Literature Review: Backtracking Algorithm in the N-Queens Problem

1. Introduction

The **N-Queens problem** is a classical combinatorial problem in computer science and artificial intelligence. It requires placing *N* queens on an *N* × *N* chessboard such that no two queens threaten each other. Since its introduction in the mid-19th century and the most influential approaches used to solve this problem is the **backtracking algorithm**.

2. Historical Background

The N-Queens problem was first proposed in **1848** by **Max Bezzel** and later generalized by **Franz Nauck**. Early solutions were manual and mathematical. Backtracking gained prominence in the **1950s–1960s**, particularly through its formalization in recursive search problems and tree-based exploration methods

3. Backtracking as a Search Strategy

Backtracking is a **depth-first search (DFS)** technique that incrementally builds candidate solutions and abandons them when constraints are violated. In the context of the N-Queens problem, backtracking exploits the following properties:

- The problem can be decomposed row by row
- Partial solutions can be evaluated early
- Invalid configurations can be pruned without exploring deeper levels

4. Comparative Studies

The backtracking algorithm has frequently been compared with other approaches, such as:

- **Brute Force Algorithms**
- **Genetic Algorithms**
- **Hill Climbing**
- **Simulated Annealing**
- **Constraint Programming (CSP)**

Literature consistently shows that:

- Backtracking guarantees **complete and exact solutions**
- Heuristic methods may find solutions faster for large *N* but do not guarantee completeness
- Backtracking performs well for small to medium values of *N* and remains a baseline for comparison

5. Limitations of Backtracking

Despite its effectiveness, the literature also identifies limitations:

- Poor scalability for very large *N*
- Exponential growth of recursive calls
- Performance heavily dependent on pruning strategies

These limitations motivated the development of hybrid and heuristic-based approaches in later research

6.References

- The **N-Queens problem** is a classical combinatorial problem widely used to evaluate search and constraint satisfaction algorithms in computer science. It involves placing *N* queens on an *N* × *N* chessboard such that no two queens attack each other. Due to the exponential growth of possible configurations, early research identified the **backtracking algorithm** as an effective and systematic solution technique (Bezzel, 1848; Knuth, 1997).
- Although backtracking becomes computationally expensive for very large values of *N*, it guarantees complete and exact solutions and remains a foundational approach in both research and education (Knuth, 1997).