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**Project Report: N-Queens Solver**

**Introduction and Overview**:

* **Project Idea and Overview**:
* To solve the N-Queens problem using a combination of algorithms (Backtracking, Best-First Search, Hill-Climbing, and Genetic Algorithm) to compare their efficiency, effectiveness, and applicability in finding valid solutions for various board sizes.

Similar Applications Links:

* <https://www.researchgate.net/publication/349525086_Parallel_Implementations_of_Candidate_Solution_Evaluation_Algorithm_for_N-Queens_Problem>
* https://www.researchgate.net/publication/220838483\_Complete\_and\_Incomplete\_Algorithms\_for\_the\_Queen\_Graph\_Coloring\_Problem

Literature Review Links:

* <https://www.researchgate.net/publication/240320772_The_n-Queens_Problem>
* <https://www.sciencedirect.com/science/article/pii/S0012365X07010394#sec1>

**Proposed Solution, Dataset & Features:**

* **Backtracking:** Systematically explore all possible placements of queens, ensuring that no two queens threaten each other. This approach guarantees finding all possible solutions but may be time-consuming for larger boards.
* **Best-First Search:** Implement a heuristic-based search to prioritize placing queens in positions with the least potential conflicts, aiming to find a solution more quickly than backtracking.
* **Hill-Climbing:** Start with an initial configuration and iteratively move to a neighboring configuration that improves the placement of queens (fewer conflicts), potentially finding a solution faster but with a risk of getting stuck in local optima.
* **Genetic Algorithm:** Use a population of potential solutions (board configurations) and evolve them over generations using selection, crossover, and mutation to find a solution. This method is robust in avoiding local optima and can handle larger board sizes effectively.

**Dataset**:

* Each configuration represents a potential solution where N queens are placed on an NxN chessboard.

**Components:**

* **Initial Configurations:** Randomly generated or systematically created board setups for different values of N (e.g., 4x4, 8x8).
* **Evaluation Metrics:** Number of conflicts in each configuration, where a conflict is defined as two queens threatening each other.
* **Heuristic Scores:** For Best-First Search and Hill-Climbing, store heuristic scores indicating the quality of each configuration.
* **Genetic Algorithm Data:** Track generations, mutation rates, crossover points, and fitness scores for each population member.

**Experiments & Results**:

* examples of output:

**Backtracking:** A function to recursively place queens on the board, backtracking when a conflict is detected.

**Sol1: Sol2:**

**Best-First**: A heuristic-driven search function that prioritizes placements leading to fewer conflicts.

**Sol1: Sol2:**

**Hill-Climbing**: An iterative improvement function that seeks to minimize conflicts, with an option to restart if stuck in a local optimum.

**Sol1: Sol2:**

**Genetic**: A function to evolve a population of board configurations, using selection, crossover, and mutation to optimize queen placement.

**Sol1: Sol2:**

**Discussion and Future Work**:

* **Advantages & Disadvantages:**
* **Backtracking** is comprehensive but slow.
* **Best-First Search** is efficient with good heuristics but may miss solutions.
* **Hill-Climbing** is fast but prone to getting stuck in suboptimal solutions.
* **Genetic Algorithms** offer global search and flexibility but require more computational resources and careful tuning.

**Behavior Analysis and Future Modifications**:

**1. Backtracking**

* **Behavior Analysis:**
  + Explores all possible solutions.
  + Guarantees finding all solutions but can be slow for larger boards.
* **Future Modifications:**
  + Implement pruning techniques to reduce unnecessary exploration and speed up the process.

**2. Best-First Search**

* **Behavior Analysis:**
  + Uses heuristics to focus on promising paths.
  + Faster than backtracking but might miss optimal solutions.
* **Future Modifications:**
  + Enhance the heuristic function to better guide the search towards optimal solutions.

**3. Hill-Climbing**

* **Behavior Analysis:**
  + Quickly find a solution by improving the current state.
  + Prone to getting stuck in local optima.
* **Future Modifications:**
  + Implement random restarts or simulated annealing to help escape local optima.

**4. Genetic Algorithm**

* **Behavior Analysis:**
  + Uses evolution-inspired techniques to explore the solution space.
  + Avoids local optima but may require many generations to converge.

GitHub Repository Link:

* [Mostafa-moha/N-Queens\_Problem\_Project: Using 4 Algorithms with Simple Gui (github.com)](https://github.com/Mostafa-moha/N-Queens_Problem_Project)