

## Chapter 12

# Comparison of Zipper and Non-Zipper Merging Patterns Near Merging Point of Roads

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### **ABSTRACT**

*At the merging point, vehicles on the main road must reduce their velocity to avoid slow merging vehicles from a branch road, which leads to a traffic jam. Some researchers point out the effectiveness of a zipper merging pattern for improving the traffic near the merging point. In this study, the authors discuss the effectiveness of a zipper merging pattern using cellular automata simulation. Firstly, the single and multiple vehicle following models are defined. The stability analysis of the models then gives the parameters. In the simulation, two merging patterns are compared. In the non-zipper merging pattern, two vehicles merge continuously from a branch road. In the zipper merging pattern, two vehicles merge between main road vehicles. The results show that the zipper merging pattern is more effective than the non-zipper merging pattern for reducing the traffic jam near the merging point.*

DOI: 10.4018/978-1-4666-1574-8.ch012

## 1. INTRODUCTION

We will focus, in this study, on the traffic jam near the merging point of roads. At the merging point, the vehicles on the main road have to reduce their velocity in order to avoid the slow vehicles merging from the branch road, which leads to the traffic jam. Some researchers have pointed out that the zipper merging pattern of the vehicles is effective for improving the traffic jam near the merging point of roads. In the zipper merging, slower vehicles driving along a branch road merge between the faster vehicles driving along a main road.

We would like to discuss two points in this study. The first is to discuss the effectiveness of the zipper merging pattern for improving the traffic jam near the merging point of roads. The second is to enhance the effectiveness of the zipper merging pattern still more by using the multiple vehicles following model. For these purpose, we will use the cellular automata based traffic simulation model.

A driver controls his vehicle according to the information from the nearest vehicle ahead. When the nearest vehicle ahead accelerates (decelerates), the following vehicle also accelerates (decelerates). The vehicle following model, which is very popular mathematical model of traffic flow simulation, is designed according to this situation (Chandler et al., 1958; Nagel & Schreckenberg, 1992; Yukawa et al., 1994; Bando et al., 1995; Fukui & Ishibashi, 1996; Berg & Woods, 1999; Tadaki et al., 2006; Nishi et al., 2008; Wakita et al., 2009). Chandler et al. (1958) have presented the vehicle following model which changes the velocity according to the velocity difference from its nearest vehicle ahead. In this paper, we will show the extension of Chandler model which changes a velocity according to the velocity differences for its three vehicles ahead. While Chandler model is called in this paper as single-vehicle following model (SVF model), the present model is as multiple-vehicles following model

(MVF model). In the simulation, the vehicles are modeled according to SVF and MVF models and then, the traffic flow simulations in the zipper and no-zipper merging patterns are performed.

Traffic simulation models are classified into macro and micro models. In the macro model, the traffic flow is modeled by the differential equation, as flow phenomenon. In the micro model, each vehicle behavior is controlled individually by the program and then, complex phenomenon between the vehicles lead to the traffic flow. Since traffic jam is modeled as the mutual interface among vehicles in this study, the simulation is performed by the cellular automata model which is one of micro models. Traffic flow simulation model based on cellular automata was firstly presented by Wolfram (1994). After that, many researchers have presented similar models (Yukawa et al., 1994; Nishi et al., 2008; Tamaki et al., 2005).

The remaining part of this paper is organized as follows. The vehicle following models and their stability analysis are explained in section 2 and the cellular automata simulation is modeled in section 3. The simulation results are shown in section 4. Finally, the conclusions are summarized in section 5.

## 2. VEHICLE FOLLOWING MODELS AND STABILITY CONDITIONS

### 2.1 Vehicle Following Models

The convoy of vehicles is shown in Figure 1. One of the simple vehicle following model is presented by Chandler (1958) as follows

$$\ddot{x}_n(t + \tau) = k \cdot \{\dot{x}_{n-1}(t) - \dot{x}_n(t)\} \quad (1)$$

where  $x_n(t)$  denotes the position of the vehicle  $n$  at the time  $t$ . Therefore, the function  $x_{n-1}(t)$  denotes the position of the nearest vehicle ahead.

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