

AI Project Proposal

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FAST NUCES

# AI-Powered Robotic Warehouse Management System Using Search Algorithms and Constraint Satisfaction Problems

## Team Members:

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## Project Overview:

The goal of this project is to develop a simulated warehouse management system where intelligent robots handle tasks such as item retrieval, placement, and pathfinding using various AI techniques. The project will simulate a grid-based warehouse environment and incorporate search algorithms for path planning and CSPs for efficient task allocation and shelf organization.

## **Objectives:**

* Implement robot agents that can navigate the warehouse efficiently using informed and uninformed search algorithms.
* Utilize CSPs to assign storage locations, organize shelves, and manage task scheduling to avoid conflicts.
* Compare the performance of different search strategies (e.g., A\*, BFS, DFS, UCS) in real-time warehouse scenarios.
* Provide a visualization of the robot movements and warehouse layout to demonstrate system functionality.

## Key Features:

1. **Path Planning using Search Algorithms**
   * Robots will use algorithms such as:
     + **Breadth-First Search (BFS)**
     + **Depth-First Search (DFS)**
     + **Uniform Cost Search (UCS)**
     + *A Search*\* (with customizable heuristics)
   * Each algorithm's performance (speed, cost, optimality) will be evaluated in different warehouse layouts.
2. **Task Allocation using CSPs**
   * Constraints such as:
     + Avoiding robot collision.
     + Assigning tasks based on robot availability.
     + Optimizing item placement based on access frequency.
   * Use of **Backtracking**, **Forward Checking**, and **Arc Consistency (AC-3)** algorithms to solve CSPs.
3. **Simulation Environment**
   * A 2D grid-based warehouse interface where:
     + Shelves, robots, and items are visualized.
     + Obstacles and dynamic tasks can be introduced.
     + User can select different algorithms and scenarios for testing.

## Tools and Technologies:

* **Language:** Python
* **Libraries:**
  + pygame or matplotlib for visualization
  + networkx for graph representation
  + heapq, queue, and custom implementations for search algorithms
* **Optional:** Jupyter Notebook for algorithm comparison and performance graphs.

## Expected Outcomes:

* A functional AI system where robots complete warehouse tasks using search and CSP techniques.
* Comparative analysis of algorithms based on time, efficiency, and path optimality.
* An interactive simulation demonstrating AI in a practical, industrial scenario.