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Estimation of Traffic Characteristics by Fuzzy Reasoning Method

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Abstract

This paper makes a trial to build the model of car-following in the state of starting to stable driving on the basic of driver's knowledge that is easily characterized by linguistical cognition.

There are three main steps in building the model. Firstly, each driver's rule of three testees is studied in linguistical experssion by the interview and questionary surveys that are repeated once a day for ten days. Secondly, quantification of the linguistical expression is investigated by driving experiments that includes the questionary survey to the testee in the test vehicle, and the membership functions of variables of rule are obtained. Thirdly, implication and composition of fuzzy inference is made by Max-Min Methods and defuzzification by gravity method.

It can be said that the proposed model of car-following based on driver's knowledge is practically allpicable to the estimation of drivering of car-following on trunk roads in urban area.

1) Introduction

The characteristics of traffic flow in a car-following state has to be treated on the basis of driver's fuzziness, because it is easily understood that a driver makes decision with his own knowledge, habits, career and personality, and driving manervers are more and less affected by individual drivers. Here, it is tried to estimate the traffic characteristics on roads, not probabilistically and deterministically, but by fuzzy method.

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As an example of application of the estimation model the relation between traffic density and speed is compared with the observed on the trunk road of urban area.

2) Basic Concept of Driving Maneuvering

Generally speaking, a driving way is closely and directly related to the three main factors, which are enviornmental features of roads, driver's experience and knowledge, and characteristics of acceleration and decelerstion of motor vehicle.

The enviornment features of roads are informations on traffic conditions of his lane and neighbor lanes, physically dimension of lane width, radius of curves, sight distance and lux of lightening etc.. Driver's features are driving experience, knowledge of physical and enviornmental features of roads, and also his personality.

Driver's knowledge and experience are directly related to all steps of maneuvering vehicle, because a driver usually decides to maneuver vehicle, after observing his situation thought eyes and sensible organies and predicting safety on his desire.

Figure-1 shows the flow diagram of maneuvering vehicle on roads.

3) Driving Rules

It is quite natural to consider that a man drivers according to his own systematic and linguistical rule under various conditions of speeds and following distances. Figure-2 shows the building process of inference models. Various factors which control driving characteristics are searched for though interview survey and linguistical experssions of driving condition observed in the driving experiments. Then the inference models of the state of

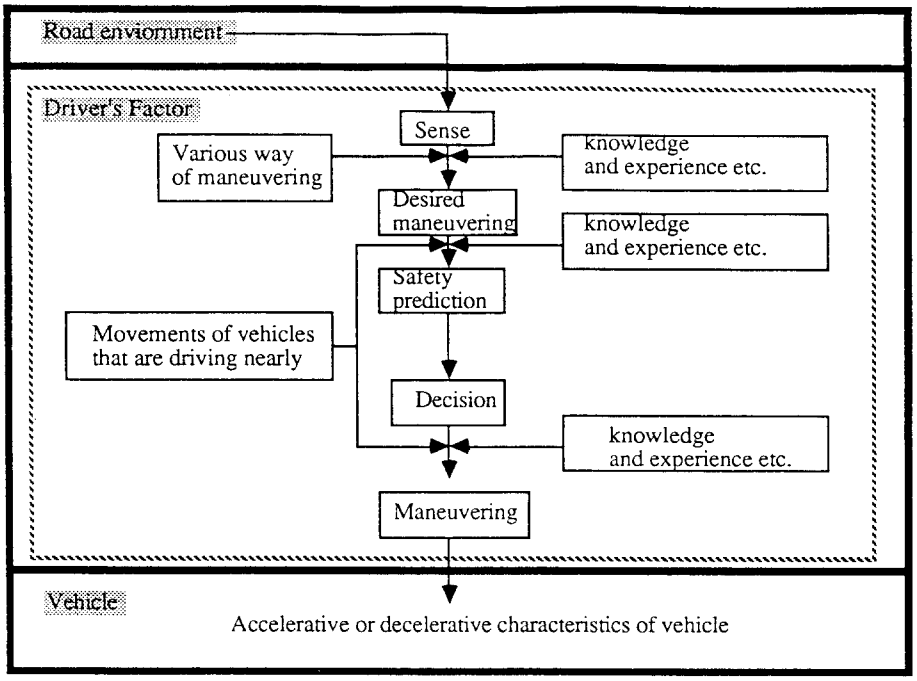

Fig.-1 Flow of maneuvering vehicle on roads

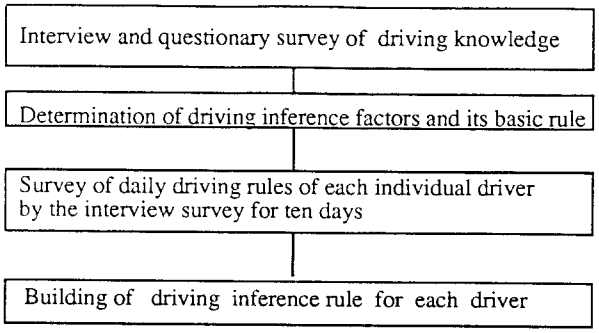

Fig-2 Flow of building driver's driving inference model

starting to stably driving are built according to the procedual knowledge type: - IF -- THEN -. The interview survey and the questionary survey about individual rules of driving are done once a day for a successive 10 days on the same drivers.

3-1) Building Inference Model of Driving Rule

It is found through the interview survey that drivers would like to drive at their own desirable speed. Therefore the desired speed of a driver is to be considered as an important factor in model building. As a step to model building, the driving of starting to reaching stably driving state is treated. And model building is made both in the state of reading and following driving.

4) Determination of Inference Models

It is necessary for building practical inference models to determine the linguistical degree of acceleration or deceleration correspondent to DV in the case of starning rule, a set of DL and DV in the case of following vehicle, and a set of DL and RV in the case of stably rule.

Considering convergence and frequency of the same answer to the same questions repeated for tne days, the final rules of selction of acceleration are fixed, as shown in Fig.-3. It is easily understood that drivers are in a less fuzzy state during the time from starting to reaching stably driving then after reaching stably driving. All of the fixed rules as shown in Fig.-6 are practically through not to be fuzzy, but some of them are deterministic. It is concluded that deterministic and fuzzy rules are necessary for making simulation of car-following.

5) Quantification of Qualitative Variables

Qualitatively determined rules of car-following are linguistically experssed, and linguiatical cognition of the desired speed, relative speed, car-following distance, acceleration and deceleration are to be quantitatively experssed according to fuzzy experssion as membership functions.

Rule No. / Testee	R1	R2	R3	R4
E1	L	M	S	N
E2	M	M	S	N
E3	L	L	S	N

Note) L : large , M : medium , S : small
N: nagative

a) Starting model of leading state

Testee 1

DV / DL	N	Z	P	VP
N	1 N	2 SN	3 0	4 0
Z	5 SN	6 0	7 SP	8 SP
P	9 0	10 0	11 P	12 VP
VP	13 0	14 0	15 P	16 VP

Testee 2

DV / DL	N	Z	P	VP
N	VN	SN	0	0
Z	SN	0	0	0
P	0	0	SP	P
VP	0	0	P	P

Testee3

DV / DL	N	Z	P	VP
N	N	SN	0	0
Z	0	0	SP	SP
P	P	SP	P	VP
VP	P	SP	VP	VP

b) Starting model of following vehicle

Testee 1

RV / DL	N	Z	P	VP
N	N	SN	-	-
Z	SN	0	SP	SP
P	0	0	P	VP
VP	0	0	P	VP

Testee 2

RV / DL	N	Z	P	VP
N	VN	SN	-	-
Z	SN	0	0	0
P	0	0	SP	P
VP	0	0	P	P

Testee 3

RV / DL	N	Z	P	VP
N	N	SN	-	-
Z	0	0	P	P
P	SP	P	VP	VP
VP	P	P	VP	VP

c)Stably driving model of following vehicle

Note)The cells of matrix represent the amount of acceleration.
Number 1-16 in the cells of matrix are rule numbers.
Mark - means the case that can not be happened.
□ : most reliable cases where the answer of rule is always the same to each testee and day.

Fig-3 Driving inference model

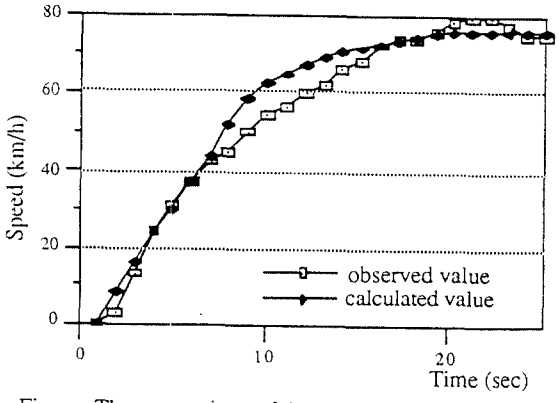

Fig.- 4 The comparison of the observed with the calculated value for the testee 3 (E3)

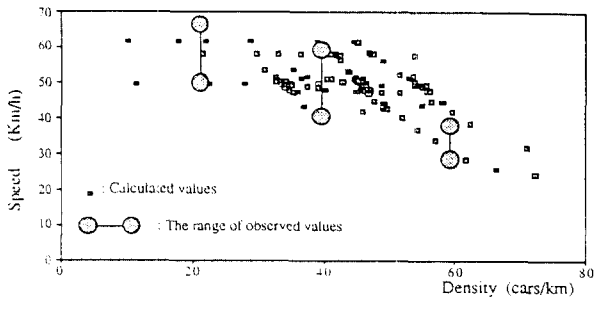

Fig.-5 Results of simulation

6) Example and Conclusion

Mamdani's method and Max-Min operation method (A. Kaufmann, M. M. Gupta (1988)) are applied to determining rules of implication and composition, respectively, and gravity method to defuzzification. Fugure-4 shows relation between speed and driving distance from starting to stable state of driving of a test driver. The observed and estimated curves are nearly equal to each other, thouthere are some defference in the range of speed 40 to 70 km/h due to neglecting enviorimental factors. Figure-5 shows relation between traffic density and speed. The estimated data are scattered within the range of the observed data.

It can be said that the proposed model of car-following based on driver's knowledge is practically applicable to the estimation of driving of car-following on trunk roads of urban area, by adding this study to enviornmental factors and over-taking characteristics through the successive studies.

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