

Multiobjective water resources systems analysis using genetic algorithms – application to Chou-Shui River Basin, Taiwan

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Abstract Multipurpose operation is adopted by most reservoirs in Taiwan in order to maximize the benefits of power generation, water supply, irrigation and recreational purposes. A multiobjective approach can be used to obtain trade-off curves among these multipurpose targets. The weighting method, in which different weighting factors are used for different purposes, was used in this research work. In Taiwan, most major reservoirs are operated by rule curves. Genetic algorithms with characteristics of artificial intelligence were applied to obtain the optimal rule curves of the multi-reservoir system under multipurpose operation in Chou-Shui River Basin in central Taiwan. The model results reveal that different shapes of rule curves under different weighting factors on targets can be efficiently obtained by genetic algorithms. Pareto optimal solutions for a trade-off between water supply and hydropower were obtained and analyzed.

Keywords Chou-Shui River Basin; genetic algorithms; multiobjective programming; rule curves

Introduction

The study of genetic algorithms (GAs) was originated by Holland (1975). GAs have been developed to become a powerful optimization approach. In the theory of GAs, Brindle (1981) improved the roulette wheel selection; Wright (1991) and Eshelman *et al.* (1992) developed real-value coding to solve related problems. GAs were applied to water resources systems by Goldberg and Kuo (1987) for pipeline optimization. Wang (1991) applied GAs to the calibration of a conceptual rainfall-runoff model. McKinney and Lin (1994), Ritzel *et al.* (1994), and Cieniawski *et al.* (1995) solved ground-water problems with GAs.

So far, there have been very few applications of GAs to reservoir systems optimization. East and Hall (1994) applied GAs to a four-reservoir problem; the objective was to maximize the benefits from power generation, irrigation and water supply. Fahmy *et al.* (1994) also applied GAs to a reservoir system, and compared the performance of the GAs with dynamic programming. Oliveira and Loucks (1997) used GAs to evaluate operating rules for a multi-reservoir system. Chang and Chen (1998) applied a GA to solve a flood control operation problem. Sharif and Wardlaw (2000) used GAs to solve a multi-reservoir system optimization problem in Brantas Basin located in Indonesia.

This research uses GAs for obtaining optimal rule curves in a reservoir system operation and finds the Pareto optimal solutions for water supply and hydropower generation in Chou-Shui River Basin in central Taiwan.

Genetic algorithms

Characteristics of GAs

The need for solving optimization problems arises in almost every field. Genetic

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Multi-objective Analysis for Sustainable Analysis of Water Resources Jayson J. Samec (University of Manitoba student), 1994 **Multiobjective Water Resource Planning** David C. Major, 1977 **Water Resources Systems Planning and Management** Sharad K. Jain, V.P. Singh, 2023-11-25 Water Resources Systems Planning and Management Second Edition Volume 51 presents new and updated material including case studies examples and important updates on topics such as climate change and integrated water resources management Authored by two renowned experts in the field of water resources this text provides an overview of the current status of water resources utilization the likely scenario of future demands simulation and techniques of economic analysis concepts of planning the planning process integrated planning public involvement reservoir sizing and finally systems operation and management This book presents a comprehensive overview of the field that is relevant for students professors scholars researchers and consultants in the fields of Water Resources Civil Engineering Environmental Engineering and Hydrology Provides an overview of the current status of water resources utilization the likely scenario of future demands and advantages and disadvantages of systems techniques Includes numerous examples and real world case studies Discusses the concepts of planning the planning process integrated planning public involvement and reservoir sizing New to this edition Thoroughly updated content with an improved presentation new figures examples and case studies Includes comprehensive new coverage focusing on the impact of climate change and environmental flows All chapters are updated with three brand new chapters Environmental flows and their assessment Climate change and its impacts on water management Integrated river basin planning and management Integrated Water Resources Management Selected Water Resources Abstracts , 1978 *Multiobjective Water Resources Planning* Daniel P. Loucks, 1975 **Models and Methodologies in Multi-objective Water Resources Planning** Dean M. Mades, George Tauxe, 1980 **Multicriteria Optimization in Engineering and in the Sciences** Wolfram Stadler, 2013-12-14 We are rarely asked to make decisions based on only one criterion most often decisions are based on several usually conflicting criteria In nature if the design of a system evolves to some final optimal state then it must include a balance for the interaction of the system with its surroundings certainly a design based on a variety of criteria Furthermore the diversity of nature s designs suggests an infinity of such optimal states In another sense decisions simultaneously optimize a finite number of criteria while there is usually an infinity of optimal solutions Multicriteria optimization provides the mathematical framework to accommodate these demands Multicriteria optimization has its roots in mathematical economics in particular

in consumer economics as considered by Edgeworth and Pareto The critical question in an exchange economy concerns the equilibrium point at which each of N consumers has achieved the best possible deal for himself or herself Ultimately this is a collective decision in which any further gain by one consumer can occur only at the expense of at least one other consumer Such an equilibrium concept was first introduced by Edgeworth in 1881 in his book on mathematical psychics Today such an optimum is variously called Pareto optimum after the Italian French welfare economist who continued and expanded Edgeworth's work efficient nondominated and so on

Selected Water Resources Abstracts, 1986 Multicriteria Decision Analysis in Water Resources Management Janos J. Bogardi, Hans-Peter Nachtnebel, 1994 The concept of integrated water resources management as a decision making problem Introduction of systems analysis terminology concepts objective functions and constraints Concepts of multicriterion decision making value and utility concepts in multiple criteria decision making Distance based techniques in multicriterion decision making Multicriterion decision making methods with ordinal and cardinal scales electre I III Interactive multiobjective decision making learning about tradeoffs Discrete decisions in water resources planning an interactive sequential approach with multiple objectives The search beam method Comparison of multicriterion modelling techniques and guidelines for selection Computer assisted negotiation of multiobjective water resources conflicts IRIS an interactive simulation tool for water resources systems A decision support system for interactive groundwater modeling and management Legal and administrative imbedding of the technical decision making in the planning process of integrated water resources management *Multiobjective Analysis in the Maumee River Basin* Yacov Y. Haimes, 1977 **Multiple Objective Planning for Water Resources**, 1975 **Water Resource Systems Planning and Analysis** Daniel P. Loucks, Jerry R. Stedinger, Douglas A. Haith, 1981 **Multi-objective Planning for Water Resources Management** W. T. O'Brien, 1977 **Hydrology and Water Resources in Arizona and the Southwest**, 2003 Water Management in Michigan: Political aspects of water resource planning : theory and practice, 1985 **Water Resources Journal**, 1998 **California. Court of Appeal (3rd Appellate District). Records and Briefs** California (State)., Number of Exhibits 6 Journal of the Water Resources Planning and Management Division American Society of Civil Engineers. Water Resources Planning and Management Division, 1982 **Social and Environmental Objectives in Water Resources Planning and Management** Warren Viessman, Kyle E. Schilling, 1986

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