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Feedback control method in lattice hydrodynamic model under honk environment

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HIGHLIGHTS

- A lattice model with feedback control method is proposed under honk environment.
- Linear stability analysis is deduced with control theory.
- Early time effect is investigated with feedback control.
- Long-time effect is studied with feedback gain.

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ABSTRACT

A feedback control sign is inserted into traffic system based on lattice hydrodynamic model of traffic flow under honk environment which impacts on traffic flux. The control theory is applied to get the linear stability condition. Moreover, numerical simulation is carried out to investigate the honk effect which plays important role on traffic flow. The result shows that the feedback gain resulted from honk effect can stabilize the traffic flow and suppress the traffic jam efficiently.

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1. Introduction

In recent years, traffic modeling, which has attracted considerable attention of many scholars, is very vigorous to solve the traffic problem. To solve the traffic congestion, there occur a variety of traffic models such as car-following models, cellular automation models, lattice hydrodynamic models, and coupled map models etc. [1–21]. With the rapid increase of traffic flux, traffic environment is deteriorating more and more. Under congested traffic situation for the anxious running drivers in some countries such as China, the honk phenomenon often occurs. Usually, the leading vehicle will accelerate or change lane according to his own traffic situation when the drivers of the leading car hear the honk. In view of this phenomenon, the honk effect has been studied in cellular automaton model on two-lane freeway [22], car-following models and macro traffic model [23–26]. The results showed that the honk effects can improve the stability of traffic flow. Recently, Peng et al. [27] thought over the honk effect on the local velocity in lattice model. In fact, the honk can be taken as a control signal for the preceding driver to adjust his/her velocity. Recently, control theory [28–36] has been introduced into traffic flow. On the basis of the coupled-map (CM) car-following model [7–9], a decentralized delayed-feedback control in KKH model [28] was proposed. Subsequently, some control methods resulted from the velocity difference [29,30] were brought

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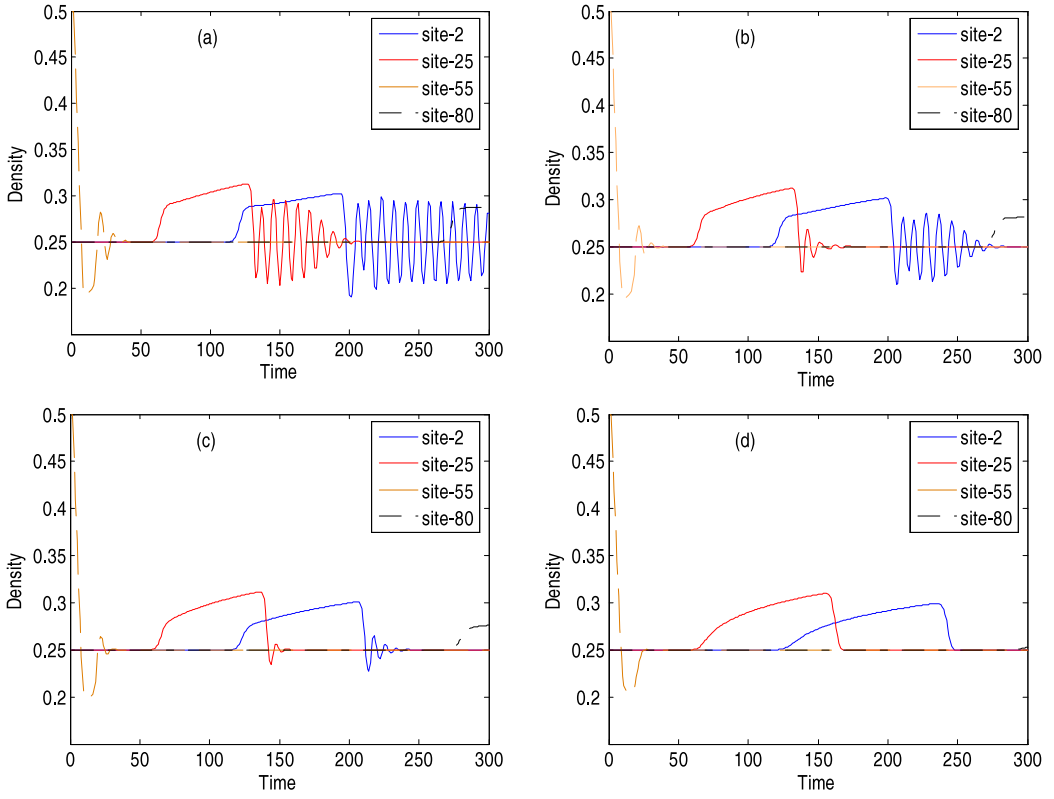

Fig. 1. Temporal density behavior of four sites between time 1–300 s for (a) $\frac{\mu}{\tau'} = 0$, (b) $\frac{\mu}{\tau'} = 0.1$, (c) $\frac{\mu}{\tau'} = 0.2$, and (d) $\frac{\mu}{\tau'} = 0.6$, respectively.

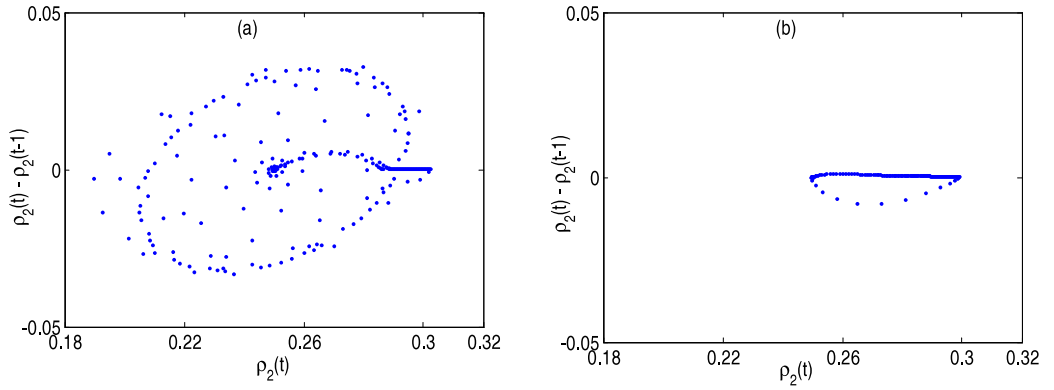

Fig. 2. Scatter plot at site-2 between time $t = 1$–500 s for (a) $\frac{\mu}{\tau'} = 0$, and (b) $\frac{\mu}{\tau'} = 0.6$, respectively.

forward. Moreover, control theory [31–33] was taken into car-following model to suppress traffic jam. Very recently, the control theory [34–36] was further applied into lattice hydrodynamic model by some scholars. However, the honk effect on the traffic flux has not been investigated in lattice hydrodynamic model. Therefore, based on the lattice hydrodynamic model, we will put forward a new control method which comes from the honk influence on the traffic flux in the following sections. Subsequently, we apply control theory to get the linear stability with control signal in successive section. Numerical simulations will validate the influence of the control signal on the traffic flow in consecutive section. Finally, the conclusions will be drawn.

2. Lattice hydrodynamic model with control signal

In 1998, Nagatani [20,21] firstly put forward a lattice hydrodynamic model described by

$$\partial_t \rho_j + \rho_0(q_j - q_{j-1}) = 0 \tag{1}$$

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