

SAFETY EVALUATION OF ON-STREET PARKING SCHEME USING VIRTUAL REALITY TRAFFIC EXPERIMENT SYSTEM

**Shinji TANAKA^{1*}, Masao KUWAHARA², Yoshihiro SUDA²,
Ken HONDA², Tomoyoshi SHIRAISHI², Masaaki ONUKI², Makoto KANO²**

1. Institute of Industrial Science, University of Tokyo, Japan

2. Center for Collaborative Research, University of Tokyo, Japan

4-6-1 Komaba, Meguro-ku, Tokyo, JAPAN

TEL:+81-3-5452-6565, FAX +81-3-5452-6800,

E-mail: stanaka@iis.u-tokyo.ac.jp

ABSTRACT

A well-ordered on-street parking scheme in a city is highly desired to support urban social activities. This research studies the feasibility of making on-street parking space on surface streets in an aspect of safety by examining driving behavior around on-street parking. For this safety evaluation, the virtual reality traffic experiment system is updated and used to conduct testee experiments by reproducing several patterns of on-street parking spaces. The result is analyzed by the recorded testees' vehicles behavior data and the questionnaire answers.

KEYWORDS

on-street parking, safety evaluation, driving simulator

INTRODUCTION

In Japan, parking has been regarded to be treated off street and basically prohibited to park on urban streets because it can cause heavy traffic congestions and sometimes traffic accidents in a city. However, urban business and commercial activities depend on on-street parking greatly, therefore to admit the role of on-street parking and to make parking space on street will be highly desired.

In order to allow on-street parking on surface streets, it is quite important to ensure traffic capacity as well as safety between parked vehicles and passing vehicles. In this study, the authors focus on examining the safety aspect of on-street parking space through passing vehicle's driving behavior using virtual reality traffic experiment system, which is an integrated system of driving simulator and microscopic traffic simulator.

PROPOSED ON-STREET PARKING SCHEME

As for traffic congestion in urban area, the bottleneck is almost always at a signalized intersection, because limited amount of green time has to be allocated among different directions of traffic. Therefore, on-street parking around an intersection which reduces the road capacity significantly should be strictly controlled. In other words, there is a possibility to allow parking at a straight section between intersections. According to this idea, the authors propose to make on-street parking space between intersections as shown in Figure 1.

This on-street parking scheme is designed inside road space, therefore before entering this section, the width for passing vehicles has to be narrowed, which may sometimes cause dangerous situations. However in the current situation in Japan, there are a lot of disordered illegal parking vehicles almost everywhere including near intersections, this concentrated parking could be better solution. Anyway, to implement this kind of parking scheme, it is necessary to examine the safety of vehicles' behavior around this parking section like merging, lane changing etc.

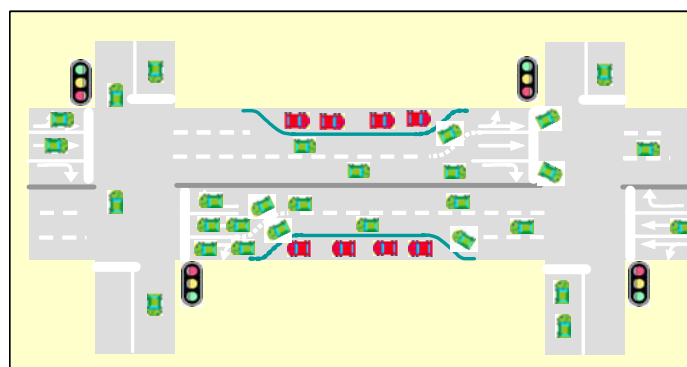


Figure 1 - Proposed on-street parking space

VIRTUAL REALITY TRAFFIC EXPERIMENT SYSTEM

The virtual reality traffic experiment system, which is an integrated system of a 6 axis motion driving simulator and a microscopic traffic simulator, has been developed in Sustainable ITS Project at CCR, University of Tokyo. Figure 2 shows the current system and the details are explained in the references [1], [2]. The system can reproduce a realistic interaction between a driven vehicle by a testee and surrounding vehicles run by traffic simulator, and can observe his/her driving behavior in several scenarios under fully controlled environment.

For the safety evaluation of the proposed on-street parking scheme, vehicle behavior model of surrounding vehicles at the parking section was newly developed and introduced to this system.



Figure 2 - Virtual Reality Experiment System

SETTINGS OF EXPERIMENT

Using this system, an experiment was conducted to evaluate safety aspects of the proposed parking scheme. In the settings of the experiment, 3 patterns of on-street parking spaces were

designed and the simulation datasets were prepared as follows.

Current lane marking (pattern A)

This is a lane marking which does not consider parking vehicles should be outside of through traffic lanes (Figure 3). This marking actually imitates the current situation where illegal parking occurs.

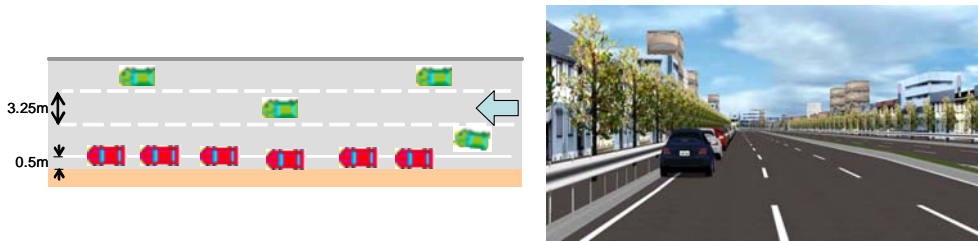


Figure 3 - Current lane marking (pattern A)

Parking lane with reducing through traffic lane width (pattern B)

This is a lane marking which creates parking lane by reducing each lane width for through traffic (Figure 4). The number of lanes for through traffic is maintained.

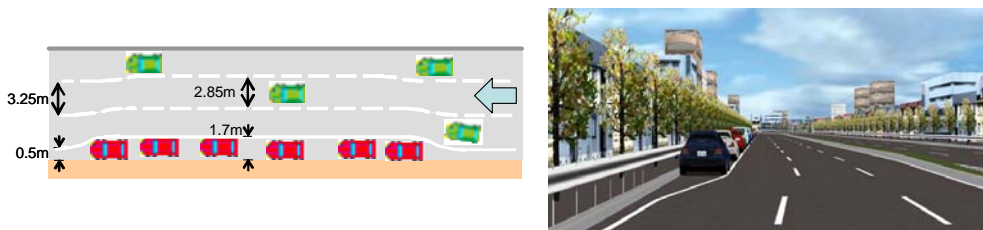


Figure 4 - Lane width reduction (pattern B)

Parking lane with reducing through traffic lane number (pattern C)

This is a lane marking which creates parking lane by reducing number of lanes for through traffic (Figure 5). The lane width for through traffic is maintained or widened.

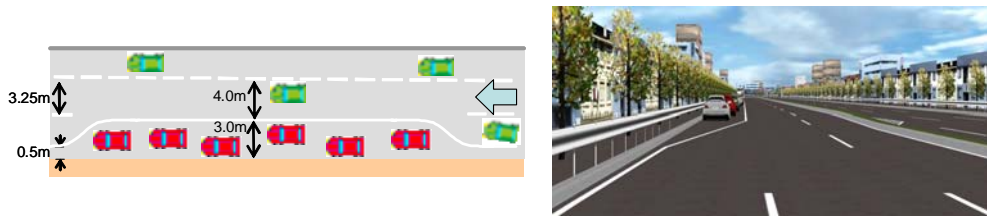


Figure 5 - Lane number reduction (pattern C)

In the experiment, a testee is asked to drive a road stretch including these parking sections. Driving behavior data in every second are recorded and questionnaire survey is also done after driving. Here is an example of collected data.

Driving behavior data: vehicle's location, speed, acceleration/deceleration rate, steering angle, driver's eye point etc.

Questionnaire survey: subjective evaluation on safety, uneasiness etc.

RESULT

A few dozens of testees has been invited to conduct the experiment. Table 1 shows the number of testees of the experiment.

Table 1 - Number of testees

Total	46			
Gender	Male: 32		Female: 14	
Age	20s: 30	30s: 12	40s: 2	50s: 2

Some of the results are shown in the following sections.

Driving trajectories

Figure 6 shows the driving trajectories by several testees in the pattern A. In this pattern, most of the drivers change their lane to the right completely although parked vehicles occupy less

than half of the first lane. We can see the trajectories vary especially at the entrance point of the parking section.

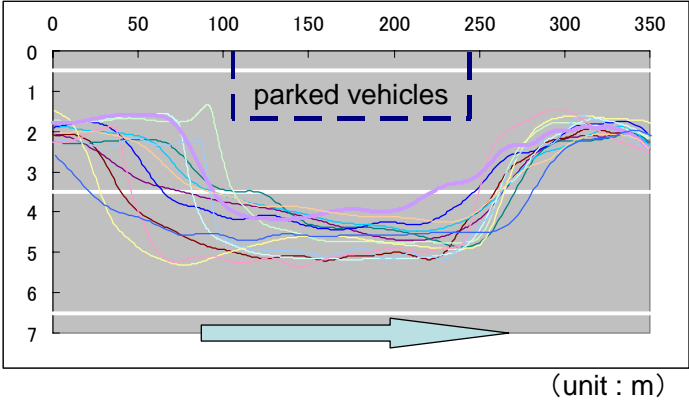


Figure 6 - Driving trajectories

Analysis on recorded driving data

At the entrance point of the parking sections, we can see the driver takes several actions, such as steering and accelerating / braking, in order to get into the adjacent lane. If these values exceed certain thresholds, it may cause some dangerous situation. Therefore, from the recorded driving data, we selected the maximum values of deceleration and heading angular speed of each testee as indices of safety. Figure 7 and 8 show the aggregation of them including maximum/minimum value and standard deviation. From these results, pattern B shows lower value than others, which implies smoother and less dangerous driving could be realized.

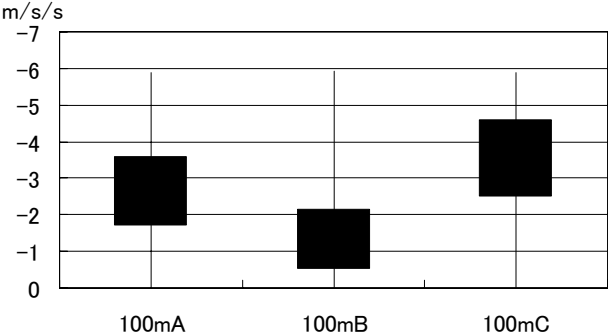


Figure 7 - distribution of maximum deceleration

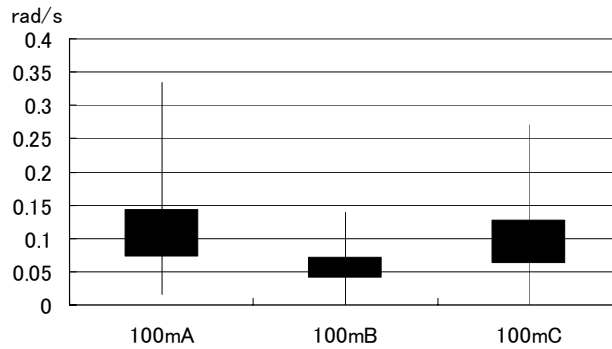


Figure 8 - distribution of maximum heading angular speed

Analysis on questionnaire

Subjective evaluation by testees is also done using questionnaire survey. Figure 9 shows whether testees felt dangerous or not on each of the patterns of lane marking. Compared with pattern B and C, testees feel more dangerous in the pattern A, a situation of illegal parking.

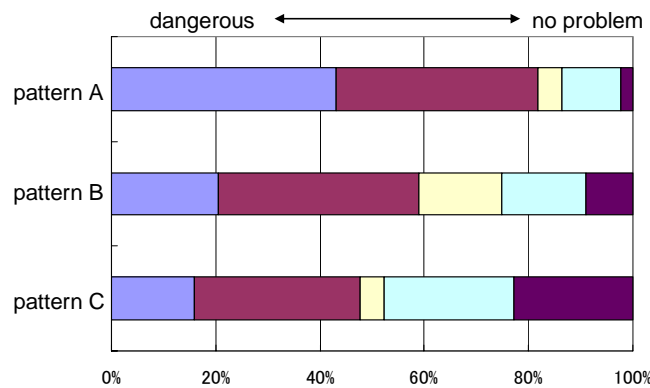


Figure 9 - Subjective evaluation

Figure 10 shows the result asking which was the most preferable pattern of marking and why the pattern was preferred. Drivers who preferred the pattern B raised no need of lane change, while drivers for pattern C find an advantage in wide lane configuration.

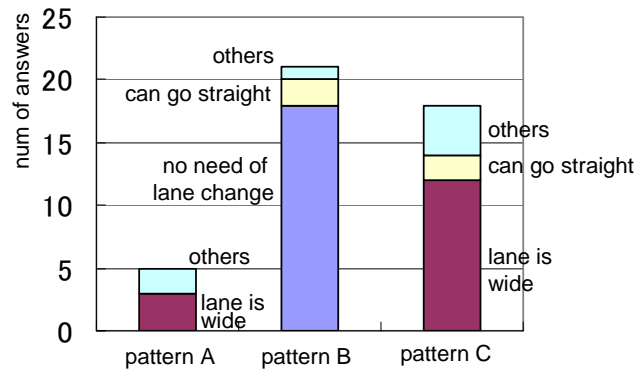


Figure 10 - Reason of lane marking preference

CONCLUSION

From the analysis based on the experiment so far, testees feel uneasiness or danger in the pattern A, which is similar to actual illegal parking situation, and also, indices of recorded driving data show relatively high value of dangerous. Therefore, it would be justified to make some types of parking lane, such as pattern B and C, on street.

We are continuing to analyze the driving data in more precise way, for example, considering relative relationship with surrounding vehicles. It may reveal which geometric design of parking lane is desirable and which location of the section potentially become dangerous, and so on.

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