East West University

Department of Computer Science and Engineering

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Assignment Report

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Assignment: Genetic Algorithm - Robot Resource Optimization

Objective: The goal of this assignment is to develop and implement a Genetic Algorithm (GA) to optimize the assignment of multiple robots to a set of tasks in a dynamic production environment. Our primary objectives are to minimize the total production time, ensure a balanced workload across robots, and prioritize critical tasks effectively. Additionally, we will create a detailed visualization to illustrate the final task assignments, robot efficiencies, and task priorities.

Total Production Time (Ttotal): The total production time is determined by the robot that finishes last, considering the efficiency of each robot.

$$Tr = \text{sum}\{n \in \text{tasks}(r)\}((\text{duration of task } n * \text{priority weight of task } n) / \text{efficiency of robot } r)$$

$$Ttotal = \max(T1, T2, \ldots, TR)$$

Workload Balance (B): Workload balance evaluates how evenly tasks are distributed among robots in a production or task allocation scenario using standard deviation.

$$B = \sigma(T1, T2, \ldots, TR)$$

Fitness Function: Fitness function is built to minimize both the total production time and the imbalance in workload. The fitness function combines the objectives of minimizing total production time and achieving workload balance. By minimizing the fitness function, the algorithm searches for task assignments that result in both faster task completion and a more balanced workload distribution among the robots.

$$F(I) = Ttotal + B$$

Tournament Selection: By using tournament selection, genetic algorithms can efficiently explore the solution space. The Tournament Selection is a selection process used in genetic algorithms that selects individuals with higher fitness values for crossover by organizing fitness competitions. Winners become parents, ensuring better fitness parents contribute to the next generation.

Cross-over: For crossover, the Single-Point cross over technique is used which generates new offspring by combining the genetic information of two parent individuals. In this process, the crossover point on the parent individuals' genomes is chosen randomly and then genes are exchanged between the parents. If our crossover point is 3 and we have two parents,

[A, B, C, D, E] and
[V, W, X, Y, Z]

the offspring would be [A, B, C, Y, Z] and [V, W, X, D, E].

Mutation: Mutation function implements the task of mutation which swaps assigned robots for randomly selected tasks within an individual's list, introducing random genetic variations and facilitating exploration in the genetic algorithm's search space.

Visualization: Genetic Algorithms (GAs) are an optimization technique based on natural selection, used to solve complex problems with multiple objectives. They maintain a population of potential solutions and evolve them over generations through mechanisms like crossover and mutation. GAs balance exploration and exploitation, efficiently navigating vast solution spaces. It repeatedly modifies a population of individual solutions, selecting individuals to be parents and using them to produce children for the next generation. GAs use visualization techniques to give significant insight into the optimization process, allowing for the effective visualization of final task allocations, robot efficiencies, and task prioritization.