# ECII/ECSI 3206:
# Artificial Intelligence [and expert systems]
# Topic 4: Logic and Truth Tables

By: Edgar Otieno

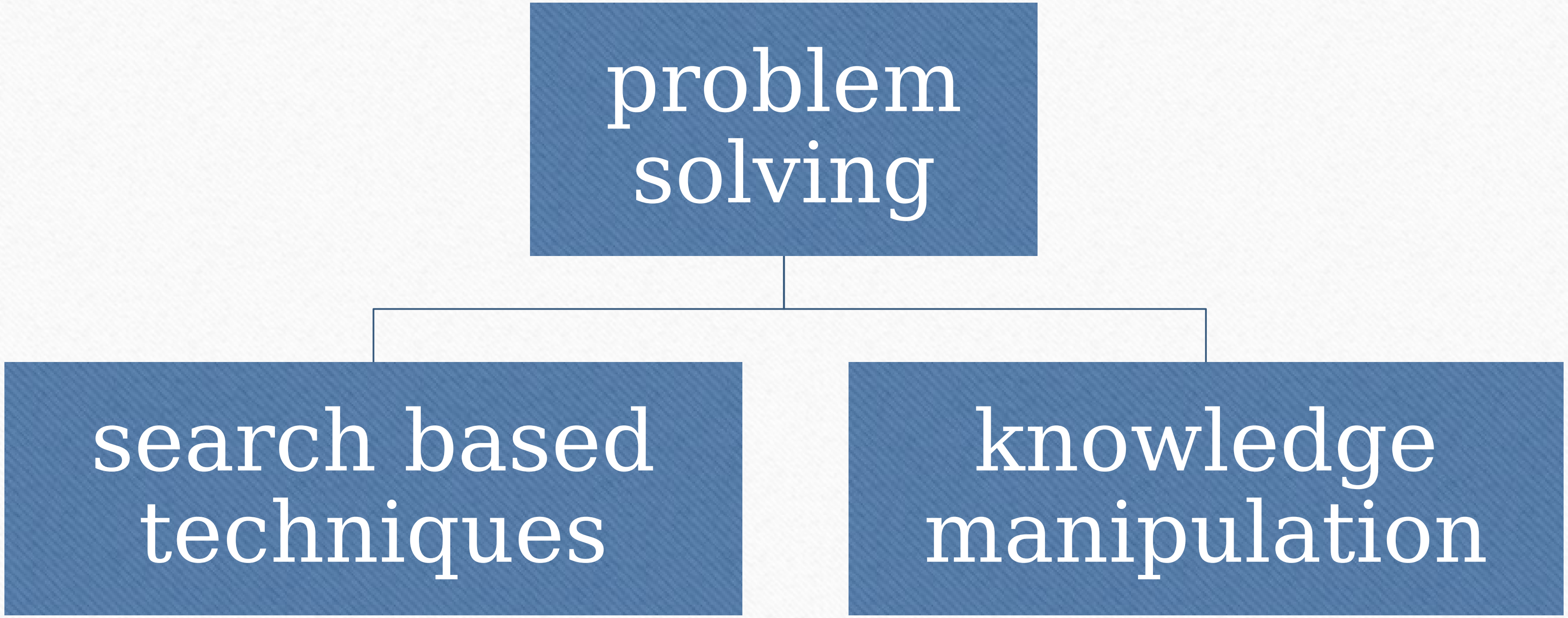
# Introduction to Logic

Problem solving could be broadly subdivided into either **Search based techniques** or **Knowledge based techniques**

Knowledge based techniques can be further subdivided into either **knowledge representation** or **Knowledge manipulation**.

The schemes for knowledge representations may be either use of **Logic statements** or use of **Semantic networks**.

# Problem Solving approaches



# 1.Introduction to Logic/Logic statements

- **Logic**-It’s a truth perceiving system of inference.
- **Proposition**-defines a statement that valuates to either true or false but not both .
- **Propositional Logic**-Defines rules of mathematical logic used to specify methods of reasoning.
- Which one is a proposition and which is not out of the statements below?
  - This is AI class
  - Today is Monday
  - B.Tech CN students are doing AI course
  - A is less than 14

# Connectors and logic operators

- AND/CONJUNCTION [∧]
- OR/DISCJUNCTION[V]
- EXCLUSIVE DISJUCTION/EXCLUSIVE OR [⊕] or [ $\veebar$ ]
- NOT/NEGATION[¬] or [ ˜ ] or [ ! ]
- IMPLICATION/CONDITIONAL IMPLICATION[→]
- BICONDITIONAL IMPLICATION[↔]

# Propositional logic connectives Meaning summary

| Name | Symbol | Connection | Meaning |
|---|---|---|---|
| AND (Conjunction) | $\wedge$ | $P \wedge Q$ | $(P \wedge Q)$ is true if both P and Q are true otherwise false. |
| OR (Disjunction) | $\vee$ | $P \vee Q$ | $(P \vee Q)$ is true if either P or Q is true (or both) otherwise false. |
| NOT (Negation) | $\neg$ | $\neg P$ | $\neg P$ is the opposite of P. If P is true, $\neg P$ will be false and vice versa. |
| Exclusive OR | $\oplus$ | $P \oplus Q$ | Either P or Q but not both. If both are different, then $P \oplus Q$ will be true otherwise false. |
| Implication | $\rightarrow$ | $P \rightarrow Q$ | If P happens then Q happens. |
| Double Implication | $\leftrightarrow$ | $P \leftrightarrow Q$ | P happens if and only if Q happens. |

# Truth tables

- Truth tables-are diagrams used to show every possible truth value

| $p$ | $q$ | $p \wedge q$ | $p \vee q$ | $p \oplus q$ | $p \to q$ | $p \leftrightarrow q$ |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 | 0 | 1 | 1 |

# Truth tables terminologies.

**Compound truth tables**-These are those truth tables that use multiple connectors e.g **((P V Q) ∧R)**

**Tautology-** It is a compound proposition that always evaluates to TRUE e.g **((P V ¬P)**

**Contradiction**-It is a compound proposition that always evaluates to FALSE e.g **((P ∧ ¬P)**

**Contingency**-any proposition that is neither a Contradiction or a Tautology

# Cont..

- **Well formed formulae-**This is an sentense/expression that is constructed correctly according to the rules of propositional calculus
- **Logical equivalence**-two compound propositions are said to be logical equivalent iff $P \leftrightarrow Q$ is a tautology[always evaluates to TRUE]
  - e.g $\neg(P \wedge Q) \equiv (\neg P \vee \neg Q)$
    - $\neg(P \vee Q) \equiv (\neg P \wedge \neg Q)$

**[The above two statements are Defined as De'morgans Laws]**

# English statements and their equivalent propositional representation

- It is raining in Nairobi: **R(N)//RAINING(NAIROBI)**
- It is raining in Nairobi and I'm either sick or very tired: **R(N) ∧(S(I)VT(I))**
- It is Not Raining in Nairobi:**¬R(N)**
- If it is Raining in Nairobi then I will get wet: **R(N) →W(I)**

# Predicate Logic/Predicate Calculus

- Some statements cannot be represented using propositional logic e.g X>3, all men die..etc
- **Predicate logic**-It is an expression of one or more Variables defined within some specific domain.

# Structure of Predicate statements

- Consider the statement P(X,Y)
  - P is he predicate describing the relationship
  - X and Y are Variables/arguments that the relationship P applies upon

e.g.

Likes(edgar,chapati)

Father(sonko,saumu)

Mother(X,Y):-son(Y,X) V daughter(Y,X) ∧ female(X)

# Quantifiers used in Predicate Logic

- These are symbols used to express the extent to which a predicate is True over a set of elements.
- They include:-
  - Universal/for all: $\forall$
  - Existential/for some: $\exists$

# Predicate Logic examples

- Everyone likes Chapati: $\boldsymbol{\forall(x)\ P(x) \rightarrow L(x,c)}$
- There exists a person that likes Chapati : $\boldsymbol{\exists(x)\ L(x,c)}$
- For everyone, there exist a Y where X loves Y: $\boldsymbol{\forall(x)\ \exists(y)\ L(x,y)}$
- Some persons in our class have visited Mombasa: $\boldsymbol{\exists(x)\ (C(x) \wedge M(x))}$
- No one in our class is a musician?

# Using De’morgan rules to evaluate statements

- Consider the expression for : Not everyone likes Chapati.

  $$\neg\forall(x)\ (P(x) \rightarrow L(x,c))$$

- Using De’morgan rules, we can rewrite the statement as follows to eliminate implication symbol[→].
- **De’morgan rules:**
  - $\neg(P \wedge Q) \equiv (\neg P \vee \neg Q)$
  - $\neg(P \vee Q) \equiv (\neg P \wedge \neg Q)$

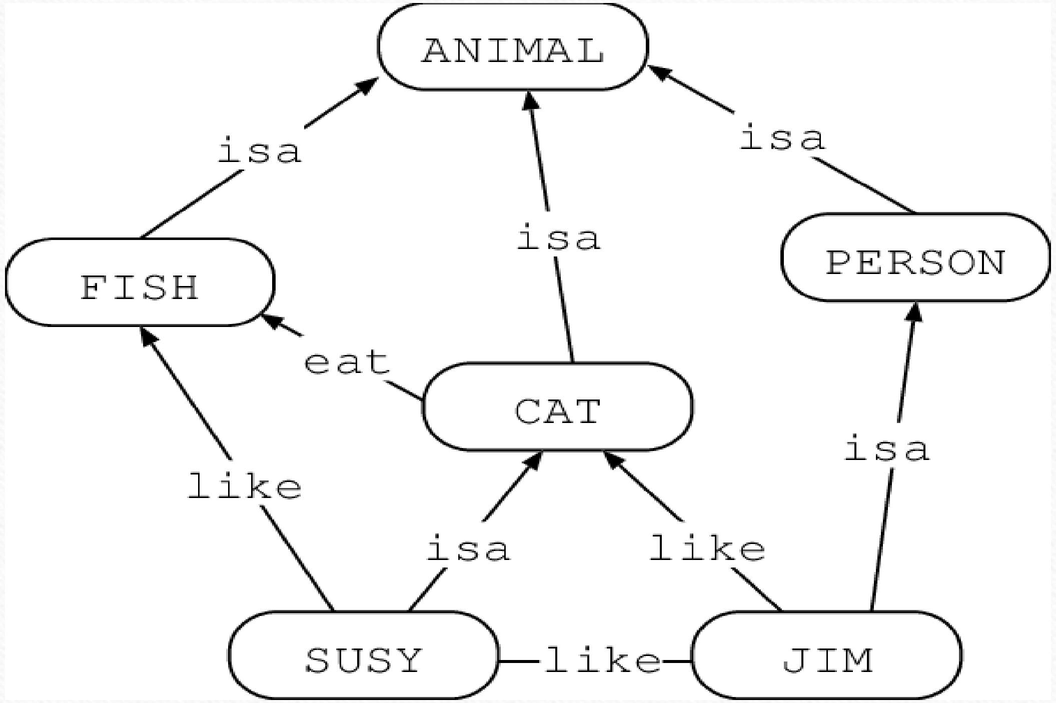
# Cont…

- $\mathbf{A \rightarrow B \equiv \neg A \lor B}$ and also $\mathbf{\neg A \lor B \equiv \neg\ (A \land \neg\ B)}$
- So let $\mathbf{P(x)}$ be represented by $\mathbf{A}$ and $\mathbf{L(x,c)}$ be represented by $\mathbf{B}$
- Therefore form the first statement we can re write the part $\mathbf{(P(x) \rightarrow L(x,c))}$ as follows: $\mathbf{\neg\ (P(x) \land \neg( L(x,c))}$
- The final expression evaluates to **:** $\mathbf{\neg\forall(x)\ \neg\ (P(x) \land \neg( L(x,c))}$

# 2. Semantic Networks(Semantic nets)

- **Semantic nets**-are structures used to represent knowledge as a set of interconnected nodes and arcs.
- **Nodes**-Represent Entities , attributes and Events
- **Arcs**-Represent the relationship between Nodes

# Sample Semantic Net



# Advantages of Semantic Nets

- Easy to understand
- We can identify relationships
- Easy categorization of knowledge
- Nodes and objects are represented only once

# Disadvantages of Semantic Nets

- It has limited handling of quantifiers
- Cannot express connectives
- Difficult to represent some statements e.g how would we represent the statement “Khadija  and Adannor really Caused trouble during the last school trip to Mombasa”