QUESTIONS

CHAPTER ONE

1. The expert's knowledge about solving specific problems is called
   a. Problem domain
   b. Knowledge base
   c. Knowledge domain
   d. Inference

2. …………………………… is an ideal solution guaranteed to yield a solution in a finite amount of time. a. Program
   b. Process
   c. Algorithm
   d. Task

3. knowledge based on empirical and heuristic knowledge is said to be …………………… knowledge. a. Deep
   b. Hollow
   c. basic
   d. shallow

4. ……………………………… Is used in chemical mass spectroscopy to identify chemical constituents. a. Mycin
   b. Dendral
   c. Dipmeter
   d. Prospector
5. …………………………… is used for geological data analysis for oil.
   a. Dipmeter
   b. Prospector
   c. Mycin
   d. Xcon/R1

6. …………………………… a prioritized list of rules created by the inference engine, whose patterns are satisfied by facts or objects in working memory. a. Knowledge
   b. Working memory
   c. Exploration facility

d. Agenda

7. ………………………………. is a global database of facts used by rules.
   a. Working memory
   b. Inference engine
   c. Knowledge base
   d. Memory base

8. Knowledge base is also called ………………………………….
   a. Working memory
   b. Inference engine
   c. Rules
   d. Production memory

9. …………………………………. reasoning from facts to the conclusions resulting from those facts.
   a. Backward chaining
   b. Forward chaining
   c. Hypothesis
   d. Inference

10. Choose the appropriate order of the building process of an expert system.
   i. The knowledge engineer codes the knowledge explicitly in the knowledge base.
   ii. The knowledge engineer establishes a dialog with the human expert to elicit knowledge.
   iii. The expert evaluates the expert system and gives a critique to the knowledge engineer. a. iii, ii, i
   b. ii, iii, i
   c. ii, i, iii
   d. i, ii, iii

CHAPTER TWO

1. …………………………. refers to the formal way facts and rules of inferences are used to reach valid conclusions. a. Logical reasoning
   b. Argument
   c. Logic

d. Knowledge

2. ………………………….. is the formal study of knowledge.
   a. Epistlemology
   b. Inference
   c. Psychology
   d. Epistemology

3. Unconscious knowledge is also known as ………………………………… a. Tacit
   b. Priori
   c. Tacid
   d. Postpriori

4. …………………………….. are the end-product of inferences when done according to formal rules. a. Facts
   b. Hypothesis
   c. Conclusions
   d. Priori

5. In an expert system, a(n) ………………………… is the metaknowledge that describes everything known about the problem domain. a. Ontology
   b. Epistemology
   c. Tacit
   d. Knowledge domain

6. ………………………………. is a valid deductive argument having two premises and a conclusion. a. Frame
   b. Semantic net
   c. Schema
   d. Syllogism

7. Choose which best represents a universal affirmative statement.
   a. No S is P
   b. All S is P
   c. Some S is P
   d. Some S is not P

8. …………………….. is a statement that cannot be classified as true or false. a. Proposition
   b. Open sentence
   c. Paradox
   d. Compound statement

9. ……………………………… a statement that is true for all possible cases.

a. Tautology
b. Contradiction
c. Contingent
d. Biconditional

10. The symbol means ……………………………….

a. For all
b. For every
c. At least
d. There exists

CHAPTER THREE

1. …………………………… have only a single pathway from root to its one leaf. a. Degenerate trees
b. Binary trees
c. Balanced trees
d. Generate trees

2. A path through a graph beginning and ending with the same node is called ……………………….

a. Acyclic
b. Connected
c. Digraphs
d. Circuit

3. ………………………... is a reasoning where conclusions must follow from premises. a. Induction
b. Heuristics
c. Deduction
d. Intuition

4. …………………………… is a collection of objects such as rules, axioms, statements, and so forth in a consistent manner. a. Reasoning
b. Deduction
c. Rules
d. Logic System

5. ……………………………… implies every wff can either be proved or refuted. a. Sound

b. Completeness
c. Consistency
d. Verifiable

6. A group of multiple inferences that connect a problem with its solution is a ………………………

a. Chain
b. Tree
c. Graph
d. Lattice

7. Reasoning back from a true condition to the premises that may have caused the condition is called …………………… a. Deduction
b. Abduction
c. Generate and test
d. Intuition

8. A binary decision tree having N nodes will have a maximum of ……………………………. answers for N questions. a. 2n

b. 2_{n-1}

c. 2^n

d. N

9. A lattice can be formed from acyclic and digraphs.
a. True
b. False
c. None

10. A state space can be used to define an object's ……………………
a. Mode
b. Structure
c. Environment
d. Behavior

CHAPTER FOUR

1. ………………………… essentially lack of information to formulate a decision. a. Incompleteness
   b. Completeness
   c. Uncertainty
   d. Probability

2. Accepting a hypothesis when it is not true is also known as………………………… a. False positive
   b. False negative
   c. True positive
   d. False positive

3. Rejecting a hypothesis when it is true is also known as …………………………………. a. False positive
   b. False negative
   c. True negative
   d. True positive

4. Induction proceeds from ……………………………… to ………………………………...
   a. General to specific
   b. General to individual
   c. Specific to genuine
   d. Specific to general

5. Classical or priori probability was first proposed by ……………………. and ……………………. in ………………..

   a. Pascaline, Fermat, 1655
   b. Pascal, Fermat, 1655
   c. Pascal, Fermat, 1654
   d. Pascaline, Fermat, 1655

6. When repeated trials give the exact same results, the system is ……………………………………………..

   a. Probabilistic
   b. Deterministic
   c. Non-deterministic
   d. Non-probabilistic

7. ………………………………………defines the probability of an event, as the limit of a frequency distribution.

a. Subjective probability
b. Objective probability
c. Experimental probability
d. Certainty

8. represents the probabilities that the system in one state will move to another a. State matrix
b. Change matrix
c. Dynamic matrix
d. Transition matrix

9. ……………………………….... deals with events that are not reproducible and have no historical basis on which to extrapolate. a. Subjective probability
b. Objective probability
c. Experimental probability
d. Certainty

10. ……………………… implies there is some evidence favoring the hypothesis but not enough to prove it. a. Possible
b. Probable
c. Plausible
d. uncertain

CHAPTER FIVE

1. …………………………… refers to minimizing the global uncertainties of the entire expert system.
a. Verification
b. Validation
c. Authentication
d. Authorization

2. A way of combining belief and disbelief into a single number is known as ………………………
a. Uncertainty factor
b. Probable factor
c. Certainty factor
d. Combination factor

3. An environment is called …………………………….. when its elements may be interpreted as possible answers and only one answer is correct. a. Frame of discernment
b. Discernment

c. Environment of discernment
d. Frame of concern

4. ……………………………… theory assumes that there is a fixed set of mutually exclusive and exhaustive elements called environment. a. Dampster-Shafer
b. Dampster- Shalfer
c. Dempster- Shalfer
d. Dempster- Shafer

5. In Bayesian theory, the posterior probability changes as evidence is acquired.
a. Dampster-Shafer
b. Bayesian
c. Uncertainty
d. Priori

6. The environment is another term for the ………………………………. in set theory. a. Universe of discuss
b. Universe of concern
c. Universe of interest
d. Universe of discourse

7. A set is called a singleton because it contains ……………………… element(s). a. No
b. Only two
c. Only one
d. More than two

8. ………………………. is a superset of conventional logic – extended to handle partial truth.
a. Fuzzy logic
b. Logical reasoning
c. Neural network
d. Probabilistic reasoning

9. All the following are examples of soft-computing **expect**……………………….
a. Abduction Reasoning
b. Fuzzy logic
c. Neural networks
d. Probabilistic reasoning

10. A discrimination function is a way to represent which objects are ……………………… of a set.
a. not members
b. Complements
c. Members

d. Not subsets

CHAPTER SIX

1. The objective here is to determine the correctness, completeness, and consistency of the system.
    a. Knowledge definition
    b. Knowledge design
    c. Knowledge verification
    d. Knowledge requirement

2. High standards are a necessity in expert systems and can be measured by……………………….
    a. Mean time between successes
    b. Mean time between failures
    c. Mean time between outputs
    d. Mean time between different systems

3. Expert systems require more maintenance because they are based on knowledge that is……………………. and ……………………………
    a. Heuristic, Experimental
    b. Heuristic, Probable
    c. Heuristic, experiential
    d. Heuristic, uncertain

4. Usually the method of choice for new programming students in conventional and expert systems is…………………………..
    a. Waterfall model
    b. Code and fix model
    c. Incremental model
    d. Spiral model

5. ………………………………… is a refinement of the ………………………………… and top-down-approach.
    a. Incremental model, water model
    b. Waterfall model, incremental model
    c. Incremental model, spiral model
    d. Waterfall model, spiral model

6. Each ………………………. of the spiral adds some functional capability to the system. a. Stage
    b. Step

c. State
d. Circuit

i. Pattern matching ii.
Conflict resolution iii.
Execution of actions

7. Inference engine errors may result from errors in……………………… a. i only
   b. i, ii
   c. i, ii, iii
   d. i, iii

8. A problem common to all previous stages of the development of an expert system is called ………………………..

   a. Limits of ignorance
   b. Resistant errors
   c. System bugs
   d. Engine bugs

9. …………………………….. and …………………………….. are ways of ensuring the commercial quality of a system. a. Maintenance, evolution
   b. Validation, testing
   c. Maintenance, verification
   d. Verification and testing

10. Designing of expert systems of part of a general field known as

    ………………………………………..

    a. Knowledge base
    b. Knowledge definition
    c. Knowledge elicitation
    d. Knowledge management

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ExpertSystemsMCQs Chapter1

1...........isthemostcommonlyexploredbranchofArtificialIntelligence.

a)Robotics

b)Speech

c)NaturalLanguageProcessing

d)ExpertSystems

2.……………….Isconcernedwithengineeringattemptstoduplicatehumanphysical attributes.

a)Expertsystems

b)Robotics

c)Vision

d)ArtificialNeuralSystems

3.………………isanexpertsystemusedinchemicalmassspectroscopytoidentify chemicalconstituents.

a)MYCIN

b)DENDRAL

c)DIPMETER

d)PROSPECTOR

4.Iamanexpertsystem.Iamdesignedfortheanalysisoflungfunctiontests.Who amI?

a)DENDRAL

b)INTERNIST

c)MACSYMA

d)PUFF

5.……………..isprimarilydata-driven.

a)Forwardchaining

b)Backwardchaining

c)Upwardchaining

d)Downwardchaining

6.………isprimarilygoal-driven.

a)Upwardchaining

b)Forwardchaining

c)Backwardchaining

d)Downwardchaining

7.……….involvestheconceptsofverticalandlateralthinking.Theretwobasic thinkingstyles,verticaland………

a)Humancognitivethinking,lateral

b)Associativethinking,lateral

c)Philosophicalthinking,horizontal

d)Deductivereasoning,lateral

8.…………..involvestheconceptofgatheringofinputdataandthemanipulationof symbols,themanipulationofsymbolstakeplacethroughmentalmodels. Machinethinkingdoesandadmirableemulationoftheoverallprocess.

a)Philosophicalthinking

b)Inductivereasoning

c)Humancognitivethinking

d)Associativethinking

9.Expertsystemscontainthefactandproceduresrepresentingtheruleofthumbs decision-makingprocessofanexpert.Thecollectioniskeptina…………..thatis separatefromthecontrolprogram.

a)Database

b)Knowledgebase

c)Workspace

d)Scratchpad

10.Naturallanguageprocessingisdividedintotwosub-branches.Understanding andoutput.Naturallanguageunderstandingexploresmethodsofcomputer comprehensionofhumanlanguagestimuli.Naturallanguage……….Istheability ofcomputertocommunicateverballywithahuman.

a)Input

b)Talking

c)Silence

d)Interpretation

1. An expert system is
A) A computer that can answer questions like a human expert
B) A group of scientists who design computer programs
C) A method of producing new words
D) A computer that can feel emotions
2. "Heuristic" is a Greek word which means "to ………
A) Guess
B) Assimilate
C) Discover
D) Propound
E) Deduce
3. A compared to ES, conventional software development technology deals with knowledge which access and maintain structured data. This statement is …………….
A) True
B) False
C) None of the above
D) No idea
4. A …………. is essentially a meta-explanation that explains the expert system's explanation of its reasoning.

A) Meta-rule
B) Syllogism
C) Warrant
D) Deduction
E) Premise
5. I am an expert system. I am designed for the analysis of lung function tests. Who am i?
A) DENDRAL
B) INTERNIST
C) MASCYMA
D) MYCIN
E) PUFF
6. An expert System may be highly interactive(directly asking the user questions) or ………. Where all input comes from another program.
A) In-built
B) Off-line
C) Embedded
D) Functional
E) Encapsulated
7. Expert Systems contain the facts and procedures representing the rule of thumb decision-making processes of an expert. That collection is kept in a ………… that is separate from a control program.
A) Database
B) Knowledge base
C) Workspace
D) Scratchpad
E) Blackboard
8. Knowledge representation is a method used to ………. The knowledge for use by the expert system, and putting the knowledge into rules or cases or other representations.
A) Decode
B) Interpret
C) Explain
D) Encode
E) Decipher
9. Expert systems can replace human decision makers because the rules abstracted from the human experts can capture everything. This statement is …………
A) True
B) False
C) None of the above
10. I am an expert system, a very prominent one. I am designed to identify organic compounds from mass spectrometer data. I am widely used by research chemists. Who am i?
A) DENDRAL
B) INTERNIST
C) MASCYMA
D) MYCIN

E) PUFF

11. I am a backward-chaining artificial intelligent language and comes in several flavours, the latest being visual. I provide possible integration with other visual programming languages. Who am i?

A) ECLIPSE

B) PROLOG

C) OPSS

D) CLIPS

E) JESS

12. The best way to model the expert system architecture is to use a specialized tool. One such tool is the ………….

A) INGRESS

B) JAVA SERVER PAGES(JSP)

C) VB.NET

D) UNIFIED MODELLING LANGUAGE(UML)

E) OBJECT ORIENTED MODELLING(OOM)

13. I am a component of an expert system and contain some of the data of interest to the system. I may be connected to an on-line company and a human user may be considered as my replacement. Who am i?

A) Database

B) Inference engine

C) User

D) Knowledge base

E) Working storage

14. During ES development, the domain should be relatively …………. In particular, dramatic changes over the period of the development effort should not be forseen.

A) Strong

B) True

C) Acceptable

D) Known

E) None of the above

15. In developing expert systems, substantial amount of time is devoted to the development of the ……………..

A) Knowledge base

B) User I/O interface

C) Staff to maintain the system

D) Program codes

E) Platform

16. Robotics is concerned with engineering attempts to duplicate human ……………. Attributes. Robots are electromechanical machines that are programmable perform manipulative tasks. These task range from delicate to heavy-duty.

A) Programmable

B) Delicate

C) Physical

D) Chemical

E) Work

17. Heuristics are not guaranteed to succeed in the same way that an algorithm is a guaranteed solution to a problem. Instead, heuristics are rules of thumb or …………. knowledge gained from experience that may aid in the solution but are not guaranteed to work.

A) Research
B) Historical
C) Empirical
D) Scientific
E) Diverse

18. The facts and rules concerning a specific case that are derived during and at the conclusion of a consultation with the expert system are known as ………….

A) Inferred knowledge
B) Derived data
C) Priori knowledge
D) Classified knowledge
E) Acquired knowledge

19. In an expert system, the knowledge contained within both the expert system's knowledge base and its working memory are entirely different. This statement is ………….

A) True
B) False
C) None of the above

20. There are several possible ways in which knowledge can be expressed, but the dominant form in use in contemporary expert systems is what is called ……………

A) Rules
B) Production
C) Antecedent
D) Consequent
E) None of the above

21. Expertise is a large amount of ……….. in a particular domain.

A) Data
B) Information
C) Stuff
D) Material
E) None of the above

22. Intelligence allows you to use your ………. that is to apply the expertise.

A) Data
B) Stuff
C) Information
D) Material
E) None of the above

23. Numerically controlled machines can also be called "Industrial Robots".

A) True
B) False
C) Not sure

D) None of the above

24. A …………. Diagram may be used to represent the path of a robot.

A) Venn

B) Universal Model Language(UML)

C) Flow chart

D) Tree

E) Deterministic

25. The sentence “X + 5 = 7” is a proposition.

A) True

B) False

C) No idea

26. Which of the following systems mimics human thinking?

A) Artificial intelligence

B) Intelligent agent

C) Bot

D) Database Management System

27. Which AI system provides a diagnosis to a specific problem?

A) Intelligent agent

B) Expert system

C) Geographical Information system

D) Data mining system

Name: Botty Lucky Index No: 2563714

1. All the following are major uncertainties in rule-based expert systems except
    a) Individual rules
    b) Conflict rules
    c) Incompatibility of rules
    d) Integration of rules
2. Another method of dealing with uncertainty uses certainty factors, originally developed for the …………………………… expert system.
    a) MYCIN
    b) PROSPECTOR
    c) XCON
    d) DENDRAL
3. ……………………………… is/are the way/s to represent uncertainty.
    a) Fuzzy Logic
    b) Probability
    c) Entropy
    d) All the above
4. ……………………………. Are the algorithms that learn from their more complex environments to generalize, approximate and simplify solution logic

a) Fuzzy Relational DB
b) Ecorithms
c) Fuzzy Set
d) None of the above

5. Fuzzy logic is usually represented as
   a) If-Then-Else rules
   b) If-Then rules
   c) Both If-Then-Else rules & If-Then rules
   d) None of the above
6. Fuzzy Set theory defines fuzzy operators. Choose the fuzzy operators from the following
   a) AND
   b) OR
   c) NOT
   d) All of the above
7. The value of the set membership is represented by
   a) Discrete Set
   b) Degree of truth
   c) Probabilities
   d) Both Degree of truth & Probabilities

8. The room temperature is hot. Here the hot (use of linguistic variable is used) can be represented by……………………..
   a) Fuzzy Set
   b) Crisp Set
   c) Fuzzy & Crisp Set
   d) None of the above
9. The true values of a traditional set theory is ……………………… and that of fuzzy set is …………………
   a) Either 0 or 1, between 0 & 1
   b) Between 0 & 1, either 0 or 1
   c) Either 0 or 1, either 0 or 1
   d) Between 0 & 1, between 0 & 1
10. Fuzzy logic is a set of ………………………………………………..
    a) Two-valued logic
    b) Crisp set logic
    c) Many-valued logic
    d) Binary set logic

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EXPERT SYSTEM

GROUP ASSIGNMENT

1. I am an expert system, and I perform real-time control tasks and therefore look very much like an agent. Who am I?
   a) ARCHON
   b) SOPHIE
   c) PRICE-STRAT
   d) MOLGEN
   e) None of the above

Ans:

2. Based on the number of rules in the rule base, expert system maybe classified as small, medium and large. A medium system may consist of up to……………..rules in its rule base.
   a) 5000
   b) 10000
   c) 20000
   d) 25000
   e) 30000

Ans:

3. Quite often in the expert systems literature warnings are given against becoming one's own expert. In fact, one of the most highly touted expert system, and one that is in actual use is the ... ... system for the configuration of VAX computers at the DEC. The initial prototype of this system was developed primarily by a knowledge engineer.
a. MYCIN
b. PROSPECTOR

c. MOLGEN
d. XCON
e. ARTIFACT
Ans: d

4. It is a belief (based on rather substantial empirical evidence) that it takes approximately 1 5 years to become an expert in a particular domain. This statement is ....
a. True
b. False
Ans: a

5. As compared to ES, conventional software development technology deals with knowledge which access and maintain structured data. This statement is
a. True
b. False
Ans: a

6. A...... is essentially a meta-explanation that explains the expert system's explanation of its reasoning.
a. Meta-rule
b. Syllogism
c. Warrant
d. Deduction
e. Premise
Ans: b

7. Each of these drawbacks above may be alleviated to some degree, by providing access to an in-house or external group of.... ...
a. Domain experts
b. Users
c. Subject matter experts
d. Knowledge engineers
e. Computer programmers
Ans: d

8. An Expert System may be highly interactive (directly asking the user questions) or ………where all input comes from another program.
a. In-built
b. off-line
c. embedded
d. functional
e. encapsulated

Ans: c

9. Expert Systems software can be developed for any problem that involves a selection from among a definable group of choices where the decision is based on .... steps. Any area where a person or group has special expertise needed by others is a possible area for an expert system.
a. Programmable
b. Sequential
c. Algorithmic
d. Logical
e. Ordered
Ans: d

10. Expert Systems contain the facts and procedures representing the rule of thumb decision making processes of an expert. That collection is kept in a .... that is separate from a control program
a. Database
b. Knowledge base
c. Workspace
d. Scratchpad
e. Blackboard
Ans: b

GYAWU KOFI BAFFOUR

2565114

CSM 497 MCQS

1. Which of the following is an advantage of using an expert system development tool? a. Imposed structure
   b. Knowledge engineering assistance
   c. Rapid prototyping
   d. All the above

2. The first widely-used commercial form of artificial intelligence is being used in many popular products like microwave ovens, automobiles and plug in circuit boards for desktop PCs. It allows machines to handle vague information with a deftness that mimics human intuition. What is the name of this artificial intelligence? a. Boolean logic

b. Human logic
c. Fuzzy logic
d. Functional logic

3. An expert system is
   a. A computer that can answer questions like a human expert.
   b. A group of scientists who design computer programs.
   c. A method of producing new words.
   d. A computer that can feel emotions.

4. Expert system is an area in AI?
   a. True
   b. False

5. What language is used in expert systems?
   a. Java
   b. Visual basic
   c. CLIPS
   d. Python

6. Expert systems consist of ………….. main components.
   a. 2
   b. 3
   c. 4
   d. 5

7. ……………………………… Is obtainable from books, magazines, knowledgeable persons, etc. a. Inference engine
   b. Problem domain
   c. Knowledge domain
   d. Knowledge base

8. …………………………… draws conclusion from knowledge base.
   a. Inference engine
   b. Problem domain
   c. Knowledge domain
   d. Knowledge base

9. The expert's knowledge about solving specific problems is called?
   a. Inference engine

b. Problem domain
c. Knowledge domain
d. Knowledge base

10. The problem domain is always a superset of the knowledge domain.
    a. True
    b. False

11. What is logic?
    a. Process of reasoning
    b. Process of thinking
    c. Study of making inferences
    d. Process of making good decisions

12. Formal logic is a more rigorous approach to proving a conclusion to be true or false. a. True
    b. False

13. Semantics refers to meanings we give to words.
    a. True
    b. False

14. All the following are goals of expert systems except?
    a. We need to be able to separate actual meanings of words with the reasoning process itself
    b. We need to make inferences without relying on semantics
    c. We need to teach machines how to reason correctly
    d. We need to reach valid conclusions based on facts only

15. Expert systems are designed for knowledge representation based on rules of logic called…………………… a. Semantics
    b. Logic
    c. Inferences
    d. Reasoning

16. Arguments refers to the formal way facts and rules are used to reach valid conclusions. a. True
    b. False

17. The process of reaching valid conclusions is referred to as ……………
    a. Logical reasoning
    b. Heuristics
    c. Precedents handling

d. Declarative knowledge

18. Epistemology is the formal study knowledge.
    a. True
    b. False

19. Expert systems reason while humans infer.
    a. True
    b. False

20. How many categories are in epistemology?
    a. 5
    b. 6
    c. 7
    d. 8

21. A tree is a hierarchical structure consisting of ……………… and ………….
    i. Nodes
    ii. Branches iii.
    Lines iv. Links

    a. I and III
    b. II and III
    c. I and II
    d. III and IV

22. Which node is referred to as the root node and occupies the highest hierarchy?
    a. Bottom node
    b. Top node
    c. End node
    d. Last node

23. The nodes at the bottom of a tree are referred to as
    a. Top node
    b. End node
    c. Last node
    d. Leaves

24. The root node of a tree has exactly one parent.
    a. True

b. False

25. Every node may give rise to zero or more child nodes.
    a. True
    b. False

26. A binary tree restricts the number of children per node to a maximum of 2.
    a. True
    b. False

27. Degenerate trees do not have only a single pathway from root to its one leaf.
    a. True
    b. False

28. Graphs are sometimes called a …………………….. or net
    a. Directed trees
    b. Multiple trees
    c. Network
    d. Links

29. A …………………… Is a path through the graph beginning and ending at the same node. a. Links
    b. Circle
    c. Circuit
    d. Loop

30. Lattice is an undirected acyclic graph.
    a. True
    b. False

31. Lack of information to formulate a decision is termed as?
    a. Unreliability
    b. Uncertainty
    c. A and B
    d. None of the above

32. Uncertainty may result in one of the following
    a. Making poor or bad decision
    b. Making information available
    c. Making information unreliable
    d. Making information irrelevant

33. Deductive reasoning deals with
    a. Premises supporting the conclusion
    b. Exact facts and exact conclusions
    c. A and B
    d. None of the above

34. When repeated trials in a system give the exact same results, the system is termed as a. Unrealistic
    b. Nondeterministic
    c. Deterministic
    d. Ambiguous

35. …………………………… probability defines the probability of an event, as the limit of a frequency distribution.
    a. Subjective
    b. Experimental
    c. Classic
    d. Theoretical

36. ………………………….. probability deals with events that are not reproducible and have no historical basis on which to extrapolate. a. Subjective
    b. Experimental
    c. Classic
    d. Theoretical

37. …………………………… events are events that do not affect each other.
    a. Reliable
    b. Independent
    c. Simple
    d. Compound

38. The probability of an event A occurring, given that event B has already occurred is called a. Theoretical probability
    b. Classic probability
    c. Subjective probability
    d. Conditional probability

39. Dijkstra's algorithm is an approach to dealing with uncertainty.
    a. True
    b. False

40. Shannon theory is an approach to dealing with uncertainty.
   a. True
   b. False

41. …………………… is concerned with the correctness of the system's building blocks.
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   b. Verification
   c. Authorization
   d. validation

42. ……………………. refers to minimizing the global uncertainties of the entire system.
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43. The certainty factor is a way of combining belief and disbelief into a single number. a. True
   b. False

44. In MYCIN, a rule's antecedent certainty factor must be less than 0.2 for the antecedent to be considered true and activate the rule. a. True
   b. False

45. What is an environment is called when its elements may be interpreted as possible answers and only one answer is correct? a. Knowledge base
   b. Inference engine
   c. A frame of discernment
   d. Mutually exclusive

46. Dempster's rule combines ……………… to produce a new mass that represents the consensus of the original, possibly conflicting evidence. a. Theorems
   b. Mass
   c. Probabilities
   d. None of the above.

47. The lower bound is called ……………………
   a. Support
   b. Plausibility
   c. Belief measure
   d. None of the above

48. The upper bound is called ……………………
   a. Support
   b. Plausibility
   c. Belief measure
   d. None of the above

49. …………………… is theory of uncertainty based on fuzzy logic and concerned with qualifying and reasoning using natural language where words have ambiguous meaning. a. Complete reasoning
   b. Approximate reasoning
   c. Partial reasoning
   d. None of the above

50. Fuzzy logic is a subset of conventional logic extended to handle partial truth. a. True
   b. False

51. Building an expert system, what do we take in consideration?
   a. Why are we building the system?
   b. What tools will be available to build the system?
   c. How much will the system cost?
   d. All the above

52. How many stages are involved in building an expert system?
   a. 3
   b. 4
   c. 5
   d. 6

53. At what stage do knowledge engineers do verification?
   A. Feasibility study
   B. Rapid prototype
   C. Refined system
   D. Field testable

54. At which stage do you demonstrate ideas?
   a. Feasibility study
   b. Rapid prototyping
   c. Refined system
   d. Field testable

55. In the waterfall model, each stage ends with ……………… and ………………… activity to minimize any problems in that stage. i. Authentication ii. Verification iii. Validation iv. Authorization

a. I and IV
b. I and II
c. II and III
d. II and IV

56. In the waterfall model, arrows go back and forth only one stage at a time.
a. True
b. False

57. What model led to the do-it-twice concept where a prototype then a final system was built? a. Waterfall model
b. Code-and-fix model
c. Incremental model
d. Spiral model

58. Which model is a refinement of the waterfall model and top-down-approach? a. Spiral model
b. Code-and-fix model
c. Incremental model
d. None of the above

59. Expert systems may have serious responsibilities.
a. True
b. False

60. At which stage in the development stages of expert systems are bugs repaired to enhance capabilities?
a. Rapid prototyping
b. Feasibility study
c. Field testability
d. Maintenance and evolution

1. Which of the following is an advantage of using an expert system development tool?
   a. Imposed structure
   b. Knowledge engineering assistance
   c. Rapid prototyping
   d. All the above

2. The first widely-used commercial form of artificial intelligence is being used in many popular products like microwave ovens, automobiles and plug in circuit boards for desktop PCs. It allows machines to handle vague information with a deftness that mimics human intuition. What is the name of this artificial intelligence?
   a. Boolean logic
   b. Human logic
   c. Fuzzy logic
   d. Functional logic

3. An expert system is
   a. A computer that can answer questions like a human expert.
   b. A group of scientists who design computer programs.
   c. A method of producing new words.
   d. A computer that can feel emotions.

4. Expert system is an area in AI?
   a. True
   b. False

5. What language is used in expert systems?
   a. Java
   b. Visual basic
   c. CLIPS
   d. Python

6. Expert systems consist of ………….. main components.
   a. 2
   b. 3
   c. 4
   d. 5

7. ……………………………… Is obtainable from books, magazines, knowledgeable persons, etc.
   a. Inference engine
   b. Problem domain
   c. Knowledge domain
   d. Knowledge base

8. …………………………… draws conclusion from knowledge base.

a. Inference engine
b. Problem domain
c. Knowledge domain
d. Knowledge base

9. The expert's knowledge about solving specific problems is called?
   a. Inference engine
   b. Problem domain
   c. Knowledge domain
   d. Knowledge base

10. The problem domain is always a superset of the knowledge domain.
    a. True
    b. False

11. What is logic?
    a. Process of reasoning
    b. Process of thinking
    c. Study of making inferences
    d. Process of making good decisions

12. Formal logic is a more rigorous approach to proving a conclusion to be true or false.
    a. True
    b. False

13. Semantics refers to meanings we give to words.
    a. True
    b. False

14. All the following are goals of expert systems except?
    a. We need to be able to separate actual meanings of words with the reasoning process itself
    b. We need to make inferences without relying on semantics
    c. We need to teach machines how to reason correctly
    d. We need to reach valid conclusions based on facts only

15. Expert systems are designed for knowledge representation based on rules of logic called……………………
    a. Semantics
    b. Logic
    c. Inferences
    d. Reasoning

16. Arguments refers to the formal way facts and rules are used to reach valid conclusions.
    a. True

b. False

17. The process of reaching valid conclusions is referred to as ……………
    a. Logical reasoning
    b. Heuristics
    c. Precedents handling
    d. Declarative knowledge

18. Epistemology is the formal study knowledge.
    a. True
    b. False

19. Expert systems reason while humans infer.
    a. True
    b. False

20. How many categories are in epistemology?
    a. 5
    b. 6
    c. 7
    d. 8

21. A tree is a hierarchical structure consisting of ……………… and ………….
    i. Nodes
    ii. Branches
    iii. Lines
    iv. Links

    a. I and III
    b. II and III
    c. I and II
    d. III and IV

22. Which node is referred to as the root node and occupies the highest hierarchy?
    a. Bottom node
    b. Top node
    c. End node
    d. Last node

23. The nodes at the bottom of a tree are referred to as
    a. Top node
    b. End node
    c. Last node
    d. Leaves

24. The root node of a tree has exactly one parent.
    a. True
    b. False

25. Every node may give rise to zero or more child nodes.
    a. True
    b. False

26. A binary tree restricts the number of children per node to a maximum of 2.
    a. True
    b. False

27. Degenerate trees do not have only a single pathway from root to its one leaf.
    a. True
    b. False

28. Graphs are sometimes called a …………………….. or net
    a. Directed trees
    b. Multiple trees
    c. Network
    d. Links

29. A …………………… Is a path through the graph beginning and ending at the same node.
    a. Links
    b. Circle
    c. Circuit
    d. Loop

30. Lattice is an undirected acyclic graph.
    a. True
    b. False

31. Lack of information to formulate a decision is termed as?
    a. Unreliability
    b. Uncertainty
    c. A and B
    d. None of the above

32. Uncertainty may result in one of the following
    a. Making poor or bad decision
    b. Making information available
    c. Making information unreliable
    d. Making information irrelevant

33. Deductive reasoning deals with
    a. Premises supporting the conclusion
    b. Exact facts and exact conclusions
    c. A and B
    d. None of the above

34. When repeated trials in a system give the exact same results, the system is termed as
    a. Unrealistic
    b. Nondeterministic
    c. Deterministic
    d. Ambiguous

35. ………………………… probability defines the probability of an event, as the limit of a frequency distribution.
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EXPERT SYSTEMS ASSIGNMENT

MCQs

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CHAPTER 1

1. A/an ………….is a computer system that emulates or acts in all respects with the decision making capabilities of a human expert.
   a. **Expert System**
   b. Knowledge System
   c. Robotics
   d. AI

2. The expert's knowledge about solving specific problems is called ………
   a. **Knowledge Domain**
   b. Solution Domain
   c. Research Domain
   d. Problem Domain

3. ……… is always a superset of the ………
   a. Knowledge Domain, Problem Domain
   b. Problem Domain, Research Domain
   c. **Problem Domain, Knowledge Domain**
   d. Solution Domain, Research Domain

4. ……… is used in chemical mass spectroscopy to identify chemical constituents.
   a. PROSPECTOR
   b. MYCIN
   c. DIPMETER
   d. **DENDRAL**

5. ……… Is used in medical diagnosis of illness.
   a. PROSPECTOR
   b. **MYCIN**
   c. DIPMETER
   d. DENDRAL

6. ……… is used in geological data analysis for oil.
   a. PROSPECTOR
   b. MYCIN
   c. **DIPMETER**
   d. DENDRAL

7. . ………………… is used in geological analysis for minerals.
   a. PROSPECTOR
   b. MYCIN
   c. DIPMETER
   d. DENDRAL

8. . ……………… is used in configuring computer systems.

   a. PROSPECTOR
   b. MYCIN
   c. DIPMETER
   d. **XCON/RI**

9. ……………….. is a prioritized list of rules created by the inference engine, whose patterns are satisfied by facts or objects in working memory.

   a. Agenda
   b. Algorithm
   c. Knowledge Acquisition Facility
   d. Propaganda

10.……… refers to reasoning in reverse from a hypothesis, a potential conclusion to be proved to the facts that support the hypothesis --- best for diagnosis problems.
   a. Forward chaining
   b. Middle chaining
   c. **Backward chaining**
   d. Basic idea

CHAPTER 2

1. ……… is the study of making inferences given a set of facts
   a. Wisdom
   b. **Logic**
   c. Semantics
   d. Argument

2. ……… refers to the meanings we give to symbols
   a. Logic
   b. Argument
   c. **Semantics**
   d. Inference

3. Expert systems are designed for knowledge representation based on rules of logic called ………
   a. Logic
   b. Semantics
   c. **Inferences**
   d. Arguments

4. An ……… refers to the formal way facts and rules of inferences are used to reach valid conclusions.
   a. **Argument**
   b. Rules
   c. Epistemology
   d. Tacit

5. Which of the following is not a category of epistemology?
   a. Philosophy
   b. Tacit
   c. A priori
   d. **Uncertainty**

6. In expert systems, an ……… is the metaknowledge that describes everything known about the problem domain.
   a. Semantic net
   b. ANS
   c. **Ontology**
   d. Conceptual graph

7. Semantic nets consists of ……… and ………
   a. Objects and Relationships
   b. Propositions and Prepositions
   c. **Nodes and Arcs**
   d. Atoms and Chains

8. In PROLOG, a predicate expression consists of the ……… followed by zero or more ……… enclosed in ……… separated by commas.
   a. **Predicate name, Arguments, Parenthesis**
   b. Predicate name, Inferences, Parentheses
   c. Expression header, Logical expressions, Parenthesis
   d. Predicate name, Logical expression, Parenthesis

9. The OAV triplet can be used to characterize all the knowledge in a semantic net. OAV stands for?

a. Objective---Allocation---Valuation
b. Object---Allocation---Value
c. Objective---Attribute---Valuation
d. **Object---Attribute---Value**

10. In propositional logic, a statement that is neither a tautology nor a contradiction is called a ………

a. Material Implication
b. **Contingent statement**
c. Biconditional
d. Open sentences

CHAPTER 3

1. A ……… is a hierarchical structure consisting of nodes and branches. a. Linked list
   b. Struct
   c. **Tree**
   d. Net

2. What type of tree has only a single pathway from the root to its one leaf?
   a. Binary tree
   b. **Degenerate tree**
   c. Lean tree
   d. Atomic tree

3. A ……… is a diagram describing the finite number of states of a machine.
   a. ANS
   b. DNS
   c. **FSM**
   d. FGM

4. In the types of Logic, Intuition is explained as ………
   a. **No proven theory**
   b. Rules of thumb based on experience
   c. Trial and error
   d. Reasoning where conclusions must follow from premises

5. In the types of Logic, Heuristics is explained as ………

a. No proven theory
b. **Rules of thumb based on experience**
c. Trial and error
d. Reasoning where conclusions must follow from premises

6. Default is also explained as ………
   a. Self---knowledge.
   b. Reasoning back from a true condition to the premises that may have caused the condition.
   c. Inferring conclusions based on similarities with other situations
   d. **Absence of specific knowledge**

7. Which of the following is not a requirement of a Formal System
   a. An alphabet of symbols
   b. Completeness
   c. Axioms
   d. **Accurate Semantics**

8. What does Wffs stand for in Expert Systems?
   a. **Well formulated formulas**
   b. Well founded facts
   c. Well formulated facts
   d. Well founded formulas

9. A ……… is a group of multiple inferences that connect a problem with its solution.

a. Connect
b. **Chain**
c. Inference net
d. Hypothesis

10. Which of the following is **not** a type of logic?
    a. Nonmonotonic
    b. Autoepistemic
    c. Generate and Test
    d. **Trial and Error**

CHAPTER 4

1. Logic system provides an advantage when dealing with
    a. Logic
    b. **Uncertainty**
    c. Humans

d. Semantic nets

2. Which of the following deals with exact facts and exact conclusion
   a. Inductive reasoning
   b. Uncertainty
   c. Logic
   d. **Deductive reasoning**

3. Accepting a hypothesis when it is not true is
   a. **False positive**
   b. False negative
   c. Semantic nets
   d. Inductive reasoning

4. Inductive reasoning
   a. Deals with exact facts and exact conclusion
   b. **Support the conclusion but do not guarantee it**
   c. A form of declarative knowledge
   d. Using knowledge in beneficial way

5. Rejecting a hypothesis when it is true is
   a. False positive
   b. **False negative**
   c. Semantic nets
   d. Inductive reasoning

6. When repeated trials give the exact same result, the system is
   a. Unreliable
   b. Deductive
   c. **Deterministic**
   d. Inaccurate

7. How well the truth is known is
   a. Error of accuracy
   b. Unreliability
   c. **Error of precision**
   d. Inductive reasoning

8. Random fluctuations are also termed as
   a. Systematic errors
   b. **Random error**
   c. False negative
   d. Error of precision

9. Compound probabilities can be expressed by
   a. **P(A∩B) = n(A∩B) / n(s)**
   b. LS = P(E|H) / P(E|H)
   c. P(H|e)
   d. Ln = p(E'|H) / P(E'|H')

10. Which type of belief is false
   a. Possible
   b. Probable
   c. **Impossible**
   d. Plausible

CHAPTER 5

1. Two of the following are not sources of uncertainty that expert systems operate in

i. Conflict resolution ii. Knowledge base iii. Individual views

iv. Incompatibility of rules

a. i and ii

b. ii and iii
c. iii and iv
d. i and iii
Answer **b**

2. The certainty factor, CF, is way of combining __________ and _________ into a single number. a. Belief and truth
b. Disbelief and falsehood
c. Belief and disbelief
d. Truth and falsehood
Answer **c**

3. The certainty factor can be used to rank ________ in order of importance. a. Truth
b. Belief
c. Evidence
d. Hypothesis
Answer **d**

4. In MYCIN, suppose another rule also concludes the same hypothesis, but with a different certainty factor, the certainty factor of rules concluding the same hypothesis are calculated from the ________________.
a. Certainty function
b. Reduction function
c. Combining function
d. Attenuation function Answer **c**

5. A theory that attempts to model uncertainty by a range of probabilities rather a single probabilistic number is a. Dempster---Shafer
b. Propagation of Probabilities
c. Approximate Reasoning
d. Inference Nets
Answer **a**

6. Evidential reasoning deals with information that is expected to be

a. uncertain, imprecise and occasionally inaccurate.
b. certain, precise and always accurate
c. imprecise and occasionally accurate
d. certain, precise and occasionally inaccurate. Answer **a**

7. Computing not based on classical two –valued logics which includes fuzzy logic, neural networks and probabilistic reasoning is known as

a. Approximate Logic
b. Soft Computing
c. Hard computing
d. Extended computing
Answer **b**

8. Which principle defines how to extend the domain of a given crisp set function to include fuzzy sets.

a. Approximate principle
b. Extended principle
c. Fuzzy set principle
d. Crisp set principle Answer **b**

9. Translation rules specify how modified or composite propositions are generated from their elementary propositions. The correct order for category of rules are

I. Modification rules
II. Quantification rules
III. Composition rules
IV. Qualification rules

a. I, III, II and IV
b. I, II, III and IV
c. IV, I, II, and III
d. II, III, I, IV

Answer **a**

10. Conditional, conjunctive, disjunctive fall under which category of translation rules.

a. Modification rules

b. Quantification rules

c. Composition rules

d. Qualification rules

Answer **c**

CHAPTER 6

1. Designing of expert systems of part of a general field is known as

a. Knowledge Management

b. Product Management

c. Project Management

d. Resource Management

Answer **a**

2. Expert systems payoff may include two of the following

i. Increased possibility

ii. Increased probability

iii. Increased efficiency

iv. Money

a. i and ii
b. ii and iii
c. iii and iv
d. i and iii

Answer **c**

3. The major sub management levels under project management are

a. Activity Management, Product Management, Change Management
b. Product Configuration Management, Resource Management, Change Management
c. Product Management, Resource Management, Activity Management
d. Activity Management, Product Configuration Management, Resource Management

Answer **d**

4. The general stages in the development of an expert system starts at the Feasibility study and ends with Maintenance and evolution.
The middle stages are

i. Commercial quality system
ii. Rapid Prototype
iii. Field Testable
iv. Refined System

a. i, ii, iii and iv
b. ii, iv, iii and i
c. iii, i, iv and ii
d. iv, ii, iii, i

Answer **b**

5. Major errors in expert systems may arise from knowledge base, knowledge engineer, inference engine and

a. Inference chain and expert
b. Expert and inference view
c. Inference chain and knowledge
d. Inference view and knowledge Answer **a**

6. A difficult term to describe in a general sense because it means different things to different people is ___________. a. quantity
b. quality
c. metrics
d. cost
Answer **b**

7. Factors to be considered in the design of expert systems include problem selection,
a. cut backs and money
b. cost and product assurance
c. payoff and expert knowledge
d. cost payoff
Answer **d**

8. Another term for life cycle is __________, because it is concerned with the two fundamental issues of software development. a. Life development
b. Software process
c. Process model
d. Process evolution Answer **c**

9. The knowledge definition stage consists of two main tasks one of which is
a. Knowledge source identification and analysis
b. Knowledge acquisition and selection
c. Knowledge acquisition, analysis and extraction
d. Knowledge source identification, analysis and extraction
Answer **c**

10. The objective of the knowledge verification stage is to determine the ______, _____ and _______.

a. Correctness, formal tests, test analysis
b. Correctness, completeness and consistency
c. Completeness, test analysis and consistency
d. Consistency, test analysis and formal tests.

Answer **b**

CSM 497(EXPERT SYSTEMS) MCQS

61. Which of the following is an advantage of using an expert system development tool?
    e. Imposed structure
    f. Knowledge engineering assistance
    g. Rapid prototyping
    h. All the above

62. The first widely-used commercial form of artificial intelligence is being used in many popular products like microwave ovens, automobiles and plug in circuit boards for desktop PCs. It allows machines to handle vague information with a deftness that mimics human intuition. What is the name of this artificial intelligence?
    e. Boolean logic
    f. Human logic
    g. Fuzzy logic
    h. Functional logic

63. An expert system is
    e. A computer that can answer questions like a human expert.
    f. A group of scientists who design computer programs.
    g. A method of producing new words.
    h. A computer that can feel emotions.

64. Expert system is an area in AI?
    c. True
    d. False

65. What language is used in expert systems?
    e. Java
    f. Visual basic
    g. CLIPS
    h. Python

66. Expert systems consist of ………….. main components.
    e. 2
    f. 3
    g. 4
    h. 5

67. ……………………………… Is obtainable from books, magazines, knowledgeable persons, etc.
    e. Inference engine
    f. Problem domain
    g. Knowledge domain
    h. Knowledge base

68. …………………………… draws conclusion from knowledge base.
    e. Inference engine
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69. The expert's knowledge about solving specific problems is called?
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f. Heuristics
g. Precedents handling
h. Declarative knowledge

78. Epistemology is the formal study knowledge.
c. True
d. False

79. Expert systems reason while humans infer.
c. True
d. False

80. How many categories are in epistemology?
e. 5
f. 6
g. 7
h. 8

81. A tree is a hierarchical structure consisting of ……………… and ………….
v. Nodes
vi. Branches
vii. Lines
viii. Links

e. I and III
f. II and III
g. I and II

h. III and IV

82. Which node is referred to as the root node and occupies the highest hierarchy?
    e. Bottom node
    f. Top node
    g. End node
    h. Last node

83. The nodes at the bottom of a tree are referred to as
    e. Top node
    f. End node
    g. Last node
    h. Leaves

84. The root node of a tree has exactly one parent.
    c. True
    d. False

85. Every node may give rise to zero or more child nodes.
    c. True
    d. False

86. A binary tree restricts the number of children per node to a maximum of 2.
    c. True
    d. False

87. Degenerate trees do not have only a single pathway from root to its one leaf.
    c. True
    d. False

88. Graphs are sometimes called a …………………….. or net
    e. Directed trees
    f. Multiple trees
    g. Network
    h. Links

89. A …………………… Is a path through the graph beginning and ending at the same node.
    e. Links
    f. Circle
    g. Circuit
    h. Loop

90. Lattice is an undirected acyclic graph.
    c. True

d. False

91. Lack of information to formulate a decision is termed as?
    e. Unreliability
    f. Uncertainty
    g. A and B
    h. None of the above

92. Uncertainty may result in one of the following
    e. Making poor or bad decision
    f. Making information available
    g. Making information unreliable
    h. Making information irrelevant

93. Deductive reasoning deals with
    e. Premises supporting the conclusion
    f. Exact facts and exact conclusions
    g. A and B
    h. None of the above

94. When repeated trials in a system give the exact same results, the system is termed as
    e. Unrealistic
    f. Nondeterministic
    g. Deterministic
    h. Ambiguous

95. …………………………… probability defines the probability of an event, as the limit of a frequency distribution.
    e. Subjective
    f. Experimental
    g. Classic
    h. Theoretical

96. ………………………….. probability deals with events that are not reproducible and have no historical basis on which to extrapolate.
    e. Subjective
    f. Experimental
    g. Classic
    h. Theoretical

97. …………………………… events are events that do not affect each other.
    e. Reliable
    f. Independent
    g. Simple

h. Compound

98. The probability of an event A occurring, given that event B has already occurred is called
e. Theoretical probability
f. Classic probability
g. Subjective probability
h. Conditional probability

99. Dijkstra's algorithm is an approach to dealing with uncertainty.
c. True
d. False

100. Shannon theory is an approach to dealing with uncertainty.
c. True
d. False

101. …………………… is concerned with the correctness of the system's building blocks.
e. Authentication
f. Verification
g. Authorization
h. validation

102. …………………….. refers to minimizing the global uncertainties of the entire system.
e. Authentication
f. Verification
g. Authorization
h. Validation

103. The certainty factor is a way of combining belief and disbelief into a single number.
c. True
d. False

104. In MYCIN, a rule's antecedent certainty factor must be less than 0.2 for the antecedent to be considered true and activate the rule.
c. True
d. False

105. What is an environment is called when its elements may be interpreted as possible answers and only one answer is correct?
e. Knowledge base
f. Inference engine
g. A frame of discernment
h. Mutually exclusive

106. Dempster's rule combines ……………… to produce a new mass that represents the consensus of the original, possibly conflicting evidence.

e. Theorems
f. Mass
g. Probabilities
h. None of the above.

107. The lower bound is called ………………………

e. Support
f. Plausibility
g. Belief measure
h. None of the above

108. The upper bound is called ……………………

e. Support
f. Plausibility
g. Belief measure
h. None of the above

109. …………………… is theory of uncertainty based on fuzzy logic and concerned with qualifying and reasoning using natural language where words have ambiguous meaning.

e. Complete reasoning
f. Approximate reasoning
g. Partial reasoning
h. None of the above

110. Fuzzy logic is a subset of conventional logic extended to handle partial truth.

c. True
d. False

111. Building an expert system, what do we take in consideration?

e. Why are we building the system?
f. What tools will be available to build the system?
g. How much will the system cost?
h. All the above

112. How many stages are involved in building an expert system?

e. 3
f. 4
g. 5
h. 6

113. At what stage do knowledge engineers do verification?

E. Feasibility study

F. Rapid prototype
G. Refined system
H. Field testable

114. At which stage do you demonstrate ideas?

e. Feasibility study
f. Rapid prototyping
g. Refined system
h. Field testable

115. In the waterfall model, each stage ends with ……………… and ………………… activity to minimize any problems in that stage.

v. Authentication
vi. Verification
vii. Validation
viii. Authorization

e. I and IV
f. I and II
g. II and III
h. II and IV

116. In the waterfall model, arrows go back and forth only one stage at a time.

c. True
d. False

117. What model led to the do-it-twice concept where a prototype then a final system was built?

e. Waterfall model
f. Code-and-fix model
g. Incremental model
h. Spiral model

118. Which model is a refinement of the waterfall model and top-down-approach?

e. Spiral model
f. Code-and-fix model
g. Incremental model
h. None of the above

119. Expert systems may have serious responsibilities.

c. True
d. False

120. At which stage in the development stages of expert systems are bugs repaired to enhance capabilities?

e. Rapid prototyping
f. Feasibility study
g. Field testability
h. Maintenance and evolution

MEMBERS

DWAMENA SANDRA – 2564714
OSEI ASIBEY KENNEDY – 2567614
BONSU SHADRACH – 2563514
FUAKYE-AKYEMPIM CHARLES – 2565014
ANKRAH JOSEPH – 2561914
DADZIE EBENEZER GEOFFREY – 2563914
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AGYEI-ANTWI DAVID – 2561314
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Introduction to Artificial Intelligence and Expert Systems

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Table of Contents

- Introduction
- What is Expert Systems (ES)
- Knowledge
- Representation

Knowledge Acquisition

Knowledge Acquisition Via Domain Expert Knowledge Acquisition Via Rule Induction

-
- [Inference Engine]
- [Advantages and Disadvantages]

Developing Knowledge Base

Introduction

The Human-Machine Contrast

Human intelligence consists of fact,concepts,rules and heuristic knowledge. Facts and concepts can be thought of as structures that house symbols. Rules and heuristic knowledge can be thought of as manipulators of the symbols. Mental models are formed using facts,concepts, rules, and heuristic knowledge in ever-changing arrays.
Human thinking can be viewed in term of categories of thinking. These categories are cognitive, associative, and philosophical.

Human cognitive thinking involves the gathering of input data and the manipulation of symbols. the manipulation of symbols take place through mental models. Machine thinking does an admirable emulation of the cognitive process. Both the human and machine are able to process input to reach decisions for action of project future events from that input.

Associative thinking consists of the concepts of vertical and lateral thinking. According to deBono (1973) there are two basic thinking styles, vertical and lateral. Vertical or logical, thinking involves movement from state to state through a series of justified steps. Lateral thinking uses information not for its own sake, but for its side effects. Vertical thinking is selective and lateral thinking is generative. Human are able to think laterally and machine cannot. Lateral thinking is associative with creativity and the ability of the mind to be self-organizing and self-maximizing.

Maximally efficient problem-solving uses both vertical and lateral thinking to address and resolve problem situations. While machine systems are adequate for certain tasks, there is still room for improvement in their capability for this kind of reasoning.

Philosophical thinking involves rhetorical query. It can encompass a patter-matching attempt such as, "Is there a correspondence between the breadth of a tree's branches and the breadth of its root system?, If so, is this correspondence consistent across species? What could I do with this information?".
Philosophical thinking can also involve pondering one's existence. It is the realm of original thought and involves self-consciousness. At this time, philosophical thought is the sole domain of humans.

Human Reasoning

- They use specific rules, a priori rules
- They Use Heuristics --- "rules of thumb"
- They use past experience --- "cases"
- They use "Expectations"

Artificial intelligence

Artificial intelligence is the branch of computer science that focuses on the development of computer systems to simulate the processes of problem solving and duplicate the functions of human brain. According to Elaine Rich (1983), "Artificial intelligence is the study of how to make computers do things at which, at moment, people are better". This simple, but eloquent, statement captures the essence of the pursuit.

Artificial intelligence comprises hardware and software systems and thechniques that attempt to emulate human mental and physical processes. The mental processes emulated include thinking, reasoning, decision making, data storage and retrieval, problem-solving, and learning. The physical processes include human senses and motor skills. Artificial is also called machine intelligence. Artificial intelligence is a serous pursuit, but most of its components are currently limited to the status of research and theory-based laboratory goals.

More detail

Expert Systems

An expert system is a narrow slice of computer intelligence and knowledge-based application. Its program are designed to emulate human decision-making expertise in a particular domain. Expert systems belong to a group of systems known as knowledge-based systems. Knowledge-based systems contain the facts and procedures representing the rule of thumb (heuristic) decision-making processes of an expert. That collection is kept in a knowledge base that is separate from a control program.

Natural Language Processing

Natural language processing is the most commonly explored branch of AI. A natural language is a spoken or written human language. Natural language are designed to accept language input, interpret and process the input, and output natural language result.
Natural language processing is divided into two sub-branches: understanding and output. Natural language understanding explores methods of computer comprehension of human language stimuli. Natural language output is the ability of computer to communicate verbally with a human.

Speech Recognition

Whereas natural language processing receives commands in text format, speech recognition allows a computer to respond to voice input. The goal of speech recognition research is to simplify the process of interactive communication between human and computers.
Speech recognition is accomplished by use of an electronic process which converts analog voice input into signals that can be understood by the NLP system. A process involving search and pattern recognition, and pattern matching is used. The speech recognition ability accomplished through hardware, although the use of software processes is gaining. By using a software approach, speech recognition and NLP can be combined.

Robotics

In contrast to AI efforts to emulate human mental abilities, robotics is concerned with engineering attempts to duplicate human physical attributes. Robot are electromechanical machines that are programmable and perform manipulative tasks. These task range from delicate to heavy-duty. A typical robot is a manipulator arm used in manufacturing to weld, paint, insert screws, lift, and move parts.

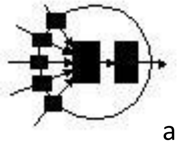
Artificial neural networks

- Based on pattern recognition - used for credit assessment and fraud detection
- A set of interconnected relatively simple mathematical processing elements
- Looks for patterns in a set of examples and learns from those examples by adjusting the weights of the connections to produce output patterns
- Input to output pattern associations are used to classify a new set of examples
- Able to recognize patterns even when the data is noisy, ambiguous, distorted, or has a lot of variation
- Neural network construction and training the architecture
    - used (e.g. feed-forward)
    - how the neurons are organized (e.g. an input layer with five neurons, two hidden layers with three neurons each, and an output layer with two neurons.) the state function
    - used (e.g. summation function) the transfer functions used (e.g. sigmoid squashing function)
    - the training algorithm used (e.g. back-propagation)
- Architecture
    - How the processing elements are connected Commonly used architectures:
        - feed-forward

Feed-Forward Neural Network Structure

        - Boltzmann
- Layers (also called levels, fields or slabs)
    - Organized into a series
        - of layers input
        - layer
        - one or more hidden layers
    - output layer
    - Some consider the number of layers to be part of architecture
    - Others consider the number of layers and nodes per layer to be attributes of the network rather than part of the architecture
- Neurons - the processing elements

The vocabulary in this area is not completely consistent and different authors tend to use one of a small set of terms for a particular concept. [Structure of a Neuron]

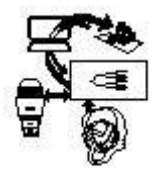


- consists of
    - a set of weighted input connections
    - a bias input
    - a state function
    - a nonlinear transfer function
    - an output
- Input connections have an input value that is either received from the previous neuron or in the case of the input layer from the outside
- Bias is not connected to the other neurons in the network and is assumed to have an input value of 1 for the summation function
- Weights
    - A real number representing the strength or importance of an input connection to a neuron
    - Each neuron input, including the bias, has an associated weight
- State function
    - The most common form is a simple summation function
    - The output of the state function becomes the input for the transfer function
- Transfer function
    - A nonlinear mathematical function used to convert data to a specific scale
    - Two basic types of transfer functions: continuous and discrete
    - Commonly used continuous functions used are Ramp, Sigmoid, Arc Tangent and Hyperbolic Tangent
    - Continuous functions sometimes called squashing functions
    - Commonly used discrete functions are Step and Threshold
    - Discrete transfer function sometimes called activation function

- Training
    - The process of using examples to develop a neural network that associates the input pattern with the correct answer
    - A set of examples (training set) with known outputs (targets) is repeatedly fed into the network to "train" the network
    - This training process continues until the difference between the input and output patterns for the training set reaches an acceptable value
    - Several algorithms used for training networks most common is back-propagation
    - Back-propagation is done is two passes
        - First the inputs are sent forward through the network to produce an output
        - Then the difference between the actual and desired outputs produces error signals that are sent "backwards" through the network to modify the weights of the inputs.

What is Expert Systems (ES)?

Currently, the most common form of expert system



Structure of a Rule-based Expert System

- User Interface
  - Friendly
  - Maybe "Intelligent"
    - Knowledge of how to present information
    - Knowledge of user preferences...possibly accumulate with use
- Databases
  - Contains some of the data of interest to the system
  - May be connected to on-line company or public database
  - Human user may be considered a database
-
  - Inference Engine general
  - problem-solving knowledge or
  - methods interpreter analyzes and processes the rules scheduler determines which rule to look at next

    the search portion of a rule-based system takes advantage of heuristic information
  -
    - otherwise, the time to solve a problem could become
    - prohibitively long this problem is called the combinatorial
    - explosion
  - expert-system shell provides customizable inference engine
- Knowledge Base (rule base) contains much
  - of the problem solving knowledge
  - Rules are of the form IF condition THEN action condition portion of the rule is usually a
    - fact - (If some particular fact is in the database then perform this action)
    - action portion of the rule can include actions that affect the
      - outside world (print a message on the terminal) test
      - another rule (check rule no. 58 next) add a new fact to
      - the database (If it is raining then roads are wet).

- Rules can be specific, a priori rules (e.g., tax law . . . so much for each exemption) - represent laws and codified rules
- Rules can be heuristics (e.g. If the meal includes red meat then choose red wine). "rules of thumb" represent conventional wisdom.
- Rules can be chained together (e.g. "If A then B" "If B then C" since A--->B--- >C so "If A then C").

  (If it is raining then roads are wet. If roads are wet then roads are slick.)
- Certainty factors represent the confidence one has that a fact is true or a rule is valid

Classification of Expert Systems

In an attempt to classify expert system for discussion purpose, schemas have been devised that are based on the number of rules. These classification systems suggest that there are three basic classes of expert system : small, medium, and large. A small systems has been defined as one that uses a knowledge base comprising fewer than 500 rules. A medium system consists of up to 10,000 rules, and large system has in excess of 10,000 rules.

Classification based on number of rules

Classification	Number of Rules
Small	< 500 rules
Medium	£ 10,000 rules
Lar ge	> 10,000 rules

Human professionals are classified in term of their level of performance, ranging from novice to expert. The proposed schema is based on function and performance rather than rule quantity. Each level of system provide the functionality of its preceding level or levels.

Level 0

The base-level system is self-contained. This system makes no call outside its knowledge base, but can display explanations. A Level 0 system has restricted reasoning methods such as backward chaining, forward chaining, inductive reasoning, a rule-based method, or example-based reasoning.

Level 1

Level 1 systems can make use of external program calls. These systems are used for a wide variety of popular applications such as intelligent databases, diagnostic systems, and other application that can effect a two-way flow of communication. These system have a free exchange of data between the user an peripherals.

In addition, level 1 systems have the following options: forward and backward chaining selection, math ability, control over peripherals, data interface option, an explanation sub-system that describes the line of reasoning upon request, inference cut-off, window definition, import of text, leaner control, line positioning option, and user interface control.

Level 2

Level 2 systems can serve as closed-loop or modified closed-loop systems. They are typically used to perform such as diagnosis and prescription and then to effect the prescription through communication links. For example, a system could be located in a manufacturing facility. This system would be designed to monitor a control process and detect out-of-range limits through sensors. Once an out-of-range situation is detected, the system send messages that modify operations by shutting valves, altering a flow, etc.

Level 3

Level 3 systems offer higher-level functioning across a variety of application. In addition, these system operate in a variety of operating systems and environments such as OS/2 or UNIX, and they can execute on mainframe or Pcs. The developer has control over the type of output code generated such as LISP, Prolog, C, or Pascal. Level 3 system developers also have control over search selection: Hierarchical search, depth-first, breadth-first, etc. Level 3 systems are found in applications that typically involve over six person-years to develop.

Level 4

A level 4 system is a system that can automatically add to and thereafter alter its knowledge base. This is a system that can learn. Level 4 system are found in research labs and are not available for commercial use at this time.

Classification based on performance

Feature	Level 0	Level 1	Level 2	Level 3	Level 4
Explanation facility	√	√	√	√	√
External program call		√	√	√	√
Inference selection		√	√	√	√
Serve as closed-loop			√	√	√
Variety of OS				√	√
Can learn					√

Knowledge Representation

Knowledge representation is a method used to encode the knowledge for use by the expert system, and putting the knowledge into rules or cases or other representations.

COMPONENTS OF KNOWLEDGE IN EXPERT SYSTEMS

The knowledge that is contained within an expert system consists of :

- A priori knowledge. The facts and rules that are known about a specific domain prior to any consultation session with the expert system
- Inferred knowledge: the facts and rules [1] concerning a specific case that are derived during, and at the conclusion of. a consultation with the expert system

Our concern will be with the manner in which these types of knowledge. and in particular knowledge of the first type, may be represented within the digital computer. In particular, our attention will be focused on the use of rule bases for the representation of expert knowledge.

(1) Actually. rules are generated during a consultation session only if our expert system is capable of learning. In general. inferred knowledge consists simply of new facts, or conclusions.

In the brief introduction to expert systems, it was noted that knowledge is contained within both the expert system's knowledge base and its working memory. The knowledge within the knowledge base is that of the first type, that is, a priori facts and rules about the specific domain. The knowledge within the working memory is dynamic as it changes for each problem addressed and is of the second type. that is, inferred knowledge about the particular problem under consideration. To clarify these concepts, consider the following example in which we are concerned with the knowledge base of a loan officer at a bank.

THE KNOWLEDGE BASE OF AN EXPERT LOAN OFFICER.

Let us introduce Dan Smith. Dan has been one of the senior loan officers for a bank in Houston for nearly 20 years, and he is generally considered to be the most capable of the loan officers at the bank. Thus, in the specific domain of bank loans, Dan is an expert.

As a loan officer, it is Dan's job to decide the disposition of loan applications received by the bank. Specifically, he must evaluate each application to determine whether or not a loan should be granted and, if granted, the rate and duration (and any other pertinent terms) of the loan.

There are two basic types of mistakes that a loan officer can (and will, regardless of his or her expertise) make. First, a loan may be denied to a person who might actually have made all the payments. Denial of such a loan represents, on the part of the bank. a lost opportunity. Second, a loan may be granted to someone who later defaults on the payments. In this instance, the granting of this type of loan results in reduced revenue. The loan officer must thus establish some sort of policy to balance off these two events in order to attempt to maximize the bank's profits, minimize its risks, and still maintain good customer relations.

The policy ultimately arrived at will be one that combines two sources of knowledge. That is, the loan officer will use what he or she has been taught through formal course work and training. The knowledge obtained through formal study, or available in the public domain (e.g., in books, manuals) is termed deep knowledge and forms just one part of the expert's knowledge base. However, in addition to this deep knowledge, an expert develops, through experience, his or her own set of heuristic rules. These heuristic rules are termed shallow knowledge: and they are the rules that we particularly wish to include in the knowledge base. Through the use of the expert's heuristic rule set. and in conjunction with the facts that are accessible, he or she is able to obtain better results, and in less time, than that of a novice.

Returning to the specific case of Dan Smith. Let us consider the portion of the knowledge base which is stored within his memory. Irrespective of the applicant under consideration. Dan has somehow accumulated a set of heuristic rules and facts concerning the granting of loans. For example, some of the facts that may be stored might include the following:

- Loan applicants fill out formal application forms.
- At this time, the bank is particularly concerned with avoiding
- bad loans. The XYZ Corporation is considering personnel layoffs.

Also stored in Dan's memory are the heuristic rules he uses in the disposition of any loan application. For example. one such rule may be "whenever the bank expresses particular concern about bad loans. place additional emphasis on the applicant's long-term employment prospects.'' This might be represented by the following statement, or rule:

If the bank is particularly worried about bad loans

Then emphasize the applicant's employment prospects

Remember that the above facts and rules are those appropriate for any case. Let us now turn to the actual decision making process for a specific loan applicant. Our applicant, Pete Jones. first fills out an application form on which he is asked to list the values for such attributes as his age, annual income, employer, length of time with employer. education, address, marital status, number of dependents, previous credit history, home ownership status (i e., does the applicant own or rent his or her residence and what are the monthly payments), number of automobiles (and monthly payments). and so on.

The information on this form represents facts about a particular individual (i.e., Pete Jones in our example). While Dan Smith will certainly consider these facts during his decision making process. they most likely will be forgotten once the decision has been reached. And there is, in .act, no point in remembering all the details of every loan application. Thus, we can consider the facts derived from Pete Jones' application form to be in Dan's working memory, where this working memory is physically represented by the application form itself. Some of the facts that may become available through Pete Jones' application are that he works for the XYZ Corporation and makes S50.000 per year, or

- Applicant's name = Pete Jones
- Applicant's salary = $50,000
- Applicant's employer = XYZ Corporation

Now, based on the data (i.e.. facts) on the application form, there are typically certain formal policies that the bank follows with regard to the evaluation process. They may, for example, have a policy that a loan should not be granted if the monthly payments associated with that loan exceed some percentage of the applicant's takehome income. Such rules are those associated with deep knowledge in that they are in the public domain (i.e., available to all key bank personnel) Consequently, if Dan examines the form and finds that Pete is in clear violation of several such rules, he may immediately conclude that no loan should be made Such clear-cut cases are not. however. situations in which expertise is most valuable. Rather. it is quite often in the marginal cases where an expert can make significant difference.

For the purpose of discussion, let us assume that the facts available through Pete's application form are such that, while marginal, they do not serve to rule out the granting of a loan However. since the application is marginal, this is a signal to Dan to give it even more attention than usual.

For example, Dan might first look at Pete's address. which happens to be in a section of town that is in somewhat of a state of decline. Dan recalls that it is taking longer and longer to sell houses in that area, and that house prices there have declined relative to the rest of the housing market. Further. Pete has been with his present employment for only two years, and that particular employer {i e., the XYZ corporation). is not noted for employment stability. Coupled with this is the fact that Pete's present mortgage payments are relatively high and the amount paid for his house now seems somewhat on the high side. Dan concludes that there is good reason to expect that the applicant might soon be placed in a position that would result in a default on the loan. And he has made this decision based on the rules and facts in his knowledge base coupled with the facts in working memory (i.e., the application form). At this point, a loan investigator might well conclude that the loan should be denied. However, Dan has learned that a personal interview is often of prime importance to his decision (and this is yet another heuristic rule in his memory. or knowledge base). Thus. he decides that even though the situation appears bleak, it may be worthwhile to talk directly with Pete.

During the interview, Dan asks a number of carefully calculated questions: questions that are intended to draw out additional information from the applicant. However, Dan has also learned, through his experience, to first relax the applicant by making small talk. In doing so in the past, he has found that quite often some unexpected, but pertinent information may result. In fact, when chatting with Pete, Dan discovers that he is married to the daughter of the vice president of the XYZ Corporation. This vice president, in turn, is a major shareholder and very securely positioned in the company. Dan concludes that Pete's loan should be granted. He also adds a new heuristic to his knowledge base; that is, if the applicant is married to the child of one of the executives of the firm at which the applicant is employed. then the loan application is to be given additional weight.

CONSIDERATION IN KNOWLEDGE REPRESENTATION

In the above example, a large part of Dan's knowledge base (i.e.. including some portion of the deep knowledge available in the public domain) is retained within his memory. Somehow. some way. the facts and heuristic rules that he employs have been transformed into a format that can be both stored and retrieved from his brain. Investigators in artificial intelligence and psychology (among others) are keenly interested in just how this is achieved. and several theories have been proposed.

Our concern, however, shall be more immediate and far more pragmatic. We wish to store the knowledge base of an expert system in the memory of a digital computer, using means presently at hand. We are not, in fact, really concerned about whether or not the method of storage we employ has some analogy to the manner in which knowledge is stored in the human brain. We simply seek a fast, effective procedure for use with the computer. This is not at all meant to imply that we should consider the study of the brain and human memory to be unimportant. It most definitely is; but until that study provides results that may be used to refine or replace existing methods. we shall simply remain interested observers.

Thus, our major concerns deal with how to represent the facts and rules within the knowledge base to :

- Provide a format compatible with the computer.
- Maintain as close as possible a correspondence between this format and the actual facts and rules (i e.. the rules as they are perceived by the domain expert).
- Establish a representation that can be easily addressed, retrieved, modified, and updated .

Elaborating further on the last two points, it would be highly desirable to use a format that is transparent, that is, a representation scheme that may be easily read and understood by humans.

Several modes of knowledge representation have been proposed. As we have emphasized, the primary focus will be on rule-based systems for knowledge representation. since it is through this process that the knowledge bases of the expert systems to be described in this text will be developed. However, before we cover rule-based systems in detail, let us first discuss certain alternative modes of knowledge representation.

ALTERNATIVE MODES OF REPRESENTATION

In this section, briefly described will be the pertinent features of such modes of knowledge representation as OAV (or object attribute value) triplets, semantic networks, frames, logic programming. and neural networks. To begin, OAV triplets will be addressed. Not only are they a mode of knowledge representation in themselves. they also form the building blocks of virtually any other approach to knowledge representation.

1. OAV Triplets

Object attribute value triplets provide a particularly convenient way in which to represent certain facts within a knowledge base and may be extended (as we shall see) to provide the basis for the representation of heuristic rule. Each OAV triplet is concerned with some specific entity. or object. For example, our object of interest might be an airplane. Associated with every object is a set of attribute that serve to characterize that object. Using the airplane as an example (i.e., a the object), some of its attributes include the following:

- Number of engines
- Type of engine (e.g., jet or prop)
- Type of wing design (e.g., conventional or swept back)

FIGURE 4.1 OAV Network

For each attribute, there is an associated value, or set of values. For instance, in the case of the C:130 military cargo aircraft (known as the Hercules), the number of engines is four, the type of engine is prop, and the wing design is conventional. Notice in particular that values in OAV triplets may be numeric or symbolic. We may list these facts as shown below:

- Number of engines = 4
- Engine type = prop
- Wing design = conventional

Observe that, in this list, the object itself (i.e., the C130 aircraft) is never explicitly stated. Actually, the above statements represent AV (attribute value) pairs.

However, associated with any AV pair in some object. Thus, any pair implies an OAV triplet.

Yet another way to represent an OAV triplet would be through the use of a network representation as indicated in Fig. 4.1. The basic building blocks of a network are its nodes (i.e., the circles) and branches, or edges (i.e., the lines connecting two nodes). In Fig. 4. 1, the object is Pete Jones, the attribute is his income, and the specific value of his income is $50,000.

2. Semantic Networks

A semantic network may be thought of as a network that is composed of multiple OAV triplets in network form as illustrated in Fig. 4.1. However, rather than pertaining to just one attribute for a single object, semantic networks may be used to represent several objects, and several attributes per object. Returning to our aircraft illustration of the previous section. we might develop a partial semantic network as illustrated in Fig. 4.2. Here, we note that the C5A is a special type of aircraft (i.e., a large military cargo plane). Further, since the C5A is an aircraft, it inherits the properties associate with aircraft in general (e.g., it flies. has wings, carries people). Such an inheritance property can prove to be of considerable value in the reduction of memory storage requirements. That is, since a C5A is an airplane. there is no need to store at the C5A node, the fact that it can fly, has wings, and can carry people. Thus, the semantic network scheme provides for a convenient approach for the representation of associations between entities.

We might also note that the OAV triplet is actually just a restricted subset of semantic networks wherein the only relationships that may be used are those of "is-a" and "has-a " OAV nodes, in turn, may be any of three types: objects, attributes, or values.

FIGURE: 4.2 Semantic network.

3. Frames

While semantic networks provide a relatively versatile means for knowledge representation, the use of frames represents an alternative approach that serves to capture most of the frames of the semantic network while providing certain additional aspects. In fact, we may think of a semantic network as being a subset of the concept of frames.

The employment of frames represents a particularly robust way in which to present knowledge. A frame contains an object plus slots for any and all information related to the object. The contents of such slots are typically the attributes and attribute values of the particular object However, in addition to storing values for each attribute, slots may contain default values, pointers to other frames. and sets of rules or procedures that may be implemented

Figure 4.3 illustrates a frame based representation for the object dog. Note that the slots within this frame include values (e.g., Beagle), defaults (e.g., four legs). and procedures (e.g.. for a medical examination). The procedures, in turn, could well point to other frames. The versatility of the frame based mode of knowledge representation should be obvious.

The primary drawback to the use of frames is. ironically, caused by the very robustness of such a mode of representation. Frames have so many capabilities as to make their use a rather complex matter.

Jackson [19861 states that "many people are unhappy with frame and object based systems because they seem to depart from logic and because their flexibility in matters of context and control can make their behavior both hard to predict and difficult to understand." As a result, to obtain any reasonable proficiency in the use of frame based tools in expert systems, a lengthy training period is required. Despite such drawbacks, frames can prove quite useful, if not essential, in the design of large scale, complex expert systems particularly those involving a large amount of a priori facts (i.e., data) and multiple object. While fame are not focused on in this text, it is strongly encouraged that serious student investigate this topic after he or she has attained a reasonable level of competence in the use of rule bases.

FIGURE 4.3 A Frame based representation

4. Representation via Logic Statements

The most common form of logic is that known as prepositional logic. A Proposition, in turn, is a statement that may be either true or false. Propositions may be linked together with various operators (termed logical connectives) such as AND, OR. NOT, and EQUIVALENT. Linked propositions are termed compound statements. To demonstrate, consider the statement X, Y, and Z where the first two statements (X and Y) are true while Z is false. Thus we may conclude that

- X AND Y is true and X AND z is false. If two statements connected by AND, both must be true for compound statement to be true.
- X OR Y is true and Z OR Z is also true, If two statements are connected by OR, that statement is true as long as either one or both statements are true.
- NOT Z is true. The NOT connective imply negates the statement. Since Z was false, NOT Z must be true.

Predicate calculus represents an extension of prepositional logic. The fundamental element of predicate calculus are the object and the predicate. A predicate is simply a statement about the object, or a relationship that the object possesses. Predicate may address more than one object and may be combined by use of logical connectives. Some examples of the use of predicate calculus follow:

- Mamma(dog), which is read as "a dog is a mammal"
- Four_legs(dog), which is read as "a dog has four legs".
- Mammal(chicken). which is read as "a chicken is a mammal"
- Sister(joan,jack). which is read as "Joan is Jack’s sister"

The first of these statements is true. the second is in general true, and the third is definitely false. Unless we know Joan and Jack personally, the validity of the fourth statement is unknown. Using predicate calculus, we can then represent such compound statements as "Joan is Jack's sister and Fred's cousin" as

Sister(joan, jack) AND cousin(joan, fred)

We can also represent various relationships, or rules, by means of predicate calculus. For example, consider the heuristic that states that, if interest rates a: rising, bond prices will fall: Using predicate calculus, and the logical

IF statement we can represent this

heuristic as *fall(bond prices) if rises*

interest_rates)

where we have used a format similar to that employed in PROLOG, a computer programming language popular in artificial intelligence.

One major advantage of the use of logic for knowledge representation that logic-based languages. such as PROLOG, do exist. However, such language have been criticized for a certain lack of flexibility: a criticism that is becoming less valid with recent enhancements to their procedures. A more immediate are pragmatic drawback of the use of logic for knowledge representation is the fact that one must learn some logic programming language (e.g., PROLOG) in order to develop expert systems.

5. Neural Networks

Obviously, somehow, some way, the human brain stores knowledge. What is r. so obvious is the precise manner in which this is accomplished. Neural network represent mankind's attempt to replicate, in hardware. theories pertaining to the brain. Specifically, it is thought that knowledge is stored in neurons (or, actually. the connections between neurons). Figure 4.4 depicts a simplified representation of only two neurons within the neural network of the human brain.

In the human brain there are more than 10 billion neurons, and each neuron is connected to one or more other neurons, resulting in a massively interconnecting network. At each neuron, impulses are received by the dendrites and transmit by the axons. If the output of the axon is at a high enough level, the signal X jump the synaptic junction and trigger the connected neuron (or neurons). It believed that knowledge might then be represented by the weightings on e. neuron to neuron interconnection, which in turn influence the level of strength the interconnecting impulses.

The attempts to duplicate the neural network structure of the brain has been. at best, extremely modest. Typically, electronic amplifiers are used to represent the neurons and resistors to correspond to the interconnecting weights. And existing systems have but a few layers of relatively few neurons. Despite this. neural networks can be used to accomplish some intriguing tasks, including some FIGURE 4 4 A portion of a neural network

success in speech recognition. In particular. they provide a robust approach to the general problem on pattern recognition. Probably the biggest single disadvantage of the neural network approach to knowledge representation is the fact that any knowledge that exists is almost tonally opaque. (2)

Since neural networks are often excellent choices for problems of classification, they may be combined with an expert system to perform certain tasks. That is, the neural network may be used to classify and, based upon this class, the expert system may then be used to determine the specific course or courses of action to take.

(2).One of the major areas now being addressed and funded in neural network research is , in fact, the development of rules for representation of the process employed by the neural network.

6. REPRESENTATION VIA RULE-BASED SYSTEMS

Undoubtedly, the most popular mode of knowledge representation within expert systems, at least at this time, is the mode obtained through the use of rules, or rule-based systems. Alternatively, such rules are referred to as IF THEN, or production rules. We have selected rule based expert systems as our approach to knowledge representation for a number of reasons, including their popularity and widespread use. however, it should be stressed that this decision does not imply that rule based systems are necessarily the best approach or. in particular, the best approach for every situation. There are those who present quite persuasive arguments for other approaches; in particular for the employment of frame-based representation. Our choice of rule-based knowledge representation has been made for the following reasons:

The majority of existing expert systems development packages (and this is especially true for expert systems shells) employ rule bases.

Rule-based expert systems development packages are normally much less expensive (in terms of both the initial cost of the package as well as the overall cost of using the package) than those employing alternative modes of representation.

Specifically, they cost less to purchase, normally do not require any expensive hardware (most run on inexpensive, general purpose personal computers), and require minimal expenditures toward training.(3)

The widespread availability (if rule based expert systems shells permits the knowledge engineer to focus his or her attention on the most critical phase of the development of an expert system, that is. on the knowledge base.

Rules represent a particularly natural mode of knowledge representation. Consequently, the time required to learn how to develop rule bases is minimized.

The learning curve for rule-based expert systems is much steeper than for any alternative mode of representation (i.e., it takes less time to learn how to use and implement rule-based expert systems).

Rules are transparent, and are certainly far more transparent than the modes of knowledge representation employed by rule-based systems' two major competitors: frames and neural networks. Further. such transparency often leads to an increased willingness, on the part of management. to accept the solutions obtained. And the importance of this last factor should not be underestimated.

Rule bases can be relatively easily modified. In particular, additions, deletions, and revisions to rule bases are relatively straightforward processes. And this is particularly so in the case of well designed rule bases.

Rule-based expert systems can be employed to mimic most features of frame-based representation schemes (the amount of work that may be needed to accomplish this, however. is not necessarily trivial).

Validation of the content of rule-based systems (i.e., the determination of the completeness and consistency of the representation) is a relatively simple process. Similar validation of frames or neural networks, on the other hand, is normally difficult to impossible. .

Finally, it is our opinion that the rule-based approach provides the most appropriate introduction to the topic of expert systems. With the rationale for our selection of rule-based knowledge representation behind us, let us now address the topic of the development of rule bases.

(3) The costs of training are all too often grossly underestimated by firms considering the in-house development and maintenance of expert systems. In particular, the cost associated with the employment of frame-based systems can be on the order of ten to a hundred times that of the initial investment in the systems. Such expenditures may be minimized through the employment of rule-based expert systems.

Knowledge Acquisition

Knowledge acquisition is the process of acquiring the knowledge from human experts or other sources (e.g. books, manuals) to solve the problem.

Knowledge acquisition and knowledge representation are phases of expert systems development that proceed virtually hand in hand. And both phases are absolutely vital to the integrity of the rule base for the expert system ultimately constructed.

Knowledge Acquisition Via Domain Expert

The knowledge acquisition phase of development is also one that can be extremely frustrating as well as time consuming. Some have termed it the; *bottleneck* of expert systems development, Here, we are often dealing directly and intimately with domain experts. While dealing with people in general can be difficult, interfacing with domain experts can be many times as frustrating.

<u>Knowledge acquisition and the domain expert</u>

- It would seem that the most obvious way in which one may acquire a knowledge base is to go directly to the human expert. However, there are at least four reasons why this may not work, or at least not provide totally satisfactory results.
- For some problems. there simply may not be an expert. One example that comes to mind is that of investing in the stock market. While some investors or investment advisory services do well for a relatively brief time, they typically have spells in which their performance is mediocre to terrible. One school of thought claims that there simply aren't any stock market experts while another claims that, if such experts exist. they would never be so foolish as to consider revealing their approach.
- The alleged experts may actually be exhibiting poor to mediocre performance, All too often. the term expert is loosely applied to anyone who simply gets the *job done.* Thus, while such experts may be available. it may well be wise to avoid building a knowledge base about (or, at least, solely about) their heuristic rules.
- The experts may not wish to reveal their tricks of the trade. In some cases, such individuals simply refuse to cooperate. In others, a potentially far more serious problem occurs - they appear to cooperate but intentionally provide false information.

- Finally, there are some experts who are just unable to articulate the approach that they use. Many experts. in fact, simply and honestly do not really understand how they actually make their decisions. As such, when asked to explain how they solve a problem, they respond with a description of their most recent *perception of* the process, which may or may not have any relationship to the procedure they actually employ.

There are a number of good papers that discuss the conduct of the knowledge acquisition phase. Prerau ll987] and Surko [1989]. in particular, have provided some excellent guidelines for knowledge acquisition. Here, we have attempted to summarize our own thoughts on knowledge acquisition, where the influence of numerous other authors is acknowledged. These guidelines are presented in the list that follows. While it may not be possible to abide by each and every point, the guidelines should at least be considered in the planning of the knowledge acquisition effort.

Selection of the Domain

The domain should be one for which the expert systems approach is truly appropriate, and for which an expert system would provide some distinct advantage over any alternative methods.

Good decision making within the domain should be of sufficient importance to management that they are willing to commit the time and resources necessary to support the development and implementation of the expert system.

Management must recognize both the costs and risks of expert systems development. Any nontrivial expert system is going to require the employment of competent knowledge engineers, over a reasonable period of time. If management has totally unrealistic expectations (e.g. in terms of time, cost, or capabilities), make an attempt to clarify the process. If their expectations remain unrealistic**,** there is probably no point whatsoever in pursuing the project.

The domain should be relatively stable; in particular. dramatic changes over the period of the development effort should not be foreseen.

Selection of the Knowledge Engineers

The Role of the Knowledge Engineer

Ideally. two knowledge engineers should be used, where at least one of these is experienced in the development and implementation of (successful) expert systems .

- The knowledge engineers should not be *one-trick ponies.* That is, they should at the very least be aware of alternative approaches to decision analysis.
- The primary skills of the knowledge engineers should be in the areas of eliciting knowledge and in forming a model of that knowledge (i.e., the rule base).

Selection of the Expert

Ask the organization to provide you with the names of candidate domain experts, that is, those individuals who are believed to have significant expertise within the domain in question.

- Select a domain expert whose performance is generally acknowledged to be *above and beyond* that of most others performing the same task.
- Select an expert with a successful *track record* over a period of time.
- Select an expert who is both willing and able to communicate personal knowledge. and who is relatively articulate in doing so.
- Select an expert who is both willing and able to devote the time necessary to support the development effort.

If no expert can be identified, or made available, consider the development of the rule base through alternative means (as will be discussed in the sections to follow)

The Initial Meeting

Prior to this meeting. the knowledge engineers should make an all out effort to familiarize themselves with the problem, the domain. and the terminology used within the domain.

- Locate this meeting in comfortable surroundings. Limit the duration of tile meeting (in our opinion, such a meeting should last less than 2 hours).
- This meeting should be conducted(l in an informal, relaxed manner.
- Tell the expert what your plans and goals are, and explain just what an expert system is and what it can do (and cannot do) for the expert as well as the organization .
- Explain the evolution of the expert system (in particular, discuss how initial decisions, developed by early prototypes, are likely to appear naive).

Reinforce your discussion of expert systems with the demonstration of the use of some existing expert system. However, avoid the demonstration of an expert system that is all too obviously a toy (e.g., one that selects the type of wine to go with a meal).

- If audio/visual recording is desired, ask the expert for permission to do so, and explain

that these recordings will be for the private use of the knowledge engineering team.

Background

- Where appropriate, make a site visit-and do this as soon as possible.
- Determine the existence of any existing manuals, response, or other written material that serve to describe the domain, the problem, and the terminology employed.
- Ask the expert to present an informal tutorial session on the subject. In this session, no questions are asked, the knowledge engineers merely listen and learn.

Organization of Follow-on Meetings

- Attempt to minimize the possibility of interruptions. Set aside meeting times during which the expert can devote his or her full attention to the effort.
- Establish a formal agenda for each meeting.
- Establish goals and objectives for each meeting.
- Once a prototype expert system has been developed. establish access to the supporting software and hardware (e.g., for prototype demonstrations and their critique) .

Conduct of the Follow-on Meetings

- Elicit the rules through discussion and demonstration.
- Attempt to identify all external sources of data and information that are used by the expert.
- Be patient. Don't interrupt the domain expert.
- Avoid Criticism - instead, focus on clarification.
- Always remember that you are building a model of the expert's rule base, not a model of your rule base.
- If you don't understand a point made by the expert. don't be afraid to admit it. Ask for clarification. Use test cases to both demonstrate the decision-making process and to identify the limits over which the rule base is valid.
- Acquaint the domain expert with production rules: this may encourage the expert to begin stating his or her rules in this format.
- Always remember what you are there for.

Documentation

Document the results of the meeting as soon as possible after the meeting (preferably, immediately after the meeting).

Documentation for each meeting should include such facts as:

- Date, time, and location of meeting
- Name of expert (i.e., if more than one expert is being used)
- List and description of the rules identified during the meeting
- Listing of any new objects, attributes and/or values encountered - and their properties
- Identification of any new outside sources and references
- Listing of any new terminology encountered, and associated definitions
- Listing and discussion of any gaps or discrepancies encountered
- Reminders (e.g., of points that need to be clarified)

Documentation in support of still production rules thus far developed shouldinclude such facts as:

- A listing and description of all rules thus far developed
- A listing and description of all objects, attributes, and values thus far encountered
- Source and reference list
- Glossary of domain terminology

Listing and discussion of tile test cases used to evaluate the prototype

While there will obviously be exceptions to such guidelines. they do provide an overall basis for the systematic and efficient conduct of the knowledge acquisition phase of expert systems development. Those who follow such a procedure will most likely reach their goal in less time and with greater efficiency.

However, one word of warning. Examine once again the last element of the list under the "Conduct of the Follow-on Meetings" guidelines. Sometimes, we can get so involved in the problem. and in procedures in general, that we lose sight of just what it is that we are there for. Remember, your goal is to develop a rule base that represents, as closely as possible the heuristics used by the domain expert. This must always be the focus of the effort.

In order to establish a (good) rule base, there are certain things to look for. in particular:

The expert may not understand the concept of rules and heuristics. It is generally best to ask him or her about any neat little *tricks* or *shortcuts* that are employed to reach a decision. Usually, these represent pruning, or filtering, heuristics (i.e., heuristics used to reduce the number of paths searched in the inference network) .

Ask the expert about those instances in which he or she can come to a really quick conclusion. That is. just when are decisions easy? For example. the example may note that, under certain circumstances he or she can immediately determine that outside help is needed. or that the problem is trivial. Associated With these situations are rules that need to be incorporated at the very top of the knowledge base. We want to identify these easy decisions as soon as possible in the inferencing process. in order to reduce both the time required to find a solution and the number of .questions presented to the user.

Is the problem one of *classification* or *construction?* If it appears to be a classification (i.e., diagnosis) problem. then try, in particular. to determine

The *symptoms* the expert uses in classification.

The treatments that the expert recommends the relationships between symptoms and treatments (i.e., how are they matched)

If the problem faced is one of construction (e.g., the development of a schedule. loading scheme), then look; especially for:

The data employed by the expert

The list of alternatives (i.e. final conclusions), and whether or not this list may be preenumerated

The heuristics used to prune the list of alternatives

Determine, as soon as possible in the effort, the data used (and its source) by the expert in reaching his or her conclusions. If your expert system is to reach conclusions similar to those of the domain expert. it will require access to thesame data.

Multiple Domain Experts

Surko addresses. in her paper 11989], one additional consideration in knowledge-base development: the existence of more than one domain expert. Some authors have noted that this situation can be particularly frustrating if not properly and delicately handled. Surko. however. advises that the knowledge engineer neednot be particularity concerned about multiple experts. That is. using a rule base cloned from an expert. we build a prototype expert system and then let the other cloning experts critique the results. She states: if two experts disagree, then you'd probably better just quiet choose the version you feel is right. Your aim is to get the best knowledge. but !you must do so with the minimum discord...." In a(additional. she notes that getting experts together to air their differences is usually too risky for the potential gains.

Our own experiences in dealing with multiple experts has followed a similar approach. We have always selected one domain expert as the individual from whom the rules were to be acquired, that is. as the *key expert.* And, as Surkosuggests. we have presented the prototypes to the remaining experts for a critique. III doing this. we have tried to discourage the key expert from attending such presentations. We feel that his or her attendance may cause the other experts to feel less free in making their comments and criticisms. From the suggestions, comments. and criticisms received from the other experts. we have then attempted to identify those that seemed to be both constructive and important. We then presented these to the key expert for his or her comments. Rather surprisingly, at least to us. we have almost always found the key expert to be responsive and objective in such situations.

There is yet another situation in which multiple experts may be encountered. However. rather than having mastery across the entire domain of interest, these experts may each have expertise in various portions of the domain. One approach to this situation is to develop a set of expert systems. one for each *subdomain.*Another is to utilize separate knowledge bases (i.e., one for each expert) and to coordinate these through a single expert systems package by means of the blackboarding approach. And this is precisely the approach used in HEARSAY, an expert system described in Chap. 8.

KNOWLEDGE ACQUISITION: AN EXAMPLE

In the August 12, 1988 issue of *The Wall Street Journal* [Rose, 1988], a front page story described one recent, and somewhat less than successful attempt at knowledge acquisition. Since there are lessons to be learned through both success and failure, let us consider this particular situation. While reading the summary of this effort (as extracted from the referenced article), compare if you will what was done with the guidelines that we have presented earlier.

Mr. Thomas Kelly was, at the time of the publication of this story, a 5.5 year-old civil engineer working for Southern California Edison. Over a period of 20 years he had become an expert in the diagnosis and treatment of problems of a massive and troublesome earthen dam high in the Sierra Nevada mountain range of central California. For example, from supposedly just a trickle, Mr. Kelly is able to determine if the dam is bleeding or just breathing.

Mr. Kelly's expertise was considered too valuable to risk losing. Thus, the company spent two years and roughly S300,000 in an attempt to create an expert system that cloned his knowledge of earthen dams. One particular dam under consideration is named Vermilion. It is a trouble-plagued, 24-year-old dam that spans Mono Creek, a tributary of the San Joaquin River. The dam is 165 feet high and about a mile in length and can hold as much as 40 billion gallons of water, It is particularity prone to water seeping through its foundation and Mr. Kelly's expertise has been a major factor in keeping the dam and the population in the valley below safe. An expert system was proposed to achieve a level of problem solving comparable to the human expert, for application to any earthen dam.

Southern California Edison called upon Texas Instruments, Inc. for the development of an earthen dam expert system. Texas Instruments sent two knowledge engineers to proceed with the knowledge acquisition phase. One was a 30-years old engineer and *computer whiz and* the other was a 30-year-old management systems expert. This was the first assignment for both.

To quote directly from The W*all Street Journal* article:

The programmers were nervous when they first sat down With Mr. Kelly, who is almost twice their age They had boned up on books about dam safety and construction, but that was just a start. Before them was a professional engineer, with decades of experience that they needed to dissect....

Their first meeting was a marathon, 7-hour session in a windowless room, where the programmers grilled Mr. Kelly. Tell us about Vermilion's earth and gravel interior the pair asked. What about the drainage systems that riddle the dam? Every syllable was tape-recorded and transcribed for later study. When [they] left the meeting, everyone's eyes were bugging out....

As the sessions continued, Mr. Kelly began to find them more and more troubling. The knowledge engineers were equally frustrated. Mr. Kelly would listen to questions and reply with a simple "yes'' or 'no." When he provided explanations, which was evidently not too often, they were brief. While Mr. Kelly insisted that he was being cooperative, the knowledge engineers wondered if he was perhaps unconsciously reluctant to *part with his expertise.*

The knowledge engineers' first attempt at constructing a prototype expert System met with equally frustrating results. For almost every problem posed, the system would respond with the suggestion to pack the offending wet area of the dam with gravel and keep it under observation. Finally, the knowledge engineers visited the dam. And this visit provided them with what they termed a visual breakthrough, an enhanced appreciation of the elements of the problem.

However, even months later. the expert system's knowledge base consisted of only about 20 rules, and still produced trivial advice. After a year, and concerned now about the time and funds being expended, Southern California Edison decided to narrow the project's scope to consider only the Vermilion dam.

Texas Instruments assigned yet another employee to the project. Gradually, the group’s insight into the problem grew. as did the knowledge base. The number of rules increased to about 80. However. confidence in the system, on the part of Mr. Kelly. seemed lacking.

Ultimately, the project wound down. The Texas Instruments' team moved on to other projects. The expert system developed is not in regular use and Southern California Edison officials state that the system ''needs more work to be really useful.''

The less than satisfactory results of this particular effort are hardly unique. A formula for the lack of success in developing the earthen dam expert system can be noted in a host of other expert systems efforts. Analyzing the situation. One may note a number of factors that may have diminished the project's chance of success. These include:

- The assignment of inexperienced knowledge engineers (recall that this was the first assignment, in the construction of an expert system, for both)
- An initial knowledge acquisition session that immediately may have served to get things off on the wrong foot (i.e., the 7-hour marathon/grilling described above)
- A failure to make an on-site visit of the dam as soon as possible in the effort (such a visit should have ideally taken place before the acquisition sessions were actually initiated)
- An evident failure. on the part of the knowledge engineers, to overcome the domain expert's reluctance to provide detailed explanations
- An evident failure to achieve a relationship of mutual respect

To clarify the last point, it would seem, at least from reading the article, that the two novice knowledge engineers were in awe of the domain expert, On the other hand, Mr. Kelly may have perceived such a reaction as an indication of a lack of experience coupled with naivete. Mr. Kelly could point to a successful career as an earthen dam expert; the two knowledge engineers had yet to accomplish their first successful expert systems project. And this was evidently still the case at the conclusion of this $300.000, two-year effort.

THE KNOWLEDGE ENGINEER AS THE DOMAIN EXPERT

As mentioned earlier, the selection of an expert may be a problem in the knowledge acquisition phase. There may, in fact, be no practical access to a domain expert. The expert may have died. Left the company. or may simply refuse to participate in the development of an expert system. In such an instance, we have at least two options. One is to use (or generate) historical data through which a rule based expert system may be constructed. The second is to become our own expert. In this section we will focus on the latter approach.

Quite often in the expert systems literature there are warnings against becoming one's own expert. While we agree that such an approach is a matter of concern, we also believe that it may prove worthwhile if conducted properly. In fact, one of the most highly touted expert system, and one that is in actual use. is the Rl (or XCON) system for the configuration of VAX computers at the Digital Equipment Corporation (DEC) and the initial prototype of this system was developed primarily by knowledge engineer. Specifically. John McDermott of Carnegie Mellon University began this project with a meeting of the VAX configuration experts at DEC. This meeting simply provided McDermott with an overview of the task. He then took: two DEC configuration manuals back to his office and reviewed them in detail. Using this input, he developed a prototype expert system consisting of about 250 rules in about three person-months. The demonstration of the prototype indicated that it was able to satisfy all of the basic configuration problems provided by DEC. This success resulted in an extension of the project wherein an expert was used to evaluate the refine system. However, the initial prototype was developed primarily by the knowledge engineers. And this demonstrates that it is indeed possible to be one's own expert, at least in certain situations.

One argument against becoming one's own expert is the belief (as based on rather substantial empirical evidence) that it takes approximately 10 years to become an expert in a particular domain. Rather obviously, if this were the case, it would be very rare indeed to devote those 10 years to the development of our expertise simply for the purpose of constructing a single expert system. However, the 10-year figure is based on the belief, by psychologists, that a world-class expert (e.g., 3 chess grandmaster, a composer of classical music, or a Nobel laureate in a field of science) must store somewhere between 50.000 and 100,000 chunks of heuristic information prior to becoming an expert and that it takes at least 10 years to acquire 50,000 chunks [Harmon and King, 1985]. Such an estimate may be reasonable. However. most often the types and breadth of expertise that a knowledge engineer is concerned still are hardly in the same league as that of a Nobel laureate.

In some respects, there are certain benefits to he gained by such an approach That is, when knowledge engineers are their own experts, some aspects of the knowledge acquisition procedure are immediately simplified. For example. one can proceed directly to a statement of the rules in the IF-THEN format. Also, we do not have to worry about the expert's schedule, or the expert's reluctance (or inability) to describe the procedures used. Further, we may obtain a more objective view of the procedure since the knowledge engineer may have no vested interests in the organization under consideration. All too often, those who are dealing directly with a problem are *unable* to *see the forest for the trees,* and thus an outsider's perspective may represent a significant improvement. At any rate, there are advantages and disadvantages in being one's own expert and one should not dismiss, out of hand, such an approach.

THE DOMAIN EXPERT AS THE KNOWLEDGE ENGINEER

Now, if the knowledge engineer can act as the domain expert, why not employ the domain expert as the knowledge engineer? Actually, the ultimate goal of expert systems is to provide a development package that interacts directly with the domain expert, and thus supposedly eliminates the need for the knowledge engineer. However, this goal has yet to be reached and it is unlikely, despite certain claims in this area. that it will be at least in the foreseeable future.

There has been, however, a certain amount of success in training domain experts to develop small-to-modest sized rule bases, and to implement these rule bases on various expert systems development packages particularly on some of the more user friendly expert systems shells that are now available. Several firms have, in fact, reported significant improvement in overall productivity through the development of numerous small (rulebased) expert systems by their domain experts.

Our reaction to such an approach is mixed. We are all for the increased involvement on the part of everyone in the organization in expert systems development and implementation. Further, it is not inconceivable that many domain experts can, through proper training, become competent knowledge engineers. As just one example, in the case of Mr. Kelly, our expert on earthen dams for Southern California Edison, such an approach may have well proved fruitful. However, there are certain drawbacks. These include:

- The time and funds required to train the domain expert
- The likelihood that any domain expert, so trained, will tend to *solve* any and all problems through expert systems even when far more appropriate, effective, and efficient means exist

Each of these drawbacks may be alleviated, to some degree, by providing access to an in-house or external group of knowledge engineers. The knowledge engineers may provide the training and assist in rule base development. This is, in fact, the approach that has been taken by a number of firms.

KNOWLEDGE ACQUISITION VIA RULE INDUCTION

An alternative to the acquisition of knowledge through the interface with a human (i.e., an expert or a knowledge engineer assuming the role of the expert) is to convert an existing *(and appropriate)* database into a set of production rules [Carter and Catlett, *1987;* Quinlan, 1983, *1987a;* Thompson and Thompson, 1986]. The appropriate database, in turn, must consist of data that encompass examples pertaining to the type of problem under consideration *where the*examples selected *should represent desirable outcomes* (i.e., it makes little sense to use examples which reflect poor judgment). More specifically, one needs examples of *good* decision making. In some cases, this approach may provide adequate results while, in others, it may at least lead to the development of a credible prototype system. Several commercial expert systems shells, in fact, incorporate means (actually, supporting programs) for the accomplishment of such a process. We will, in fact, present the results of the application of two commercial software packages (i.e., for the development of rules from a database) later in this chapter. However, one should most definitely first understand precisely how this is done, as well as the scope and limitations of this approach.

Before describing one popular approach to rule generation from data, let us first reflect upon the components of a knowledge base consisting of production rules. To clarify our discussion, let us return to the simplified aircraft identification problem. Our problem is concerned with the identification of various types of aircraft, where we will limit the number of aircraft under consideration to just the C130 (Lockheed Hercules), C141 (Lockheed Starlifter), CSA (Lockheed Galaxy), and B747 (Boeing jumbo Jet). Note carefully that, for purpose of illustration, these four aircraft will be the *only* inhabitants of our universe of airplanes.

Identification of Objects, Attributes, and Values

Rather obviously, the objects in our knowledge base are the four different types of aircraft. Our next step is to consider the attributes that serve to distinguish these aircraft from one another. For example, some of the many attributes exhibited by these aircraft include

- Number of engines
- Type of engines (e.g., jet or propeller)
- Wing position (i.e., high on the fuselage or low on the fuselage)
- Wing shape (i.e., swept back or conventional)
- Tail shape (e.g., T-shaped or conventional)
- Bulges on the fuselage (e.g., aft of the cockpit, aft of the wing, under the wing, or
- none) Size and dimensions
- Color and markings

Speed and altitude

Having identified a candidate set of attributes and their values, we should next consider filtering out those attributes that do not serve to support our decision making process. For example, the number of engines is obviously not necessary since each of the four aircraft under consideration has exactly four engines. (However, in a more realistic aircraft identification model, we would extend our concern to all possible aircraft and there the number of engines does. of course, serve to distinguish one aircraft from another.)

We might also be able to drop the last three attributes since, at the distance we expect to see the aircraft, we will not be able to distinguish colors and markings or estimate size and dimensions, speed and altitude. We are then left with the second through the sixth set of attributes, which may or may not be enough to permit precise aircraft identification. Actually, as we will see, these five attributes (i.e, engine type, wing position, wing shape. tail shape, and bulges) will be more than sufficient under the rigid assumptions of a strictly deterministic rule base and a completely stable system.

Before we proceed, let us repeat our warning, with regard to the avoidance of false economics. Realize that, by eliminating attributes, we are eliminating premise clauses in the rule base, as well as knowledge about the situation. Thus, one must always be careful that the attributes dropped from consideration are not a part of the *necessary knowledge* for the problem under consideration. This guideline can, however, create a dilemma. That is, should we seek the minimal set of attributes or, to be safe, should we try to incorporate every conceivable attribute? Unfortunately. there is no clear cut answer. Too many attributes may make the knowledge base unwieldy and require an inordinate amount of data and/or responses from the user. As a result. the expert system will appear to be plodding. if not outright dumb. Too few attributes can limit the usefulness of the expert system, as well as make future modifications more difficult. Thus, when all is said and done, we normally seek some acceptable compromise .

Assuming that we feel relatively confident with the filtered set of attributes, we may list these and their associated values.

		Aircraft type		
Attribute	C130	C141	C5A	B747
Engine type	Prop	Jet	Jet	Jet
Wing position	High	High	High	Low
Wing shape	Conventional	Swept back	Swept back	Swept back
Tail	Conventional	T-tail	T-tail	Conventional
Bulges	Under wings	Aft wings	None	Aft cockpit

Developing Knowledge Base

Inference Engine

Advantages and Disadvantages

Advantages of Expert Systems

- **Permanence** - Expert systems do not forget, but human experts may
- **Reproducibility** - Many copies of an expert system can be made, but training new human experts is timeconsuming and expensive
- If there is a maze of rules (e.g. tax and auditing), then the expert system can "unravel" the maze
- **Efficiency** - can increase throughput and decrease personnel costs
  - Although expert systems are expensive to build and maintain, they are inexpensive to operate
  - Development and maintenance costs can be spread over many users
  - The overall cost can be quite reasonable when compared to expensive and scarce human experts Cost savings:
  - Wages - (elimination of a room full of clerks)

    Other costs - (minimize loan loss)
- **Consistency** - With expert systems similar transactions handled in the same way. The system will make comparable recommendations for like situations.

  Humans are influenced by recency effects (most recent information having a
  - disproportionate impact on judgment) primacy effects (early information
  - dominates the judgment).
- **Documentation** - An expert system can provide permanent documentation of the decision
- process **Completeness** - An expert system can review all the transactions, a human expert can only review a sample
- **Timeliness** - Fraud and/or errors can be prevented. Information is available sooner for decision
- making **Breadth** - The knowledge of multiple human experts can be combined to give a system more breadth that a single person is likely to achieve
- Reduce risk of doing
  - business Consistency
  - of decision making
  - Documentation
- Achieve Expertise
- **Entry barriers** - Expert systems can help a firm create entry barriers for potential competitors
- **Differentiation** - In some cases, an expert system can differentiate a product or can be related to the focus of the firm (XCON)

  Computer programs are best in those situations where there is a structure that is noted as previously existing or can be elicited

Disadvantages of Rule-Based Expert Systems

- **Common sense - In addition to a great deal of technical knowledge, human experts have common sense.** It is not yet known how to give expert systems common sense.
- **Creativity** - Human experts can respond creatively to unusual situations, expert systems cannot.
- **Learning** - Human experts automatically adapt to changing environments; expert systems must be explicitly updated. Case-based reasoning and neural networks are methods that can
- incorporate learning. **Sensory Experience** - Human experts have available to them a wide range of sensory experience; expert systems are currently dependent on symbolic input.
- **Degradation** - Expert systems are not good at recognizing when no answer exists or when the

problem is outside their area of expertise.

CHAPTER 1

1. An expert system is

a. a computer that can answer questions like a human expert
b. a group of scientists who design computer programs
c. a method of producing new words
d. a computer that can feel emotions.

2. ……………… involves relating something new to what we already know in a psychologically complex way.

a. Knowledge Acquisition
b. Knowledge retrieval
c. Reasoning
d. Meta-level reasoning

3. The expert's knowledge about solving specific problems is called the ……………… a. domain

b. problem domain
c. knowledge domain.
d. expertize

4. The following are the main component of an expert system

i. Agenda
ii. Knowledge base
iii. Inference engine iv. User interface
v. Working memory

a. i, ii & iv
b. ii & iii
c. ii only
d. i, ii, iii & v

5. Another name for knowledge base is …………….

a. Main memory
b. Knowledge acquisition
c. Production memory
d. Distribution memory

6. The method of inference that starts with hypothesis and look for rules that allow the hypothesis to be proven true is called …………….

a. Rule based chaining
b. Forward chaining
c. Reverse chaining
d. Backward chaining

7. In comparing between the forward chaining and the backward chaining, …………
a. Forward chaining is goal driven whereas backward chaining is data driven
b. Backward chaining is goal driven whereas forward chaining is data driven
c. They are both goal driven
d. They are both data driven

8. A prioritized list of rules created by the inference engine, whose patterns are satisfied by facts or objects in working memory is known as …………
a. Rule based
b. Knowledge acquisition
c. Agenda
d. Knowledge base

9. The expert system used for geological data analysis for minerals is called ………..
a. DIPMETER
b. XCON/R1
c. DENDRAL
d. PROSPECTOR

10. The expert system used for configuring computer systems is called ……….
a. DENDRAL
b. MYCIN
c. XCON/R1
d. PROSPECTOR

CHAPTER 2

1. Formal logic can also be referred to as ……….
    a. Logic
    b. Semantic
    c. Symbolic logic
    d. Inference

2. ………. is the study of making inferences.
    a. Semantics
    b. Logic
    c. Knowledge
    d. Epistemology

3. Knowledge affect the following of a system except?
    a. Maintenance
    b. Efficiency
    c. Development
    d. None of the above

4. The formal way fact and rules of inferences used to reach valid conclusions is referred to as……..
    a. Semantics
    b. Argument
    c. Logic
    d. Knowledge

5. The metaknowledge that describes everything known about the problem domain in expert systems is called?
    a. Ans
    b. Tacit knowledge
    c. Priori knowledge
    d. Ontology

6. Which is not a knowledge-representation technique?
    a. Priori
    b. Semantic tree

c. Logic
d. Scripts

7. A ……… is a group of slots and fillers that defines a stereotypical object that is used to represent generic / specific knowledge.
    a. Net
    b. Frame
    c. Schemata
    d. Tacit

8. A schema; Some S is P, means?
    a. Universal negative
    b. Universal affirmative
    c. Particular negative
    d. Particular affirmative

9. Semantic nets consist of ………. and ……..
    a. Nets and Arcs
    b. Chains and Atoms
    c. Nodes and Nets
    d. Arcs and Nodes

10. Statements that cannot be classified as true or false are
    a. Paradoxes
    b. Contradictions
    c. Tautology
    d. Contingent statements

CHAPTER 3

1. "Heuristic" is a Greek word which means "to…………………..."
    a. Guess

b. **Deduce**
c. Discover
d. Propound

2. The top node is the ………… Occupying the highest hierarchy

    a. Branches
    b. **Root**
    c. Levels
    d. Neighbors

3. Every node except the root has exactly …….. parents

    a. Two
    b. **One**
    c. Three
    d. Six

4. ………. has only a single pathway from root to its one leaf.

    a. Nodes
    b. **Degenerate trees**
    c. Descending branches
    d. Binary trees

5. Graphs are sometimes called ………

    a. Semantic
    b. **Net**
    c. Lines
    d. Links

6. A circuit is a path through the graph that ……

    a. Begins and ends with the parents' node
    b. **Begins and ends with the same node**
    c. Begins and ends with a sibling node
    d. Ends with the same node

7. Well formed problems have all the following except …….

   a. Bounded problem space
   b. **Opened-structured environment**
   c. Deterministic
   d. Discrete state

8. PROLOG uses ……...Channing to divide problems into smaller problems and solves them a. Forward

   b. **Backward**
   c. Reverse
   d. Open

9. ………. Is a rule of thumb based on experience?

   a. Deduction
   b. **Heuristics**
   c. Intuition
   d. Induction

10. In ……..inference is from a specific case to general

    a. Intuition
    b. **Induction**
    c. Deduction
    d. Heuristics

Chapter 4

1. Using logic to represent and reason we can represent knowledge about the world with facts and rules. a) True

b) False

Answer: a

2. Uncertainty arises in the wumpus world because the agent's sensors give only

a) Full & Global information
b) Partial & Global Information
c) Partial & local Information
d) Full & local information

Answer: c

Explanation: The Wumpus world is a grid of squares surrounded by walls, where each square can contain agents and objects. The agent (you) always starts in the lower left corner, a square that will be labeled [1, 1]. The agent's task is to find the gold, return to [1, 1] and climb out of the cave. So uncertainty is there as the agent gives partial and local information only. Global variable are not goal specific problem solving.

3. A Hybrid Bayesian network contains

a) Both discrete and continuous variables
b) Only Discrete variables
c) Only Discontinuous variable
d) Both Discrete and Discontinuous variable

Answer: a

Explanation: To specify a Hybrid network, we have to specify two new kinds of distributions: the conditional distribution for continuous variables given discrete or continuous parents, and the conditional distribution for a discrete variable given continuous parents.

4. How is Fuzzy Logic different from conventional control methods?

a) IF and THEN Approach
b) FOR Approach
c) WHILE Approach
d) DO Approach

Answer: a

Explanation: FL incorporates a simple, rule-based IF X AND Y THEN Z approach to a solving control problem rather than attempting to model a system mathematically.

5. If a hypothesis says it should be positive, but in fact it is negative, we call it

a) A consistent hypothesis
b) A false negative hypothesis
c) A false positive hypothesis
d) A specialized hypothesis

Answer: c

Explanation: Consistent hypothesis go with examples, If the hypothesis says it should be negative but infact it is positive, it is false negative. If a hypothesis says it should be positive, but in fact it is negative, it is false positive. In a specialized hypothesis we need to have certain restrict or special conditions.

6. The primitives in probabilistic reasoning are random variables. a) True

b) False

Answer: a

Explanation: The primitives in probabilistic reasoning are random variables. Just like primitives in Propositional Logic are propositions. A random variable is not in fact a variable, but a function from a sample space S to another space, often the real numbers.

7. Which is true for Decision theory?

a) Decision Theory = Probability theory + utility theory
b) Decision Theory = Inference theory + utility theory
c) Decision Theory = Uncertainty + utility theory
d) Decision Theory = Probability theory + preference Answer: c

Explanation: The Wumpus world is a grid of squares surrounded by walls, where each square can contain agents and objects. The agent (you) always starts in the lower left corner, a square that will be labeled [1, 1]. The agent's task is to find the gold, return to [1, 1] and climb out of the cave. So uncertainty is there as the agent gives partial and local information only. Global variable are not goal specific problem solving.

8. A constructive approach in which no commitment is made unless it is necessary to do so, is a) Least commitment approach

b) Most commitment approach
c) Nonlinear planning
d) Opportunistic planning View Answer

Answer: a

Explanation: Because we are not sure about the outcome.

9. 1. How many issues are available in describing degree of belief? a) 1

b) 2
c) 3
d) 4

Answer: b

Explanation: The main issues for degree of belief are nature of the sentences and the dependance of degree of the belief.

10. How many terms are required for building a bayes model? a) 1

b) 2
c) 3
d) 4

Answer: c

Explanation: The three required terms are a conditional probability and two unconditional probability.

Chapter 5

1. Which of the following is NOT a source of uncertainty in rules?

a) Uncertainty due to conflict resolution

b) **Uncertainty due to compatibility of rules**
c) Uncertainty related to individual rules
d) Uncertainty due to incompatibility of rules
2. Which of the following is/are consequent uncertainty in individual rules?

I. Errors
II. Likelihood of evidence
III. Combining evidence IV. Combining antecedent **a. I & II**
b. I only
c. I,II,III
d. All the above
3. _______ refers to minimizing the global uncertainties of the entire expert system. a) Verification b) Antecedent

c) Validation
d) Lexicographic

4. In MYCIN, a rule's antecedent CF must be greater than ______ for the antecedent to be considered true and activate the rule. **a) 0.2**

b) 0.3
c) 0.4
d) 0.5
5. Which of the following a danger to Ad-hoc methods?

a) Redundant rules are accidentally entered.
b) The rules may fire with contradictory consequents.
c) One rule is subsumed by another if a portion of its antecedent is a subset of another rule.
d) **Lack of complete theory to guide the application or warn of inappropriate situations.**

6. . ______ refers to minimizing the local uncertainties.

a) Verification
b) Antecedent
c) Validation
d) Lexicographic

7. An environment is called a __________ when its elements may be interpreted as possible answers and only one answer is correct. **a) Frame of discernment** b) Framework of discernment

c) Area of discernment
d) Domain

8. Sets in the power set of the environment which has mass greater than 0 is a/an______. a) Original element b) Element

c) Focal element
d) Mass element

9. _________ means computing not based on classical two-valued logics

a) Soft-computing
b) Logical reasoning
c) Cloud computing
d) General computing

10. Odd one out

a) fuzzy logic
b) neural network
c) **logical reasoning**
d) probabilistic reasoning

Chapter 6

1. All the following tasks fall under activity management when doing project management except …………….
   a. Scheduling
   b. Planning
   c. **Acquiring Resources**
   d. Analysis

2. The two most popular programming languages for building expert systems are…………. a. LISP and .NET
   b. .NET and Haskell
   c. Java and Prolog
   d. **LISP and Prolog**

3. The first stage in the development of an expert system is:
   a. Rapid Prototyping
   b. **Feasibility Study**
   c. Field Testing
   d. Maintenance and Evolution

4. Fixing bugs and enhancing the system's capabilities is done at which stage of the system development?
   a. Rapid Prototyping
   b. Feasibility study
   c. **Maintenance and evolution**
   d. System implementation

5. Inference engine errors in the development of an expert system can result from all the following except…………….
   a. Pattern matching
   b. **Misinterpretation of the knowledge base**
   c. Conflict resolution
   d. Execution of actions

6. Inference chain errors may be caused by all the following except …………….
   a. Erroneous knowledge
   b. Semantic errors
   c. Inference engine bugs

d. **Conflict resolution**

7. Which of the following aims at producing a detailed design for the expert system ?
   a. **Knowledge design**
   b. Code and check out
   c. Knowledge verification
   d. Knowledge definition

8. The last stage in the development of an expert system is ……………….
   a. **Maintenance and evolution**
   b. Feasibility study
   c. Rapid prototyping
   d. Refined system

9. The knowledge base of an expert system is knowledge obtained …………………
   a. By simulating the expected function of the expert system
   b. From questionnaires and interviews
   c. **From a human expert in the domain of the expert system**
   d. Professors and research scientists

10. _________________is a refinement of the waterfall model and it has the idea of developing the system in a top down approach using bits of increments. a. Water fall model
   b. Agile model
   c. **Incremental Model**
   d. Spiral Model