



**CSE366: Artificial Intelligence**  
**(Section 04)**  
**[SPRING 2024]**

**Assignment: 02**

Assignment Title:

**Robot Task Optimization Using Genetic  
Algorithm**

**Submitted by:**

Md. Abir Hasan Khan

ID: 2019-1-60-013

## Analysis and Report: Genetic Algorithm for Task Assignment

This report analyzes the application of a Genetic Algorithm (GA) to optimize task assignments for robots, considering robot efficiencies and task priorities.

### Approach:

The implemented GA utilizes a population-based search approach. Each individual in the population represents a potential task assignment scheme, where each task is assigned to a specific robot.

### Implementation Details:

- **Data Generation:** The `generate_mock_data` function creates random data for tasks (durations and priorities) and robots (efficiencies).
- **Fitness Function:** The `calculate_fitness` function evaluates an individual's (assignment scheme's) effectiveness. It considers three factors:
  - **Total Production Time:** The maximum time taken by any robot to complete their assigned tasks.
  - **Workload Balance:** The standard deviation of completion times across robots. Lower deviation indicates balanced workload.
  - **Task Priorities:** The sum of task priorities not assigned to robots efficiently (based on their efficiency).
- **Selection, Crossover & Mutation:** The GA employs tournament selection to choose parents for crossover, favoring individuals with lower fitness scores (better assignments). Single-point crossover combines genes (task assignments) from parents to create offspring. Mutation randomly changes some task assignments in the offspring with a low probability, introducing diversity in the population.
- **Visualization:** The `visualize_assignments_improved` function creates a heatmap depicting the final solution (task assignments), task durations, robot efficiencies, and task priorities.

### Challenges Faced:

- **Fine-tuning Parameters:** Setting optimal values for population size, number of generations, and mutation rate requires experimentation to balance exploration (finding new solutions) and exploitation (converging towards good solutions).
- **Real-world Complexity:** The provided implementation uses simplified data. Real-world scenarios might involve task dependencies or robot limitations, requiring further adaptation of the GA.

### Analysis of Results:

- **Impact of Robot Efficiency:** Robots with higher efficiencies are likely to be assigned tasks with longer durations in the optimized solution. This is because the GA prioritizes minimizing the total production time, and efficient robots can complete longer tasks faster.
- **Impact of Task Priority:** High-priority tasks are more likely to be assigned to robots with higher efficiencies to ensure faster completion and minimize the impact on overall production time. The fitness function penalizes assigning high-priority tasks to less efficient robots.
- **Workload Distribution:** The GA aims for balanced workload distribution among robots. However, there might still be cases where some robots have slightly higher workloads depending on the task durations and robot efficiencies. Further optimization could involve introducing a penalty in the fitness function for imbalanced workloads.

### Insights from GA Optimization:

The GA helps find task assignments that minimize production time while considering robot efficiencies and task priorities. This leads to a more efficient utilization of resources and potentially faster completion of high-priority tasks.

### Critical Evaluation of Workload Distribution:

While the GA strives for balanced workload, complete uniformity might not always be achievable. Task durations and robot efficiencies can lead to situations where some robots have slightly higher workloads due to having more efficiently completed tasks.

### Future Work:

- **Real-world adaptation:** Extend the GA to handle task dependencies, robot limitations, and dynamic environments.
- **Multi-objective optimization:** Explore incorporating additional objectives in the fitness function, such as minimizing energy consumption or maximizing robot utilization.
- **Hybrid approaches:** Combine the GA with other optimization techniques to potentially achieve even better solutions.

By analyzing the impact of robot efficiency and task priority on the GA's optimization process, we gain valuable insights into how the GA allocates tasks for efficient completion. While the workload distribution might not be perfectly uniform, it achieves a balance between minimizing production time and maximizing resource utilization. Further optimization can be explored by incorporating additional factors or employing hybrid approaches.

