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Variable-weight Multi-target Adaptive Cruise Control Strategy based on Naive Bayes Algorithm

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Abstract: Multi object adaptive cruise control system is a new type of assistant driving system, which can reduce the occurrence of traffic accidents and ensure the safety rate of people and vehicles during driving. This paper summarizes the concept of Naive Bayes algorithm and control system, proposes an improved Naive Bayes classification algorithm and adaptive cruise system strategy, analyzes the constant speed cruise mode, and conducts experiments on the classification effect of the improved Naive Bayes classification algorithm. The results show that, in contrast, only one attribute satisfies the condition.

1. Introduction

With the continuous development of data acquisition technology, all kinds of information are accumulating at an unprecedented rate. Efficient analysis of large amounts of data has become a common requirement in all fields [1].

With the continuous progress of science and technology, many experts have studied variable weight multi-objective adaptive cruise control. For example, Xu X, Yang R, Fu Y proposed a hierarchical control structure, which is divided into upper controller and lower controller. Future lane changing behavior of vehicles in front of self owned vehicles predicted according to Gaussian Naive Bayes algorithm, [2]. Martinez Penaloza M G, Mezura Montes E experts proposed an efficient and reliable heuristic method, which uses particle swarm optimization algorithm and adaptive random inertia weight (ARIW) strategy to establish a multi-objective optimization model for reservoir operation [3]. In addition, Kai, Liu and Liang designed multiple ACC modes by slightly adjusting the control objectives and system inputs, constraint boundaries and relaxed weights [4]. Although the research results are abundant, there are still some deficiencies in the research of variable weight multi-objective adaptive cruise control strategy based on naive Bayesian algorithm.

In order to study the variable weight multi-objective adaptive cruise control strategy based on naive bayesian algorithm, naive bayesian algorithm and multi-objective adaptive control strategy are studied, and the probability theory of bayesian classification algorithm is established. The results show that the naive Bayesian algorithm is beneficial to the realization of variable weight multi-objective adaptive cruise control strategy.

2. Method

2.1. Naive Bayesian Algorithm

(1) Concept of Naive Bayesian Algorithm

The higher the performance of naive Bayesian algorithm [5]. The accuracy of classification is an indicator of classifier performance. The higher the classification accuracy is, the higher the probability of Naive Bayes algorithm to correctly judge the attributes of classified sample data is. Naive Bayes algorithm is a heuristic search algorithm. Although the naive Bayesian algorithm is also an iterative method, it is different from the common search method [6]. On the contrary, the lower the classification accuracy, the lower the probability of correct judgment and classification of sample data attributes, that is, the lower the performance of naive Bayesian algorithm. Contrary to the prior probability, after such events occur many times, the probability obtained by combining the prior probability and sample data is a posterior probability [7]. In fact, both a priori probability and a posteriori probability estimate the probability of the target event, but the estimation of the prior probability is very rough. The posterior probability combines the prior probability and the probability obtained from the sample data, so it is closer to the true probability.

(2) Improved naive bayesian classification algorithm

In fact, the improved naive Bayesian classification algorithm is a huge and diverse potential information resource, which is considered as the key source of value creation [8]. This is a process of scientific evolution. Big data is based on the coexistence of ontology and structural theory, so it is advanced. Existence indirectly indicates the existence of an object, but it cannot specifically construct the required object. In terms of dimension understanding, it is necessary to study the thinking mode of combining dimension improvement and dimension reduction. Dimension improvement means that when thinking about big data issues initially, it is a gradual dimension improvement process to think about issues as comprehensively, in as many quantities, across scopes and other dimensions as possible. However, at the same time, in the actual processing and analysis of big data problems and in the process of further scientific research, a dimension reduction operation path is required [9]. The construction theory refers to the specific construction of the required objects. The combination of the two can produce the required big data. It not only exists and can be obtained, but also is limited, that is, it exists and can be obtained under certain constraints. The data left with limiting factors and a certain period of time cannot be called big data. It is invalid data and cannot be used for analysis and research. In terms of data collection, the Internet era not only makes it easy to obtain the static data of the entire sample, but also improves the availability of large, continuous, fast and continuous stream data [10].

2.2. Variable Weight multi-objective Adaptive Cruise Control Strategy

(1) Control system

The feature is selected by the control system and then used for the classification of subsequent classifiers, which may cause the feature subset selected by the filtering method may not be coupled with the classifier used to affect the classification effect. The packing method combines the subsequent classifiers to search and learn, which makes the selected feature subset more coupled with the classifier, thus improving the classification accuracy. However, there are also some problems in the control system [11]. For example, when the control system searches, it needs to classify each selected feature and evaluate the feature after obtaining the accuracy, which makes the control system have high computational complexity, especially when the feature subset is particularly large, the efficiency of the control system is very low. In view of the problems existing in the control system, before selecting the feature subset, the control system is statistically analyzed to preprocess it. Therefore, the dimension of the feature space is reduced and the computational complexity of the search control system is reduced [12].

(2) Cruise control mode

When the driver presets the constant cruising speed of the vehicle, the integral coefficient is used to eliminate the accumulated error of the system in the control process. The constant speed cruise mode decision-making algorithm will calculate the corresponding expected acceleration according to the actual driving speed of the vehicle measured by the on-board speed sensor. In the PID control system, it is output to the control layer, tracking the expected acceleration according to the actual acceleration of the vehicle, and the proportional link reflects the basic deviation of the control system [13]. Large scale factor can improve the response speed of the system. However, if the scale factor is too large, the vehicle can cruise at a constant speed set by the driver. It may cause overshoot and reduce the stability of the system; It can improve the accuracy of the system; The differential link can reflect the future trend of the deviation signal. However, by adding a correction signal in advance, the differential link can play a role in amplifying the interference signal [14].

(3) Adaptive cruise system strategy

If the distance between the vehicle and the target vehicle in front is too large, although it will reduce the possibility of collision with the target vehicle in front, it will also reduce the driver's psychological pressure, but it will lead to frequent entry and exit of vehicles in the side lane, which will affect the stability and safety of the vehicle in the lane [15]. If the relative workshop distance is short, the driver's psychological pressure will increase, and the possibility of collision with the vehicle in front will increase. Based on the above analysis, a reasonable spacing strategy can not only ensure the safety of the vehicle when following the target vehicle in front, but also improve the road traffic efficiency and the driver's acceptance of the adaptive cruise system. Fuzzy control and neural network control algorithms are very suitable for solving nonlinear systems. Their self-learning characteristics can better simulate the driving styles of different drivers, so they are widely used in adaptive cruise systems. Direct control determines the control quantity of accelerator and brake directly according to the environmental information and driving data of the vehicle [16]. The utility model has the advantages of simple structure and convenient use. However, its robustness is poor when dealing with vehicle parameter changes and complex driving conditions, and it is difficult to achieve optimal control under multiple working conditions. Hierarchical control refers to separating the acquisition of expected acceleration from the realization of expected acceleration, so as to control the accelerator and brake of the vehicle and realize the adaptive cruise function. Hierarchical control can improve the stability of the system and achieve control objectives more accurately. Its modular form can facilitate future debugging and calibration [17].

2.3. Bayesian Classification Algorithm Probability Theory

Suppose A and B are two events and P (B)>0, then Formula (1) [18]:

$$P(A|B) = \frac{P(AB)}{P(B)} \tag{1}$$

P is the conditional probability of event A under the condition that event B occurs. It is also called the posterior probability of A because it is derived from the value of B.

$p(a_i \mid c)$ is the conditional probability. When a_i is a discrete attribute variable, the formula for calculating conditional probability is (2):

$$g(x,\eta,\sigma)=\frac{1}{\sqrt{2\pi\sigma}}e^{-\frac{(x-\eta)^2}{2\sigma^2}} \tag{2}$$

N (c) represents the number of samples of category c, and N represents the total number of data samples.

Calculate the prior probability of each label, and calculate the formula (3) according to the conditional probability:

$$\begin{aligned} theta(i)(j) &= \log(p(a_j \mid y_i)) \\ &= \log(sumTerFreqs(j)+labda)-thetaLogDenom \end{aligned} \tag{3}$$

Calculate the conditional probability theta (i) (j) of each feature in each tag.

3. Experience

3.1. Object Extraction

As a research hotspot in the field of active safety, vehicle longitudinal dynamics control strategy is the basis of ACC system, active collision avoidance system and other advanced driving assistance systems, which is of great significance to the realization of the upper decision-making algorithm and the function of the entire ACC system. Since the model predictive control can coordinate multiple targets at the same time, in order to consider the target tracking ability, safety, fuel economy and passenger comfort of the adaptive cruise system, and consider that if the order of the state equation is too high, the load on the on-board processor is too large, the third-order state space equation is used to establish the predictive model. Establishing a linear constant model, that is, using a simplified linear model, is conducive to the design of control strategies, but will lead to serious model mismatch. At the same time, because the simplified model cannot adapt to the changes of vehicle parameters and external traffic environment, the system robustness will also be affected, and it is difficult to achieve effective control of the controlled object in the complex driving environment. At the same time, because the vehicle is a complex nonlinear system, its own parameters and changes in the external environment will have a great impact on it. In order to avoid the long control chain, the lower control strategy of ACC system should be designed according to the vehicle's inverse longitudinal dynamics model before designing the upper decision-making algorithm.

3.2. Experimental Analysis

First, there are two methods to determine the performance indicators of the flight control system: one is to select the performance indicators that meet the requirements of the first class flight quality according to the requirements of GJB001-002; the second is the performance index of the flight control system given by the user. In this paper, the performance index of the flight control system is determined by the way given by the user. After the performance indicators are determined, they will be allocated. At present, the project is mainly based on static control law. According to experience, the performance indicators of the flight control system are allocated to each component, and the performance parameters of each component are determined. Then, design each component. The designed components are reconnected with the controller, and the control law is modified to obtain the design model of the flight control system.

4. Discussion

4.1. Effect of Performance Parameters of Command Sensor on Performance Indexes of Flight Control System

The damping ratio of the command sensor, the performance parameters of the actuator and the attitude sensor are fixed values. The natural frequency of the command sensor varies within its decision range. Analyze the influence of the natural frequency of the command sensor on the bandwidth of the flight control system, as shown in Table 1.

Table 1. Relationship between natural frequency of command sensor and bandwidth of flight control system

Command sensor natural frequency(%)	System width(mm)
20	9.03
30	9.34
40	9.45
50	9.56

It can be seen from the above that when the natural frequency of the command sensor is 20%, the system width is 9.03mm; When the natural frequency of the command sensor is 30%, the system width is 9.34mm; When the natural frequency of the command sensor is 40%, the system width is 9.45mm; When the natural frequency of the command sensor is 50%, the system width is 9.56mm; The specific results are shown in Figure 1.

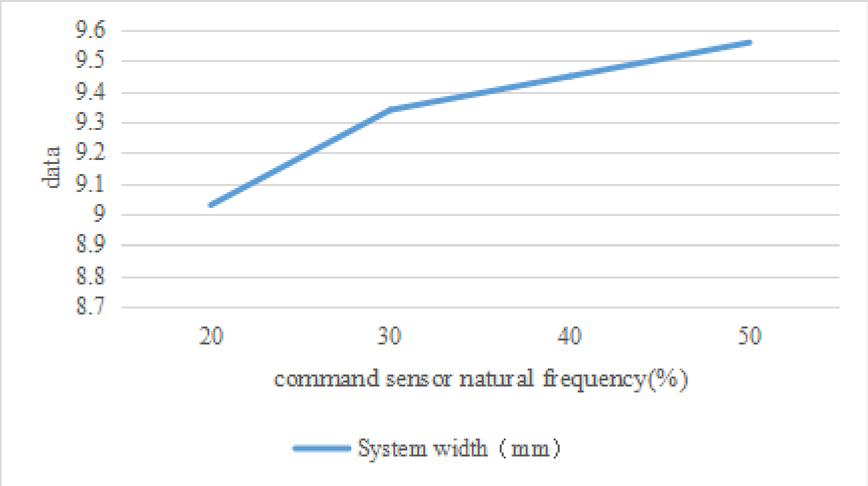

Figure 1. Relationship between natural frequency of command sensor and bandwidth of flight control system

It can be seen from the above figure that with the increase of the natural frequency of the command sensor, the bandwidth of the flight control system is generally on the rise, but the increase is large at the initial stage.

4.2. Experimental Verification

In order to verify the classification effect of the improved Naive Bayes algorithm, this paper selects three data sets from UCIR, and focuses on the binary classification problem. The number of decision attributes for the selected dataset is 0. All experiments were completed by weka version 3.8.1 platform. The experiment of the improved naive Bayesian algorithm is shown in Table 2, which shows the relevant information of the dataset used in the experiment.

Table 2. Data set representation

Data set	Number of samples	Iv index threshold
A	32	0.12
B	12	0.21
C	22	0.11

It can be seen from the above that the number of samples in data set A is 32 and index IV is 0.12; The number of samples in data set B is 12, and index IV is 0.21; The number of samples in the C data set is 22, and the IV index is 0.11. The specific results are shown in Figure 2.

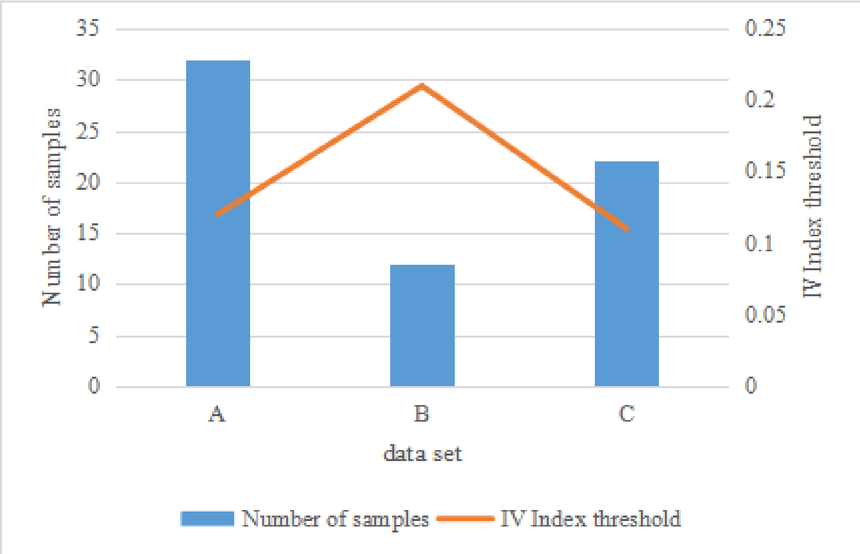

Figure 2. Data set representation

The number of attribute subsets and classification accuracy of ABC under different thresholds are compared. Referring to the description of IV index, two thresholds of 0.02 and 0.12 were selected for the experiment. It can be seen that setting the IV indicator threshold to 0.01 can select a better attribute subset, which makes the ABC classification performance better.

4.3. Simulation Verification

Step signal and sine signal are selected as the input values of the lower controller. At the initial time of simulation, the vehicle speed is set to 1km/h and the initial acceleration is 10m/s2. In the first second, the expected acceleration is reduced to 2m/s2. Until the second second, the expected acceleration becomes 3m/s2 again. At the tenth second, the expected speed is accelerated to 20m/s2 until the simulation is completed. The simulation results are shown in Table 3.

Table 3. Simulation verification of acceleration, speed, throttle opening and brake pressure

Type	Time(s)
Acceleration	1
Speed	2
Throttle opening	6
Brake pressure	10

It can be seen from Table 3 that the actual acceleration can quickly track the expected acceleration, and the error is within a certain allowable range; The ordinate of Figure 3 is the throttle opening, which is a numerical parameter. It can be seen that the throttle system responds quickly with a small amount of overshoot and relatively small amplitude. The vehicle is relatively stable in the acceleration phase without obvious fluctuation; It can be seen that the brake pressure is always zero, indicating that the control mode is always in the throttle control state.

5. Conclusion

Because the closed-loop system composed of components is a high-order link, it is difficult to derive explicit mathematical expressions of cruise control system performance indicators and component performance parameters. Even if the expression is too complex, it is difficult to have practical application value for engineering design. Therefore, this paper studies the influence of command sensor performance parameters on flight control system performance. The results show that, with the increase of the natural frequency of the command sensor, the bandwidth of the flight control system generally shows an upward trend, but increases greatly in the initial stage.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

Reference

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