Chapter 3
GIS-Based Evolutionary Approaches Using Multiple-Criteria Decision Analysis for Spatial Issues

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ABSTRACT

Geographic information systems (GIS) have been considered as good decision support tools to provide the decision maker (DM). However, their spatial data functionalities fail to provide any report about the potentials of the information and cannot make rational choice between conflicting alternatives. Literature review shows that the integration of GIS with multiple-criteria decision analysis (MCDA) makes GIS more robust in decision making process. While MCDA are used to support DMs to deal and solve spatial multi-objective optimisation problems (SMOPs), the use of their methods are suited for eliciting the preferences of small group of stakeholders. Unlike to MCDA, Multi-Objective Evolutionary Algorithms (MOEA) perform well on solving SMOPS conflicting objectives since only one iteration of the algorithm gives rise to a set of trade-off solutions. However, only choosing better compromise doesn't completely solve the problem. Recently, a growing interest in combining MCDA and MOEA techniques has been seen. The chapter approaches the idea of integration of GIS, MOEA, and MCDA to solve SMOP.

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INTRODUCTION

"Geographic Information Systems are computer-based tools for mapping and analyzing features and events on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps" (Monroe County, 2008). GIS are defined then as the capture, storage, manipulation, analysis and display of spatial data based on the user's request.

GIS have many benefits and have gained much attention for their applications in many problems such as in Vehicle Routing Problem (VRP) (Tlili et al., 2014), land use allocation (Li & Parrott, 2016), Future Urban Development (Caparros-Midwood et al., 2017), water distribution networks (Bashi-Azghadi et al., 2017), disaster management (Hsu et al., 2005).

Despite the vast potential applications of GIS in assisting the decision-making process, they remain unable to present any report about the potentials of the information. For example, GIS enables geographic data from one sector (such as safe water supply, education, employment) to be combined with data from other sectors (such as transportation, health care) to provide a comprehensive picture of the situation in any given community, region or country, and there by facilitating the setting of priorities for control and surveillance activities, the rationalization of the use of scarce resources, and effective planning.

On the other hand, in the field of spatial decision-making, MCDA has become a widespread tool, able to tackle problems involving more than one objective. Theoretical and empirical studies showed that MCDA provides a useful tool for decision aid, as it allows for multiple objectives, for the use of different types of data and the involvement of different stakeholders.

MCDA can be used before the optimization, to specify partially the preferences of the user, after optimization, to help selection of the most favorite solution from the set of solutions generated by the MOEA or be closely integrated with MOEA to guide the optimization towards the most favorite solution. This paper addresses the last case.

Unlike MCDA, MOEAs have shown a great success in dealing with SMOP but solving the problem does not mean only finding the Pareto set but also the DM still must choose a single solution out of this set. The process of selecting a single solution is not trivial. As the number of criteria increases, several important difficulties arise in performing this task. In the beginning, the MOEA community has developed independently from the "classical" MCDA community. Only in recent years, it has been recognized that MOEAs and MCDA have a lot to offer to each other, and subsequently the communities have grown together.

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