A Road Information Sharing Scheme with a Still-Picture Internet Broadcasting System

Yoshia Saito* and Yuko Murayama**

*Faculty of Software and Information Science, Iwate Prefectural University, Japan
y-saito@iwate-pu.ac.jp
**Department of Computer Science, Tsuda College, Japan
murayama@tsuda.ca.jp

Abstract – With an increase in navigation systems by portable terminals and car navigation devices, ITS which supports comfortable and effective driving has been evolved. However, in existing systems, it is difficult to offer real-time information to users since it needs to collect information from sensors and to analyze the collected information. Road information has to be provided timely so that drivers can pass through safe and comfortable roads. In this research, we use a still-picture Internet broadcasting system as a technique to share road information. It enables users to share the road information timely and to choose a road which is easy to pass. In addition, we implement an automatic photography function and conduct an experiment of the photography timing as a broadcaster. In this paper, we describe the design and implementation of our proposed system and evaluation experiments about the right photography timing of the automatic photography function. From the result of the experiments, we found road information was required more in the bad road situation such as rain and snow, and the road information could be grasped easily by introducing audience requests to the photography timing.

Keywords: Road Information Sharing, Still-Picture Internet Broadcasting, Photography Timing

1 INTRODUCTION

ITS (Intelligent Transport System) technology which addresses traffic information has been developed in recent years with the introduction of recent information technology to deal with increased volume of traffic. The road situation changes from moment to moment due to change of road surface conditions, weather conditions, traffic volume and various factors. The road information is an important factor and has high demand for drivers.

VICS (Vehicle Information and Communication System) [1] is one of systems to get road information in Japan. VICS provides road information which is collected by an information center via communication and broadcasting media such as FM multiplex broadcasting. Drivers can receive the road information by their car navigation systems and utilize it to select an appropriate route to the destination. However, VICS takes time to provide the road information to the drivers because the center needs to collect and analyze information. In addition, the ways of providing road information is limited to text, audio and map display. It is difficult for the drivers to understand the detailed road situation. The road information should be timely and provided in an easy-to-understand way.

Meanwhile we have studied a still-picture Internet broadcasting system [2]-[4] which uses still-pictures and audio streaming instead of video streaming to realize practical broadcasting via row-speed or limited high-speed cellular network by reducing data traffic. This system can broadcast anywhere using smartphones even if only connected to row-speed network. To provide timely and easy-to-understand road information, we propose a road information sharing scheme based on the still-picture Internet broadcasting system. The proposed system provide road information to users who want to know the road situation for route selection using still-pictures and audio streaming in real-time. To provide still-pictures and audio streaming, cooperative drivers set their smartphones on their cars. The broadcasting system works on the smartphones and automatically takes still-pictures and sends the still-pictures to the broadcasting server at the right time not to disrupt their driving operation. Users can select a car and view the broadcasting to get the road information in a certain area. The users can also communicate with the driver and get more detailed road information by the drivers through the communication.

In this paper, at first, we explain features and issues of existing traffic information systems. Secondly, we describe detail of the road information sharing scheme with a still-picture Internet broadcasting system. Then, preliminary experiment is conducted using the implemented prototype system to study appropriate timing to take still-pictures. At last, we introduce several photography timing algorithms to the prototype system and evaluate the algorithms.

2 ISSUES OF EXISTING SYSTEMS AND OUR APPROACH

There are probe vehicle systems [5] to get road information. The probe vehicle system collects wide-area road information from probe vehicles which have various sensors and reduces cost for sensor installation. One of the services of the probe vehicle system, there is a vehicle tracking map which is provided by Honda [6]. This service shows whether the road is travelable or not on the map based on collected information from probe vehicles and aims to support driving in disaster area. It was used in 2007's the Niigataken Chuetsu-oki Earthquake and 2011's the Great East Japan Earthquake. This fact means road information is in great demand.

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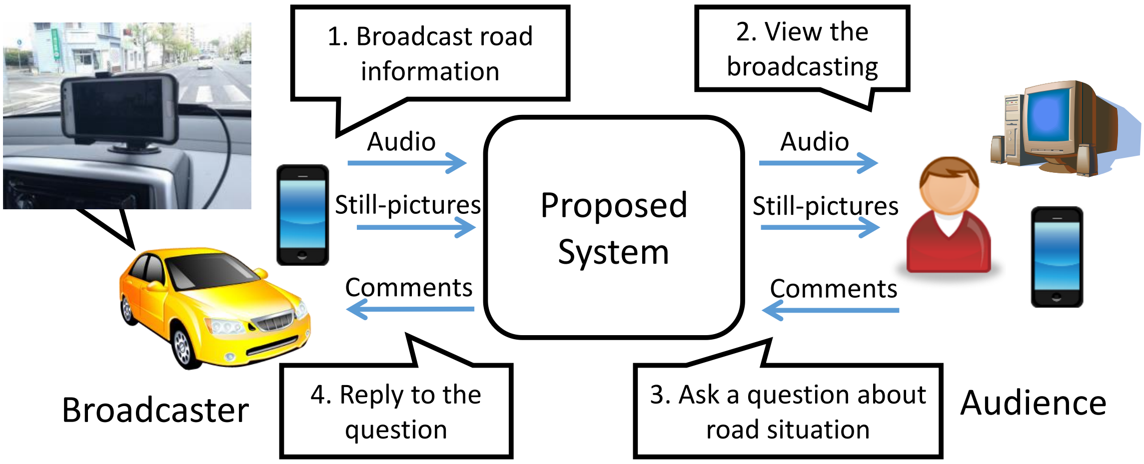

Figure 1: The proposed system model

There are several issues in the probe vehicle system. At first, the road information from probe vehicle system lacks timeliness. For example, a service provider checks road information to avoid traffic jams in advance but the road could be backed up when the user arrived. This is because the probe vehicle system takes time to collect and analyze the road information from probe vehicles and the information lacks timeliness. Secondly, the road information is not flexible and intuitive. Typical road information which is provided by the probe vehicle system and VICS is predetermined by service providers and shown as text and icons. The users cannot know road situation in detail. Thirdly, the probe vehicle system requires dedicated sensor devices such as a specific car navigation system and it is difficult to prepare many probe vehicles. To get wide-are road information in real-time, the dedicated sensor devices should be eliminated. From these issues, it is important to provide flexible road information timely in an easy-to-understand way without dedicated sensor devices.

We focused on drive broadcasting which is one of the broadcasting styles to show driving landscape using in-vehicle camera and communication devices. The audience enjoys the driving landscape and communicating with the broadcaster. The drive broadcasting is a popular content in live streaming services such as Ustream [7] and NicoNico Live [8]. The drive broadcasting can share road information timely. However, it has an issue about network communication. In the drive broadcasting, 3G/4G cellular network devices are used generally. Although 3G cellular network covers wide-area, it is too low-speed for video streaming. The video can be frequently stopped and low-quality. While 4G cellular network provides enough network bandwidth, it usually has limitation of amount of data traffic per day and month. Cellular carriers in Japan make communication speed slow when the subscriber uses hundreds of megabytes in a day or several gigabytes in a month. Therefore, the data traffic should be reduced for drive broadcasting.

3 PROPOSED SYSTEM

We have studied a still-picture Internet broadcasting system using smartphones which uses still-pictures and audio streaming instead of video streaming to reduce data traffic. Even if only 3G cellular network is available, the system realizes stable broadcasting. However, the previous study did not specify the use cases. In this research, we use the still-picture Internet broadcasting system for drive broadcasting to share road information.

The proposed system provides road information in real-time by live still-picture broadcasting so that users can choose safe and comfortable roads. The live still-picture broadcasting enables the users to understand road situation intuitively and also realize stable broadcasting anywhere by reducing data traffic. The users also can communicate with any broadcasters and ask a question about road situation.

Figure 1 shows the proposed system model. The broadcaster sets a smartphone on his/her car. The smartphone sends still-pictures and audio stream to the proposed system in order to share road information. It is on the assumption that the still-pictures are taken and sent automatically at the right timing. The broadcast programs are shown on a map.

Audience can select a broadcast program on the map and view the broadcasting by using their PCs or smartphones. The PCs/smartphones receive the still-pictures and audio stream from the proposed system. The audience can interactively ask a question about road situation to the broadcaster through the proposed system and the broadcaster can reply to the question to complement the road situation which is not understood by the still-pictures and audio stream.

The proposed system realizes timely road information sharing between broadcasters and audience and helps audience understand the road situation by still-pictures and interactive communication with broadcasters. Because it also does not require dedicated sensor devices and just uses smartphones, anyone can share road information and wide-area road information can be covered when there are a lot of broadcasters.

The use case of the proposed system is as follows. The broadcasters are people who drive for commuting or trip. The motivation of the broadcasters is to enjoy communicating with audience like fellow passengers. The audience are people who have a plan to go to the broadcasting place for commuting or trip and want to know

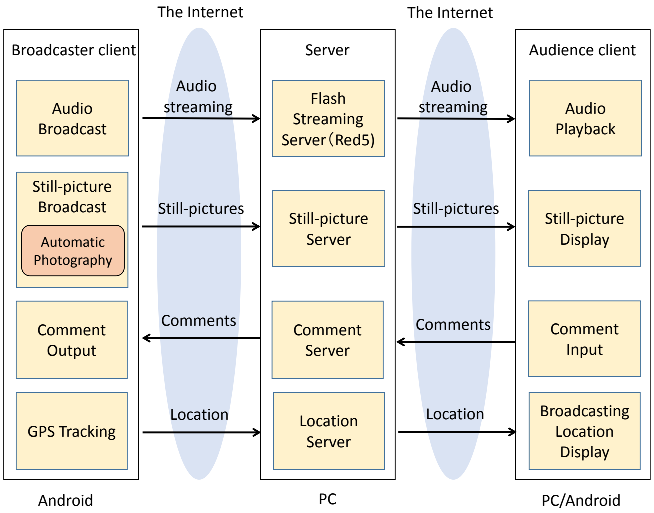

Figure 2: The system architecture

the road situation. The audience can confirm traffic, road surface, and weather and so on by viewing the broadcasting to select routes.

4 PROTOTYPE SYSTEM

We implemented a prototype system based on the system model to conduct a preliminary experiment. A client software for broadcasters was developed on a smartphone and two client software for audience were developed on a smartphone and PC. Android smartphones were used for the client development.

Figure 2 shows the system architecture. At first, a broadcaster launches a broadcaster client on the smartphone and starts broadcasting. The audio broadcast function on the broadcaster client sends audio stream to a server using RTMP. The still-picture broadcast function on the broadcaster client sends still pictures which are encoded by JPEG2000 to the server. Since the broadcaster cannot touch the smartphone in driving, the automatic photography function takes still-pictures at right timing automatically. In this implementation, the timing is fixed time interval but it is variable.

On the server, Red5 which is a flash streaming server receives the audio stream from the broadcaster client. When an audience client connects to the server and select a broadcasting, the Red5 sends the audio stream to the connected audience clients. The audience client receives and plays the audio stream. The still-pictures are also sent to the connected audience clients through a still-picture server which is implemented in Java. The audience client receives and display the latest still-picture.

The audience client can send text comments to the broadcaster through a comment server which is implemented in Java. The broadcaster client display the comments and read out the comments so that the broadcaster can communicate with audience without watching the smartphone in driving. The broadcaster client does not have the comment input function because the broadcaster cannot touch the smartphone in driving. The broadcaster hears the comments from audience and speaks about the reply to them.

Figure 3: The user interface for the broadcaster client

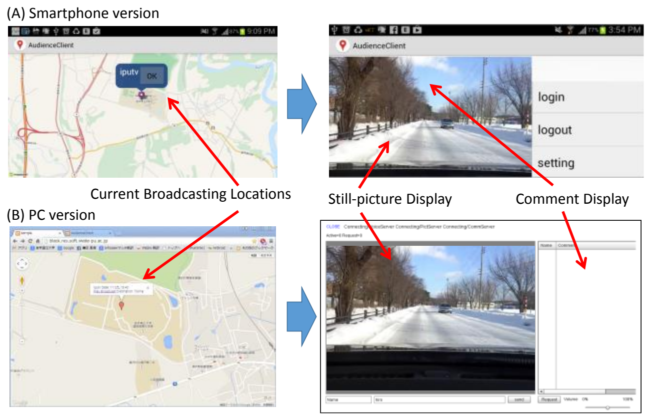

Figure 4: The user interfaces for the audience clients (A: smartphone version, B: PC version)

The location of the broadcaster client is tracked by GPS on the smartphone and sent to the server. The server associates the location with the broadcasting and stores the location information in real-time. The audience can view the list of broadcastings on the map and select a broadcasting which they want to watch.

Figure 3 shows the user interface for the broadcaster client. The real-time camera image is displayed on the center. On the bottom part, there are control buttons. The connect button is used for connecting to the server. The login button starts to send audio stream and still-pictures to the server. The send button is used for manually sending still-picture to the server. The logout button stops the broadcasting. The comments from audience are displayed over the camera image and read out.

Figure 4 shows the user interfaces for the audience clients. The upside is smartphone version and the downside is PC version. The smartphone version is developed as an Android application and the PC version as a Web application. On start-up, the both audience clients show current broadcasting points on the map. When a broadcasting point is selected, the user interface is changed and the correspondent broadcasting is started. The audience can input comments. The inputted comments are displayed over the still-picture on the smartphone version and the comment display field on the PC version.

Table 1: Feedbacks in the preliminary experiment

Categories	Feedbacks	Countermeasures
Broadcasting information	* I would like to know where the still-pictures were taken. * I started watching from the middle of the broadcast. I didn't understand where the broadcaster came from.	* The location information should be added to the still-picutres. * The history of the still-pictures should be given to the audience.
Automatic photography timing	* I would like to shorten the interval of the automatic photography. * I do not need so many still-pictures because the still-pictures are similar ones. * During night-time, many rayless still-pictures were displayed and I did not understand the road situation when there were not streetlights.	* The automatic photography timing should be not fixed and more flexible. * The photography timing sould be determined when the audience can understand the road situation from the still-picture

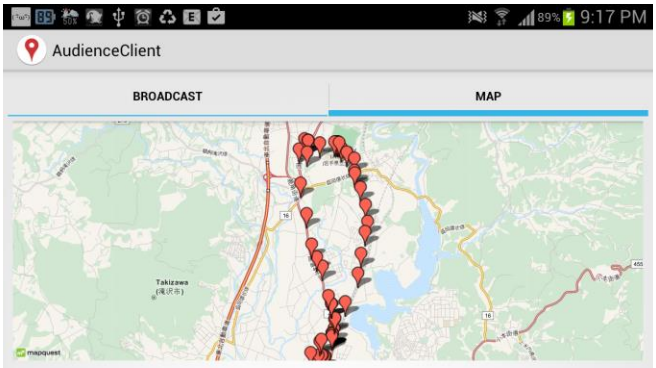

Figure 5: Location and history of still-pictures

5 PRELIMINARY EXPERIMENT

To check operation of the prototype system and find its issues, we conducted a preliminary experiment using a real car. The experimental period was from May 5th to July 4th in 2014 and the broadcasting was performed for 30 minutes in twice during daylight hours and night-time hours in a day. The subjects were 14 students of Iwate Prefectural University. They viewed the broadcasting using the audience client of PC version. The interval of the automatic photography was set to 30 seconds per a still-picture and the resolution of the still-pictures was 320x240.

5.1 Feedbacks and Countermeasures

From the experiment, we got several feedbacks from the subjects. Table 2 shows the feedbacks. The feedbacks can be categorized by two groups. The first group of feedbacks is about "broadcasting information." The feedbacks were "I would like to know where the still-pictures were token" and "I started watching from the middle of the broadcast. I didn't understand where the broadcaster came from." These feedbacks point out the lack of information about still-pictures. Since the prototype system only showed current broadcasting points at the start, the audience could not understand location of the still-pictures and prior still-pictures on the route. To solve the problems, the location information should be added to the still-pictures and the history of the still-pictures should be given to the audience. We added these functions to the prototype system. Figure 5 shows the implemented function for location and history of still-pictures. The audience can confirm the location and history of still-pictures shown as pins on the map and the still-pictures are displayed by clicking on the pins.

The second group of feedbacks is about "automatic photography timing." Many subjects told about the automatic photography timing. The feedbacks were "I would like to shorten the interval of the automatic photography" and "I do not need so many still-pictures because the still-pictures are similar ones." Furthermore, some subjects told about what still-pictures were required to help users understand the road situation. For example, the typical feedback was "During night-time, many rayless still-pictures were displayed and I did not understand the road situation when there were not streetlights." The still-pictures have higher demand in well-lighted area than in dark area. These results show the automatic photography timing should not be fixed and more flexible. If the timing was a fixed interval, poor demand still-pictures could be sent to audience. To enable audience to understand road situation more easily, the photography timing should be determined when the audience can understand the road situation from the still-picture.

5.2 Discussion

Since there were strong demand for improvement of the automatic photography timing, we focus on developing new photography timing algorithm in this paper. To improve the photography timing, we make two hypotheses about the photography timing. The first hypothesis is that the demand of road information is changed depending on the road situation. For example, the demand of road information can be higher in a good weather condition than in a bad weather condition, and higher in a congested road than in a no traffic road. The second hypothesis is that the demand of road information is different from person to person. In the experiment, we got different feedbacks about the photography timing even if they watched same broadcasting. These are also mentioned in a related work. Münter [9] found drivers need more support when they don't have spatial knowledge and sense of direction of the person, and

Table 2: Utilization of road information in similar services

Service Name	Vehicle Speed	Sudden Braking	Road Surface	Traffic	Weather
SAFETY MAP		○			
EuroRAP	○		○		
SafeRoadMaps			○	○	○
Mi Drive	○				○

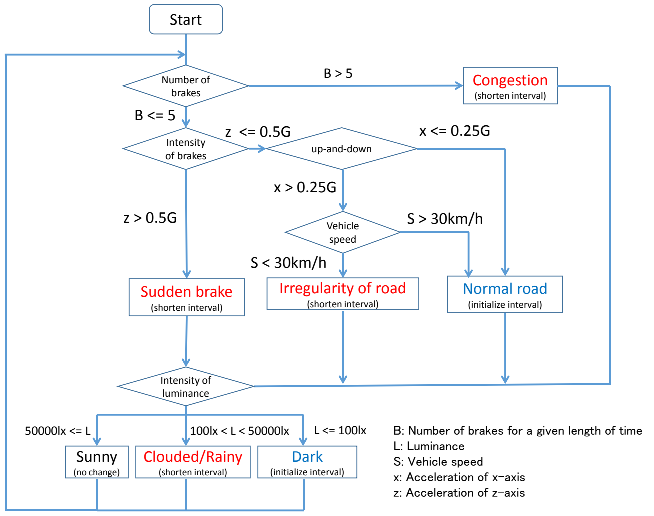

Figure 6: the photography timing algorithm based on road situation

weather condition is bad. An effective photography timing algorithm needs to be studied based on the hypotheses to provide high demand still-pictures to the audience.

6 PHOTOGRAPHY TIMING ALGORITHM

We developed two photography timing algorithms to verify the hypotheses. The first algorithm changes the photography timing based on road situation utilizing sensors of a smartphone. This algorithm takes into account the first hypothesis. The second algorithm changes the photography timing based on audience request in addition to road situation. This algorithm takes into account the second hypothesis.

To develop the first algorithm, we researched similar road information services and what types of road information is utilized. Table 2 shows the result. The SAFETY MAP [10] which is provided by Honda uses sudden braking information for detecting unsafe points. The EuroRAP (European Road Assessment Programme) [11] which aims to reduce death and serious injury uses vehicle speed and road surface information. SafeRoadMaps [12] which is developed by University of Minnesota and Claremont Graduate University uses road surface, traffic and weather information for safety alerts. Mi Drive [13] which is provided by Michigan Department of Transportation (MDOT) uses vehicle speed and weather information for safety information. From these results, the first algorithm collects vehicle speed, sudden braking, road surface, traffic, and weather information by smartphone sensors and changes the photography timing based on these information.

Figure 6 shows the photography timing algorithm based on road situation. The algorithm starts operation when the driver puts on the brake. If the number of brakes for a given length of time is greater than 5, the algorithm shorten the interval of photography timing because a lot of brakes mean current road is congested [14]. If the number of brakes is below 5, it checks intensity of the brake to detect a sudden brake. The interval of photography timing is shortened when acceleration of z-axis which is anteroposterior acceleration of the vehicle is greater than 0.5G. If the acceleration of z-axis is below 0.5G, the algorithm checks acceleration of x-axis which is vertical acceleration of the vehicle and its speed to detect irregularity of road [15]. If the road is bumpy, the algorithm shortens the interval of photography timing. Otherwise, the interval will be initialized. After that, the algorithm checks weather and daylight sensing intensity of luminance. If the weather is clouded or rainy, the algorithm shorten the interval of photography timing. If it is in dark, the algorithm initializes the interval because the still-picture will be black one.

For the second algorithm which introduces audience request, in addition to the first algorithm, it shortens the interval when an audience request is received. The audience requests are sent from audience clients by pushing on a request button on the user interface. If our hypotheses are true, the first algorithm based on road situation will be more effective than the fixed interval one and the second algorithm will be more effective than the first algorithm.

7 EVALUATION

We introduced the two algorithms of photography timing to the prototype system and evaluate how well the system provide profitable road information to the audience. We compared the effects of the fixed interval scheme and the algorithm based on road situation and the algorithm based on road situation and audience request in an evaluation experiment.

7.1 Environment

A broadcaster drove on a predefined route near our university as shown in Fig. 7 and broadcasted the driving scene with the prototype system switching the photography timing algorithms. The fixed or initial interval was set to 60 seconds. The smartphone which was used for the experiment was the au Galaxy S II. The maximum upload speed was 1.8 Mbps and download speed was 3.1 Mbps. The route included a broad road with heavy traffic, a narrow road in the neighborhood of housing estate, and a narrow road with many slopes and curves.

Figure 8 shows the user interface for evaluation. Subjects viewed the broadcasting using the audience client of PC version. A button for audience request, a question and answer section for the evaluation were added to the audience client. The subjects were 20 students who were from 19 to 22 years old, 17 male students and 3 female students. We conducted five broadcastings under the condition as shown in Table 3.

Figure 7: The driving route of the experiment

Table 3: The condition of the broadcastings

Date	Time	Weather	Num of Subjects
11/17	15:40~15:50	Rainy	5
11/25	13:00~13:40	Cloudy	2
11/26	15:30~16:10	Rainy	3
12/11	13:00~13:40	Cloudy	5
12/24	13:45~14:30	Snowy	5

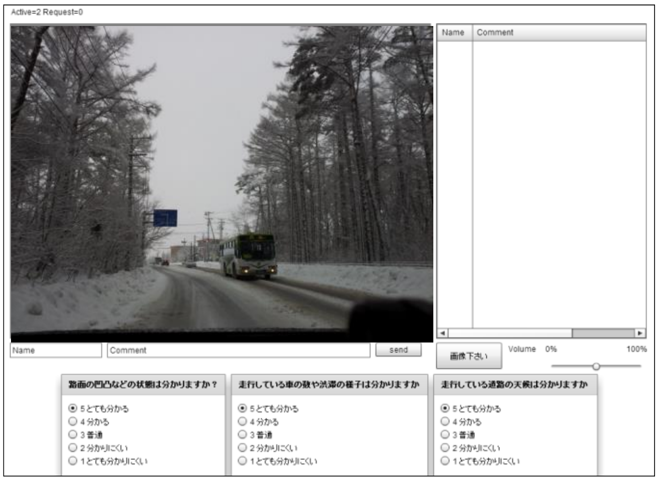

Figure 8: The user interface for evaluation

7.2 Results

Figure 9 shows the evaluation result comparing with each algorithm. We asked 5 questions to the subjects and they scored each question on 5-point scale. The blue bar shows the scores of the fixed interval one, the red bar is the algorithm based on road situation, and the green bar is the algorithm based on road situation and audience request. The first question shows usefulness of the proposed system for the route selection. The second question shows adequateness of the photography timing. The third, fourth and fifth questions show the understandability of weather, congestion and irregularity on the road respectively. For all questions, the green bar which is the score result of the algorithm based

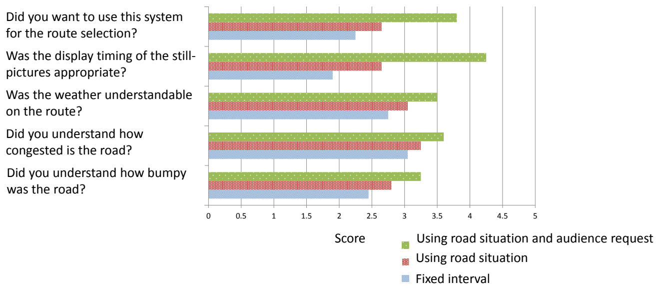

Figure 9: The result of the questionnaire comparing with each algorithm

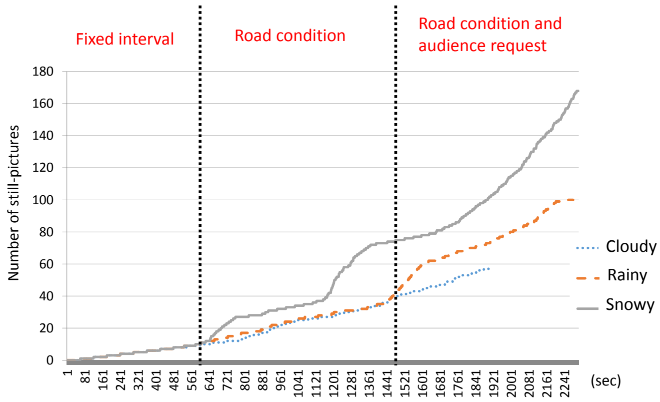

Figure 10: The number of still-pictures of each algorithm

on road situation and audience request is the highest. The score exceed 3 point which is the average score. Especially, the score of the second question exceeds 4 point. The red bar which is the score result of the algorithm based on only road situation is higher than the blue bar which is that of the fixed interval one. Meanwhile the red bar scores below the average score on first, second and fifth questions. This result shows the audience request is effective to provide timely still-pictures for sharing road information. This means that one of our hypotheses, "the demand of road information is different from person to person" is verified.

Figure 10 shows the number of still-pictures of each algorithm in different weather conditions. The horizontal axis indicates elapsed time from the beginning of the broadcasting. The vertical axis indicates the accumulated number of still-pictures. The algorithms were switched at the boundary of the vertical dotted line. From this graph, we found the number of still-pictures increased in worse weather conditions. Thus, the snowy condition increased the number of still-picture than rainy and cloudy conditions because the road surface was in the worse condition by fallen snow. The sensors of the broadcaster smartphone detect it and the algorithms shorten the photography interval. Considering the result of the questionnaire in Fig. 9 and the result of the number of still-pictures in Fig. 10, one of our hypotheses, "the demand of road information is changed depending on the road situation" is verified.

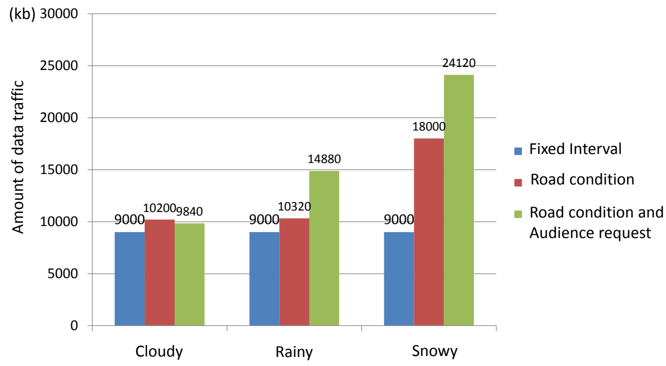

Figure 11: The amount of data traffic of each algorithm

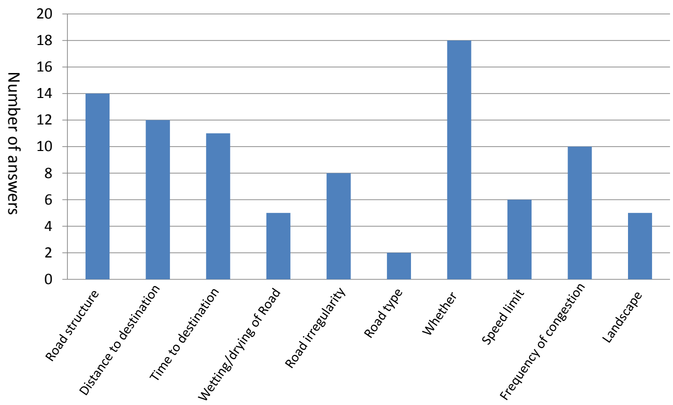

Figure 12: Attention points in driving a vehicle

At last, we evaluated the amount of data traffic of each algorithm in order to realize stable broadcasting without large increase in data traffic. Figure 10 shows the amount of data traffic of each algorithm. The horizontal axis indicates weather and the vertical axis indicates the amount of data traffic. The green, red and blue bar means the same as Fig. 11. From this graph, we found the data traffic increased in rainy and snowy weather conditions but the amount could be acceptable value. The amount of data traffic was highest in the snowy weather condition with audience request and it was about 24 MB. Comparing with the red bar, the data traffic increased about 30 % in the snowy weather condition. However, if we used a video streaming for sharing road information by Ustream in the same condition, the data traffic got about 114 MB. Since the algorithm based on road condition and audience request reduces about 80 % data traffic comparing with the video streaming scheme and realizes high user satisfaction, our proposed system can be effective and the photography timing algorithm should be based on road situation and audience request.

Additionally we asked the subjects about attention points in driving a vehicle for the future research. Figure 12 shows the results. The most subjects answered paying attention to the weather and it coincide with the result of figs. 10 and 11. Road irregularity and frequency of congestion which were introduced to our algorithm were also important for half the number of the subjects. These factors improved scores of our algorithms. On the other hand, road structure such as number of lanes, distance and time to the destination were important for more than half the number of the subjects. These factors will be effective to improve our algorithms for the future.

8 CONCLUSION

In this paper, we proposed a road information sharing scheme with a still-picture Internet broadcasting system. From the preliminary experiment, the right photography timing was an issue for the system. About the photography timing, we proposed two hypotheses that "the demand of road information is changed depending on the road situation" and "the demand of road information is different from person to person". Based on the hypotheses, we developed two photography timing algorithms which changes the photography timing based on road situation utilizing sensors of a smartphone, and based on road situation and audience request. From the evaluation, we found the algorithm based on road situation and audience request was most effective and our two hypotheses were proven.

In future work, we will improve the usability of the proposed system (e.g. the audience can see the vehicle information of the broadcasting in addition to still-pictures, and can watch the past broadcast programs by archiving environment.). We will also study a business model to provide more motivation to broadcast the driving.

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Yoshia Saito received his Ph.D. degree from Shizuoka University, Japan, in 2006. He had been an expert researcher of National Institute of Information and Communications Technology (NICT) from 2004 to 2007, Yokosuka, Japan. He was a lecturer from 2007 to 2011 at Iwate Prefectural University and He is currently an associate professor at the University. His research interests include computer networks, internet broadcasting. He is a member of IPSJ, IEICE, IEEE, and ACM.

Yuko Murayama is a professor at the Department of Computer Science at Tsuda College, Japan. Her research interests include internet, network security, human aspects of security and trust. She had a B.Sc. in Mathematics from Tsuda College, Japan in 1973 and had been in industry in Japan. She had M.Sc. and Ph.D. both from University of London (attended University College London) in 1984 and 1992 respectively. She had been a visiting lecturer from 1992 to 1994 at Keio University, and a lecturer at Hiroshima City University from 1994 to 1998. She has been with Iwate Prefectural University from April 1998 to 2015 and with Tsuda College since 2016. She is IFIP Vice President as well as TC-11 Chair. She serves as the Chair of the Security Committee for IPSJ (Information Processing Society of Japan) as well as a secretary for IPSJ Special Interest Group on Security psychology and trust (SIG on SPT). She is a senior life member of IEEE, as well as a member of ACM, IPSJ, IEICE, ITE and Information Network Law Association.