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Online Prediction with Variable Horizon for Vehicle's Future Driving-Cycle

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Abstract

With traditional driving cycle predictive model, the state point in vehicle-acceleration projection plane couldn't cover the real driving state completely. And date-missing caused by this lead to interruption of the prediction process. So in this paper, a real-time prediction model with variable horizon is proposed to solve the problem. Real driving data is used to reconstruct the driving cycle and the accuracy of the real time prediction model could be estimated based on historical information. By using principal component analysis and cluster analysis, an online prediction model with variable horizon based on Marco Chain is established. The correctness of this method is verified by experiment of Hardware-in-loop simulation. And the result shows that the accuracy of variable time prediction model is 8.203km/h, which has been improved by 20% comparing with fixed time prediction model.

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Keywords: Model predictive control; vehicle-acceleration projection plane, variable time, Cluster analysis, Principal component, Marko Chain

1. Introduction

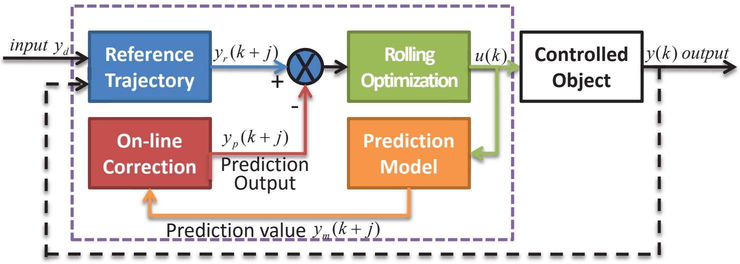

Fig. 1. Model Prediction Control

Online prediction for hybrid electric vehicle's driving-cycle is essential for optimizing the energy management strategy and achieving real-time control[1]. Existing online prediction method is mainly

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based on real-time traffic information[2] or historical driving information[3]. Relying on intelligent traffic which is not advanced enough, the first way is of low feasibility. Thus, the way based on historical driving information is widely used.

As shown in figure 1, model prediction control consists of four main parts[4] and online prediction is the core one[5]. The predicted driving-cycle is taken as target driving-cycle of optimizing control. So the accuracy of predicted driving-cycle has a great influence on the final control effect. Several model including Marco, Neural Network and Support-Vector-Machine could be adopted for online prediction.

2. Solution to state-loss

Based on historical data of driving cycle, traditional real-time prediction is of fixed horizon[6] and works by the state space and transfer matrix of these data. Due to the limited amount of data, as velocity-acceleration state space is divided into smaller pieces, state-loss will occur as figure1 shows.[6]

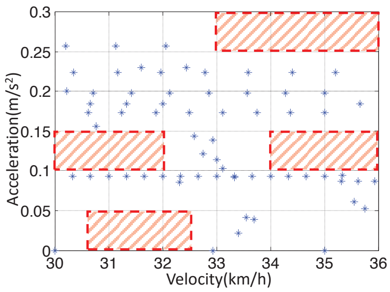

Fig. 2. (a) Data-loss

When the vehicle runs in the real environment, the results of model predictive control may be influenced by many factors, so the vehicle's data will appear in any area of the vehicle-acceleration projection plane, which will lead to data-loss in the Marko transfer matrix. So, the process of model predictive control will be interrupted.

The solution includes the following two parts.

(1)On-line reconstruction of driving cycle

State of real driving condition is added into the driving cycle to achieve the online reconstruction, so the Marko transfer matrix could express the process of vehicle state transition. In other words, new driving cycle is built by information of original and real driving cycle, and the two parts of the data each accounted for 50%. The data is being updating once per second.

(2)State-fill

When state-loss occurs, state point in vehicle-acceleration projection plane which is the closest to real driving condition will be added into where there is no state point for prediction, so that the prediction process could continue. This is an approximate method which will reduce the accuracy of model predictive control. The following formula is used to find the approximate data.

$$d\left(P_i, P_k\right) = \min\left\{d\left(P_i, P_j\right)\right\}\left(j = 1, 2, \cdots, n\right) \quad (1)$$

By combining the two methods, we could achieve the purpose of on-line reconstruction and ensure the prediction will be carried out continuously without data-loss.

3. Estimate method of predictive accuracy