Chapter 6: Knowledge-based Decision Support and Artificial Intelligence

- **Managerial Decision Makers are *Knowledge Workers***
- **They Use Knowledge in Decision Making**
- **Issue: Accessibility to Knowledge**
- **Knowledge-Based Decision Support Through Applied Artificial Intelligence Tools**

6.1 Opening Vignette: A Knowledge-based DSS in a Chinese Chemical Plant

- **The Problem**
  - **Dalian Dyestuff plant**
  - **Managers determined own production plans**
- **The Solution**
  - **DSS with a knowledge-base component**

Subsystems

- Production Planning
- Accounting and Cost Control
- Financing and Budgeting
- Inventory and Material Management Control
- Information Services
- LP-based production planning model in model base
- Two Expert Systems (ES) to
  - Plan monthly production and
  - Analyze working capital

The Expert System

- **Generates a proposed plan**
- **Models the working capital**

ES Advantages

- Combines quantitative and qualitative analysis
- Provides flexibility and adaptability
- Involved decision makers
- Allows better and more efficient decisions
- Increased profit by more than $1 million / year (about a 10% increase)
- Allows users to express preferences and expertise
- Improves service to customers
- Improved the competitive position of the plant

6.2 Artificial Intelligence (AI)

AI Concepts and Definitions

- Encompasses Many Definitions
- AI Involves Studying Human Thought Processes (to Understand What Intelligence Is)
- AI Deals with Representing Thought Processes on Machines

Artificial Intelligence

- ***Artificial intelligence*** **is behavior by a machine that, if performed by a human being, would be called intelligent (well-publicized)**
- **"Artificial Intelligence is the study of how to make computers do things at which, at the moment, people are better" (Rich and Knight [1991])**
- **AI is basically a theory of how the human mind works (Mark Fox)**

Objectives of Artificial Intelligence

(Winston and Prendergast [1984])

- Make machines ***smarter*** (primary goal)
- Understand what ***intelligence*** is (Nobel Laureate purpose)
- Make machines more ***useful*** (entrepreneurial purpose)

Signs of Intelligence

- ***Learn*** **or** ***understand*** **from experience**
- **Make sense out of ambiguous or contradictory messages**
- **Respond quickly and successfully to new situations**
- **Use *reasoning* to solve problems**

(Continued on next page)

Signs of Intelligence (cont'd)

- Deal with perplexing situations
- *Understand* and *Infer* in ordinary, rational ways
- Apply *knowledge* to manipulate the environment
- *Think* and *reason*
- Recognize the relative importance of different elements in a situation

Turing Test for Intelligence

A computer can be considered to be *smart* only when a human interviewer, "conversing" with both an unseen human being and an unseen computer, could not determine which is which

Symbolic Processing

- **Use *Symbols* to Represent Problem Concepts**
- **Apply Various Strategies and Rules to Manipulate these Concepts**

AI: Represents Knowledge as Sets of Symbols

A *symbol* is a string of characters that stands for some real-world concept

Examples

- **Product**
- **Defendant**
- **0.8**
- **Chocolate**

Symbol Structures (Relationships)

- (DEFECTIVE product)
- (LEASED-BY product defendant)
- (EQUAL (LIABILITY defendant) 0.8)
- tastes_good (chocolate).

- **AI Programs Manipulate Symbols to Solve Problems**
- **Symbols and Symbol Structures Form Knowledge Representation**
- **Artificial intelligence is the Branch of Computer Science Dealing Primarily with *Symbolic*, N*onalgorithmic* Methods of Problem Solving**

Characteristics of Artificial Intelligence

- ***Numeric versus Symbolic***
- ***Algorithmic versus Nonalgorithmic***

Heuristic Methods for Processing Information

- Search
- Inferencing

Reasoning **- Inferencing from Facts and Rules using heuristics or other search approaches**

Pattern Matching

Attempt to describe objects, events, or processes in terms of their qualitative features and logical and computational relationships

6.3 Artificial Intelligence versus Natural Intelligence

Commercial Advantages of AI Over Natural Intelligence

- AI is more *permanent*
- AI offers *ease of duplication and dissemination*
- AI can be *less expensive*
- AI is *consistent and thorough*
- AI can be *documented*
- AI can execute certain tasks much *faster* than a human can
- AI can perform certain tasks *better* than many or even most people

Natural Intelligence Advantages over AI

- Natural intelligence is *creative*
- People *use sensory experience* directly
- Can use a *wide context of experience* in different situations

AI - Very *Narrow Focus*

Information Processing

- Computers can collect and process information efficiently
- People instinctively
  - Recognize relationships between things
  - Sense qualities
  - Spot patterns that explain relationships
- *BUT*, AI technologies can provide significant improvement in productivity and quality

6.4 Knowledge in Artificial Intelligence

Knowledge encompasses the implicit and explicit restrictions placed upon objects (entities), operations, and relationships along with general and specific heuristics and inference procedures involved in the situation being modeled

Of data, information, and knowledge, KNOWLEDGE is most abstract and in the smallest quantity

Uses of Knowledge

- **Knowledge consists of facts, concepts, theories, heuristic methods, procedures, and relationships**
- **Knowledge is also information organized and analyzed for understanding and applicable to problem solving or decision making**
- ***Knowledge base*** **- the collection of knowledge related to a problem (or opportunity) used in an AI system**
- **Typically limited in some specific, usually *narrow*, subject area or *domain***
- **The *narrow domain* of knowledge, and that an AI system must involve some *qualitative aspects* of decision making (*critical* for AI application success)**

Knowledge Bases

- Search the *Knowledge Base* for Relevant Facts and Relationships
- Reach One or More Alternative Solutions to a Problem
- **Augments** the User (Typically a Novice)

6.5 How Artificial Intelligence Differs from Conventional Computing

Conventional Computing

- Based on an *Algorithm* (Step-by-Step Procedure)
- Mathematical Formula or Sequential Procedure
- Converted into a Computer Program
- Uses Data (Numbers, Letters, Words)
- Limited to Very Structured, Quantitative Applications (Table 6.1)

Table 6.1: How Conventional Computers Process Data

- Calculate
- Perform Logic
- Store
- Retrieve
- Translate
- Sort
- Edit
- Make Structured Decisions
- Monitor
- Control

AI Computing

- **Based on *symbolic representation* and manipulation**
- **A *symbol* is a letter, word, or number represents objects, processes, and their relationships**
- ***Objects* can be people, things, ideas, concepts, events, or statements of fact**
- **Create a *symbolic knowledge base***

AI Computing (cont'd)

- Uses various processes to manipulate the symbols to generate advice or a recommendation
- AI reasons or infers with the knowledge base by search and pattern matching
- Hunts for answers

  (Algorithms often used in search)

AI Computing (cont'd)

- ***Caution*: AI is NOT magic**
- **AI is a unique approach to programming computers**

(Table 6.2)

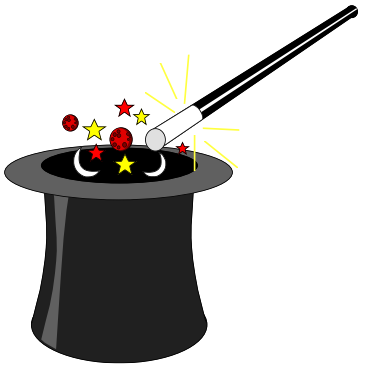


Table 6.2: Artificial Intelligence vs. Conventional Programming

Dimension	Artificial Intelligence	Conventional Programming
Processing	Primarily Symbolic	Primarily Algorithmic
Nature of Input	Can be Incomplete	Must be Complete
Search	Heuristic (Mostly)	Algorithms
Explanation	Provided	Usually Not Provided
Major Interest	Knowledge	Data, Information
Structure	Separation of Control from Knowledge	Control Integrated with Information (Data)
Nature of Output	Can be Incomplete	Must be Correct
Maintenance and Update	Easy Because of Modularity	Usually Difficult
Hardware	Mainly Workstations and Personal Computers	All Types
Reasoning Capability	Limited, but Improving	None

6.6 Does a Computer Really Think?

- **WHY?**
- **WHY NOT?**

- **Dreyfus and Dreyfus [1988] say NO!**

- **The Human Mind is Very Complex**

AI Methods are Valuable

- Models of how we think
- Methods to apply our intelligence
- Can make computers easier to use
- Can make more knowledge available to the masses
- S*imulate* parts of the human mind

6.7 The Artificial Intelligence Field

- **Involves Many Different Sciences and Technologies**
  - **Linguistics**
  - **Psychology**
  - **Philosophy**
  - **Computer Science**
  - **Electrical Engineering**
  - **Hardware and Software**

(More)

- Mechanics
- Hydraulics
- Physics
- Optics
- Others

- **Commercial, Government and Military Organizations Involved**

Lately

- Management and Organization Theory
- Chemistry
- Physics
- Statistics
- Mathematics
- Management Science
- Management Information Systems

Artificial Intelligence

- AI is a Science and a Technology
- Growing Commercial Technologies

Major AI Areas

- Expert Systems
- Natural Language Processing
- Speech Understanding
- Fuzzy Logic
- Robotics and Sensory Systems
- Computer Vision and Scene Recognition
- Intelligent Computer-Aided Instruction
- Machine Learning (Neural Computing)

(Figure 6.3)

Expert Systems

- **Attempt to Imitate Expert Reasoning Processes and Knowledge in Solving Specific Problems**
- ***Most Popular Applied AI Technology***
  - **Enhance Productivity**
  - **Augment Work Forces**
- ***Narrow* Problem-Solving Areas or Tasks**

Human Expert Characteristics

- Solve problems quickly and accurately
- Explain what (and how) they do
- Judge own conclusions
- Know when stumped
- Communicate with other experts
- Learn
- Transfer knowledge
- Use tools to support decisions
- Knowledge is a major resource
- Important to capture knowledge from a few experts
- Experts become unavailable -> knowledge not available
- Better than books and manuals

Expert Systems

- **Provide Direct Application of Expertise**
- **Expert Systems Do Not Replace Experts, But**
  - **Makes their Knowledge and Experience More Widely Available**
  - **Permits Non Experts to Work Better**

Expert Systems Software Development Packages

- Resolve (was EXSYS)
- K-Vision
- KnowledgePro

Natural Language Processing

- Can Communicate with the Computer in a Native Language
- Conversational Interface
- Limited Success

Natural Language Processing (NLP)

- Natural Language *Understanding*
- Natural Language *Generation*

Speech (Voice) Understanding

- **Recognition and Understanding by a Computer of Spoken Language**

Robotics and Sensory Systems

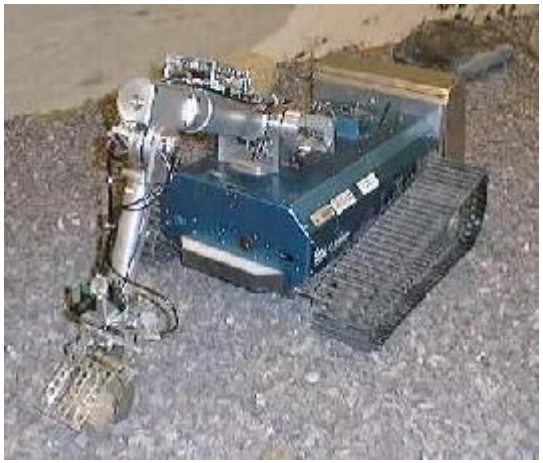
- ***Sensory Systems***
  - **Vision Systems**
  - **Tactile Systems**
  - **Signal Processing Systems**

- **Plus AI = Robotics**

Robot

An Electromechanical Device that Can be Programmed to Perform Manual Ta

Dante II: Robotics Institute, Carnegie Mellon University: http://www.frc.ri.cmu.edu



Mars Rover: The AI Laboratory at MIT: http://www.ai.mit.edu

Robot

"a reprogrammable multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks."

Photo: Wheelesly, a Robotic Wheelchair: The AI Laboratory at MIT: http://www.ai.mit.edu

Are Robots Part of AI?

- **Not Always!**

Computer Vision and Scene Recognition

Cheap Vision Machine: The AI Laboratory at MIT: http://www.ai.mit.edu

Robotics and Computer Vision Web Sites

- Carnegie Mellon University Robotics Institute: http://www.frc.ri.cmu.edu
- The AI Laboratory at MIT: http://www.ai.mit.edu
- Jet Propulsion Lab (NASA): http://robotics.jpl.nasa.gov
- List at the JPL: http://robotics.jpl.nasa.gov/people/welch/other-robotics.html

Intelligent Computer-Aided Instruction (ICAI)

- **Machines that Can Tutor Humans**

Neural Computing

- Mathematical Model of the Way a Brain Functions
- Other Applications
  - Automatic Programming
  - Summarizing News
  - Language Translation
  - Fuzzy Logic
  - Genetic Algorithms
  - Intelligent Agents

6.8 Types of Knowledge-based Decision Support

- Knowledge component *extends the capabilities* of computers well beyond data-based and model-based DSS
- Possible support for
  - Qualitative aspects of the decision process
  - Model management in a multiple model DSS
  - Uncertainty analysis in applying AI tools
  - The user interface (NLP and Voice Technology)
  - Other

6.9 Intelligent Decision Support Systems

- **Active (Symbiotic) DSS - Needed for**
  - **Understanding the domain**
  - **Problem formulation**
  - **Relating a problem to a solver**
  - **Interpreting results**
  - **Explaining results and decisions**

Mili [1990]

- **Need for an Intelligent Component(s) in the DSS**

Self-Evolving DSS - Extra Capabilities

- Dynamic menu
- Dynamic user interface
- Intelligent model base management system

Purposes of Self-Evolving DSS

- Increasing the *flexibility* of the DSS
- Making the system more user friendly
- Enhancing control over the organization's information resource
- Encouraging system sharing

Structure of Self-Evolving DSS (Figure 6.4)

Major Components

- Data management, model management, and a user interface
- Usage record
- The user interface elements
- The central control mechanism

Table 6.3: Problem Management

Problem Management Stage	Functional Requirements	Architectural Support
Problem finding	Perceptual filters, knowledge management	Flexible knowledge management, intelligent filters
Problem representation	Model and pattern management, suspension of judgment	Flexible dialog and knowledge management, reason maintenance system, pattern search strategies
Information surveillance	Knowledge and model management	Demons, intelligent lenses, scanners, evaluators, interpreters
Solution generation	Knowledge management, idea generation	Idea and solution model management, heuristic and analytic drivers
Solution evaluation	Meta-level dialog and knowledge management	Flexible knowledge management, analytic and symbolic processors

6.10 The Future of Artificial Intelligence

- AI Research and Development
- Subfields Evolve and Improve
- New Software Techniques
- Improved Software Development Tools
- Improvement in ALL Decision Making Areas

Hardware Advances

- Special search, pattern-matching, and symbolic processing chips
- New parallel computing and neural computing architectures
- Increased integration AI with other CBIS

PLUS

- Natural language interfaces common
- Intelligent databases economical
- *Internet* tools with intelligent agents and knowledge components
- Programs with knowledge-based subsystems for performance improvements
- Expert systems will become widely available

Now

- Relatively few stand-alone AI application products (except ES)
- Combinations of AI software and conventional algorithmic software / DSS

AI Transparent in Commercial Products

- Anti-lock Braking Systems
- Video CAMcorders
- Kitchen Appliances
  - Toasters
  - Stoves
- Data Mining Software
- Help Desk Software

Summary

- Artificial intelligence is an interdisciplinary field
- The primary objective of AI is to build computer systems that perform intelligent tasks
- The major characteristics of AI are symbolic processing, heuristics and inferencing

- AI has several major advantages over people
- Natural (human) intelligence has advantages over AI
- Knowledge is the key concept of AI
- Knowledge base
- Conventional computing vs. AI

- **Digital computers are algorithmic but can be programmed for symbolic manipulation**
- **Techniques of reasoning: search and pattern matching**
- **AI computers may not think, but can be valuable**
- **Major application areas of AI**

- **Expert systems attempt to imitate experts**
- **Effective expert systems are applied to a narrow knowledge domain and include qualitative factors**
- **Natural language processing**
- **Speech understanding**
- **Intelligent robots**

- Computer vision
- Fuzzy logic
- Genetic algorithms
- Intelligent agents
- Intelligent Computer-Aided Instruction
- AI technologies can be integrated together and with other CBIS

- **Intelligent DSS: Active**
- **Intelligence is added to DSS by embedding knowledge bases**
- **Intelligence needed in problem management**
- **Active, symbiotic, and self-evolving DSS are different configurations of intelligent DSS**

Questions for the Opening Vignette

- Justify the need for a DSS
- Describe the role of the ES. Why was such a component needed?
- Review the role of the managers-users in this case
- What unique aspects in this case are related to the Chinese environment?
- What managerial lessons regarding DSS can be learned from this system?

Exercise

5. Commander Data, a member of the Enterprise starship crew was declared, legally, to be a sentient being, a culture of one, entitled to full rights as a citizen of the United Federation of Planets.

Answer the Following

- **Describe the consequences of such a legal decision in today's culture (recognizing that an artificial life form has equal stature to a human being).**
- **Do you think that such a court ruling will ever be possible? Why or why not?**
- **Should a sentient, artificial life form be entitled to "rights" in the human sense? Why or why not?**

Group Exercise

1. Make a peanut butter and jelly sandwich in class.

Debates

- **Do chess playing computer systems exhibit intelligence? Why or why not?**
- **Justify the position that computers cannot think. Then prepare arguments that show the opposite.**

- **Bourbaki [1990] describes Searle's argument against the use of the Turing Test. Summarize all the important issues in this debate.**
- **<u>The Soul</u>: Proponents of AI claim that we cannot ever have machines that truly think because they cannot, by definition, have a soul. Supporters claim a soul is unnecessary. They cite the fact that originally humanity set out to create an artificial bird for flight. An airplane is not a bird, but yet it functionally acts as one. Debate the issue.**

APPENDIX 6-A: Human Problem Solving--An Information Processing Approach (The Newell-Simon Model)

- Problem solving can be understood as information processing
- Based on a cognitive approach that uses a qualitative description of the ways in which people are similar, and of the manner in which people think

The Newell-Simon Model of Human Information Processing

- Perceptual subsystem
- Cognitive subsystem
- Motor subsystem
- External memory

(Figure 6-A.1)

Perceptual Subsystem

- **External stimuli - inputs for human information processing**

Cognitive Subsystem

- **Selects appropriate information from sensory buffers and transfers it to the *short-term memory***
- **Works in cycles**
- **Cognitive Subsystem Parts**
  - **Elementary processor**
  - **Short-term memory**
  - **Interpreter**

- **Complex tasks - more elaborate processing**
- **Cognitive processor draws on long-term memory**
  - ***Long-term memory* - large number of stored symbols with a complex indexing system**

Simple Model of LTM

- **Related symbols are associated with one another**

Complex Model 1 of LTM

- Symbols are organized into temporal scripts
- Memory consists of clusters of symbols called chunks
- Supports the decision-making process with external memory
- The long-term memory has essentially unlimited capacity
- The short-term memory is quite small

Major Limitations of Humans

- The human operates in serial

Motor Subsystem

- **After scanning and searching memories, the processor sends information to the *motor subsystem*. Motor processors initiate actions of muscles and other internal human systems**

- **Results in some observable activity**