3.4 Resolution Algorithm

Resolution algorithm is a rule used in Artificial Intelligence (AI) for logical reasoning. It helps our AI system to figure out if the given statement is logically proven from a set of known facts or not. It operates mainly on statements expressed in Conjunctive Normal Form (CNF) and is most commonly used in Propositional Logic and First-Order Predicate Logic.

For example:

If you have a statement like “It is raining OR it is sunny,” the algorithm will try to determine if this is always true, sometimes true or never true based on the information provided. The algorithm works by systematically combining logical statements until it either finds a contradiction meaning the statement is false or confirms that the statement is true.

Working of Resolution Algorithm

The Resolution Algorithm works on clauses that are small logical statements connected by “AND” or “OR.” It works by:

Step 1: Convert Statement into Logical Forms

First, input sentence is converted into a standard format called Conjunctive Normal Form

(CNF) means we break down the complex statements into simple parts connected by “AND” and “OR.”

If the Original statement: “If it is raining then the ground is wet.” Then its CNF is:

“NOT(Raining) OR Wet.

Step 2: Combine Clauses Using Resolution Rule

The core idea of the Resolution Algorithm is the resolution rule which combines two clauses to produce a new clause.

If you have two clauses say A OR B and NOT(A) OR C you can combine them to get B OR C.

This process eliminates one variable (A in this case) and simplifies the problem.

Step 3: Repeat Until You Find an Answer

The algorithm keeps applying the resolution rule to pairs of clauses until one of two things happens:

Contradiction Found : If the algorithm produces an empty clause (written as FALSE) it means the original set of statements is inconsistent and cannot be true at the same time. No

Contradiction : If no empty clause is found after trying all combinations then the statements are consistent and can coexist..

Applications of the Resolution Algorithm in AI

The Resolution Algorithm is widely used in the following AI applications:

Automated Theorem Proving : It helps computers to automatically prove mathematical theorems or verify logical arguments without human intervention.

Knowledge Representation : In AI systems knowledge is represented as logical statements. The Resolution Algorithm allow these systems to reason about that knowledge effectively.

Problem Solving : Many real-world problems can be framed as logical puzzles. For example scheduling tasks, diagnosing faults in systems or planning routes can all benefit from logical reasoning using resolution.

Foundation for Advanced Techniques : The Resolution Algorithm forms the basis for more advanced AI techniques such as SAT solvers which is used to solve Boolean satisfiability problems and logic programming languages.

Limitations of the Resolution Algorithm

The Resolution Algorithm has limitations as well::

Efficiency: The algorithm can be computationally expensive due to the large search space, especially for complex systems.

Requires CNF Conversion: Every logical formula must be converted to CNF before applying the algorithm which can be time-consuming.

No Direct Answer: The resolution algorithm works through refutation meaning it doesn't construct a solution directly but rather disproves the negation of the goal.

Resolution Algorithm is a useful technique tool in AI for logical reasoning, enabling systems to deduce conclusions and solve complex problems. However its computational cost and conversion requirements can be challenging especially in large and complex systems.

Example:

Goal:

We want to use the resolution algorithm to prove:

A is true

Knowledge Base (What we know):

1. $A \vee B$ (read: A or B is true)
2. $\neg B$ (read: B is false)
3. $\neg A$ (we assume A is false — this is how we use proof by contradiction)

Resolution Steps:

Step 1: Resolve $A \vee B$ and $\neg B$

$A \vee B$

$\neg B$

Remove B because B is false

We get: A

Step 2: Resolve A and $\neg A$

A

$\neg A$

This gives us a contradiction

⟶ So we reached an impossible situation.

Conclusion:

Since assuming A is false caused a contradiction, that means A must be true! This is how the resolution algorithm works — by finding a contradiction and proving the goal.