A WARNING SYSTEM FOR OVERSPEED AT THE CORNER USING VISIBLE LIGHT BASED ROAD-TO-VEHICLE COMMUNICATION

Kuniyoshi Okuda, Ryoichi Yoneda, Tomoo Nakamura and Wataru Uemura

Department of Electronics and Informatics, RyukokuUniversity, Shiga, Japan

ABSTRACT

When a car enters a corner with over speed, it rises the accident risk higher. To warn the risk and urging the caution to drivers, many of the accident-prone corners have warning rights. The driver can decelerate the car smoothly and pass through the corner safety by those devices. However, appropriate speed for each corner is different by curvature of the corner and characteristics of the vehicle. The driver has to suppose the safe speed for every corner only by experience, usually. Of course too much slow causes traffic jam. Especially at the first road in the first place for the driver, it is difficult to suppose the curvatures of the corners. Then, we propose a visible light communication system so that the warning lights in the corner send appropriate warning information. Visible light communication transmits a signal by blinking the light. One of the characteristics of visible light communication is that it can use existing lighting equipment as a transmitter. In our system, we can distribute the warning information to the driver using the visible light communication. Though the curvature(R:radious) of the corner does not change, the speed of each vehicle to approach the corner always to different. Focusing the distance from the corner to the car, we consider a communication system to send different kind of information according to that distance. If the distance is enough long, the driver has a plenty of time to decelerate the vehicle. The more the distance becomes short, the more the driver is required rapid deceleration. Therefore, to distribute the appropriate warning information to the driver, dividing the distance from the corner into some areas, we make the system to send different information in each area. Generally in communication system, modulation primarily changes the amplitude, phase or frequency. In visible light communication, change of the amplitude changes the brightness, which causes flickering that burdens the drivers. Therefore we cannot use amplitude based modulation. Next we consider the varying the phase. Unfortunately, it is difficult for the receiver using photodiode or phototransistor to read the difference of the phase of the signals, because the frequency of the light is very high in visible light communication. Then we employ 'symbol length' with the Pulse Position Modulation (PPM).In our method, brightness does not change when the symbol length is changed. We investigate the system performance by changing the communication speed. Short symbol length in high frequency is sensitive and vulnerable to noise, instead of low frequency with strong against noise. Using this characteristic of symbol length modulation, different information in each distance can be delivered by changing the frequency. As conclusions, we propose awarning system for over speed at the corner using visible light based road-to-vehicle communication. The installed light in the wall deliver the information using visible light communication. In our system, lighting device delivers different information according to the distance from the corner to the car.In our proposing method, brightness does not change by using the PPM and symbol length modulation.

KEYWORDS

Baseband modulation, Frequency, Visible light communication

DOI : 10.5121/ijasuc.2015.6201

1.INTRODUCTION:

The well occurring locations of traffic accidents are intersection or corner. The one of cause accidents at the corner are mainly over speed. So, bulletin boards and electric bulletin boards have been installed in order to prevent accidents. The bulletin board shows the accident-prone location and speed limit. Drivers apply the brake and pass through the corner seeing the bulletin board. However bulletin boards may be overlooked. So the lights are installed in the corners to prevent accidents (shown at Figure 1). The lights give the warning to the driver. We can intuitively understand warning of the lights. When drivers see the lights, they slow down the speed of the car. And they can pass thorough the corner safety. Many lights are lit day and night. This lights stand out at night. Drivers often misjudge the distance to the wallet night. Therefore, these lights are effective. Lights are installed at the certain corners. Its locations are where drivers often speed exceeded. For example, the location is ICs (Inter Charges) or corners after straight. In many cases, the lights are not installed in other locations. From the comparison, the driver may receive warning and caution information.

Figure 1. The light installed on the wall

2. SOME PROBLEMS OF INFORMATION TRANSMISSION

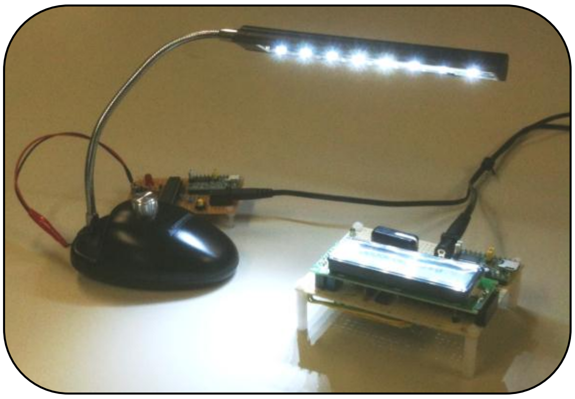

Figure 2. Visible light communication

When we pass through the cornersafely, we require some information. These information include corner radius, inclination and road conditions. In addition, car information is required. Car information can be getin advance. Weshow theexpressionofthe car turnstationarycircular.

$$a_y = Vr = \frac{1}{1+AV^2}\frac{V^2}{l}\delta \qquad [1]$$

Note that a_y is the lateral acceleration, V is the speed, A is the carof testability factor, l is the wheelbase, and δ is the turning angle a_y does not exceed the friction coefficient of the road. A and l are the eigen values of the car. So when lights senda value of δ using visible light communication, the speed is determined. So a safe speed is derived by multiplied a coefficient rate. We need to know the information of the corner by some means. These information by using the maps and positioning system can be determined. However there are some corner sat ICs and JCs(Junction). Therefore the system might mistake the value.

It is possible to distribute the warning and caution information using the light from the corner. R(Radius of curvature) of the corners are different depending on the location. A value of R and a slope are different in each corner, respectively. The driver must obtain the information by some means. Therefore we send the information from the light of the wall using a visible light communication [2][3][4][5][6]. The visible light communication transmits a signal by blinking the light (shown at figure 2). One of the characteristics of the visible light communication is that it can use lighting equipment as a transmitter. We can deliver the information of caution and warning to the driver using the visible light communication.

Smoother braking is made possible by getting the distance to the corner. Appropriate speed varies depending on distance to the corner. Therefore, the amount braking the driver depresses go increases to bring in over time, the risk is also increased. A solving problem is difficult for information delivery.

There are several ways for the distance measurement. The distance measurement by infrared is useful at close range. The distance measurement by radar does not matter the distance. Recently there is also the distance measurement by the camera. These methods will need to attach some of the sensors in the car. So we consider the distance measurement using the visible light communication.

A modulation varies amplitude, phase or frequency. The easy modulation is to change the amplitude. When the receiver receives strong signal strength, it can determine short distance. In the visible light communication, varying the amplitude is equal to change the brightness [7][8]. If the brightness is changed, it will cause flickering. And the driver will confuse. Therefore, changing the amplitude is inappropriate for visible light communication. Next we consider the method of changing the phase. A wavelength range of light used in the visible light communication is from about 380nm to 780nm. That frequency is from 385THz to 790THz. These are very high frequency. Distance estimation method using a phase is not common. In addition, the LED is mainly used in the visible light communication. The response speed of the LED is faster than traditional light and a high-speed communication is expected. The wave length of the LED varies depending on the material. Therefore, changing the wavelength is difficult for transmitter arbitrarily.

So we focus on the symbol length. If the symbol length against frequency of the noise is short, it is susceptible to noise. And if the distance between the transmitter and the receiver is near, SN ratio is good. When a symbol length is long, we can receive signal of low SN ratio. That is, when the distance is far, the long signal symbol length arrives far. However, the symbol length and the communication speed are inversely proportional. The short symbol length is sensitive to noise, especially. This method is suitable for the envisaged system. And if the lighting infrastructure used as a transmitter for the visible light communication, we must constant the brightness.

Brightness is proportional to the transmission energy. That is, Transmission energy should be constant regardless of the code. Some modulations of the constant transmitting energy are PPM or FSK. We can estimate the distance by changing the symbol length and combine with PPM and FSK. In addition, it is possible to keep the constant brightness.

3. A WARNING SYSTEM FOR OVER-SPEED AT THE CORNER USING VISIBLE LIGHT BASED ROAD-TO-VEHICLE COMMUNICATION

We propose awarning system for over-speed at the corner using visible light based road-to-vehicle communication. We send the information using visible light communication, as mentioned in Section 2. We show the system diagram in Figure 3.

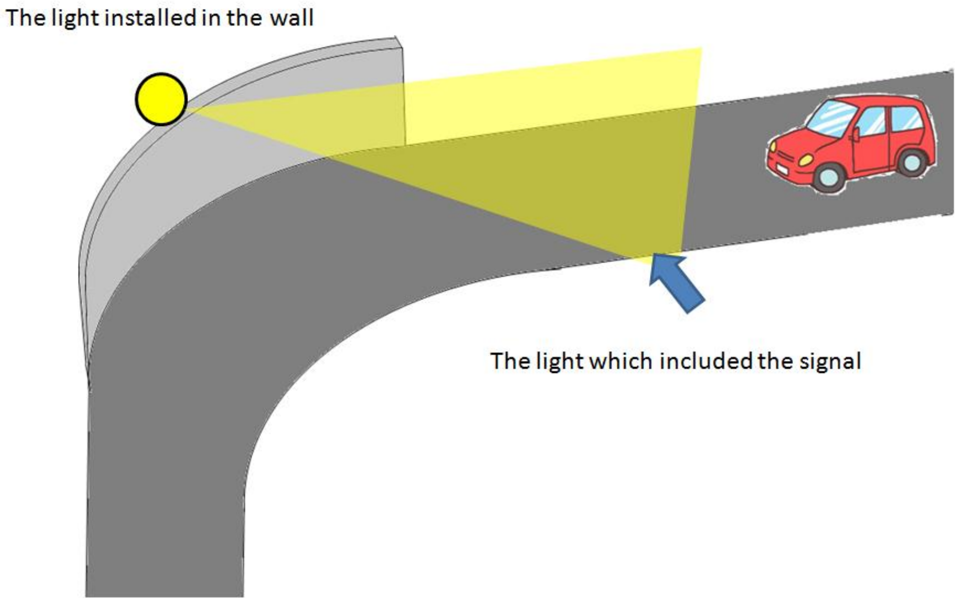

Figure 3. Our proposed system

Our proposed method uses the baseband modulation and PPM as the modulation scheme. The baseband modulation is sensitive to noise [7][8]. When the distance between the transmitter and receiver is away, a high frequency is affected by noise. So the influence of the noise is different depending on the symbol rate. Received information of each the distance between the transmitter and the receiver is different. The proposed system sends several pieces of information by changing the symbol rate. And the proposed system sends these signals from the light that has been installed in the corner using visible light communication. When the distance between the wall and the car is close, the car can receive both of low and high frequency signals. When the distance is far, the high frequency is affected by noise. Therefore, the car may not receive the high frequency signal. However, the car can receive low frequency signal. By knowing the maximum value of the frequency of the signal can be received, the car is able to estimate the distance from the light. It is necessary to consider the speed of the car when estimating. When the car runs at high speed, a reception environment is rapidly changing. And when the car receives an optical signal, the distance between the wall and the car is changing ever, because the car is running. When at the corner, the car travels at a faster speed than the speed at which designers of the road assumed, risk of an accident may occur. Our proposed system can estimate the distance to the wall by gettingthe maximum frequency that can be received. If the car approaches the corner at over speed, the car can pass the corner safely by the system slows down the car. Also if the driver does not operate the car in sudden illness or looking aside, the system can stop the car. If the error occurs in the received signal, the system to estimate the distance to the wall from the frequency of signal with error and the speed.

Knowing the frequency of the maximum that can be received is important in our proposed method. It must have a means of finding the error for that. We use a Cyclic Redundancy Check[9]. If a system calculates necessity, it will slow down and stop a car.

Transmission energy is different depending on the sign in the ASK and OOK. It is the cause of the flickering. Therefore, we used the PPM. Transmission energy of each code is constant at PPM. Therefore, no flickering occurs. We show in a diagram of the signal to be transmitted Figure 4.

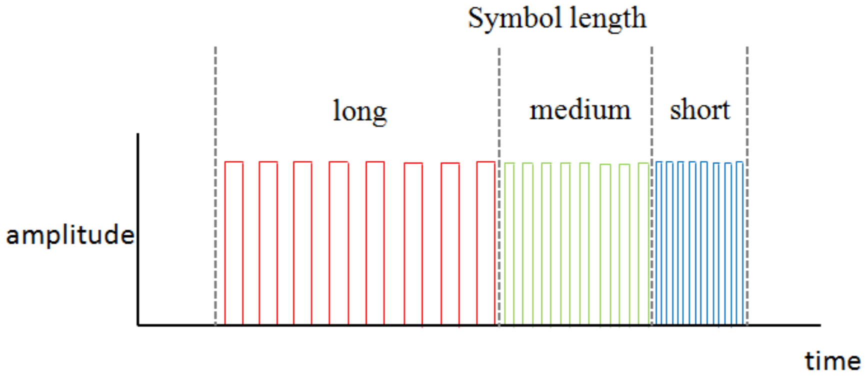

Figure 4. Waveform of the signal to be transmitted

4. EXPERIMENT

Wecheckin the experimentproposed methodmentioned insection 3. In addition, we estimate the relationship between the speed of the receiving frequency and the distance, and we search a use maximum receivable frequency corresponding to the speed. Thus, it is possible todetermine the distancetoapply thebrakesto avoidaccidents. We show thetransmitter andthe receiver inFigure5.

Figure 5. The transmitter and the receiver

Weuse the 1/32 carin the experiment. The transmitter is equipped with a microcomputer for the control and the LED for transmission. The transmitter sends signal of the different baseband using visible light communication. The receiver is attached to the car. The car is equipped with an optical receiver, a pilot LED and microcomputer for control. We show block diagrams of the transmitter and receiver in figure 6.

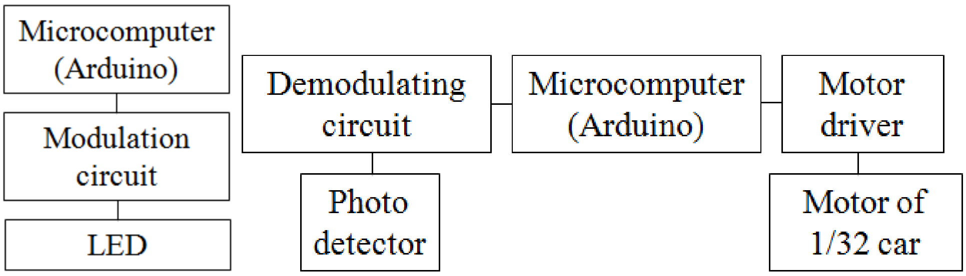

Figure 6. The transmitter and the receiver

Transmitter and receiver are controlled by the microcomputer.The microcomputer at the transmitter sends the signal to the modulation circuit and blinks the LED.Optical signal is converted into electrical signal by a photodetector. Electrical signal through the demodulation circuit is processby the microcomputer.The microcomputer controlsmotorby the signal.

At first we search thecapable of receiving the maximum distance for each frequency. This experiment obtained the two types of the distance of the car running and stopped condition. Byacquiringdataduring running, it is possible toobtain the relationshipof thedistancebetween the frequency and eachspeed. The carruns ata speed of7 km/h. The car is braked by receiving the signal however it movies by inertia. Therefore, we shoot a movie, and we confirm the light of the pilot LED. The pilot LED is turn on usually. And when the car receives signal pilot LED turn off the light. We show the experimental environment in Figure 7.

Figure 7. Experimental environment

The transmitter changes the frequency to be sent to each measurement. Used frequencies are 5 patterns from 5 kHz to 20 kHz. We show the experimental results in Figure 8.

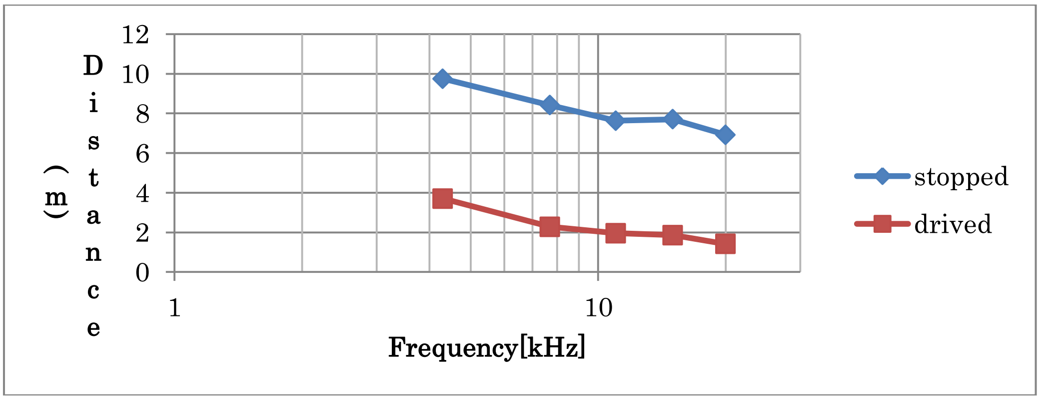

Figure 8. Experimental result

Longest reception distance of the stop is 10m. And shortest distance is 7m. When the car is running, longest reception limit distance is 4m and shortest distance is 1.5m. We have confirmed that the reception distance is shorter when the frequency is high from the experimental results. The receivable frequency is low when the car is running at the same distance.

Then we estimate the reception limit distance at multiple speeds. We can know the frequency of braking at each speed by knowing the estimation result. With knowledge of these data, the system can determine the degree of braking to safely pass through the corners. We determined the relationship between the distance and frequency of travel time and stop time in the experiment. The car travels at a speed of 7km/h. Therefore, it travels at 224km/h in actual size. Therefore, we estimate the results of from 84km/h to 168km/h from the experimental results of 224km/h and stopped. We show the estimation results in Figure 9.

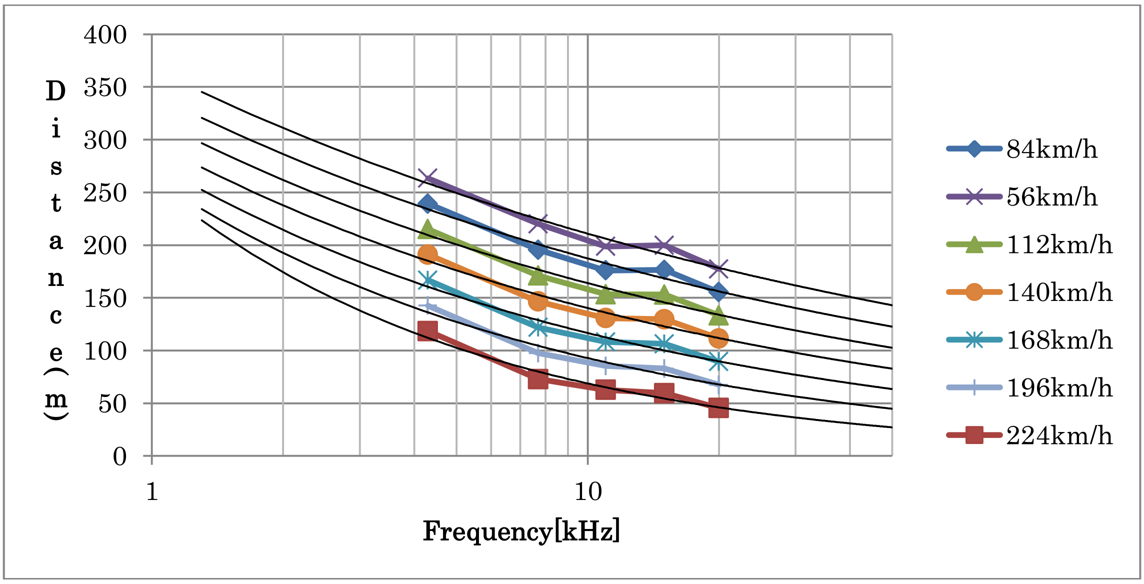

Figure 9. The estimation results

We can know the frequency used at each speed from the results of this experiment. And the transmitter assumes the speed faster than design speed and sends signal of each frequency. The proposed system mounted on the car receives the signal and applies the brakes as needed. And with knowledge of the corners R(radius) and the data of the car, the system can know the velocity through the corner safely.

The car mounted proposed system can pass the corner safety and decelerate or stop.

5. Conclusion

When the car entered the corner at over speed, there is a risk of an accident. Light are installed in the corners to prevent accidents. The light prompts the warning to the driver. The driver can know the existence of the corners when they look the light. The light is not installed at all corners. This light is installed in a common site of accidents. By looking the light, the driver can decelerate safety and pass through the corner. However, the driver cannot know the corner by just looking the light. It is difficult at the corner to see for the first time especially.

The light that has been installed in the corner sends the information of the corner and they can prevent accidents it is using the visible light communication. Visible light communication transmits a signal by blink the visible light. The feature of visible light communications can treat lighting apparatus as a transmitter. The light that is installed at the corner by using a visible light communication can send information of the corner and warning to the car and the driver.

However the car so running often, the situation is ever-changing. The distance to the corner and the car becomes shorter with time, and appropriate speed and the amount of brake changes. The car decelerate slowly when it is far from the corner. However sudden braking is required when it is close to the corner. Therefore, the distance of between the wall and the corner and the corner information is necessary to pass through the corner safely. However knowing the distance to the wall is difficult. Distance sensors using radio waves are valid for a short distance.

So we focus on the visible light communication that is described above. It is difficult only to receive signals transmitted uniformly to know the distance. When the light sends information to change the amplitude, the car can know the distance from the signal strength. However, in visible light communication the brightness is not constant, because amplitude is brightness. It is the cause of the flickering. Flicker is a burden of the human eye. Therefore, it is inappropriate. Next we consider the varying phase. Frequency of visible light is very high. Therefore, changing the phase is difficult. As well we focus on changing the frequency. However baseband modulation is different. Baseband modulation is sensitive to noise. It is more remarkable as high frequency. S / N is deteriorated when a long distance, an error occurs in the high-frequency signal. Therefore, the receiver can receive the signal of low frequency and high frequency at close range. It is possible to receive the low frequency signals in long distance. However the brightness of baseband modulation is not constant using only baseband modulation. PPM is a certain brightness modulation scheme. Thus, it is possible to solve the problem by using the PPM and baseband modulation.

We propose awarning system for overspeed at the corner using visible light based road-to-vehicle communication. The proposed system sends the information of the corner from the light that has been installed in a corner by using the visible light communication. The receiver mounted on the car receives the optical signal and gets the information of the corner. The receiver can calculate the distance to the wall from the car speed and the maximum frequency that can be received. From these information, the proposed system can brake automatically, and pass through the corner safely or stop the car.

We use the 1/32 car in the experiment. The transmitter is equipped with a microcomputer for control and the LED for transmission. The transmitter sends signal of the different baseband using visible light communication. The receiver is attached to the car. The car is equipped with an optical receiver, a pilot LED and microcomputer for control. And we search capable of receiving the maximum distance for each frequency. By acquiring data during running, it is possible to obtain the relationship of the distance between the frequency and each speed. Then we estimated the reception limit distance of at multiple speeds. We can know the frequency of braking at each speed by knowing the estimation result. It was possible to know the maximum frequency of braking for stopping by knowing the braking distance at each speed and this data.

From the above results, with knowledge of the information of the corner, the distance to the wall and the speed of the car, our proposed system brakes automatically and it can pass through the corner safety and stop as necessary.

REFERENCES

[1] S.Horiuchi, "Motion performance of automobile", Motor RIng of Society Of Automotive Engineers Of Japan, No. 16, Chapter 5, 2003.

[2] S. Haruyama,"Visible light communication", Journal of IEICE, 94(12), D, pp. 1055-1059, 2011

[3] Rajan Sagotra, "Visible Light Communication", International Journal of Computer Trends and Technology (IJCTT) volume4 Issue4, pp. 906-910, 2013

[4] Dominic C. O'Brien, "Visible Light Communications: challenges and possibilities", PIMRC 2008. IEEE 19th International Symposium on Personal, Indoor and Mobile Radio Communications, pp.15-18, 2008

[5] K. Okuda, "The Key Providing System for Wireless Lan Using Visible Light Communication" Journal of IJASUC, Volume5, Number3, 2014

[6] K. Okuda, "A Novel Keyless Entry System Using Visible Light Communication" Journal of IJASUC, Volume5, Number5, 2014

[7] T. Saito, "A Study for flicker on Visible Light Communication", Technical Report of IEICE CS, vol. 106, No. 450, pp. 31-35, 2007.

[8] I. Shouichi, "Reduction of Flicker by Coding and Modulation for Visible-Light Communication" Technical Report of IEICE OCS, vol. 108, No. 39, pp. 1-4, 2008.

[9] W. W. Peterson, "Cyclic Codes for Error Detection", Proceedings of the IRE, vol.49, pp228~235 1961.

Authors

Kuniyoshi Okuda (b.1986) is a student of Ryukoku University in Japan. After studying Electronics and Informatics at Ryukoku University, he completed his Master of Engineering at Osaka City University. Now he is a doctor course student at Ryukoku University.

Ryouichi Yoneda received B.E. degrees from Ryukoku University, in 2013.

Tomoo Nakamura was born in 1948, and received B.E, M.E. and D.E. degrees from Kyoto University, in 1970, 1972, and 1988. He is a professor of Ryukoku University in Shiga, Japan.

Wataru Uemura was born in 1977, and received B.E, M.E. and D.E. degrees from Osaka City University, in 2000, 2002, and 2005. He is an associate professor of the Department of Electronics and Informatics, Faculty of Engineering Science, Ryukoku University in Shiga, Japan. He is a member of IEEE, RoboCup and others.