개인고속이동 시스템의 차량운행에 대한 제어

Control of the Operational Vehicles for Personal Rapid Transit System

이준호†
Jun-Ho Lee

Key Words : Personal Rapid Transit System(개인고속이동 시스템), Control(제어), Guideway(주선로), Station(역)

ABSTRACT

PRT(Personal Rapid Transit) systems requires very short headways to increase the line capacity and a very reliable vehicle control algorithm for avoidance of the impact between vehicles. In this paper a brake curves (or speed patterns) for PRT system that make it possible the effective vehicle control and a collision avoidance algorithm are introduced. For the simulations and the evaluations of the proposed algorithm a combined simulation platform that consists of Labview Simulation Interface Toolkit and Matlab/Simulink and a specific hardware configuration are employed.

1. INTRODUCTION

The fundamental concept of personal rapid transit(PRT) is defined by the Advanced Transit Association as an automated guideway transit system in which all stations are on bypass, the vehicles are designed for a single individual or small group traveling together by choice on a network of guideways, and the trip is non-stop with no transfers. West Virginia University has employed PRT system in the early 1970's to make connection between city downtown and the university campus. This is the first system implemented in the real world and still in operation without any specific troubles that are related with the system safety.

In this paper we focus on the design of the operational control scheme providing the avoidance of the impact between the vehicles when they are operated in maximum speed, with 1-5 passengers per vehicle and with maintaining very short headways.

The control scheme is divided into two parts: one is for the simulations and the other is for the implementation and evaluation of the designed vehicle control algorithm. For simulations a simulation platform which combines Matlab/simulink and Labview Simulation Interface Toolkit is introduced. A configuration that consists of the central control module, the virtual control module, the GUI(Graphic User Interface) and monitoring devices is presented. The central control module collects the status information of all vehicles and provides a control command for each vehicle. The virtual vehicle sends its status information to the central control module periodically and receives a control command from the central control module to calculate the brake curves (speed patterns). GUI and monitoring device displays the status of the all vehicles by the graphical methods based on the information transmitted from the central control module.

First we presents the quadratic equation to produce the brake curve for the vehicle and then show the vehicle control system running on the simulation platform which combines Labview Simulation Interface Toolkit and Matlab/Simulink. Finally we show the configuration of the experimental set up to evaluate

† 교신저자; 한국철도기술연구원
E-mail : jhlee77@krri.re.kr
Tel : (031) 460-5040, Fax : (031) 460-5449

the simulated control algorithm.

2. Quadratic Equation

A speed pattern or a brake curve of a vehicle in the PRT system can be expressed such as:

$$v_B = \sqrt{2a(D_b - d_{bp}) + v_{cf}^2} \quad (1)$$

Equation (1) means that if there are the information for the final speed to be reached (v_{cf}), the instantaneous vehicle position (d_{bp}), the block distance or the brick wall safety distance (D_b), and the deceleration (a), then it is easy to calculate the vehicle speed (v_B). In reality the vehicle speed v_B is a function of time and the speed versus time indicates the vehicle speed pattern or the vehicle brake curve. Eq. (1) does not include the term considering the delay time to recognize the brake activation of the vehicle in front. Eq. (1) is modified by including the delay time as follows:

$$v_B = \sqrt{2a(D_b - d_{Bp} - v_B t_{br}) + v_{cf}^2} \quad (2)$$

where t_{br} is the delay time to recognize the brake reaction of the vehicle in front.

3. Test Algorithms

Two different test algorithms are presented. One is for a normal mode and the other is for an emergency mode. The normal mode has fourteen different speed transitions in 3km guideways as shown in Table 1. The vehicles in normal mode has a constant distance and speed between vehicles. On the contrary in the emergency mode once the vehicle in front activates its emergency brake due to some reasons, the vehicle in rear should activate its emergency brake to avoid the impact between the vehicles. Fig. 1 shows the task flow of the emergency mode.

4. Simulations

A simulation platform that combines Matlab/simulink and Laview simulation interface toolkit is employed. Fig. 2 present the Matlab/simulink model that provides the speed patterns for the vehicles and Fig. 3 show the Labview front panel that displays the vehicle speed and parameter set blocks. Fig. 4 and Fig. 5 are simulation results for the normal mode and for the emergency mode. Both simulation results show that the vehicles are controlled well based on the test scenarios, especially in the emergency mode the vehicle in rear provides good speed pattern to avoid the impact against the vehicle in front.

Table 1. Speed transitions

Speed Transition	Track No.	Distance/Step	Total Distance	Acc/Cont/Dec	Initial Speed	Final Speed
1	1-5	100m		Acc	0km/h	40km/h
2	6-13	160m	260m	Cont	40km/h	40km/h
3	14-20	140m	400m	Dec	40km/h	30km/h
4	21-38	360m	760m	Cont	30km/h	30km/h
5	39-50	240m	1000m	Acc	30km/h	60km/h
6	51-75	500m	1500m	Cont	60km/h	60km/h
7	76-80	100m	1600m	Dec	60km/h	40km/h
8	81-88	160m	1760m	Cont	40km/h	40km/h
9	89-95	140m	1900m	Dec	40km/h	30km/h
10	96-113	360m	2260m	Cont	30km/h	30km/h
11	114-125	240m	2500m	Acc	30km/h	60km/h
12	126-135	200m	2700m	Cont	60km/h	60km/h
13	135-145	200m	2900m	Dec	60km/h	30km/h
14	146-150	100m	3000m	Stop	30km/h	0km/h

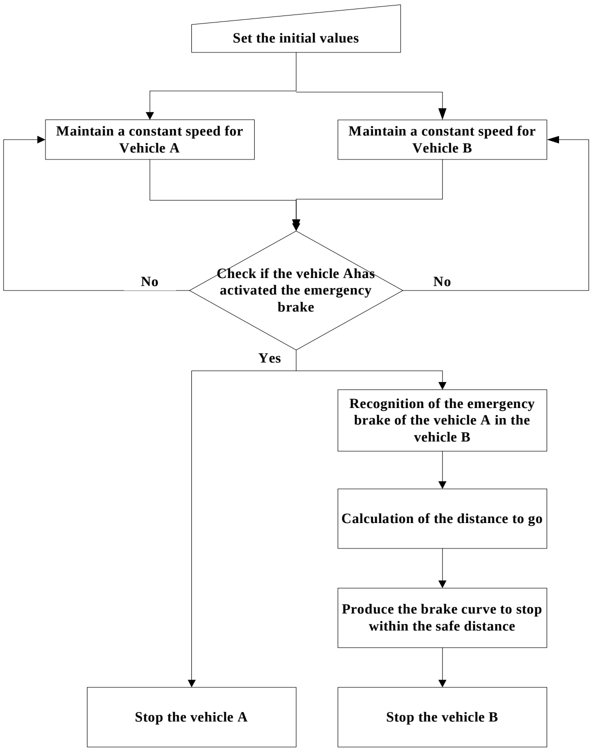

Fig 1. Task flow for the emergency mode

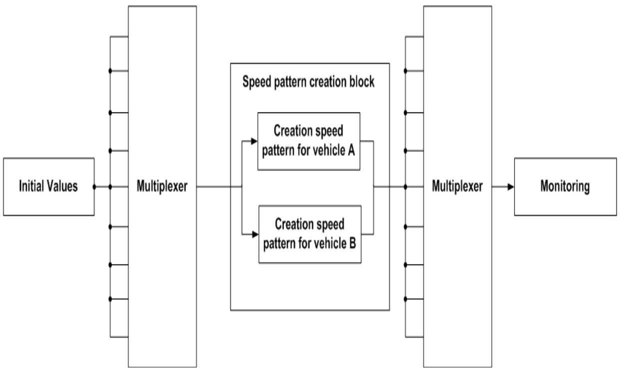

Fig. 2 simulink model

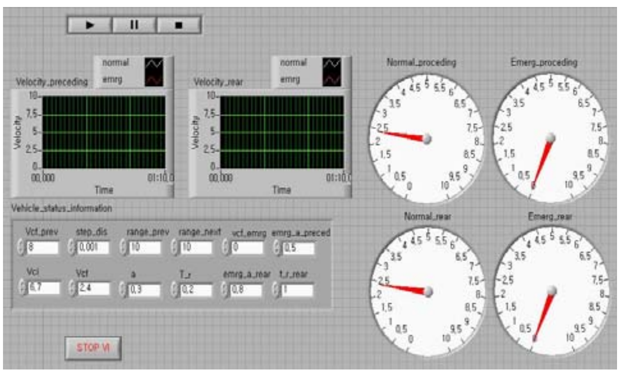

Fig. 3 Labview front panel

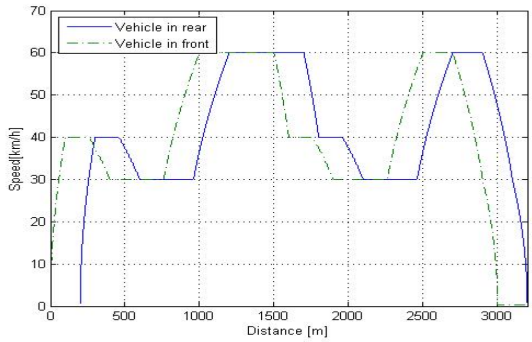

Fig. 4 Simulation results for the normal mode

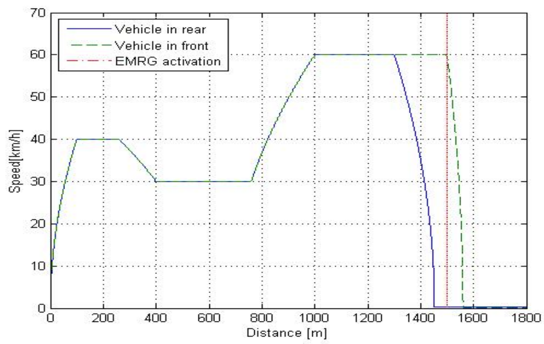

Fig. 5 Simulation results for the emergency mode

5. Hardware Configuration

Fig. 6 represents the configuration of the apparatus to evaluate the designed vehicle operational control algorithm. As seen in the figure the apparatus consists of the central control module, the virtual vehicle module, GUI and monitoring device. They are connected by the TCP/IP communication protocol using Ethernet communication port.

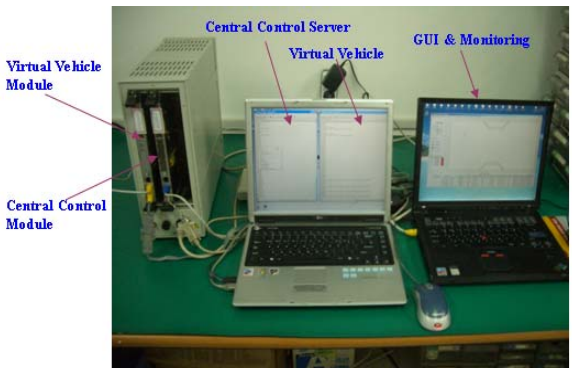

Fig. 6 Hardware configuration

Fig. 7 and Fig. 8 show the results of the emergency mode that are calculated on the proposed hardware configuration. Fig 7 is very similar to Fig. 4 of the simulation results for the normal mode, which means that the proposed apparatus is effective to evaluate the designed vehicle control algorithm. On the contrary Fig. 8 represents the calculation results of the emergency mode. Those two cases of Fig. 8 indicate that no matter where the vehicle in rear recognizes the activation of the emergency brake of the vehicle in front the vehicle in rear can provide the proper speed pattern to avoid the collision between two vehicles.

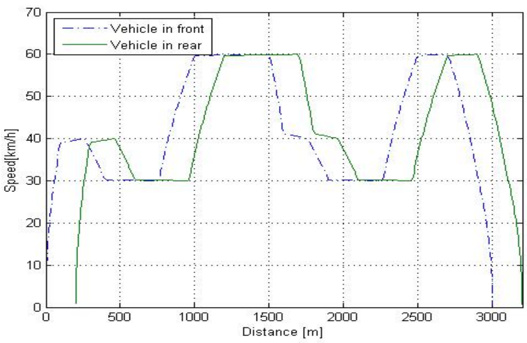

Fig. 7 Calculation results for the normal mode

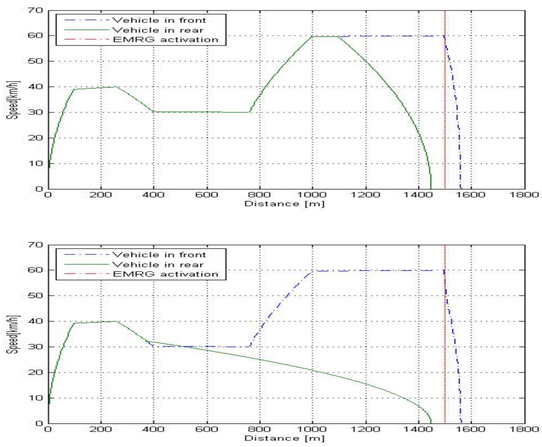

Fig. 8 Calculation results for the emergency mode

6. Conclusions

First in this paper we have introduced the test algorithm to control a vehicle on a the giuuideway of 3[km] km in length. The test algorithm is composed of the normal mode that has fourteen speed transitions and the emergency modeto test the impact avoidance algorithm between vehicles. Brake curves for the speed transitions were provided by the virtual vehicle module that receives the vehicle control information from the central control module.

Second we have showed the simulation platform for the development of the PRT operational control algorithm and the hardware configuration for the assessment of the designed operational control algorithm.

Finally, The processor that has been employed by the central control module and the virtual vehicle module is the commercial processor and there is the merit that it can be applied to the real system to control the real vehicle with the minor changes for the implementation of the control algorithm developed by using the proposed apparatus in this paper.

참 고 문 헌

[1]. Ollie Mikosza, Wayne D. Cottrell, "MISTER and other New-Generation Personal Rapid Transit Technology", *Transportation Research Board, 2007*

[2]. Jun-Ho Lee, Ducko Shin, Yong-Kyu Kim, "A Study on the Headway of the Personal Rapid Transit System", *Journal of the Korean Society for the Railway, Vol. 8, No. 6, pp. 586-591, 2005.*

[3]. Jun-Ho Lee, Kyung-Ho Shin, Jea-Ho Lee, Yong-Kyu Kim, "A Study on the Construction of a Control System for the Evaluation of the Speed Tracking Performance of the Personal Rapid Transit System", *Journal of the Korean Society for the Railway, Vol. 9, No. 4, pp. 449-454, 2006.*

[4]. Markus Theodor Szillat, "A Low-level PRT Microsimulation", *Ph. D. dissertation, University of Bristol, April 2001.*

[5]. Duncan Mackinnon, "High Capacity Personal Rapid Transit System Developments", *IEEE Transactions on Vehicular Technology, Vol. VT-24, No. 1, pp. 8-14, 1975*

[6]. J.E. Anderson, "Control of Personal Rapid Transit", *Telektronikk 1, 2003*

[7]. Bih-Yuan Ku, Jyh-Shing R. Jang, Shang-Lin Ho, "A modulized Train Performance Simulator for Rapid Transit DC Analysis", *Proceedings of the 2000 ASME/IEE Joint Railroad Conference, pp. 213-219, April, 2000.*