Expert Systems and Artificial Intelligence

What is information?

- Information has the capacity to change behavior.
- Data and information have the same structure, but the difference is in the observer.
- If the observer can interpret the raw data, then changes in behavior can result as decisions are made.

What is Knowledge?

- System of information
- Various elements of information are related to each other
- Is based in experience
What are Advanced Information Systems?

- Explicit focus on decision making
- Data-oriented systems
  - Executive Information Systems
  - Model-based Decision Support Systems
- Knowledge-based systems
  - Expert Systems
  - Results of developments in artificial intelligence...

Part II: History of Artificial Intelligence

On AI

"We may hope that machines will eventually compete with men in all purely intellectual fields. But which are the best to start with? Even this is a difficult decision. Many people think that a very abstract activity, like the playing of chess, would be best. It can also be maintained that it is best to provide the machine with best sense organs that money can buy, then teach it to understand and speak English. This process could follow the normal teaching of a child. Things would be pointed out and named, etc. Again I do not know what the right answer is, but I think both approaches should be tried."

What is AI?

- Program devoted to actualizing human behavior
- Program devoted to actualizing human reasoning

Behavior

Reason
AI and Expert Systems

AI Branches

- Expert systems
- Natural language processing
- Robotics
- Vision
- Speech recognition
- Machine learning

AI Milestones

- 1930's Turing Challenge
- 1956 - Dartmouth Conference
  - McCarthy, Shannon, Minsky, Newell, Simon
  - General problem solver
- 1970's- first expert systems
  - DENDRAL
- 1980's - commercialization of AI
  - Fortune 500
  - Japanese 5th generation project

How is AI different?

- Symbolic vs. numerical processing
- Heuristic vs. algorithmic processing

Processing illustrations

1. Numerical Processing
   4 \times 6 = 24

2. Symbolic Processing
   \[ \text{sky} \rightarrow \text{take umbrella} \]
   \[ \text{rain} \]
What are Heuristic Methods?

- Heuristic come from root that means "to discover."
- Rules are developed through intuition, experience, and judgement.
- Sometimes called "rules of thumb"
- Heuristics should not be used when algorithmic or analytical solutions are available

Processing Illustration2

Algorithmic Processing:
put 1 into n
put 5% into rate
Repeat until (n= 100)
get price
Amount = price*rate
Total = Amount + Total
n = n + 1
end repeat

Heuristic Programming:
Rule EPA >>>
Rule hazardous
Rule liquid or rule solid
Rule combustible>>>
>>>Rule
Remediation>>>

Pro's and cons of Heuristic Programming

- Scheduling problem (pro)
  - Advantage: addresses "combinatorial explosion" (10^26 possible paths). Analysis will not yield solution in finite time.
- Inventory problem (con)
  - Disadvantage: Rules are sub-optimal. Analytical solution is better.

Part III: Function and Structure of Expert Systems
AI and Expert Systems

Who Uses Expert Systems?

- Novices!

Functions of ES

- Transfer knowledge from experts to non-experts
- Allows non-experts to make decisions and to take action
- Based on heuristic programming methods

Expert System Structure

Expert System Components Explained

- The user interface mediates between the user and the expert system.
- The knowledge base is made up of rules of thumb or heuristics
- The inference engine controls the way the program searches for a solution
- Working memory is a place for the facts of the consultation
AI and Expert Systems

Knowledge Base

- Representation of the knowledge in the system
  - includes time, causality, actions, goals
- Rules, semantic nets, logic, frames

Rules

- IF....THEN format
- IF class = solid
  AND combustibility = yes
  THEN material = hazardous
  AND legal framework = RCRA

Inference Engine

- Controls the order the rules are tested
- Forward chaining
  - data driven
  - start with initial conditions and work toward goal
- Backward chaining
  - goal driven
  - start with goal and work back to initial conditions

User Interface

- Customized display
- Explanation facility
  - How did you arrive at that conclusion?
Part IV: Examples of Expert Systems

Major Types of Problems

- Classification Problems
- Construction Problems

Classification Problems Defined

- Draw boundaries around existing elements
- Well defined set of alternatives
- Mapping objects to well-defined groups or classes
- Diagnosis is typical problem

Construction Problems Defined

- Elements must be constructed or ordered
- Alternatives not clearly defined
- Groups must be created before element mapping can occur
- Creation of plan or schedule is typical
AI and Expert Systems

Classification Expert Systems

- DENDRAL (1967)
  - Identify molecular compounds
  - No explanation facility
- INTERNIST/CADUCEUS (1974)
  - Diagnose diseases in the field of internal medicine

Classification Expert Systems (cont.)

- MYCIN (1976)
  - Diagnose infectious diseases
  - Pioneered the shell concept; i.e. separation of knowledge base from inference engine, etc.

Classification Expert Systems (cont.)

- DELTA/CATS (1983)
  - Diagnose diesel problems
  - Maintenance problem!
- Insurance ExperTax (1988)
  - Identify tax implications of insurance products
  - 3000 rules

Construction Expert Systems

- XCON (1981)
  - Configures VAX computer systems
  - Successful, but large and hard to maintain
- HESS (1988)
  - Determines products to produce, timing, and processing elements
Generic Uses of Expert Systems

- To replace a human expert

Uses (cont.2)

- To support a human expert

Uses (cont.3)

- To support a computer application

Uses (cont.4.)

- Embedded within an application
AI and Expert Systems

Uses (cont.5)

• As a front end to an application

Before
User
Computer Application
Report
After
User
Expert System
Computer Application
Report

Uses (cont.6)

• As a back end to an application

Before
User
Computer Application
Report
After
User
Computer Application
Expert System

Uses (cont.7)

• To replace documentation

Before
User
Printed Documentation
Advice
After
User
Expert System
Advice

Part V: Developing Expert Systems
Tools

- Languages
  - LISP; Prolog
  - Shells
    EXSYS; VP Expert; XCODE/XDESK

Personnel

- Expert
  - Who are they?
- Knowledge Engineer
  - converts knowledge into appropriate representation

Development Method (Prototyping/Spiral)

- Problem framing
- Justification
- Identification of knowledge and experts
- Knowledge acquisition
  - interviews
- Prototype development
- Testing and Implementation
- Maintenance

Summary
## Benefits of Expert Systems

- Faster
- Lower error rates
- Consistency
- Captures and preserves expertise
- Can operate in hazardous environments

## Problems with Expert Systems

- Limited class of applications
- Knowledge acquisition is an art!
- Finding suitable expertise is difficult (what is it?)
- Knowledge maintenance
- User confidence in outputs

## Conclusions

- Expert Systems can be built to meet a variety of needs
- Today there are several thousand significant applications
- Systems can range in size from 50-5000 rules
- Success has been mixed over time
- Selecting an appropriate application requires research

end...