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”\textsuperscript{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

