International Journal of Informatics Society

12/11 Vol. 3 No. 3 ISSN 1883-4566

Informatics Society

Aims and Scope

The purpose of this journal is to provide an open forum to publish high quality research papers in the areas of informatics and related fields to promote the exchange of research ideas, experiences and results.

Informatics is the systematic study of Information and the application of research methods to study Information systems and services. It deals primarily with human aspects of information, such as its quality and value as a resource. Informatics also referred to as Information science, studies the structure, algorithms, behavior, and interactions of natural and artificial systems that store, process, access and communicate information. It also develops its own conceptual and theoretical foundations and utilizes foundations developed in other fields. The advent of computers, its ubiquity and ease to use has led to the study of informatics that has computational, cognitive and social aspects, including study of the social impact of information technologies.

The characteristic of informatics' context is amalgamation of technologies. For creating an informatics product, it is necessary to integrate many technologies, such as mathematics, linguistics, engineering and other emerging new fields.

Guest Editor's Message

Teruhisa Ichikawa
Guest Editor of the Ninth Issue of International Journal of Informatics Society

We are delighted to have the eighth and special of the International Journal of Informatics Society (IJIS) published. This issue includes selected papers from the Forth International Workshop on Informatics (IWIN2010), which was held in Edinburgh, Scotland, UK, Sept. 13-16, 2010. The workshop was held at Royal British Hotel. This workshop was the fourth event for the Informatics Society, and was intended to bring together researchers and practitioners to share and exchange their experiences, discuss challenges and present original ideas in all aspects of informatics and computer networks. In the workshop, 26 papers were presented at four technical sessions. The workshop was complete in success. It highlighted the latest research results in the area of networking, business systems, education systems, design methodology, groupware and social systems.

Each IWIN2010 paper was reviewed in terms of technical content and scientific rigor, novelty, originality and quality of presentation by at least two reviewers. From those reviews, 17 papers were selected for publication candidates of IJIS Journal. This ninth includes six papers of them. The selected papers have been reviewed from their original IWIN papers and accepted as publication of IJIS. The papers were improved based on reviewers' comments.

We hope that the issue would be of interest to many researchers as well as engineers and practitioners in this area.

We publish the journal in print as well as in an electronic form over the Internet. This way, the paper will be available on a global basis.

Teruhisa Ichikawa is a professor at Faculty of Informatics, Shizuoka University. He graduated Department of Administration Engineering, Faculty of Engineering, Keio University in 1965 and received the Ph.D. in Engineering from Keio University in 2006. He joined Mitsubishi Electric Corporation in 1965. After 33 years of computer industry experience, he was transferred to Niigata International Information University in 1999. After that, he was transferred to Shizuoka University in 2002. His current research interests include modeling of enterprise systems and educational curriculum related to information systems. He is a member of IPSJ, JASMIN, ISSJ and INFSOC.

Distributed System with Portable Device Based on Gesture Recognition

Osamu Yuuki, Hiroshi Mineno and Tadanori Mizuno

Graduate School of Science and Technology, Shizuoka University, Japan
f5045016@ipc.shizuoka.ac.jp

Abstract –In this study, the communication between a server and a client is controlled via a user's gestures. Because a laptop device is usually operated through a handheld device such as a keyboard, mouse, laser-tracked pen or stylus, nearby people is disturbed by sounds such as the tapping of a keyboard or the clicking of a mouse. Contrastingly, natural communication involves the use of noiseless hand and body gestures. Client operators can use the proposed portable device through gestures. By this proposed method, people around the client can avoid the disturbance from handheld devices. And, -an operator can use the portable device based on intuitive gesture recognition.

In studies using three-dimensional (3D) imaging, high-performance computing is often required. Therefore, we usually use large computers. Such computers occupy a large space in an operation room, and a patient feels overwhelmed by computers in the room. Although a portable device does not have high calculation performance, it is possible to process many calculations between distant places by using the proposed distributed system. A portable device in a distributed system can perform data processing without having many internal resources. Therefore, people around the client do not feel overwhelmed by the client. We conducted the experiment by using GPU. The server was downsized by GPU. And its calculation speed was faster than the conventional technology such as a CPU.

The working of the proposed portable device operated by gestures is demonstrated. And, we evaluated a data transfer time, and calculation time.

Keywords: gesture recognition, distributed system, portable device

1 INTRODUCTION

In case of the studies containing 3D imaging, the ability of high-performance computing is often required to the computers. For example, Optoacoustic imaging in the field of medical requires many optoacoustic wave equations to be solved. For the calculation processing, we usually use large size computers. Such computers occupy a large space in an operation room, and a patient feels overwhelmed by computers in an operation room. Specifically, quiet surroundings are strictly required in a medical diagnosis room. It is important that a patient does not feel overwhelmed by any imposing surroundings. By using the proposed distributed system, large servers and a portable sized client can be set in place in separate locations. Because it is possible to handle data transmission between these separate locations, a portable device in the distributed system can perform data processing without having significant resources. Therefore, the servers do not disturb people in the room where the portable device is being operated. Client operators perceive that one database performs all the processing [1]. Of course, many portable devices can exist in a network. Better and simpler software development tools, along with cheaper electronics, make it possible to embed web interfaces into small and inexpensive microprocessor-based devices. This paper proposes the concept of an imaging device that can be incorporated into a web interface. We propose and design a wired or wireless distributed data acquisition system. The networks include a wired or wireless portable device as the client.

There have been some studies related to wireless client devices. This type of a system can be used as tele-medical system. The client devices in this environment would monitor standard physiological signals: Electro-cardio-gram (ECG), Electro-encephalo-gram (EEG), oxygen saturation (SO2), breathing, temperature [2][3] etc. The data of acquisitions would be processed by the client device. Then the data is stored on their secondary storage until the server could download and display the data. The physician monitoring a patient, connected to the client devices, would carry around a his mobile device to investigate/monitor the measurement from the patient [4]. The major requirements of the monitoring devices in such a wireless distributed data acquisition system are long battery life, lightweight, small size and big storage capacity [5][6][7]. However, these devices mainly communicate with the server unidirectionally. Usually a client devices cannot have high calculation performance.

In this paper, we describe the study of a wired or wireless distributed-data-acquisition-system based on an intelligent portable device.

The next topic concerns the control of a device. The operator can communicate with machines via a handheld device like a keyboard, mouse, remote control, laser-tracked pen, or stylus. If the machine is operated with a handheld device, people around the machine are disturbed by the sounds of the tapping of the keyboard or clicking of the mouse. The operator may try to communicate with machines via speech or activity/gesture. Because a variety of spontaneous gestures, such as finger, hand, body and head movements are used to convey information in interactions among people, among these methods, gestures can be considered a natural communication channel [8]. However the communication between a server and a client is controlled by an operator. We propose the communication operated by gestures. By this method, an operator can use the portable device based on intuitive gesture recognition.

2 SYSTEM STRUCTURE

2.1 Client/Server Distributed System

We describe the structure of our proposed client/server distributed system. The portable device, as a client, transmits the acquired data to the server. The server constructs the 3D image from the acquired data. After processing, all or parts of the data in the server are transmitted to a client. Figure 1 shows the system organization.

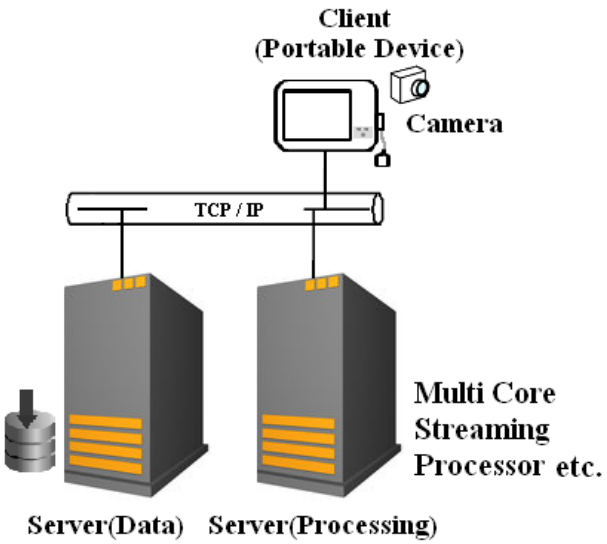


Figure 1: System Organization

The network is able to organize multi-clients/servers by sharing the data stored in servers. A monitor of client displays the functional 3D image. Volume rendering visualize a 3D dataset in a single image. Processing such images can be very compute intensive. And high quality renderings require the high calculation performance and the much storage spaces. 3D texture hardware can be addressed by three indexes (i, j, k). Index k is a depth of an image. In other words, it represents time series. Three indexes present a voxel (Volumetric Picture Element) cubic data set. A voxel is a volume element, representing a value on a regular grid in three dimensional spaces. Such images may be stored for viewing later or displayed in real-time. While simple images can be produced rapidly, more realistic and complicated higher-resolution images can now be produced in more reasonable amounts of the time. The desire to create high-quality work rather than simply wanting the same images created faster drives the need for increased computing power. The performance of a big server is typically limited by the performance of data room's cooling systems and the total electricity cost rather than by the performance of the processors. The computers, routers, power supplies and related electronics are typically mounted on racks in a server room or data center. Servers are currently too large to place in an operation room. Recently, one of our studies explored the feasibility of reprogramming modern video cards to perform rendering in the card's hardware. A GPU has many streaming processors [9]. If a GPU is used in the server, the calculation speed is faster than when the processing is performed by several multi-core-processors.

In this paper, we propose the recognition of gestures as a mean of command-input. The client merely consists of a camera (command-input-device), a data-acquisition-device and a monitor. The data-acquisition-device consists of a transducer (The transducer is the piezoelectric device that can measure sound levels.), analog-digital converters (A/D converters), the minimum amount of data memory (These is used for preserving digital data from channels of analog to digital converters.), and wired or wireless communication interface. In order that it can be embedded into a portable device, the monitor should be a type of flat-panel-display.

2.2 Data Flow

The portable devices record the data onto their temporary storage memory and transmit the data to the server using the "Transmission Data" command. The data flow of the portable device is shown in Fig. 2.

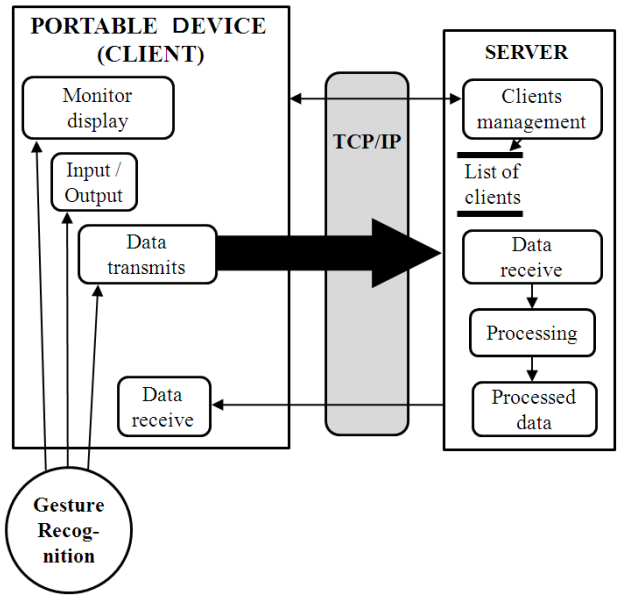


Figure 2: Data Flow of System

The sensor (such as a camera sensor, a time of flight measurement sensor, etc.) is fixed to the device, either internally or externally. The sensor (in this case, a camera) captures the image information in order to support the controlling of the device by gestures. The types of commands include I/O commands (such as data acquisition, monitoring, data transmission, etc.). The processing related to image recognition entails classifying gestures into different command types. These commands control sensors and actuators of the portable device. In other words, the gestures initiate controlling the events for the portable device. For example, a "Data-transmit" event transmits data, acquired by a transducer, transducer from the client to a processing-server. After the processing is completed by the processing-server, the client receives the voxel image data from the processing-server via a LAN or a WLAN.

Table 1: Assigned commands to gesture actions

Commands	Gesture Style	Direction
Acquire Data	Gripping Transducer	Client Only
Transmit Data	Assigning one finger	Client to Server
Display Image	Assigning two fingers	Server to Client
Display Information	Assigning three fingers	Server to Client

The complete system data flow is described as follows.

1. If the operator grips the transducer, the client starts the acquisition of data and stores the data to the memory in real time.
2. If a "Transmit Data" command is recognized by the Image Recognition Unit, the data is transmitted from the client to a processing server. After the processing server completes the reconstruction of a volumetric image from the data, the volumetric image is transmitted from the processing server to the client via a LAN or a WLAN
3. Finally, when a "Display Image" command is issued, display i/f outputs the volumetric image data to a client monitor.

2.3 Commands Based on Gesture Actions

We show the commands implemented for clients in Table 1. As mentioned above in Section 2.2, various command types are implemented in order to control the portable device. One command is used for acquiring data. The operator grips a transducer with hands to begin data acquisition. Another command is used for transmitting data. Commands for monitoring are used in order to display image or text information on the screen of a monitor.

If the portable device is operated with a handheld device such as a keyboard, mouse, laser-tracked pen, or stylus, people around the portable device are disturbed by the sounds of the tapping of the keyboard or the clicking of the mouse. Further, the operator must grip a transducer by hand for data acquisition. If he grips a handheld device in the other hand to communicate with the portable device, both his hands are now occupied.

Therefore, we use gesture recognition to enable the operation of the portable device. Object recognition in computer vision is the task of finding a given object in an image or video sequence. Humans recognize a multitude of objects in images with little effort, despite the fact that the image of the objects may vary somewhat in different viewpoints, in many different sizes, scale or even when they are translated or rotated. Objects can even be recognized when they are partially obstructed from view. This task is still a challenge for computer vision systems in general. However, we challenged to adapt the object recognition for the portable device.

2.4 Wireless Communication

The portable device, as a client, enables communication via a wireless port as well. A wireless portable device has many advantages, such as low power consumption, a small size, low cost, scalability, mobility, and flexibility.

We show the organization of a wireless system in Fig. 3. The system contains servers, portable devices, and an access point. Servers are placed in a fixed location. A processing server responds to requests from the portable device and reconstructs an image from the data acquired by the portable device that is placed in the operation room. The server returns a reconstructed image to the portable device after processing. The use of wireless communication provides more flexibility to the distributed system.

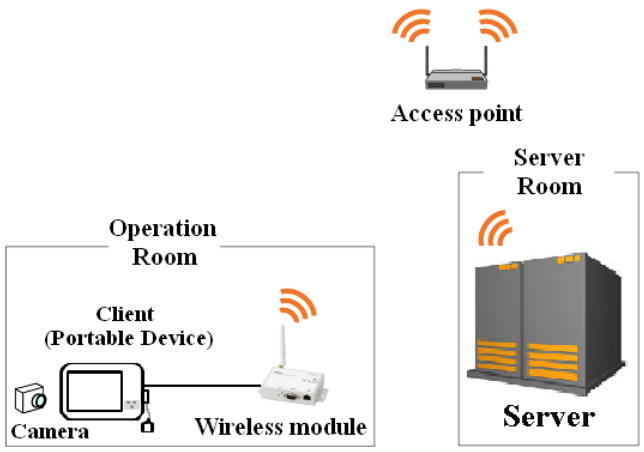


Figure 3: Wireless System Organization

3 DEVELOPMENT OF A PROPOSED PORTABLE DEVICE

3.1 Functional Prototype Device

We show the structure of a client in Fig. 4.

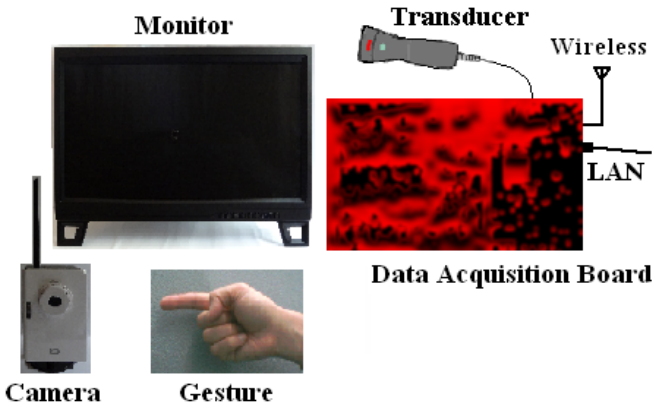


Figure 4: Functional prototype of the portable device

This is a functional prototype. The client consists of a camera as an input device, a data-acquisition-board, a monitor, and a transducer for scanning the object. The flat-panel-display device is used for monitoring the reconstructed im-

age, but it has not yet been embedded into the portable device. The data-acquisition board has communication ports: both wired and wireless. Therefore, the client can work as a standalone device, without the need to be placed near the server. Furthermore, the client operator can easily control the device via gestures.

We show a functional block diagram of the data-acquisition board in Fig. 5.

The Data-Acquisition Board consists of A/D Converters, the Memory, the CPU Core, the Image Recognition Unit, the Display i/f, the LAN port and the WLAN port. The A/D converters are connected to a transducer. The Memory caches the acquired data. The Image Recognition Unit recognizes the pattern of gestures using feature descriptors. The Display i/f outputs the reconstructed image or text information. Finally, the wired or wireless LAN is used to communicate with servers. The wired LAN port is a 1 Gbps Ethernet port. The wireless LAN port is an 802.11n wireless port.

If the operator grips the transducer, the board initiates the data acquisition and stores it to the memory in real time. If a Transmit Data command is recognized by the Image Recognition Unit, the data is transmitted to a processing server. After the processing server finishes reconstructing a voxel image from the data, the board receives the reconstructed image data from the processing server via a LAN or a WLAN. When a "Display Image" command is issued, the Display i/f outputs the voxel image to a monitor.

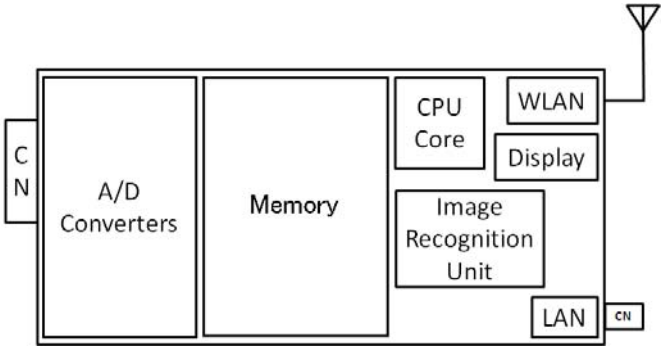


Figure 5: Functional block diagram of the board

3.2 Future Structure

We show a more suitable client structure in Fig. 6. The client consists of a camera as the input device, a monitor, and a transducer for scanning the object. The transducer has a data acquisition function and a WLAN function. The WLAN hardware inside the transducer is used for communication with servers. A transducer does not need to have cables. While the camera and the monitor are shown separate in this figure, these devices will be placed in the same casing in the future. An operator can hold the device by hand if the portable device is smaller and thinner. The operator can use the portable device by moving it. The portable device will recognize the direction of the movement of the background using its camera and perform the corresponding function. Other operators may hang the portable device on the wall, making gestures at the wall to control it. The portable device will recognize gestures and perform the corresponding function.

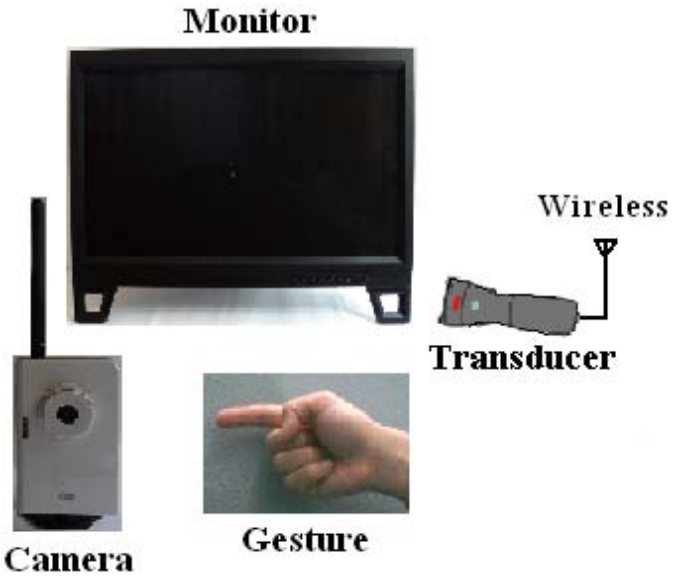


Figure 6: Functional parts for the suitable client

We describe a sample operation of the suitable client in Fig. 7.

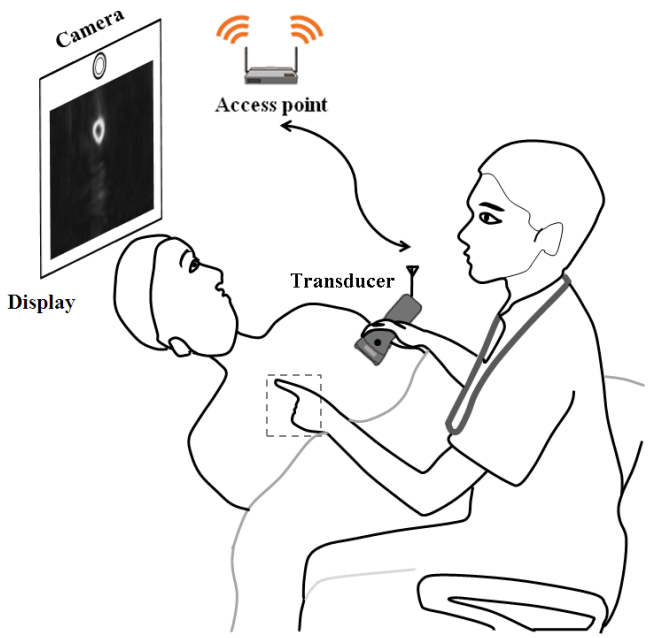


Figure 7: Assumed operation example of the suitable client

A monitor with a camera is hanging in an operation room. The transducer acquires the data because the operator grips the transducer. The operator makes a gesture with the left hand, to transmit the data. This gesture action is assigned the label "Transmit Data." The transducer has a data acquisition function and a WLAN function. The WLAN inside the transducer is used to communicate with servers. The trans-

ducer communicates with an access point (the access point communicates with the servers), as shown in this figure. The transducer does not have cables.

3.3 Gesture Recognition

Portable devices should be easy to use. As a target goal, the operator should be able to operate the portable device using intuitive gestures. We use a histogram of oriented gradient descriptors in order to recognize gestures. Histogram of oriented gradient descriptors is feature descriptors used in computer vision and image processing for the purpose of object detection [10]. The technique counts occurrences of gradient orientation in localized portions of an image. This method is similar to that of edge orientation histograms, scale-invariant feature transform descriptors, and shape contexts, however differs in that it on a dense grid of uniformly spaced cells and uses overlapping local contrast normalization for improved accuracy. The essential thought behind the histogram of oriented gradient descriptors is that local object appearance and shape within an image can be described by the distribution of intensity gradients or edge directions. Since the histogram of oriented gradients descriptor operates on localized cells, the method upholds invariance to geometric and photometric transformations such changes would only appear in larger spatial regions.

Moreover, coarse spatial sampling, fine orientation sampling, and strong local photometric normalization permit the individual hand movements of operators to roughly classify a finger position.

We recorded 2D images of gestures with a camera. Then, the images were saved to memory. We created template patterns from the images. We input a complete image from a camera to classify the image. We recognized the pattern of each image using histograms of oriented gradient descriptors. The result is shown in Fig. 8. The black rectangle is drawn around a recognized pattern

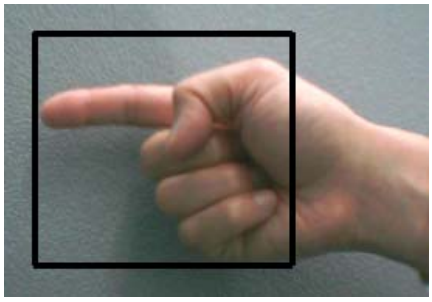


Figure 8: Example of Image Recognition for Classifying Gesture Actions

4 EVALUATION

4.1 Algorism of Optoacoustic Imaging

We selected optoacoustic imaging for the system evaluation. Optoacoustic imaging recently became the one of a subject of an emergency research in the field of medical diagnostics. We took a voxel image by using the distributed system including the portable device. Electromagnetic wave source are commonly used. The temporal shape and the duration of the optoacoustic yield information about the distribution of absorbed optical energy. The optoacoustic is measured outside the tissue and is used for generating tomography images of absorbing structures inside biological tissue [11]. The method of the optoacoustic signal detection is shown in Fig. 9 [12]. Optoacoustic imaging is a three-dimensional (3D) imaging technique since the scattered incident electromagnetic wave pulse generates thermo elastic pressure waves in absorbing structures located inside the whole irradiated volume. The detected acoustic pressure waves contain this 3D information which is utilized to reconstruct the distribution and shape of the absorbers in the irradiated volume. To acquire the amount of information necessary to reconstruct a 3D image, a method has to be used that efficiently samples the acoustic waves. One method is the measurement of two-dimensional (2D) snapshots of the pressure distribution in a plane at different delay times after the incident laser pulse. Based on such 2D measurements the pressure source can be reconstructed by using a radial back projection of the recorded pressure distributions from the detector plane into the source volume [13]. This is a very robust algorithm, which gives an image even if the number of collected 2D stress images and their resolution are low. Optoacoustic imaging has to solve many optoacoustic wave equations. We need huge power to solve these equations. These equations are defined by Equation (1), (2) and (3).

Wave equation for the velocity potential ψ can be expressed by next equation.

$$\Delta\psi - \frac{\partial^2\psi}{c^2\partial t^2} = \frac{\beta}{\rho C_p} S \qquad (1)$$

Where gradψ is the velocity vector of the wave motion, c is the speed of sound, β is the thermal expansion coefficient, ρ is the density, C_p is the specific heat capacity at constant pressure and S is the heat generated by absorption of an electromagnetic wave per unit volume and time. This equation is valid under the assumptions that heat conduction and viscous damping can be neglected. Under short pulsed irradiation the heat source term S can be expressed as $S(r,t) = W(r)\delta(t)$, using the volumetric energy density W.

With $p = -\rho\frac{\partial\psi}{\partial t}$, the wave equation for the acoustic pressure p can be expressed by next equation.

$$p(r,t) = \frac{\partial}{\partial t}\left[\frac{\iint p_{0(r')}ds}{4\pi c^2 t_{|r-r'|=ct}}\right] \qquad (2)$$

$$\text{With } p_0(r') = \frac{\beta c^2}{C_p} W(r')$$

The integration is performed over the surface of a sphere with surface element ds and radius ct around the detection point r.

In the following we will use a Cartesian coordinate system and assume that a line detector of infinite length is oriented parallel to the z -axis. It receives signals given by next Equation (3).

$$q(x,y,t)=\int_{-\infty}^{+\infty} p(x,y,z,t)dz \quad (3)$$

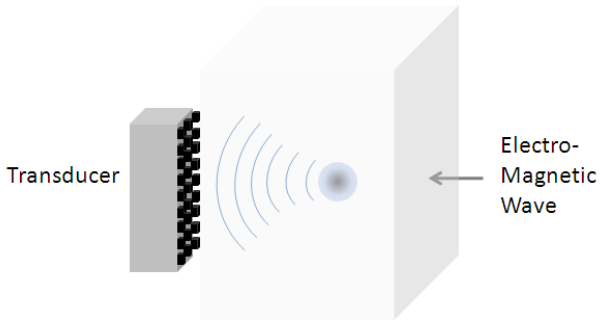


Figure 9: The method of optoacoustic signal detection

4.2 Evaluation System

Client configuration performed is as follows. (Refer to Fig. 4)

The client consists of a camera input device, a data-acquisition board, a monitor, and a transducer for scanning the object. The flat-panel-display device is used for monitoring a voxel image.

Server configuration is as follows.

The server has two 4-core Xeon processors and a GPU. The specifications of the video card using the GPU (nVIDIA Quadro FX4800) are as follows.

- Chipset:Quadro FX4800
- Stream Processors: 192
- Memory Bandwidth: 76.8GByte/sec

The video card's processing chip (GPU) has a parallel streaming architecture. The GPU has 192 streaming processors. If the GPU is used in a server, the speed of calculations becomes 100 times faster than a single-core processor with optimal parallelization. We used two 19-inch rack-mount cases with 36 units. The size of a server was downsized considerably by using a GPU. However, servers are still too large to fit in the operation room.

4.3 Experiment & Results

We evaluated the process of reconstructing a volumetric image. We show the material of a target object in Fig. 10. The target object is a black colored sphere shaped object in the intralipid with the coagulant. The black colored sphere is india ink as the absorber. First, we irradiate the electromagnetic wave to the target object. We receive the optoacoustic waves from the target object. Then we reconstructed an image of the black colored sphere shaped object in intralipid with the coagulant.

The system configuration for the evaluation is shown in Fig. 11. The transducer is connected to the proposed portable device. The electromagnetic wave is irradiated from the right side of a target object. And a transducer is arranged to the left side of a target object. The transducer detects optoacoustic signals. The signals are transmitted to A/D converters on the data-acquisition board, while the operator holds the transducer. The converted digital data are transmitted to a processing server via a LAN or a WLAN when a "Transmit Data" command is recognized. After the processing server completes the reconstruction of the volumetric image from the data, the volumetric image is transmitted from the processing server to the data-acquisition board via a LAN or a WLAN. When a "Display Image" command is recognized, the display i/f outputs the volumetric image to a system monitor.

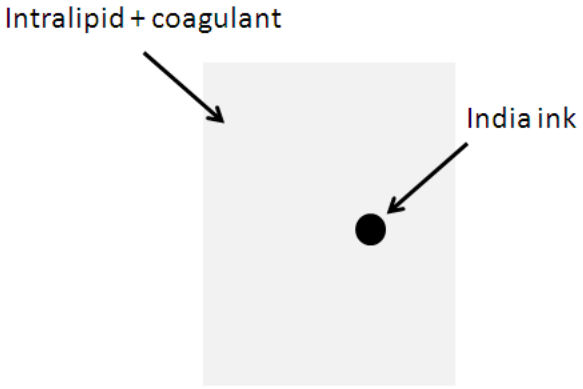


Figure 10: Material of the target object

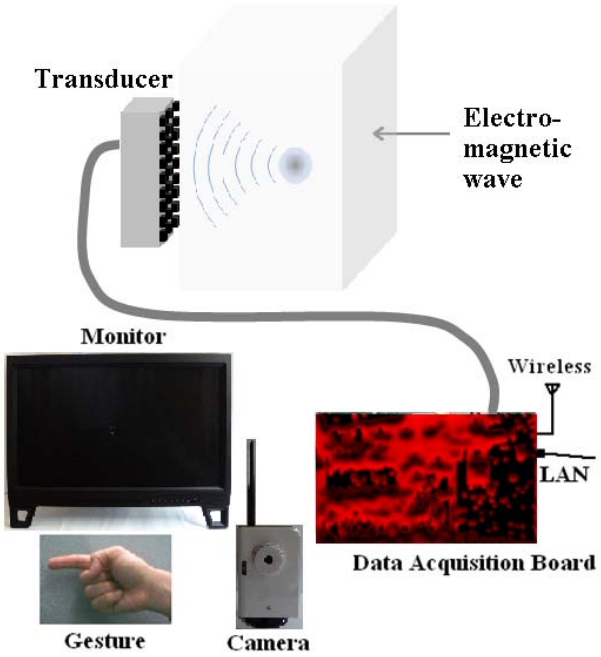


Figure 11: The system configuration for the evaluation

We performed image processing to reconstruct a volumetric pixel image. The reconstructed 3D image is shown in Fig. 12; it was obtained using the reconstruction algorithm mentioned above. In this experiment, it took approximately

to reconstruct a volumetric image using the two 4-core Xeon processors and the GPU in the processing server.

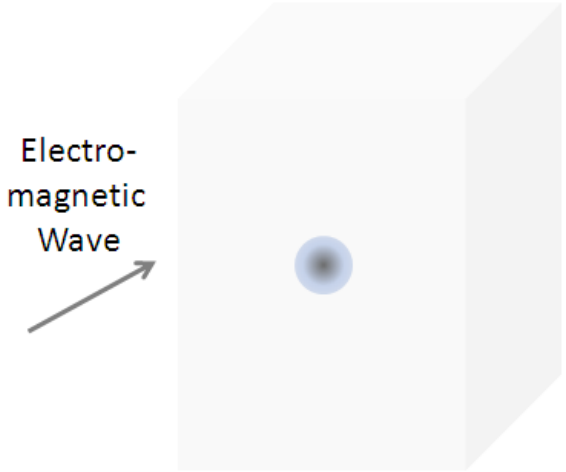


Figure 12: Reconstructed 3D Image

4.4 Summary of the Evaluation

The summary of the evaluation is as follows.

(1) The client prototype is not small enough to be treated as a portable device. Our future target is an iPad-size device that includes an embedded camera. The transducer will have a data acquisition function and a WLAN function.

(2) The gesture recognition system sometimes failed to classify gestures correctly. The rate of misrecognition was approximately 42%.

(3) It took 234 mS to process an optoacustic image using the wired network system. And, it took 303 mS to process an optoacoustic image by the wireless network system. The processing time consists of the data acquisition time, image reconstruction time, and communication time. It took approximately 60 mS to reconstruct a volumetric image using the GPU in the processing server. Other modalities are taking 5 minutes to 30 minutes for taking imaging. These systems are workable for screening diagnosis. For more many applications available, hereafter, we are trying to speed up the reconstruction time. The processing speed of the processing server is good. The portable device has a 1 Gbps Ethernet port. However, the average speed of communication is lower than the speed given in the specifications. It took approximately 74 mS to communicate between the client and the server. The transfer rate was approximately 122 Mbps.

For wireless communication, the portable device has an 802.11n wireless port. However, the average speed of this communication medium is lower than the specified speed. It took approximately 143 mS to communicate between the client and the server. The transfer rate was approximately 65 Mbps.

We have summarized these processing times in table 2.

Table 2: Time required for optoacoustic image processing

	Wired	Wireless
Amount time	234 mS	303 mS
Data acquisition time	100 μS	100 μS
Reconstruction image time	60 mS	60 mS
Communication time	74 mS	143 mS

5 CONCLUSION

In this study, we developed a portable device based on gesture recognition as a functional prototype. The communication between the server and the client is controlled by a gesture. We conducted an experiment using the portable device. The device was operated through gestures. We demonstrated that near natural communication could be achieved with the device by conveying information through gestures. People around the portable device were not disturbed by the noise of handheld devices. In addition, one hand of the operator remained free and could be used for other purposes. Furthermore, we conducted the experiment using a GPU. The server was downsized as a result of using the GPU, and its calculation speed was faster than that of conventional processors such as CPUs. We optimized the gesture recognition time, data transfer time, and calculation time. The proposed system used a Client/Server architecture. Therefore, servers did not disturb the people in the operation room, and people near a client did not feel overwhelmed.

In the future, we will design a smaller and thinner portable device. The communication and image-reconstruction speeds of the system achieved in this experiment will be improved. In addition, we will include many more cameras for a more accurate control of the portable device. We optimized a gesture recognition time, data transfer time and calculation time.

REFERENCES

[1] A. S. Tanenbaum and M. V. Steen, Distributed Systems: Principles and Paradigms, Pearson Education, (2003), T. Mizuno, T. Higashino, Y. Miyanishi, K. Suzuki, S. Nishiyama, and F. Satou interpreted to Japanese.

[2] J. Kela, P. Korpipaa, J. Mantyjarvi, S. Kallio, G. Savino, L. Jozzo, and S. Dimarca, “Accelerometer-based gesture control for a design environment,” in Personal and Ubiquitous Computing, vol. 10, Springer-Verlag, London, 2005.

[3] R. M. Satava, “Future Technologies for Medical Applications,” chapter in M. Akay, A. E. Marsh, ds, blfornzatiori Technologies in Medicine, Volume I: Medical Siniulation and Education, New York: John Wiley and Sons, pp. 219-236, 2001.

[4] SARCOS, http://www.sarcos.com

[5] S. Barro, et al., “Intelligent Telemonitoring of Critical Care Patients”, IEEE Engineering in Medicine and Biology, 18(4):80-88, 1999.

[6] B. Priddy and E. Jovanov, “Wireless distributed data acquisition system,” Proceedings of the Thirty-Fourth Southeastern Symposium (System Theory 2002), pp. 463-466, 2002.

[7] A. R. Al-Ali, Y. R. Aji, H. F. Othman, and F. T. Fakhreddin, "Wireless smart sensors networks overview," Proceedings of Second IFIP International Conference on Wireless and Optical Communications Networks (WOCN 2005). pp. 536-540, 2005.
[8] C. Lethanhman, H. Isokawa, and T. Kato, "Multipath Data Transmission for Wireless Thin Clients," Proceedings of Third International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies (UBICOMM '09), pp. 108-112, 2009.
[9] J. D. Owens, M. Houston, D. Luebke, S. Green, J. E. Stone, and J. C. Phillips, "GPU Computing," Proceedings of the IEEE, Vol. 96, Issue 5, pp. 879–899, 2008.
[10] N. Dalal and B. Triggs, "Histograms of oriented gradients for human detection," IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2005 (CVPR 2005). Vol. 1, pp. 886-893, 2005
[11] K. P. Köstli, D. Frauchiger, J. J. Niederhauser, G. Paltauf, H. P. Weber, and M. Frenz, "Optoacoustic Imaging Using a Three-Dimensional Reconstruction Algorithm," IEEE Journal of Algorithm Selected Topics in Quantum Electronics, Vol. 7, Issue 6, pp. 918–923, 2001.
[12] S. E. Vaartjesa, J. C. G. van Hespena, J. M. Klaaseb, F. M. van den Enghc, A. K. H. Thec, W. Steenbergena, T. G. van Leeuwena and S. Manohar, "First clinical trials of the Twente Photoacoustic Mammoscope (PAM)," Proceedings of SPIE-OSA Biomedical Optics, SPIE Vol. 6629 662917-1, 2007.
[13] G. Paltauf, R. Nuster, M. Haltmeier and P. Burgholzer, "Experimental evaluation of reconstruction algorithms for limited view photoacoustic tomography with line detectors," 2007.
[14] Beard PC, "Photoacoustic imaging of blood vessel equivalent phantoms," Proc. SPIE BIOS, SPIE Vol. 4618, pp. 54–62, 2002.

(Received July 6, 2010)
(Revised January 22, 2012)

Osamu Yuuki received the B.E. degree from Keio University, in 1998. He is currently in the doctoral course in information science in Shizuoka University, Japan. His research interests include distributed computing, and computer networks. He is a member of Information Processing Society of Japan, the institute of electronics, information and Communication Engineers, IEEE.

Hiroshi Mineno received his B.E. and M.E. degrees from Shizuoka University, Japan in 1997 and 1999, respectively. In 2006, he received the Ph.D. degree in Information Science and Electrical Engineering from Kyushu University, Japan. Between 1999 and 2002 he was a researcher in the NTT Service Integration Laboratories. In 2002, he joined the Department of Computer Science of Shizuoka University as an Assistant Professor. His research interests include sensor networks as well as heterogeneous network convergence. He is a member of IEEE, ACM, IEICE, IPSJ and Informatics Society.

Tadanori Mizuno received the B.E. degree in industrial engineering from the Nagoya Institute of Technology in 1968 and received the Ph.D. degree in computer science from Kyushu University, Japan, in 1987. In 1968, he joined Mitsubishi Electric Corp. Since 1993, he is a Professor at Shizuoka University, Japan. Now, he is a Professor at graduate school of Science and technology of Shizuoka University. His research interests include mobile computing, distributed computing, computer networks, broadcast communication and computing, and protocol engineering. He is a member of Information Processing Society of Japan, the institute of electronics, information and Communication Engineers, the IEEE Computer Society, ACM and Informatics Society.

Science and mathematics education using robot simulations

Taiji Koike[1*], Osamu Yuuki[2*], Kouji Yoshida[3*],Naoyuki Kubota[4*],
Tadanori Mizuno[2*], and Kunihiro Yamada[1*]

*1 Tokai University, *2 Shizuoka University,
*3 Shonan Institute of Technology, *4 Tokyo Metropolitan University
yamadaku@tokai.ac.jp

Abstract - We have developed four courses using special teaching materials, taking advantage of simulation experiments, and using game-like procedures with modern technologies to help students in primary and junior high schools understand science and mathematics and to augment their interest in these disciplines. These are based on commonly observed phenomena: (1) experiments help students feel and understand laws and principles of science and mathematics, and (2) amazing game-like operations often provide students with interest in these disciplines. We found that consecutive classes of these four courses in a short period promote their performance. For development, we have produced robots that simulate scientific experiments and perform game-like operations. Additionally, we have conducted experimental classes in primary and junior high schools to place our materials at the disposal of schools and to improve the materials by doing so. This research has been conducted under the auspices of Science Partnership Projects (SPP, a public research project) of the Japan Science and Technology Agency, an independent administrative institution.

Keywords: young students' aversion to science, robot, education, game

1. INTRODUCTION

We can recognize and appreciate recent developments in electronic devices, appliances, and vehicles that have been achieved through rapid development of microprocessors making full use of technologies of communication and control. Those technologies have transformed capabilities of mechanisms and electromechanical parts and have allowed them to mature over the years into higher systems. Consequently, boosted by growing human technology, great innovation has occurred in human–machine interfaces. In particular, remarkable innovations have been made in semiconductor and electronic parts. Hierarchical hardware and software mechanisms in conjunction with product development and computer aided design (CAD) systems have worked together effectively. Systems in product development are structured hierarchically and virtualized. Complicated products incorporating various technologies can be realized rapidly. That virtualization technology is indispensable in modern product and system development. Although that technology is a key in those endeavors, we only slightly recognize its exciting nature [1].

Students of the younger generation are moving away from exploration of science, perhaps because of virtualization technology. Although students of primary and junior high schools enjoy and resort to the convenience that products made using virtualization technology provide them, they might not be interested in overly complicated products themselves. Showing them the inside of a complicated product might be effective to help them become interested in science and related technologies, but we have not taken that road in this research. Instead, we have invented a course providing them simulation experiments using robots. The experiments, although not very spectacular, can be repeated at any time and can therefore offer students game-like fun. Consequently, we have sought to help them feel and know the laws and principles of science and mathematics. Our four courses are equipped with features of both simulation and game-like fun realized using robots.

2. PEDAGOGICAL CONSIDERATIONS

The trend of young people moving away from science has neither been defined clearly nor investigated sufficiently as a problem of elementary education systems in Japan. Although the importance of experiments in courses teaching science has been emphasized as a countermeasure against that trend, it has never been overlooked [2]. Not all problems in education are attributable to those of elementary education. We might think of three measures to settle any problem. The first is to remove the cause of the problem if found, the second is to alleviate problems irrespective of the knowledge of their causes. The third is to do nothing. We have taken the second option to activate science education.

The methodology of edutainment, with instruction accompanied by entertaining elements, was introduced long ago to enlighten and educate the public; in 1970, it was incorporated into radio programs. Such efforts are based on the idea that games enrich education [3][4]. We can imagine education-giving robots of three types. The first is a robot contest, in which students compete with their own developed robots. In this type of activity, students learn many techniques and skills in developing robots that might work. They acquire, along the way, better capabilities of working together. Then, the second is a course using robots where students learn the dynamics of robot behavior by watching them and learning further general knowledge and theory [5]. Finally in the third type, students learn with robots or robots teach them. Their robots become their friends and partners [6].

3. DEVELOPMENT OF TEACHING ROBOTS

We have developed four robots for courses in primary

and junior high schools and tested them in experimental classes as activities of Science Partnership Projects (SPP) [7] of Japan Science and Technology Agency, an Independent Administrative Institution. Four robots are an Imagine car of the future robot (FUTURE VEHICLE), a SUMO ROBOT, a Parabola-throwing bio-pitcher (BIO PITCHER), and a MATH ROBOT. Features of these robots are presented in Table 1.

Table 1: Education programs using Robots

	FUTURE VEHICHLE	SUMO ROBOT	BIO PITCHER	MATH ROBOTE
Educational merit in science and mathematics	very small	small	medium	large
Teaching skills using game-like procedures	large	medium	small	very small

Table1 shows the ratio of the element.
large > medium > small > very small

In the table, the row of "educational merit in science and mathematics" expresses the educational performance of each robot in illustrating or teaching laws and principles of science and mathematics. The next row of "teaching skills by game-like procedures" expresses how each robot teaches skills involved in these disciplines in a game-like environment. These four robots contained the element of "educational merit in science and mathematics" and" teaching skills by game-like procedures" though it did not intend. "Bioloid Beginner Kit" [8] and "ROBOBUILDER" [9] were used for our experiments.

3.1 FUTURE VEHICLE

This is a robot simulation automobile that is very familiar to students. Safety devices embedded in automobiles are crucial for the eventual implementation of safe cars. The central technology in them is automatic control using microprocessors. We have developed a robot that can stop immediately before colliding with a wall or a human. Such devices for real automobiles are under development [10] and will soon be mounted in them. Our robot is hoped to help students understand the future automobile we are anticipating. Figs. 1 and 2 depict the concept of our robot.

The robot is equipped with an obstacle-avoidance mechanism. Its sensor unit has an infrared transceiver module. Working together with these supportive devices, the PC maneuvers the robot through Zig-Bee communication. Students might simulate a driving situation, operating a PC by watching a picture transmitted from the camera mounted on the robot head. This driving simulation provides them with various effective edutainment, teaching safe driving techniques through two robots racing for example. This robot is intended to introduce sensor and control technology.

The first goal of the course using the "FUTURE VEHICLE" is to help students learn the outline of infrared communication that is widely used in our electric appliances, such as the remote controller for a TV set. Students therefore understand that they are relying on invisible light rays. The second is to learn a method to develop automobiles that might forestall collision by themselves. Students are asked to tune their robot vehicles equipped with obstacle avoidance mechanisms and a sensor unit that has not been adjusted properly yet. Third, students experience car racing and learn how to avoid accidents. Figure 3 shows the class scenery in the primary school.

Figure 1: Configurations of future vehicles.

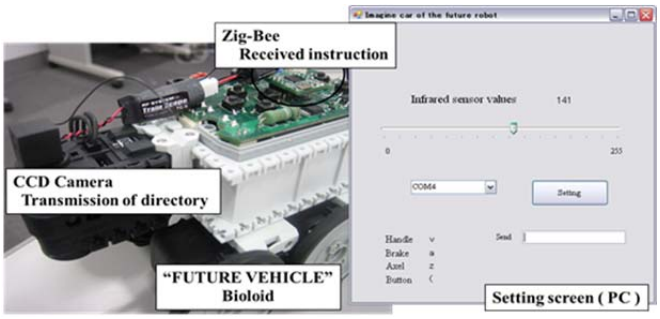


Figure 2: Configurations of future vehicles.

Figure 3: Air of the lecture [11]

3.2 SUMO ROBOT

Students often encounter robots, enjoying animated movies, for example. Such robots typically move exactly as human beings and their performance often outpaces that of human beings. However, practical robots perform only a few functions. Using this robot, we expect students to understand whether robots can move exactly as human beings. Students

are asked to discuss that after manipulating the robot we prepared for them.

For this robot, we used "ROBOBUILDER", which walks with two legs and which can be maneuvered by students quite easily. "ROBOBUILDER" can memorize any movement of the body (motion), if one gives any motion to it using one's hand. This procedure is designated as "making a motion." Figure 4 shows the PC display when this is being performed.

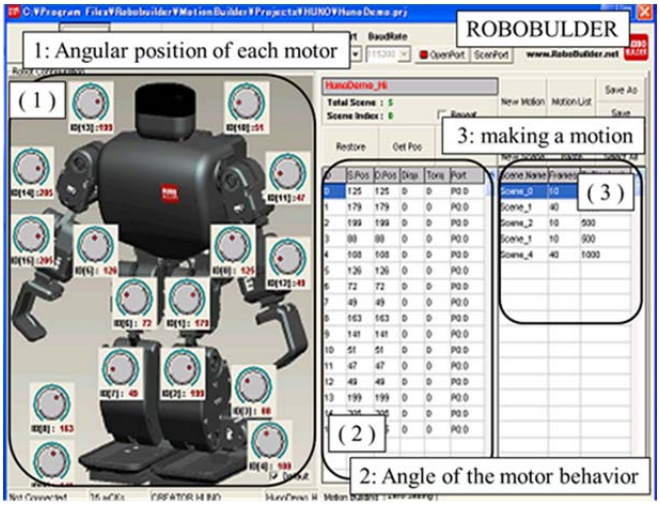


Figure 4: Sumo robot's programming motions on display.

The first goal of this Sumo robot is to make students recognize the difference of movements between those of robots and human beings. Students learn about the low visibility and poor maneuverability of robots and their difficulties in balancing. They then try to teach the robot some jujitsu moves (sumo wrestling). Meanwhile, they recognize the mobility and flexibility of human muscles. The second is to develop a robot itself making use of the "ROBOBUILDER". They program motions while considering the movement of the center of gravity and balance of the body. Finally they fight each other, maneuvering their robots using their own planned motions. Students might notice the difference in field of vision between the human eye and that of a robot because they fight only through wireless cameras mounted on robots. Figure 5 shows the lecture making scenery. Figure 6 shows the class scenery in the primary school.

Figure 5: Development scenery

3.3 BIO PITCHER

By maneuvering this robot, students explore the skill of throwing by questioning how far they can throw. They learn about the high degrees of freedom of joint characteristics of humans and the difference of body movements between robots and human beings at the scene of throwing. We expect

Figure 6: Air of the lecture [12]

them to understand the function of force and the nature of parabolas through this experiment of throwing. Furthermore, we hope they realize that force is a vector, having two properties of magnitude and direction, and that the natural phenomena are controlled by the principles of science and mathematics. Figure 7 portrays a parabolic course of a ball thrown by the "BIO PITCHER".

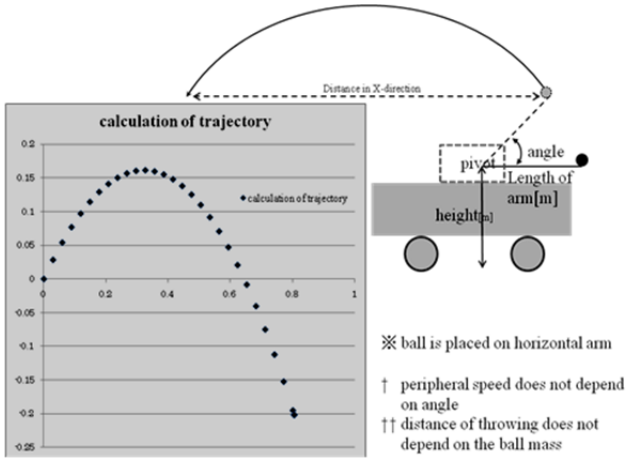


Figure 7: Parabolic path that a Bio-pitcher makes.

Our bio-pitcher is equipped with a controller and actuator and can exert force on an object. Students recognize that force can deform things and change the condition of movement. Furthermore, as described above, they are to understand that force has two properties of magnitude and direction. The configuration of our BIO PITCHER is portrayed in Fig. 8.

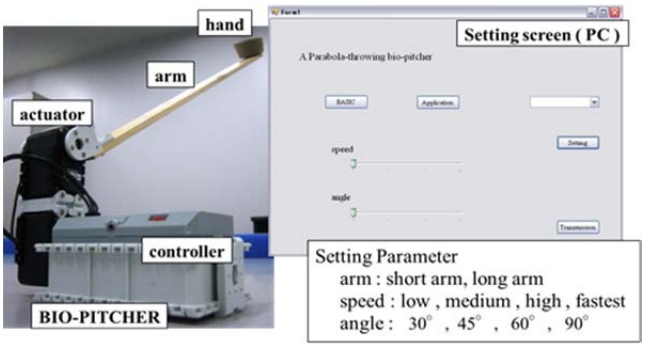


Figure 8: Configurations and setting parameter of Bio-pitcher

Students adjust parameters of throwing on their display and find, experimentally, the best setting to get the longest distance of throwing. Subsequently, they are asked to submit instinctive and logical estimations about throwing summarizing their group discussion. The adjustable parameters of throwing are the arm length, the actuator angle, and the launch speed: 32 combinations of these parameters can be set. Figure 9 shows the class scenery in the junior high school.

Figure 9: Air of the lecture

Students collect the throwing distance data for all these settings and discuss the differences between data and the two estimations presented above. It is necessary about the following two items if it is possible and learns. Simulation and reality differ, experiment is important.

3.4 MATH ROBOT

Displacement, velocity, and time are some of the central concepts in physics and the relations among them described by mathematics. Using this robot, students learn the relations from the travel motion of the robot car. They feel and recognize the relations at two occasions. The first occurs when they are watching a running robot; the second is when they are preparing graphs demonstrating the robot car's travel motion. They might feel them as they like. It might be the proportional relation or the linearity of graph. If they expect the existence of a functional relation, then the experiments can be said to have been very productive.

The graph doesn't do the thing generally drawn in the line chart. Because a few error margins go out. However, the elementary school student uses the line chart because it doesn't learn it. Finding the relation becomes a purpose in the graph. Drawing style in graph is learning by the compulsory education accurately. Figure 10 Gap by graph.

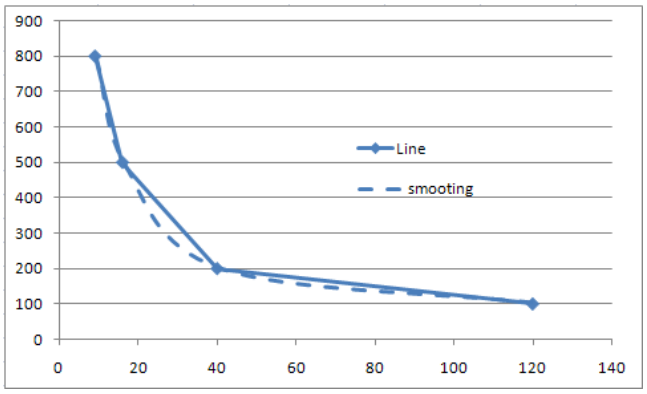


Figure 10: Gap by graph

Students are guessing, in daily life, the relation between displacement, velocity, and time by knowing the time interval required for walking a finite distance. Using the Math robot, they measure the displacement and time by themselves and present the data on graphs. They feel the relation among these physical quantities and then might reduce it to a simple mathematical expression. A set of these experiences is of the primary importance. In many classrooms, teachers are apt to adhere to teaching of the mathematical expression and will try to ask students to memorize it. This is, we believe, one of the causes of the trend among young students away from science. Our Math robot might make a linear run with uniform velocity and students might set a relation among displacement, time, and velocity on their PCs. Figure 11 shows our Math robot and the program controlling it. We merely ask students to show their data on a graph. At that time, we should not tell them about the type of graph and co-ordinate system. We should merely ask for some graphical representations. Perhaps they should be told that the common graph type used in these situations is only a rough representation. The instructor should not specify the type of graphical representation. If that were done, it would become another cause of young people's aversion to science. Figure 12 shows the lecture making scenery.

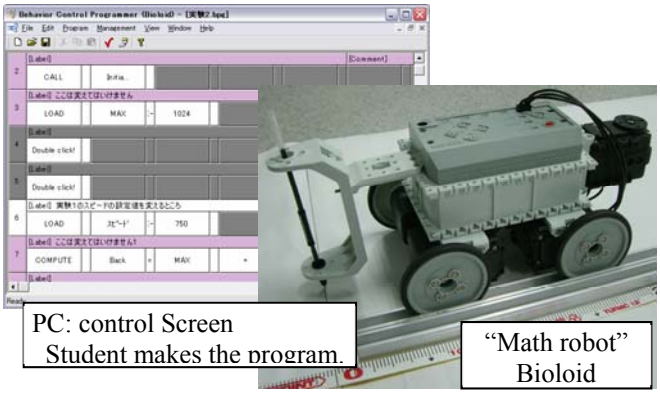


Figure 11: Math robot and program controlling it.

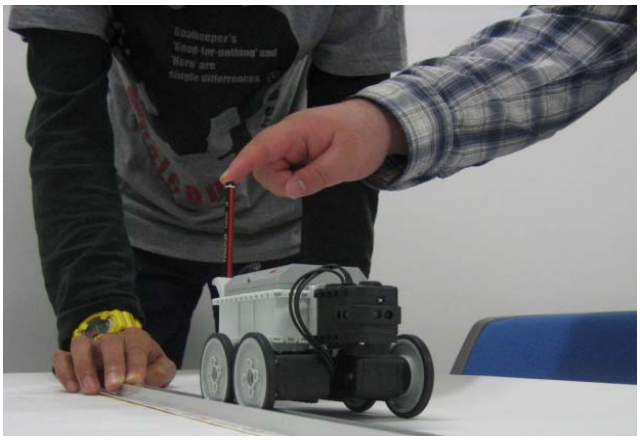


Figure 12: Development scenery

4. EXPERIMENTS AND EVALUATION

We gave experimental classes for 35 students of primary school and 16 students of junior high school and made a questionnaire survey of the change of interest toward science and mathematics after experiencing our experimental classes. The results of the survey are shown in Fig. 13. Before the classes, the percentage of students in primary school who liked (L) science and mathematics was 45%. That of students in junior high school was 38%. The weighted mean of these is 43.1%: all are less than 50%, as expected. After the classes, the percentage of students in primary school who changed from "dislike" (D) to "like" was 40%, whereas that of students in junior high school was 43.8%. The weighted mean of these is 41.2%.

In summation, students voted the L element (D⇒L⇒LL) after the classes, they occupied 85.7% in primary school. That percentage in junior high school was 81.2%. The weighted mean of these two marks was 84.3%.

We must refine the art of asking questions next. Although we shall expect no great improvement by this first trial, we have not detected anything bad. Therefore, similar ones are worth further trial.

Some students in junior high school confessed that they attended our classes simply because their friends did so. Therefore, their attendance did not necessarily reflect a special curiosity about science and mathematics, and these data suggest the effectiveness of group learning. In a free description section of the questionnaire, students in primary school wrote that they found the role of science and mathematics in daily life and that they were interested in the mechanical and electronic parts used in robots. This report suggests polarization of the effectiveness of the robots: as an experiment or as a game. Some students said that they could accommodate the tough discipline of science and mathematics if they were helped by a robot. This might be a similar notion to that shown by students imitating their friends, and might reflect the recent loneliness of students in Japan. If so, it might be developing not only to an aversion to science and mathematics but also to an aversion to human beings, which we might also be concerned about. To our great surprise, many students of junior high school expressed skepticism and criticism of the idea of robots in the questionnaire before

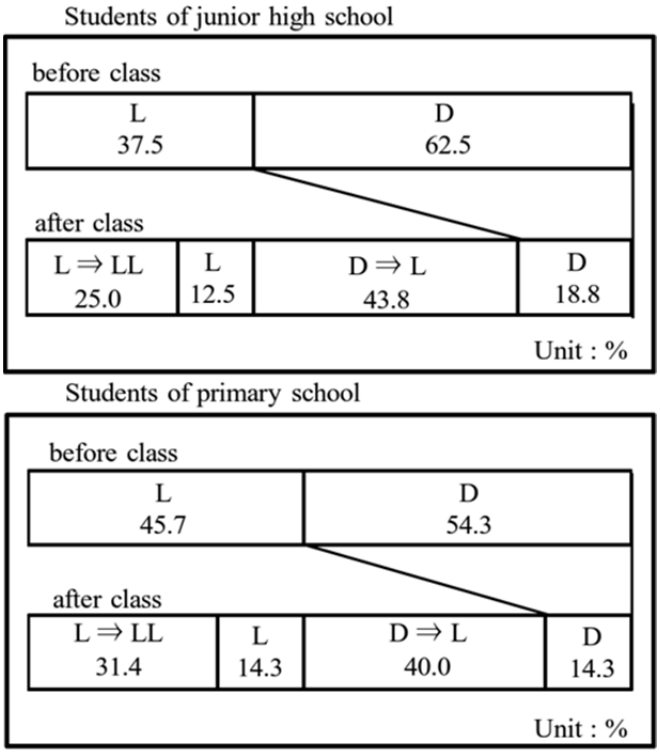


Figure 13: Students' interests changed after attending the course.

the class because of their imaginary nature. We are greatly interested in the underlying cause of that skepticism, whether it is the rough nature of robot systems or the surrealism of stories of robots losing touch with real life. However, students seemed happy touching and using the robots. Robots might constitute an effective countermeasure against the trend of young people moving away from science and mathematics and might simultaneously provide them with fun.

The first key point is to abandon one-sided lectures and explanations and to ask students to repeat a simple measuring experiment. The second is to make them understand the meaning of that experiment, playing games packed with modern technologies. Do not teach theory and natural laws first. Summarize them simply after the experiment and playing game. Do not place importance on theories and natural laws. Never ask students to memorize them. That surely enhances the aversion of young people to science and mathematics.

It is important as a countermeasure against aversion to science and mathematics to lead students to infer something from simple repeated actions. That stance is valuable by itself as well and encourages students to pursue their definite goal. To guide students into that direction is the very role of education. We have felt some success in this context. After experiments, students exercised great enthusiasm in calculation, discussion, and presentation. Students of primary

school have been very active and excited, and have shown strong concentration. Students of junior high school have shown excellent persistence in their logical progression to raising points at a question and answer session given after the presentation.

5. SUMMARY

We have developed four teaching materials to induce students in elementary education to be more interested in science and mathematics. Each covered the elements of experiments and games in different weight. Then we had experimental classes making use of those teaching materials in primary and junior high schools. We made questionnaire studies of the change of interest toward science and mathematics before and after our experimental classes, finding a positive trend. Providing four courses consecutively in a class yielded unexpected success. Students operated different robots, made group discussions and attended presentations. They were filled with tense excitement and made a unified effort with group members. They struggled and fought with science and mathematics, and then became winners.

In this article, two problems were left. First, it questioned immediately after and immediately before. It was very a great result. Next stage, we want to investigate and to examine whether the interest and the concern continue. Second, we have developed four teaching materials to induce students in elementary education to be more interested in science and mathematics. But they were only continuously executed. Next stage, how do the concern and the concern change while teaching each element ("Technical element" and "Educational element ") from a strong lecture to a weak lecture? This will become one of the research topics.

ACKNOWLEDGEMENT

The authors would like to thank Principal Tomoo Kume, Mr. Nobuaki Nakano, and students of Mikkabi Higashi Elementary School in Hamamatsu-shi, Shizuoka JAPAN (December 3–4, 2009). And,The authors acknowledge the contributions of Dr. Ryo Ishii and his students of Junior High School of Takanawadai High School attached to the Tokai University who contributed to prepare the class for us (December 19, 2009). The project was supported by Japan Science and Technology Agency (JST). The authors would like to thank the members of Science Partnership Projects (SPP), and Ms. Komiyama-san in SPP Head Office of JST for their management.

REFERENCES

[1] K. Yamada, K. Yoshida, M. Kojima, T. Matsumura, and T. Mizuno, "New System Structuring Method That Adapts to Technological Progress of Semiconductors," Proc. KES 2009, Part II, LNAI5712, pp. 773-782, (2009).
[2] K. Kamitori et al., "Report on Reviewing Experiments in Science Class at Public Junior High School in Three Prefectures of Kinki-district," Annual Report of Science Education, Osaka Kyoiku University, No. 25, pp. 21-32, (2004).
[3] K.H. Veltman, Edutainment, Technotainment and Culture, Veltman, K. H., Città Annual Report, 2003.
[4] M. Ito, "Engineering plays: Children's software and the cultural politics of edutainment," Discourse 27 (2), pp. 139-160, (2004).
[5] N. Kubota, Y. Wagatsuma, and S. Ozawa, "Intelligent Technologies for Edutainment using Multiple Robots," Proc. 5th Int'l. Symp. Autonomous Minirobots for Research and Edutainment (AMiRE 2009), pp. 195-203, (2009).
[6] A. Yorita, T. Hashimoto, H. Kobayashi, and N. Kubota, "Remote Education based on Robot Edutainment," Proc. 5th Int'l. Symp. Autonomous Minirobots for Research and Edutainment (AMiRE 2009), pp. 204-213, (2009).
[7] http://spp.jst.go.jp/
[8] http://www.robotis.com/zbxe/main
[9] http://roboone.shop12.makeshop.jp/html/newpage.html?code=13
[10] Safety Technology of Automobile, Web page of Nissan Motors, http://e2a.jp/trend/070627.shtml
[11] Chunichi Newspaper, "The science and arithmetic are interesting," December 5, 2009.
[12] Shizuoka Newspaper, "The operation of the robot is freedom," December 5, 2009.

(Received July 16, 2010)
(Revised May 2, 2012)

Taiji Koike graduated from Tokai University in 2009, received the M.E. degree from professional graduate school of embedded technology of Tokai University. In 2011, he joined TOYOTA TECHNICAL DEVELOPMENT Corp.

Osamu Yuuki received the B.E. degree from Keio University, in 1998. He received the M.E. degree from Tokai University, in 2010. He is currently in the doctoral course in information science in Shizuoka University, Japan. Since 1990, he joined Canon Inc.. He is currently a senior researcher at Canon corporate R & D. His research interests include image information processing, distributed computing, and computer networks. He is a member of Information Processing Society of Japan, the institute of electronics, information and Communication Engineers, IEEE.

Kouji Yoshida is a professor at Shonan Institute of Technology, Japan. He had Ph.D. from Shizuoka University of Japan in 2001. He worked at a Computer Scientist in the Information Engineering Works at Mitsubishi Electric Corp from 1972 to 2001. He had been a visiting lecturer at Nagoya Institute of Technology from 1996 to 1999. His major research includes distance learning and information technology. He is one of the members of IPSJ, IEICE Japan.

Naoyuki Kubota graduated from Osaka Kyoiku University in 1992, received the M.E. degree from Hokkaido University in 1994, and received the D.E. degree from Nagoya University, Japan in 1997. He joined Osaka Institute of Technology, in 1997. He joined the Department of Human and Artificial Intelligence Systems, Fukui University as an associate professor in 2000. He joined the Department of Mechanical Engineering, Tokyo Metropolitan University in 2004, and he has been a professor at the Department of System Design, Tokyo Metropolitan University since 2012. He was a visiting professor at University of Portsmouth, UK, in 2007 and 2009, and was an invited distinguished professor at Seoul National University from 2009 to 2012.

Tadanori Mizuno received the B.E. degree in Industrial Engineering from the Nagoya Institute of Technology in 1968 and received the Ph.D. degree in Computer Science from Kyushu University, Japan, in 1987. In 1968, he joined Mitsubishi Electric Corp. From 1993 to 2011, he had been a Professor at Shizuoka University, Japan. Since 2011, he is a Professor at Aichi Institute of Technology, Japan. His research interests include mobile computing, distributed computing, computer networks, broadcast communication and computing, and protocol engineering. He is a member of Information Processing Society of Japan, the Institute of Electronics, Information and Communication Engineers, the IEEE Computer Society, ACM and Informatics Society.

Kunihiro Yamada received the M.E. degree in electric engineering from the Ritsumeikan University in 1973 and received the Ph.D. degree in industrial science and engineering from Shizuoka University, Japan, in 1992. In 1973, he joined Mitsubishi Electric Corp. Since 2005, he is a professor at professional graduate school of embedded technology of Tokai University. His major research are improvement in a performance by form reform of a microprocessor and the mutual complement networks by wired and the wireless. He is one of the members of IPSJ Japan.

Evaluation of Mitigation to Bursty Packets by a TCP Proxy in a Wired and Wireless Network

Toshihiro Shikama†

†Fukui University of Technology, Japan
shikama@fukui-ut.ac.jp

Abstract - This paper investigates a TCP proxy that splits a TCP connection into two parts consisting of a wireless link and a wired network. The TCP proxy is effective for improving TCP performance in such a heterogeneous network including a wireless link, on which transmission errors occur. This paper describes how the TCP proxy produces large size forward data due to a packet loss on the wireless link. It also identifies a new problem that the output traffic from the TCP proxy becomes bursty due to the large size forward data. To mitigate bursts of packets by the TCP proxy this paper proposes a scheme that the proxy performs a pacing function, which places a gap between two consecutive packets. Since this function is performed in cooperation with the flow control between two TCP connections, the scheme has an advantage that it requires a small amount of forwarding buffers for the pacing. Simulation results using ns-2 show that bursty packets are produced by the conventional TCP proxy and the pacing function suppresses them. The results also show that throughput is improved by the proposed scheme, while the throughput of the conventional TCP proxy suffers from packet losses in the wired network due to the bursts of packets.

Keywords: TCP proxy, PEP, burst, pacing, reassembling

1 INTRODUCTION

Transmission errors have to be considered in IP networks that employ wireless links. Although TCP is mainly employed end-to-end in the Internet, it is well understood that TCP cannot achieve sufficient throughput in the environment where packets are lost due to transmission errors. TCP assumes that losses of packets are derived from a buffer overflow at a forwarding node; it invokes the congestion control to reduce traffic. In the case where losses of packets are caused by transmission errors on a wireless link, the congestion control is performed unnecessarily; a degradation of TCP throughput occurs.

One approach to mitigate this problem is to employ a TCP proxy called PEP (Performance Enhancing Proxy) that terminates a TCP connection from a source terminal and establishes another TCP connection to the destination terminal [1]. It forwards receive data from one TCP connection to another. As the large round-trip delay causes low throughput and the PEP makes the delay short by splitting a TCP connection, the throughput is improved. Although termination of a TCP connection by the PEP has a significant impact on the characteristics of an IP flow, a study on this aspect hitherto has not been done. This paper focuses on the property of output traffic from the PEP and identifies a problem concerning bursts of packets due to the termination of a TCP connection. It also proposes a mitigation scheme for the problem and evaluates its effectiveness by simulations using ns-2.

This paper assumes that a PEP is placed in a node which connects a wireless link to a wired network. In the following description, we introduce the term “a wireless section” to refer to the wireless link. We also call the wired network “a wired section.” Figure 1 illustrates an example of an error recovery sequence by the PEP placed between the wireless section and the wired section. When a loss of a packet occurs on the wireless section, an error recovery by a retransmission of associated segment is performed by TCP over the wireless section. The figure assumes that the fast retransmit is invoked after three duplicate ACKs. If a receiving side of TCP in the PEP accepts out-of-order segments after the lost one, it retains them in its receive buffer to reassemble them. When the lost segment is retransmitted and received correctly, the reassembling of data is completed; the whole data consisting of the lost segment as well as the buffered segments is forwarded to the next TCP connection over the wired section. In this paper, we call this data “forward data.” Since the size of the forward data might be up to the window size of TCP over the wireless section, a large number of segments might be generated at the same time. In Fig. 1, a burst of packets is immediately sent by the PEP after the arrival of the retransmitted segment. The burst of packets should be avoided, since it may cause a buffer overflow at a node forwarding these packets on the wired section.

With regard to the busty packets from TCP, RFC 2581 specifies that TCP should employ a slow-start after a silent period of more than one RTO (Retransmission Time Out) [2]. In the normal case, when an application program issues a send request for large size data, the transmission of segments begins with the slow-start and enters the ACK clocking state after some transient period [3]. A burst of packets occurs during the period of the slow-start only. The maximum transmission rate of the burst by the slow-start is suppressed to the rate twice as large as the bandwidth of a TCP connection. However, in the case of a burst by the PEP, its transmission rate may become up to the rate of the Physical Layer, which is generally much larger than the bandwidth of a TCP connection. This means that bursts by the PEP have significant effects compared with bursts by the slow-start.

In the case of the conventional end-to-end TCP, a burst of packets of which size is equal to the TCP window may occur, if two send requests of large size data are issued within the interval of less than one RTO period. The second send request

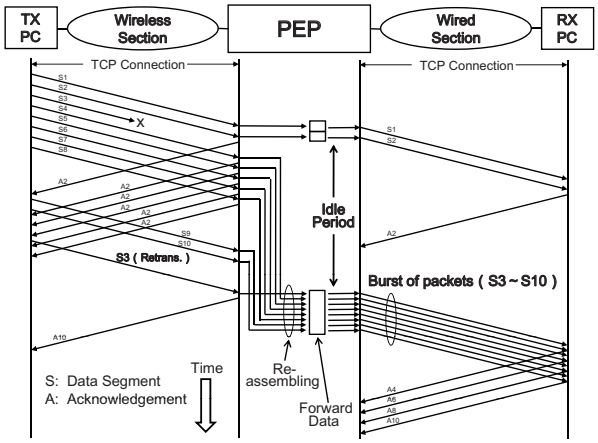


Figure 1: Data forwarding by a PEP and its output traffic.

may cause such large burst, since the slow-start is not invoked for this request. However, in the case of conventional applications based on the client-server model, a send request of large size data occurs after the previous transfer of large size data to a destination client has been completed and the client issues the next data request. As the interval between two send requests is usually larger than the RTO period, the slow-start is invoked for each send request. Therefore, the large size burst issued by TCP is not serious for the conventional end-to-end TCP.

In the case of the error recovery sequence by the PEP illustrated in Fig. 1, there is an idle period over the wired section from the loss of the segment to the reception of the retransmitted segment. However, the duration of this period is comparable with one round-trip time of the wireless section, which is much smaller than the RTO value of TCP over the wired section. Therefore the slow-start is not invoked in this case; a burst of packets derived from the large size forward data is likely fed into the wired section. Based on these reasons, it can be said that bursts of packets issued by the PEP may cause serious effects to the wired network in comparison with the case of end-to-end TCP and their mitigation is significant.

The rest of this paper is organized as follows: Section 2 discusses related work concerning PEP. Section 3 discusses the condition of burst generation and proposes a scheme to mitigate bursts of packets. Section 4 describes the simulation models and associated assumptions. Section 5 describes simulation results and discussion. Finally our conclusion is presented in Section 6.

2 RELATED WORK

Concerning the problem of the poor performance by TCP for a network including a wireless link, improvements of the congestion control done by TCP are studied. A typical version of TCP is Westwood [4], which estimates an available bandwidth. When it detects a packet loss, it identities the cause of the loss by checking whether the available bandwidth is larger than the actual transmission rate. If this is the case, the congestion control is not invoked. This approach of improving TCP has a problem that TCP in an existing PC has to be changed.

Another approach to improve the TCP performance in a wireless network is to employ local retransmissions by Link Layer protocol over the wireless section [5]. Since the Link Layer protocol hides from TCP all packet losses over the wireless section, the performance of TCP is improved. However, the modification of the protocol stack in an existing PC is needed. This approach also has the problem of spurious timeouts in TCP. Snoop [6] is a kind of local retransmission scheme, which uses duplicate TCP ACKs to invoke a retransmission of a lost packet. This scheme has an advantage of no modification of an existing PC. However, since it merely performs retransmissions of lost packets, packets arrive at the destination out-of-order. It requires a mechanism to avoid unnecessary duplicate ACKs, which is hard to implement if TCP employs SACKs.

PEPs are traditionally employed in satellite networks where a propagation delay is large. However, it is also effective to improve throughput of terrestrial radio networks of which transmission rate is increasing rapidly [7]. RFC3135 surveys various PEP architectures and their effects on the performance as well as reliability of a system. It also describes details of the controversial problem that a PEP cannot keep end-to-end semantics of TCP acknowledgement. It refers to the possibility that a PEP may send a burst of data segments due to ACK handling done by the PEP. It also describes the scheme that places a gap between ACKs to suppress the bursts. However, it never refers to the bursts of segments by the reassembling function done by the PEP.

The PEP architectures include a scheme, in which a PEP does not terminate a TCP connection, but it returns an early ACK to the sender on behalf of the destination. As the PEP does not terminate a TCP connection, bursts of segments due to the reassembling never occur in this scheme [8]. Since this scheme has to keep copies of forwarded segments in provision for segment losses for which the PEP has sent ACKs, it has problems that complex retransmission procedures as well as the buffer management are required.

Concerning bursts of packets sent by TCP for the case where TCP is employed end-to-end, bursts of packets issued by TCP are studied and classified into micro-bursts and macro-bursts [9]. However, the cause of bursts by the PEP described in the previous section is different from mechanisms described in the literature.

A natural way to mitigate the bursts of packets is to suppress the peak rate of packets at the output of TCP. In a Linux environment, a simple way is to employ TBF (Token Bucket Filter) to shape the output traffic from TCP. However, if there are multiple TCP connections, it is hard for this scheme to suppress the peak rate of each TCP connection. A scheme that suppresses the peak rate of packets precisely at the output of TCP has been proposed in Linux [10]. This scheme employs a special PAUSE frame to place a gap between two consecutive packets. However, if there are multiple TCP connections, it is hard for this scheme to suppress the peak rate of each TCP connection. In addition to this problem, although this scheme needs a large number of buffers to perform the packet pacing, it is hard to predict the required number of buffers. Packet losses due to internal buffer overflows may occur at

the pacing, if there are a large number of TCP connections.

There is a possibility that introduces the pacing function into TCP itself. Although the best performance can be expected by this approach, a modification of existing TCP implementations, which is generally hard, is needed. There is a study [11] that implements TCP as a user level library, where the rate control consistent with the TCP flow control is implemented. Although this approach has advantages that new functionalities can be easily added to TCP and development including debugging is easier than in-kernel implementation, it requires a large software development cost. A large test cost is also needed to check the conformance to the existing implementations of TCP. In this paper, we assume that the PEP is realized using existing TCP implementations in the conventional Operating Systems that have been well test and widely used.

3 THE CONDITION OF BURST GENERATION AND A MITIGATION SCHEME FOR BURSTS

3.1 The condition on bursts of packets by TCP

Since a sending side of TCP stores send data in its buffer and it performs the window flow control, a send request for large data may not directly cause a burst of packets by TCP. However, the pacing at the input of TCP can be effective for the following reasons. When TCP continues the transfer of data in a steady state, ACK clocking is effective. In this case bursts of packets are not generated, even though a send request for large data is issued. Figure 2 (a) shows the window of this condition. After TCP sends data segments of TCP window size, it waits for an ACK from the receiving side of TCP; it cannot send further segments even though a new request for send is issued. Transmission of segments is performed, only when a new ACK arrives; TCP cannot be disturbed by the arrival of a new send request. In this condition, bursts of packets never occur.

Bursts of segments can be sent by TCP, when the window is open largely as shown in Fig. 2 (b). Segments up to the open window size can be immediately send by TCP, when a send request for large data is invoked. From Fig. 1, as mentioned before, there is an idle period over the wired section from the loss of a packet to the reception of the retransmitted packet. During this period, since a number of ACKs are received by the sending side of TCP of the wired section, a substantial number of outstanding segments are acknowledged; the TCP window opens largely, before a send request for the large size forward data is issued. Therefore, a burst of segments is sent by TCP.

3.2 A proposed scheme

This paper proposes a scheme that performs the pacing at the input of TCP as shown in Fig. 3. The pacing function is performed by the application program that forwards data from TCP. This function segments the large size forward data into multiple data chunks of which size is MSS over the wired

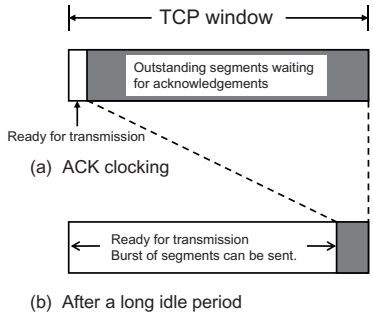


Figure 2: The condition on the occurrence of packet bursts.

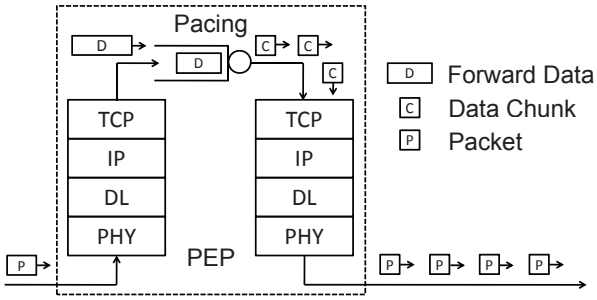


Figure 3: Relation between forward data and bursts of packets.

section. It issues a send request for each data chunk to TCP at a specific rate. This scheme has the following advantages.

- Pacing on each TCP connection can be performed independently.
- Pacing can be performed in cooperation with the flow control between two TCP connections. If large size data is forwarded from the wireless section to the wired section, the pacing function is able to stop receiving further data from the wireless section until the send requests for all chunks of the large size forward data have been completed. Because of this flow control, a packet loss due to a buffer limit never occurs at the PEP.

3.3 A pacing rate

When the pacing is employed, a problem is how to determine the suitable packet rate after the pacing. In this paper, we simply apply the packet rate derived from the transmission rate of the wireless section, assuming that the rate of the wireless section is smaller than the bottleneck rate of the wired section. There are possibilities of sophisticated schemes to determine the pacing rate, for example, estimation of end-to-end throughput over the wired section. These are left for further study.

4 SIMULATION MODELS

This paper evaluates output traffic from the PEP and effectiveness of the proposed scheme by simulations using ns-2 [12]. We compare the following three schemes.

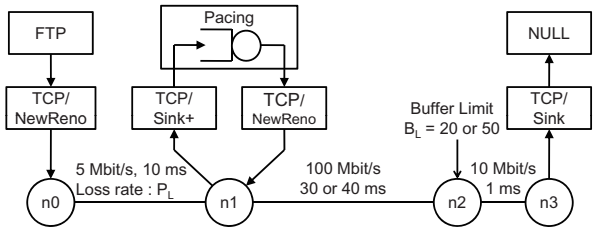


Figure 4: Simulation model for Scheme A (PEP with pacing).

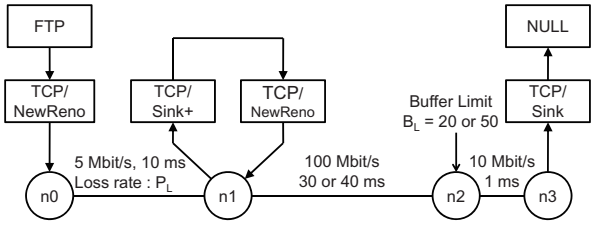


Figure 5: Simulation model for Scheme B (PEP without pacing).

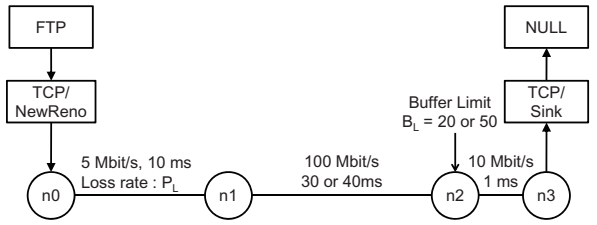


Figure 6: Simulation model for Scheme C (No PEP).

- Scheme A: PEP with pacing (proposed scheme)
- Scheme B: PEP without pacing (conventional PEP)
- Scheme C: No PEP (end-to-end TCP)

Figure 4 shows the simulation model for the proposed scheme where the PEP with pacing is employed, while Fig. 5 shows the simulation model for the conventional PEP where the pacing is not employed. NewReno TCP is employed for both the wireless and wired sections. Node n1 represents the PEP that terminates a TCP connection over the wireless section (from node n0 to node n1) and forwards received data to the next TCP connection over the wired section (from node n1 to node n3). Since original ns-2 does not have the function of delivering received data to the upper application layer, we added this function to a TCP sink in ns-2. This is indicated as "TCP Sink+" in Figs. 4 and 5. We measured the throughput of these schemes as well as the distributions of the number of packets included in a burst sent by the PEP.

The bandwidth of the wireless section is assumed to be 5 Mbit/s, while the PEP is connected to node n2 with the rate of 100 Mbit/s. Node n2 is connected to destination node n3 with the rate of 10 Mbit/s, which is assumed to be the bottleneck bandwidth B_W over the wired section. Since there is a difference of packet transmission rate between input and output in node n2, bursts of packets may be queued at this node. Moreover, we assume insufficient buffering at a node connected to the bottleneck link. The number of buffers in node n2 is limited; packets may be lost when a burst of packets is fed into this node. In order to confirm the improvement of the total throughput by the PEP we also simulate the case where a PEP is not employed. Figure 6 shows the model of scheme C (No PEP), where an error recovery is performed by TCP end-to-end. Table 1 summarizes the simulation parameters.

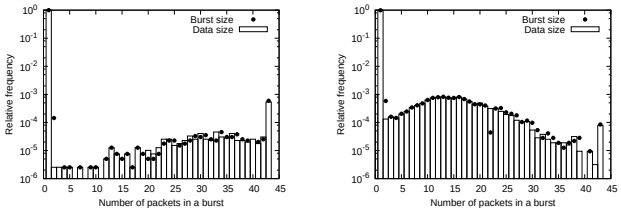
Table 1: Simulation parameters

Rate of the wireless section	5 Mbit/s
Delay of the wireless section	10 ms
TCP version for the wireless section	NewReno
TCP window for the wireless section	64 KB
Generation of packet losses	random
Packet loss rate: P_L	0.0001, 0.0002, ... , 0.05, 0.1
TCP version for the wired section	NewReno
TCP window size for the wired section	128 KB
Delay of the wired section: D_W	30 ms, 40 ms
Window size of end-to-end TCP	128 KB
The number of TCP connections	1
Rate of the wired section (PEP to n2)	100 Mbit/s
Interface rate from node n2 to n3: B_W	10 Mbit/s
The number of buffers at node n2: B_L	20, 50 packets
Simulation time	1000 sec
The number of simulation runs	10

5 SIMULATION RESULTS AND DISCUSSION

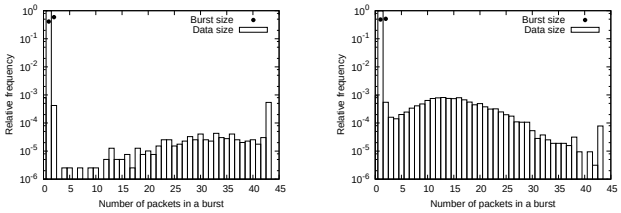
5.1 The distributions of the forward data sizes and the number of packets in a burst, where node n2 has sufficient buffering

Figure 7 shows the distributions of both the forward data sizes and the number of packets in a burst, where node n2 has enough number of buffers and the pacing is not performed. The packet loss rate P_L is selected to 0.001 and 0.01. The simulations for this figure are performed on the condition that the pacing is not performed and node n2 has enough number of buffers, which is larger than the window size of TCP over the wired section, to eliminate effects of packet losses due to buffer overflows caused by the bursts of packets. Since the maximum size of bursts can be suppressed by the window size, if node n2 has the number of buffers that is larger than the maximum window size (43) of TCP over the wireless section, a buffer overflow never occurs at node n2. The bandwidth of the bottleneck link is also twice as large as the bandwidth of the wireless section, so that the throughput of the wired section is always larger that that of the wireless section. This means that the PEP does not invoke the flow control between the wireless section and the wired section. As the original size of forward data is measured in bytes, the values of data size indicated in the figure are divided by MSS (Maximum Segment Size: 1460 B) to compare with the number of packets in a burst. In this figure rectangle boxes (Data size) represent the distribution of the forward data sizes, while



$P_L = 0.001$ $P_L = 0.01$

Figure 7: The distribution of the forward data sizes and the number of packets in a burst, where pacing is not performed.



$P_L = 0.001$ $P_L = 0.01$

Figure 8: The distribution of the forward data sizes and the number of packets in a burst, where pacing is performed.

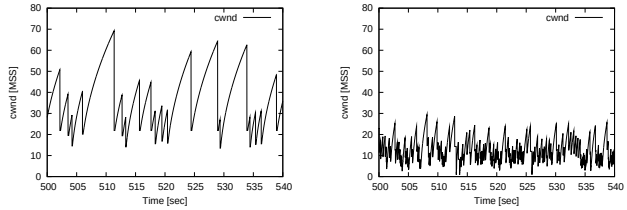
black dots (Burst size) show the distribution of the number of packets in a burst, which are sent by TCP.

The maximum size of forward data is about 43, which is consistent with MSS and the size of TCP window (64 KB) over the wireless section. We can observe that the distributions of the forward data size and the number of packets in a burst are well consistent. This means that the PEP sends bursts of packets corresponding to the forward data sizes.

In the case of the small packet loss rate (P_L = 0.001), although the frequency of burst occurrence is generally small, there is a trend that large size bursts occur compared with the case of the large packet loss rate (P_L = 0.01). The reason for this trend is as follows: When TCP detects a loss of a segment by duplicate ACKs, it retransmits the lost segment and decreases its congestion window (cwnd) in half. In the case of the large packet loss rate (P_L = 0.01), the decrease in cwnd occurs more frequently compared with the case of the small packet loss rate (P_L = 0.001). As the size of cwnd becomes small on the average and TCP window is limited by cwnd, the size of forward data in the case of large packet loss rate (P_L = 0.01) tends to be small. Figure 9 shows the time changes of the congestion window value for P_L=0.01 and P_L=0.001. In the case of P_L=0.01, the congestion window stays at around small values, where retransmissions occur frequently. On the other hand, in the case of P_L=0.001, the congestion window can have enough time to grow and take large values.

Figure 8 shows the same distributions as Fig. 7, except that the pacing is performed by the PEP. Although the distribution of the forward data sizes represented by rectangle boxes (Data size) is the same as Fig. 7, the distribution of the number of packets in a burst represented by black dots (Burst size) is completely different. The number of packets in a burst is suppressed to up to 2. This is due to the effect of the pacing. The reason of two packets in a burst after the pacing is that TCP employs the delayed ACK.

In the following subsections, parameters of the wired section, such as the number of buffers at node 2, delay of the



$P_L = 0.001$ $P_L = 0.01$

Figure 9: Examples of time changes of cwnd.

wired section and the bandwidth of the bottleneck link, will be changed. The condition of the wireless section in each subsection is always the same; the distributions of the forward data sizes for a specific packet loss rate are the same. However, the distribution of the number of packets in a burst is different depending on the conditions of the wired section. Moreover, the distribution of the number of packets in a burst is different for each packet loss rate; the distribution is not appropriate for the performance evaluation index. From this reason, we will focus on the total throughput and the packet loss rate over the wired section as the performance evaluation measures.

5.2 Throughput for the case where the number of buffers at node n2 is limited

Figure 10 shows the relation between the packet loss rate over the wireless section and the total throughput, where the number of buffers at node n2 is limited to 20. Throughput generally decreases as the packet loss rate becomes large. However, the decrease in throughput is suppressed significantly by the PEP with the pacing; scheme A achieves the best performance among three schemes. When the packet loss rate is small, the throughput of the conventional PEP (scheme B) is smaller than scheme C, in which an error recovery is performed end-to-end. The reason why the throughput of scheme B is inferior to scheme C is that packet losses occur at node n2 due to bursts of packets by the conventional PEP.

The packet losses over the wired section cause retransmissions by the fast retransmit algorithm or timeouts. The congestion widow of TCP decreases according to the fast recovery algorithm or the slow- start. The throughput of the wired section becomes small due to the decrease in the size of the congestion window. If the throughput of the wired section becomes smaller than that of the wireless section, the total throughput becomes small, since the total throughput is determined by the smaller value between the throughput of the wired section and that of the wireless section.

Figure 11 shows the relation between the packet loss rate over the wireless section and that over the wired section. Large packet loss rate is observed in scheme B, since packet losses occur due to buffer overflows at node n2.The packet loss rate over the wired section becomes larger than or comparable with that of the wireless section, when the packet loss rate of the wireless section is less than 0.005. We cannot observe any packet loss in schemes A and C. Since there is no packet loss and RTT of the wireless section becomes small due to the PEP architecture, the performance of scheme A is the best. It

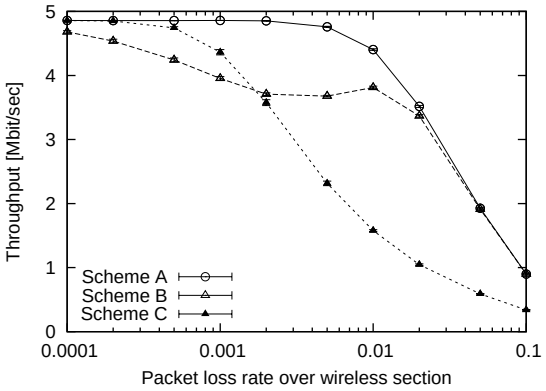


Figure 10: Packet loss rate vs. throughput, D_W = 30ms, B_L = 20, B_W = 10 M bit/s.

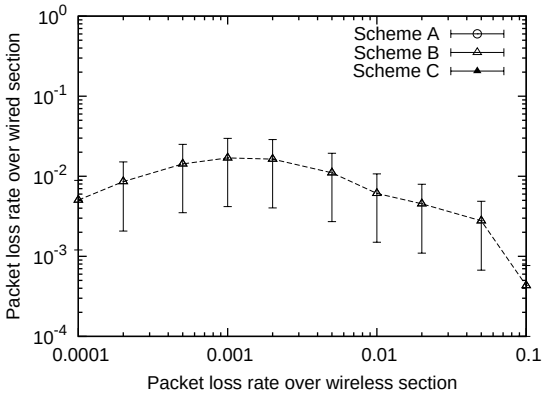


Figure 11: Packet loss rate over wireless section vs. that over wired section, D_W = 30ms, B_L = 20, B_W = 10 M bit/s.

is clear that the effect of the pacing is outstanding.

5.3 Throughput for the case where the number of buffers at node n2 becomes large

Figure 12 represents the total throughput for the case where the number of buffers at node n2 is increased from 20 to 50. Although the throughput of scheme B is much improved, its value is still lower than that of scheme A for cases of small packet loss rates (less than 0.005). When the packet loss rate is 0.005, the throughput of scheme B takes larger value than the throughput values of lower packet loss rates.

In Fig. 12, although the parameter of the wired section is changed, the throughput of scheme A is completely the same as that in Fig. 10. The reason is as follows: As mentioned before, the total throughput is determined by the smaller value between the throughput of the wired section and that of the wireless section. In scheme A, as the parameter of the wired section changes, the throughput of the wired section varies. However, its throughput is always larger than that of the wireless section. Since the total throughput is always determined by the throughput of the wireless section, the parameter of the wired section does not affect the total throughput of scheme A.

Figure 13 shows the relation between packet loss rate of

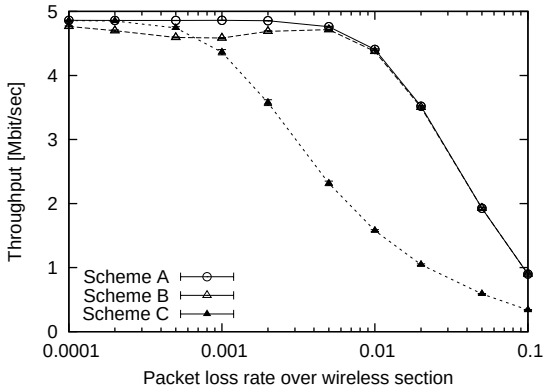


Figure 12: Packet loss rate vs. throughput, D_W = 30ms, B_L = 50, B_W = 10 M bit/s.

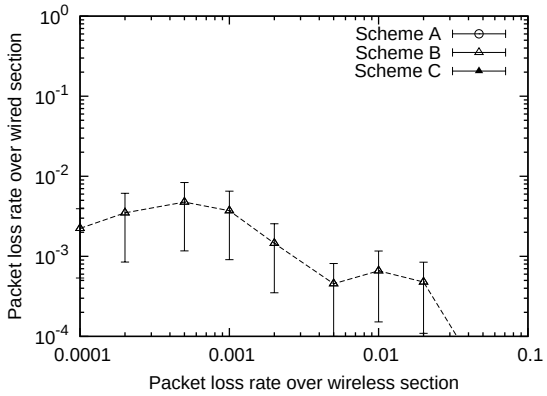


Figure 13: Packet loss rate over wireless section vs. that over wired section, D_W = 30ms, B_L = 50, B_W = 10 M bit/s.

the wireless section and that of the wired section. Due to the increase in the number of buffers, the packet loss rates of scheme B become smaller than those of Fig. 11. Although the packet loss rate over the wired section becomes small in comparison with the case of Fig. 11, its value is still larger than that of the wireless section for the cases of the packet loss rates less than or equal to 0.001. Similar to the case of Fig. 10, this explains the degradation of the throughput when the packet loss rate of the wireless section is small. As there is no packet loss in schemes A and C, the performance of these schemes is the same as the case of Fig. 10.

5.4 Throughput for the case where the delay of wired section becomes large

Figure 14 shows the relation between the packet loss rate over the wireless section and the total throughput, where the delay of the wired section is 40ms, which is 10ms larger than the case of Fig. 10. The throughput of scheme B becomes worse while the throughput of scheme A is the same as the case of Fig. 10. In the case of scheme A, although the maximum throughput of the wired section becomes small due to the increase in the delay of the wired section, its value is still larger than the throughput of the wireless section. Then, the total throughput scheme A is the same as the case of Fig. 10. Since the increase in the delay of the wired section is relatively small compared with with the total end-to-end delay,

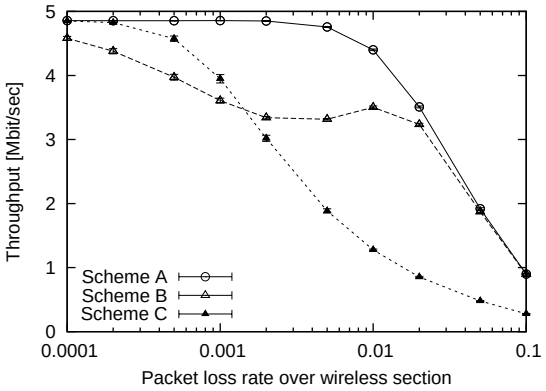


Figure 14: Packet loss rate vs. throughput, D_W = 40ms, B_L = 20, B_W = 10 M bit/s.

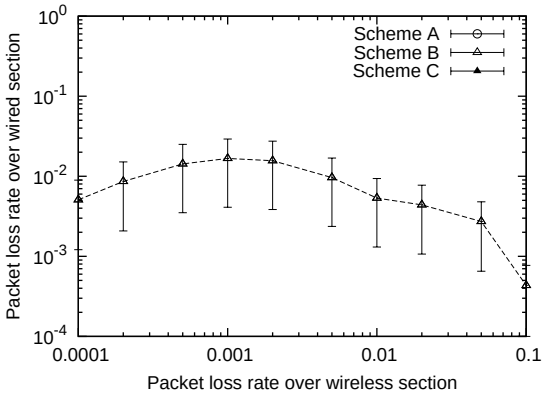


Figure 15: Packet loss rate over wireless section vs. that over wired section, D_W = 40ms, B_L = 20, B_W = 10 M bit/s.

the throughput of scheme C is also almost the same as Fig. 10.

In Fig. 14, although the parameter of the wired section is changed, the throughput of scheme A is completely the same as that in Fig. 12. The reason is as follows: The total throughput is determined by the smaller value between the throughput of the wired section and that of the wireless section. In scheme A, as the parameter of the wired section changes, the throughput of the wired section varies. However, its throughput is always larger than that of the wireless section. Since the total throughput is always determined by the throughput of the wireless section, the parameter of the wired section does not affect the total throughput of scheme A.

Figure 15 shows the relation between the packet loss rate over the wireless section and that over the wired section. This figure is almost the same as Fig. 11. As the RTT of the wired section increases, the effect of packet losses to the throughput becomes large. The reason is that losses of packets cause decrease in the congestion window (cwnd), which leads to the decrease in throughput. This indicates that the effect of bursts of packets by the conventional PEP becomes serious when the delay of the wired section becomes large.

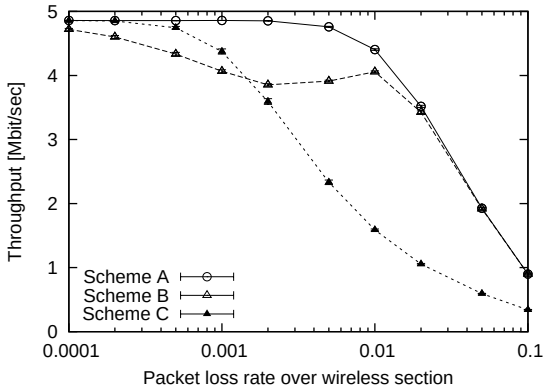


Figure 16: Packet loss rate vs. throughput, D_W = 30ms, B_L = 20, B_W = 20 M bit/s.

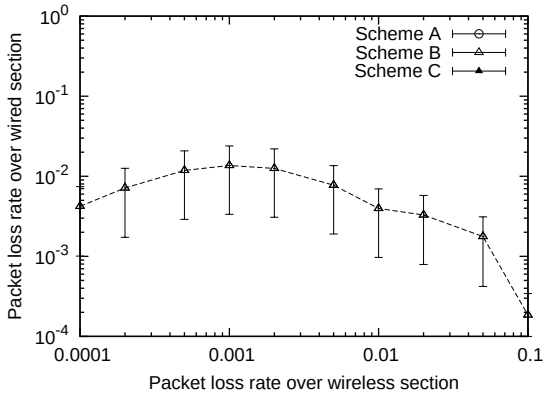


Figure 17: Packet loss rate over wireless section vs. that over wired section, D_W = 30ms, B_L = 20, B_W = 20 M bit/s.

5.5 Throughput for the case where the bandwidth of the bottleneck link becomes large

All the results presented above are taken on the condition that the bandwidth of the bottleneck link B_W is 10 Mbit/s. Figure 16 shows the relation between the total throughput and the packet loss rate over the wireless section, when the bandwidth B_W is doubled (20 Mbit/s) and the number of buffers at node n2 is 20. The throughput of scheme A and C is the same as the case of Fig. 10, since there is no packet loss in Fig. 16 and Fig. 10. We can observe improvement of throughput of scheme B compared with Fig. 10. However, the throughput of scheme B is still the smallest among the three schemes for the cases of small packet loss rates.

Figure 17 shows the relation between the packet loss rate of the wireless section and that of the wired section. Although the packet loss rate of the wired section is improved, its value is still large. We cannot observe significant effectiveness of the increase in the bottleneck bandwidth. This shows that the increase in the bandwidth of the bottleneck link has small impact on suppressing packet losses due to a large burst of packets.

6 CONCLUSION

This paper has investigated the architecture of a TCP proxy (PEP), where the PEP forwards receive data from one TCP connection on the wireless section to another TCP connection on the wired section. We have focused on the output traffic from the PEP. When losses of packets occur due to transmission errors, we have identified a problem that the output traffic from the PEP becomes bursty due to the reassembling function done by the receiving side of TCP over the wireless section. To mitigate the bursts of packets we proposed a pacing function at the PEP. This scheme has advantages of no packet loss with a limited amount of buffers and independent pacing for each TCP connection. We simulated the case where the output traffic from the PEP is forwarded by a node that is connected to a bottleneck link in the wired section and the node has insufficient number of buffers compared with the window size of TCP. The simulation results have shown that the performance of the PEP with pacing is improved significantly. We have also observed that the total throughput of the conventional PEP becomes worse than that of end-to-end TCP for the cases of small packet loss rates. As the rate of wireless links is increasing, a TCP proxy will be important to attain high throughput. Accordingly, a burst of packets by the TCP proxy will be serious and its mitigation will be significant.

ACKNOWLEDGMENT

This work has been supported by KAKENHI (20500079) and Special Research Grant in Aids of Fukui University of Technology.

REFERENCES

[1] J. Border, M. Kojo, J. Griner, G. Montenegro, and Z. Shelby, “Performance Enhancing Proxies Intended to Mitigate Link-Related Degradations,” IETF, RFC3135, June 2001.
[2] M. Allman, V. Paxson, and W. Tevens, “TCP Congestion Control,” RFC 2581, April 1999.
[3] W. R. Stevens, “TCP/IP Illustrated, Volume 1: The Protocols,” Addison-Wesley, 1994.
[4] Casetti, M. Gerla, S. Mascolo, M. Y. Sanadidi, and R. Wang, “TCP westwood: Bandwidth estimation for enhanced transport over wireless links,” ACM MOBICOM 2001, pp. 287–297, July 2001.
[5] G. Fairhurst and L. Wood, “Advice to Link Designers on Link Automatic Repeat reQuest (ARQ),” IETF, RFC3366, August 2002.
[6] H. Balakrishnan, S. Seshan, E. Amir, and R. Katz, “Improving TCP Performance over Wireless Networks,” 1st ACM International Conference on Mobile Computing and Networking (Mobicom), Nov. 1995.
[7] M. Meyer, J. Sachs, and M. Holzke, “Performance evaluation of a TCP proxy in WCDMA networks,” IEEE Wireless Commun., vol. 10, no. 5, pp. 70–79, Oct. 2003.
[8] D. Dutta and Y. Zhang, “An Active Proxy Based Architecture for TCP in Heterogeneous Variable Bandwidth Network,” IEEE GLOBECOM 2001, pp. 2316–2320, Nov. 2001.
[9] M. Allman and E. Blanton, “Notes on Burst Mitigation for Transport Protocols,” ACM Computer Communications Review, vol. 35, no. 2, pp. 53–60, April 2005.
[10] R. Takano, T. Kudo, Y. Kodama, M. Matsuda, F. Okazaki, and Y. Ishikawa, “Improving TCP Performance by Using Precise Software Pacing Method,” IEICE Technical Report, NS2005-157(2006-1).
[11] Y. Miyake, T. Kato, and K. Suzuki, “Implementation Method of High Speed Protocol as Transport Library,” ICNP, pp. 172–179, Nov. 1995.
[12] The Network Simulator – ns-2, http://www.isi.edu/nsnam/ns/, 2010.

(Received July 6, 2010)
(Revised February 29, 2012)

Toshihiro Shikama received his B.E. and M.E. degrees from Tokyo Institute of Technology in 1974 and 1976, respectively. From 1984 to 1985, he was at University of Waterloo. He received his Ph.D. degree from Shizuoka University in 2006. He joined Mitsubishi Electric Corp. in 1976 and had engaged in developing a computer network using a satellite channel, high speed ring type LANs, time division multiplexers, ATM equipment, a high speed IP switch, and network security systems. Since April of 2007, he has been a professor at Department of Electrical, Electronic and Computer Engineering, Fukui University of Technology. He is a member of IPSJ, IEICE, and IEEE Communications Society.

[Practical Paper] Trial of a distance learning system using a brain wave sensor

Kouji Yoshida†, Isao Miyaji††, Kunihiro Yamada†††, and Satoru Fujii††††

†Department of Information Science, Shonan Institute of Technology, Japan
††Faculty of Informatics, Okayama University of Science, Japan
†††Professional Graduate School of Embedded Technology, Tokai University, Japan
††††Matsue National College of Technology
yoshidak@info.shonan-it.ac.jp, miyaji@mis.ous.ac.jp, yamadaku@tokai.ac.jp, fujii@matsue-ct.ac.jp

Abstract—We developed a self-study system using Perl language. To date, no device has been available to observe a human state effectively. However, brain wave sensors have become inexpensive recently, allowing observation of the human state. We analyzed the information effectively; a brain wave sensor for human feedback has become usable. This feedback system can measure a student's state of concentration and a state of a motivation. Additionally, students show raised motivation because the system transmits a message indicating motivation. Sensing that motivation, effective methods can be recognized. This report presents our results.

Keywords: Brain wave sensor, Perl language, Distance Learning, e-Learning, Blended Learning, e-Collaboration

1 INTRODUCTION

In recent years, growing interest has arisen in the progress of information and communication systems, high-speed networking, and multimedia environments [1]. Software development has become large-scale and complicated. Consequently, independent systems have become increasingly rare. Student skills related to system design and communication are therefore not good. We must consider learning systems that exploit group communication and iteration of practice to develop good quality software [2].

During cooperative software development, the same information must be taught repeatedly for it to become practical knowledge [2][3]. We produced a distance education system that can instruct students repetitively, but it is difficult to complete a program using this distance learning system alone.

To date, it has been extremely difficult to respond while grasping the state of a student using a distance learning system [4]. Nevertheless, we can cheaply use a brain wave sensor to observe the state of a student. We experimented on construction of a system for learning while using this feedback [5][6].

2 PROBLEMS AND PRESENT CONDITIONS

From the beginning, remote education systems have presented the problem of whether or not the learner is well accustomed to accessing the necessary media electronically. The learner is isolated: aside from the learning system itself, they can contact only an instructor. Therefore, the learner is usually apprehensive, wondering whether the system will behave as expected, whether the system is useful as expected, and whether it is possible to access the necessary contents associated with the received lectures.

It is very useful to measure the feeling of a student and their level of consciousness using distance learning systems. Such a system can feedback information from the students.

3 SYSTEM OVERVIEW

This system consists of basic software ideas for general learning based on the Perl language, including specifications for the specific learning method. In addition, the system includes an information bulletin board and chat room. It is possible to exchange messages with other learning members. The system shows the students' grade situation by ranking their relative progress.

This system is supported by both Linux and Windows operating systems. A student accesses the web browser via a personal computer. Students start advanced learning and group work using learning support and communication support. Then they start personal learning and group work with learning support and communication support. They can check their degree understanding by solving some problems for confirmation. A learner and lecturer can communicate. They can examine a function of a language using a database. An image of this system is presented in Fig. 1.
In addition, the system can measure the state of learners such as concentration power using the brain wave sensor.

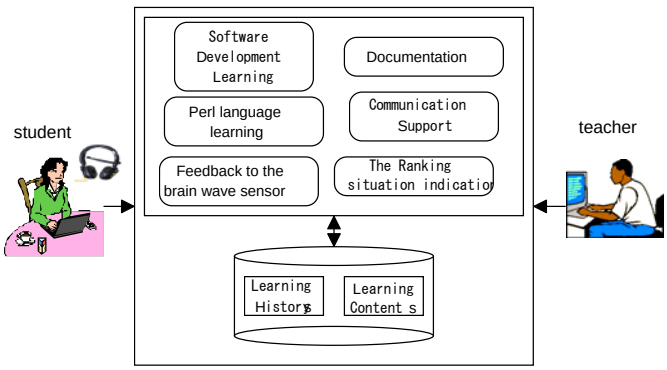


Figure 1: System image.

4 CONTENTS OF LEARNING

4.1 Learning Software Development

When students learn software development, they learn the contents on the Web. These contents for learning are generated using Power Point (Microsoft Corp.), but are then con-

verted into HTML format. The contents are separated into five levels of learning for software development. Confirmation questions are prepared at each level. Moreover, if all chapters are completed, then students must answer a series of 20 questions.

・Support contents

Software development, requirement analysis, software design, program testing and maintenance

4.2 Documentation

When students are working on problems using the program, the system checks their understanding of the situation. The learning contents generated using PowerPoint are changed to HTML. The specification's documents are classifiable into three categories:

(1) External specifications form
(2) Internal specifications
(3) Test specifications

After each level is completed, a validation test is performed, followed by validation planning. Through a selection process, we correct the students' understanding. The documentation content is shown in Fig. 2.

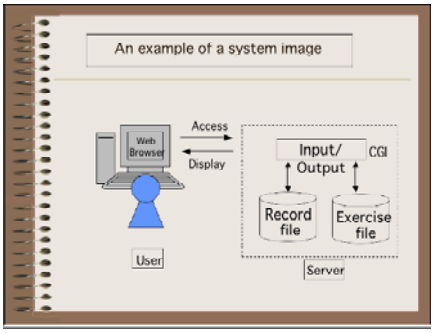


Figure 2: Documentation.

4.3 Using Perl Language

(1) Usage of Perl language

The programs are classified according to the item and display a step-by-step process on how to use Perl language functions. Each function is then displayed entirely making it easier to examine the parameter. The main functions are printf, scanf, if-else, array, for and while.

(2) Exercise to understand the Perl program

The purpose of this exercise is to confirm what content was understood by the student from using the given Perl explanations. The exercise is selective and provides a percentage representing the degree of comprehension.

(3) Perl Program Exercise

This displays both the Perl program's mock validation exercise and the implementation section. Step 1 consists of validation, and it displays the content (e.g., the parameters and results of the program). After the students input their functions into the text field, they can confirm the entry by running the program.

When students do not comprehend the basic function, an example answer is displayed. They can confirm it through this step. This creates a simple explanation that is sufficiently clear for a novice programmer to comprehend. Step 2 consists of implementation in an exercise form. They can experience a mock implementation and debugging of a complicated program. These ideas are displayed in Fig. 3.

・Discussion Board Q&A

This section is used for questions and for information exchange between the teacher and students. This section also allows the teacher to create or respond to messages. The page's background color changes whenever a new message is posted alerting students of the message.

・Message Exchange

This section carries sent questions and other information exchanges on a peer-to-peer level. Even with encrypted mail addresses, messages can be sent using a user-defined nickname.

(1) Mail transmission function and data exchange
(2) Mail receiver function
(3) Mail transmission and history function
(4) Learning schedule setting and communication function

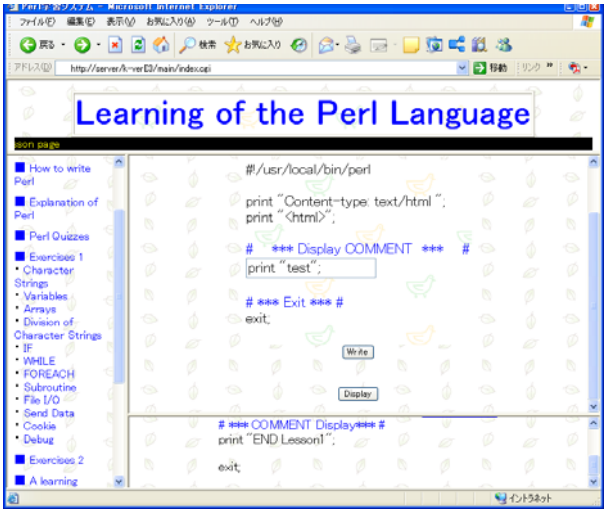


Figure 3: Programming image.

4.4 Support for the module

This support function programming technique lets learners practice basic program-linking to enable the learner to experience test trials to learn how to link modules.

Listed below are the practice steps to be followed.

· Practice of maintaining data integrity
· Practice of correcting programs for linking
· Practice of multi-program linking as a test trial

Following are additional descriptions for practice.

(1) Practice of maintaining data integrity

This is provided to the learner to show points of caution when exchanging data among modules. Every learner is expected to join a group for this purpose; everyone in the group is expected to enter variable names or real numbers that come to mind. Through this process, among other things, the learner is expected to learn how important it is to use consistent variable names in a specification document.

(2) Practice of a correcting programs for linking

The learner practices programming for module linking by giving the learner a program for use to link some modules in which at least one error is included intentionally. Consequently, the learner must correct the erroneous portion to

finish the module linking. In this practice lesson, a mode of giving special attention was provided, by which the color of the program line number changed when the learner corrected the wrong line mistakenly, or when the learner put wrong information related to a line, even though the line number itself was correct.

(3) Practice of multi-program linking as a test trial

The learner is provided with a program in which some program statement portions are intentionally left missing. The learner is then expected to complete the program to make it work properly while simultaneously reviewing and checking the associated specification. The program has been left intentionally as missing an important segment to exchange data when linking modules. Then the learner is expected to complete such an incomplete program, thereby learning the importance of data structures that are used when modules are linked.

4.5 Ranking Identification

A teacher can follow the learning progress of a student using the Web application. Students can track their progress status using a clear bar graph. The system delivers each Q&A using a mailing list and searches the mailing list's archives. From the instructor's side, it is possible to see the progress of students. This allows the instructor to measure the gap separating students. It is also possible to add explanations or hints for specific lessons, such as helpful teaching materials to assist the students' learning and progress further.

Students can also receive an explanation of the lecture via PowerPoint (Microsoft Corp.). When students wish to see a lecture's contents, they can observe the contents on their personal computer using the HTML conversion.

Each student can browse practicum contents using a personal computer. The content advances according to the student's own progress. The practicum content is created from JavaScript and is displayed as PowerPoint (Microsoft Corp.) changed to be displayed as HTML data. After the students solve the practicum problem by attending lectures, the answer is submitted on paper. Students can see their relative ranking in the class at any time. The teacher can easily supervise each student's progress, thereby allowing a direct channel to advise those who have fallen behind.

If a question or comment is brought up during a lecture, that question could be posted in the discussion board's Q&A section for all students to access easily. The background color of the page would be changed when a new message is submitted allowing for rapid notification to students. Students have access to contact the teacher and other students via e-mail.

Students can learn in their spare time while attending school for lectures and can then pose face-to-face questions. The program allows students to learn from the privacy of their home using a mobile phone or personal computer. The program allows each student to plan their own schedule. If a student falls behind schedule, then a reminder message is sent to their mobile phone. The problems presented to students in the study support section of this system are presented in a multiple-choice format. These are prepared before lectures. Students can exchange information with the teacher and other students using the communication function.

The teacher can observe any particular problem that students are working on at any time throughout the process. This function displays each student's progress in relation to the whole group. In addition, students can see the rankings of other students who are solving the same problems. The practicum's progress is displayed for students as shown in Fig. 4.

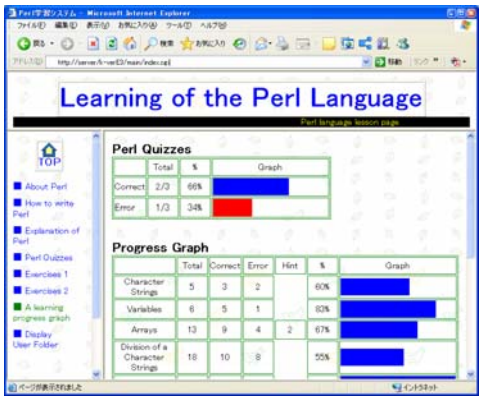


Figure 4: Bar graph showing progress.

The teacher can supervise the class by observing the list of problems that each student is currently solving. This allows the teacher to advise any student who has fallen behind, as well as students whose progress has stopped altogether. This function also permits the teacher to track the overall progress and understanding of the class' content better.

5 RESULTS AND EVALUATION

5.1 PERIOD AND METHOD

We used a seminar method and a distance learning system for third-year students of our department [6]. The period was four months. The contents that we used were shared with three groups and used as described below. We divided 10 students into three groups with 4, 4, and 3 members.

First, the installation of Apache and the Perl language are expected to be done on the local server. Thereby, the learner is expected to understand how and in what combination the Perl language would work with the Apache server as a system overall. Such a work of understanding would include a problem for which knowledge that the learner has acquired is insufficient. In other words, support from the instructor is necessary: otherwise, the problem might be difficult to resolve unless a quick response to the questions the learner might have is given through a blended learning technique.

Subsequently, premised on the understanding of c language, students learn about the relation between html and CGI. Students learn themselves through self-study about a Perl language function that is supported by Perl language. For the ensuing month, students learn the basics of Perl language to file access. Then they understand the entire Perl language. They learn basic information related to connections among programs using a program combination support function [7].

Students started group work in the third month. First, they chose a leader among the members. Next, they discussed

problems among groups and decided the subject of the program they wanted to make. In these circumstances, they learned using this support system, along with communication through mail and chat facilities. Seminars were held twice a week.

5.2 Contents and Results

After they decided which program to make in their groups, they chose a title and performed basic specifications design. They decided the charge part of a program among members after having determined an external design and a user interface. Students designed the data structures of programs of the charge program. Each member wrote the documentation. After each program that they debugged was completed, they combined the programs and reached completion.

They chose "(1) A bulletin board that recorded an access history and blackjack; (2) An electronic shopping lacing braid purchasing system [The example images display by Fig. 5]; (3) A Web page that combined touch-typing with a game."

Use of the brain wave sensor revealed that all groups confronted difficulties related to file input and output by CGI and a combination of programs. Programs were finished through group work. They were improved through a combination of a program to arriving at high technology through a generation process. Standardization and documentation were improved at a certain level using this practice as well.

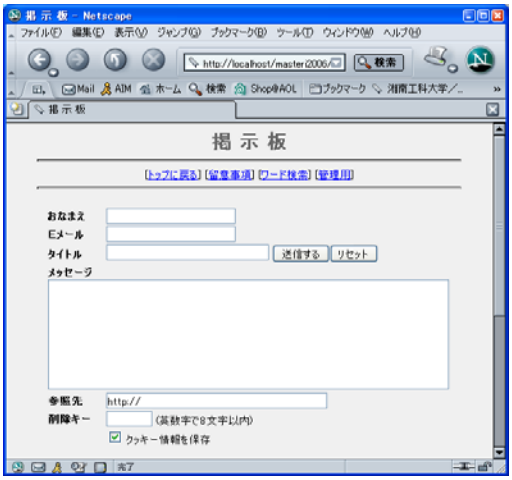


Figure 5: Screenshot of an e-Shopping Mall purchasing system.

5.3 Results and Evaluations

Evaluations of the self-study supporting functions of Perl differed depending on the level of programming used by the student. Regarding support for combining the programming, although comprehension grew by presentation of examples showing the difficulty of combining programs and problem occurrence while remaining conscious of documentation and standardization, it remained at the knowledge level.

In the meantime, with electronic communication, although information and knowledge are conveyed somewhat, detailed explanation of complicated contents is difficult. Therefore, a means for explaining concrete images and complicated matters briefly using motion pictures and illustrations in addition to letters is necessary. Furthermore, what one has to say can only slightly involve emotional content. In particular, students are not accustomed to electronic communications. They are not good at using mailing lists and chatting.

Under these circumstances, the brain wave sensor was used; the obtained results were fed back. Then we obtained the following findings:

(1) Reading the explanation of Perl language

There is a premise understanding Perl language by a seminar to some extent. Therefore an examinee is relaxed at the time of a start. Content is not so difficult. An examinee loses an intensive degree to understand contents, and meditation degree rises adversely. When an examinee passes around 4 minutes, an intensive degree rises and follows afterwards while concentration goes up and down (Fig.6).

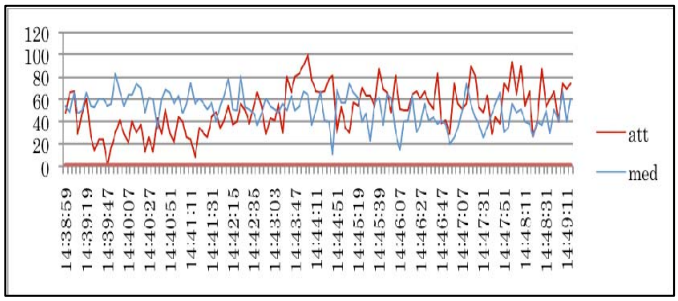


Figure 6: Example of reading the explanation of Perl language.

(2) Solving a question of Perl language

When the examinee began easily about the question, for example Print sentences or so. He answered the question with highly meditation degree. And a variable and an arrangement are simple, but concentration (att) rises so that a thought is necessary in various ways when he become a condition sentence. Concentration declines when he stands around 10 minutes (Fig.7).

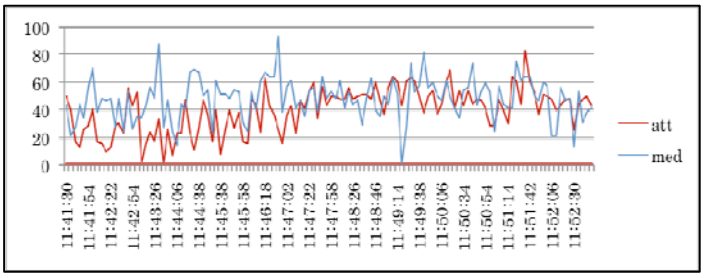


Figure 7: Example of solving a question of Perl language.

5.4 Evaluations and Discussion

Use of the brain wave sensor enables objective measurement of motivation and concentration power of the learner. In general, this enables detection of items that learners have difficulty understanding and those which cause stress. It is also possible to know favorite and weak subjects of individual learners, motivation depending on feelings that day, and the degree of concentration power.

Therefore, it is considered that construction of a finely designed follow-up system is possible using a distance learning system into which this brain wave sensor is built.

6 CONCLUSIONS

To date, blended learning has been incorporated into the distance learning system and effects of group learning were used. Under these circumstances, the brain wave sensor was used in this study, enabling effective measurement of the state in which the learners are learning.

As expected, results reveal that learners are in stressful circumstances in preparing specifications that are difficult to understand and in preparing combinations of programs that necessitate communication. In contrast, repeated learning and language learning such as Perl language, in which examples are presented clearly, support stress-free learning.

In the future, the authors intend to analyze functions of the distance learning system that ensure better effects and to analyze features of contents through detailed assessment of these findings and verification of their applications. This study received support from the scientific research cost subsidy “22500949” and from the organizations named above.

REFERENCES

[1] L. Neal, “Virtual Classrooms and Communities”, Proc. ACM GROUP'97, 1997.

[2] N. Lopez, M. Nunez, I. Rodriguez, and F. Rubio, “Including Malicious Agents into a Collaborative Learning Environment,” Proc. ITS2002, LNCS 2363, pp. 51–60, 2002.

[3] R. A. Dumont, “Teaching and Learning in Cyberspace”, IEEE Transactions on Professional Communication Vol. 39, No. 4, pp. 192-204, 1996.

[4] K. Nakada, T. Akutsu, C. Walton, S. Fujii, H. Ichimura, and K. Yoshida, “Practice of Linux Lesson in Blended Learning”, Proc. Knowledge-Based Intelligent Information and Engineering Systems (KES2004), Part 2, pp. 920-927, 2004.

[5] NSW Department of Education and Training, “Blended Learning”, http://www.schools.nsw.edu.au/learning /yrk12focusareas/learntech/blended/index.php.

[6] K. Yoshida, I. Miyaji, H. Ichimura, and K. Yamada, “Web application construction by group work and practice”, Proc. Knowledge-Based Intelligent Information and Engineering Systems (KES2008-WIRN2008), pp. 144-151, 2008.

[7] K. Yoshida, I. Miyaji, K. Yamada, and H. Ichimura, “Distance Learning System for Programming and Software Engineering”, Proc. Knowledge-Based Intelligent Information and Engineering Systems (KES2007-WIRN2007), pp. 460-468, 2007.

(Received July 6, 2010)
(Revised September 7, 2011)

Kouji Yoshida is a professor at Shonan Institute of Technology, Japan. He had Ph.D. from Shizuoka University of Japan in 2001. He worked at a Computer Scientist in the Information Engineering Works at Mitsubishi Electric Corp from 1972 to 2001. He had been a visiting lecturer at Nagoya Institute of Technology from 1996 to 1999. His major research includes Internet/Intranet, distance learning and information gathering on the Internet. He is one of the members of IPSJ, IEICE Japan.

Isao Miyaji received the B.S. and M.S. degrees from Okayama University in 1969 and 1971, and he received the Ph.D. of Engineering from Kyoto University in 1984. Since 1989 he has been with Okayama University of Science, Okayama, Japan. Since 1993 he has been a Professor with Faculty and Graduate School of Informatics, the University. From 1975 to 1976 he has a visiting Research Associate at Kyoto University, Japan. From 1981 to 1982 he has a visiting Research Associate at University of Minnesota and University of California Barkley, USA. His current interests are in e-learning, blended learning, educational technology, and improvement of the instruction technique by using ICT. He was a vice president at Chugoku Branch of JSiSE from 2000 to 2002, and the president from 2002 to 2008. He was a vice executive chair of ORSJ in 2001 and an executive chair of JSSE in 2008. He is currently a president at Chugoku Branch of JSSE from 2007. He received a letter of appreciation from NEC computer SP workshop in 1991. He is a member of JSISE, JSET, JSSE, IEICE, IPSJ, ORSJ, and JSAI.

Kunihiro Yamada is a professor at Tokai University, Japan. He had Ph.D. from Shizuoka University of Japan in 2002. He worked at a operation division of Semiconductor at Mitsubishi Electric Corp from 1973 to 2003, and he worked at a Renesas Corp from 2003 to 2005. His major research includes Computer Architecture and Mutual Complement Network. He is one of the members of IPSJ, IEICE Japan.

Satoru Fujii received the Professional Engineer (Information Engineering) in 1990 and Ph.D. from Shizuoka University in 2005. Currently, he is a professor of Matsue College of Technology. He worked at Matsushita Electric (Panasonic) Co. Ltd. from 1968 to 1994. His interests are e-Learning, mobile communication system and virtual reality. He is a member of the Institute of Electronics Information and Communication Engineering (IEICE) and Japan Society for Information and Systems in Education (JSiSE).

[Practical Paper] Jump-in-Ad: Embedding a Viewer's Face to an Advertisement for Increasing Attention

Tomoo Inoue*

*Faculty of Library, Information and Media Science, University of Tsukuba, Japan
inoue@slis.tsukuba.ac.jp

Abstract - This paper presents a video advertisement system named "Jump-In-Ad." As a large public display becomes common, its usage has been the issue of research in information technology. Advertisement is one of the major uses of such displays. It can be interactive by the software together with a computer. With some other background research contexts, the proposed system has been developed. It captures a face of a viewer who is in front of the system, and replaces the main character's face of the advertising videos with the viewer's face in real time. It has been developed to attract people and to get their attention to the advertisement. An experiment, which compared the proposed system with a normal video advertisement system, was conducted. The result demonstrated that more people looked at the "Jump-In-Ad" than the other.

Keywords: Digital signage, video advertisement, public display, interactive system.

1 INTRODUCTION

Public displays have become commonly used to replace conventional media such as posters and bulletin boards recently. They have been called digital signage systems and have often been used for advertisement. Advertisement by such display systems can be processed digitally unlike conventional paper advertisement. For example, it can be a slide show that changes multiple advertisements in regular intervals. However, many of these advertisements have not been fully explored the possibility of being the digital advertisements and/or digital processing yet. Typically they simply play some images or videos repeatedly, which are not different from the conventional advertisement very much.

An important aspect of advertisement is to draw people's attention. Drawing attention increases the value of the advertisement. In this paper, we propose an interactive advertisement system named "Jump-in-Ad" which embeds the viewer's face to the advertisement in real time, after some consideration of related research. By embedding the viewer's face to an advertisement, his/her attention to the advertisement is expected to increase. The experiment to evaluate it is also presented in the later part of this paper.

2 RELATED RESEARCH

2.1 Digital Signage

Digital signage represents a type of public display that uses typically a flat panel large display or a video projector and a personal computer that is connected to the display to control the displayed images. It sometimes includes a computer network to provide content update and the system management.

Digital signage systems have been in the market is increasing its presence. Fujitsu has introduced the digital signage system UBWALL including the interactive information kiosk called UBWALL Station that is a touch sensitive large display. It can also equip with an RFID reader/writer. The user can get personalized information by placing his/her device over the reader/writer and can save it [1][2]. Other companies have introduced digital signage systems, too [3][4].

Some systems also use the user's mobile device for interacting with the display. Ubiquitous Information Delivery System (UIDS) provides detailed information to the mobile personal device via short-range wireless communication when it receives the request from the user who watches the broadcasted information on the public display [5]. SuiPo is not strictly a digital signage system but is a digitally enhanced signage service. It uses Suica which is a very popular IC card primarily used as a prepaid train ticket. SuiPo is an information-enhanced poster. First as a setup, the user registers his/her Suica IC card to the service through the Internet by his/her mobile phone. Then if the user is interested in a poster, he/she holds his/her Suica IC card over the card reader placed next to the poster. This way the user receives additional information related to the poster [6].

Our research system falls into a type of digital signage. Certainly digital signage systems in the market have often been used for advertisement. However as have been introduced in this section, these systems typically need user's operation. Because user's explicit operation put extra load to the user, we do not think this way becomes most popular.

2.2 Interactive Display

As the cost of display devices decreases, public displays have become more common than before. Most of them are used in combination with computers and are interactive.

(1) Community display

Semi-Public Display is a public display system for supporting community. It is placed at a common area of a community, and provides shared information among the community such as reminders, collaboration space for asynchronous group work, attendance panel which registers attendance to events. It indicates the community members' whereabouts by changing the color saturation of the members of a group photo in ambient fashion [7].

MessyBoard is a public bulletin board projected on a wall of a common room, which activated discussion among the group members [8].

Dynamo is a large multi-user interactive display system that enables sharing and exchange of a variety of digital media such as photos, video clips, and websites [9].

HuNeAS is a system for promoting face-to-face information sharing. The user registers what he/she want to announce in public to the system in advance, and keep the RFID tag. The RFID tag reader is placed next to the large public display. When the user with the tag pass through the display, the tag reader detects the user's tag and the public display displays the registered announcement, which is intended other community members notice the announcement and start conversation [10].

These are the display systems for a group or a community of people, and in this sense they are semi-public displays. Here the displayed content is the information to be shared among the users and is often related to the target users from the beginning. Thus direct intention to draw the user's attention to the content itself has not been a focus of research very much.

(2) Interaction with a large public display

Interactive Public Ambient Display is a system to present information according to the distance of the user from the display. The system recognizes four interaction phases according to the distance and has different functions for each. Ambient Display phase is the most distant phase. The system displays big text characters and figures for distant people to glance at as the ambient display and does not offer operation from the users. Implicit Interaction phase is the next distant phase. The system recognizes the user's body position and orientation and uses this information to infer the user's openness to receiving information. The user is notified in a subtle manner if there is urgent information that requires attention. Subtle Interaction phase the closer phase. When the user approaches the display and provides an implicit cue such as pausing for a moment, the system enters this interaction phase. In this phase the system displays the personalized information typically of shared public information for the user. The system recognizes simple hand gestures and body movements, for which the user can select information to watch. Personal Interaction phase is the closest phase. The user can touch the display directly and operate personal information. The user has to put infrared reflective markers on his/her body and hands to be recognized by the system that employs the Vicon motion tracking system. This system demonstrates how displayed information and their interaction technique should change according to the distance of a user [11].

Frisbee is a technique for interacting with areas of a large display that are difficult or impossible to access directly. It consists of two display areas called the "telescope" that is in local areas and the "target" that is in remote areas. The remote data surrounded by the target is drawn in the telescope and interactions performed within it are applied on the remote data [12].

Many interaction techniques with a large public display can be found including the research introduced here. Some have been applied to the digital interactive advertisement as introduced later. However the first step of advertisement is to draw attention of people. Thus we thought drawing-attention step should have more research priority than the later steps.

(3) Drawing attention

"Mirai Tube" is an interactive very large display system or an installation that uses the ceiling area of a subway station. It detects a person on the concourse and displays various images according to the location, the walking speed, and the behavior such as coming close to the image, stopping of the person. This is realized by the sensors on the ceiling. For example, it moves along with the walking [13].

Historical interactive media art VideoPlace by Myron Krueger captures the user's figure and overlaid it to the video in 1970's [14]. This demonstrates the user interacting with the video, visual effects of the video, and the visual effects of the user's figure processed such as changing its sizes and extracting body contour.

Because interactive visual image can draw people's attention, many similar attempts have been conducted since then. EffecTV is a toolkit to add visual effects to a movie in real time [15]. It is thought to be capable of applying to an advertisement, but not done.

2.3 Portrait Application

Applications of visual image or video of a user have been investigated.

With the virtual fashion simulator, a user can add decorations of a cloth, hair, and makeup to the movie of him/herself. The system merges the video of the user and computer graphics objects [16]. However CG must be aligned with the video images at initial stage manually.

Responsive Mirror is a social fashion comparison system for a physical retail fitting room. It consists of the camera to capture the user's image and recognize classes of clothing, another camera to detect orientation toward the mirror, a conventional mirror, and two displays. One display shows the user with previously worn cloth and the other display shows other people's images for comparison [17].

Countertop Responsive Mirror is a mirror system that records and matches images across jewelry trials for physical retail shopping [18].

In a research named DIM (Dive Into the Movie) [19], a 3D viewer's face is captured and used as the actor's face of a 3D movie. The system is named FCS (Future Cast System). Although it is capable of capturing 3D face image, it uses 7 cameras to scan the facial image and takes a few minutes. It cannot embed the image into the movie in real time.

"Aura Shindan" is an entertainment application system of face recognition that consists of a video camera and a display. When the user stands in front of the display, the video overlaid by "aura" around the face is shown in real time. The aura color is chosen according to the feature quantity of the face image [20].

People care about themselves more or less, which requires or prompts to look at the self images. This means that the

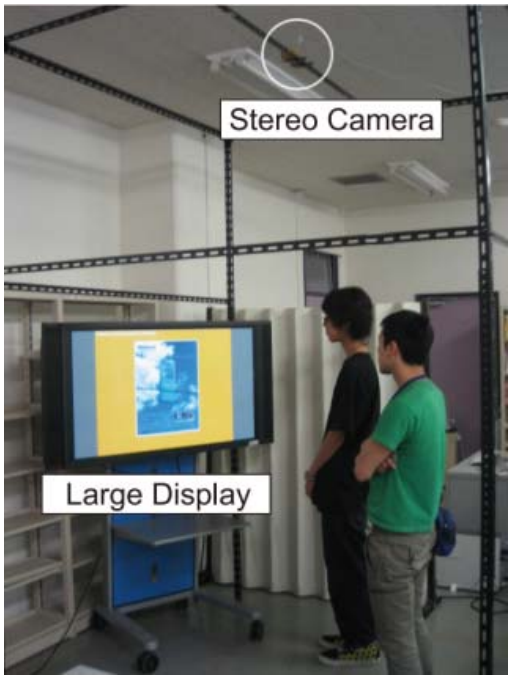


Figure 1: GAS

self portrait image draws good attention, which can be applied to advertisement.

2.4 Advertisement System

Some of above introduced research elements have been applied to advertisement.

Interactive Fliers is a prototype electric advertisement system for a community intended to facilitate communication between advertisers and advertisees. The system consists of a public display with a sensor to detect a person and a computer network. It notifies the advertiser who is waiting behind the advertisement across the network when a person watches the advertisement, and allows him/her to appeal directly to the person by displaying real time captions below the advertisement. It also provides the person watching the advertisement the real time chat function to the advertiser when he/she go to the detailed advertisement page by touching the advertisement screen [21]. This is an application of a digital signage system and draws the advertisee's attention by real time interaction. However text communication, not visual image, is the way of drawing attention. Most importantly the advertiser must keep waiting for the advertisee with this system, which is not realistic.

GAS (Group-adaptive Advertisement System) is a system that displays advertisements to a group of viewers in front of the system, not like common systems that displays advertisements to an individual (Fig. 1). It senses the interpersonal distances of a group of people in front of the display as important nonverbal cue, and estimates the attribute of the group from the cue. Then it selects appropriate advertisements according to the estimated group profile of the users and displays them [22]. This system is more advanced than the adaptive advertisement systems for the single user that the user must register his/her profile to the ID tag in advance. Although the advertisement is selected from the collection of advertisements for the users, the each content is fixed.

Interface agent has been applied in an advertisement system to draw attention of the passerby. The system also uses the interpersonal distance of the user from the interface agent shown in a display and changes behavior of the interface agent. It estimates the position of the user and the interface agent looks to the position. This is another way of drawing attention [23].

"tenoripop" is an interactive display system that recognizes a hand by its skin color and projects visual images to the hand. It also recognizes a few hand gestures and changes the images [24][25]. This suggests that interactivity is a way of drawing involvement from the participant.

Saika is an entertaining digital signage software developed by SIKUMI DESIGN [26]. It captures a viewer's face and decorates the image with illustrations in real time when it is displayed. It also detects motions of a viewer and changes the color of the related area when displayed. The company announced that the produced video drew 13.5 times more than the normal video [27]. Although it has been announced that the software can be used for advertisement, it does not handle advertisement as the main content. It can decorate the viewer's image but does not deal with advertisement itself. Advertisement seems to be shown beside this entertainment content. Different from this, our research focuses on the dynamic change of the advertisement itself.

East Japan Marketing and Communications conducted the interactive advertisement for Japan Racing Association in the year's end of 2009. It captured the viewer's face image and embedded the image to the advertisement poster. It was just like a self-portrait signboard for a souvenir photograph which is often placed at a tourist spot mainly in Japan.

Shiseido created the website for promoting a men's hairdressing product. The user could upload his face image to the website and could watch the promotion movie with his face image embedded. Although this advertisement embeds the viewer's face image, the user must use the system spontaneously to make the movie. Moreover, the face image must be a still picture, and it could be embedded only to the few special promotion movies on the website.

The proposed system "Jump-in-Ad" is different from any of these various advertisement systems. It does not select an advertisement from the collection. It does not use unrelated elements such as an interface agent or another entertaining content other than the advertisement. Rather it directly relates the viewer to the advertisement by embedding the viewer's face movie to the advertisement movie in real time.

3 PROPOSAL OF "JUMP-IN-AD," AN INTERACTIVE ADVERTISEMENT SYSTEM

Based on the survey in the previous section, we propose an interactive video advertisement system named "Jump-in-Ad." It captures a viewer's face and embeds it to the advertisement in real time (Fig. 2). Unlike any other related works, it aims to attract the viewer's interest to the advertisement by applying the real time video processing technology to the advertisement itself. It is also different from the previous

Figure 2: Appearance of the Jump-in-Ad system.

viewer-adaptive systems that select an advertisement from the list of advertisements.

3.1 Hardware

The system consists of a 52 inch display panel for showing advertisements in public, a camera to capture a viewer's face, and a PC for processing the captured video and the advertisement. It needs a viewer as close as 2.5 m to detect the face.

3.2 Software

Figure 3 represents the software process of the system. The software is written in C++ and OpenCV on Windows.

First, the system tries to detect a face in the frames from the camera. It is done by every frame. Haar-like algorithm was used for the face detection. The number of faces, their locations in x and y, and their sizes in width and height are recognized. When multiple faces are detected, the biggest face is selected as the closest one to the system and used as the viewer's face currently.

The same face detection process is also executed in the advertisement. The size of the area to embed the face is recognized.

Next, the face image is extracted from the frame according to the location and the size data. The mask image to trim the face shape as ellipse is prepared. It is a white ellipsoidal figure with black background (Fig. 4). The size of the mask is adjusted to the size of the area to embed the face.

Then the size of the viewer's face is adjusted to the size of the face area in the advertisement. The face image is trimmed by the mask image and is embedded to the area.

Figure 5 shows the original advertisement on the top and the processed advertisement that embeds the viewer's face at the bottom.

Example movies were prepared as the advertisement. They were 15 second short movies that show a face. This is because of the copyright issue. The system does not require specially prepared advertisement.

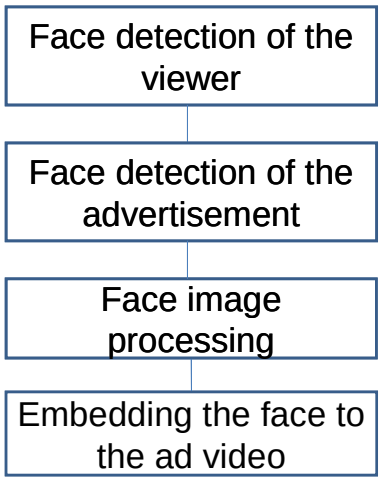


Figure 3: Software process of the system.

Figure 4: Mask image to trim the face shape.

4 EVALUATION

We have evaluated the system through a field experiment of comparing with a simple public display system.

4.1 Procedure

The proposed system and the simple public display system as the control system were used in the same condition. The control system displayed the same advertisement but was not interactive.

Two places were used in a university campus. One was an elevator hall and the other was a corridor (Fig. 6). Each system was set an hour at a time. The systems were switched after an hour. The order of the systems was counterbalanced. The systems were set 8 times in 2 days all together.

The advertisement area was videotaped.

4.2 Result

The measure of the effect of public advertisement has not been standardized yet, which is thought to be different from the viewing rate of the television programs. The number of people in front of the advertisement or the gaze at the advertisement has been used to measure the effect in previous research [28][29]. "Audience Metrics Guidelines" that has been publicized by Out-of-home Video Advertising Bureau in the US in 2008. "Average Unit Gross Impression," which is the total quantity of looking at display and sojourn time in

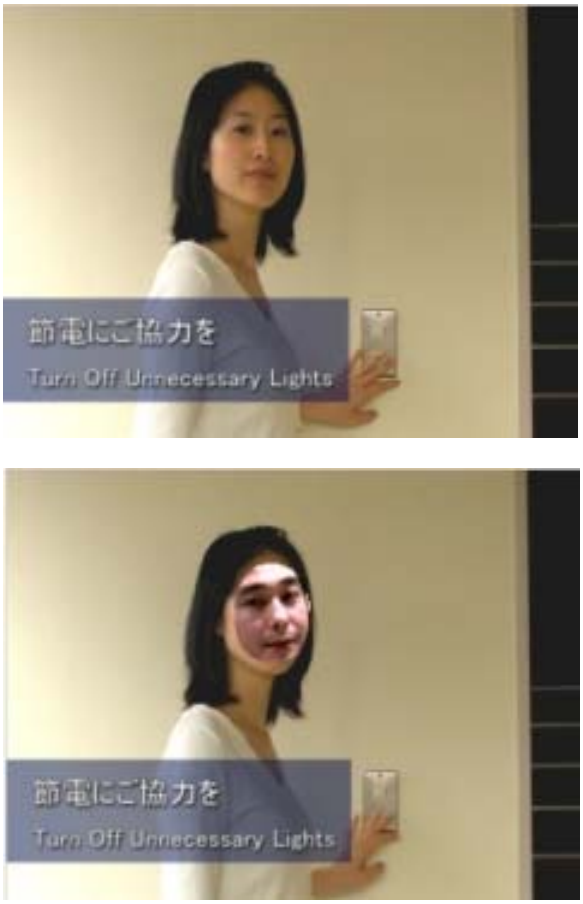


Figure 5: Top: original advertisement, Bottom: processed advertisement that embeds the viewer's face.

Figure 6: Places of the experiment.

a unit time, is proposed as the indicator of advertising effect [30].

Taking this into account, the system was evaluated in the behavior of the viewers and the sojourn time in front of the system.

The viewers were categorized in the following three types according to their behaviors. They are A) Pass by without looking, B) Pass by with looking (face detected), and C) Stop and look (face detected).

Figure 7 shows the rate of the viewer's behavior in terms of these types. 3.7% was type C in the proposed system while it was 2.3% in the control system. More percentage of people stopped and looked in the proposed system. Also, 4.5% was type B in the proposed system while it was 3.5% in the control system. More percentage of people passed by with looking the advertisement in the proposed system.

The sojourn time in front of the system in type C and type B were shown in Figs. 8 and 9 respectively. It was 13.6 second in the proposed system and 13.8 second in the control system in type C, and 5.6 second in the proposed system and 4.1 second in the control system in type B.

4.3 Discussion

(1) Attention increase

According to SIKUMI DESIGN, the video produced by their entertainment digital signage software Saika drew 13.5 times more than the normal video [27].

According to Wang, research shows that people are 5 to 10 times more likely to pay attention to dynamic rich-media content in contrast to the traditional static signs [31].

In our experiment, the proposed system attracted more attention than the control system. This can be calculated as the type B and C behaviors. Thus 3.7+4.5=8.2% paid attention to the proposed system and 2.3+3.5=5.8% paid attention to the control system. The proposed system attracted 1.4 times more attention than the control system. From this result, previous results of digital signage attention that both came from digital signage companies seem to be very high. Investigating the detailed conditions may help to understand the advertising effect.

Although the rate of type B and C was less than 10% of all the passers-by even in the proposed system, this rate cannot be discussed if it is small or not without the normal viewing ratio of this type of advertisement. Also the rate must be dependent on the content of advertisement.

(2) Advertising effect measurement

People do not just buy things. They experience a series of decision making processes including buying, which is called consumer behavior [32].

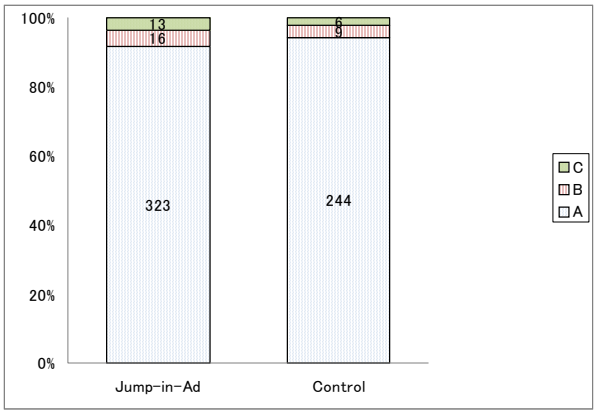


Figure 7: Viewers' behavior in the experiment.

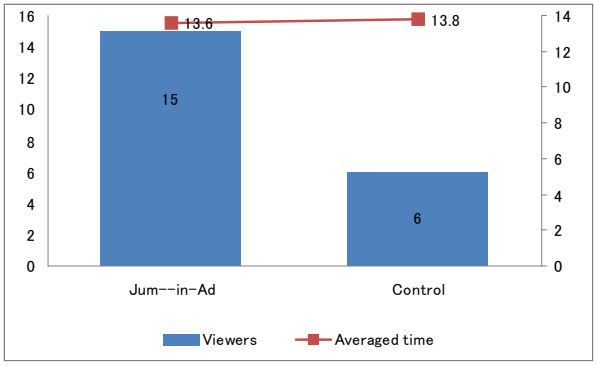


Figure 8: Sojourn time of type C people.

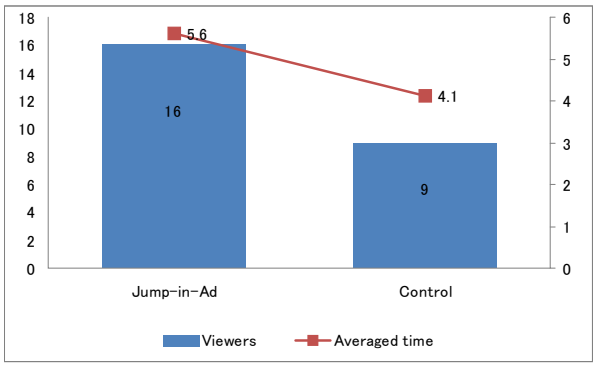


Figure 9: Sojourn time of type B people.

Models that explain consumer behavior have been proposed in marketing for understanding how to target a market effectively.

AIDA is an acronym introduced by Strong as proposed by Lewis that describes a common list of events that may be undergone when a person is selling a product or service [33]. "A" represents attention; the salesperson should attract the attention of the customer. "I" represents interest; the salesperson should raise customer interest by focusing on and demonstrating advantages and benefits. "D" represents desire; the salesperson should convince customers that they want and desire the product or service and that it will satisfy their needs. "A" represents action; the salesperson should lead customers towards taking action and purchasing.

AIDMA is another acronym shown in a book by Hall where "A" represents attention, "I" represents interest, "D" represents desire, "M" represents memory, and the last "A" represents action [34].

AISAS is yet another acronym proposed and trademarked by Dentsu where "A" represents attention, "I" represents interest, "S" represents search, the second "A" represents action, and the last "S" represents share [35].

In any of them, "attention" and "interest" appear as the initial steps of consumer behavior. These are contributed by the out-of-home advertising we have focused on.

(3) Findings for improvement

The proposed system did not work to type A people, who were not close enough to the system. The system works only when it detects the face of a viewer. A few people who came close to the system when they saw the system working to another viewer were found in the experiment. The system must be effective when it is placed where there are some people around. To use the system effectively even when there are not many people around, another method may be desired that makes the distant passers-by notice the system.

5 CONCLUTION

We have proposed a video advertisement system "Jump-in-Ad" that embeds the viewer's face into the advertisement in real time to attract more attention to the advertisement.

Interactive advertisement can be adaptive to the viewer. While most previous systems select an appropriate advertisement from the list of advertisements according to the viewer's profile, the proposed system is unique in changing the presentation of the advertisement video with the viewer's face in real time.

From the field experiment, the proposed system could attract more attention than the normal video system.

ACKNOWLEDGMENT

This research was partially supported by the JSPS Grant-in-Aid for scientific research 22500104, the Telecommunications Advancement Foundation, and the Research Projects of Graduate School of Library, Information and Media Studies, University of Tsukuba.

REFERENCES

[1] M. Sekiguchi, H. Naito, A. Ueda, T. Ozaki, and M. Yamasawa, "UBWALL", ubiquitous wall changes an ordinary wall into the smart ambience," Proc. 2005 joint conference on Smart objects and ambient intelligence: innovative context-aware services: usages and technologies, Vol. 121, pp. 47-50 (2005).

[2] Fujitsu General, "UBWALL," http://www.fujitsu-general.com/jp/products/ubwall/ (in Japanese)

[3] Hitachi Advanced Digital, "Digital Signage Plus," http://www.hitachi-ad.co.jp/signage/ (in Japanese)

[4] Sony, "Sony Digital Signage," http://www.sony.co.jp/Products/digital-signage/index.html (in Japanese)

[5] M. Takahashi and T. Nakao, "Conceptual design and its prototype of ubiquitous information delivery system,"

IPSJ SIG Technical Reports, Vol. 2002, No. 94, pp. 47-54 (2002) (in Japanese).
[6] F. Tsunoda, T. Matsumoto, T. Nakagawa, and M. Utsunomiya, "Implementation of interactive poster SuiPo," CHI '07 extended abstracts on Human factors in computing systems, pp. 1863-1868 (2007).
[7] E. M. Huang, E. D. Mynatt, "Semi-public displays for small, co-located groups," Proc. CHI 2003, pp. 49-56 (2003).
[8] A. Fass, J. Forlizzi, and R. Pausch, "MessyDesk and MessyBoard: Two designs inspired by the goal of improving human memory," Proc. DIS 2002, pp. 303-311 (2002).
[9] H. Brignull, S. Izadi, G. Fitzpatrick, Y. Rogers, and T. Rodden, "The introduction of a shared interactive surface into a communal space," Proc. CSCW 2004, pp. 49-58 (2004).
[10] K. Matsuda and K. Nishimoto, "HuNeAS: Supporting information-sharing and activating human network by exploiting spontaneous encounters in an organization," IPSJ Journal, Vol. 43, No. 12, pp. 3571-3581 (2002) (in Japanese).
[11] D. Vogel and R. Balakrishnan, "Interactive public ambient displays: transitioning from implicit to explicit, public to personal, interaction with multiple users," Proc. UIST 2004, pp. 137-146 (2004).
[12] A. Khan, G. Fitzmaurice, D. Almeida, N. Burtnyk, and G. Kurtenbach, "A remote control interface for large displays," Proc. UIST 2004, pp. 127-136 (2004).
[13] A. Shinohara, J. Tomita, and T. Kihara, "Mirai Tube: A field trial of an interactive media in public space," IPSJ SIG Technical Reports, Vol. 2006, No. 14, pp. 163-168 (2006) (in Japanese).
[14] M. Krueger, Artificial Reality, Addison-Wesley, MA, p. 215 (1983).
[15] K. Fukuchi, S. Mertens, and E. Tannenbaum, "EffecTV: a real-time software video effect processor for entertainment," Entertainment Computing - ICEC 2004, LNCS, Vol. 3166, pp. 602-605 (2004).
[16] J. Hoshino and H. Saito, "Building Virtual Fashion Simulator by Merging CG and Humans in Video Sequences," IPSJ Journal, Vol. 45, No. 5, pp. 1182-1193 (2001) (in Japanese).
[17] W. Zhang, T. Matsumoto, J. Liu, M. Chu, and B. Begole, "An intelligent fitting room using multi-camera perception," Proc. Intelligent User Interfaces 2008, pp. 60-69, (2008).
[18] M. Chu, B. Dalal, A. Walendowski, and B. Begole, "Countertop Responsive Mirror: Supporting physical retail shopping for sellers, buyers and companions," Proc. CHI 2010, pp. 2533-2542 (2010).
[19] S. Morishima, ""Dive into the Movie" Audience-Driven Immersive Experience in the Story," Trans. IEICE, Vol. 91-D, No. 6, pp. 1594-1603 (2008) (in Japanese).
[20] AITIA, Aura Shindan, http://www.aitia.co.jp/showcase/aura.html (in Japanese)
[21] H. Nemoto, K. Nishimoto, and K. Yamashita, "An electric ad system for a community to facilitate communication between advertisers and advertisees," IPSJ Journal, Vol. 46, No. 1, pp. 115-126 (2005) (in Japanese).
[22] T. Inoue and K. Heishi, "GAS: a group-adaptive advertisement system for public spaces," IPSJ Journal, Vol. 49, No. 6, pp. 1962-1971 (2008) (in Japanese).
[23] H. Mori, K. Shiratori, and J. Hoshino, "The digital signage system using virtual human for getting attention of passerby," IPSJ Journal, Vol. 52, No. 4, pp. 1453-1464 (2011) (in Japanese).
[24] NTT IT, "tenoripop," http://tenoripop.com/ (2008) (in Japanese).
[25] NTT IT, "News Release Digital signage system "tenoripop", http://www.ntt-it.co.jp/press/2008/0609/080609ssj.html (2008) (in Japanese).
[26] SIKUMI DESIGN, http://www.shikumi.co.jp (in Japanese)
[27] Nikkan Kogyo Shimbun, 2010.5.5 (2010) (in Japanese).
[28] C. J. Lee, et al., "Attention Meter: A vision-based input toolkit for interaction designers," CHI 2006 extended abstracts, pp. 1007-1012 (2006).
[29] S. Minamitake, S. Takahashi, and J. Tanaka, "A gaze information and movement trace acquisition toolkit to the digital advertisement," IPSJ Symposium Series, Vol. 2010, No. 4, SA12 (2010) (in Japanese).
[30] H. Arai, "Measuring the advertising effectiveness of digital signage," IEICE Journal, Vol. 93, No. 7, pp. 576-578 (2010) (in Japanese).
[31] P. Wang, "Digital Signage 101," http://www.dynasign.net/ds3/doc/digital_signage_101.pdf (2008).
[32] Nikkei Advertising Research Institute (ed.), "A comprehensive textbook for ad people through theories and case studies," Nikkei Advertising Research Institute (2007) (in Japanese).
[33] E. K. Strong, "Theories of selling," Journal of Applied Psychology, Vol. 9, pp. 75-86 (1925).
[34] Dentsu Advertising terminological dictionary Project team, Advertising terminological dictionary revised edition, Dentsu (2001) (in Japanese).
[35] Dentsu, Annual report for the year ended March 31, 2006, http://www.dentsu.com/ir/data/pdf/AR2006_E.pdf (2006)

(Received July 20, 2010)
(Revised May 15, 2012)

Tomoo Inoue is Associate Professor of the Faculty of Library, Information and Media Science of University of Tsukuba. His research interests include HCI, CSCW, and CSCL. He received Ph.D. in Engineering from Keio University in 1998. He is a recipient of awards including Best Paper Award, Activity Contribution Award and SIG Research Award from Information Processing Society of Japan (IPSJ). He has served a number of academic committees, currently including IEICE SIG Human Communication Science, IEICE SIG Multimedia on Cooking and Eating Activities, IEEE TC CSCWD, and IEEE TC HCI.

[Practical Paper] An evidence preservation method for a portable terminal by using data prioritization and signature history intersection

Takashi Mishina*, Yoh Shiraishi**, and Osamu Takahashi**

*Graduate School of Systems Information Science, Future University Hakodate, Japan
**School of Systems Information Science, Future University Hakodate, Japan
{siraisi, osamu}@fun.ac.jp

Abstract – A portable terminal currently contains not only a lot of personal information such as addresses, telephone numbers, e-mail addresses but also personal behavior information such as telephone call history, operation log, location information. As corporate use of portable terminals increases, it will become necessary to prove the cause of computer security incidents to decrease information leaks due to human factors.

In order to reduce such computer security incidents and prove a user's behavior, we apply digital forensics to a portable terminal. Digital forensics is a technique that collects and preserves evidences to prove information security incidents. When applying the technique to a portable terminal, we need consider the following problems: unexpected data loss on the terminal, the few calculation resources of CPU and memory, poor reliability of collected and preserved evidences.

This paper proposes a practical method of evidence preservation for a portable terminal to solve the above problems. Our method periodically collects various kinds of data on the terminal and preserves them as evidences on a server through a network. For load reduction on the terminal, data on the terminal are prioritized and collected at the frequency based on the priority level. To prevent the signature from the counterfeit and improve the evidence reliability, we adopted the signature history intersection and hysteresis signature.

Keywords: Evidence preservation, portable terminals, digital forensics, security, signature history intersection.

1 INTRODUCTION

Portable terminals are important devices that many people use for various purposes from personal use to corporate use, such as voice communication, sharing information in data communications, and internal and external access to corporate intranet systems. Moreover, portable terminals use ad hoc networks and exchange information, for example, during natural disasters. Further developments in portable terminal technology will produce more applications.

In these situations, important personal information is used such as addresses, telephone numbers, e-mail addresses, telephone call history, operation logs, file information, etc. When personal information is used for corporate use, information security measures are needed. Current information security measures have been chiefly designed to prevent invasion and operation from outside the network. However, information leaking from the inside to the outside is also a problem. Ninety percent or more of the information security breaches in which information leaks from the inside to the outside is attributed to three human factors: "ignorance", meaning information is mistakenly leaked out; "fault", meaning the terminal is operated incorrectly, lost, or stolen; and "intention", meaning information is intentionally sold illegally [1].

There are two methods for decreasing the breaches caused by these human factors. One is continuously educating the person. The other is giving the portable terminal physical measures and covering the person's mistake. The problem with education is it is expensive and takes time to see effects. Therefore, we apply digital forensics to the portable terminal, and focus on methods for decreasing the negative effects of the human factors.

Collecting periodically evidences in a portable terminal and preserving these evidences are required while a user operates the terminal as usual (namely, without stopping the system) in order to prove a user's behavior at occurring information security incidents. Also, ensuring reliability of the preserved evidences is required. It is desirable to collect and preserve as much information as possible such as telephone call history, transmitted and received information via mail, operation logs, setting files. Recently, portable terminals as smartphones are equipped with many sensors such as GPS, IC tag. By using these sensors, it is being able to collect information about a user's behavior such as movement, entering / leaving a room, electronic payment at a store. These information can be evidences to prove a user's behavior: where a user is, what a user is doing at the time.

Digital forensics [2] is a set of techniques in which evidence is collected, stored, and analyzed to prove information security incidents such as an illegal invasion, leak of information, etc. However, there are problems with digital forensics. Sometimes if information is not collected, its performance decreases and stops the system, detection is delayed, and evidence can be destroyed during an investigation [3]. In order to deal with these problems, live forensics that periodically collects evidences without stopping the system has been proposed [3][4]. This characteristic of live forensics is required for collecting evidences in a portable terminal. However, the existing methods for live forensics focus on data on personal computers with rich computation resources, and it is difficult to apply these methods to portable terminals with poor computation resources such as CPU and memory.

In addition to these problems, there are some specific problems when digital forensics is applied to portable terminals: illegal access by enhancement of communication functions, data memory composed of flash memory, and unreliable evidence [2]. Volatile data on flash memory in a

portable terminal are lost at the power off. Consequently, important evidences on the flash memory will be lost by the sudden system shutdown and battery off. There is a possibility that hardware reset by fault and malicious intention eliminate all of the evidences from the system. Preserving evidences in a portable terminal has a significant risk. Assuming illegal access from outside of the terminal, it is difficult to secure reliable evidences using only the terminal.

Therefore, our research aims to prove information security incidents caused by the human factor with a portable terminal and to prove how the terminal (namely, the user) behaves. In this paper, we apply digital forensics to a portable terminal and propose a method that periodically collects much information in a portable terminal as evidences and preserve them. The proposed method solves the problems when applying digital forensics to portable terminals and has the following characteristics.

a) Our method preserves evidences collected from a portable terminal on a remote server via a network in order to deal with vulnerability of preserving these evidences in only the portable terminal.
b) It collects evidences in a portable terminal at the different frequency according to characteristics of these evidences (volatility of data, overhead at collecting data) in order to consider limited computation resources of the terminal. We prioritize the evidence data and decide the collecting frequency based on the priority level.
c) It intersects signature histories between a portable terminal and a server in order to improve the reliability of the preserved evidences. In addition, we use the hysteresis signature technique together in order to prevent the signature from counterfeiting.

2 RELATED WORK

In this section, we clarify the position of the proposed method in the field of digital forensics, details details an existing digital forensic method for portable terminals (mobile forensics) and signature techniques to secure reliable evidence (the hysteresis signature and the signature history intersection).

2.1 Digital forensics

In digital forensics intended for the computer, usually data is maintained by the following process: (1) to detect information security incidents, (2) to judge whether evidence data disappear by turning off the power supply, (3) to turn off the power, and (4) to maintain data from the outside with some special equipment. The data disappears when the computer is switched off, but it is a possibility to add some changes to the data by collection activity.

Recently, there is other approach that tries to collect evidence data without turning off the power (namely, stopping the computer). This approach is called “live forensics” [3][4]. Since a user is always carrying a portable terminal, the characteristics of live forensics is desirable use for collecting evidence data from the terminal. However, it is difficult to apply these methods to data on portable terminals with limited computation sources. The existing methods for live forensics deal with data on computers with rich computation resources. In the case where these methods apply to portable terminals, there is a possibility that data collection activities increase the load of the computer and change the state of the system.

“Network forensics” [2] is a technique that collects and preserve data flowed on a network as evidences. Many tools for network forensics have been developed. These tools monitors network nodes such as terminals, servers and relay nodes, and collects evidence data on a network. However, this study focus on not only information flowed on a network such as call history and receiving/transmitting information, but also information recorded inside a portable terminal such as operation logs and application data. Network forensics is not enough for evidence preservation on a portable terminal.

2.2 Mobile forensics

Mobile forensics is a set of techniques that collect information inside portable terminals such as PDA and memory card as evidences in order to prove illegal use of a user with a portable terminal and prove the user’s behavior.

2.2.1 Forensics method using portable terminal memory

Willassen suggests two methods of investigating information that has been deleted from the memory of a portable terminal [5]. One of his methods uses seven pieces of information as evidence.

- Images
- Sounds
- Multimedia messages
- WAP / web browser history
- Email
- Calendar items
- Contacts

In the first method, it is connected to the on-board flash memory tip directly and reads the content of the memory. The second method uses the boundary scanning test, which is an inspection method that uses an IC tip to read the contents of the device’s memory. Both methods need a physical connection to the portable terminal, but the correct information cannot be found with a portable terminal alone.

2.2.2 Digital forensic method using a portable terminal itself

Kunii proposed a system for digital forensics and files management in a small-scale computing environment [6]. In this method, the PC files are distributing preserved. Each user proves the legitimacy of each other's file update histories and realizes digital forensics. The portable terminals are used to generate signatures in this method. However, because information in the portable terminal is not collected, it is difficult to determine what has happened using the portable terminal.

2.2.3 Device seizure

Device seizure [7] is a forensic tool for cell phones, PDAs, and GPS devices. The features all preserve the files of the original data and can run the processes of collection, preservation, and analysis independently. PDA seizure requires connection with a special device when collecting various data.

2.2.4 SIMIS

SIMIS [8] is a forensic tool for SIM cards. The features of SIMIS correspond to SIM card data collection and analysis, composed of a control card, a data preservation card, analysis application, and card reader. The features of each process ran independently. SIMIS uses cable when collecting physical copy of SIM card. SIMIS requires connection with a special device when collecting data.

2.3 Improving reliability of evidences

2.3.1 Signature history intersection

The signature history intersection [9] is a chain method between one's signature history and others' signature histories used as the signature record. As a result, it is thought that the counterfeit becomes difficult as histories become longer because it needs the falsification of others' signature histories when a person illegally forges the signature (Fig. 1).

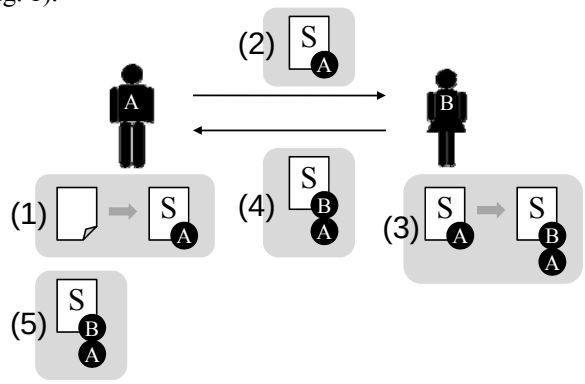


Figure 1: Signature history intercrossing

2.3.2 Hysteresis signature

The hysteresis signature [4][9] is one of the measures technologies to reduce damage because of the leakage and the presumption of the signature generation key that becomes a problem when a long term of the electronic filing document is operated a minimum. When the electronic filing document is registered, signature information is left for the history in this technology. When the electronic filing document is signed, signature information left for the history is taken and a new signature is generated. Therefore, a time series chain architecture arises between electronic documents. Concretely, the signature generation processing of the past is done by uniting the hash values of the electronic filing document to be signed and the signature record immediately before, and using own private key and the message with the hysteresis signature is generated. Moreover, signature information is left for the history at the same time (Fig. 2).

A part of the signature history is safely kept by the tamper resistant module. As a result, even if a past signature is forged, this can be detected by confirming whether it corresponds to the history.

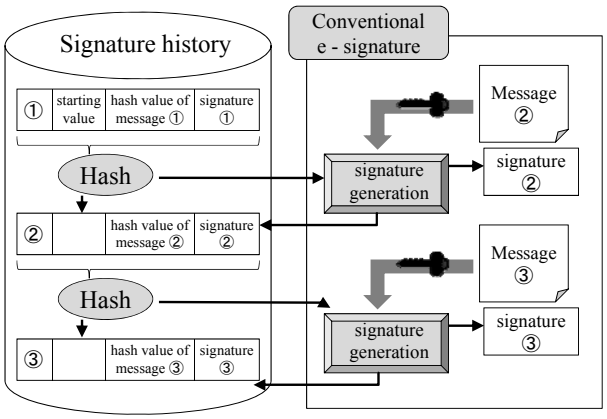


Figure 2: Hysteresis signature scheme

When the hysteresis signature is inspected, usual signature verification by the public key is done to the message with the hysteresis signature. Moreover, it can be confirmed whether there is information on a past signature in the message with the hysteresis signature as a correspondence verification of the signature generation history when inspecting it, and confirm the chain of the signature record. Therefore, it is necessary to reflect the time series chain architecture between electronic documents that not only forge the signature by counterfeiting the document to counterfeit the document with an illegal person and the signature and using electronic document manufacturer's private key but also reflect a past signature generation history and to counterfeit. It is thought that the forgery of the signature is difficult for using the hysteresis signature from the above-mentioned.

3 PROPOSED METHOD

This section describes requirements when digital forensics is applied to the portable terminal, priority level and collection frequency of information, and the flow of the proposed method.

3.1 Requirements

As described in Section 1, there are various problems when applying digital forensics to a portable terminal. We decide the requirements of an evidence preservation method for a portable terminal based on the above discussions.

a) To deal with the risk of unexpected loss of evidences on a portable terminal.

A portable terminal uses the flash memory for the data carrier and can delete all information by hardware reset. Signs of the relevant information leakage possibly cannot be acquired when evidence is maintained in the terminal. When connecting a portable terminal with a special device and collecting evidences by the device, it is difficult to collect these evidences anytime and anywhere because a user is carrying the terminal basically. Consequently, to deal with the loss of the evidences, collecting periodically data and preserving the collected data on an appropriate site as evidences are required.

b) To collect and preserve evidence data with consideration of the limitation of computation resources on a portable terminal.

When connecting the portable terminal to the special equipment from the outside and collecting evidence data, it is necessary to stop the system. Such method is unsuitable for the portable terminal that a user carries and operates anytime and anywhere. When a lot of calculation resources are needed for the portable terminal in such method of frequently acquiring the bit stream image, the performance of the system worsens. The decrease in performance and the stop of the system make it impossible to contact in the emergency. Consequently, data collection and evidence preservation without decreasing the performance and stopping the system are required.

c) To secure reliability of evidences collected from a portable terminal.

When collecting and preserving evidence only with the portable terminal and putting the e-signature on the evidence by itself, the private key leaks become possible to counterfeit of the e-signature. Moreover, evidence may be falsified by a malicious operation because the telecommunication facility of the portable terminal has been enhanced. Therefore, evidence must later be verified to make sure it is not falsified.

To satisfy these requirements, we adopt the following approach.

A) Our method collects data periodically from a portable terminal and preserves these data as evidences on a server via a network.

B) It prioritizes data in the portable terminal and collects at the frequency based on the priority level in order to reduce the load of the terminal.

C) It prevents the e-signature from the counterfeit by intersecting the signature histories between the portable terminal and the remote server, and secures the reliability of the evidences.

3.2 Priority level and collection frequency

3.2.1 Priority level of information

The data of PC and the portable terminal exists in volatility and nonvolatile states. Nonvolatile data is the data (like file system stored in the hard disk drive and the flash memory) that continues after the computer is switched off. Volatility data indicates the disappearing data (like the present network connection of the system) when turning the computer off. Table 1 shows the list and the priority level of volatility and nonvolatile data of the portable terminal.

Table 1 refers to the priority levels when data was collected that are generally recommended [10][11].

Priority levels are decided by considering the burden given to the portable terminal. "Content of memory" should acquire the memory image of the bit stream. Therefore, “content of memory” is the lowest priority level in volatility data.

About priority level of the nonvolatile data, these information that call record, SMS/MMS information, etc. are unique information of portable terminal. Therefore, we thought that these information are needed in a proving situation of human factor incidents of using portable terminal. The bit stream image can generate a copy including the space domains of the original medium. However, an execution time longer and the burden on the terminal more than that for a logical backup that copies a file simply are needed. Because as many as a seventh to an eighth of the nonvolatile data are needed to acquire the bit stream image, the priority level is low.

Table 1: Volatile data and nonvolatile data

		Volatile data	Nonvolatile data
Priority	1	Network connection	Call record
	2	Login session	SMS / MMS record
	3	Running processes	Contact information
	4	Opened files	Calendar information
	5	Network composition	Config file
	6	Time of OS	Log file
	7	Content of memory	Data file
	8		Application file

3.2.2 Change in collection frequency

With the priority levels that we showed in Section 3.2.1, we collect and maintain evidence in three phases. Table 2 lists the collection range and frequency of the evidence.

The high collection frequency acquires logical backup from volatility data priority level 1 to 6. The medium collection frequency acquires the image of the bit stream of RAM and logical backup from nonvolatile data 1 to 2. Finally, the low collection frequency acquires the image of the bit stream of ROM. By changing the collection frequency and range of information gathering, it is possible to prevent the system degrading the performance and being stopped by lowering the burden on the terminal. In addition, there is the difference in collection frequency, but the loss of evidence can be prevented to collect all information. As a result, we can solve problems (a) and (b) in Section 3.1.

Table 2: Collection frequency and collection range

Frequency	Range
High	Volatile data: priority 1 ~ 6
Medium	Volatile data: priority 7 Nonvolatile data: priority 1 ~ 6
Low	Nonvolatile data: priority 7 ~ 8

3.3 Algorithm of proposed method

The proposal method is composed of the portable terminal and the server. The portable terminal gathers and transmits evidence. The server secures maintenance and

reliability of the evidence that has been sent. The server can be trusted enough like providers of digital certification services, and the access in the server must be severely limited. Figure 3 shows the flow of the proposal method.

3.3.1 Behavior of portable terminal

The portable terminal is processed as follows.

・Regular acquisition of evidence

・Generation of hysteresis signature

・Encryption and transmission of evidence and hysteresis signature

Evidence is regularly acquired by using the collection frequency and the range of the collection of evidence listed in Table 2. To minimize effects on the system, the program that gathers evidence is executed in the conserved region near a tamper resistant SD memory card. Moreover, to prove the completeness of evidence, the hash values with former data are compared. Collected evidence is stored in the SD memory card.

Next, the hysteresis signature is generated by using acquired evidence and signature history. Afterwards, evidence and the hysteresis signature are transmitted to the server, after which evidence is deleted and the hysteresis signature is preserved as the latest signature history. Information leaks are prevented by deleting evidence. When the hysteresis signature is received from the server, it is preserved as the latest signature history. The hysteresis signature is generated and the signature history preserved in separate processes in each range of the collection.

Evidence and the hysteresis signature are both transmitted an odd number of times, but only evidence is transmitted an even number times. By right, two or more terminals acquire data respectively, and the hysteresis signature is signed in the chain. However, in this process, only the portable terminal acquires data and a chain signature with the server is enabled. The reliable evidence can be secured by this process, and the problems described in Section 3.1 can be solved.

3.3.2 Behavior of server

The server is processed as follows.

・Reception of evidence and hysteresis signature sent from portable terminal

・Generation and transmission of hysteresis signature

All evidence and the hysteresis signatures sent from the portable terminal are preserved on the server side. The hysteresis signature is generated, and signature history preserved in separate processes in each range of the collection as well as the portable terminal side. The hysteresis signature is not generated and transmitted an odd number of times but an even number times (Fig. 3). Because evidence is preserved only on the server side, evidence can be prevented from being falsified.

4 EVALUATION AND DISCUSSIONS

This section shows the effects of the human factor with which the proposed method can deal and the results of the qualitative evaluation.

4.1 Incidents that can be dealt with

The biggest cause of information leaks is "operational errors", in which information is leaked through e-mails sent to the wrong recipient. The second biggest cause is "management mistakes", in which important information is mistakenly leaked out with other information. Other causes of leaks are losing or leaving behind memory devices that contain important information, theft, illegal removal of information, configuration errors, etc. Using the portable terminal with the proposed method enables these human factors to be proved.

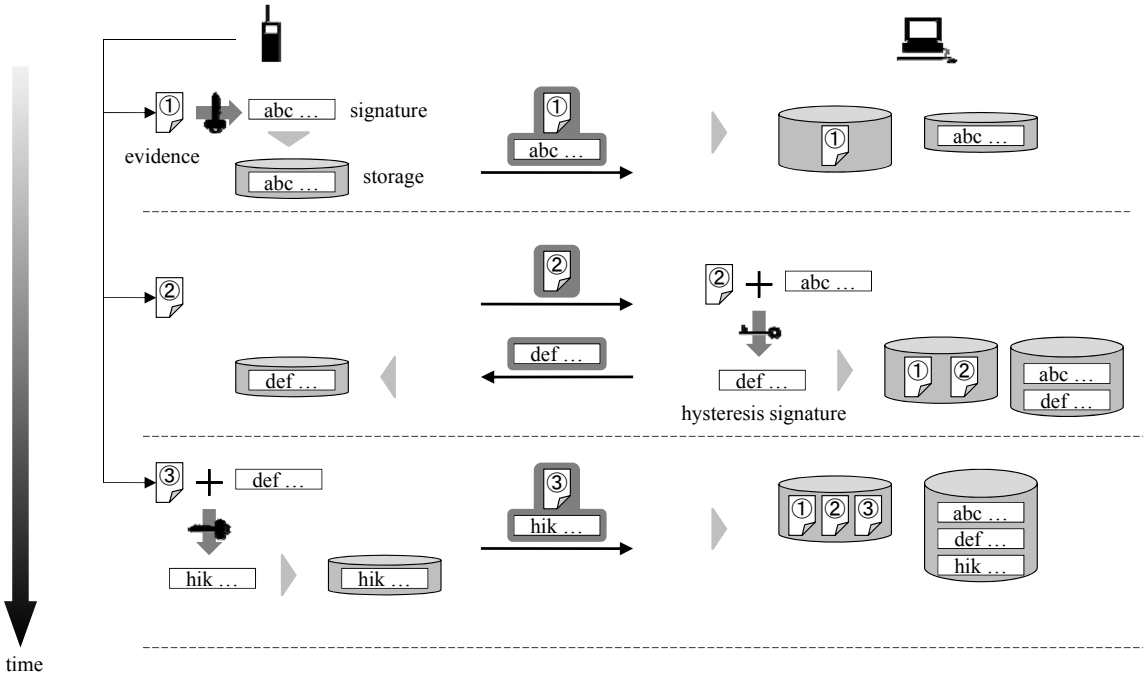


Figure 3: Flow of the proposed method

(1) Ignorance

This includes management mistakes and configuration errors. When important information is thrown away by mistake, proposed method can prove when, how and what information was thrown away. At that time, proposed method uses running processes, time of OS, and data files. When the information leaks due to a setting mistake in the application, the cause can be proven. At that time, configuration files and application file are used.

(2) Fault

This includes operational errors, theft, loss, or leaving the device unattended. Proposed method can prove what e-mail has been sent by mistake due to operational error by the portable terminal. At that time, proposed method uses the network connection, network composition, and log file. This can determine whether the portable terminal was being operated while it was lost or stolen. At that time, xxx checks the login session, running processes, and opened files. The proposed method should be able to determine whether someone had the portable terminal.

(3) Intention

This includes illegally removing information. The proposed method can prove what information has been illegally removed by using with the address and the telephone number, etc. At that time, proposed method uses data files and the content of the device memory.

Much volatile data with high collection frequency is requested in typical information leaks. It is thought that problems can be dealt with because a lot of volatile and nonvolatile data are collected in the proposed method even when incidents other than those above occur. When the cause is proven, proof that keeps the temporal order is possible because data and the hysteresis signature of information are acquired regularly.

4.2 Qualitative evaluation

The case where existing digital forensics of the computer is applied to the portable terminal is defined as "non-apply" and is carried out as follows. The portable terminal is connected to a PC, and an image of the RAM bit stream is acquired. Afterwards, the ROM data is maintained as a bit stream image while the portable terminal system is stopped. Table 3 shows the results of the qualitative evaluation by comparing the "non-apply" and the proposed method.

Table 3: Qualitative evaluation results
(O: good , Δ: poor , X: no good)

	Non-apply	Proposed method
Mistake acquisition	O	Δ
Performance degradation	X	O
Reliability	O	O

The problems enumerated in Section 3.1 were used to evaluate the method.

(1) Mistake acquisition of information

Non-apply collects and maintains the ROM and RAM data as a bit stream image. Therefore, non-apply can reduce miss acquisition of information by collecting and storing it as soon as security incidents happen.

The proposed method acquires images of the ROM and RAM bit stream. However, the information acquired is frequently a physical data copy of volatile data. Therefore, nonvolatile data may be missed in some cases.

(2) Degradation of the system

In non-apply, there is no communication in an emergency because the portable terminal must be stopped.

In the proposed method, the collection frequency and the range of the collection are changed in accordance with the priority level of information. Therefore, the burden on the portable terminal is small, so it is never stopped.

(3) Reliability of the evidence

To connect with a trustworthy PC and to gather evidence in non-apply, the reliability of the evidence is secured enough.

In the proposed method, collected evidence is preserved in the portable terminal once. However, it is thought that the reliability of evidence is secure enough so that hysteresis may be signed between the server and the portable terminal, and the servers preserve evidence for a long time.

This qualitative evaluation showed that, when non-applying, the proposed method was inferior at preventing information from being deleted. However, it prevented degradation of system performance, which is the most important thing in the portable terminal.

4.3 Quantitative evaluation

4.3.1 Experiment environment

We implemented the proposed method as an application and quantitatively evaluated the proposed method for three processes.

- Regular acquisition of evidence
- Generation of hysteresis signature
- Encryption and transmission of evidence and hysteresis signature

The experimental environment is as follows (Table 4).

Table 4: Experimental objects

OS	Android 1.6
Terminal	HT-03 A [12] CPU : 528 MHz Storage : 512 MB Memory (RAM) : 192 MB
Network	IEEE 802.11 g
Symmetric-key cryptography	AES 128-bit key
Public key cryptography	DSA 1024-bit key
Target data (from Table 2)	High-frequency data Low-frequency data

Experimental items are as follows.

(1) CPU load

The CPU load on to the terminal in each of the three processes for the proposed method.

(2) Memory usage

Memory usage shows the memory area used in each of the three processes for the proposed method.

(3) Runtime

During the acquisition process, the runtime shows the time until the application finished the evidence acquisition starting.

The measurement method is as follows.

・One of the three processes, acquisition, signing, or transmission from the portable terminal, is run.

・The running load is measured using the vmstat command.

・The mean is calculated using five measurements

As a prerequisite for evaluation, I finished all applications except for the application of the proposed method, and I evaluated the proposed method at a stationary state of about 0–3% CPU load for the system.

4.3.2 Experimental result

(1) High-frequency collection

Table 5 shows the result of the quantitative evaluation using high-frequency collection.

The CPU load when the evidence was acquired was low, and the runtime was short. The CPU load when evidence was signed was highest, and the runtime was the shortest. The CPU load when the evidence was encrypted and transferred was high, and the runtime was longest. Therefore, this process puts a heavy workload on the portable terminal. I thought the difference between the signature and encryption was due to the difference of the processing data volume. In the signature process, the proposed method sign for the hash value from original data. However, in the process of encryption, the proposed method encrypts the original data. The data volume of the original data is larger than the hash value. I found that the memory usage was always low.

Table 5: Result of the high-frequency collection

	CPU (%)	Memory (MB)	Runtime (s)
Acquisition	16.7	0.09	2.8
Signature	98	0	0.03
Transmission	71.4	0.96	9.3
Average	58.83	0.76	(Total time) 12.13

(2) Low-frequency collection

Table 6 shows the results of quantitative evaluation by low frequency.

This result shows the same tendency as the high-frequency, because the only difference between low- and high-frequency is the volume of data. However, the runtime when the evidence is encrypted and transferred is unacceptably long. This is because the proposed method encrypts and transfers the original data without dividing it.

Table 6: Results of the low-frequency collection

	CPU (%)	Memory (MB)	Runtime (s)
Acquisition	55.57	1.13	70.20
Signature	97.60	0.00	17.45
Transmission	63.15	0.11	2217.24
Average	63.19	0.14	(Total time) 2304.89

4.4 Summary of evaluation

In the quantitative evaluation, I measured the load of the proposed method for high-frequency data and low-frequency data. The portable terminal had a workload from high-frequency data of about 12 seconds and about 58% load of the CPU. The portable terminal had a workload from the low-frequency data of about 38 minutes and about 63% load of the CPU. This suggests that the proposed method can acquire volatile data without requiring the system to stop. The proposed method could not acquire, sign, encrypt and transfer nonvolatile data as a whole.

Therefore, for portable terminals, the proposed method should acquire evidence at fixed intervals, and the proposed method should sign, encrypt, and transfer at a little-used time.

5 CONCLUSION

A technique to preserve evidence was proposed to change the collection frequency and range by using the priority level of information when using digital forensics for portable terminals. Evidence that corresponds to many information leaks can be gathered by frequently collecting important volatility data and reducing the burden on the portable terminal. Nonvolatile data is collected at low frequency. Therefore, this data can correspond to the data file and the application file that are requested as proof of an information leak. The signature using the portable terminal can be verified as evidence by using the hysteresis signature. Therefore, reliable evidence can be securely maintained. Quantitative evaluation demonstrated that the proposed method was useful.

For future work, it is necessary to improve acquisition, signature, encryption, and transmission. The proposed method must process the data in parts. Moreover, it is necessary to determine the optimum evidence collection frequency while minimizing the load on the system.

REFERENCES

[1] H. Ohtani (Working Group Leader), Information Security Incident Survey Report, NPO Japan Network Security Association Security Incident Investigation Working Group (2008).

[2] S. Tsujii (editorial supervisor), Digital Forensics Dictionary, Digital Forensics Society (2006).

[3] T. Ochi, T. Kojima, M. Togawa, and Y. Itakura, “The Proposal of Incident Detection Method using the Hot Digital Forensic,” IPSJ SIG Notes 2008, pp. 267–272, Information Processing Society of Japan (2008).

[4] M. Shinoda, Y. Ueda, and R. Sasaki, “Proposal and Evaluation of Hysteresis Signature System with Paper

Document," Proc. Technical Report of IEICE. ISEC, Vol. 103, pp. 77–82 (2003).
[5] S. Willassen, "Forensic Analysis of Mobile Phone Internal Memory," Proc. International Federation for Information Processing (IFIP), Vol. 104, pp. 191–204 (2005).
[6] Y. Kunii and R. Uda, "A Proposal of A Distributed File Backup System for Digital Forensics Using Cellular Phone," Proc. Multimedia, Distributed, Cooperative, and Mobile Symposium (DICOMO 2009), pp.671–678 (2009).
[7] Paraben Corporation, Device Seizure http://www.paraben.com/device-seizure.html
[8] 3g Forensics Smart Forensic Solutions, SIMIS http://www.crownhillmobile.com/simis.htm
[9] S. Susaki and T. Matsumoto, "Alibi Establishment for Electronic Signatures," IPSJ Journal, Vol. 43, No. 8, pp. 2381–2394 (2002).
[10] K. Kent, S. Chevalier, T. Grance, and H. Dang, "Guide to Integrating Forensic Techniques into Incident Response," Proc. NIST Special Publication, pp. 800–886 (2006).
[11] D. Brezinski and T. Killalea, "Guidelines for Evidence Collection and Archiving," RFC3227 (Best Current Practice) (2002).
[12] htc, HT-03A,http://www.htc.com/jp/product/ht03a/overview.html.

(Received July 6, 2010)
(Revised May 14, 2012)

Takashi Mishina received his B.E. and M.E. degrees in information science from Future University Hakodate, Japan in 2009 and 2011. His research interests include mobile computing and information security. He currently works in NTT East Corporation.

Yoh Shiraishi received doctor's degree from Keio University in 2004. He is currently an associate professor at the Department of Media Architecture, School of Systems Information Science, Future University Hakodate Japan. His research interests include database, mobile sensing and ubiquitous computing. He is a member of IPSJ, IEICE, GISA and ACM.

Osamu Takahashi received master's degree from Hokkaido University in 1975. He is currently a professor at the Department of System Information Science at Future University Hakodate, Japan. His research interest includes ad-hoc network, network security, and mobile computing. He is a member of IEEE, IEICE, IPSJ.

Submission Guidance

About IJIS

International Journal of Informatics Society (ISSN 1883-4566) is published in one volume of three issues a year. One should be a member of Informatics Society for the submission of the article at least. A submission article is reviewed at least two re viewer. The online version of the journal is av ailable at th e following site: http://www.infsoc.org.

Aims and Scope of Informatics Society

The evolution of i nformatics heralds a new information society. It provides more convenience to our life. Informatics and technologies have been integrated by various fields. For example, mathematics, linguistics, logics, engineering, and n ew fields will join it. Esp ecially, we are co ntinuing to maintain an awaren ess of informatics and c ommunication convergence. Informatics Society is t he organization that tries to d evelop informatics and technologies with this convergence. International Journal of Informatics Society (IJIS) is th e journal of Informatics Society.

Areas of interest include, but are not limited to:

- Computer supported cooperative work and groupware
- Intelligent transport system
- Distributed Computing
- Multi-media communication
- Information systems
- Mobile computing
- Ubiquitous computing

Instruction to Authors

For detailed instructions please refer to the Authors Corner on our Web site, http://www.infsoc.org/.

Submission of manuscripts: There is no limitation of page count as full papers, each of which will be subject to a full review process. An electronic, PDF-based submission of papers is mandatory. Download and use the LaTeX2e or Microsoft Word sample IJIS formats.

http://www.infsoc.org/download/sample_IJIS.pdf

LaTeX2e

LaTeX2e files (ZIP) http://www.infsoc.org/download/template_IJIS.zip

Microsoft Word™

Sample document http://www.infsoc.org/download/sample_IJIS.doc

Please send the PDF file of your paper to secretariat@infsoc.org with the following information:

Title, Author: Name (Affiliation), Name (Affiliation), Corresponding Author. Address, Tel, Fax, E-mail:

Copyright

Publisher

Address: Informatics Laboratory, 3-41 Tsujimachi, Kitaku, Nagoya 462-0032, Japan

E-mail: secretariat@in fsoc.org

CONTENTS