Assignment 2 Report

Course Name: Artificial Intelligence

Course Code: CSE-366

Section - 3

Assignment Name: Genetic Algorithm - Robot Resource Optimization

Submitted By
Name: Ismail Mahmud Nur
ID: 2021-2-60-052
Dept. of Computer Science & Engineering

Submitted To
Dr. Mohammad Rifat Ahmmad Rashid
Assistant Professor,
Department of Computer Science and Engineering
East West University

Genetic Algorithm - Robot Resource Optimization

Introduction

The efficient allocation of tasks to robots is a critical aspect of various industries, including manufacturing, logistics, and service sectors. Inefficient task assignments can lead to bottlenecks, delays, and decreased productivity. To address this challenge, we employed a Genetic Algorithm (GA) approach to optimize task assignments among a group of robots with varying efficiencies and task priorities.

Theory

Genetic Algorithm(GA): Genetic Algorithm (GA) is a powerful optimization technique inspired by the principles of natural selection and evolution. It is widely used to solve complex optimization problems where traditional methods may struggle due to the problem's combinatorial nature or high dimensionality. The underlying concept of GA is based on Charles Darwin's theory of natural selection, where individuals with favorable traits are more likely to survive and reproduce, leading to the evolution of species over time.

1. Representation: In GA, candidate solutions to the optimization problem are encoded as chromosomes, typically represented as binary strings or arrays of values. Each chromosome corresponds to a potential solution in the solution space, and the collection of chromosomes forms a population.

2. Fitness Evaluation: The fitness of each chromosome is evaluated using a fitness function that quantifies how well the solution satisfies the objectives of the optimization problem. The fitness function guides the search process by assigning higher fitness scores to better solutions.

3. Selection: Individuals with higher fitness scores are more likely to be selected for reproduction, mimicking the natural selection process. Various selection methods, such as roulette wheel selection, tournament selection, or rank-based selection, are employed to choose parents for the next generation.

4. Crossover: Crossover involves exchanging genetic information between pairs of parent chromosomes to create offspring. This process promotes exploration of the solution space by combining features of different solutions. Common crossover techniques include single-point crossover, multi-point crossover, and uniform crossover.

5. Mutation: Mutation introduces random changes in the offspring's chromosomes to maintain diversity in the population and prevent premature convergence to suboptimal solutions. Mutation typically involves randomly flipping bits or altering values in the chromosome representation.

Approach

My approach leverages the principles of evolutionary computing to iteratively improve task assignments. The GA operates on a population of candidate solutions, representing different task allocations to robots. These solutions undergo selection, crossover, and mutation operations to evolve towards fitter solutions over multiple generations.

Implementation Details

Mock Data Generation:

- Generated mock data for task durations, task priorities, and robot efficiencies.
- Task durations and priorities were randomly assigned within predefined ranges, while robot efficiencies were randomly sampled from a uniform distribution.

Fitness Function:

- Defined a fitness function that evaluates the performance of each solution based on the total time taken by robots to complete tasks, considering their efficiencies.
- The fitness function also incorporates the standard deviation of completion times across robots to promote workload balance.

Genetic Operators:

- **Selection:** Employed tournament selection to choose the most promising solutions based on their fitness scores.
- **Crossover:** Performed a single-point crossover to exchange genetic information between pairs of selected parents.
- **Mutation:** Random mutations were introduced to diversify the population and explore new regions of the solution space.

Visualization:

- Visualized task assignments using a heatmap, where rows represent robots and columns represent tasks.
- Task durations and priorities were annotated within each cell to provide insights into the allocation process.
- A color bar was added to denote task durations, aiding in identifying tasks with varying completion times.

Analysis of Results

Optimization Process:

- The GA effectively optimized task assignments, reducing the total completion time and improving workload distribution among robots.
- Evolutionary pressure drove the population towards fitter solutions, leading to improved task allocations over generations.

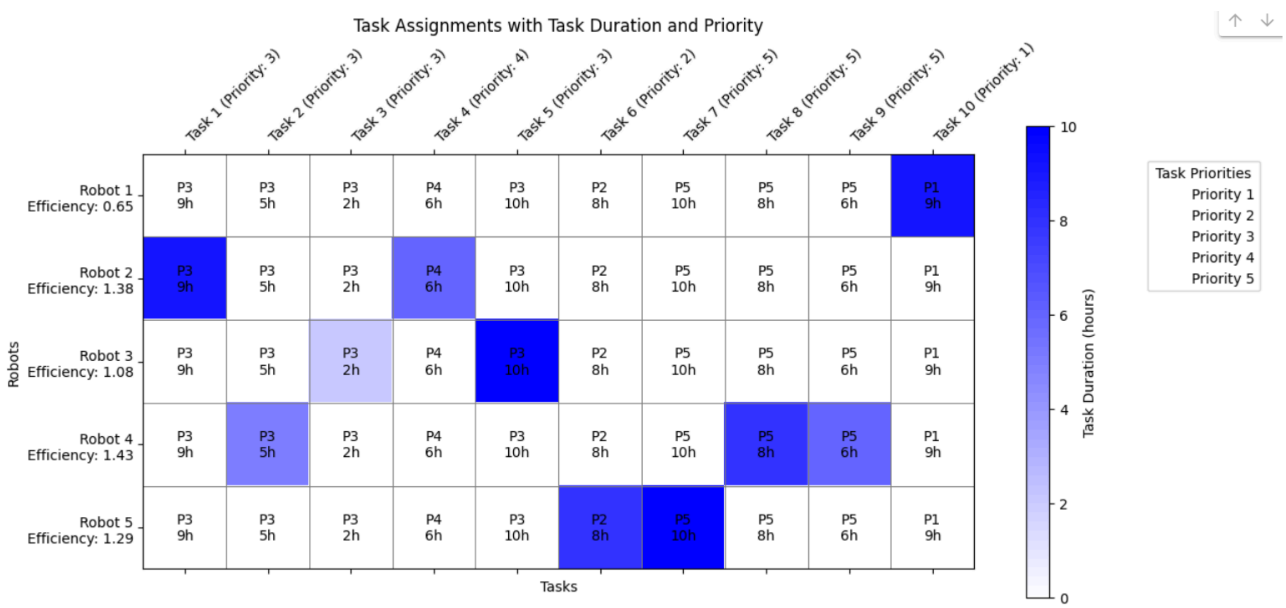
Impact of Robot Efficiencies and Task Priorities:

- Robot efficiencies influenced the optimization process significantly. Robots with higher efficiencies were assigned more tasks, leading to faster completion times.
- Task priorities also played a crucial role, as higher priority tasks were assigned to robots with higher efficiencies to ensure timely execution.

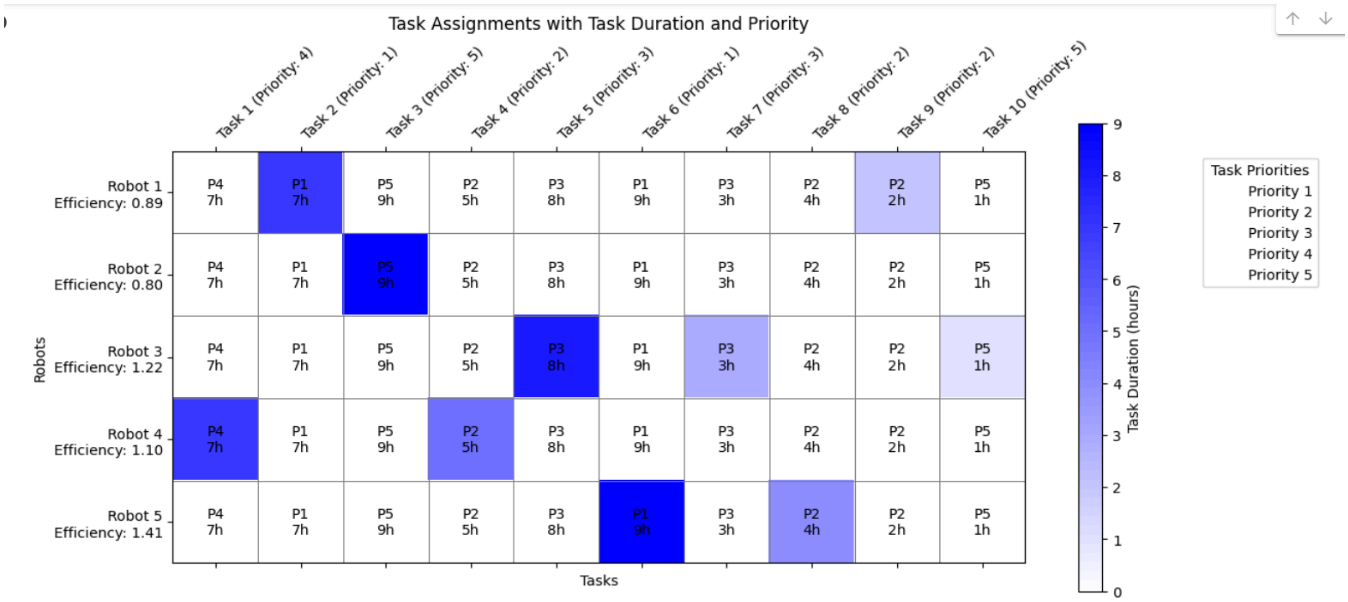
Workload Distribution:

The GA achieved a relatively balanced workload distribution among robots, reducing idle time and maximizing resource utilization.

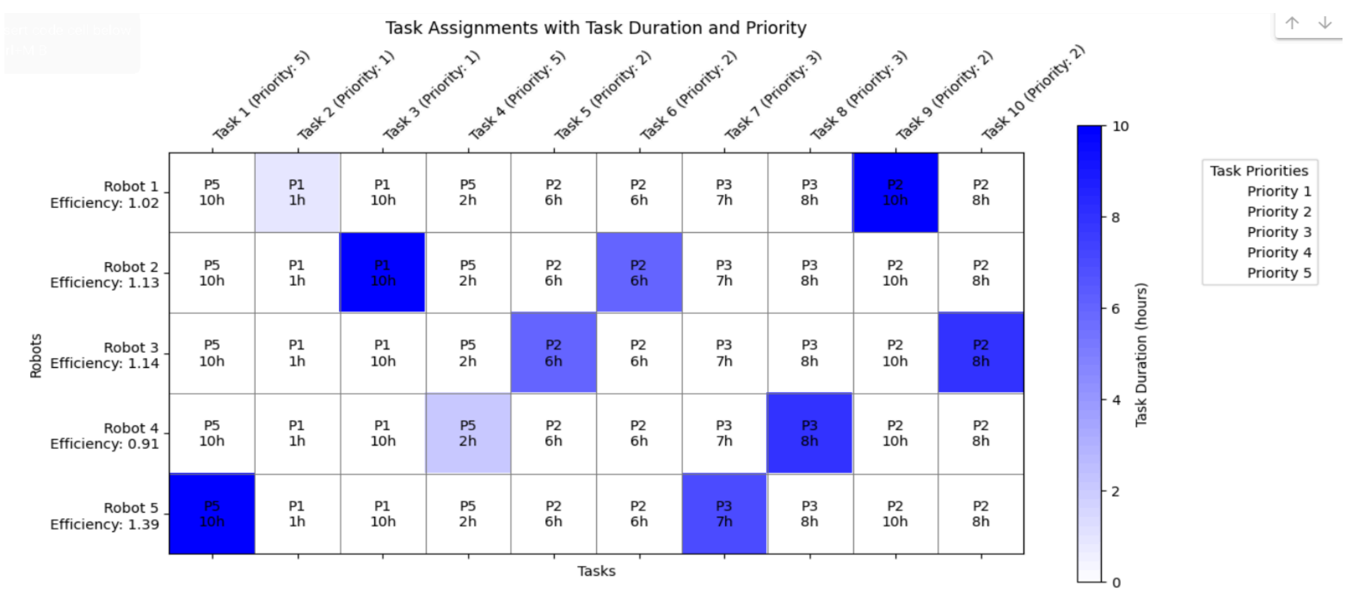
Output



(1)


Task Assignments with Task Duration and Priority
Task 1 (Priority: 4)
Task 2 (Priority: 1)
Task 3 (Priority: 5)
Task 4 (Priority: 2)
Task 5 (Priority: 3)
Task 6 (Priority: 1)
Task 7 (Priority: 3)
Task 8 (Priority: 2)
Task 9 (Priority: 2)
Task 10 (Priority: 5)
Robot 1 Efficiency: 0.89
Robot 2 Efficiency: 0.80
Robot 3 Efficiency: 1.22
Robot 4 Efficiency: 1.10
Robot 5 Efficiency: 1.41
P4 7h
P1 7h
P5 9h
P2 5h
P3 8h
P1 9h
P3 3h
P2 4h
P2 2h
P5 1h
Robots
Tasks
Task Duration (hours)
0
1
2
3
4
5
6
7
8
9
Task Priorities
Priority 1
Priority 2
Priority 3
Priority 4
Priority 5

(2)


Task Assignments with Task Duration and Priority
Task 1 (Priority: 5)
Task 2 (Priority: 1)
Task 3 (Priority: 1)
Task 4 (Priority: 5)
Task 5 (Priority: 2)
Task 6 (Priority: 2)
Task 7 (Priority: 3)
Task 8 (Priority: 3)
Task 9 (Priority: 2)
Task 10 (Priority: 2)
Robot 1 Efficiency: 1.02
Robot 2 Efficiency: 1.13
Robot 3 Efficiency: 1.14
Robot 4 Efficiency: 0.91
Robot 5 Efficiency: 1.39
P5 10h
P1 1h
P1 10h
P5 2h
P2 6h
P2 6h
P3 7h
P3 8h
P2 10h
P2 8h
Robots
Tasks
Task Duration (hours)
0
2
4
6
8
10
Task Priorities
Priority 1
Priority 2
Priority 3
Priority 4
Priority 5

(3)

Conclusion

In conclusion, the assignment demonstrates the effectiveness of Genetic Algorithm (GA) techniques in optimizing task assignments among robots with varying efficiencies and task priorities. By harnessing evolutionary principles, the GA facilitated the creation of optimal task allocations, resulting in tangible improvements in operational efficiency and resource utilization. The optimized task assignments fostered by the GA hold significant implications for various industries, promising enhanced operational efficiency, reduced lead times, and improved resource utilization. Notably, by considering both robot efficiencies and task priorities, the GA ensures optimal allocation of resources while meeting task deadlines.