A Study on Terminal mode system using Smart phone and Rear-screen

Kensuke Sawada†, Yuichi Hanada†, Shinichiro Mori†and Shigenobu Sasaki‡

†Fujitsu Laboratories, LTD.
4-1-1 Kamikodanaka, Nakahara-ku, Kawasaki, Kanagawa, 211-8588 Japan
‡Graduate School of Science and Technology, Niigata University
2-8050 Ikarashi, Nishi-ku, Niigata, 950-2181 Japan

Keywords: Terminal mode, Vehicle on-board unit, Smart phone, Laser projector, Translucent type Panel, Rear-screen

1 INTRODUCTION

In recent years, R&D activity of smart car has accelerated[1], [2]. This things advanced technical innovation of vehicle ICT on-board unit, and they are expected that a user can receive the benefits of the safety, comfortably, and energy-saving performance of a car on high level.

However, as the negative effect of these benefits, the problem that the life cycle of vehicle on-board unit such as a car navigation equipment becomes shorter than a car's life cycle has occurred. That is, if the user wants to receive the benefits of the latest function, there is a problem that the user has to continue buying the latest vehicle on-board unit at a short period than a car's life cycle. In order to solve this problem, the "terminal mode" which connects an in-vehicle information system with highly efficient cell phone units, such as a smart phone appeared[3].

However, because of a display panel of a smart phone is too small to use in a car, it is not suitable for a driver and passengers in a car. Thus, a device which has both a function of display which has enough size to recognize information by a driver and passengers, and a function of user interface to input the operation information on the on-board unit, such as a touch panel is necessary. For these purpose, the touch panel which emulates the LCD panel of a smart phone has attached in the car in the terminal mode. The user uses the display panel which is attached on the dashboard of the car just like the display panel of the smart phone for a user interface. In order to realize the function of the terminal mode, the function to transfer the information of which the information of the finger touch event and the position information of the finger at the moment that the finger is touched on the screen.

Thus, the purpose of this study is to offer a new technology to solve these two subjects. In this paper, a new technology to realize a function of the terminal mode using a small laser projector and a camera both which were built in a smart phone is described

2 CONVENTIONAL TECHNOLOGY

Although it was not developed for the automotive usage, there is a conventional technology which can offer the function of the terminal mode using a very small projector and a camera[4]. In the technology, the images are projected by the projector to the screen. And, in order to offer the function of the touch panel, the camera recognizes the hand which overlapped on the screen and its shadow[4]. However, this technology needs to enlarge azimuth difference between a projector and a camera in order to make both of shadows of a hand and the hand on a screen recognize.

So, although this technology is suitable for the large-sized projector used in a conference room etc., it is not suitable for small devices like a mobile phone. Because a projector and a camera both which are built-in such small equipment like a mobile phone cannot make the azimuth difference enlarge. As solution when there is little azimuth difference, there is technology to recognize the motion and number of color markers which is attached on a fingertip in advance by camera[5]. Since this technology can be used even if azimuth difference is small, it is suitable for application to small devices. However, in this technology, the user who has not equipped a fingertip with the color marker cannot control a picture. As mentioned above, in realizing technology of sharing a screen and operation using the projector and camera which were built in the mobile phone, the following issues are exists:

1. Detection of "finger touch on the screen" by a small device which has little azimuth difference
2. Detection of "position of finger touch on the screen" by finger with no marker

3 PROPOSED METHOD

In this paper, a new terminal mode system using smart phone and the rear-screen is proposed to solve these problems. The basic composition of the proposal system is shown in Figure 1.

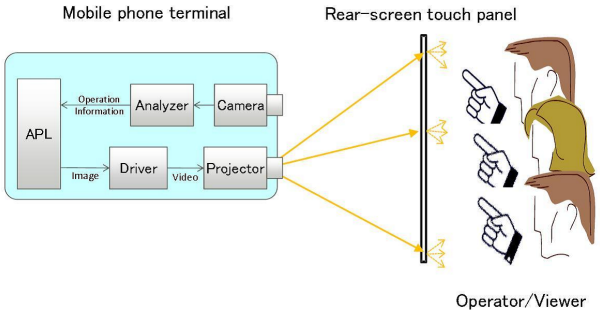

Figure 1: Basic composition of the Proposal system

In the proposal method, the images are projected by the small projector built in the mobile phone from back side of a translucent rear-screen. And when the screen is touched by a user's finger to control the system, the touch event and the position of finger on the screen are detected by the small camera also built in the smart phone. In order to detect the position of the finger which is touched on the screen, the amount of change of each RGB pixels at some discrete points is observed.

4 TEST IN THE LABORATORY

The performance of the proposed system is tested by experiment. In this experiment, a mobile phone and a portable projector were used. Both equipments are commercial product. These two equipments are able to docking. So we considered that these are a set of equipment like a smart phone. The resolution of a camera built in the terminal is 320×160 pixels, and the brightness of a projector built in the terminal is 9 lumen. The screen is "NTK vision", a product of "Nihon Tokushu Kogaku Jushi", and it has a Fresnel lens whose focus length is 25 cm.

The internal composition of the terminal is shown in Figure 2.

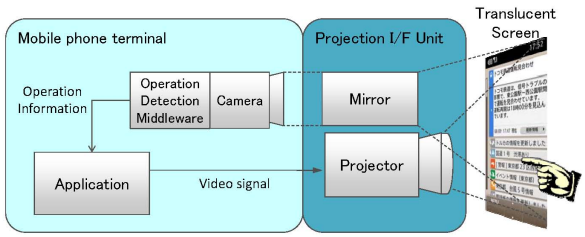

Figure 2: Composition inside the Terminal

In evaluation, first, the projector projects two domains that are colored with red and blue on same screen. Then, as shown in Figure 3, the software of smart phone make the images and projects either "RED was selected" or "BLUE was selected" when the finger touch event of either one of the two domain is touched by a finger is detected. And then, the images "BACK" colored by green is projected. The software of the terminal is programmed to return to the initial red and blue image again when the green picture is touched by a finger.

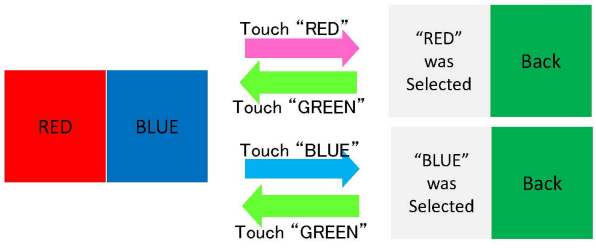

Figure 3: Sequence of Image changes

In this evaluation, the evaluator carried out the sequence of this operation 10 times at random, and the system performance was evaluated by counting the number of times that the change of the screen was performed correctly.

The results of the experiment are summarized in Table 1. The number of the result is times of succeeding in the change of an image per number of trial.

Table 1: Result

projection color	0 [lux]	700 [lux]	3000 [lux]
RED	8/10	10/10	8/10
GREEN	9/10	10/10	9/10
BLUE	9/10	10/10	9/10

5 SUMMARY

In this paper, first, the life cycle of vehicle ICT on-board unit had shortened compared with the life cycle of the car since the ICT accelerated vehicle ICT on-board unit is described. And, the terminal mode which is appeared to solve this problem, the following subjects to achieve this in the car was described. The subjects are: 1) the method to absorb distinction to resolution of screen on terminal and in-vehicle display, 2) the means to transmit screen images generated by the terminal to in-vehicle display, and 3) the means to achieve function of touch panel.

Second, a system that solved these problems and achieved the terminal mode was proposed. By the experiment test in the environment of the illumination level of 0 lux and 3000 lux, the proposal system was confirmed that it work correctly by the accuracy of about 80%.

For future work, the correspondence to arbitrary image, various fingers, and various operations (slide, drag, drop, and so on) are scheduled to be examined. Moreover, to make generality higher, the method using the reflective type screen and the method that can be used in outdoor environment are scheduled.

REFERENCES

[1] J.P. Conti, Smart cars, IET Communications Engineer, Vol.3, No.6, pp. 25-29, (2006).

[2] W.D. Jones, Building safer cars, IEEE Spectrum, Vol.39, No.1, pp. 82-85, (2002).
I

[3] R.Bose, J. Brakensiek, P. Keun-Young, and J. Lester, Morphing Smartphones into Automotive Application Platforms, IEEE Jour. Computer, Vol.44, No.5, pp. 53-61, (2011).

[4] T. Kashima, and K. Nakajima, Accuracy Improvement of Touch-Screen by Projector and Camera, ITE Tech. Rep., Vol.34, No.31, pp. 33–36, (2010).

[5] P. Mistry, P. Maes, and L. Chang, WUW - Wear Ur World - A Wearable Gestural Interface, CHI2009, Spotlight on Works in Progress, Boston, MA, USA, (2009).