~~NLP:-~~ → Syntax Driven Semantic analysis

Description Logics:-

↳ are family of formal languages designed to:

- Represent structured knowledge (concept, roles, Individuals)
- Support reasoning over that knowledge
- Serve as the backbone for semantic web technologies like OWL.

John is brother of Ram

FOL Brother(John, Ram)

DL

Key components of DL's

CRISP - Concept, Roles, Individuals, Syntax, Parsing

Letter	component	Description
C	concepts	classes or sets (eg. person, doctor)
R	Roles	Relationships (eg. has child, practices)
I	Individuals	Specific instances (eg. Alice, Bob)
S	Syntax	Formal grammar for combining concepts & roles
P	Parsing	Driven by sentence structure (syntax), maps to semantics

KEY CONCEPTS

1. Concepts (Classes:) :-

- basic building blocks of DL
- represents sets of objects / entities

→ Atomic concept : simplest concepts
Eg: person, car

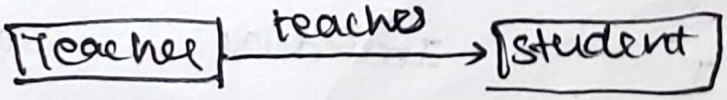
→ complex concept : constructed using atomic concepts & logical operators

Eg. For Eg:-
Intersection : Human ∩ Mortal → set of human are mortal
union :- Human ∪ Robot
complement :- ¬ Human
↓
represent not human thing

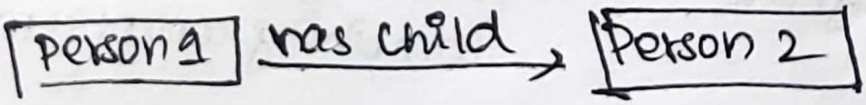
2. Roles (Relations:)

- Relationship b/w entities

Eg:- Teacher might have a role of teaching a student

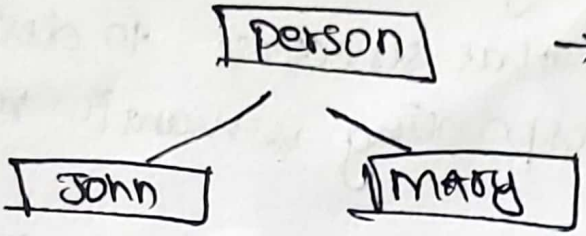


- A role connect 2 concepts



Individuals (Objects) :-

These are specific objects or instances of concepts. For example



→ concept

→ objects.

4. Axioms & TBoxes :-

TBoxes - (Terminological Boxes) - Define relationship b/w concepts.

- They consist of concept inclusion axioms

Eg :- (Human ⊆ Mortal)

RBoxes :- Defines relationship between roles such as transitivity

Eg :- $hasChild(x,y) \wedge hasChild(y,z)$

$\downarrow$

$hasChild(x,z)$

5. ABoxes :-

Assertional Boxes - Instances of concepts & roles, representing facts about individual entities.

hasChild (John, Mary) → asserts that

$\downarrow$

John has Mary as a child.

Syntax Driven Semantic Analysis

↓

analyzing syntactic structure of sentence
eg using that structure to derive
corresponding semantic representation

(1) Mapping syntactic structures to DL Reps.

Step 1 :- Identify the syntactic structure
(uses syntactic parser)

① Eg :- John is a human

syntactic structure
- subject :- John (individual)
- predicate :- is (linking)
- object :- human (concept)

② Description logic Representation

concept : Human (John)

John is a instance of concept Human

FOL DL

Step2:- Constructing semantics from syntax

↓

process of translating syntax → semantic

↓

governed by grammar rules + logical op.

Eg:- John teaches mary

↳ Teaches (John, mary)

complex sentence: John is a teacher & mary is a student

Teacher (John) ^ student (mary)

Step3:- Reasoning with DL:-

After converting a sentence to DL representation, reasoning performed through knowledge base.

1) classification:- Entering an individual belongs to certain class based on its attributes

Eg:- John is human → Humans are mortal

↓

John is mortal.

2) consistent checking → Ensures no contradiction info exist.

human (John) → ¬Human (John)

↓

Inconsistent.

(3) subsumption - check whether one concept is more general than another.

Eg:- Every human is a mammal

↓

mammal subsumes human

↓

more general → dogs, cats, humans

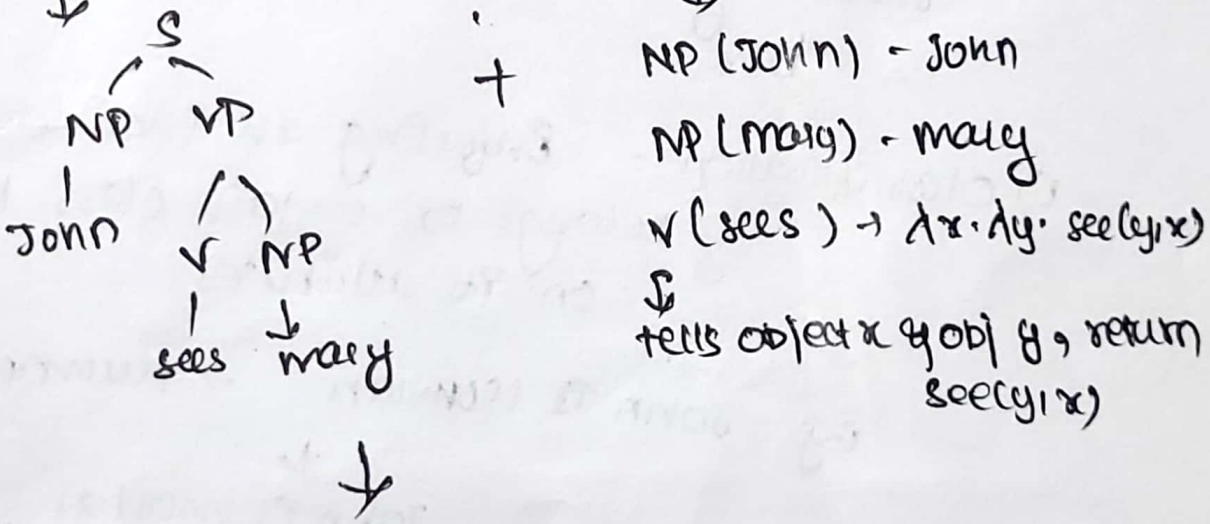
(4) Eg:- ~~Alice eats an apple~~ . John sees mary

Syntax Rule:- $S \rightarrow NP\ VP$

$NP \rightarrow Det\ N$ $\quad NP \rightarrow John \mid mary$

$VP \rightarrow V\ NP$ $\quad V \rightarrow sees$.

Parsing + semantic



↓

Final see (John, mary)

Advantages

1) Formal Representation - structured way
↓
helps in manage ambiguity & ensure consistency.

2) Reasoning - Allows reasoning the relationship b/w concepts, entities & facts

3) Scalability - used in large scale KR systems such as OWL.

4) Inference - allows inferring new facts from existing knowledge which is useful in applications like semantic search.

Applications

1) Semantic Parsing - Translates sentences to logic representation

2) Ontology - based Reasoning

3) Information Retrival - allows more precise retrival

4) Question Answering - using DL map questions to formal representation & reason about the best answers based on KB.