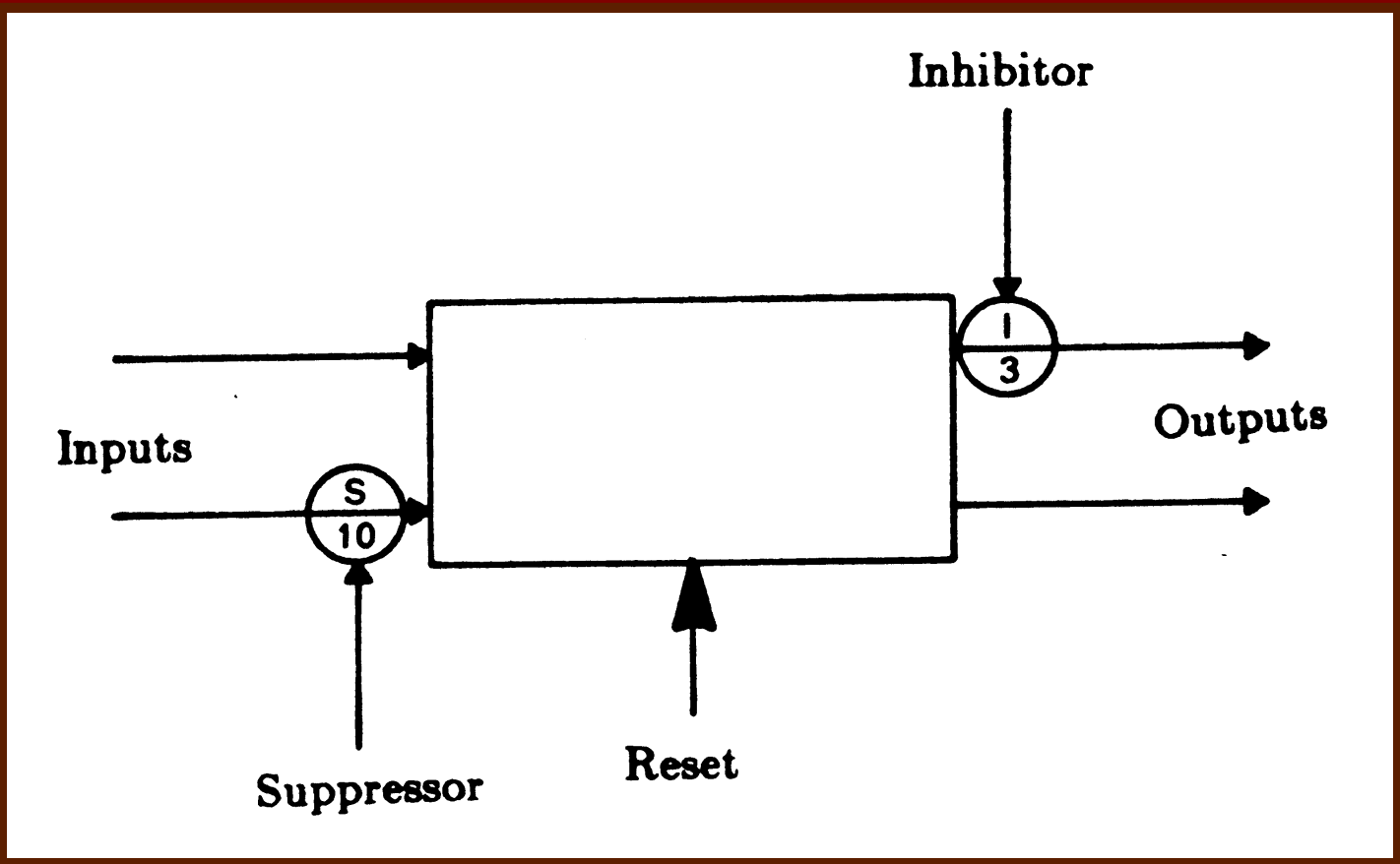
The Subsumption Architecture

- The Subsumption Architecture is:
  - A layering methodology for robot control systems
  - A parallel and distributed method for connecting sensors and actuators in robots



The Subsumption Architecture

- Each layer is made up of connected, simple processors: Augmented Finite State Machines

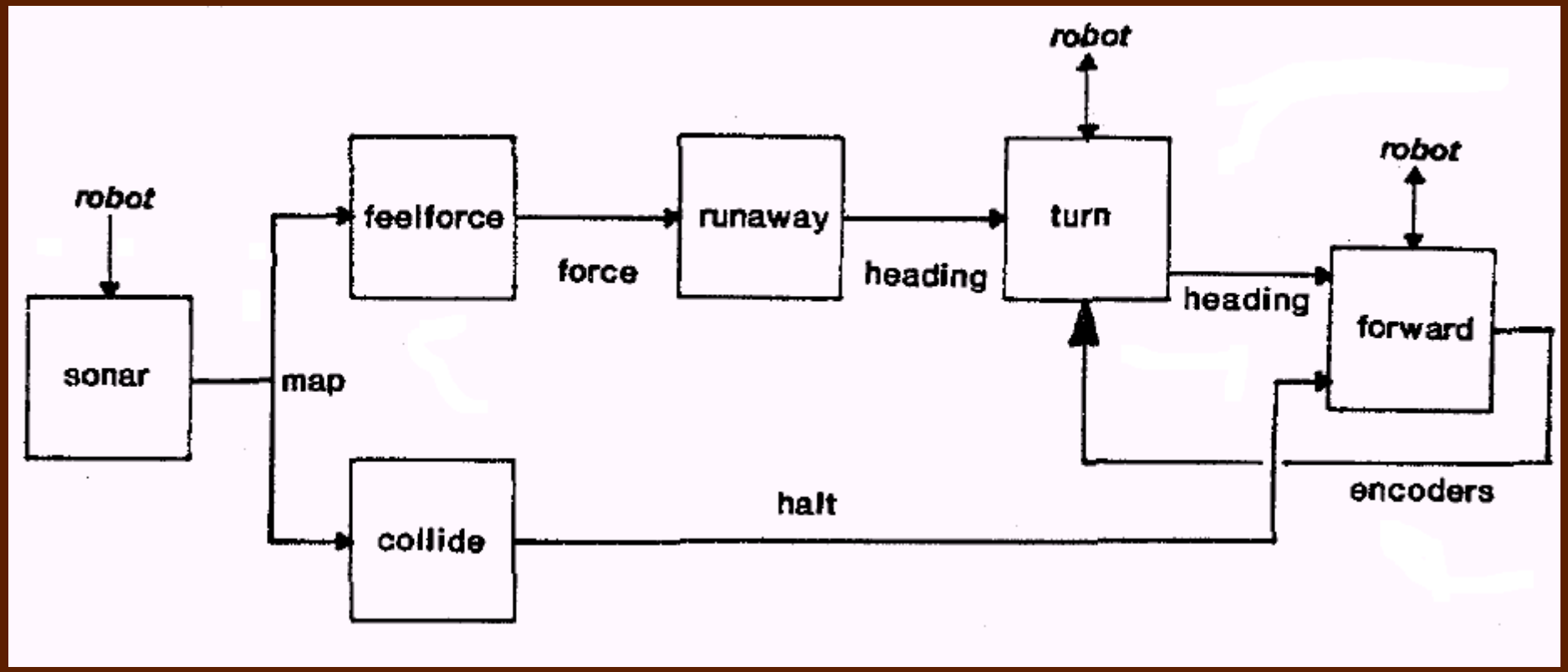


The Subsumption Architecture

- The most important aspect of these FSMs
  - Outputs are simple functions of inputs and local variables
  - Inputs can be suppressed and outputs can be inhibitated
    - This function allows higher levels to subsume the function of lower levels
    - Lower, therefore, still function as they would without the higher levels

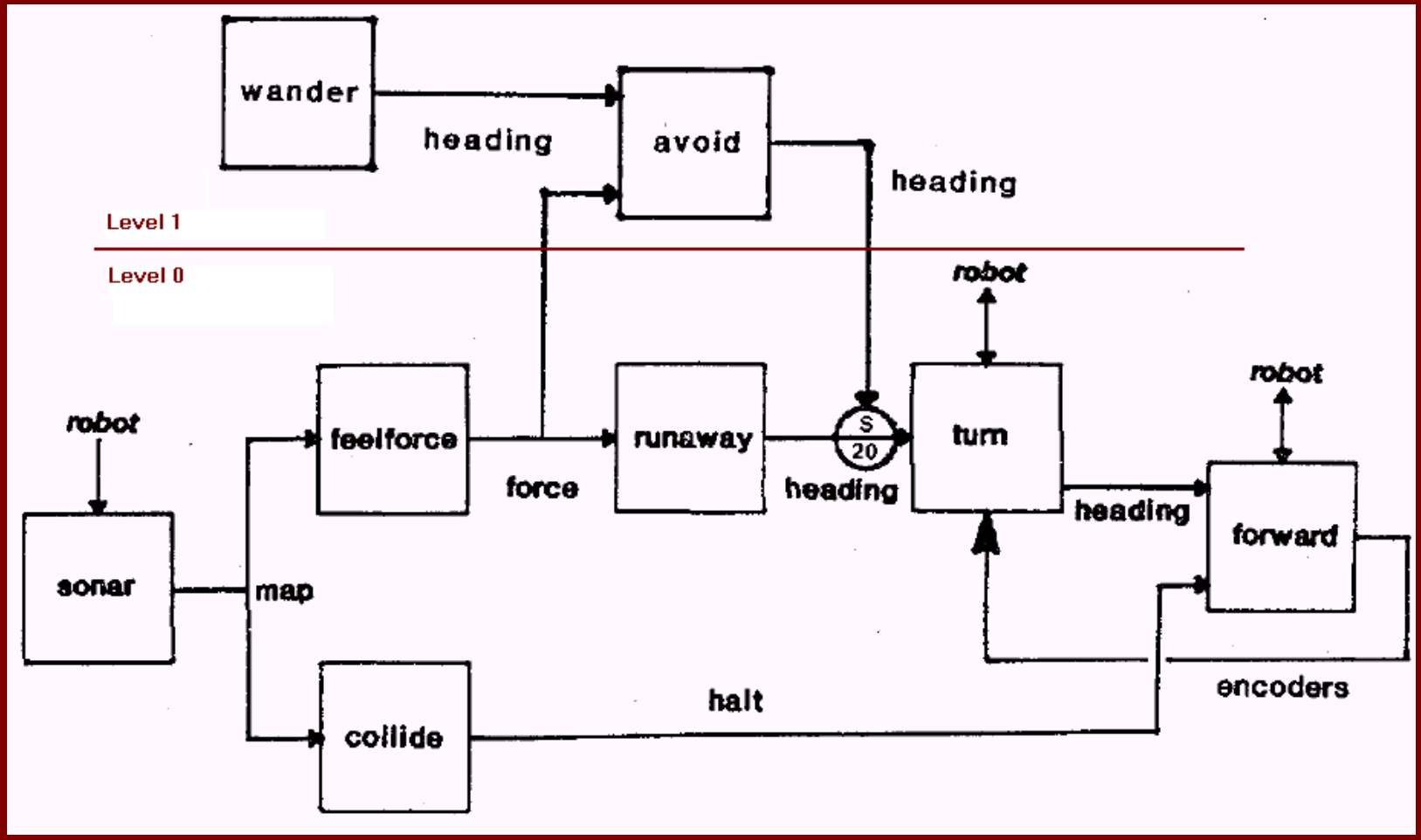
An Example: Allen

- Brooks' first Subsumption robot
- Level 0: Runs away if approached, avoids objects



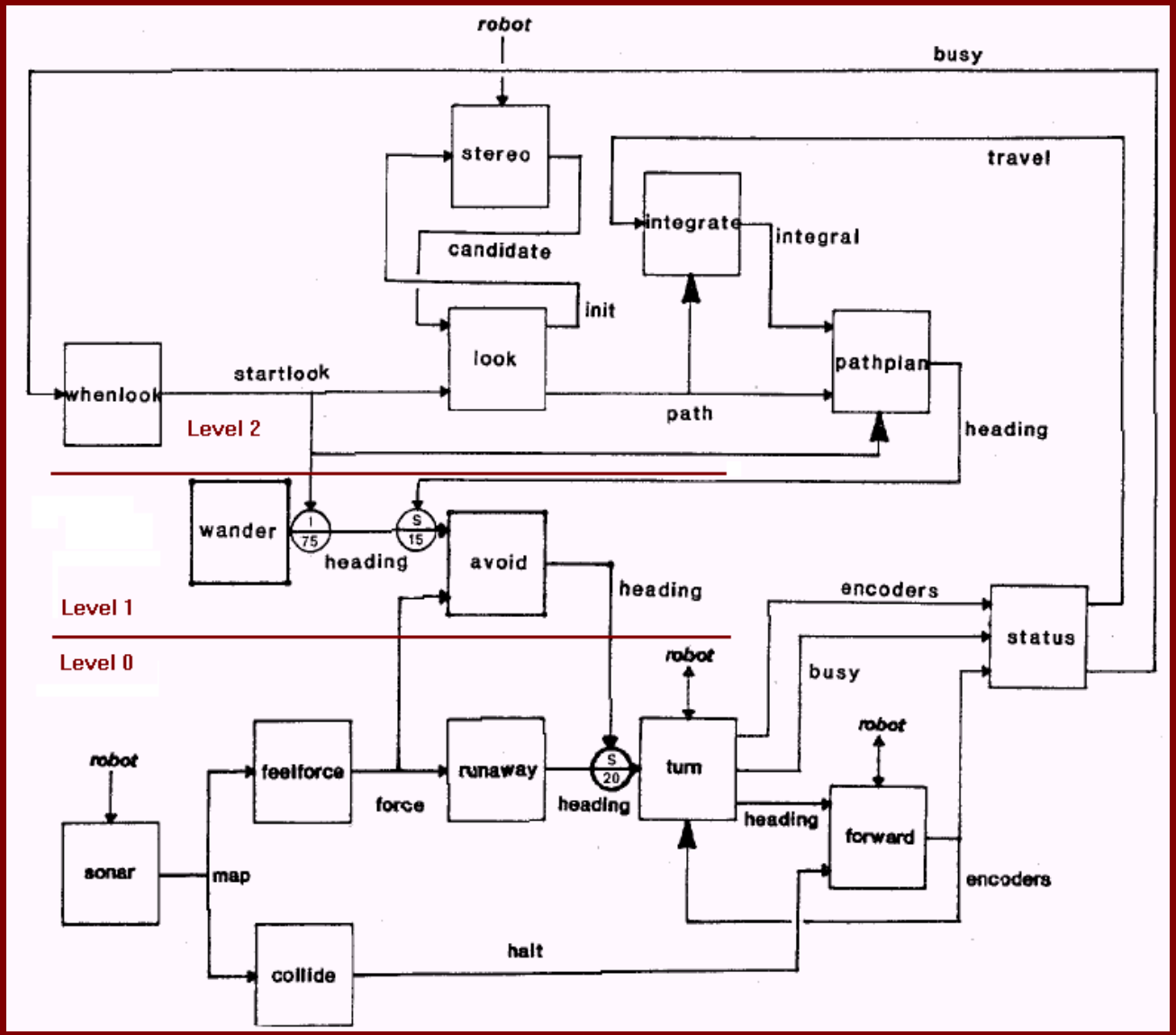
An Example: Allen

- Levels 1 and 0: Adds wandering



An Example: Allen

- Levels 2, 1, and 0: Adds hallway following



Programming Characteristics of Subsumption

- No internal model of the real world because:
  - No free communication
  - No shared memory
- So, use real world as the model
  - "The world really is a rather good model of itself"[1]
  - Very accurate
  - Never out of date
  - No computation needed to keep model up to date
- Real world used for sub-system communication
  - Instead of direct communication, sub-systems just sense the real world

Conclusion

- Subsumption Architecture based on evolutionary path of intelligence
- Simple sub-systems developed in layers
- Higher levels subsume the actions of lower levels
- Produces robots that are more robust with parallel, distributed, simple processors
- Demo: http://www.ifi.unizh.ch/groups/ailab/people/lambri

References

1. VanLehn, “Architectures for Intelligence, The 22 Carnegie Mellon Symposium on Cognition”, 1991, ch 8 (Brooks)

3. Brooks, “A Robust Layered Control System for a Mobile Robot”, Robotics and Automation, IEEE Journal of; Mar 1986, pp. 14 – 23, vol. 2, issue 1

5. Brooks, Connell, and Ning, “Herbert: A Second Generation Mobile Robot”, M.I.T. AI Memo, Jan 1988, http://hdl.handle.net/1721.1/6483