Progressively Interactive Evolutionary Multi-Objective Optimization

Ankur Sinha
Ankur.Sinha@aalto.fi
Department of Information and Service Economy
Aalto University School of Economics
Outline

➢ Introduction

➢ Background
  • Multi-objective Optimization
  • Types of Approaches
  • Evolutionary Algorithms

➢ Research Contributions
  • Progressively Interactive Procedures
  • Bilevel Multi-objective Optimization

➢ List of Papers
Introduction

• Multi-objective optimization problems are problems with two or more conflicting objectives
• Evolutionary algorithms are potent tools to handle complex multi-objective optimization problems
• Dissertation addresses two kinds of multi-objective optimization problems
  • Problems with high number of objectives
  • Problems with two levels of optimization
• Evolutionary principles and decision making ideas have been used
Multi-objective Optimization

Maximize \( f(x) = (f_1(x), f_2(x), \ldots, f_m(x)) \)
Subject to \( x \in S \)
Aposteriori Approach

Maximise
\[ f(x) = (f_1(x), f_2(x)) \]

Computational Resources

Most Preferred Solution

Decision Maker

Doctoral Programme Seminar
23\textsuperscript{rd} - 26\textsuperscript{th} May 2011
Apriori Approach

Maximise
\[ f(x) = (f_1(x), f_2(x)) \]

Decision Maker

Computational Resources

Most Preferred Solution
Interactive Approach

Maximise

\[ f(x) = (f_1(x), f_2(x)) \]

Computational Resources

Most Preferred Solution

Decision Maker
Evolutionary Algorithms

Used to handle optimization problems

Inspired by biological evolution

1. Mate Selection
2. Reproduction
3. Mutation
4. Survival of higher fitness individuals
Evolutionary Multi-objective Optimization

Initialise Population

Assign Fitness
Evolutionary Multi-objective Optimization

Evolutionary Principles

1. Selection
Evolutionary Multi-objective Optimization

Evolutionary Principles

1. Selection
Evolutionary Multi-objective Optimization

Evolutionary Principles

1. Selection
2. Crossover

![Diagram showing evolutionary principles with axes $f_1$ and $f_2$, green points representing offspring and brown points representing parents.](image-url)
Evolutionary Multi-objective Optimization

Evolutionary Principles

1. Selection
2. Crossover
3. Mutation
Evolutionary Multi-objective Optimization

Evolutionary Principles

1. Selection
2. Crossover
3. Mutation
4. Replacement

Aalto University
School of Economics

Doctoral Programme Seminar
23rd - 26th May 2011
Evolutionary Multi-objective Optimization

Evolutionary Principles

1. Selection
2. Crossover
3. Mutation
4. Replacement
Research Contributions

• Handling high objective optimization problems

• Handling bilevel multi-objective optimization problems
Progressively Interactive EMO Approach
Progressively Interactive EMO Approach

Contributions

• Progressively interactive EMO procedures are proposed
  • PI-EMO-VF
    – Generalized polynomial value function
    – Optimal value function fitting
Progressively Interactive EMO Approach

Using Value Functions

Most Preferred Point

Decision Making Instances

f_2

f_1
Progressively Interactive EMO Approach

Contributions

• Progressively interactive EMO procedures are proposed
  • PI-EMO-VF
    – Generalized polynomial value function
    – Optimal value function fitting
  • PI-EMO-PC
    – Polyhedral cones are constructed using preferences
Progressively Interactive EMO Approach

Using Polyhedral Cones

Most Preferred Point

Decision Making Instances

$\mathbf{f_1}$

$\mathbf{f_2}$
Progressively Interactive EMO Approach

Contributions

• Progressively interactive EMO procedures are proposed
  • PI-EMO-VF
    – Generalized polynomial value function
    – Optimal value function fitting
  • PI-EMO-PC
    – Polyhedral cones are constructed using preferences
• Preference information is incorporated in the EMO in different ways
  • Rank ordering a given set of points
  • Choosing the best point from a given set
• Upto five objective test problems have been successfully handled
Bilevel Multi-objective Optimization

- Bilevel multi-objective problems involve two levels of optimization task

  Optimize $F(x_u, x_l)$

  Subject to $x_l \in \text{argmin } f(x_l; x_u)$

- They are challenging optimization problems and have received less attention from researchers

- Such problems are often referred as the leader-follower problem
An Example: A Company Scenario

**Leader:** CEO of a Company
- **Objectives:** Maximize Company Profit
  - Maximize Product Quality

** Followers:** Department Heads
- **Objectives:** Maximize Department Profit
  - Maximize Employee Satisfaction
Bilevel Multi-objective Optimization

Contributions

• A Hybrid Bilevel EMO algorithm to handle multi-objective bilevel problems has been proposed

• DS (Deb-Sinha) test problems have been proposed to evaluate the methodology

• Integration of progressively interactive approach leads to increase in accuracy and reduction in computational cost
Thank You!
List of Papers


