

- knowledge representation and reasoning part of AI that is concerned with AI agents and how they think. This is the way by which machine think and reason like human.

It is not just storing data, but it also enables intelligent machine to learn from knowledge and experience like human.

What to represent -

- object - all fact about object e.g. guitar contains strings
- Events - actions in real world
- Performance - behaviour to do things
- meta knowledge - knowledge about we know
- facts - truth about real world
- knowledge base - central component of knowledge base agent.

knowledge - awareness gained by experience of facts, data & situations

Type of knowledge -

Declarative - include facts and objects

Structural - basic problem-solving knowledge that define relations

Procedural - this define how to do things

Meta knowledge - knowledge about other type of knowledge.

Heuristic - knowledge of experts in some field.

Approach to knowledge representation -

1) Simple relational knowledge - simple way of storing facts.
- like our database system

2) Inheritable knowledge - data stored in hierarchy form
- inheritance is applied.

3) Inferential knowledge - knowledge representation in form of formal logic, can be used to derive more fact, it guarantee correctness.

4) Procedural knowledge - it use small programs that describe how to do things., if then rule are use

* **Propositional logic** - Simplest form of logic where all statements are made by propositions. A proposition is declarative statement that is true or false, way of knowledge representation.
Ex - 5 is prime no, It is sunny

- Propositional logic also called Boolean logic as it works 0, 1.
- It can either true (tautology) or false (contradiction).

Two type of proposition -

- **Atomic** - single proposition symbol. These are sentence which are true or false. Ex - Sun is hot.
- **Compound** - proposition constructed by combining atomic proposition.

a) It is raining and street is wet.

Operators - $\neg, \wedge, \vee, \rightarrow, \Leftrightarrow$

- * **First order logic** - way of knowledge representation it is extension to propositional logic.

- also called predicate logic. it is very powerful

- it not only contain fact but also relations, function

Two main part - Syntax
Semantic

Syntax - Symbol used in first order logic it contains - constant, variable, predicate, function, connective, quantifier.

Semantic - It is the meaning of expression, statements.

Atomic sentence - Ravi and Ajay are brother.

Brother (Ravi, Ajay)

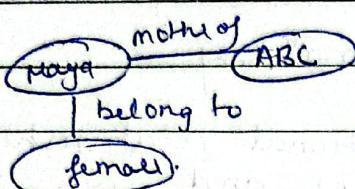
Complex sentence - All bird fly - $\forall \text{bird}(x) \rightarrow \text{fly}(x)$

Quantifier

Universal for all, every one	Existential for some at least.
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- * **Graph anacrtive network** - A means of representing relational knowledge as a labelled directed graph. Each vertex represent concept and label represent a relation between concepts.

- * Semantic network → graphical notation for representing knowledge in interconnected node pattern, alternative to predicate logic, knowledge representation in form of network



- Conceptual dependency - conceptual dependency is model of natural language understanding used in AI.
- 2 sentence having same meaning have same representation.
- helpful to draw inference from sentence.
- A set of dependencies which connect primitive action with each other.
- Frames - A frame is record like structure which consist of collection of attribute and its value. It contains slot and slot values then slot may be any type or size.
- Script - It is a structured representation describing a stereotyped sequence of events in particular context. Used in natural language understanding. systems to organise a knowledge base in terms of situations that system should understand.
- Horn clause - A horn clause is either a definite clause or an integrity constraint, it is a clause containing at most one positive literal.
- * Prolog - Prolog is logic programming language.
 - declarative programming language.
 - In this logic is expressed as relation (Fact & Rule)
 - core is logic.
 - formulation of computation is carried out by running query over these relation.

key feature - unification - can give term made to represent same
 Backtracking - when task fail, prolog trace back.
 Recursion - basis for searching.

Advantage - easy to build database
 Pattern matching is easy
 It has built-in list handling.

disadv - LISP is better.

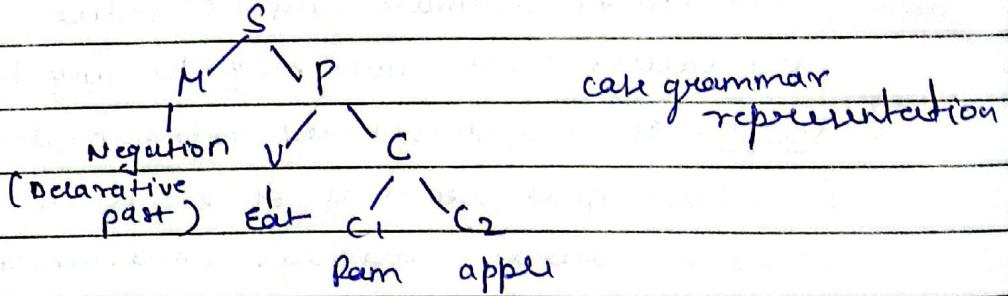
Input, output is tough

Application - used for pattern matching.

Fillmore's case grammar theory - we functional relationships between noun phrases and verb to conduct the more deeper role of sentence. In English sentence are very similar. In 1970 Fillmore gave some idea about different case of English sentence. In case grammar a sentence is defined as being composed of preposition p, modality M, mood, tense, aspect, negation.

$$S \rightarrow M + P$$

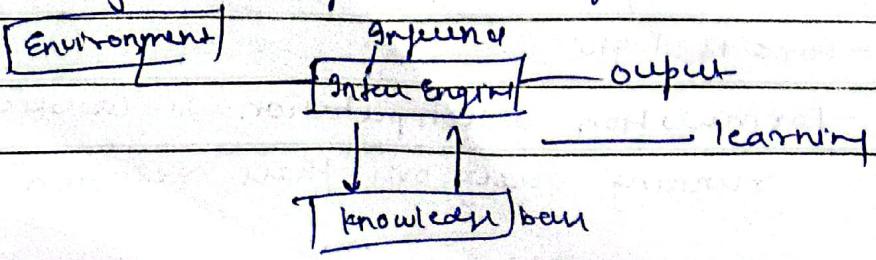
Ram did not eat the apple.



- Production rule - It consists of (condition, action). It is a way of representing knowledge in the form of if then rules.

if (at bus stop and bus arrives) then
 action (get into the bus).

- Knowledge base - It is a form of AI that aims to capture knowledge of human experts to support decision making.
 Component of knowledge based agent.



Structure.

- Inference system - Inference means deriving new sentence from old. Inference system allow us to add a new sentence to knowledge base.

Inference system generates new facts so that an agent can update knowledge base. An inference system works mainly in two rules -

Forward chaining -

Backward chaining -

- Forward chaining - also known as forward deduction or forward reasoning method. In this inference rule are applied in forward direction to extract more data until goal is reached.

- down-up approach.

- making conclusion based on fact.

- Backward chaining - also known as backward deduction or backward reasoning method used in inference engine. Start with goal and work backward, chaining through rules to find known fact.
 - top down approach.
 - goal driven approach.
 - used in game theory, proof assistant.

- * Reasoning under uncertainty - Based on probability, also called probabilistic reasoning.

$$\text{Baye's rule} - P(A|B) = \frac{P(B|A) P(A)}{P(B)}$$

Need - when there is unpredictable outcome

- when possibility are too large..

- unknown error occur during experiment.

Propositional logic - A proposition is basically a declarative sentence that has truth value. It can be 0 or 1.

Ex - The sun rises in west.

* Predicate logic - Predicate ^{are} properties, additional information to better express the subject of the sentence.

Predicate logic is expression consisting of variable with specified domain. contain extra quantification.

Ex - $x > 5$ x is subject > 5 is predicate.

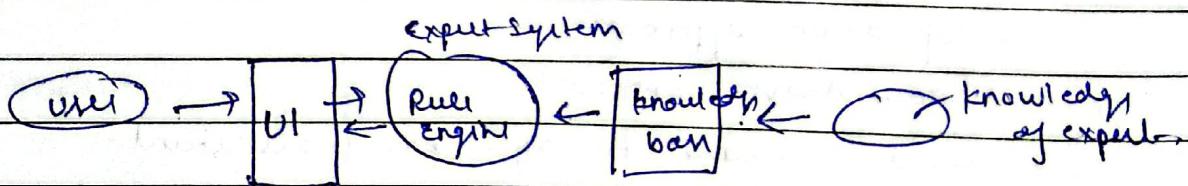
$$x = y$$

$$ab + c = 0$$

Units

Expert system - An expert system is a computer program that uses artificial intelligence technologies to simulate judgement & behaviour of human or organisation that has expertise and experience in particular field.

modern expert system use machine learning an AI these system can improve their performance over time as they gain experience just as human.



characteristics - High performance - can solve complex problem efficiently and accurately.

Understandable - easily understandable to user.

Reliable - accurate output

Responsive - respond quickly.

component - UI, inference engine, knowledge base.

It is interface to communicate	brain of expert system, by use of this it extract knowledge from knowledge base	base that store knowledge from expert.
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some popular Expert system -

- Dendral - It is chemical analysis expert system. used in organic chemistry to detect unknown organic molecule with help of their mass spectra and knowledge base chemistry.
- Mycbn - One of earliest backward chaining expert system designed to find bacteria causing infection like bacteraemia and meningitis. It is also used for recommendation of antibiotic and diagnosis of blood clotting.
- Pbody - expert system that is used to determine type and level of lung cancer. It take pic. of upper body, look like shadow, then shadow identify degree of harm.
- Cadet - Cadet expert system is diagnostic support system that can detect cancer at early stages.
- capability - Advising
decision making
Problem solving
Diagnosis
Explaining problem
predicting result.

Adv - highly reproducible
used at risky places.
Error are less.
high speed.

disadv - may produce wrong result
- high maintenance
- specific domain knowledge.

Application - Finance - Ex-tax advisor

diagnose - detection of disease.

Planning scheduling -

design & Manufacturing - like camera lens.

LISP - Programming language that has overall style that is organised around expression and function.

Features - machine-independent language

- use iterative design methodology and is extensible
- high level debugging
- OOP based
- support all data type - objects, lists, vectors, ~~sets~~ adjustable array, tree, hash table
- expression based language.
- Support statement like do, loop, loop for dolist, dotimes.
- we can create our own function.

JCH - JCH is a rule engine for Java.

Superset of CLIPS programming language.

Shell - A shell is nothing but an expert system without knowledge base. A shell provides developer with

knowledge acquisition, inference engine, user interface and explanation facility. ex -

JESS (Java expert system shell) that provides fully developed JAVA API for creating expert system. Can run on CLI or applet.

Features - Forward rule chaining

backward rule chaining.

Benefits - Suited for bigger problem

Faster than expert system shell written on C.

Contains some command allows less memory usage.

Limitation - Some capability are limited when used in browser.

development of expert system -

- Identify problem domain -
 - must be suitable for expert system to solve
- design system - Realize how concepts can be implemented
- develop Prototype - Acquire knowledge, apply rules.
- Test and refine - End user test the engine
 - Expert - whose knowledge is used.
- Participant
 - knowledge engineer - gather knowledge & code them to a system
 - End-user - person who use expert system
- knowledge acquisition - Process of extracting, organizing and structuring the domain knowledge and storing them to knowledge base.
- Representing domain knowledge -
 - if then rule
 - semantic network
 - frame.
- domain knowledge - knowledge of experts or knowledge of specific, specialised field.
- Explanation system - It supply information that clarify the structure and problem of computer program.
It allow the user with facility to know system reached to some conclusion.

unit-4

→ Natural language processing uses method like AI, ML, data science to enable computer to understand human language both written and verbal forms. It works by taking unstructured data and converting it to structured data format.

Eg: Sentiment analysis, machine translation.

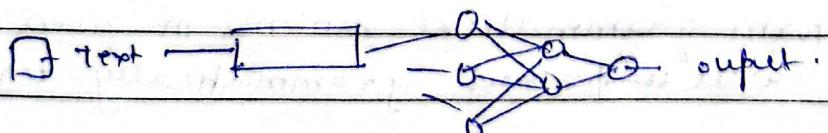
- Natural language understanding subset of natural language processing which uses syntactic and semantic analysis of text and speech to determine meaning of sentence. Syntax refers to grammatical structure and semantic related to meaning. NLU establishes the relation between word and phrase.
- Sentiment analysis, text summarization
- Natural language generation subset of NLP this enables computer to write. NLG is process of producing a human language based on some input data, this can be converted to speech.
NLG example text summarization.

Various approaches to NLP -

- 1) Rule based - These are written manually. In this rules are written and basic automation is done. These are used today to solve small problem.
 - Rules are written by people who have strong grasp of domain.
 - A small set of rules are used because large rule lead to unexpected behaviour.
 - Existing rule base - Example grammar already contain set of rules.
- 2) Machine learning based - ML method of NLP involve using AI algorithm to solve problem without explicitly programmed. ML model find the patterns independently.

just by analyzing texts. Two main step involve -

- Text annotation and formatting - It is called building corpus. collection of text for ML training. You can't simply fed data to system, so text must be annotated. we do tokenization, part of speech tagging, pausing. and then it becomes structured.
- Feature engineering - machine use feature to perceive text. Feature are different characteristic like, word count, word frequency, punctuation count.
- Model training and deployment - Prepared data is then fed to the algorithm for training. Algo like - SVM, Naive Bayes, Decision tree.
- Deep learning based - Similar to traditional machine learning but use neural networks for training with some difference like -
 - feature engineering is generally skipped as network will learn feature
 - streams of raw parameter are fed into neural network
 - very high training corpus.



- Parsing techniques - Parsing is known as syntax analysis. comparing rules of formal grammar, with text to check it for meaningfulness. It may be defined as process of analyzing string of symbol in natural language conforming to the rule of formal grammar.

- Parser report syntax error
- Parse tree is constructed
- find commonly occurring error.

Type of parser

- 1) Top down parsing - generates parse tree from root to leaves. In top down parsing begin from start symbol.
- 2) Bottom up parsing - In generates parse tree from leaves to root for given input string. Input string is reduced to starting symbol.

- Context free grammar - It is formal grammar which is used to generate all possible strings in given formal language.

$$G = (V, T, P, S)$$

V - Variable

P - Production rule

T - Terminal

S - Start symbol

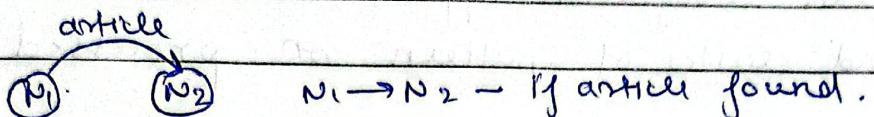
$$L = \{ wCwR \mid w \in (a,b)^* \}$$

$$S \rightarrow aSa \mid bSb \mid c$$

- Transformational grammar - It considers grammar to be system of rules that generate exactly those combination of word that form grammatical sentence in given language. It generate well formed grammatically correct sentences.

- Transition network - It is finite state automation that is used to represent part of grammar. A transition network parser uses a number of transition network to represent entire network.

- method to represent natural language in form of graph and finite state automata.
- It is used to recognize article, noun, verb etc.

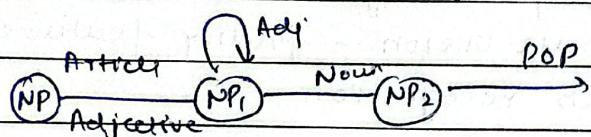


* Type -

- Recursive transition network (RTN)

- made of nodes and arcs

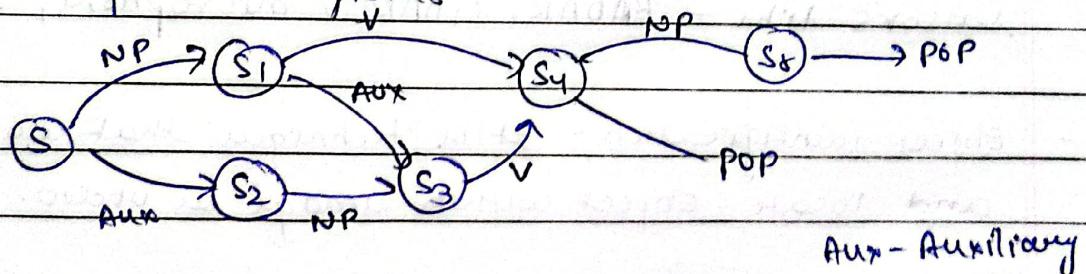
- It permits arc label to refer to other networks and they in turn ^{they} may refer back to referring networks



- Augmented transition network - Extension of RTN uses top down parsing procedure. to gather various type of information to be later used for understanding system.

ATN is RTN that can perform test and take action during arc transition.

- Store info in registers



- Sentence generation - the computational process of automatically producing sentence in human language - (NLG)

- Sentence translation - converting language of one form to other using AI, ML algorithm.

Intro. to Pattern recognition - process of recognizing patterns by using machine learning algorithm.

Pattern recognition application involve classification and clustering of pattern on processed data.

- classification - finding category

- clustering - find to related data

Adv - solve classification problem disadv - slow process
cloth recognition for blind - complex to implement

Application - image processing

computer vision - finding feature in image/video.

Speech recognition

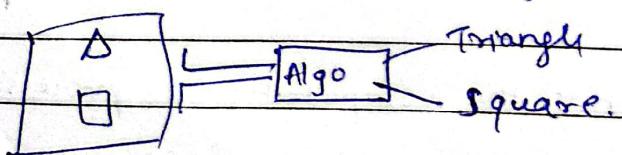
Fingerprint identification.

- Machine perception - it is a term for machine and allows machine to perceive world like human do.

Machine perception works with sensory data to perform required task. large scale concept gives ability to machine to think and work like humans.

sensors like - RADAR, LIDAR, microphone, signals etc.

- Object identification - it is technique that works to identify and locate object within image or video.



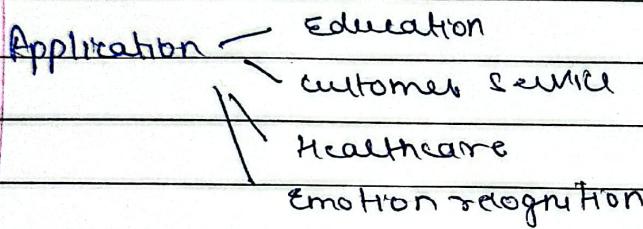
Object is recognized using deep learning method like CNN.

- Speech recognition - it is ability of a machine to identify words spoken aloud and convert them to readable text.

speech recognition is used to identify word in spoken language while voice recognition is identifying individual voice.

- Steps involved

- analyze audio
- break into parts
- digital to computer readable format
- use algo to match it to most suitable text representation



Adv - Machine to human communication

Easy to use

automatic improvement

disadv - drawbacks

- inconsistent performance
- slow process