Introduction to knowledge-based systems

KBSs & Knowledge

- What is a knowledge-based system?
  - A system which is built around a knowledge base. i.e. a collection of knowledge, taken from a human, and stored in such a way that the system can *reason* with it.
- What is knowledge?
  - Knowledge is the sort of information that people use to solve problems.

Knowledge

- The explicit functional associations between items of information and/or data' (Debenham, I988).
- Knowledge includes:
  - facts, concepts, procedures, models, heuristics, examples.
- Knowledge may be:
  - specific or general
 - exact or fuzzy
  - procedural or declarative

OBJECTIVES OF KBS

- Provides a high intelligence level
- Assists people in discovering and developing unknown fields
- Offers a vast amount of knowledge in different areas
- Aids in management of knowledge stored in the knowledge base
- Solves social problems in a better way than the traditional computer-basedinformation systems.
- Acquires new perceptions by simulating unknown situations
- Offers significant software productivity improvement

Knowledge-Based versus Computer-Based Information Systems

Traditional Computer-Based Information System (CBIS)	Knowledge-Based System (KBS)
Gives a guaranteed solution and concentrates on efficiency	Adds power to the solution and concentrates on effectiveness without any guarantee of solution
Data and! or information processing approach	Knowledge and/ or decision processing approach
Assists in activities related to decision making and routine transactions; supports need for information	Transfer of expertise; takes a decision based on knowledge, explains it, and upgrades it, if required
Examples are TPS, MIS, DSS, etc.	Examples are expert systems, CASE-based systems, etc.
Manipulation method is numeric and algorithmic	Manipulation method is primarily sybolic/connectionist and nonalgorithmic
These systems do not make mistakes	These systems learn by mistakes
Need complete information and/or data	Partial and uncertain information, data, or knowledge will do
Works for complex, integrated, and wide areas in a reactive manner	Works for narrow domains in a reactive and proactive manner

General structure of a KBS
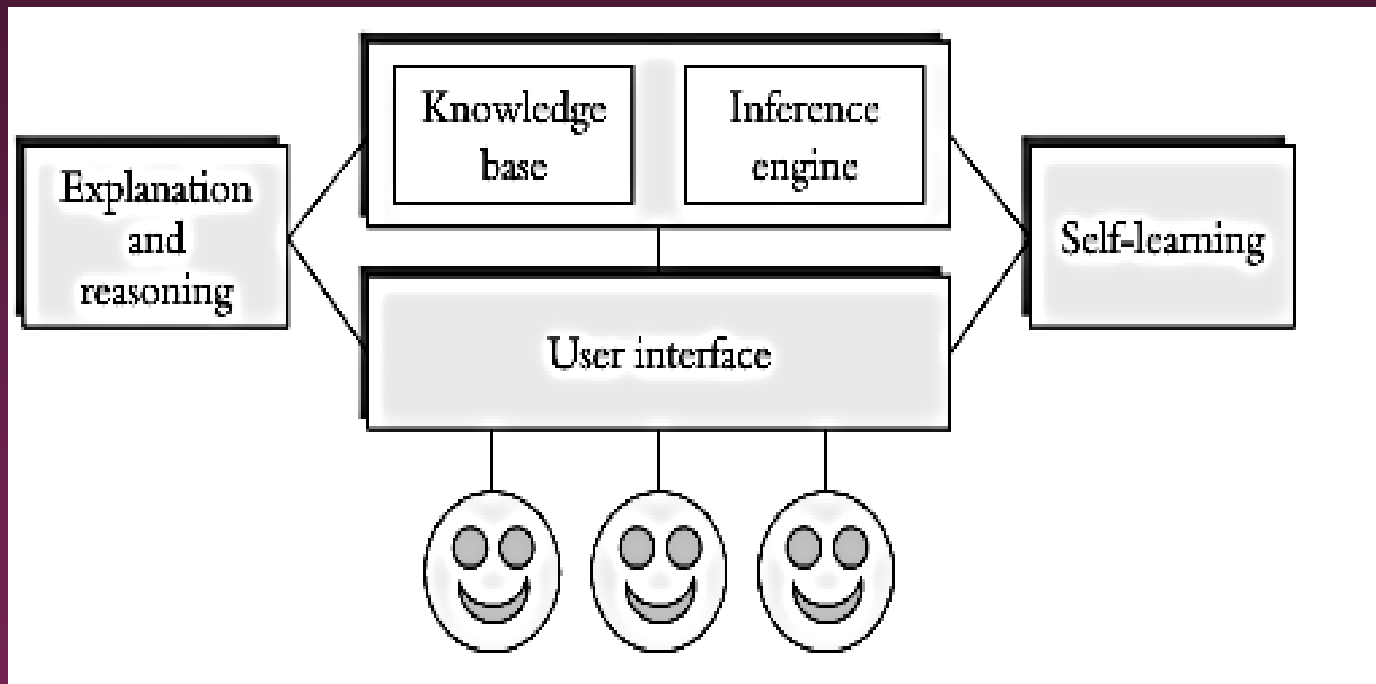
TYPES OF KBS (Tuthhill & Levy 1991)

- (i) Expert Systems,
- (ii) Hypertext Manipulation Systems,
- (iii) CASE Based Systems,
- (iv) Database in conjunction with an Intelligent User Interface and
- (v) Intelligent Tutoring Systems.

Expert Systems

- The pioneer of knowledge-based systems and the most popular. It replaces one or more experts for problem solving. They may

- Useful when:
  - An expert is not available
  - Expertise is to be stored for future use or Expertise is to be cloned or multiplied
  - Intelligent assistance and/ or training are required for decision making or problem solving
  - More than one expert's knowledge has to be grouped on one platform

Expert System: Benefits

- Increased output and productivity
- Improved quality
- Reduced downtime
- Capturing scarce expertise
- Flexibility and reliability
- Integrated knowledge
- Educational benefits/ease of training
- Enhanced problem-solving capability
- Knowledge documentation and ease of knowledge transfer

DBMS in Conjunction with an Intelligent User Interface

- An intelligent user interface is used to enhance the use of the Database content available in the traditional format

Linked Systems

- Hypermedia systems, such as hypertext, hyperaudio, and hypervideo
- linked in such a way that they generate meaning and exhibit intelligence
- Multimedia-based linked systems are currently quite common.

CASE-Based Systems

- Intelligent systems for computer-aided software engineering (CASE)

- These systems guide the development of information/ intelligent systems for better quality and effectiveness

- the CASE-based system provides necessary guidelines to choose the model, acquire important requirements about the product being developed, design the framework of the systems accordingly, encode it, and test the information and/ or knowledge-based system

Intelligent Tutoring Systems

- Knowledge-based systems are used to train and guide students, trainers, and practitioners in specific areas and at different levels

- useful in evaluating students' skills, preparing documentation of subject material, and managing the question bank for the subjects

- E.g dialog-based tutoring systems
  - The underlying metaphor is conversation

TYPES OF KNOWLEDGE

- Tacit knowledge,
- explicit knowledge,
- factual knowledge,
- procedural knowledge,
- commonsense knowledge,
- domain knowledge,
- meta knowledge

TYPES OF KNOWLEDGE

Knowledge Type	Description
Domain knowledge	Domain knowledge is valid knowledge for a specified domain. Specialists and experts develop their own domain knowledge and use it for problem solving.
Meta knowledge	Meta knowledge can be defined as knowledge about knowledge.
Commonsense knowledge	Common sense knowledge is a general purpose knowledge expected to be present in every normal human being. Common-sense ideas tend to relate to events within human experience.
Heuristic knowledge	Heuristic is a specific rule-of-thumb or argument derived from experience.
Explicit knowledge	Explicit knowledge can be easily expressed in words/numbers and shared in the form of data, scientific formulae, product specifications, manuals, and universal principles. It is more formal and systematic.
Tacit knowledge	Tacit knowledge is the knowledge stored in subconscious mind of experts and not easy to document. It is highly personal and hard to formalize, and hence difficult to represent formally in system. Subjective insights, intuitions, emotions, mental models, values and actions are examples of tacit knowledge.

EXAMPLES OF KBS

- Expert systems
- Neural networks (NNS)
- Case-based reasoning (CBR)
- Genetic algorithms
- Intelligent agents
- Data mining.

Expert systems

- What is an expert system?
  - The most popular kind KBS
  - The pioneer of KBS
  - One in which the knowledge, stored in the knowledge base, has been taken from an expert in some particular field.
- Therefore, an expert system can, to a certain extent, act as a substitute for the expert from whom the knowledge was taken.

DBMS In conjunction with an Intelligent User Interface

- Recent DBMS interface is limited
  - cannot handle partial information in a natural language
  - cannot make or justify decisions for itsefl
- An intelligent user interface can enhance the traditional content.
- An intelligent user interface provide the facility of natural-language processing as an intelligent front end with a database.

Linked Systems

- Hypermedia systems, such as hypertext, hyperaudio, and hypervideo,

- Contain nonsequentially linked text, audio, and video chunks that generate meaning and exhibit intelligence.

- Multimedia-based linked systems are currently quite common.

CASE-Based Systems

Artificial intelligence

- What is Artificial Intelligence?

- Artificial Intelligence (AI) is concerned with exploring such aspects of human (and other animal) mental activity as:

  - understanding
  - creativity
  - perception
  - problem-solving
  - consciousness
  - using language
  - intelligence

  by simulating them using computers.

It is therefore closely connected with such social sciences as:

- psychology
- linguistics
- philosophy

Applied artificial intelligence

- What is applied AI?
- Applied AI is concerned with producing software which is "intelligent"
- It is intelligent in that it is based on what we know about human reasoning and other mental abilities
- We are therefore talking about a branch of advanced computing - computer technology - rather than social science

Knowledge engineering

- The term "knowledge engineering" is often used to mean the process of
    - designing
    - building
    - installing

    an expert system or other knowledge-based system.
- Some authors use the term to mean just the knowledge acquisition phase.

Experts

- An expert is an experienced practitioner in his/her particular field. More than that, he/she is a highly effective problem-solver and decision-taker in that field.
- Experts have three qualities:
  - They make good decisions
  - They make those decisions quickly
  - They are able to cope with a wide range of problems.

- As a result, they are valuable, highly-paid, and tend to be overworked.

Experts and expert systems

- Note that:
  - The task that an expert system performs will generally be regarded as difficult.
  - An expert system almost always operates in a rather narrow field of knowledge. The field of knowledge is called the knowledge domain of the system.
  - There are many fields where expert systems can usefully be built.
  - There are many fields where they can't.

Experts and expert systems

Note also that an expert can usually

- explain

and

- justify

    his/her decisions.

Reasons for building an E.S.

- One might build an expert system for any or all of the following reasons:
  - To archive an expert's knowledge, to insure against the day when he/she leaves, or retires, or dies.
  - To disseminate his/her knowledge, so that it is available in more (possibly many more) places than the location of the expert.
  - To ensure uniformity of advice/decisions.
  - As a basis for training other specialists.

Advantages of expert systems

- Put another way, E.S. have the following advantages over human experts:
  - The knowledge is permanent
  - The knowledge is easily replicated
  - The knowledge is represented explicitly, and can be evaluated
  - The system is consistent - whereas human practitioners have bad days, computers don't.
  - Once built, running costs are low

Disadvantages of expert systems

- Developing an expert system usually costs a great deal of time & money

- Historically, there has been a high failure rate in E.S. projects

  - The project may well fail during development - most likely during the "knowledge acquisition" phase.

  - The development may succeed, but the organisation may fail to accept and use the finished system.

Disadvantages of expert systems

- A human expert can update his/her knowledge in the light of
  - Common sense
  - Knowledge derived from other domain
  - Contacts with other experts.

  An expert system can't.

Choosing an E.S.project

- Because of cost, and the danger of failure, it is important that E.S. projects are carefully chosen.

Choosing an E.S.project

- The expense must be justified, in the light of the possible benefits.

- E.S. technology must be appropriate

  - the right kind of expertise is involved

  - it isn't a problem which conventional programming could do better.

- Management, and the participants, must support the project fully.

Types of expertise

- Mike Greenwell's classification of types of expertise, according to identifiable mental components of the skill (with examples):

- [source: Greenwell (1988)]

The phone call test

- A rather simpler approach to answering the question which domains are worth building into an expert system?

- "Any problem that can be and frequently is solved by your in-house expert in a 10-30 minute phone call can be automated as an expert system."

- *Prof.Morris Firebaugh*

Possible expert systems - case histories

- For discussion.

- The following seven problem areas may, or may not, be suitable for computerisation as expert systems.

Possible expert systems - case histories

A certain third world country has a large population, very few trained doctors, and insufficient resources to train many more. It is proposed to provide paramedics, who can be trained relatively cheaply and easily, with medical kits and portable PCs, each PC to be loaded with an expert system that can advise on the diagnosis and treatment of a variety of common diseases.

Possible expert systems - case histories

- The housing department in a provincial English town is overworked, although the staff turnover is quite low. Much of the work the staff do involves interviewing clients, and there is a clear pattern of questioning (which varies to a limited degree, depending on the circumstances of the client). It is proposed to build an expert system, which will direct the questioning process.

Possible expert systems - case histories

A firm of wine importers relies heavily on its chief wine expert, who is skilled at selecting wines that are destined to be popular, on the basis of their taste, colour, scent etc. She is soon to retire. It is proposed to build an expert system that will enable any of several junior wine specialists to do her job.

Possible expert systems - case histories

- An education authority has a severe shortage of primary school teachers. It is proposed that an expert system should be built which can do the job of teaching English and arithmetic to five year old children.

Possible expert systems - case histories

A software company proposes to build an expert system which can perform book-keeping for small commercial concerns.

Possible expert systems - case histories

A large manufacturer of diesel electric locomotives has problems in providing enough maintenance personnel who are sufficiently skilled to locate faults in these (highly complex) locomotives. They propose to build an expert system which can perform fault location on such a machine.

Possible expert systems - case histories

A mineral exploitation company wishes to extend its operations, which involve searching for hitherto undiscovered deposits of valuable metal ores. It is short of trained geologists. It proposes to build an expert system which can assess a geological site and come to a conclusion about how likely it is that there is a worthwhile mineral deposit there.

Project I

Suppose you are assigned the task of adding intelligence to any of the software systems below, show how these systems can have built-in intelligence.

a. Students registration system

b. English vocabulary learning system

c. Sales and marketing management system

d. Hospital management system

Project II

The objective of this project is to give you a chance to research a topic from the following list. You must critically study the problem domain, formulate interesting questions, and creatively analyze What you have studied during this research phase.

a. Cell phone selector system: This system helps users select the best possible cell phone to satisfy their needs

b. Animal recognition system: This system assists in the recognition of an animal based on facts the user provides.

c. Palm reading system: This system supports the analysis of a person's hand and making an inference based on such an analysis.

d. Online test system: This system aids in testing knowledge learned by a student in a specific course.

e. Farming system: This system helps in the management of diseases and pests on a farm. (You can select any type, e.g., vegetable farm, wheat farm, etc.)