Advanced Topics in Optimization

Applications in Civil Engineering

Introduction

Applications:

- Water Quality Management: waste load allocation.
- Reservoir Operation.
- Water Distribution Systems
- Transportation Engineering.

Water Quality Management

- Waste Load Allocation (WLA) in streams refers to the determination of required pollutant treatment levels at a set of point sources of pollution to ensure that water quality standards are maintained throughout the stream.
- Stakeholders involved: Pollution Control Agency (PCA) and the dischargers (municipal and industrial) who are discharging waste into the stream
- Goals/ Objectives: goals of the PCA are to improve the water quality throughout the stream whereas that of dischargers is to reduce the treatment cost of the pollutants
- Optimization model with conflicting objectives

Water Quality Management (Contd..)

$Maximize \quad c$ → Maximization of water quality indicator (Dissolved Oxygen)

$Minimize \quad x$ → Minimization of fractional levels to pollutant to reduce treatment cost

Multi-Objective

$c = f(x)$ → Water Quality Simulation Model: Nonlinear

Suggested Readings: Tung and Hathhorn (1989), Sasikumar and Mujumdar (1998), and Mujumdar and Subbarao (2004)

Evolutionary Algorithm can be used

Reservoir Operation

- In reservoir operation problems, to achieve the best possible performance of the system, decisions need to be taken on releases and storages over a period of time considering the variations in inflows and demands.
- The goals can be:

1. Flood control
2. Hydropower generation
3. Meeting irrigation demand
4. Maintaining water quality downstream.

Multiobjective in nature

Reservoir Operation (Contd..)

- Characterized by the uncertainty resulting from the random behavior of inflow and demand, incorporation of which in terms of risk may lead to a nonlinear optimization problem.
- Application of evolutionary algorithms is a possible solution for such problems.
- Suggested Readings: Jangareddy and Nagesh Kumar (2007), Nagesh Kumar and Janga Reddy (2007).

Water Distribution Systems

Objectives can be:

1. Meeting the household demands.
2. Minimizing cost of pipe system.
3. Meeting the required water pressure at all nodes of the distribution system.
4. Optimal positioning of valves.

Multiobjective in nature

Water Distribution Systems (Contd..)

- Simulation model (e.g., Hardy Cross method): Nonlinear
- Determination of optimum dosage of chlorine is also another important problem which is highly nonlinear because of nonlinear water quality simulation model.
- Possible solution: Evolutionary Algorithm

Transportation Engineering

- Efficiently moving empty or laden containers for a logistic company or Truck and Trailer Vehicle Routing Problem (TTVRP).
- Objectives:
  1. Minimize routing distance
  2. Minimize number of trucks
- Model is nonlinear due to complicated inter relationship between the components.
- Evolutionary Algorithm: Possible Solution.
- Suggested Reading: Lee et al. (2003)

Thank You