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EUGENIC BACTERIAL MEMETIC ALGORITHM FOR FUZZY ROAD TRANSPORT TRAVELING SALESMAN PROBLEM

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Abstract. *The aim of the Traveling Salesman Problem (TSP) is to find the cheapest way of visiting all elements in a given set of cities (nodes) exactly once and returning to the starting point. In solutions presented in the literature costs of travel between nodes are based on Euclidean distances, the problem is symmetric and the costs are constant and crisp values. Practical application in road transportation and supply chains are often uncertain or fuzzy. The risk attitude depends on the features of the given operation. The model presented in this paper handles the fuzzy, time dependent nature of the TSP and also gives a solution for the asymmetric loss aversion by embedding the risk attitude into the fitness function of the eugenic bacterial memetic algorithm. Computational results are presented for different cases. The classical TSP is investigated along with a modified instance where some costs between the cities are described with fuzzy numbers. Two different techniques are proposed to evaluate the uncertainties in the fuzzy cost values. The time dependent version of the fuzzy TSP is also investigated and simulation experiences are presented.*

Keywords: Traveling salesman problem, Eugenic bacterial memetic algorithm, Time dependent fuzzy costs, Uncertainty management

1. **Introduction.** The aim of the Traveling Salesman Problem (TSP) is to find the cheapest path reaching all elements in a given set of cities (nodes) where the cost of travel between each pair of them is given, including the return to the starting point. The TSP is a very good representative of a larger class of problems known as combinatorial optimization problems [2]. For its practical importance and the wide range of applications in practice many approaches, heuristic searches and algorithms have been suggested [4,10,12,30,38], while different extensions and variations of the original TSP and similar problems have been investigated [24,25,31]. The problem presented in the literature most frequently has the following features. Costs of travel between nodes (cities) are based on Euclidean distances, the problem is symmetric and the costs are constant. Since the original formulation of the problem states: the aim is to find the "cheapest" tour, thus the cost matrix that represents the distances between each pair must be determined by calculating the actual costs of the transportation processes. The costs of transportation consist of two main elements: costs proportional to transit distances (km) and costs proportional to transit times. Obviously, the physical distances can be considered as constant values in a given relation, however, transit times are subject to external factors [14] such as weather conditions, traffic circumstances, etc., so they should be treated as a time-dependent variable. On the other hand, in real road networks the actual distance between two points