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Fuzzy Multi-Objective Approach for Emergency Location Transportation Problem

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Abstract : In the modern world emergency management decision support systems are actively used by state organizations, which are interested in extreme and abnormal processes and provide optimal and safe management of supply needed for the civil and military facilities in geographical areas, affected by disasters, earthquakes, fires and other accidents, weapons of mass destruction, terrorist attacks, etc. Obviously, these kinds of extreme events cause significant losses and damages to the infrastructure. In such cases, usage of intelligent support technologies is very important for quick and optimal location-transportation of emergency service in order to avoid new losses caused by these events. Timely servicing from emergency service centers to the affected disaster regions (response phase) is a key task of the emergency management system. Scientific research of this field takes the important place in decision-making problems. Our goal was to create an expert knowledge-based intelligent support system, which will serve as an assistant tool to provide optimal solutions for the above-mentioned problem. The inputs to the mathematical model of the system are objective data, as well as expert evaluations. The outputs of the system are solutions for Fuzzy Multi-Objective Emergency Location-Transportation Problem (FMOELTP) for disasters' regions. The development and testing of the Intelligent Support System were done on the example of an experimental disaster region (for some geographical zone of Georgia) which was generated using a simulation modeling. Four objectives are considered in our model. The first objective is to minimize an expectation of total transportation duration of needed products. The second objective is to minimize the total selection unreliability index of opened humanitarian aid distribution centers (HADCs). The third objective minimizes the number of agents needed to operate the opened HADCs. The fourth objective minimizes the non-covered demand for all demand points. Possibility chance constraints and objective constraints were constructed based on objective-subjective data. The FMOELTP was constructed in a static and fuzzy environment since the decisions to be made are taken immediately after the disaster (during few hours) with the information available at that moment. It is assumed that the requests for products are estimated by homeland security organizations, or their experts, based upon their experience and their evaluation of the disaster's seriousness. Estimated transportation times are considered to take into account routing access difficulty of the region and the infrastructure conditions. We propose an epsilon-constraint method for finding the exact solutions for the problem. It is proved that this approach generates the exact Pareto front of the multi-objective location-transportation problem addressed. Sometimes for large dimensions of the problem, the exact method requires long computing times. Thus, we propose an approximate method that imposes a number of stopping criteria on the exact method. For large dimensions of the FMOELTP the Estimation of Distribution Algorithm's (EDA) approach is developed.

Keywords : epsilon-constraint method, estimation of distribution algorithm, fuzzy multi-objective combinatorial programming problem, fuzzy multi-objective emergency location/transportation problem
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