A Different Approach for Solving the Shortest Path Problem Under Mixed Fuzzy Environment

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ABSTRACT

The authors present a new algorithm for solving the shortest path problem (SPP) in a mixed fuzzy environment. With this algorithm, the authors can solve the problems with different sets of fuzzy numbers e.g., normal, trapezoidal, triangular, and LR-flat fuzzy membership functions. Moreover, the authors can solve the fuzzy shortest path problem (FSPP) with two different membership functions such as normal and a fuzzy membership function under real-life situations. The transformation of the fuzzy linear programming (FLP) model into a crisp linear programming model by using a score function is also investigated. Furthermore, the shortcomings of some existing methods are discussed and compared with the algorithm. The objective of the proposed method is to find the fuzzy shortest path (FSP) for the given network; however, this is also capable of predicting the fuzzy shortest path length (FSPL) and crisp shortest path length (CSPL). Finally, some numerical experiments are given to show the effectiveness and robustness of the new model. Numerical results show that this method is superior to the existing methods.

KEYWORDS
Fuzzy Linear Programming, Normal Fuzzy Number, Score Function, Shortest Path Problem

1. INTRODUCTION

There are numerous circumstances in real life where we need to find the shortest path from the source to destination. In tradition SPP, it is always determined that the parameter is fixed which can be effortlessly solved by fundamental graph theory; for example, Dijkstra’s algorithm (Dijkstra, 1959) where the weighted graph is used to find the optimal path. Floyd–Warshall (Floyd, 1962) algorithm solves all pairs shortest paths, Viterbi Algorithm (Viterbi, 1967) is a based on a dynamic programming algorithm. By this algorithm, we can easily find the shortest path with an addition probabilistic weight on each connected node. Johnson’s Algorithm (Johnson, 1977) solved all pairs of the shortest path. This algorithm is faster than Floyd Warshall algorithm (Floyd, 1962) on sparse graph, but there are numerous circumstances in real life where we have to face with uncertain parameters such as flood, low visibility during winter, traffic congestion, uneven roads, strike, road accidents or bad human health arrives between the source to destination. In order to remove this uncertainty, we imply our problem into fuzzy problems. Zadeh (1965) was first to introduce the fuzzy numbers. The method of evaluating the Shortest distance with fuzzy parameters is known as the FSPP. This problem is an
extension of fuzzy numbers, and it has many real-life applications in the field of scheduling (Nip, Wang, & Xing, 2016), transportation (Scutellà & Grazia, 1998), broadcast problems (Crescenzia, et al., 2016), air traffic management (Sherali & Hill, 2009), spanning tree problem (Dey & Pal, 2016), (Dey, Mondal, & Pal, 2017) and so on.

Dubois and Prade (1983) were first analyzed the FSPP by using the classical Floyd and FMB algorithms. However, the major drawback of their method is that the path derived by the algorithms may not actually exist in the network. FSP is one of the applications where we used the ranking index to find the shortest path. Okada & Gen (1994) proposed an algorithm on the basis of Dijkstra algorithm. They used fuzzy order relation to compare two path lengths, to find the FSP. Mahdavi et al. (2009) suggested a dynamic programming (DP) technique for the FSPP considering triangular and trapezoidal arc length. Tajdin et al. (2010) also proposed an algorithm based on DP technique using α-cut, Hassanzadeh et al. (2013) suggested genetic algorithm (GA), Zhang et al. (2013) suggested biological inspired optimization model and Yang et al. (2017) proposed optimal path selection approach for solving the FSP under mixed fuzzy arc length. Chuang & Kung (2005) proposed an algorithm which is combination of two steps, i.e. heuristic procedure for finding the FSP among all probable paths in the network and the similarity degree between FSPL. Moazeni (2006) algorithm is a combination of two steps, i.e. Hansen’s multiple labeling and Dijkstra’s SP algorithm. Dou et al. (2008) algorithm also contains two-steps, i.e. classical approach for finding the FSP and use of vague similarity measure to evaluate the similarity degree between vague path length. Dou et al. (2012) also suggest a model for finding the FSP using MCDM based on his previous approach, i.e., vague similarity measure. Effati et al. (2011) proposed fuzzy neural network(FNN) model, Haung & Ding (2012) proposed a model which combines with fuzzy simulation and genetic optimization, Mohiuddin et al. (2016) proposed fuzzy particle swarm optimization algorithm(FPSO) for the weight setting problem, Qu & Yi (2007) proposed algorithm based on Pulse-coupled neural network (PCNN), Dey et al. (2016) and Dey & Pal (2017) presented some model for solving the FSPP. So, there are different approaches to find the SPP under fuzzy environment.

In this paper, we use FLP technique which was introduced by Zimmermann (1978) and lately applied by many authors to solve the varied problems. Maleki (2000), (2003), Najafi & Edalatpanah (2013), Sakawa et al. (2013), Hosseinzadeh & Edalatpanah (2016), Najafi et al. (2016), Das et al. (2017), Khan et al. (2017), Feylizadeh et al. (2018), Li & Liu (2015), Li & Wan (2013), Wan and Li (2013) and so on. Shortest path with fuzzy parameters is one of the applications where we used the linear programming principle, so this approach is also known as fuzzy linear shortest path programming (FLSPP) approach. Latterly applied by many authors Lin & Chern (1993), Yu & Wei (2007), Ji et al. (2007), Mukherjee (2015), Niroo and et. al., (2017) and so on.

In this study, a new proposed method is used for finding the FSP along with FSPL, where the length of arcs in the network is mixed fuzzy arc length. Our main aim is to formulate the existing SPP into FLP problem by using the optimization principle. Some of the SPPs with mixed fuzzy arc lengths (FAL) are chosen which cannot be settled by utilizing any of the existing methods and a new method is proposed for solving such type of problems. The proposed method not only solve existing problems but can also solve other problems which are not solved by any of the authors till date with more accuracy. Additionally, it reduces space complexity and time complexity. This is the advantage of the method over all the existing methods to solve FSP problems.

This paper is sectioned as follows: some basic knowledge, concepts on fuzzy set theory. Section 2 contains an arithmetic operation on trapezoidal fuzzy numbers (TpFN) and triangular fuzzy numbers (TrFN), Section 3 includes the existing linear programming method under crisp and fuzzy SPPs. In Section 4, the proposed method for solving FSPP are discussed. In Section 5, few numerical examples are given to reveal the effectiveness of the proposed model. In Section 6, a comparison between the proposed method with the existing methods is presented. Finally, some conclusions are provided in the last section.
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