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Artificial Intelligence

By

Dr.HARISH NAIK T **MCA, M.Tech,M.Phil Ph.D**

Associate Professor

Presidency Group

OVER 40 YEARS OF ACADEMIC WISDOM

Presidency College

Hebbal – Kempapura, Bengaluru – 560024

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UNIT II
Knowledge Representation

"A machine sounds like an empty box unless it is encoded with some features or information"

Therefore, to make it a smart machine, it is required to put the necessary knowledge in it. So that it could understand it and is able to take the right decisions.

There are three factors which are put into the machine, which makes it valuable:

Knowledge: The information related to the environment is stored in the machine.

Reasoning: The ability of the machine to understand the stored knowledge.

Intelligence: The ability of the machine to make decisions on the basis of the stored information.

What is Knowledge?

Data, information, and **past experience** combined together are termed as knowledge.

What is Knowledge representation?

Knowledge representation is the field of artificial intelligence (AI) dedicated to representing information about the world in a form that a computer system can utilize to solve complex tasks.

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***Properties of knowledge:

- Knowledge requires data
- Knowledge is voluminous
- It is hard to characterize accurately
- It is constantly changing
- It is differ from data by being organized in a way that corresponds to the ways it will be used.

***Representation of knowledge

Different levels of knowledge Representation

Mental Images

Written Text

Character Strings

Binary Numbers

Magnetic spots

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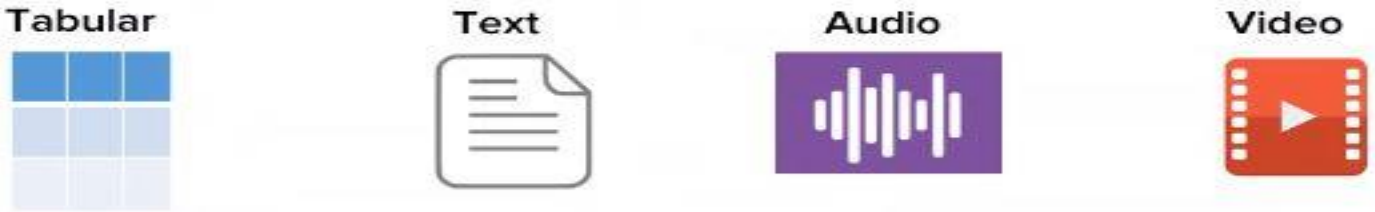
Data



Data > Information > Knowledge > Wisdom

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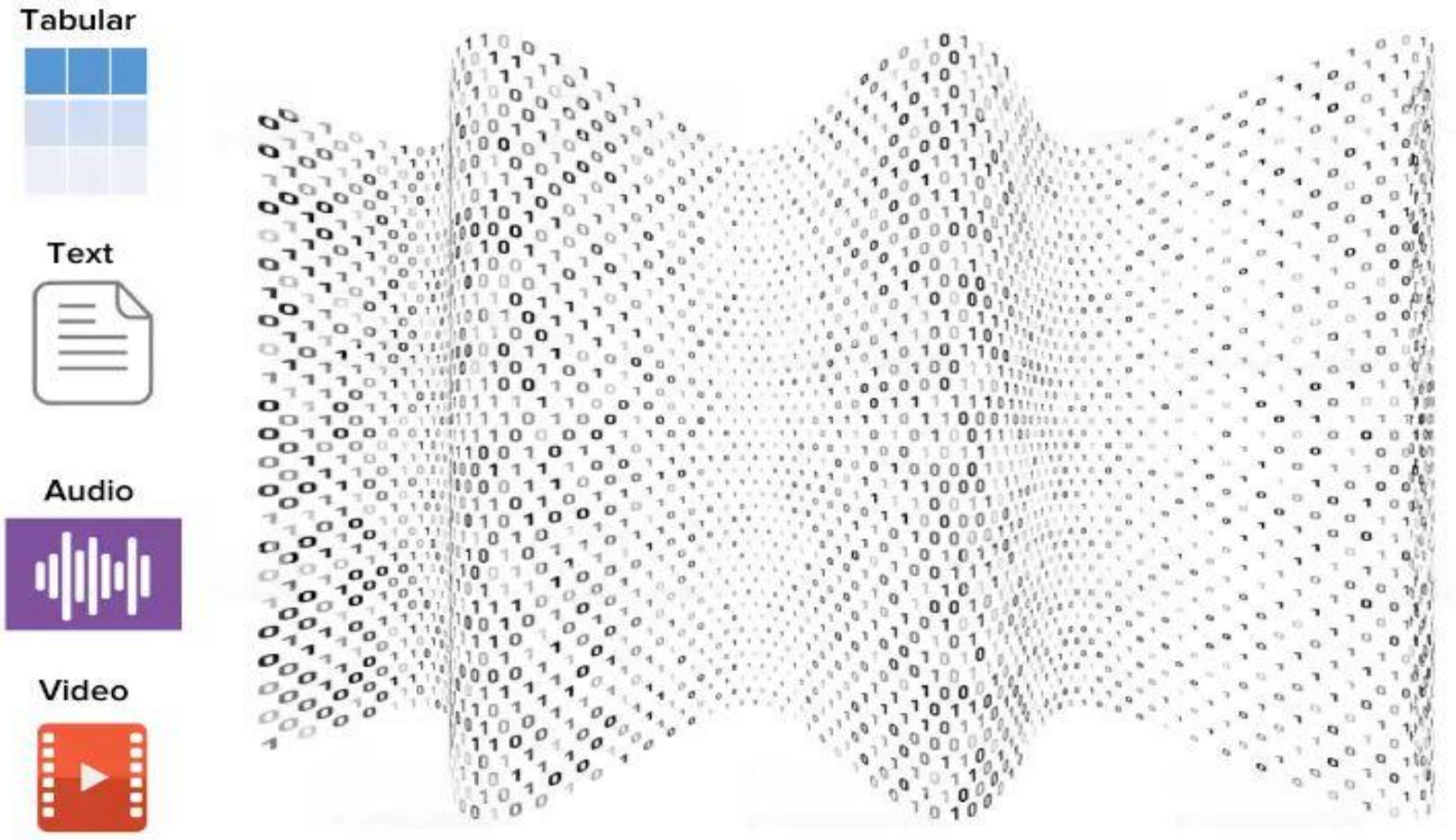

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***Types of knowledge:

- **Procedural Knowledge** is a compiled knowledge related to the performance of some task.
- **Declarative Knowledge** is defined as the factual information stored in memory and known to be static in nature.
- **Heuristic Knowledge** A special type of knowledge used by humans to solve complex problems. Heuristics are usually acquired with much experience.

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***Various Knowledge Representation Schemes

I. Logical representations

i. Propositional Logic

ii. FOPL (First Order Predicate Logic)

II.Structural representation

i. Semantic Networks

ii. Frames

iii. Conceptual Dependency

PROPOSITIONAL LOGIC (PL)

- *A proposition is a statement, which in English would be a declarative sentence. Every proposition is either TRUE or FALSE.*
- Examples: (a) The sky is blue., (b) Snow is cold. , (c) 12 * 12=144
- **propositions are "sentences" , either true or false but not both.**
- **a sentence is smallest unit in propositional logic.**
- **if proposition is true, then truth value is "true" .**
- if proposition is false, then truth value is "false" .

I. Propositional logic notations

- **Logical constants**: true, false
- **Propositional symbols**: P, Q, S, ... (**atomic sentences**)
- Wrapping **parentheses**: (…)

Sentences are combined by connectives:

∧ ...and	[conjunction]
∨ ...or	[disjunction]
⇒...implies	[implication / conditional]
⇔..is equivalent	[biconditional]
¬ ...not	[negation]

- **Literal**: atomic sentence or negated atomic sentence

Connectives and Symbols in decreasing order of operation priority

Connective	Symbols					Read as
assertion	P					"p is true"
negation	¬p	~	!		NOT	"p is false"
conjunction	p ∧ q	·	&&	&	AND	"both p and q are true"
disjunction	P v q	||	|		OR	"either p is true, or q is true, or both "
implication	p → q	⊃	⇒		if ..then	"if p is true, then q is true" " p implies q "
equivalence	↔	≡	⇔		if and only if	"p and q are either both true or both false"

Note : The propositions and connectives are the basic *elements* of propositional logic.

- ◊ Tautologies
- A proposition that is always true is called a *tautology*. e.g., *(P v ¬P) is always true regardless of the truth value of the* proposition *P.*
- ◊ Contradictions
- A proposition that is always false is called a *contradiction*. e.g., *(P ∧ ¬P) is always false regardless of the truth value of* the proposition *P.*

- ◊ Contingencies
- A proposition is called a *contingency, if that proposition is neither a tautology nor a contradiction* e.g., ***(P v Q) is a contingency.***
- ◊ Antecedent, Consequent
- In the conditional statements, $p \rightarrow q$, the 1st statement or "if - clause" (here p) is called *antecedent* , 2nd statement or "then - clause" (here q) is called *consequent.*

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Tom wants to play

But **Mumma** says **Tom**, outside its **rainy**, see its also **very cold** and **wind** is **very high**. So don't go to **play today**.

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Climates

Windy

Temperature

How Tom Understand Basics

Time

Let see how Tom Learns

Day	Climate	Temp	Wind	Time	Play
1	Sunny	40	2.5	8:00 AM	YES
2	Rainy	10	8.3	8:00 PM	NO
3	Sunny	35	4	8:00 PM	YES
4	Spring	25	4.6	8:00 PM	YES

Let see how Tom Learns

Day	Climate	Temp	Wind	Time	Play
1	Sunny	40	2.5	8:00 AM	YES
2	Rainy	10	8.3	8:00 PM	NO
3	Sunny	35	4	8:00 PM	YES
4	Spring	25	4.6	8:00 PM	YES
5	Rainy	23.5	0.1	8:00 AM	YES
6	Rainy	13.3	6.6	8:00 PM	NO
7	Rainy	12.1	4.6	8:00 PM	NO
8	Rainy	11	8	8:00 PM	?

Let see how Tom Learns

Day	Climate	Temp	Wind	Time	Play
1	Sunny	40	2.5	8:00 AM	YES
2	Rainy	10	8.3	8:00 PM	NO
3	Sunny	35	4	8:00 PM	YES
4	Spring	25	4.6	8:00 PM	YES
5	Rainy	23.5	0.1	8:00 AM	YES
6	Rainy	13.3	6.6	8:00 PM	NO
7	Rainy	12.1	4.6	8:00 PM	NO
8	Rainy	11	8	8:00 PM	?
Identifier	*Categorical*	*Continuous*	*Continuous*	*Categorical*	*Categorical*

Some simple facts in propositional logic about weather

- It is raining
  RAINING
- It is sunny
  SUNNY
- It is windy
  WINDY

Conclusion:

- If it is raining then it is not sunny.
  RAINING $\rightarrow \sim$ SUNNY

We can conclude from the fact that it is raining the fact that is not sunny.

Examples of Propositional Logic Compound sentences

i) "If it is hot and humid, then it is raining"

$(P \wedge Q) \rightarrow R$

"If it is humid, then it is hot"

If it is hot and humid then it is not raining

$(P \wedge Q) \rightarrow \neg R$

P means "It is hot."

Q means "It is humid."

R means "It is raining."

Examples of Propositional Logic Compound sentences

Example 3:

The statement

"If it is raining and I have not got a coat, then I will get wet"

Way of writing $\mathbf{R \wedge \neg G \Rightarrow W}$

Here R stands for "It is raining"

G stands for "I have got a coat"

W stands for "I will get wet".

****FOPL – First order predicate logic

- Predicate logic can make statements about objects, and the properties of objects, and the relationships between objects (propositional logic can't).
- It contains *predicates* – statements like this:

- **a(S) or : b(S, T)**

  that mean S has the property a, or S and T are connected by the relationship b.

Operators in Predicate logic

- The various operators are,
- Greater than (gt) >
- Less than (lt) <
- Less than or Equal (le) <=
- Greater then or Equal (ge) >=
- Equal (eq) =
- Not Equal (ne)≠

DE Morgan's Laws in Predicate logic

$\neg(\neg a) = a$

$\neg(a \vee b) = \neg a \wedge \neg b$

$\neg(a \wedge b) = \neg a \vee \neg b$

Predicate logic or calculus

Example 1:

"If the fat black cat sits on the mat then it is happy".

$$(f(c) \wedge b(c) \wedge s(c,m)) \Rightarrow h(c)$$

Here c stands for "the cat",

m stands for "the mat“

s stands for "sits on“

b stands for "black“

f stands for "fat“ and h stands for "happy". The statement

FOPL Examples

Example2:

It would be much better to represent these facts as

Gandhi is a Man.

- MAN (GANDHI) - FOPL

Einstein is a Man.

- MAN (EINSTEIN) - FOPL

John is tall

- John (tall)

Example 3:

All boys like cricket

Like (boys,cricket)

Some boys like cricket

Like(boys,cricket)

To remove such confusion we use quantifiers

Quantifiers are of two types

1. Universal quantifiers--------- $\forall(x)$
2. Existential quantifiers---------- $\exists(x)$

Solution:

All boys like cricket

Like (boys,cricket)

$\forall(x):boys(x) \rightarrow like(x,cricket)$

Some boys like cricket

Like(boys,cricket)

$\exists(x):boys(x) \wedge like\ (x,cricket)$

Statements in Symbolic form: Example 4

Something is good	$\exists(x)\,(G(x))$
Everything is good	$\forall\,(x)\,(G(x))$
Nothing is good	$\forall(x)\,(\neg G(x))$
Something is not good	$\exists(x)\,(\neg\, G(x))$

Note: Symbols $\neg$ or $\sim$ can be used for negation

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Example 5:

Consider the following four statements and convert in First Order Predicate Logic[FOPL]:

a. All Monkeys has a tail

b. No Monkeys have tails

c. Some Monkeys have tails

d. Some Monkeys have no tails

Solution:

- Let M(x): x is a Monkey.
- P(x) : x has a tail.

Statement	Symbolic Form
All Monkeys have tails	$\forall$ (x) [M(x) $\rightarrow$ P(x)]
No monkey has a tail	$\forall$(x)[M(x)$\rightarrow$~P(x)]
Some Monkeys has a tail	($\exists$x)[M(x) $\wedge$ P(x)]
Some Monkeys have no tails	($\exists$x) [M(x) $\wedge$~P(x)]

Example 6

Translate the following sentences into formulas in Predicate Logic

1 . Marcus was a man.

2. Marcus was a Pompeian.

3. All Pompeians were Romans.

4. Caesar was a ruler.

5. All Romans were either loyal to Caesar or hated him.

6. Everyone is loyal to someone.

7. People only try to assassinate rulers they are not loyal to.

8. Marcus tried to assassinate Caesar.

Solution:

1. Marcus was a man.

MAN (Marcus)

2.Marcus was a Pompeian

POMPEIAN (Marcus)

3. All Pompeians were Romans

∀ (for all) x: POMPEIAN (x) → ROMAN(x)

4. Caesar was a Ruler.
   RULER (Caesar)

5. All Romans were either Loyal to Caesar or hated him.
   ∀ (for all)x: loyal (x, Caesar)ᵛ Hate(x, caesar)

6. Everyone is Loyal to someone
∀ x: ∃y : Loyal to (x, y)

7. People only try to assassinate ruler they are not loyal to

$\forall(X):\forall(Y):Person(X)\wedge Ruler(Y)\wedge TrytoAssassinate(X,Y) \rightarrowtail Loyal\ to(X,Y)$

8.Marcus tried to assassinate Caesar.

trytoassassinate (Marcus, Caesar)

9) All Romans were either loyal to Ceasar or hated him.

Solution:

$$\forall x : \text{Roman}(x) \Rightarrow \text{Loyal}(x, \text{Ceasar}) \vee \text{Hated}(x, \text{Ceasar})$$

10) People only try to assasinate rulers they are not loyal to.

Solution:

$$\forall x \forall y : \text{Person}(x) \wedge \text{Ruler}(y) \wedge \neg \text{loyal}(x,y) \Rightarrow \text{tryassasinate}(x,y)$$

10) People only try to assasinate rulers they are not loyal to.

$$\forall x \forall y : Person(x) \wedge Ruler(y) \wedge \neg loyal(x,y)$$

$$\Rightarrow tryassasinate\,(x,y)$$

$$\forall x \forall y : Person(x) \wedge Ruler(y) \wedge tryassasinate\,(x,y)$$

$$\Rightarrow \neg loyal(x,y,)$$

Now suppose that we want to use these statements to answer the question

Was Marcus Loyal to Caesar?

- It seems that using 7 and 8, we should be able to prove that Marcus was not loyal to Caesar.
- Now let's try to produce a formal proof reasoning backward from the desired goal:

~loyalto(Marcus, Caesar)

4) Every Gardener Likes Sun

Solution:

$$\forall x : \text{Gardener}(x) \Rightarrow \text{likes}(x,\text{Sun})$$

5) All purple Mushrooms are poisonous

Solution:

$$\forall x : Mushroom(x) \wedge purple(x) \Rightarrow poisonous(x)$$

6) Everyone is Loyal to Someone

Solution:

$$\forall x \exists y : loyal(x,y)$$

7) Everyone loves everyone

Solution:

$$\forall x \forall y : loves(x,y)$$

8) Everyone loves everyone except himself

Solution:

$$\forall x \forall y : loves(x,y) \wedge \neg loves(x,x)$$

Semantic net:

A **semantic net** (or semantic network) is a knowledge representation technique used for propositional information. So it is also called a propositional net. Semantic nets convey meaning.

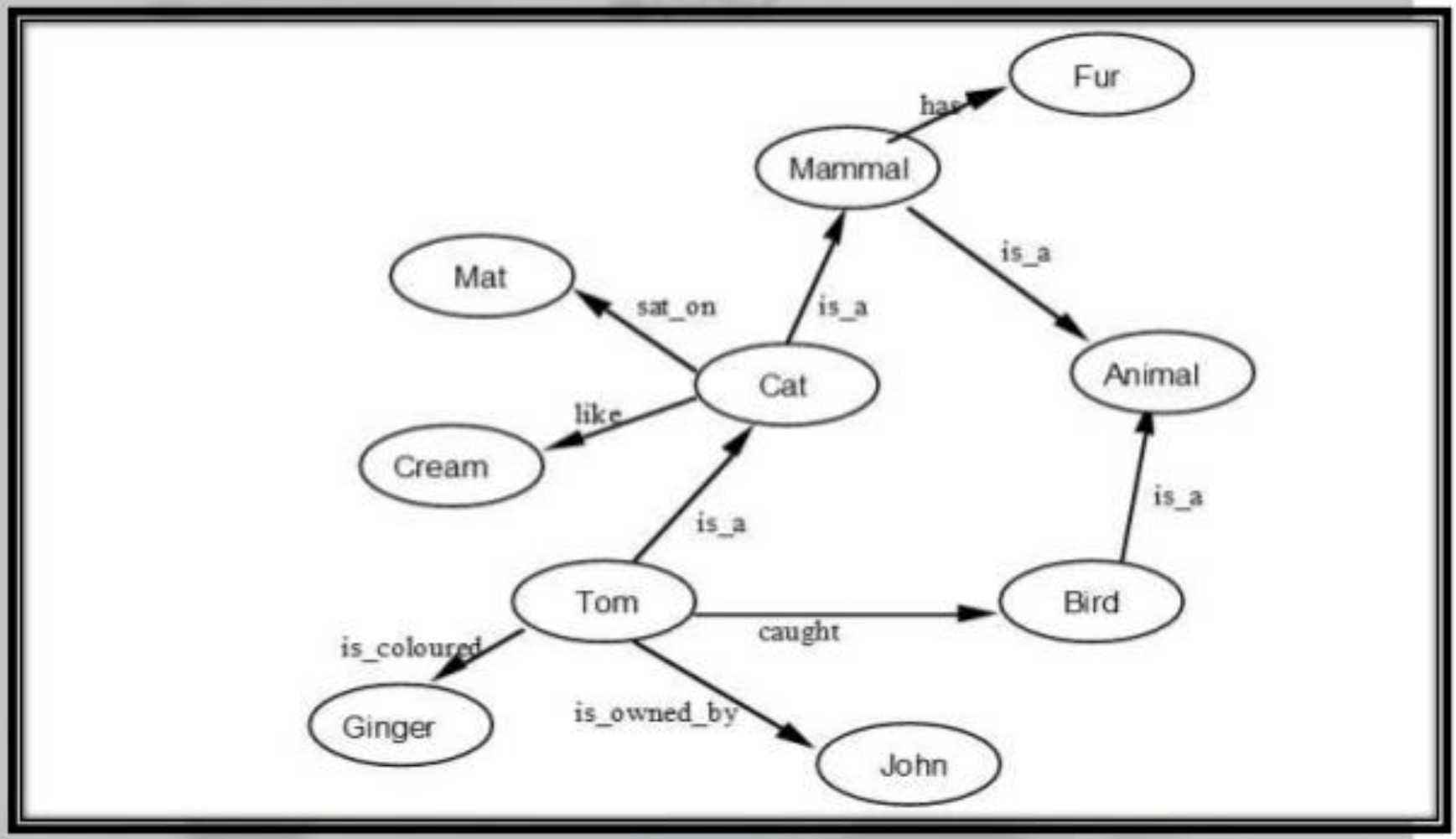
They are two dimensional representations of knowledge. Mathematically a *semantic net* can be defined as a labelled directed graph.

Example of semantic network

Is intended to represent the data:

- Tom is a cat.
- Tom caught a bird.
- Tom is owned by John.
- Tom is ginger in color.
- Cats like cream.
- The cat sat on the mat.
- A cat is a mammal.
- A bird is an animal.
- All mammals are animals.
- Mammals have fur.

Example of semantic network



Understanding Semantic Networks – An example

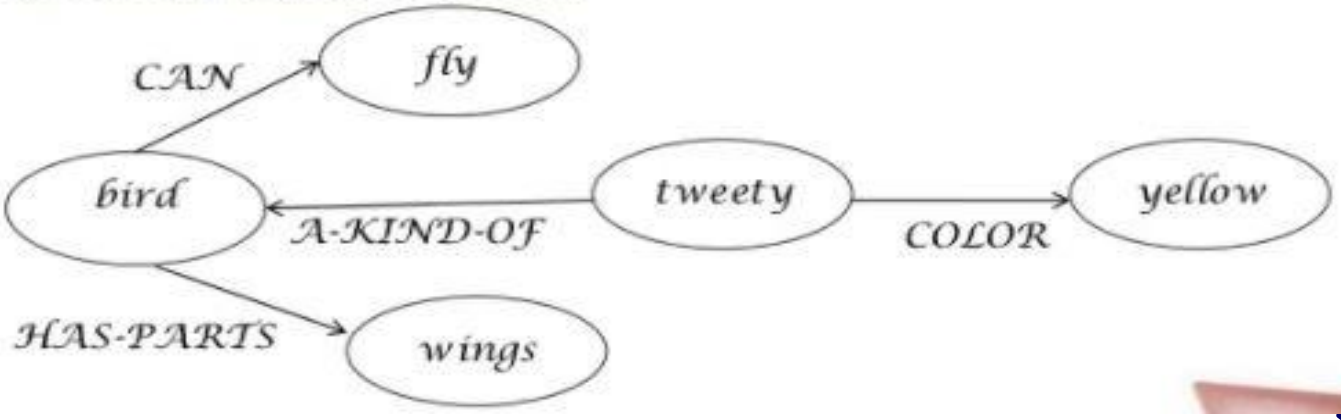
Let us make a semantic net with the following piece of information

"Tweety is a yellow bird having wings to fly."

Fact 1 : Tweety is a bird.

Fact 2 : Birds can fly.

Fact 3 : Tweety is yellow in color.



Given statements

P: Every bird can fly.

Q : Tweety is a bird.

R : Tweety can fly.

Using FOPL, lets define the following

B(x) for x is a bird.

F(x) for x can fly.

$P : \forall(x)\ ((B(x) \rightarrow F(X))$

$Q : B(TWEETY))$

$R : \forall(x)(B(x) \rightarrow F(x)) \wedge B(TWEETY) \rightarrow F(TWEETY)$

****Conceptual Dependency (CD)

Conceptual Dependency representations of a sentence is built out of primitives , which are not words belonging to the language but are conceptual , these primitives are combined to form the meaning of the words.

Examples of Primitive Acts are:

ATRANS - (Eg: give)
PTRANS - (Eg: go)
PROPEL - (Eg: push)
MOVE - (eg : kick)
GRASP - : (throw)
INGEST - (Eg: eat)
EXPEL - (cry)
MTRANS - (Eg: tell)
MBUILD-(Eg: decide)
SPEAK - (Eg: say)
ATTEND - (Eg: listen)

Six primitive conceptual categories provide *building blocks* which are the set of allowable dependencies in the concepts in a sentence:

PP

-- Real world objects.

ACT

-- Real world actions.

PA

-- Attributes of objects.

AA

-- Attributes of actions.

T

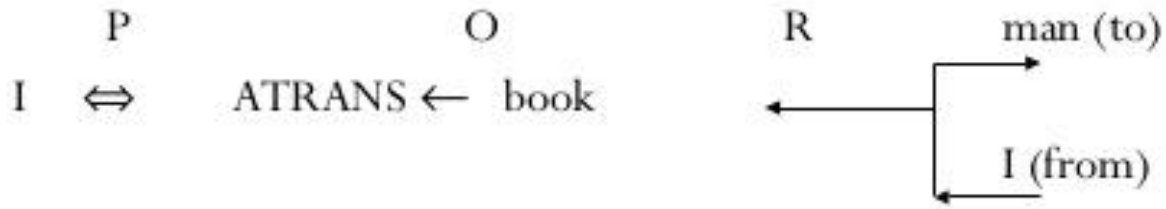
-- Times.

LOC

-- Locations.

Example

- I gave a book to the man. CD representation is as follows:



- It should be noted that this representation is same for different saying with same meaning. For example
  - I gave the man a book,
  - The man got book from me,
  - The book was given to man by me etc.

In the below representation the symbols have the following meaning:

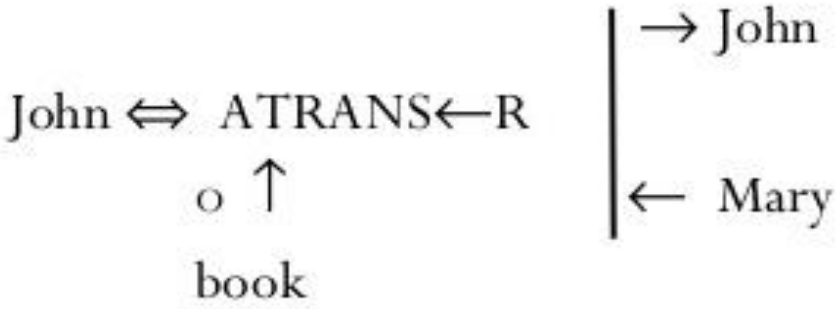
Arrows indicate direction of dependency

- Double arrow indicates two may link between actor and the action
- P indicates past tense
- ATRANS is one of the primitive acts used by the theory .It indicates transfer of possession
- O indicates the object case relation
- R indicates the recipient case relation

- It describes the relationship between an ACT and the source and the recipient of the ACT

- Example: John took the book from Mary

CD Rep:



Understanding Frames – Facts

Frames are record-like structures that have slots & slot-values for an entity

Using frames, the knowledge about an object/event can be stored together in the KB as a unit

A slot in a frame

- specify a characteristic of the entity which the frame represents
- Contains information as attribute-value pairs, default values

Understanding Frames - Examples

1. An example frame corresponding to the semantic net eg quoted earlier

(Tweety
(SPECIES (VALUE bird))
(COLOR (VALUE yellow))
(ACTIVITY (VALUE fly)))

2. Employee Details

(Ruchi Sharma
(PROFESSION (VALUE Tutor))
(EMPID (VALUE 376074))
(SUBJECT (VALUE Computers)))

From semantic network to frame

- Frame was proposed by Minsky in 1975 as an extension of the semantic network. Frame is more powerful for knowledge representation.

Slot	Value	Type
Cheetah		ID (name) of this frame
Is-a	Carnivore	Pointer to the parent frame
Food	meat	Attribute and value
Speed	Fast	Attribute and value
Character	Fearful	Attribute and value

Frames are more similar to web pages (1)

Living being	
is-a	*Thing*
Attribute	Live
Attribute	Re-producible
Attribute	Die

Animal	
is-a	*Living being*
Attribute	Move
Attribute	Eat
Attribute	Breath

Poch	
is-a	*Dog*
Popular	1
Size	Small
Origin	Japan

Cheetah	
is-a	*Animal*
Food	Meat
Character	Fearful
Speed	Fast

Dog	
is-a	*Animal*
Food	Omnivorous
Character	Friendly
Speed	Medium

Sahha	
is-a	*Cheetah*
Popular	2
Size	Medium
Origin	Sahara

Demon or agent

- The procedures are often called demons or agents.
- They are activated automatically when certain conditions are satisfied.
- Example of conditions
  - If needed,
  - if added,
  - if removed,
  - if modified,
  - etc.

- Example: If the GPA of a student is needed, and the value does not exist yet, a procedure can be called to find the value.

Yamada	
Is-a	student
GPA	**If-needed:** Proc_1
Earlier graduation	**If-needed:** Proc_2

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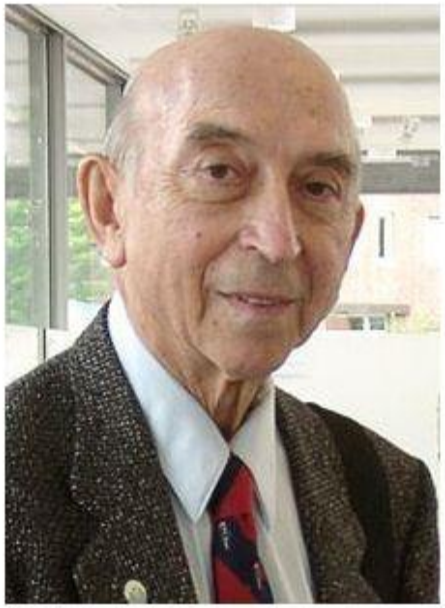
*****FUZZY LOGIC

What is Fuzzy Logic?

Fuzzy logic is a form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. In contrast with traditional logic theory, where binary sets have two-valued logic: true or false, fuzzy logic variables may have a truth value that ranges in degree

History of fuzzy logic

- The opposite word (antonym) of fuzzy is crisp. **Fuzzy** means un-clear or ambiguous, and **crisp** means clear, clean, and sharp.
- Fuzzy logic was proposed by Zadeh in 1965, and was applied in steam engine control by Mamdani in 1974.
- Fuzzy logic was made practically useful in Japan in the 1990s.



- Fuzzy logic has rapidly become one of the most successful of today's technologies for developing sophisticated control systems. The reason for which is very simple.
- Fuzzy logic addresses such applications perfectly as it resembles human decision making with an ability to generate precise solutions from certain or approximate information.
- It fills an important gap in engineering design methods left vacant by purely mathematical approaches (e.g. linear control design), and purely logic-based approaches (e.g. expert systems) in system design.

- While other approaches require accurate equations to model real-world behaviors, fuzzy design can accommodate the ambiguities of real-world human language and logic.
- It provides both an intuitive method for describing systems in human terms and automates the conversion of those system specifications into effective models.

- According to Japanese Road laws, road around the corner must be constructed based on the relation between the curvature and the speed limitation.
- For example, if the speed limit is 50 km/h, the radius of the curve must be 100m or more (see Table 5.4 in p. 94).

Fuzzy rules for speed control

- R1: If(v=Normal ∧ r=Sharp curve) Then(B=Weak)
- R2: If(v=A little fast ∧ r=Sharp curve) Then(B=Weak)
- R3: If(v=Fast ∧ r=Normal) Then(B=Weak)
- R4: If(v=Fast ∧ r=Sharp curve) Then(B=Strong)

Speed (v)	Curvature (radius r)	Break (b)
Normal	Slow curve	As is
Normal	Normal	As is
Normal	Sharp curve	Weak
A little fast	Slow curve	As is
A little fast	Normal	As is
A little fast	Sharp curve	Weak
Fast	Slow curve	As is
Fast	Normal	Weak
Fast	Sharp curve	Strong

Example

John is tall(5 feet)

Fuzzy sets

- tall
- Fairly tall
- Short

Speed=0(slow) and speed=1(fast)
If(speed=0)
Else if (speed =1){Classical example}

Fuzzy sets
0-0.25-slowest
0.25-0.50-slow
0.50-0.75-fast
0.75-1.0-fastest

What is not Fuzzy Logic ?

- Classical logic or Boolean logic has two values
- Example:
  - true or false
  - yes or no
  - on or off
  - black or white
  - start or stop

7

Differences between Fuzzy Logic and Crisp Logic

- Crisp Logic
  - precise properties
- Full membership
  - YES or NO
  - TRUE or FALSE
  - 1 or 0
- Crisp Sets
  - Jane is 18 years old
  - The man is 1.6m tall

- Fuzzy Logic
  - Imprecise properties
- Partial membership
  - YES ---> NO
  - TRUE ---> FALSE
  - 1 ---> 0
- Fuzzy Sets
  - Jane is about 18 years old
  - The man is about 1.6m

Fuzzy Logic Applications

- Aerospace
- Automotive
- Business
- Chemical Industry
- Defense
- Electronics
- Financial
- Industrial
- Manufacturing
- Marine
- Medical
- Signal Processing
- Telecommunications
- Transportation

AI well known companies

- Cycorp, Inc. http://www.cyc.com/
  - Cycorp was founded in 1994 to research, develop, and commercialize Artificial Intelligence. Cycorp's vision is to create the world's first true artificial intelligence, having both common sense and the ability to reason with it.
- Soar Technology, Inc. http://www.soartech.com/
  - Design of "highly human" intelligent agents
- Autonomous Decision Making Software
- Franz Inc. http://www.franz.com/
  - Enterprise Development Tools (Allegro CL) http://www.franz.com/enterprise_development_tools.lhtml
  - Semantic Web Technologies (AllegroGraph, RacerPro) http://www.franz.com/agraph/

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Links for the young AI learner and researcher

- AI-MAS Links of interest
- Academic publishing
  http://en.wikipedia.org/wiki/Academic_publishing
- Writing a Scientific Paper
  http://www.oup.com/us/samplechapters/0841234620/?view=usa
- ISI Web of Knowledge
  http://isiwebofknowledge.com/
- Master Journal List
  http://science.thomsonreuters.com/mjl/
- Conference Proceedings Citation Index
  http://wokinfo.com/products_tools/multidisciplinary/webofscience/cpci/
- TED – Ideas worth spreading
  http://www.ted.com/

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End of Unit 02

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS
Presidency College

Reaccredited by NAAC with A+

Presidency Group

OVER 40 YEARS OF ACADEMIC WISDOM

Any Questions?