1. **What is KKR? Why KKR is needed in A.I?**

Knowledge Representation & reasoning is a technique for representing information about the real world so that a computer can understand and can utilize this knowledge to solve the complex real world problems.

2. **Definition of PL (Propositional Logic), PDL(Predicate Logic), and FL(Fuzzy Logic).**

Propositional logic (PL) is the simplest form of logic where all the statements are made by propositions. A proposition is a declarative statement that is either true or false. It is a technique of knowledge representation in logical and mathematical form.

Predicate Logic (PDL) deals with predicates, which are propositions, consist of variables. It is a powerful language that develops information about the objects in a more easy way and can also express the relationship between those objects.

Fuzzy Logic (FL) in artificial intelligence is a generalized form of standard logic, where any concept might have a truth degree ranging between 0.0 and 1.0.

3. **What are the different types of inferences that are used on the above 3 types of knowledge representation techniques with examples?**

Propositional logic (PL)

- **Modus Ponens:** One of the most important rules of inference, and it states that if P and P → Q is true, then we can infer that Q will be true. It can be represented as:

$$\frac{P \rightarrow Q,\ P}{\therefore Q} \qquad \{((P \rightarrow Q) \wedge P) \rightarrow Q\}$$

- Hence, we can say that, if P→ Q is true and P is true then Q will be true

Example:

Statement-1: "If I am sleepy then I go to bed" ==> P→ Q

Statement-2: "I am sleepy" ==> P

Conclusion: "I go to bed." ==> Q.

Hence, we can say that, if P→ Q is true and P is true then Q will be true.

- **Modus Tollens:** This rule state that if P→ Q is true and ¬ Q is true, then ¬ P will also true. It can be represented as:

$$\frac{P \rightarrow Q,\ \sim Q}{\therefore \sim P} \qquad \{((P \rightarrow Q) \wedge \sim Q) \rightarrow \sim P\}$$

Example:

Statement-1: "If I am sleepy then I go to bed" ==> P→ Q

Statement-2: "I do not go to the bed."==> ~Q

Statement-3: Which infers that "I am not sleepy" => ~P

- **Hypothetical Syllogism (H. S.):** This rule state that if P→R is true whenever P→Q is true, and Q→R is true. It can be represented as the following notation:
- $$\frac{(P \rightarrow Q) \wedge (Q \rightarrow R)}{\therefore P \rightarrow R}$$

❑ **Example:**

Statement-1: If you have my home key then you can unlock my home. P→Q

Statement-2: If you can unlock my home then you can take my money. Q→R

Conclusion: If you have my home key then you can take my money. P→R

- **Disjunctive Syllogism (D. S.):** The Disjunctive syllogism rule state that if PVQ is true, and ¬P is true, then Q will be true. It can be represented as:
- $$\frac{(P \vee Q) \sim P}{\therefore Q}$$

❑ **Example:**

Statement-1: Today is Sunday or Monday. ==>PVQ
Statement-2: Today is not Sunday. ==> ¬P
Conclusion: Today is Monday. ==> Q

♦ **<u>Drawbacks of PL</u>** -

1. Has limited expressive power
2. No representation to relations like "All, some, none, etc"
    1. E.g All eggs are rotten, some apples are sweet, etc.
3. Alternate = Predicate Logic

Predicate Logic (PDL)

❑ **Quantifiers:**

- Logical operators which assert the scope of a predicate

$\forall$ For All (universal quantifier)

$\exists$ There Exists (existential quantifier)

- $\forall x$ LOVELY (x) Everything is lovely.
- $\exists x$ LOVELY (x) Something is lovely.
- $\forall$x IN (x, garden) $\Rightarrow$ LOVELY (x) Everything in the garden is lovely.

Fuzzy Logic (FL)

Fuzzy Inference: The process of reasoning based on Fuzzy logic.
Example:

If the power transformer is slightly overloaded,
Then keep this load for a while.

Fuzzy rule: A conditional statement in the form:
IF x is A THEN y is B, where x and y are linguistic variables, and A and B are linguistic values determined by fuzzy sets.

- ***Rule 1****: IF (GPA is high) and (Exam is satisfactory) and (Approach is Smart) then (Decision is Select)*
- ***Rule 2****: IF (GPA is low) and (Exam is bad) or (Approach is Stupid) then (Decision is Reject)*
- *Inputs to a fuzzy system can be:*
  - fuzzy, e.g. (Score = Moderate), defined by membership functions
  - exact, e.g.: (Score = 190); (Theta = 35), defined by crisp values.
- *Outputs from a fuzzy system can be:*
  - fuzzy, i.e. a whole membership function, or
  - exact, i.e. a single value is produced on the output.

Four steps: fuzzification, rule evaluation, aggregation of the rules, defuzzification

Rule 1:	**Rule 1:**
IF x is A3	IF project_funding is adequate
OR y is B1	OR project_staffing is small
THEN z is C1	THEN risk is low
Rule 2:	**Rule 2:**
IF x is A2	IF project_funding is marginal
AND y is B2	AND project_staffing is large
THEN z is C2	THEN risk is normal
Rule 3:	**Rule 3:**
IF x is A1	IF project_funding is inadequate
THEN z is C3	THEN risk is high

4. Symbols, quantifiers, rules of inference in different types of knowledge representation technique with examples.

- **Syntax of PL :**
- symbol -> P | Q | R | S | ...
- atomic sentence -> TRUE | FALSE
- sentence -> atomic sentence | complex sentence
- complex sentences -> ~ sentence | (sentence ^ sentence) | (sentence v sentence) | (sentence → sentence) | (sentence ↔ sentence)
- Precedence relation operators: ~, ^, v, →, ↔.

Predicate Logic

- **Logical Connectives:**
  - AND (∧)
  - OR (∨)
  - NOT (~)
  - IMPLIES (→)

❑ Quantifiers:

- Logical operators which assert the scope of a predicate

$\forall$ For All (universal quantifier)

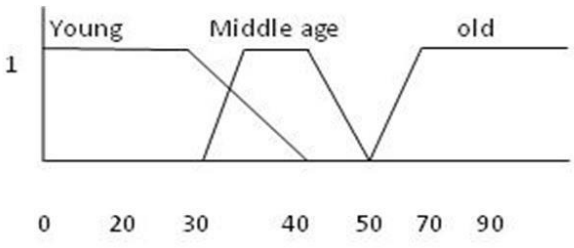
$\exists$ There Exists (existential quantifier)

Operations on Fuzzy Sets

- Operations on fuzzy sets is done by means of their membership functions. Let *A* and *B* be fuzzy sets on a mutual universe.

1. Intersection of *A* and *B* is: $A \cap B =$	= *A* **min** *B*, corresponding items in *a* and *b*.
2. Union of *A* and *B* is: $A \cup B =$	= *A* **max** *B*, corresponding items in *a* and *b*.
3. Complement of A is: A =	= 1 - A
4. Dilation (increases the degree of membership of all members by spreading out the curve) of A is:	=DIL (A) = $(u_A(x)^{1/n})$ for all x in U
5. Concentration (decreases the degree of membership of all members) of A is:	=CON (A) = $(u_A(x)^n)$ for all x in U

5. **Difference between Fuzzy Logic and Crisp Logic. What are fuzzy expert systems?**

FUZZY SET	CRISP SET
Defines value between 0 or 1	Defines either value is 0 or 1
	YES or NO

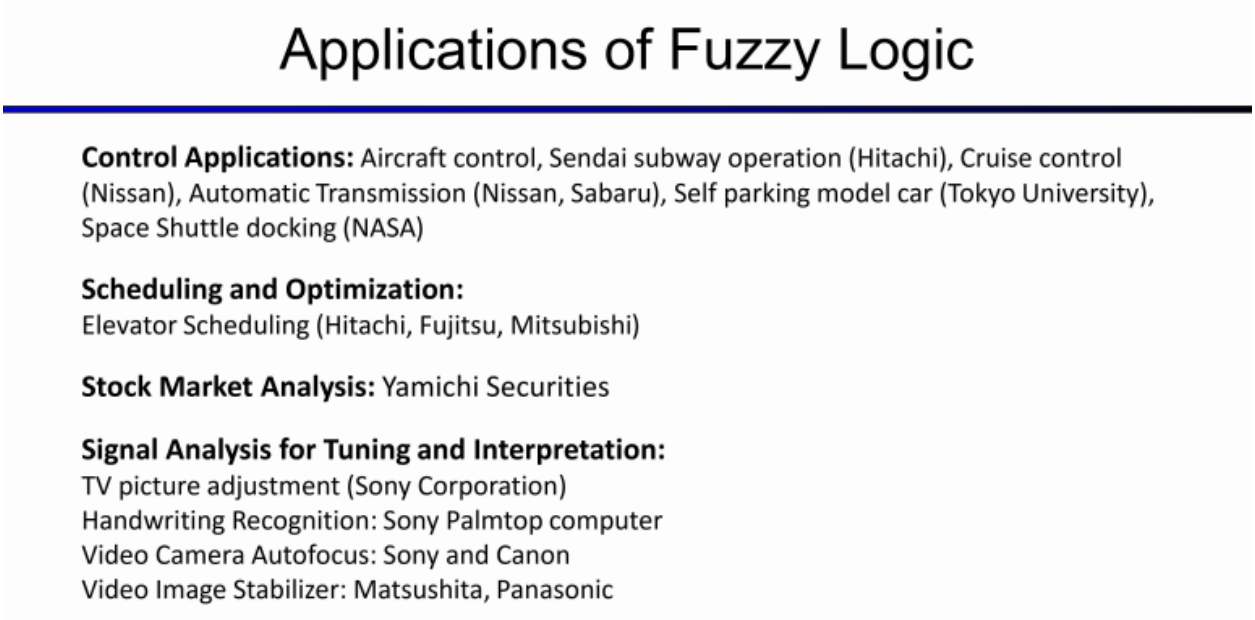
Crisp logic (crisp) is the same as boolean logic(either 0 or 1). Either a statement is true(1) or it is not(0), meanwhile fuzzy logic captures the degree to which something is true.

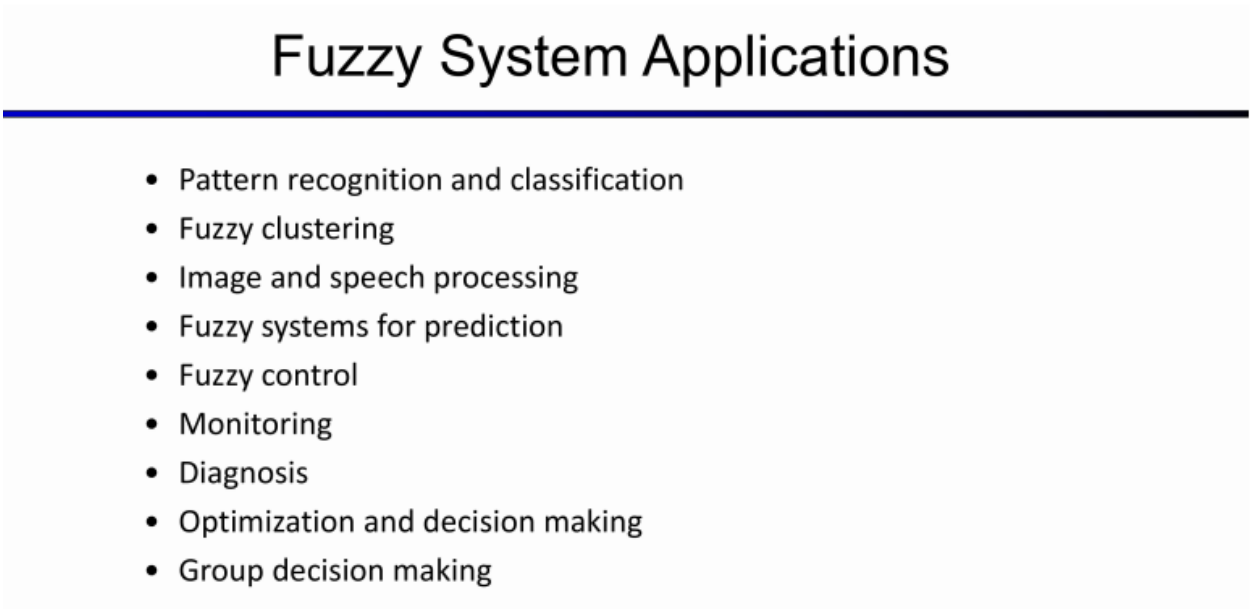
A fuzzy expert system is an expert system that uses fuzzy logic instead of Boolean logic. In other words, a fuzzy expert system is a collection of membership functions and rules that are used to reason about data. A typical fuzzy expert system has more than one rule.

6. Application of PL, PDL & FL

Propositional Logic - Design of computing machines, artificial intelligence, the definition of data structures for programming languages, etc.

Predicate Logic - Formal notations for writing clear and concise mathematical definitions.





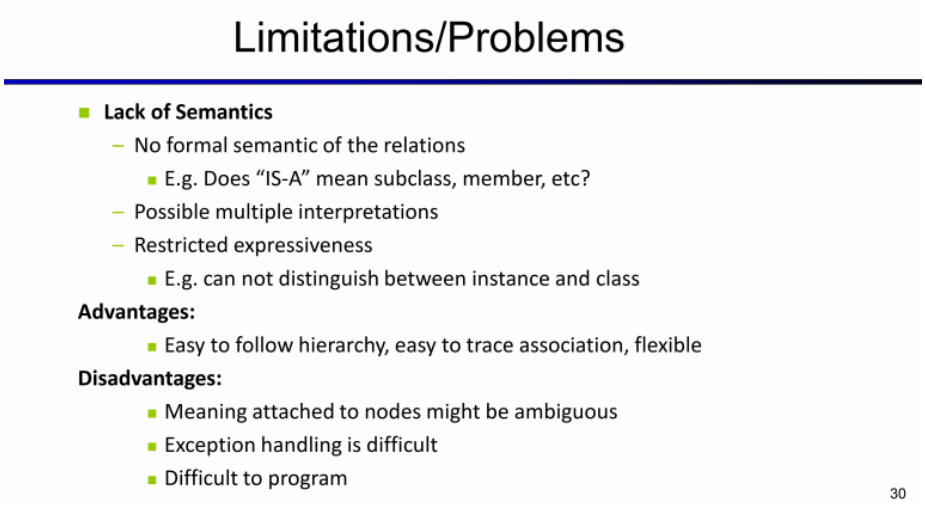
7. Limitations of PL, PDL & FL

Limitations of PL -

4. Has limited expressive power
5. No representation to relations like “All, some, none, etc”
   a. E.g All eggs are rotten, some apples are sweet, etc.

6. Alternate = Predicate Logic

Limitations of PDL -



Disadvantages of Fuzzy Logic Systems -

1. **Fuzzy logic is not always accurate, so The results are perceived based on assumption, so it may not be widely accepted.**
2. **Fuzzy systems don't have the capability of machine learning as well as neural network type pattern recognition.**

A major drawback of Fuzzy Logic control systems is that they are completely dependent on human knowledge and expertise.