

Brooks' Subsumption Architecture

EEL 6838

T. Ryan Fitz-Gibbon

1/24/2004

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

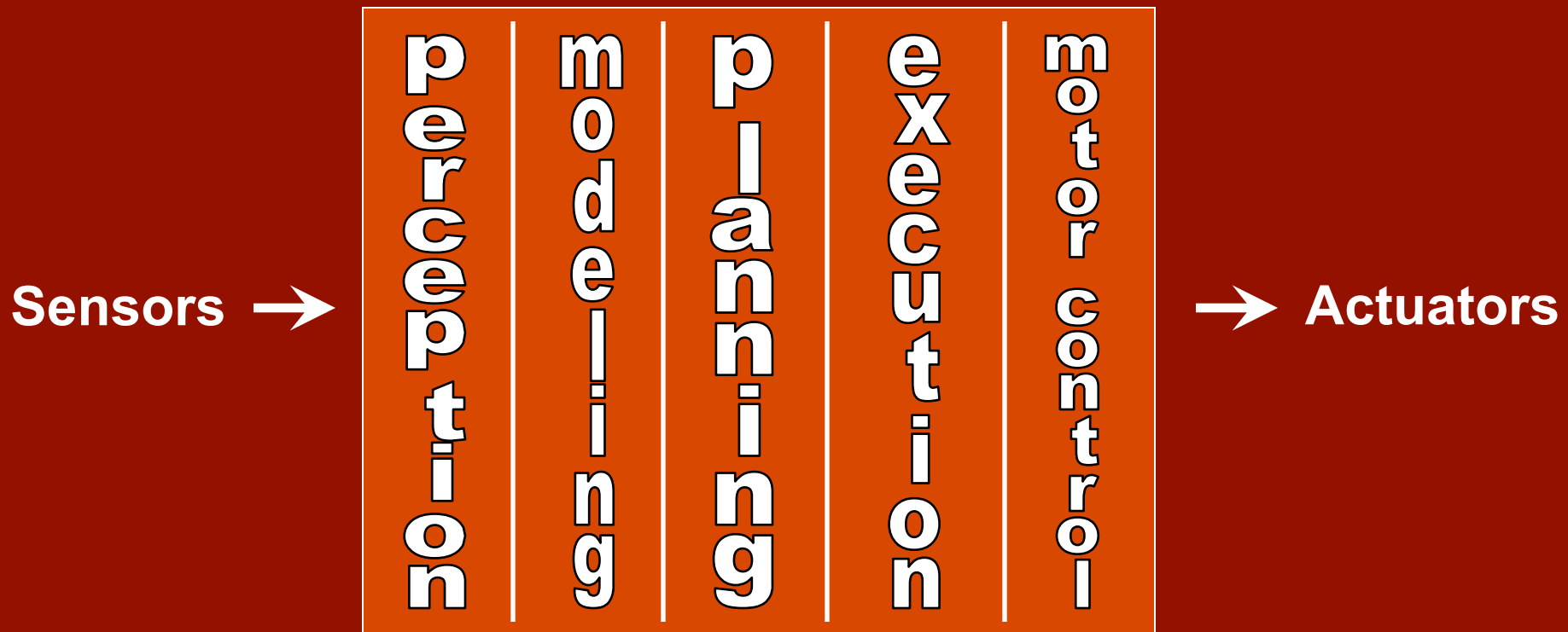
- Rodney A. Brooks
 - M.I.T professor
 - Member of M.I.T.'s Artificial Intelligence Lab
 - Developed the Subsumption Architecture for robot control in 1986
 - His goal was to develop artificial, complete creatures capable of inhabiting our world, not a simplified world

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

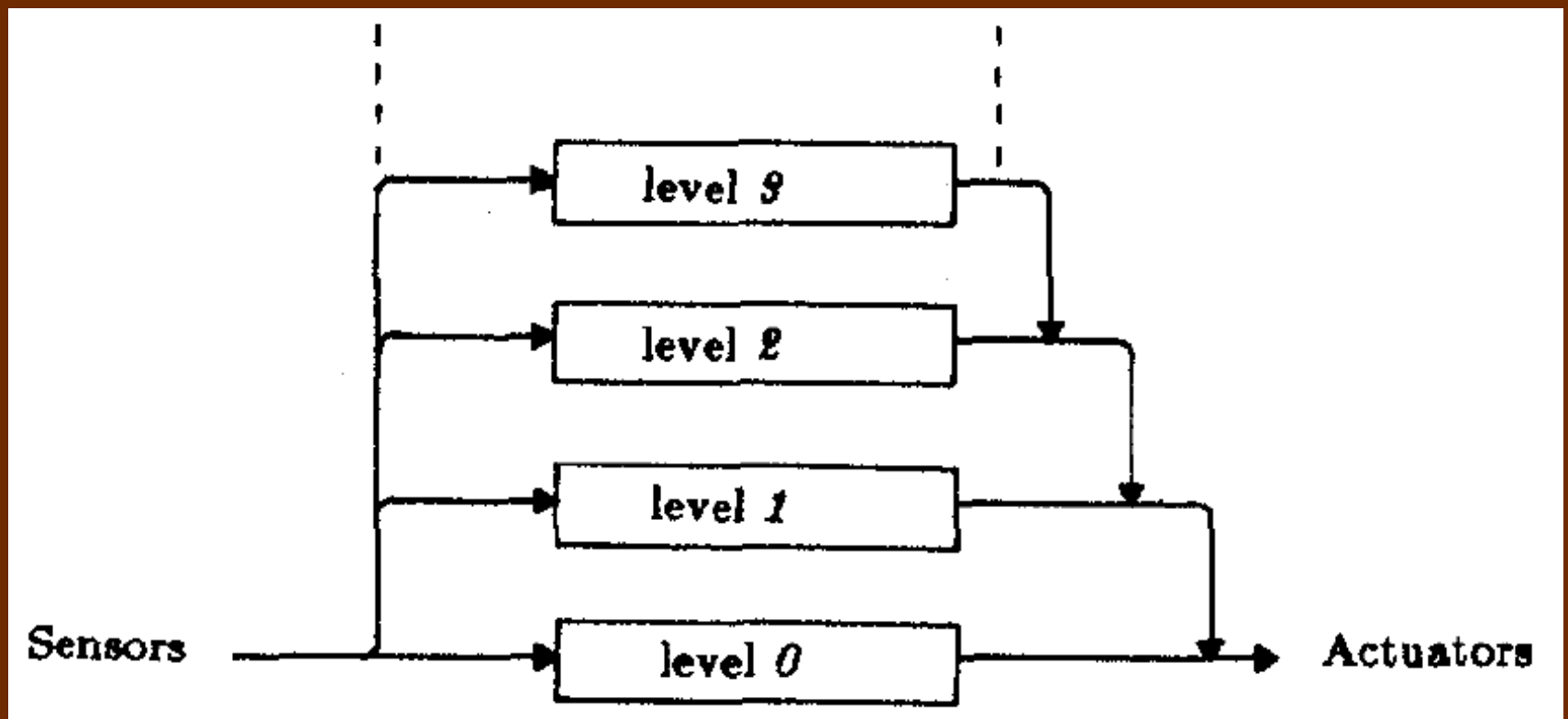
- Brooks' views of these methods:
 - Human level intelligence is clearly very difficult to implement and is not the only type of intelligence
 - Divide and conquer causes AI researchers to get bogged down in irrelevant sub-problems
 - The resulting design lacks robustness
 - Each sub-system is required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

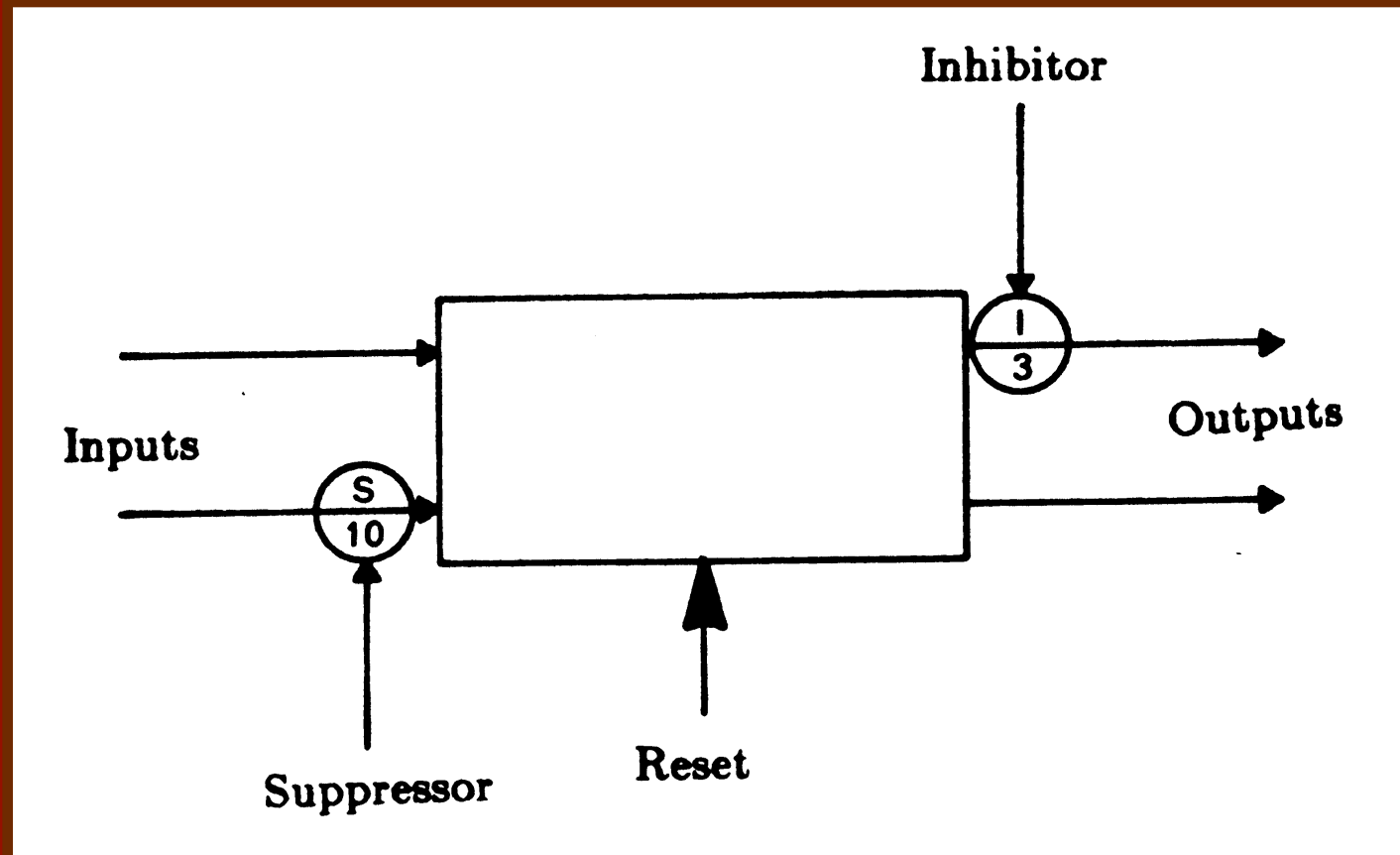
The Subsumption Architecture

- 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



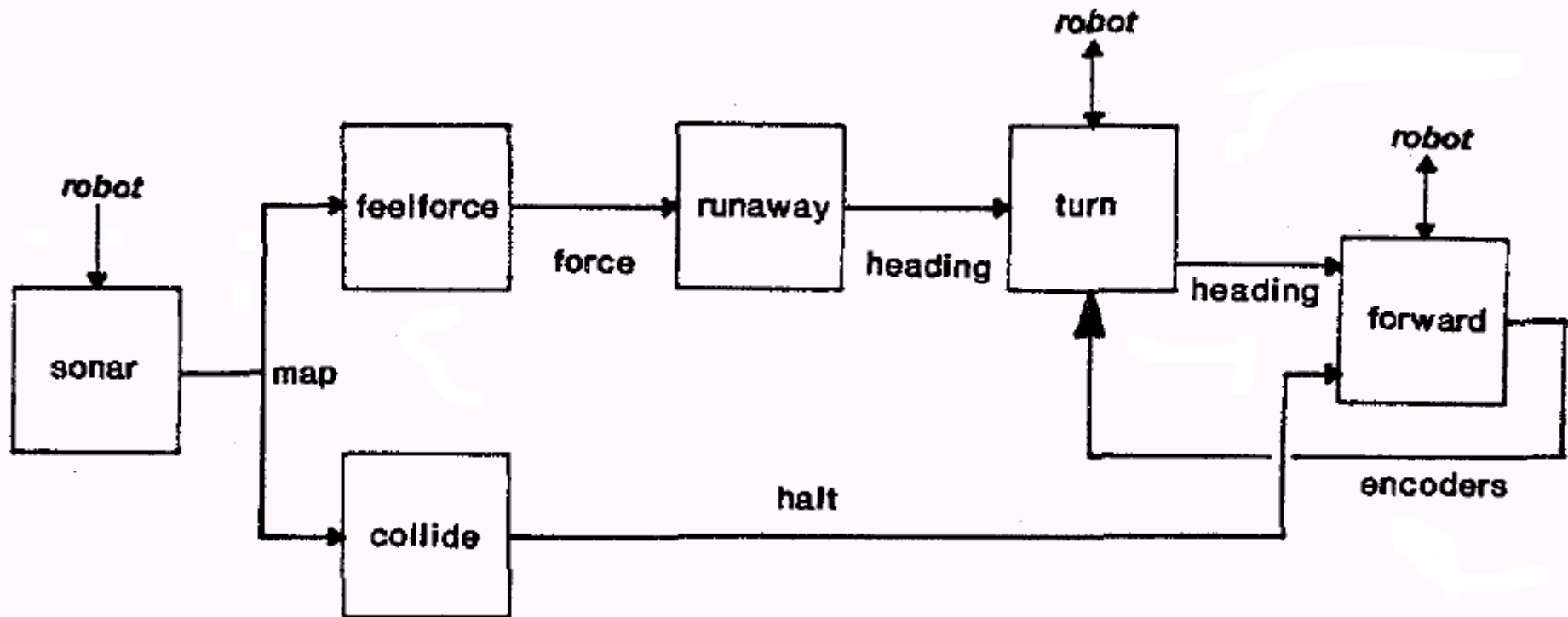
The Subsumption Architecture

- The most important aspect of these FSMs
 - Outputs are simple functions of inputs and local variables
 - Inputs can be suppressed and outputs can be inhibited
 - 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

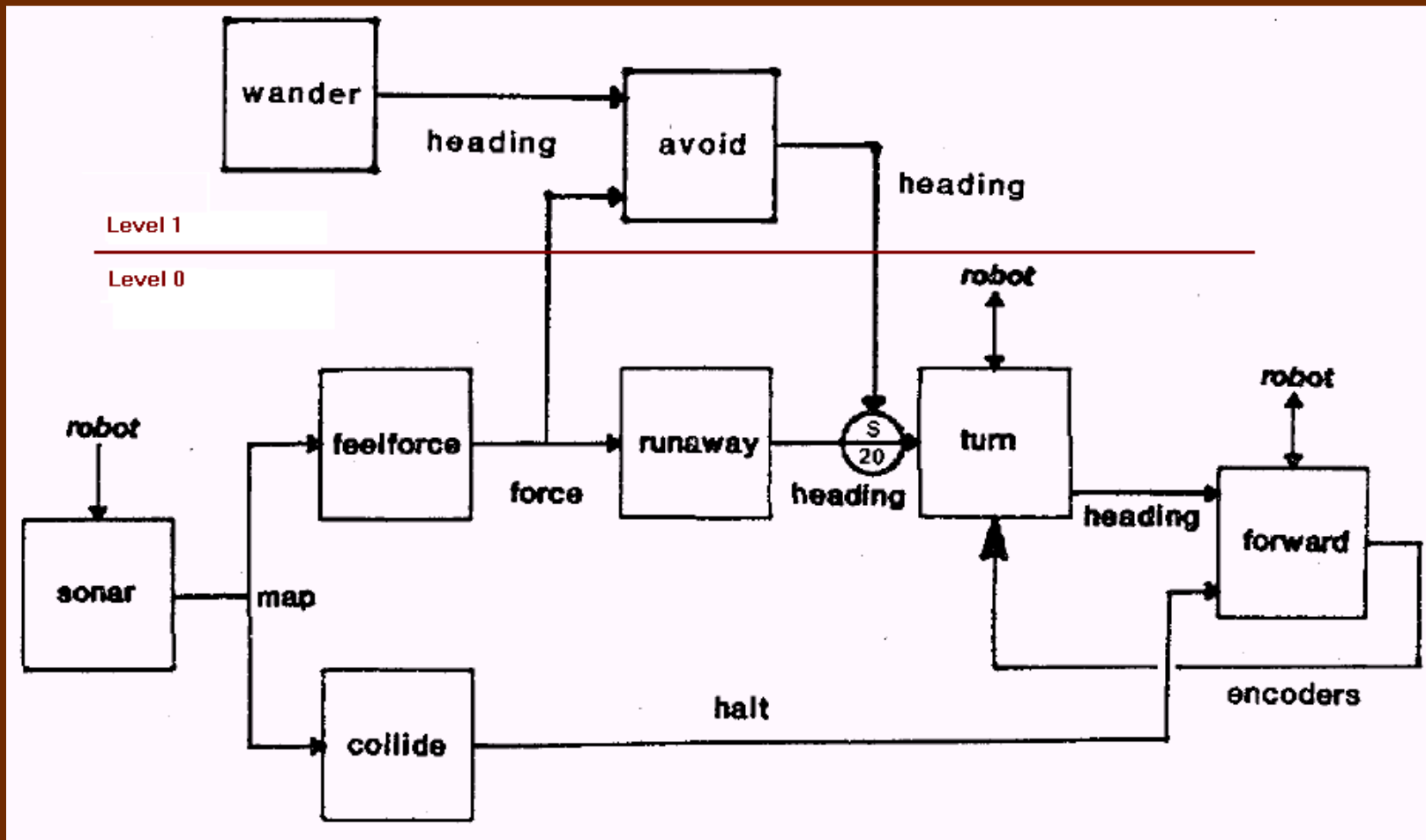


- Brooks' first Subsumption robot
- Level 0: Runs away if approached, avoids objects



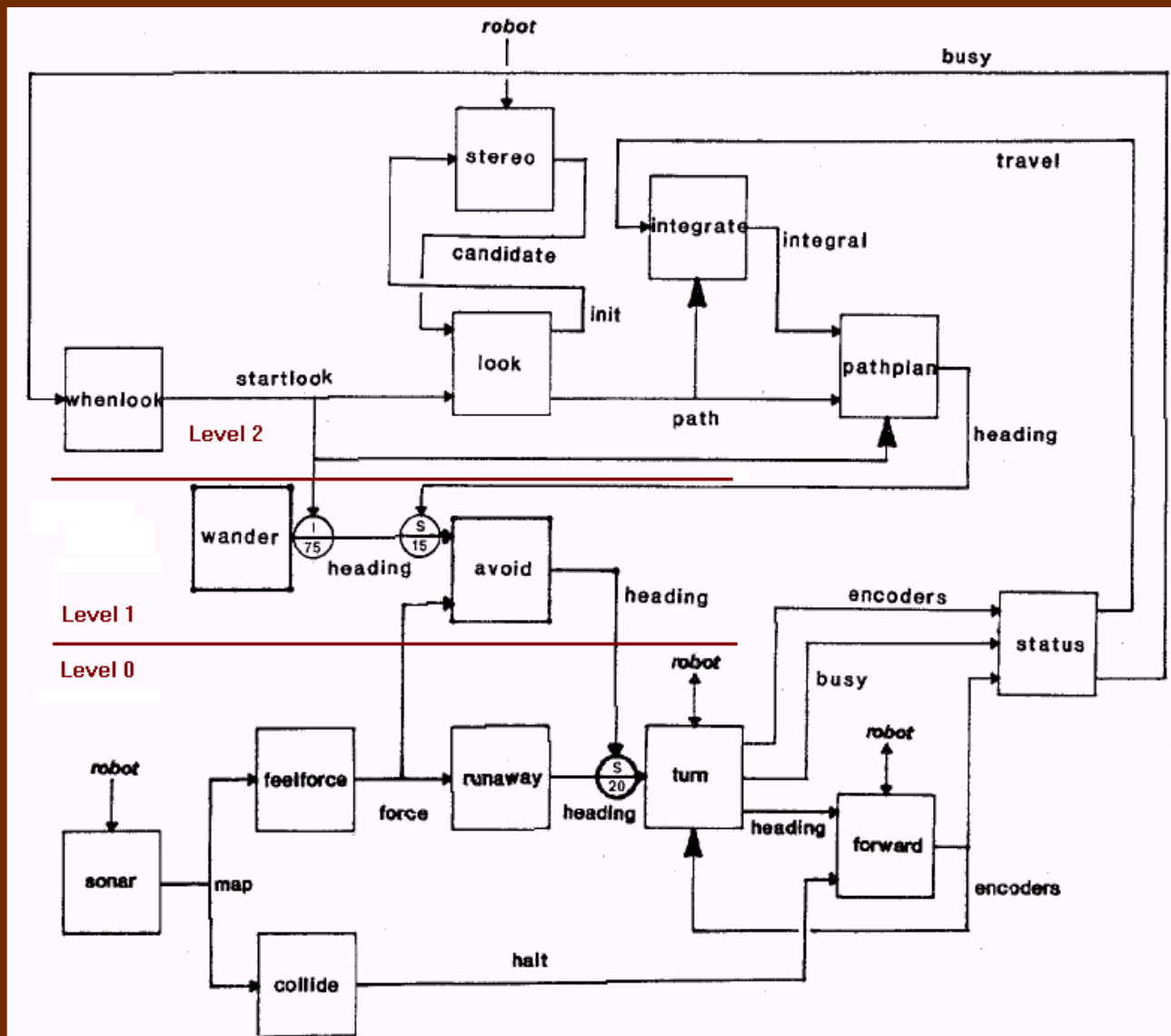
An Example: Allen

- 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/mitbook/myrmix/myrmix.html>

References

1. VanLehn, “Architectures for Intelligence, The 22 Carnegie Mellon Symposium on Cognition” , 1991, ch 8 (Brooks)
2. 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
3. Brooks, Connell, and Ning, “Herbert: A Second Generation Mobile Robot” , M.I.T. AI Memo, Jan 1988, <http://hdl.handle.net/1721.1/6483>