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Soft Computing Assignment

1) Characteristics of Soft Computing and Intelligent Systems

The following are the characteristics of soft computing are:-

a) It does not require any mathematical modeling for solving any problem.
b) It gives different solutions when we solve a problem of one input from time to time.
c) Uses some biologically inspired methodologies such as genetics, evolution, human nervous systems
d) Adaptive in nature.

The following are the characteristics of intelligent systems are-

a) Ability to predict stresses and failures
b) Automated learning and machine learning functionalities
c) Detection and resolution of events
d) Experimenting as a learning system

2) Knowledge Based Systems

→ A knowledge based system is a form of artificial intelligence that aims to capture the knowledge of human experts to support decision-making. Examples of knowledge-based systems include expert systems.

→ The typical architecture of a knowledge-based system includes a knowledge base and an inference engine. The knowledge base contains a collection of information in a given field - medical diagnosis, for example. The inference engine deduces insights from the information stored in the knowledge base.

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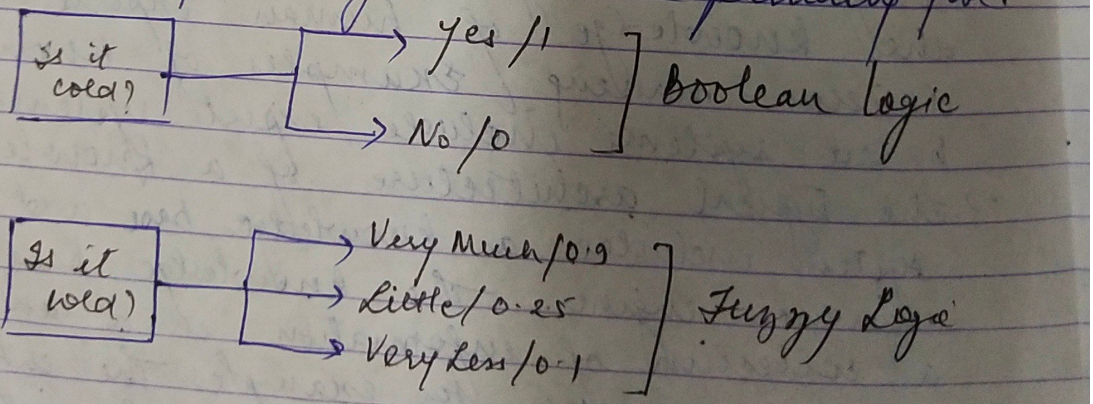
3) Knowledge representation and processing -
Knowledge representation refers to the technical problem of encoding human knowledge and reasoning into a symbolic language that enables it to be processed by information systems.
It is the field of artificial intelligence dedicated to representing information about the world in a form that a computer system can use to solve complex tasks such as diagnosing a medical condition or having a dialog in a natural language.

4) Fuzzy logic -
The term fuzzy refers to things that are not clear when we can't determine whether the state is true or false, then fuzzy logic provides very valuable flexibility for reasoning. In this way, we can consider the inaccuracies and uncertainties of any situation.
In the boolean system truth value, 1.0 represents the absolute truth value and 0.0 represents the absolute false value. But in fuzzy logic, there is an intermediate value too present which is partially true and partially false.



5) Neural Computing -
Neural computing refers to a neural network, that is a series of algorithms that recognizes relationships in a set of data through a process that mimics the way the human brain operates.
Neural networks can adapt to changing input, so the network generates the best possible result without needing to redesign the output criteria.

6) Evolutionary Computing -
Evolutionary computing is a sub-field of artificial intelligence and is used to solve problems that have too many variables for traditional algorithms. Computers performing evolutionary computing run such evolutionary algorithms as genetic algorithms, evolutionary programming, genetic programming.

7) Rough sets -
Rough sets is a formal approximation of a conventional set in terms of a pair of sets which give the lower and the upper approximation of the original set.
Rough set theory is a methodology of database mining or knowledge discovery in relational databases. We can use rough set approach to discover structural relationship within imprecise and noisy data.

8) Probabilistic Reasoning -
Probabilistic Reasoning is a way of knowledge representation where we apply the concept of

probability to indicate the uncertainty in knowledge. In probabilistic reasoning we combine probability theory with logic to handle the uncertainty.
We use probability in probabilistic reasoning because it provides a way to handle the uncertainty that is the result of someone's laziness and ignorance.
In probabilistic reasoning, there are 2 ways to solve problems with uncertain knowledge
1) Bayes' Rule
2) Bayesian statistics

Cont'd

Three req. of an Intelligent system
1. must possess human like expertise within a specific domain.
2. should be able to adapt & learn to do better in changing env.
3. should be capable of making decisions and taking actions accordingly.

Knowledge based system
→ Also includes an interface through which users query the system and interact with it.
→ Used in healthcare industry, avalanche path analysis, cash management etc

Hard Computing → traditional methods of computing that require precisely stated analytical models. Require more computational time.
Eg solving numerical problems (integration, roots of polynomials), searching & sorting, geometry problems etc

MPDDSOLF

Hard Computing

- Conventional type that requires a precisely stated analytical model.
- Requires programs to be written
- Deterministic, uses 2-valued logic
- Needs exact data
- Perform sequential computation
- Solved or output precise
- Based on crisp logic binary logic & numerical analysis.
- Not fault tolerant bcoz conventional prog and algo built in such a way that errors have serious consequences, unless enough redundancy is added into the system.

Soft Computing

- Imprecision, approximation and uncertainty tolerant techniques
- Model free. Evolve their own models & programs.
- Stochastic, uses multi valued logic such as fuzzy logic
- Can deal with incomplete, uncertain, noisy data
- Allows parallel computation eg Neural Networks
- Approx. output or n/a
- Based on neural network, fuzzy logic and evolutionary computations.
- Fault tolerant due to their redundancy, adaptability & reduced precision characteristics

Applications of Soft Computing -

- Handwritten Script recognition
- Image Processing and data Compression
- Automotive System & Manufacturing
- Soft computing based Architecture
- Decision Support System
- Power System Analysis
- Bioinformatics → Robotics
- Processing Natural Languages

Neural Networks

→ An ANN inspired by the biological nervous system tries to mimic the working of a human brain
→ Composed of large no. of highly interconnected processing elements called neurons.
All neurons work in parallel to solve a prob
→ Learns by examples the way humans learn by their experiences
→ Can be designed and configured for a specific application such as data classification, pattern recognition, data clustering etc

Adv

1. Human like AI
2. Learns and need not be reprogrammed
3. Can do tasks a linear prog cannot do
4. Parallel org of NN permits solns to problems where multiple constraints must be satisfied simultaneously.
5. Because of its parallel nature, when an element of the neural network fails, it can continue without any problem.

Application Scope – FIIOCMS

1. Forecasting –
   → forecasting exchange rates, predicting stock value, inflation & cash forecasting, weather condition etc
   → Accuracy > linear regression model
2. Image compression –
   → Digital images ⇒ large and of memory storage
   → Image compression – technique that removes redundant info in image without affecting its perceptibility.

→ NN used for compression. Eg - Kohonen's self organizing maps, Back propagation algo, Cellular NN etc

(3) Industrial process control -
→ NN → IPC → of dynamic system
→ modelly non-linear systems and implementy general purpose non-linear controllers
Eg agricultural machinery.

(4) Optical character Recognition -
→ OCR tools → image recognition → available with standard reading software
→ scanoff + NN → rule based system for correctly recognizing both characters & words

(5) customer Relationship Mgmt -
→ CRM requires key info to be derived from raw data collected for individual customers.
→ This can be achieved by building models using historical data info
→ NN → data mining in the db, patterns can be identified → valuable
→ Eg Airline reservation system.

(6) Medical science -
→ diagnostic system, bio chemical analysis, disease detection, image analysis & drug development

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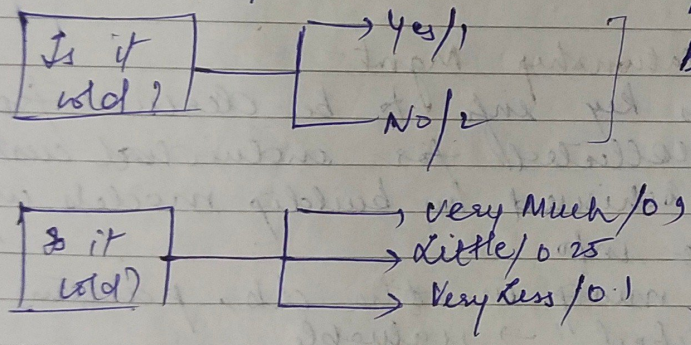
Fuzzy Logic -

→ Approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) boolean logic on which modern computer is used.

→ Like human brain, fuzzy logic is a powerful mathematical tool that can deal with imprecise, incomplete & uncertain info present in complex real world prob.

→ In boolean system, 1.0 represents the absolute truth value and 0.0 represents the absolute false value. But in fuzzy logic, there is an intermediate value present which is partially true and partially false.



→ Used in various applications such as pattern recognition, optimization, control applications, identification and decision making.

+ve

1) Simplicity & Flexibility
2) Can handle prob with imprecise & incomplete data
3) Can model non-linear func of arbitrary complexity
4) Cheaper to develop
5) Covers a wider range of operating conditions more readily customizable

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Applications of Fuzzy Logic

① Applications where human like decision making with an ability to generate precise soln from certain or approximate info rep.

② design of controllers for home appliances such as washing machine, AC, vacuum cleaner.

③ Facial pattern recog, anti-skid brake sys, transmission sys, control of subway sys & unmanned helicopters

④ dev of knowledge based systems for power sys, weather forecasting sys, models for project risk assessment, medical diag and stock trading

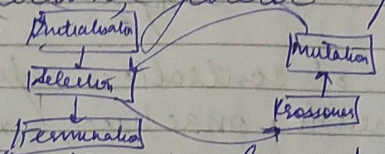
⑤ control sys engg, image processing, power engg robotics, consumer electronics & optimization

Evolutionary Computing

→ Class of algo inspired by biological evolutionary process
→ Heuristic based approach to solve prob that can't be easily solved in poly time
→ Sub-field of ~~algo~~ AI and is used to solve prob that have too many variables for traditional algo.
→ Can produce highly optimised soln in a wide range of prob settings.
→ Eg 3 types → ① Genetic algo ② Evolutionary prog ③ Evolutionary strategies

In Evolutionary computation, an initial set of candidate solutions is generated & iteratively updated. Each new gen is produced by stochastically removing less desired solutions, and introducing small random changes.

→ Depend on random sampling
→ Has a population of candidate soln, rather than just one.
→ Four steps of evolutionary algo - initialisation, selection, genetic operators and termination.



Genetic Algo -
→ Adaptive heuristic search algo based on evolutionary ideas of natural selection & genetics
→ Used to find optimal or near-optimal soln to difficult problems which otherwise would take a lifetime to solve
→ In GAs, we select the initial pool or a population of possible solutions to the given problem.
→ These soln then undergo various GA operators like recombination and mutation which in turn produce new children.
→ Process repeated over various generations
→ Sufficiently randomised in nature
→ Each individual or candidate soln is given a fitness value and the fitter individuals are given a higher chance to mate and yield fitter individuals, in accordance to Darwinian theory of 'Survival of the fittest'. Thus it keeps evolving better individuals as soln over gen, until a stopping criterion is reached.

Adv
(1) Easy to understand (2) Doesn't req. any derivative info
(3) Good for noisy env
(4) Easy to discover global optimum
(5) Inherently // and distributed
(6) Useful when search space very large & huge no of parameters involved
(7) List of "good" soln and not just one

Application → Automative design, Engg design, Robotics

Hybrid systems

→ Systems for which more than one soft computing technique is integrated to solve a real world problem.

Probabilistic Reasoning

→ A way of knowledge representation where we apply the concept of probability to indicate the uncertainty in knowledge.
→ In PR, we combine probability theory + logic ⇒ to handle the uncertainty

Need for PR in AI

1. when there are unpredictable outcomes
2. when specifications or possibilities of predicates become too large to handle.
3. when an unknown error occurs during an experiment

Two ways in PR to solve prob -

1. Bayes' Rule
2. Bayesian Statistics

Probability - Numerical measure of the likelihood that an event will occur.

$0 \leq P(A) \leq 1$ Probability ⇒ $\frac{\text{No of desired outcomes}}{\text{No of total outcomes}}$

Bayes' Rule - Relates conditional probability and marginal probabilities of 2 random events
→ Way to calculate the value of $P(A|B)$ with the knowledge of $P(B|A)$
→ Can be derived using Product rule and conditional probability of A with known event B.

$P(A \wedge B) = P(A|B) \cdot P(B)$

Similarly $P(A \wedge B) = P(B|A) \cdot P(A)$

$\therefore P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}$ ← Bayes' rule

$P(A|B)$ ← posterior ← prior prob; $P(B)$ ← marginal prob; $P(B|A)$ ← likelihood

$P(A|B)$ → posterior → need to calculate → Prob of hypothesis A when we have occurred an evidence B.

$P(B|A)$ → likelihood → Considers Hypo is true, then calculate prob of evidence

$P(A)$ → prior prob → prob of Hypo before evidence
$P(B)$ → marginal prob → pure probability of evidence

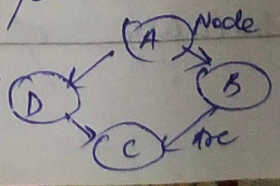
$$P(A_i|B) = \frac{P(A_i) \cdot P(B|A_i)}{\sum_{i=1}^{k} P(A_i) \cdot P(B|A_i)}$$

$A_1, A_2, A_3 \ldots$ set of mutually exclusive and exhaustive events.

Applications ① next step of robot
② Weather forecast ③ Monty Hall prob

Bayesian Statistics

→ A Bayesian Network is a probabilistic graphic model which represents a set of variables and their conditional dependencies using a directed acyclic graph.
→ Probabilistic bcoz built from a prob distribution
→ Used in prediction, anomaly detection, diagnostics, reasoning, time series prediction & decision making under uncertainty



Arc → conditional prob b/w random variables

Bayesian network graph

Node → random variables