Multi-vehicle mixed formation driving method based on fuzzy decision

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Abstract. This paper presents a multi-vehicle driving method based on fuzzy decision. Fuzzy decision-making is used to realize the process of multi vehicle merging to observe how he turns and joins other teams successfully. Establish the multi-vehicle driving fleet model, and initialize its relevant data, mainly including the speed of multi vehicle driving, the distance between vehicles in the multi vehicle driving fleet and the location from the intersection. Establish the model and data of the vehicle to be inserted into the multi vehicle driving team, mainly including its speed, the position of the vehicle to the intersection, and the intersection of the queue jumping is a fixed T-junction, and the whole process of fleet merging is implemented. The method proposed in the paper can be applied in practice.

Keywords: Fuzzy, decision making, autonomous driving, multi-vehicle

1. Introduction

Automatic driving has been a research topic for a long time, especially when it comes to the following driving of multi vehicle driving queue, it is also a problem of concern [1-5]. It has become a new research topic for people to follow driving in multi vehicle queue. The current research is generally committed to control the speed of the vehicle, so as to maintain a safe distance from the front of the vehicle. The problem of vehicle steering is left to people to drive to solve. This paper studies how to establish a multi vehicle fleet model [6-8]. In this paper, through the establishment of a multi vehicle driving fleet model and initialization of its relevant data, mainly the speed of the multi vehicle driving fleet, the distance between vehicles in the multi vehicle driving fleet, and the location of the vehicle from the intersection, the model and data of the vehicle to be inserted into the motorcade are established, mainly including the speed of the vehicle, the position of the vehicle to the intersection, and the intersection of the queue jumping is a fixed T-junction, so as to implement the whole process of fleet merging.

Fuzzy decision-making refers to the mathematical theory and method of decision-making in fuzzy environment [9-12]. In real life, a large number of decisions are fuzzy, multi-level, multi-objective and non-structural decisions. Decision making is closely related to our daily life. It is precisely because of the superiority of this method that it can deal with various complex system problems which are difficult to be described by precise mathematical methods, it is widely used in artificial intelligence, control, decision-making, expert system and other fields [13]. The characteristics of fuzzy decision-making are:
large system; the relationship between systems is relatively complex; there are variables belonging to fuzzy factors that cannot be accurately assigned in the system; with the help of sorting, fuzzy evaluation and other methods to deal with the relevant subjective factors, so that the relationship between the subsystems and variables becomes clear. Fuzzy comprehensive evaluation model is also a kind of analysis and evaluation method which unifies precision and imprecision, and combines qualitative and quantitative. One of the methods of fuzzy decision-making is fuzzy comprehensive evaluation decision-making. This decision-making model is a "fuzzy" thing analysis and evaluation method based on mathematical principles. At present, the research on automatic driving vehicles has been successful. We use fuzzy decision to realize the process of multi vehicle merging to observe how it turns and successfully join other multi vehicle mixed formation teams. At the beginning, the reaction effect of different situations can be observed by user-defined initial speed and distance. And through checking the speed, distance, speed, safety distance and other data of each multi vehicle mixed formation in the whole turning process, the quantitative analysis of the whole process is carried out.

2. Mathematical model of fuzzy comprehensive evaluation and decision making for multi-vehicle driving

2.1 The evaluation steps of single level integrated multi vehicle mixed formation model [14,15] are as follows

1) The evaluation factor set of multi vehicle mixed formation \( U = \{u_1, u_2, \ldots, u_n\} \). The above formula indicates that there are \( n \) indexes to be evaluated for the evaluated things, and the comprehensive evaluation is made from these indexes.

2) The evaluation set \( V = \{v_1, v_2, \ldots, v_m\} \) of multi vehicle mixed formation is determined. The evaluation set mainly represents the set composed of the evaluation results of the evaluated factors.

3) The factor weight set \( A = \{a_1, a_2, \ldots, a_n\} \) of multi vehicle mixed formation is established.

4) The single factor fuzzy evaluation of multi vehicle mixed formation is carried out and the fuzzy matrix \( R \) is formed:

\[
R = \begin{pmatrix}
    r_{11} & r_{12} & \cdots & r_{1m} \\
    r_{21} & r_{22} & \cdots & r_{2m} \\
    \vdots & \vdots & \ddots & \vdots \\
    r_{n1} & r_{n2} & \cdots & r_{nm}
\end{pmatrix}
\] (1)

According to the basic principle of fuzzy comprehensive evaluation, the model is as follows:

\[
B = A \circ R = (a_1 \ a_2 \ \ldots \ a_n) \circ \begin{pmatrix}
    r_{11} & r_{12} & \cdots & r_{1m} \\
    r_{21} & r_{22} & \cdots & r_{2m} \\
    \vdots & \vdots & \ddots & \vdots \\
    r_{n1} & r_{n2} & \cdots & r_{nm}
\end{pmatrix} = (b_1 \ b_2 \ \ldots \ b_m)
\] (2)

The membership degree of the fuzzy subset of \( v_j \) grade is represented by \( b_j(j=1,2,\ldots, m) \), which is determined by the j-th column of \( A \) and \( R \).

The comprehensive evaluation of multi vehicle mixed formation is to calculate \( B = A \circ R \) for weight \( A = (a_1 \ a_2 \ \ldots \ a_n) \), and make a comprehensive evaluation of multi vehicle mixed formation according to the principle of maximum membership degree. Finally, according to the principle of maximum membership, the corresponding evaluation can be obtained. In the process of merging the multi vehicle mixed formation, the vehicles move according to the fixed track.
3. Process of controlling vehicles in multi vehicle mixed formation

By calculating the time of vehicles passing through the intersection, the merging time of multi vehicle mixed formation is judged, i.e. whether it is necessary to merge [16,17]. When the multi vehicle mixed formation team arrives at the intersection time longer than the vehicle arrival time, of course, there is no merging process, and the multi vehicle mixed formation vehicle still uses its own settings for driving. Moreover, there are no other changes to the fleet of multi vehicle mixed formation; when the arrival time of vehicles in multi vehicle mixed formation is longer than the passing time of the team, the combination of vehicle rescue and multi vehicle mixed formation is successful, and there is no speed adjustment for each vehicle. The most important thing is that the fleet has not passed completely, and the queue jumping vehicles of multi vehicle mixed formation have reached the intersection, which is the existence of multi vehicle mixing Formation of vehicle control issues. The problem of which vehicle in the multi vehicle mixed formation should slow down, stop moving, or reverse to maintain a safe distance that can be inserted into the vehicle is handled by the model control of the multi vehicle mixed formation. Flow chart of control vehicle for multi vehicle mixed formation:

![Flow chart of control vehicle for multi vehicle mixed formation](image)

**Figure 1.** Control vehicle flow of multi vehicle mixed formation.

4. Experimental result

For the vehicle control of multi vehicle mixed formation, the main solution is that the vehicle will be inserted between the two vehicles, and how the speed of the vehicle behind needs to change. When the vehicle reaches the intersection, the second vehicle just wants to pass through the intersection. At this time, it is necessary to control the speed of the second vehicle and the speed of the third vehicle. Slow down or stop to ensure that the vehicle can be safely inserted into the team. When the vehicle reaches the intersection, the second vehicle just passes through the intersection, so it is necessary to control the speed of the third vehicle, so as to leave a safe distance to ensure the safety of the team. When the two vehicles in the mixed formation are in accordance with the principle of the current fleet, they first pass through the vehicles in the fleet, and then complete the task of team formation after the vehicles pass. Four experiments have been carried out, and the calculated distribution of B value is shown in Fig. 2.
5. Conclusions

The auxiliary system and automatic driving system of vehicle driving are becoming more and more complete. In the near future, the driverless driving will be the trend of vehicle driving, and the study of vehicle automatic driving is very promising. In this paper, a branch of fuzzy decision making is applied to the fuzzy comprehensive evaluation decision making model. The details of the automatic driving system of the multi vehicle mixed formation are analyzed through the process of merging multiple vehicles.

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