CS1003: Intro to CS, Summer 2008

Lecture #09
AI

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Agenda

- Networking fundamentals
- Introduction to Artificial intelligence
Recap

- Networking fundamentals
  - TCP/IP packets
  - Application layer
- AI
  - Reasoning/productions

The Internet
IP addressing

- **IPv4**: “dotted-quad notation”
  - Each machine has an address of the form xxx.yyy.zzz.www
  - Many “restricted” addresses
  - DNS (domain name service) maps a name to an IP address
    - cs.columbia.edu ➔ 128.59.16.20
- **LANs typically have contiguous IP addresses**
  - Columbia (wired): 128.59.*.*
  - Columbia (wireless): 160.39.*.*
  - getting more fragmented
- **Routers** “route” packets between one LAN to another based on addresses and a “routing table”

Some network tools

- nslookup
- Ping
- traceroute
Traceroute

- Determines the routes taken by a packet along an IP network
- Increasing TTL of successive batch packets by one
- Network troubleshooting by recording the list of traversed routers
- Who is blocking our packets?

What’s an AI?

- In order to accomplish the task, do we just use a clever combination standard computing algorithms (performance), or do we actually try to “model” the mind (simulation)?
- Is intelligence measured by the ability to win (at a game) or to be humanlike?
  - Turing test
  - Turing supposed that by the year 2000, machines would have a 30% chance of passing a 5-minute Turing test
  - DOCTOR/ELIZA: free copy in emacs!
### AI challenges

- **Knowledge representation and inference**
  - Procedural knowledge
  - Declarative knowledge

- **Learning**
  - Supervised learning
  - Reinforcement

- **Discovery?**
  - AutoClass discovered a new class of stars
    http://ti.arc.nasa.gov/ic/projects/bayes-group/autoclass/

### Declarative knowledge

- Expanding and altering the facts to derive a related and relevant conclusion
Learning

- Imitation
  - Demonstrating steps in a task

- Supervised Training
  - Correct responses for a series of examples
  - Training set

- Reinforcement
  - Agent needs to figure out responses to the training set

- Evolutionary Techniques
  - Evolution of agents through generations
  - Evolve toward the solution from a set of proposed solutions

Genetic algorithm

- A genetic representation of the solution domain
- A fitness function to evaluate the candidate solutions
- At each iteration a subset of population is stochastically selected (selection)
- They are modified, combined and possibly mutated (mutation)
- No guarantee
Evolutionary programming

- Have programs evolve; mix-and-match them to produce the best result
  - Common in building game players: mix-and-match players to produce desirable output
- Need a very focused language that you can “mix-and-match”
- Generally a very slow process to evolve

Artificial neural networks

- Traditional processing units just execute a sequence of instructions
- We need something capable of perceiving and learning
- Idea is taken from living biological neurons
An artificial neuron

A processing unit

- Positive weights exciting effect
- Negative weight inhibiting effect on the input
- What is the output for input of 1,1,0?
A simple neural network

- Programming a neural network by adjusting weights
- Output for dissimilar inputs?
- Output for exciting inputs?
- Human brain contains $10^{11}$ neurons and $10^4$ synapses per neuron!

Training an artificial network

- Backpropagation
  - Neural networks are trained not programmed
- Learns weights by supervised training
- Weights are adjusted by small increments
- Desired output 1 when inputs are different
a. The network performs correctly for the input pattern 1, 1.

b. The network performs incorrectly for the input pattern 1, 0.
c. The upper weight in the second processing unit is adjusted.

d. However, the network no longer performs correctly for the input pattern 1, 1.
ALVINN – a successful example

- Autonomous land vehicle in a neural net
- Input 32x30 array of sensors
- ALVINN was trained by watching a human drive
- Could steer the van at 55 MpH

Associative memory

- Human mind can retrieve information associated with a current topic of consideration
- Smell, music
- Hopfield networks, neural networks without input or output
- System reaches a stable state from an unstable configuration
- Stable bit pattern close to the given bit pattern
- Representing smell or memories with bit patterns
Representing an associative memory

Reaching a stable state

Start: All but the rightmost units are excited

Step 1: Only the leftmost units remain excited

Step 2: The top and bottom units become excited

Final: All the units on the perimeter are excited
First possible stable unit
- # adjacent excited perimeter units > 3

Second possible stable unit
- Center unit excited and #excited perimeter units < 3
Natural Language Processing

- Syntactic analysis
  - Apply grammar rules
  - For example, identify the subject of the sentence “Mary gave John a birthday card.”

- Semantic analysis
  - Identify the semantic role of each word, i.e., action, agent of action, object of action

- Contextual analysis
  - “A bat fell on the ground.”

- Applications
  - Information retrieval and information extraction
  - Particularly important for web-based applications

AI continued: Robotics/vision

- Historically focused on mechanical and electrical engineering aspects

- We can already do set tasks, but what about modifications?
  - Objects on a conveyor belt at irregular intervals/orientation
  - Navigate around a room with obstructions

- Need to take images of scenes, compute boundaries, determine paths

- Goal: autonomous robots
Database/expert systems

- Context drives a huge problem: how to encode context and knowledge that the human mind possesses, and retrieve said information?
- “Associative memory systems”
- Web search is just a start – just keyword-based searching so far, not semantic-based searching
- Expert systems: encode domain-specific knowledge to help solve problems

Weak vs. Strong AI

- All of these applications are essentially weak: we tell the computer what to do, and we solve problems
  - Not really “AI”, per se – useful solutions to solve real-world problems
- Is Strong AI, i.e., sentience/consciousness, possible?
  - If so, we’re still quite a long way away
  - On the other hand, there’s the Turing test...
So... what can’t computers do?

- (Or, can we summarize what can they do?)
- Given all that we’ve learned this semester, it’s actually pretty hard to characterize
- Focus of *computation theory* is to determine what is computable and what is not
  - Computable implies functions whose output values can be determined algorithmically from their input values
  - So, what’s an example of a noncomputable function?

Next time

- Theory of computation