Yeditepe University

CSE480/591 Special Topics: Optimization with Metaheuristics

Worksheet for Midterm Preparation

You should understand that an **optimization problem** is defined using the following components:

- Decision variables
- Constraints
- Objective function
- Search space
- Solution space
- Feasibility and infeasibility
- Problem instance

Similarly, any **local search algorithm** can be characterized by the following design steps:

- **Solution (Individual) Representation:** Defines how candidate solutions are structured.
- **Fitness (Objective) Function:** Evaluates the quality of a solution.
- **Initialization Strategy:** Specifies how the initial solution(s) are generated.
- **Neighborhood Operator:** Defines how new solutions (neighbors) are created from the current one.
- **Search Process:** Guides exploration and exploitation using the neighborhood operator. For example, Simulated Annealing uses a *temperature schedule*, while Tabu Search uses a *tabu list*.
- **Stopping Condition:** Determines when to terminate the algorithm.
- **Escape Mechanisms:** Help avoid local optima and explore new regions of the search space.

Terminology

Study and understand the following key concepts that were covered in the lectures. They are fundamental to formulating and solving optimization problems:

- Mathematical model of optimization problems (decision variables, constraints, objective function)
- When to use cost, profit, or fitness functions instead of the objective function
- Feasible and infeasible solutions

- Extreme (corner) points of a mathematical model
- Differences between Exact, Heuristic, and Metaheuristic algorithms
- Definition of a problem instance
- Search space vs. solution space
- Candidate solution = Individual = Chromosome
- Individual (solution) representation
- Stopping (termination) criteria of optimization algorithms
- Premature convergence, local optimum, and global optimum
- **Exploitation vs. Exploration:** Understand the difference and their balance in metaheuristic algorithms
- Strategies for escaping local optima
- Neighborhood (search) operators in local search algorithms
- General ideas of **Stochastic Hill Climbing**, **Simulated Annealing**, and **Tabu Search**. You will be expected to adapt a given algorithm pseudocode to a specific optimization problem.

1. Example Optimization Problems

For the exam, you should study the following optimization problems (as discussed in lectures):

- Job Shop Scheduling Problem (JSSP)
- Graph Coloring Problem
- Knapsack Problem
- Bin Packing Problem

For a given problem instance, you will be expected to apply three local search algorithms by performing the following steps (the general pseudocode will be provided):

- Decide the individual representation
- Define the neighborhood operator
- Formulate the fitness function
- Execute or explain how the algorithm operates on the given problem instance

2. Exam Structure

The exam will consist of **four questions**:

- **Q1:** Terminology and conceptual understanding
- **Q2:** Stochastic Hill Climbing Algorithm
- **Q3:** Tabu Search Algorithm
- **Q4:** Designing the mathematical model of a given optimization problem

Good luck!