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SOLVING THE SHORTEST PATH PROBLEM WITH IMPRECISE ARC LENGTHS USING A TWO-STAGE TWO-POPULATION GENETIC ALGORITHM

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Abstract. *This study investigates how to solve the shortest path problem with imprecise arc lengths using a two-stage two-population genetic algorithm (GA). This approach can conveniently represent imprecise numerical quantities, and therefore, it is able to handle imprecise arc lengths. In its first stage, the proposed GA simulates a fuzzy number by partitioning an imprecise arc length into a finite number of subintervals. Each subinterval represents a partition point. A random real number in [0, 1] is first assigned to each partition point. The GA then evolves the values in each partition point, with the final values in each partition point representing the membership grades of that fuzzy number. Thus, it is possible to obtain estimated values for the originally imprecise arc lengths, and the fuzzy problem becomes a defuzzified instance. The second stage of the GA is to search for the best solution to the defuzzified instance using a scheme in which two candidate populations evolve simultaneously. The first population comprises a set of feasible candidate solutions, and the second population consists of infeasible candidate solutions. The two solution populations are separately maintained and evolved, but their offspring may flow from one population into the other. Experimental results show that the proposed two-stage two-population GA approach obtains better results than other fuzzy shortest path approaches.*

Keywords: Fuzzy number, Fuzzy shortest path problem, Imprecise arc lengths, Two-stage two-population genetic algorithm, Signed-distance ranking method

1. Introduction.

A fundamental problem in the area of graph theory is that of finding the shortest path in a given graph. Over the past few years, the shortest path problem has often been posed as a subset of other optimization problems [12]. The analysis of fuzzy counterparts of the shortest path problem has also drawn much recent attention [18]. The main advantage, compared with the nonfuzzy problem formulation, is that the decision-maker is not forced into a precise formulation. Fuzziness can be introduced into a network in a variety of ways, for example, through edge capacities, vertex restrictions or arc lengths [1,2,5,10,14].

Dubois and Prade [6] first introduced the fuzzy shortest path problem in 1980. The major drawback of their formation is its lack of interpretation. More specifically, a fuzzy shortest path may be found that does not correspond to an actual path in the network. Klein [10] presented new models based on fuzzy shortest paths that circumvent this problem. He developed a hybrid multi-criteria algorithm based on fuzzy dynamic programming. Klein analyzed the fuzzy shortest path algorithm in terms of general fuzzy mathematical programming, but his proposed approach, in which he assumed that each of the arc lengths must fall between one and a fixed integer, was not reasonable. Mares