Application of Fuzzy Logic and Genetic Algorithm in Trip Distribution

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***Abstract* - This article examines possibilities for the application of soft computing techniques especially fuzzy logic and genetic algorithm for the prediction of travel demand. Fuzzy Logic (FL) addresses the imprecision or vagueness in input and output description of the system. It deals with reasoning that is approximate rather than fixed and exact. Fuzzy logic is shown to be a very promising mathematical approach for modelling traffic and transportation processes characterized by subjectivity, ambiguity, and uncertainty and imprecision. Genetic Algorithm (GA) is a search heuristic that mimics the process of natural selection. It generates solution to optimization and search problems using techniques inspired by natural evolution such as inheritance, mutation, selection and crossover. Each technology has its own advantages and disadvantages. Therefore, hybridization of these is done to overcome the weakness. This paper presents analysis of the results achieved using soft computing techniques like fuzzy logic and genetic algorithm for modeling trip distribution.**

Keywords - Fuzzy Logic, Genetic Algorithm, Genetic-Fuzzy Systems, Transportation Planning, Trip Distribution.

I. INTRODUCTION

The transportation planning process is an extensive and expensive task consuming a great deal of effort and time. It is a wide human-oriented field with diverse and challenging problems waiting to be solved. Characteristics and performances of transport systems – services, costs, infrastructures, vehicles and control systems are usually defined on the basis of quantitative evaluation of their main effects. One of the most important tasks involved in transportation planning process is the estimation of travel demand for the purpose of providing facilities and services. Estimation of travel demand must be done as accurately as possible. Therefore, transportation planners bear an exceptionally heavy responsibility. Most of the transport decisions take place under imprecision, uncertainty and partial truth. Some objectives and constraints are often difficult to be measured by crisp values.

Traditional analytical techniques were found to be non-effective when dealing with problems in which the dependencies between variables are too complex or ill-defined. Moreover, hard computing models cannot deal effectively with the transport decision-makers' ambiguities and uncertainties. In the past several decades a variety of deterministic and stochastic models have been developed to solve complex traffic and transportation engineering problems. These mathematical models use different formulae and equations to solve such problems. However, when solving real-life engineering problems, linguistic information is often encountered that is frequently hard to quantify using 'classical' mathematical techniques. This linguistic information represents subjective knowledge (linguistic information). The primary goal of this paper is the applications of soft computing techniques in traffic and transportation engineering, and to indicate the directions for future research in this area. Keeping this in view, an attempt here is to focus one segment of travel demand .i.e. Trip distribution by adopting soft computing techniques such as Fuzzy logic and Genetic Algorithm.

II. TRIP DISTRIBUTION

According to the traditional view, the transportation planning process consists of four stages: trip generation, trip distribution, modal split and route choice. In the sequential modelling of travel demand, the value of the output variable from one phase represents the value of the input variable in the next phase. Besides the sequential modeling approach there is also simultaneous modelling. Simultaneous modeling refers to the simultaneous prediction of trip generation, trip distribution and modal split. In this article only one stage of transportation planning is considered .i.e. Trip distribution.

Trip distribution models are intended to produce the best possible predictions of travelers' destination choices on the basis of trip generation and attraction information for every travel zone and generalized cost of traveling between each pair of zones. Thus, the prediction of trip distribution involves the prediction of flows in a network regardless of a possible transportation mode or travel route. Trip distribution leads to coverage of urban geographical area, in other words spatial travel coverage. Commonly used methods of trip distribution are Growth Factor method and Synthetic method. Traffic flows and trip distribution resulted from human choices that are affected by social and individual variables of the commuters. Due to this fact that human decision making are more consistent with fuzzy logic in comparison with crisp mathematics, it seems that fuzzy logic could be a logical tool to map such areas. Modelling a trip distribution system with fuzzy inference systems would enjoy the exploration of subjective pattern of decision makers. Genetic algorithms are adaptive heuristic search algorithm based on the evolutionary ideas of natural selection and genetics. In order to combine the uncertainty nature and the probabilistic nature of the transportation problem and to achieve better result hybridization of these techniques can be done.

III. FUZZY LOGIC AND GENETIC ALGORITHM IN TRIP DISTRIBUTION

A pioneering fuzzy logic approach to trip distribution modelling was introduced by Kalic and Teodorovic (1996). They estimated air passenger flows among selected major industrial cities and tourist resorts using known productions and attractions as inputs. In another, Kalic and Teodorovic (2003) improved their work achieving better results with a GFRBS (Genetic Fuzzy Rule Based System) design. Their model consists of two parts. In the first part, the fuzzy rule base used to determine the number of trips between particular zones was generated. The fuzzy rule base obtained has a corresponding accuracy regarding the fitness between estimated and actual flows. In the second part of the model, in order to increase the degree of accuracy the initial fuzzy rule base was modified using a genetic algorithm. Graphical comparisons and a statistical analysis of real values and values of the output variable obtained by the suggested techniques were presented. According to the results achieved, it can be said that by using fuzzy logic and the genetic algorithm, good predictions of passenger flows were obtained. They used triangular membership function and Gaussian membership function for the study. From the graphs illustrating the comparison of real and estimated passenger flows, as well as from the corresponding statistical tests, it was understood that the differences were insignificant when different shapes of membership functions of input and output variables and different reasoning techniques were used. Their proposed GFRBS (Genetic Fuzzy Rule Based System) produced better results than those of conventional non-fuzzy methods. The results obtained suggest that soft computing techniques can be used in predicting travel demand.

A three phase fuzzy inference system (FIS) was proposed by Jassbi (2011) to map social and demographic variables to total number of trips between origin-destination (OD) pairs. Combinations of various social and demographic variables were used because they are the reasons for the movement of commuters in metropolitan areas.The main concern of the problem was to approximate the transfer function that is capable of mapping trip attraction and generation variables to number of trips between two given regions. A fuzzy inference system was used to map input space to output space. Fuzzy rule bases in the model were in fact the exploration of transportation experts' subjective patterns.

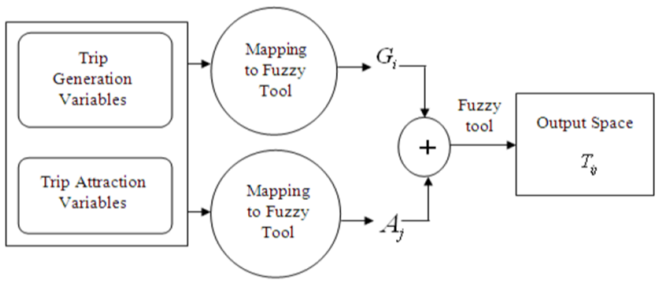

Fig 1 Conceptual fuzzy model: Mapping trip generation and attraction variables to total number of trips between two given regions

To map input space to output space, three independent fuzzy inference systems are used. The first FIS is aimed to map generation variables to number of generated trips by the given region (G_i).The second FIS is designed to map attraction variables to number of attracted trips by the given region (A_j). At the end, the third FIS is designed to combine the output of the first and second FIS for aggregation of two given regions G_i and Aj and calculating the final total number of trips between two regions (T_{ij}). Because of fuzzy nature of human decision making process, it seems that phenomena that are related to human choice could be explained using fuzzy logic more accurately. Obtained results suggests that a logical framework proposed based on fuzzy inference systems can be used successfully to approximate trip distribution function.

Goel.et.al (2012) developed a trip distribution model for Delhi urban area using genetic algorithm.This model uses the goodies of Genetic Algorithm in Trip distribution. The selection operator chosen was the Roulette wheel selection and Standard crossover operator was chosen for manipulating the representation. The operator ERO (Edge Recombination crossover Operators) was designed to manipulate permutations. The result obtained from the model was compared with the Linear Programming based model. It was observed that a Linear Programming based model gives infeasible solution for the complex problems and the same can be accurately done by using Genetic Algorithm based model.

Kompil and Celik (2013) developed a trip distribution model using Genetic Fuzzy Rule Based System. According to previous studies on applications of fuzzy logic and genetic algorithm, FRBSs (Fuzzy Rule Based Systems) can be used to solve trip distribution problems efficiently and, together with the use of GAs, it is possible to achieve better model performances. However, the performance of FRBSs against a DCGM and a NN (Neural Network) based trip distribution model was not investigated. Moreover, the GFRBS has not been adapted for the prediction of intra-city passenger flows, which adds computational burden and complexity with additional friction variable and additional fuzzy rules. Study by Kompil and Celik tries to make up for these shortages with an empirical analysis. They attempts to set out an FRBS and a GFRBS for modelling intra-city passenger flows in Istanbul. Their objective was to compare and evaluate the accuracy, applicability and generalizability of such models to that of well-known trip distribution models in a complex real-world case. For this purpose, a doubly constrained gravity model (DCGM) and a multilayer feed-forward NN-based trip distribution model were established as the benchmarks, against which model performances were evaluated empirically using the 2006 Istanbul Travel Survey data.According to their study they conclude that fuzzy and GFSs offer an alternative to traditional gravity models and NNs in modelling trip distributions.

IV. CONCLUSION

In recent decades, many techniques have been proposed for each step of travel demand analysis. Among them, trip distribution has probably been the most attractive field of demand analysis, especially given the widespread use of gravity models. Transportation researchers and practitioners have recently become more interested in exploring the capability of applying soft computing (computationally intelligent) techniques to real transportation problems.

Research in more effective and predictive methodologies in spatial interaction and trip distribution modeling has also led to some pioneering studies in this area. Many scholars have proposed new modelling procedures to forecast aggregate interactions using neural networks (NNs), fuzzy logic (FL) and genetic algorithms (GAs). The basic goal of this paper was to analyze results in the application of fuzzy logic and genetic algorithm when modeling complex traffic and transportation processes especially trip distribution. The initial experiences with these techniques have been encouraging, and the overall results suggest that NNs, FL and GAs can be used successfully in spatial interactions models.

V. REFERENCES

[1] Kompil M, Celik H,“Modelling trip distribution with fuzzy and genetic fuzzy systems”, Transportation Planning and Technology, Vol. 36(2),pp. 170-200,2013.
[2] Jassbi J., Makvandi P., Ataei M. and Sousa Pedro A. C.,“Soft system modeling in transportation planning:Modeling trip flows based on the fuzzy inference system approach”, African Journal of Business Management, Vol. 5(2), pp. 505-514,2012.
[3] Milica Kalic.,Teodorovic D.,“Trip Distribution Modelling Using fuzzy logic and a genetic algorithm”, Transportation Planning and Technology,Vol.26(3),pp.213-238,2003
[4] Goel S., J.B. Singh., Ashok K.,” Trip Distribution Model for Delhi Urban Area Using Genetic Algorithm”, International Journal of Computer Engineering Science (IJCES),Vol.2(3),pp.2250-3439,2012.