An integrated model of GIS and fuzzy logic (FMOTS) for location decisions of taxicab stands

Ebru Vesile Ocalir\textsuperscript{a,}\textsuperscript{*}, Ozge Yalciner Ercoskun \textsuperscript{b}, Rifat Tur \textsuperscript{c}

\textsuperscript{a} Department of Traffic Planning, Institute of Science and Technology, Gazi University, Ankara, Turkey
\textsuperscript{b} Department of City and Regional Planning, Faculty of Engineering and Architecture, Gazi University, Ankara, Turkey
\textsuperscript{c} Department of Civil Engineering, Faculty of Engineering, Akdeniz University, Antalya, Turkey

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\textbf{A R T I C L E I N F O}

1. Introduction

In this paper, a decision support system for taxicab stands that can be used in any metropolitan area or municipality is presented. Taxi, which has been worldwide used since the 19th century, is an indispensable component of urban transport. Compared to other modes of transport, taxi has a relative advantage with the comfort and convenience that it provides 24 h a day to its users. However, it is criticized because of its low occupancy rates and traffic burden it loads on urban streets.

Taxicab stands offer a viable service by providing an identifiable, orderly, efficient, and quick means to secure a taxi that benefits both drivers and passengers (Giuliani, Rose, & Weinsball, 2001). Stands are normally located at high-traffic locations such as airports, hotel driveways, railway stations, subway stations, bus depots, shopping centers and major street intersections, where large number of passengers are likely to be found. The choice of location for taxicab stands depends only on legal permissions. From the legal authorities’ side, there is no evidence of taking some location for taxicab stands depending only on legal permissions.

The study is focused on both issues: how well the existing taxicab stands are located and where the most appropriate places for the incoming demand should be.

This paper proposes the \textit{Fuzzy Logic Model for Location Decisions of Taxicab Stands (FMOTS)}, which is a decision support system for decision makers, who wish to alleviate long-term decision in the short to medium term. In this study, an integrated model of GIS and fuzzy logic for taxicab stand location decision is built. The location decisions of taxicab stands in Ankara (Turkey), where organizational problems of taxicab stands slow down a better quality of service, have been examined by this integrated model and their appropriateness has also been evaluated according to the selected parameters.

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Thinking, which allows modeling complex systems using a higher level of abstraction originating from our knowledge and experience, is necessary. Fuzzy logic is an organized and mathematical method of handling inherently imprecise concepts. It has proven to be an excellent choice for many control system applications since it mimics human control logic. It uses an imprecise but very descriptive language to deal with input data more like a human operator.

In this study, an integrated model of GIS and fuzzy logic for taxi-cab stand location decision is built. GIS were used for generating some of the major inputs for the fuzzy logic model. The location decisions of taxi-cab stands in Ankara, where organizational problems of taxi-cab stands slow down a better quality of service, have been examined by this integrated model and their appropriateness has also been evaluated according to the selected parameters. With the fuzzy logic application, evaluation of the existing taxi-cab stands is done and decision for new taxi-cab stands is given. The equations are obtained by artificial neural network (ANN) approach to predict the number of taxi-cab stands in each traffic zone.

In the next section, background information for the tools used (the integration of GIS and fuzzy logic) is provided. It is followed by the introduction of a decision support system, the Fuzzy Logic Model for Location Decisions of Taxi-cab Stands (FMOTS), which was developed in this study, with a case study in Ankara. The paper closes with conclusions.

2. Incorporating fuzzy logic into GIS operations

Defining service areas is an important geographical application (Upchurch, Kuby, Zoldak, & Barranda, 2004) and with use of GIS, some studies have been performed. The service area analysis of transit services by GIS has been performed in O’Neill (1995) and Horner and Murray (2004)’s researches. In O’Neill’s (1995) study, by defining a transit route’s service area, walking distance and travel time were used as acceptable limits for transit users. Another study with GIS was performed (Walsh, Page, & Gesler, 1997) for exploring a variety of healthcare scenarios, where changes in the supply, demand, and impedance parameters were examined within a spatial context. They used network analysis for modeling location/allocation to optimize travel time and integrated measures of supply, demand, and impedance.

Fuzzy systems, describe the relationship between the inputs and the output of a system using a set of fuzzy IF-THEN set theory (Zadeh, 1965). The classical theory of crisp sets can describe only the membership or non-membership of an item to a set. Fuzzy logic, on the other hand, is based on the theory of fuzzy sets, which relates to classes of objects with unsharp boundaries, in which membership is matter of degree. In this approach, the classical notion of binary membership in a set has been modified to include partial membership ranging between 0 and 1.

Fig. 1. The design of the decision support system.
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