Lecture 26

Artificial Intelligence:
Reasoning & Embodied Intelligence
(S&G, §13.5)

Read S&G ch 14
(Social & Legal Issues)
for next week
Expert Systems

- “computer systems that can help solve complex, real-world problems in specific scientific, engineering, and medical specialties” — *Hand. AI*, v.2, p. 79
- Depend on a large amount of *domain knowledge* (facts & procedures) obtained from domain experts
- Example: MYCIN provides advice on diagnosis & therapy for infectious diseases

Knowledge Base

- Knowledge is represented in language-like structures
- Typically two kinds of knowledge in KB:
  - facts
  - rules
- Rules usually have IF — THEN form
Typical MYCIN Rule

IF

1) the infection is primary-bacteremia, and
2) the site of the culture is one of the sterile sites, and
3) the suspected portal of entry of the organism is the gastrointestinal tract,

THEN

there is suggestive evidence (.7) that the identity of the organism is bacteroides.

Inference Engines

• Purpose: connecting givens and goals
• Forward Chaining: Where can I go from here?
  – breadth first
  – depth first
• Backward Chaining: How could I get here?
• Hybrid approaches
• Combinatorial explosion
Knowledge Acquisition

• Query experts about the rules they follow
• Ask them to think out loud
• Ask them after the fact why they made the decisions they made

Problems of Knowledge Acquisition

• Query experts about the rules they follow
  – may simply recite the rules they learned in graduate school
• Ask them to think out loud
  – may effect (e.g. slow down) the process
• Ask them after the fact why they made the decisions they made
  – may be after the fact rationalization
• Finally, they may be uncooperative
Five Stages of Skill Acquisition

1. Novice
   • learns facts & rules to apply to simple “context-free” features

2. Advanced Beginner
   • through experience, learns to recognize similar situations

3. Competence
   • uses developing sense of relevance to deal with volume of facts

4. Proficiency
   • analytical thinking is supplemented by intuitive organization & understanding

5. Expertise
   • skillful behavior is automatic, involved, intuitive, and fluent.

Embodied Intelligence
How Dependent is Intelligence on its Hardware?
Traditional View

- Brain is no more powerful than Turing machine
- Human intelligence is a result of the program running on our brains
- The same program could be run on any Universal TM
- In particular, it could run on a Von Neumann machine and make it artificially intelligent

Connectionist View

- Information processing on Von Neumann computers (hardware) is fundamentally different from that in brains (wetware)
- The flexible, context-sensitive cognition we associate with human intelligence depends on the physical properties of biological neurons
- Therefore, true artificial intelligence requires sufficiently brain-like computers (neurocomputers)
Importance of Embodied Intelligence

- Traditional (dualist) view: mind is essentially independent of the body
  - in principle, could have an intelligent “brain in a vat”
- Now we understand that much of our knowledge is implicit in the fact that we have a body
- Also, our body teaches us about the world
- Structure of body is foundation for structure of knowledge
- A “disembodied intelligence” is a contradiction in terms?

Embodied Artificial Intelligence

- Therefore a genuine artificial intelligence must:
  - be embedded in a body
  - capable of interacting significantly with its environment
- We expect the intelligence to develop as a consequence of interaction of its body with an environment including other agents
“Ant” Microrobots (Brooks, MIT)

- About 1 cubic inch
- 17 sensors
- Can communicate with each other
- Goal: push limits of microrobotics
- Goal: explore social interactions inspired by ant colony
- Applications: explosives disposal, Mars exploration

Clustering Around “Food”

- “Food” amongst other objects in environment
- First “ant” to encounter food, signals others
- Others cluster at food source

Clustering Around Food (Take 1)
Tag Game

- “It” robot wanders until bumps something
- Transmits “Tag”
- A “Not It” robot replies “I got tagged”
- First becomes “Not It”
- Second becomes “It”

Genghis (Brooks, MIT)

- Inspired by evolution in that more complex behaviors build on simpler ones
- Individual legs “do their jobs”
- Legs are coordinated to achieve stability
- Leg motion coordinated to achieve locomotion to goal
Genghis (Brooks, MIT)

Front view & infrared sensing of person

Cog (Brooks, MIT)

- “Humanoid intelligence requires humanoid interactions with the world”
- Form of body is fundamental to cognitive representation
  – no “brains in vats”
- Human-like intelligence requires human-like body
Learning Hand-Eye Coordination

- Before learning to reach to a visual target
- Final position of hand different from where looking

Learning Hand-Eye Coord. (2)

- View from Cog’s eyes during training trial
- Cog learns to coordinate appearance of arm’s position with “feel” of arm’s position
- Rapid motion is saccade
- Also see motion-detection & grouping algorithm
Learning Hand-Eye Coord. (3)

- After 3 hours self-training
- Robot instructed to reach toward any moving object
- Successfully reaches towards object
- (Hand is non-functional)

Cog: “Social Interaction”

- Cog attending to visual motion
- Orients head & eyes to motion
- (Arm & hand motion are not relevant to interaction)
Cog: Learning by Imitation

- Imitation is an important means of human learning
- Here, Cog learns to imitate head motions
- Recognizes the motion of faces
- Cog does not try to imitate non-faces

Cog: Learning by Imitation (2)

- Cog recognizes objects sufficiently like faces
- Imitates their motion with its own
Kismet (Brooks, MIT)

- Responds to a face with a happy expression
- Responds to rapidly moving face with disgusted expression

Kismet (Brooks, MIT)

- Example of three-way conversational interaction
Social Implications of Artificial Intelligence