Multi-Objective Optimization for Selecting and Scheduling Observations by Agile Earth Observing Satellites

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This work studies the use of multiobjective optimization applied to the scheduling of one Earth observing satellite in a context where multi users request photographs from the satellite. Genetic algorithms are proposed to solve the problem and experiments are conducted on realistic instances.

Photograph scheduling problem of agile Earth observing satellites

The mission of Earth Observing Satellites (EOSs) is to obtain photographs of the Earth surface satisfying users’ requirements.

• Minimize the maximum profit difference between users

Properties of Agile EOS

• Single camera
• Non-fixed starting time

Candidate photographs

Shape of photographs
Spot or Polygon

Types of photographs
Mono
• Acquired twice
• Same direction
• Different angles

Stereo
• Taken only once

Multi-objective optimization for photograph scheduling problem

Multi-objective
• Maximize total profit
• Minimize the maximum profit difference between users to ensure fairness

Constraints
• Time windows
• No overlapping images
• Sufficient transition times
• For each strip, only one of two possible directions can be selected
• Stereoscopic constraint

Gain function of profit calculation

Multi-objective optimization problem

\[ MOP = \min f(x) = (f_1(x), f_2(x), \ldots, f_n(x)) \text{ s.t. } \mathcal{A}_r \leq 0 \]

Pareto dominance (maximize \( f_j(x) \), minimize \( f_j(x) \))

A solution \( x \) dominates (\( > \)) a solution \( y \) if

\[ f_j(x) \geq f_j(y) \quad \text{and} \quad f_j(x) < f_j(y) \]

or

\[ f_j(x) > f_j(y) \quad \text{and} \quad f_j(x) \leq f_j(y) \]

Biased random-key genetic algorithm

Two methods to select the preferred chromosomes are:
• Fast nondominated sorting and crowding distance assignment (proposed in NSGA-II)

Duration time
Possible starting time

Chromosome 1 Chromosome 2

Conclusions

• The multi-objective optimization is applied to solve the problem of selecting and scheduling the observations of agile Earth observing satellites.
• A biased random-key genetic algorithm (BRKGA) is applied to solve this problem.

Future Work

• The other random-key decoding methods will be used to improve the results.
• We will apply an indicator-based multi-objective local search (IBMOLS) to solve this problem and compare the results between BRKGA and IBMOLS.

Acknowledgment


References