COMMUNICATIONS IN COMPUTATIONAL PHYSICS
Vol. 1, No. 3, pp. 494-502

Commun. Comput. Phys.
June 2006

Cellular Automaton Model for Fixed Autoblock System

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Received 4 June 2005; Accepted (in revised version) 27 September 2005

Communicated by Dietrich Stauffer

Abstract. In this work, we propose a kind of cellular automaton model to simulate the railway traffic which is based on NaSch traffic model. The signaling system adopted in this work is the three-aspect fixed autoblock system. We investigate the space-time diagram of traffic flow using our model. The velocities and headways of trains are discussed. The impact of the time interval of trains on train running is also analyzed. Numerical simulation results demonstrate that our cellular automaton model can successfully reproduce some actual railway traffic phenomena.

Key words: Cellular automaton; traffic flow; fixed autoblock system.

1 Introduction

The fixed autoblock system (FAS) has been playing an important role in ensuring train operation safety and improving transport efficiency. In the beginning, two-aspect and three-aspect fixed autoblock systems were very common in railways. Subsequently, European experts proposed the concept of four-aspect, five-aspect and more-aspect FAS to enhance the carrying capacity. With the progress of FAS, the theoretical analysis on FAS has been widely carried out. In order to investigate the performance of FAS, many researchers put forward different models to simulate the train running in FAS. Some professional simulation systems have also been developed [2, 4, 5].

As a simulation tool, a cellular automaton (CA) model has been widely applied to study the traffic flow of highway [1, 3, 8–11]. The advantage of CA model is that it is much simpler and more convenient for computer simulations (it is able to perform several

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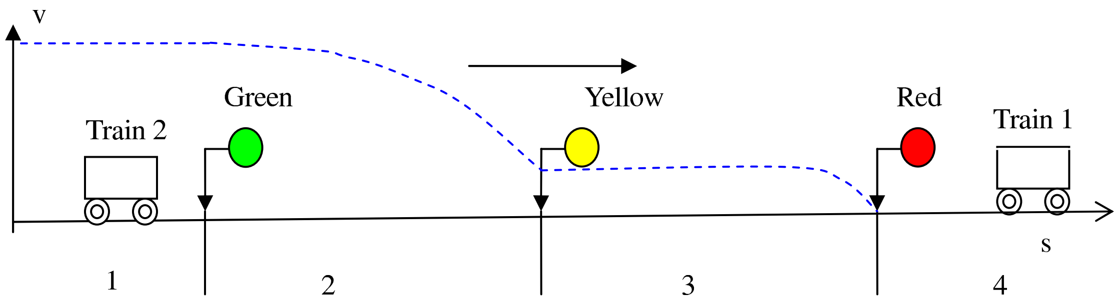

Figure 1: Three-aspect fixed autoblock system.

millions updates in a second [7]). Consequently, we can easily simulate the nonlinear characters in traffic problems using some typical CA models. For example, Wolfram's 184 rules [11], NaSch model [9] and FI model [3]. Recently, K.P. Li et al. proposed a CA model for railway traffic [6]. The signaling system adopted in this model is the moving block system. To our knowledge, this is the first time a CA model has been used to simulate railway traffic using a CA model.

In this paper, we propose another CA railway traffic model based on the NaSch model to simulate the railway traffic. Compared with the CA model proposed by K.P. Li et al., our model adopts the signaling system of FAS. The paper is organized as follows: In Section 2, we introduce the model. In Section 3, the numerical and analytical results are presented. Finally, a conclusion of this approach is presented.

2 The proposed model

2.1 Three-aspect fixed autoblock system

In fixed autoblock systems, the line is divided into blocks by wayside signaling. The length of a block depends on the maximum train speed, the worst-case braking rate and the number of signal aspects which includes a series of additional color displays (or cab indications) used in order to give a driver forewarning of a red signal. Only one train may occupy a block at any time and the presence of a train within a block is usually detected with the use of track circuits. In this study, we investigate a typical three-aspect FAS.

As shown in Fig. 1, the signaling in a three-aspect FAS has three types of colors: red, yellow and green. If the color of signaling in front of a train is green, the train keeps its speed; if yellow, the train slows down; if red, the train must stop before the red signal. The color of signaling changes is based on the trains' positions on the line. For the sake of convenience, we assign to the block k a number, $B(k)=\{1,0\}$, where $B(k)$ is a block state function. If the block k is occupied by a train, the value of $B(k)$ is 1; if the block is empty, $B(k)$ equals to 0. *Flag* (k) denotes the signaling color of block k. The updated rules of signaling color are shown in Table 2.1.