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Honk effect in the two-lane cellular automaton model for traffic flow

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Abstract

In real traffic, when a vehicle is hindered by its preceding vehicle and simultaneously it cannot change lane, it may honk the horn. As a result, the driver of the preceding vehicle may change lane to make way for it. However, this effect has seldom been investigated before. In this paper, we take this issue into account by proposing a new symmetric two-lane cellular automaton model. It is shown that the honk has almost no effect in the homogeneous traffic whereas it enhances the flux in the intermediate density regime for the heterogeneous traffic. We suggest that this is because the occurrence probability and the lifetime of the plug are suppressed due to the introduction of the honk. Finally, we argue that the honk behavior is not encouraged in the asymmetric two-lane model.

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1. Introduction

Since the earlier research in 1950s, the vehicle traffic has attracted a community of scientists [1]. A number of traffic models had been introduced. Traditionally, there

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are two different conceptual frameworks for modelling traffic, macroscopic and microscopic models. In the macroscopic model, the traffic is viewed as a compressible fluid, while in the microscopic models attention is explicitly focused on individual vehicles. In the early 1990s, the rapid development of computer capacity allowed a type of relatively new microscopic traffic flow models, i.e., cellular automata (CA) models to display its high practical importance.

In 1992, Nagel and Schreckenberg proposed the well-known Nagel–Schreckenberg (NS) model [2]. Although it is very simple, the NS model can reproduce some real traffic phenomena, such as the occurrence of phantom traffic jams. Later, various generalizations and extensions of the NS model are proposed, such as the Fukui–Ishibashi (FI) model, TT model, VDR model, etc. [3–7].

The single-lane model is not capable of modelling realistic traffic mainly for one reason: a realistic fleet is usually composed of vehicles having different desired velocities. Introducing such different kinds of vehicles in the single-lane model only results in platoon with slow vehicles being followed by faster ones and the average velocity reduced to the velocity of the slowest vehicle [8]. In order to model more realistic traffic, multi-lane model comes into one's view. Nagatani examined a two-lane system with completely deterministic rules and $v_{max} = 1$ [9,10], where cars either move forward or change lanes. By introducing a set of lane changing rules, Rickert et al. [11] presented a straightforward extension of the single-lane CA model so that it includes two-lane traffic. In Refs. [12–14], asymmetric lane-changing rules are introduced to the two-lane CA model and density inversion is reported. Considering the anticipation effects, Knospe et al. [15,16] proposed a new realistic two-lane model.

In real vehicle traffic, when a vehicle is hindered by its preceding vehicle and simultaneously it cannot change lane, the driver may honk to urge his preceding vehicle to give him a way. On the other hand, on hearing the honk, a driver will probably change lane to let the following car overtake. Nevertheless, this issue has seldom been studied in the previous researches.

Taking this situation into account, we propose a new CA model by introducing the honk effect into the basic symmetric two-lane CA model. It is found that with the introduction of the honk effect, the probability of plug formation at intermediate density regime is greatly reduced and a larger vehicle flux and lane changing frequency are reported.

The paper is organized as follows. In Section 2, our new model is introduced. In Section 3 the simulation results of the new model and the comparison with the basic model without honk effect are presented in details. The conclusion is given in Section 4.

2. Model

Before going into the details of the lane changing rules, we briefly recall the definition of the NS model. The NS model is a discrete model for traffic flow. The road is divided into cells which can be either empty or occupied by a car with a