State-dependent Modulation of Cortical Synchrony by Vagus Nerve Stimulation in Adult Rats

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Keywords: vagus nerve stimulation, cerebral cortex, local field potential, neuronal synchrony, phase-locking, rat

Vagus nerve stimulation (VNS) is a palliative treatment for intractable epilepsy. Therapeutic mechanisms of VNS have not been elucidated. In this study, we measured the local field potential (LFP) with high-spatial resolution using a microelectrode array in adult rats, and analyzed VNS-evoked phase modulation at a local network level. Eight adult Wistar rats (270 - 330 g) were used. Each rat underwent implantation of VNS system (Cyberonics, Houston, TX., USA) under 1.5% isoflurane anesthesia. One week after implantation, right temporal craniotomy was performed under the same as previous anesthesia. Subsequently, a microelectrode array was placed in the temporal lobe cortex, and LFP was recorded with a sampling rate of 1000 Hz. Phase-locking values (PLV) between all pairs of electrodes in varied frequency bands were calculated in order to evaluate the effect of VNS in terms of synchrony of neuronal activities. PLV was calculated both in a normal state and in an epileptic state induced by kainic acid. VNS increased PLV in a normal state, particularly in high-γ band. In an epileptic state, VNS increased PLV in high-γ band, and decreased in δ and low-β bands (Fig. 1 and 2). These results suggest that VNS modulates synchrony in a band-specific and state-dependent manner so as to keep cortical synchrony within the optimal state.

![Graph 1](image1.png)

**Fig. 1.** Band specific ΔPLVmean changes by VNS

![Graph 2](image2.png)

**Fig. 2.** Representative VNS-induced modulation of the cortical synchrony in the auditory cortex
Extended Summary

Chronic Co-variation of Neural Network Configuration and Activity in Mature Dissociated Cultures

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Keywords : Dissociated cultured neuron, microelectrode array, cell migration, neural activity, CMOS

Spatio-temporal neural patterns depend on the physical structure of neural circuits. Neural plasticity can thus be associated with changes in the circuit structure. For example, newborn neurons migrate toward existing, already matured neural networks in order to participate in neural computation. In the present study, we have conducted two experiments to investigate how neural migration is associated with the development of neural activity in primary dissociated cultures of neuronal cells. In Experiment 1, using a mature culture, a high-density CMOS micro-electrode array (Fig. 1) was used to continuously monitor neural migration and activity for more than two weeks. Consequently, we found that even in mature neuronal cultures, neurons moved $2.0 \pm 1.0 \mu m$ a day (Fig. 2) and that the moving distance was negatively correlated with their firing rate (Fig. 3), suggesting that neurons featuring low firing rates tend to migrate actively. In Experiment 2 using a co-culture of mature and immature neurons (Fig. 4), we found that immature neurons moved more actively than matured neurons (Fig. 5) to achieve functional connections to other neurons (Fig. 6). These findings suggest that neurons with low firing rates as well as newborn neurons actively migrate in order to establish their connections and function in a neuronal network.

Fig. 1.  High-density CMOS array.

Fig. 2.  Migration trajectories of neurons on CMOS array. Gray levels correspond to DIV: the lightest, DIV 26; the darkest, DIV 42.

Fig. 3.  Correlation between migration distance and discharge rates.

Fig. 4.  H-shaped separator for co-culture of different DIV neurons.

Fig. 5.  Estimation of cell migration. Numbers of cells were counted twice, each 2 weeks apart, at 3 ROIs: old/young culture sides and center region.

Fig. 6.  Functional connectivity between mature (left) and immature neurons (right).
3D Gaze Tracking on Stereoscopic Display Using Optimized Geometric Method

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Keywords: 3D gaze tracking, stereoscopic display, depth perception, virtual reality

Recently, active 3D technology is gaining wider attention. Consumer-level active 3D technology is commonly used in entertainment, visualization, medical, and therapeutic purposes. As the usage of active 3D technology is increasing, expectations on development of more user-friendly stereoscopic 3D content also increases. Among other issues, depth perception in virtual space is considered important for better 3D content that considers human factor.

Depth perception in virtual space is generally found to be problematic and inaccurate. During exposure of stereoscopic 3D content, all images are projected onto a 2D screen which require both eyes to always accommodate and be focused on the screen although the virtual 3D object is gazed at different depths. On the other hand, human eyes are naturally sensitive in differentiating depth of two objects. Previously published work found that human can discriminate position of two objects with 14 arcsec of angular disparity, which is equivalent to 1.3 mm depth interval at a distance of 1.12 meters. Thus, to optimize 3D content on stereoscopic display, precise depth measurement of virtual 3D object is necessary.

In this paper, we suggest a novel approach to measure 3D point of gaze on stereoscopic display. We have developed a head-mounted gaze tracking system that can be used properly with active shutter glasses, as shown in Fig. 1. A consumer-level active shutter glasses of Nvidia 3D Vision® system is used to view stereoscopic content. A Famicom gaming goggle (Nintendo Co. Ltd., Kyoto, Japan) is modified to be a gaze tracking headgear by considering the size and the installation of Nvidia 3D Vision® glasses.

Left panel of Fig. 2 shows the schematic drawing of the proposed 3D gaze tracking method. Dual-camera systems and Direct Linear Transformation algorithm are used to obtain real-time 3D pupil position of left and right eyeball. The gaze tracking algorithm maps user’s gaze to 2D screen using second order polynomial. Given information of user dependent parameters (eyeball radius and interpupillary distance), height of user eye from ground, distance of user to screen, width and height of screen, 3D point of gaze can be computed by estimating intersection of two line-of-sights in 3D space.

To improve the accuracy of 3D point of gaze calculation, the Z element of 3D point of gaze can be corrected by implementing 3D calibration. Instead of asking user to perform a time-consuming 3D calibration session using more than twenty calibration points, a simplified 3D calibration method using only three calibration points is proposed (right panel of Fig. 2). The calibration points are positioned 4 cm in front of, 0 cm from, and 4 cm behind the screen. Singular Value Decomposition (SVD) is used to solve polynomial mapping of three calibration points and Z element of 3D point of gaze.

Experimental validation was performed to confirm accuracy of the proposed 3D gaze tracking system. Four virtual planes, each of which consisted of 16 target points, were rendered in stereoscopic environment. The planes were positioned at 11 cm and 3.67 cm in front of the screen, and 3.67 cm and 11 cm behind the screen. The statistical analysis of experimental results shows that the optimized rather than conventional geometric method yields higher accuracy.

Comparison with subjective depth judgment was also carried out to inspect the usefulness of the proposed system for development of more user-friendly stereoscopic 3D content. In this experiment, 3D gaze tracking and user depth perception were used to measure depth of various sized virtual 3D object. From the experimental results, it is found that only size cue affects user depth perception significantly while the proposed gaze tracking system is more robust in measuring depth of virtual 3D object. We also find that accurate distance perception and 3D gaze measurement can be achieved by placing virtual 3D object closer to the participant. In future, based on the proposed method, an automatic gaze-to-perception conversion could be reliably developed by considering how user perceives depth of virtual 3D object at different distances.
Impact of Device Degradation Due to NBTI on Gated Clock Systems

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Keywords: NBTI, gated clock, setup time, reliability, register

With semiconductor scaling, negative bias temperature instability (NBTI) is becoming one of the most serious reliability problems. Measurement results of NBTI phenomenon, the degradation modeling, and so on have been reported. However, a problem of gated clock (well-used as one of low-power techniques), which causes the unbalance degradation due to NBTI, has been hardly reported.

In this paper, we present the impact of device degradation due to NBTI on systems with gated clock. If a part of system is stopped by gated clock, PMOS threshold voltage degradation due to NBTI is accelerated an inverted circuit alternately. We make a principle of the unbalance degradation clear first. And then, we clarify the impact that the gated clock gives circuit timing such as the setup violation to influence maximum operating frequency, the hold violation to need attention most by a digital circuit, and the clock skew which is an arrival time lag to flip-flop (FF) of the clock signal.

We demonstrated the following phenomena as a result of analysis. A circuit composed of registers with a gated clock as shown in Fig. 1 was used for the analysis. Fig. 2 shows results of the maximum operating frequency. GCR stands for a gated clock ratio. The maximum frequency related to setup time decreases and the circuit may cause malfunction. Under the assumption that 10% of $I_d$ deteriorate in ten years, about 11% of the maximum frequency decrease when 80% of circuits stop by gated clock. Next, Fig. 3 shows results of hold time. At the point of view of hold time, it becomes the direction that is better than a case without the degradation. In addition, hold time changes by each state in FFs. As the gated clock ratio increases, hold time increases when a stopped state of Q1 was high and decreases when that of Q1 was low. Finally, Fig. 4 shows the results of clock skew analysis for the former circuit of gated clock, as the gated clock ratio increases, clock skew decreases under the assumption of low-stop at the end and positive edge trigger FFs.

In other words, we exhibited that the one that does not use the gated clock is hard to cause malfunction after the aging at a point of view of setup time, and it may become the over margin when hold time and clock skew consider influence of NBTI by a design excessively.
Serial Processing FIR Inverse Filter Circuit

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Keywords: inverse filter, frequency response, FIR filter, serial calculation, impulse response, VHDL

1. Introduction

Inverse Filter is used in many fields such as audio circuit, telecom line equalization both metal and optical, and wireless equalization. The purpose of inverse filter is to compensate the distortion of the signal caused by the transmission media. Design methods of inverse filter using IIR filter, using FFT/IFFT and adaptive FIR filter are available. However IIR filter has some problem of stability, FFT/IFFT method needs a lot of calculation and adaptive FIR filter needs a lot of time. This paper proposes a new method to generate FIR inverse filter coefficient by serious calculation of impulse response and it's expecting value.

2. Architecture of Serial Processing FIR Inverse Filter

Fig. 1 shows architecture of proposed inverse filter and following equations (1) indicates the serial calculation algorism. At first all coefficient of FIR filter, g1 to gN are zero but g0 is 1. The first input the impulse response X0 applied to the filter then it is compared with Expectation value E0. The first coefficient of Inverse filter g0 is calculated by E0/X0. Coefficient memory and its setting circuit set the g0 value to the FIR filter. The second input X1 applied to the circuit and the output W1 which is g0X1. The next coefficient g1 can be calculated by W1 and expectation E1 as g1 = (E1 - W1)/X0. Following coefficients g2, g3, g4…gN are calculated as same way, comparing the output of FIR filter itself and Expectation table.

\[
\begin{align*}
g_0X_0 &= E_0 \\
g_0 &= E_0/X_0 \\
W_1 + g_1X_0 &= E_1 \\
g_1 &= (E_1 - W_1)/X_0 \\
& \quad \vdots \\
W_N + g_NX_0 &= E_N \\
g_N &= (E_N - W_N)/X_0
\end{align*}
\]

3. Simulation of Serial Processing FIR Inverse Filter

Each equation above equals each step of FIR digital filter. The serial sequence can be calculated by Excel. Fig. 2 shows calculated Impulse response of transmission line and inverse filter calculated by equation 1. The Impulse response of transmission line is 0.37 and small amplitude. The Impulse response of inverse filter is 2.7 which will regenerate the pulse to 1.

Fig. 3 shows Gain-frequency response that is the FFT result of Fig. 1 Impulse response. The frequency response H(f) attenuated at high frequency is compensated by the inverse filter G(f) to flat response H(f) + G(f).

The algorism and architecture of Serial Processing FIR inverse filter is simulated by FPGA base hardware design. The actual circuit is designed by Xilinx ISE design suite using VHDL. After the architecture is written by VHDL, real circuit is synthesized and it is simulated as behavior model. Fig. 4 shows the simulation result of time chart where real value 1.000 is equal to 1024 in order to calculate decimal. Input Xn and Expectations En are applied by the test bench data, the circuit generates Wn and gn according to equation 1 during the input of Xn immediately.

In this paper, a new method of FIR inverse filter which is more stable than IIR and quicker and simpler calculation than FFT/IFFT and adaptive filter is proposed.
A Pulse-type Hardware External Nucleus of the Inferior Colliculus Model for 2-D Sound Source Localization Based on Auditory Sense Mechanism of Barn Owl

1. Introduction
Auditory information is very important role in visual information limited. Sound source localization is nominated for particularly important ability in a hearing information processing. Barn owls especially have excellent hearing information processing. When they perform sound source localization, the barn owl uses interaural time difference (hereafter “ITD”) for localization in the horizontal direction, and interaural level difference (hereafter “ILD”) for detection in the vertical direction. In addition, the detection direction, and interaural level difference converged by position of ICx, when the positions of the output of ITD and ILD showed clearly that our proposed model could change the output signals from each output cell body model on ILD detection model. As a result, we output a pulse can change with the position of sound source.

We are constructing the 2-D sound source localization model using pulse-type hardware neuron models based on sound source localization mechanism of barn owl for the purpose of engineering application. In this paper, we purpose an ICx model for 2-D sound source localization using pulse type hardware neuron model.

2. Pulse-type Hardware ICx Model
Figure 1 shows the schematic diagram of ICx model. In this figure, the encircled CO shows output cell body model, the arrow shows excitatory synaptic model and the T shows inhibitory synaptic model. $v_{LinMj} (M=1,2,1 \leq j < N$ and $i$ is an integer) show input signals from each output cell body model on ITD detection model. $v_{LinMj} (M=1,2,1 \leq j < N$ and $i$ is an integer) shows input signals from each output cell body model on ILD detection model. Each CO is parallely-connected of a single horizontal row by excitatory connection from $v_{LinMj}$, and a single vertical row by the inhibitory connection from $v_{LinMj}$. When $v_{LinMj}$ outputs a pulse, and $v_{LinMj}$ stops it, $CO_{i,j}$ exceeds the threshold and output a pulse. Therefore, this ICx model can converge with the information between ITD, with an output pulse, and ILD, without output pulses.

3. Result
Figure 2 shows an example of the detection characteristics of ICx model. In this figure, the encircled line range shows that $CO_{1,1}$ outputs a pulse, and the enclosed line range shows that $CO_{2,2}$ outputs a pulse. This is shown that the position of CO, with an output a pulse can change with the position of sound source.

4. Conclusion
In this paper, we propose an ICx model which converged with ITD detection model and ILD detection model. As a result, we showed clearly that our proposed model could change the output position of ICx, when the positions of the output of ITD and ILD changed with the position of sound source.
A Method for Equal Power Allocation to Two Receivers in Two-dimensional Wireless Power Transfer via Magnetic Resonance

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Keywords: wireless power transfer, magnetic resonance, multiple receivers, multi-hop transfer

In 2007, the new wireless power transfer (WPT) system based on magnetic resonance coupling has reported by A. Kurs et.al. and been received much attention because of its potential of high power efficiency in length of a few decimeters. Since mobile device (e.g. a mobile phones, a laptop PC, and etc.) are driven by batteries, they must be recharged using a power code when a battery becomes empty. WPT systems can release us from a restriction of charging area around an electrical outlet, and also from many bothersome power codes when charging multiple devices at the same time. Considering the current usage of mobile devices, a WPT system to multiple devices within a few meters in radius is strongly required. Some studies discussed this issue of WPT to the multiple receivers, and the other ones reported two-dimensional multi-hop schemes (2D-WPT) for expanding the transfer range. However, it still has not been discussed to allocate power to multiple receivers in a two-dimensional multi-hop system.

This paper addressed wireless power transfer equally to two receivers in two-dimensional multi-hop system and shed light on a problem of efficiency degradation. Then, we proposed a power allocation method to two receivers with high efficiency. First we simulated the two-dimensional power transfer to two receivers by using the circuit simulator that applied the equivalent circuit of magnetic resonance couplers arranged on 3 × 3 layout. Here we defined \( \eta = |S_{21}|^2 \) as an efficiency. Two receivers were deployed to the equal distance or different distance from a transmitter. The efficiency of each deployment was evaluated by two existing path control methods: all intermediates-ON method and the virtual path control method. The virtual path control makes intermediates ON or OFF to form a square consisting of a transmitter and a receiver as its vertexes. As a result of the equal distance case, the virtual path control method achieved high efficiency, but all intermediates-ON method did low. In the other case of different distance, since the topology of both methods was identical, the same results were observed; the efficiency of one receiver was low while the other was high. This reason is the interference between multiple paths to a receiver with different hop counts, which results in unequal power allocation to multiple receivers. Next we revealed that the phase of \( S_{21} \) delays 90-degree at every hop in the multi-hop power transfer. Thus, two hop-difference on each path causes efficiency degradation due to 180-degree delay. Therefore, we proposed the single-path control method that improves efficiency by ON-OFF control of intermediates so as to form only one path to each receiver. Figure 1 shows the experimental configuration of 3 × 3 layout, and Figs. 2 and 3 are the experimental scenarios of 2D-WPT systems that we used. As the result of circuit simulation and experiments shown in Fig. 4, the efficiency using single-path control achieved higher and equal power allocation to two receivers.

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Fig. 1. Experimental configuration.

(a) All Intermediate ON. (b) Single path control.

Fig. 2. Configuration diagram in scenario 1 (3, 7).

(a) All intermediates ON. (b) Single path control.

Fig. 3. Configuration diagram in scenario 2 (3, 9).

Fig. 4. Efficiency of experiments.
Media Access Control for Improving Transmission Success Ratio for ZigBee in Coexistence Environment between ZigBee and Wireless LAN

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Keywords: ZigBee, wireless LAN, coexistence, access control

Recently the ZigBee has attracted attention as the smart home network for collecting the sensing data obtained from the home electronics and so on. Already the wireless LAN (WLAN) has been introduced in the home network. In addition, the ZigBee and WLAN use same frequency band, 2.4 GHz. Thus, the ZigBee and WLAN co-exist in the home. To overcome the contentions between the ZigBee and WLAN, the carrier sensing mechanism is used, but the access control procedure is different. The difference in the access control causes the frame losses at the ZigBee. Therefore, it is necessary to improve the transmission success ratio for sensing data periodically sent by the ZigBee.

This paper proposes a media access control for improving the transmission success ratio in coexistence environment between the ZigBee and WLAN. Fig. 1 shows the system configuration in the proposed method. The point of the proposed method is the collaboration between the ZigBee coordinator and WLAN access point (AP). As shown in Fig. 2, the primary problem of contentions is that the frame gap between Data and ACK frames at the ZigBee is much longer than the access parameter, distributed interframe space (DIFS), at the WLAN. In the proposed method, when the ZigBee coordinator detects the signal of ZigBee, the access parameter, DIFS, is changed. The extension of DIFS is specified in the IEEE802.11e as the arbitration interframe space (AIFS).

Figs. 3 - 5 show simulation results in the coexistence environment. The standard indicates AIFS is 50 µs, and the proposed method indicates AIFS is 210 or 310 µs. As shown in Fig. 3, the success ratio at the ZigBee is improved compared with the standard. In addition, the collision of ACK frame that is the primary problem of contentions is reduced as shown in Fig. 4. As a result, the loss ratio caused by exceeding the retry limit (macMaxFrameRetries) is reduced as shown in Fig. 5. The frame loss is caused by exceeding the retry limit or backoff limit concerning access control (macMaxCSMABackoff). Therefore, it is concluded that the proposed method is effective in terms of the transmission success ratio.
Conducting Waves using Multi-channel Surface EMG

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Keywords : surface EMG, MFCV

1. Introduction
Muscular activity is investigated by analyzing the action potential in muscle fiber, primarily in the field of clinical medicine. The conduction velocity of potentials, i.e., the muscle fiber conduction velocity (MFCV), is measured by needle electrodes, and recent studies have measured it by surface electromyography rather than using needles. The surface electromyogram (EMG) is mainly used to analyze the frequency and amplitude of EMG signals.

Surface EMG is recorded as an interference wave of action potential that is generated by some of motor units in muscle. If composition of the interference wave can be analyzed, we may be able to examine the mechanism of muscular contraction, for example activity of motor units.

Previous study have analyzed multi-channel surface EMG, calculating conduction velocity and comparing waveform subjectively between two channels of surface EMG. However, to analyze the muscular contraction mechanism, we should examine conduction of surface EMG quantitatively over multiple channels.

We herein propose a new method to analyze the surface EMG. The proposed method involves searching conducting wave quantitatively, which mean similar waveforms considered the same wave appearing during several channels by using multi-channel surface EMG. To use the method, we can examine various data of each conducting wave, including conduction velocity and amplitude, over channels. This method is referred to as the multi-channel method for conducting waves (m-ch method). We analyzed multi-channel surface EMG using the proposed method.

2. Method
In order to obtain conducting waves by using multi-channel surface EMG, we first divided EMG signals in sections between points of electrical potential crossing zero from minus to plus (Fig. 1). For each section, we search other sections which appear in the adjacent channel, and compare the waveforms to examine their similarity. Since these sections have different wavelengths, the coefficient of correlation cannot be calculated between sections. As such, sections are calculated a re-sampling to restore the analog signals, in pseudo-simulated.

After re-sampling, the coefficient of correlation is calculated for the two sections to determine the similarity of the waveforms. In this study, we refer to the value as the similarity ratio. Amplitude ratio and wavelength ratio of the two sections is also calculated to determine the difference of the scale of waves.

We set thresholds for the conducting conditions for these three values of ratios. If a pair of sections satisfies the conducting conditions, these sections are considered to represent a conducting wave (Fig. 1). To apply this method to a section repeatedly in adjacent channel, we can get conducting wave appearing in multiple channels.

3. Results and Discussion
We measured the multi-channel surface EMG of the biceps brachii muscle of each subject. When measuring surface EMG, subjects kept holding some value of loads, including 10% and 40% of their maximum muscular strength (MVC). And we analyzed the multi-channel surface EMG using the proposed method.

We could get some conducting waves from multi-channel surface EMG and could examine conduction velocity and amplitude of each wave to use proposed method.

We could find differences in conducting waves generated by different loads in Fig. 2. In Fig. 2, relative amplitude means the value of amplitude of conducting wave for the amplitude of their 100% maximum muscular strength. To hold larger value of load, conducting waves having large amplitude were increased. For some subjects, waves having larger velocity were increased. We think that the result show the change of working muscular fiber and recruitment of motor units.

We believe that the proposed method can be used to analyze changes in surface EMG caused by muscle fatigue or movement and to analyze mechanism of the muscular contraction.

Fig. 1. Judging sections of surface EMG to be a conducting wave

Fig. 2. Difference in conducting waves according to load
A Survey on Residents’ Behavior during a Power Outage caused by the Great East Japan Earthquake

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Keywords: Power Outage, House, Living Behavior, Great East Japan Earthquake Disaster

1. Introduction
The commercial power supply was disrupted in several parts of Japan in the aftermath of the 2011 Great East Japan Earthquake. We conducted a survey on the residents of Sendai city in Miyagi Prefecture, and Kanagawa Prefecture in order to understand the nature and extent of the power outages and the influence of the disruptions on customers. The power outage continued for a month in Sendai; however, water supply, wastewater management system and city gas supply were disrupted for a long period. In comparison, the power supply was restored within a day in Kanagawa. We also investigated the impact of the rolling blackouts in Kanagawa that started in mid-March, 2011. On the basis of the survey results, this paper will present the effects of the power outage on people’s behavior, particularly, on the evacuation and sheltering behavior in Sendai.

2. Outline of the Survey
The internet survey on the residents was conducted in 2012. Table 1 shows the outline of this survey.

3. Results of the Survey
The major results of the survey are as follows:
(1) Major inconveniences in residents’ daily lives during the power outage after the earthquake were the non-availability of “lighting”, “air conditioning” and “refrigerator” in Sendai. The residents of Sendai felt more inconvenienced than the residents of Kanagawa.
(2) The longer the blackout continued, the more inconvenienced they felt in Kanagawa. The trend was confirmed in the case of Sendai.

4. Effects of Power Outages on Evacuation and Sheltering
On the basis of the results of survey, the reasons of evacuation and sheltering behavior after an earthquake are as follows:
(1) “Blackout” was the most important reason for evacuation and sheltering behavior; it was selected by 83% of the respondents.
(2) The power, water supply, and gas supply disruptions, concern for the safety of one’s home, and aftershocks were major reasons.

We conducted a covariance structure analysis based on Structural Equation Modeling (SEM) to make clear the relationship between the blackout and people’s behavior in the case of Sendai (N=272) and Kanagawa (N=264). Moreover, the evacuation and sheltering behavior was included in the case of Sendai. Fig. 1 shows the path diagram in Sendai. There are correlations between “evacuation and sheltering behavior” and the “difficulty in housing”. On the basis of this diagram, we confirmed that the longer the blackout continued, the more difficulties they experienced.

5. Conclusion
In this study, we conducted a survey in order to understand the nature and extent of power outages and the influence of the disruptions on customers of power companies. This paper presented the quantitative effects of the power outage on people’s behavior, particularly on the evacuation and sheltering behavior using SEM based on the results of this survey. In future studies, we would like to identify the minimum energy demand in emergency situations on the basis of the average energy consumption in smart houses that control energy use using ICT.

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Table 1. Outline of the Survey.

<table>
<thead>
<tr>
<th>Survey Method</th>
<th>Survey in SENDAI</th>
<th>Survey in KANAGAWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey Period</td>
<td>2012/Feb./28 – Mar./5</td>
<td>2012/Jan./18 – Jan./25</td>
</tr>
<tr>
<td>Survey Target</td>
<td>Residents of Sendai City (All of them experienced blackout)</td>
<td>Residents of Kanagawa Pref. who experienced a blackout or rolling blackouts</td>
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<tr>
<td>Number of Questionnaires</td>
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<td>609</td>
</tr>
<tr>
<td>Survey Contents</td>
<td>Attributes of Respondents and Outline of their Houses, Earthquake Damage and Duration of Lifeline Disruptions, Influence of Lifeline Disruptions on Customers, Evacuation &amp; Sheltering Behavior in Sendai</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1. Path Diagram of Life Difficulty during Power Outage.
Empirical Study of Stepped-FM UWB Sensor for Indoor Intruder Detection

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Keywords: Ultra-wideband, stepped-fm, wireless sensor, intruder detection, zoning

Home security sensor becomes more and more practical today for the protection against intruders, thereby several types of sensor such as infrared, video camera and microwave radio are commonly used. Recently ultra-wideband (UWB) based microwave sensor has attracted considerable attention because of the high ranging accuracy and anti-multipath capability and a home security sensor system employing the UWB was suggested in (1), where the transmit and receive antennas are faced apart from each other diagonally in order to cover all over the floor. However the sensing accuracy is likely to be affected by some motion outside a house such as visitor because it detects some motion or movement, but the distance can not be detected. Also, it requires high speed AD devices for the timing detection and synchronization process.

This paper presents an indoor intruder detection sensor system employing stepped-fm based UWB which does not require any high speed AD devices. It can detect not only the motion of an intruder but also the distance. Therefore, false detection by some outdoor motion is expected to be significantly improved. It is basically a multi zone intruder alarm system, for example it can alarm ‘caution’, ‘danger’, and ‘intrusion’ for three radius zones as shown in Fig. 1. In order to discuss the performances, measurements for various intrusion scenarios were conducted by using our fabricated stepped-fm sensor in the entire house including balcony as shown in Fig. 1, and the usefulness is discussed.

In this paper, three zones are considered (zone 1: certainly outdoor, zone 2: outdoor including balcony or indoor, zone 3: certainly indoor). Figure 2 shows the estimated distance for an intrusion scenario $S_1$ where the bandwidth is 500 MHz, gray line is estimated distance and black line is actual distance. The zone decision result is also shown in Fig. 3. The results show that the presented sensor offers good performance. Table 1 shows the detection rate of each zone which is calculated from various intrusion scenarios, where it is investigated for three bandwidths (500, 300, 100 MHz) in order to compare the effect of range resolution on the performance. As a result, for the bandwidth of 500 MHz, the detection rate is high as compared to the other bandwidths. Especially, the detection rate of zone 3 achieves over 93%.

References


Table 1. Detection rate for each zone.

<table>
<thead>
<tr>
<th>Zone</th>
<th>500 MHz</th>
<th>300 MHz</th>
<th>100 MHz</th>
</tr>
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<tr>
<td>Zone 1</td>
<td>47.8%</td>
<td>44.0%</td>
<td>12.8%</td>
</tr>
<tr>
<td>Zone 2</td>
<td>66.2%</td>
<td>58.4%</td>
<td>23.4%</td>
</tr>
<tr>
<td>Zone 3</td>
<td>93.4%</td>
<td>91.4%</td>
<td>71.6%</td>
</tr>
</tbody>
</table>
Development of a Sensor Network for Continuous Water-temperature Evaluation

Results Obtained from Experiments Conducted in Brackish Lake-water

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Keywords : water-temperature, brackish lake, sensor network, Kamo Lake, Sado

1. Introduction
The objective of the present research is to develop an original, automatic water temperature-sensing network in Kamo Lake, in Niigata prefecture, Japan, to provide a web-based information-network that will allow fishermen to better understand the relationship between water temperature, red tides and dissolved oxygen. Kamo Lake, located in Sado city, Niigata prefecture is approximately 4.9 km² in circumference, 17 km in overall length, and 2 km across, at its widest point. While it is the largest lake in Niigata prefecture and ranks 46th in Japan, its deepest point lies just 10 meters below the surface. Being tidal in nature, with constant injections of seawater from the northern inlet, it has tended to be a bit brackish, making it suitable for the many oyster-farms dotting the area. But, the recent influx of red tide has resulted in a die-off of these oysters, costing local fishermen more than 100 million yen in lost revenue. Prefectural authorities have so far been unable to find a practical solution. Detailed investigations, aimed at specifying the causal relationship between this oyster die-off and red tide/general water-quality are underway, with focus on water-temperature, which can reveal some of the physical, chemical and ecological properties and variations in lake-water. Among fishermen, sea-water temperature has long been used as a means of estimating oxygen- and salinity-levels, and is even reputed to be a predictor of the size of fish-hauls. For these reasons, accurate measurements of lake- and seawater temperatures are essential. Niigata Prefectural office, and Sado city officials have kept meticulous records of water-temperature-fluctuations, since the beginning of 1974. The process has been driven-, and at the same time complicated by-; 1) the restriction of measuring-times to daylight hours; 2) the inconvenience and cost of having monitors on-duty full-time, simply for the purpose of taking hourly measurements; 3) the dependency of measurements on existing weather conditions; 4) the added costs, in terms of material resources. All of these have led our efforts to design an automatic, sensor network-based measuring system. At first, we needed to develop a simple, cost-effective measuring system with network communications functionality, to visualize results, and present them on our home page, in an easy-to-understand format. To clarify; 1) –we need to build a set of 4 buoys, each equipped with a set of two simple and robust analog thermistors; 2) –we measure water temperatures, at 4 widely-separated points on the lake, every hour, for a period of 3 years; 3) we set up a web-page to display the results; 4) we study the relationship between measured temperatures, red tide and the amount of dissolved oxygen in the water. In the experiments, we devised; 1) a unique, simple and cost-effective water-temperature measurement system consisting of 4 data-transmission buoys, each equipped with a pair of sensors, and placed them at strategic points, on Kamo Lake; 2) a means of conducting simultaneous, hourly measurements of water temperatures. We used these continuously, for the next 3 years; For example, Fig. 1 expresses change of water temperatures in 2011 (point ④); 3) method of visualizing measured data and presenting it, in downloadable format, on our web page; 4) a way to statistically evaluate the relationship between the measured temperature data, red tide, and the amount of dissolved oxygen. For example, Table 1 describes what appears to be a tenuous link, between oyster death and red tide generation, while the connection to levels of dissolved oxygen was seen as being clearly negative. From our experimental results, we determined that the amount of dissolved oxygen has a strong connection with oyster die-off, and water temperature would seem to be the deciding factor in its estimation.

Fig. 1. Change of water temperatures in 2011

Table 1. Correlation of red tide and dissolved oxygen, in oyster necrosis

<table>
<thead>
<tr>
<th>Correlation with a necrosis of an oyster</th>
<th>Point ①</th>
<th>Point ④</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface</td>
<td>Middle</td>
</tr>
<tr>
<td>Red tide</td>
<td>0.25</td>
<td>0.08</td>
</tr>
<tr>
<td>Dissolved oxygen</td>
<td>0.76**</td>
<td>0.49*</td>
</tr>
</tbody>
</table>

** t test, a significance level 1%
* t test, a significance level 5%
A Column Generation Approach to Railway Crew Recovery Problem in Disruption

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Keywords: railway, crew scheduling, recovery, integer programming, column generation method, heuristic

Transport industries have to make a schedule for their crew in order to operate their trains or flights. Crew Scheduling Problem (CSP) is to find a schedule covering all the trains or flights with a minimum cost, where a schedule of a certain crew, starting from his/her base and returning to the base, is called pairing. In the other word, a crew schedule consists of pairings. Crew Recovery Problem (CRP) frequently appears in transport industries as well as CSP. This is to modify predetermined individual schedules (pairings) of crews who cannot perform their tasks given beforehand as the result from CSP because of delays of trains or flights. In such cases, it is necessary to change the pairings of the crews affected by the delays. So far this task is done manually in many companies relying on experts but should be supported by mathematical techniques and computer technologies.

In this paper, we focus on CRP in a freight railway company in Japan. It is important to generate acceptable schedule(s) quickly in CRP. This is because, if a modified timetable of trains due to delays is given, a corresponding crew schedule is needed immediately in order to restart the operation of trains as soon as possible, while it is desirable in CSP to find as a good schedule as possible even if it needs more computation efforts because a certain schedule of CSP is used iteratively. That is, computation time is essential for CRP, and quality of the schedule is more important in CSP.

On the other hand, a modified schedule should be selected considering various performance measures. But, sometimes an inferior schedule with less modification may be desirable because it needs less time and efforts to inform the changes to the crews, but sometimes good one with more modifications may be needed. Therefore, it is necessary from a practical view point to obtain alternative schedules so that the decision maker can select a certain schedule from them based on his decision. We aim to construct such a framework as a prototype.

We model the original problem into Set Covering Problem (SCP) with side constraints. In the formulation as SCP, a row corresponds to a certain trip, which is a part of a certain train and a minimum job unit for each crew, and a column corresponds to a pairing which consists of trips sequenced to satisfy the regulations and is performed by a certain single crew from his/her base to it. We propose a heuristic approach as a basic framework for similar problems arising in transport industries.

Our approach is based on the idea of column generation method, which is known as one of effective and powerful ways for large scale integer programming problems. Our iterative procedure consists of these steps; 1) generating modified pairings for “target crews” which are selected from the whole crews now performing or to perform their tasks, as candidates to be generated their pairings, 2) getting an IP solution, and 3) selecting a crew to be added to the set of the target crews. These steps produce different schedules by updating the set of the target crew.

In our approach, column generation method is used for obtaining pairings for target crews whose schedules may be modified and for computing the lower bound of the optimal integer solution by optimizing the corresponding linear relaxation problem with limited columns. Column generation sub-problem reduces into shortest path problem as a result of simplification of the original problem in the real world. If an optimal solution of the LP is obtained, we find an integer solution from the columns already generated. We iterate these steps until no candidate crew is left. Thus, the procedure generates various schedules for a certain instance by gradually increasing the number of target crews to be rescheduled, giving the lower bound to the optimal value of the objective function in each iteration.

Numerical experiments based on instances from a Japanese railway are performed for evaluating the performance of our approach. The results indicate that our approach successfully and stably gives good schedules in short computation time and can provide various schedules for decision maker. This suggests the potential of this framework.
An $L_1$-Approximation for the Design of FIR Digital Filters with
Complex Coefficients

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Keywords: FIR digital filter, $L_1$ norm, Complex coefficients, Differentiability, Newton’s method

Digital filters are digital signal processing systems that extract only the signal of the required frequency band from an input signal including noise.

The design of FIR filters is well known as an approximation problem, where an ideal frequency response, usually a discontinuous function, is approximated by a finite number of smooth functions. Such an approximation problem usually consists of a trade-off between the steepness in the transition band and the flatness in the passband/stopband. These two requirements are contradictory.

Therefore, we need to choose the “goodness” error criterion to control the inherent trade-off of the design problem. As examples of such error criterion, there are the least-squares ($L_2$) and minimax ($L_{\infty}$) criteria. The use of the $L_p$ norm, $2 \leq p \leq \infty$, has also been suggested as a successful alternative to the $L_2$ and $L_{\infty}$ criteria.

The $L_1$ criterion can approximate the optimal filter with a smaller overshoot of the first side lobe than either the $L_2$ or $L_{\infty}$ criteria. However, since the $L_1$ norm cannot always be differentiated, there is no algorithm such as gradient method. Consequently, an approximate solution instead of the optimal solution is proposed. In these methods, in order for the approximation to be accurate, the sampling grid must be dense. This becomes computationally demanding.

Recently, Grossmann and Elder have proposed the $L_1$-optimal method for the design of linear-phase FIR filters. This method can obtain the optimal $L_1$ filter by using the differentiability possibility of the $L_1$ norm, and can also reduce the computational complexity. However, this algorithm is inapplicable to designing FIR filters with complex coefficients. Filters with complex coefficients are usually used as orthogonal filters of the time-division-multiplexing–frequency-division-multiplexing (TDM-FDM) trans-multiplexers and as envelope detectors with the Hilbert transformer. They are also applied in single-sideband modulation systems and in processing in-phase and quadrature signals in sonar and radar. However, a design method for $L_1$ FIR filters with complex coefficients has not been proposed until now.

In this paper, we present a design method for $L_1$ FIR filters with complex coefficients. In this method, we use the property that an arbitrary complex function can be given as the sum of an even function and an odd function. We prove that the approximation problem using this property can be solved by using Newton’s method. We show that the vector space of the coefficients of the $L_1$ norm is a closed set and a convex set in order to ensure that the obtained solution is global optimal solution.

Figure 1 shows the amplitude response of the $L_1$ filter with complex coefficients, and also shows the corresponding $L_2$ and $L_{\infty}$ filters. It was proven that the complex coefficients we required, since the obtained amplitude response was asymmetric around the origin. Moreover, Fig. 2 shows an enlargement of part of the passband. It is evident that all three filters resulted in an overshoot around the discontinuity, but that the $L_1$ filter overshot by the smallest amount. These tendencies are the same as that of the linear-phase FIR filter with real coefficients. Figure 3 shows the group delay of the $L_1$ filter with complex coefficients. It is clear from Fig. 3 that the group delay of the obtained filter corresponds to the nearly linear-phase characteristic in the passband.
Control of Balloon Fish Robot Based on Traveling Wave Equation

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Keywords: Fish robot, Airship robot, Traveling wave

A fish has excellent swimming ability in underwater. Fish-like robot using fish motion has been researched in recent years. On the other hand, airship robot capable of performing a low speed, low altitude flying and low energy has been researched to collect land information. Aquatic organism type airship robot “swimming in the air” combines these features has been researched and developed. This type robot will be applied as a pet robot with a host of entertainment and monitoring patrol robot. We develop fish type robot made of balloons - Balloon Fish Robot (BFR), which floats by helium gas and goes with fish-like motion. Fish-like operation is important to give healing as the pet robot and to obtain high propulsion efficiency as the monitoring robot. In this paper, we applied Traveling-Wave Equation to BFR as the movement of the fish and discuss the propulsion efficiency.

BFR has 3 joints and 4 links. Each joint is called 0th-joint, 1st-joint, and 2nd-joint in order from the front. Fish-like motion expression is called Traveling Wave Equation (TWE).

\[ y(x,t) = (c_1 x + c_2 x^2) \sin(\kappa x - \omega t) \]  

where \( y \) denotes the transverse displacement of the fish body, \( x \) denotes the displacement along the main axis, \( k \) indicates the wave number \( k = 2\pi/\lambda \), \( \lambda \) is the wavelength, \( c_1 \) is the linear and \( c_2 \) is the quadratic wave amplitude envelope, and \( \omega \) is body wave frequency.

The actuator of BFR is the RC servo motor attached to each joint. Controlling expression of the control angle of \( i \)-th motor \( \theta_i \) \((i = 0, 1) \) can be written using the eq. (2).

\[ \theta_i(t) = \begin{cases} \tan^{-1}\frac{\sin \omega t}{\kappa} & (i = 0) \\ \tan^{-1}\frac{\sin \omega t - \sin \omega \tau}{\kappa} - \sum_{j=0}^{i-1} \theta_j & (i \neq 0) \end{cases} \]  

Since the tail fin of the underwater fish robot is made of elastic body, the 2nd-motor at the base of the tail fin is simulated as spring joint. Accordingly, \( \theta_2 \) can be written using the eq.(3).

\[ \theta_2(t) = -\text{sign}(V_{\text{tail}}) \frac{L S_{\text{tail}} C_{\text{Dtail}} R}{2 k \rho} V_{\text{tail}}^2(t) \]  

where \( V_{\text{tail}}(t) = x_2 \frac{d\theta_2(t)}{dt} + (x_2 - x_1) \frac{d\theta_1}{dt} \) \((i = 0) \) and \( V_{\text{tail}} \) represents the length between 0th-joint and \( i \)-th joint, \( \rho \) is the air density, \( S_{\text{tail}} \) is the area of the tail fin, \( C_{\text{Dtail}} \) is drag coefficient of the fin, \( R \) is the density of the fin, \( k_{\text{spring}} \) is spring constant, \( r \) is length of spring. The equation of motion is written using eq. (5).

\[ \frac{23 R \rho}{300} \left( \frac{d\theta_2(t)}{dt} \right)^2 - \frac{1}{2} \rho C_D S V^2 = M \frac{dV}{dt} \]  

where the first term is thrust force, the second term is the drag force, \( C_D \) is the drag coefficient of the BFR, \( S \) is front projected area, and the right side is product of mass and acceleration. We simulate the

Table 1. Relationship between \( V_{\text{last}} \) (\( V_{\text{last}} \)) and \((c_1, c_2)\)

<table>
<thead>
<tr>
<th>( c_2 )</th>
<th>( c_1 )</th>
<th>( 0.05 )</th>
<th>( 0.10 )</th>
<th>( 0.15 )</th>
<th>( 0.20 )</th>
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<tbody>
<tr>
<td>( 0.05 )</td>
<td>-</td>
<td>0.40 (0.14)</td>
<td>0.54 (0.30)</td>
<td>0.54 (0.50)</td>
<td>-</td>
</tr>
<tr>
<td>( 0.10 )</td>
<td>0.32 (0.14)</td>
<td>0.46 (0.31)</td>
<td>0.52 (0.31)</td>
<td>0.59 (0.72)</td>
<td>-</td>
</tr>
<tr>
<td>( 0.15 )</td>
<td>0.69 (0.32)</td>
<td>0.52 (0.52)</td>
<td>0.53 (0.74)</td>
<td>-</td>
<td>-</td>
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<tr>
<td>( 0.20 )</td>
<td>0.64 (0.54)</td>
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<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>( 0.25 )</td>
<td>0.66 (0.78)</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>( 0.30 )</td>
<td>0.64 (1.0)</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
</tbody>
</table>

Table 2. Relationship between \( \eta \) (\( \eta \)) and \((c_1, c_2)\)

<table>
<thead>
<tr>
<th>( c_2 )</th>
<th>( c_1 )</th>
<th>( 0.05 )</th>
<th>( 0.10 )</th>
<th>( 0.15 )</th>
<th>( 0.20 )</th>
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<tbody>
<tr>
<td>( 0.05 )</td>
<td>-</td>
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<td>0.24 (1.6)</td>
<td>0.24 (1.3)</td>
<td>-</td>
</tr>
<tr>
<td>( 0.10 )</td>
<td>0.10 (1.4)</td>
<td>0.21 (1.5)</td>
<td>0.23 (1.3)</td>
<td>0.26 (1.2)</td>
<td>-</td>
</tr>
<tr>
<td>( 0.15 )</td>
<td>0.29 (2.2)</td>
<td>0.33 (1.3)</td>
<td>0.24 (1.2)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>( 0.20 )</td>
<td>0.40 (1.1)</td>
<td>0.44 (1.2)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>( 0.25 )</td>
<td>0.30 (1.5)</td>
<td>0.28 (1.2)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>( 0.30 )</td>
<td>0.27 (1.2)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Airspeed using the 4 degree Runge-Kutta method. Simulation airspeed is compared with actual airspeed to examine the validity of the equation of motion. And the propulsion efficiency \( \eta \) is calculated using following equation.

\[ \eta = \frac{U}{f} \]  

where \( U \) is the airspeed, \( f \) is traveling wave frequency, \( l \) is representative length of maximum amplitude of the tail fin.

In the experiment, the \( k \) and \( \omega \) is fixed parameters, and the \( c_1 \) and \( c_2 \) is variable parameters. Ranges of parameter are chosen the under limit of the RC servo motor torque. In each parameter, the airspeed was measured seven times. The average speed \( V_{\text{last}} \) was calculated from 9.2s to 10.4s (that is last 1 period), and the average speed \( V_{\text{last}} \) was calculated in same time using eq.(6). The error \( \bar{E}_{\text{last}} \) is calculated using the following equation and it is used as an index of validity of equation of motion.

\[ \bar{E}_{\text{last}} = \frac{|V_{\text{last}} - V_{\text{last}}'|}{V_{\text{last}}} \]  

Table 1 shows the \( V_{\text{last}} \) and \( V_{\text{last}} \). A mark of “+” is less than 10% \( \bar{E}_{\text{last}} \). The areas where \( V_{\text{last}} \) is faster have smaller parameter values. In simulation, the \( C_D \) is fixed. However, waving has the effect of reducing the \( C_D \). This is considered as reason \( V_{\text{last}} \) is fast. The areas where \( V_{\text{last}} \) is slower is the bigger parameter value. TWE assumed that front of the 0th-joint is fixed. However, head of BFR swings and the amplitude of the tail fin is reduced in the experiment. So the thrust force in simulation is bigger than in experiment and \( V_{\text{last}} \) is slower. Table 2 shows the propulsion efficiency \( \eta \) of each parameter. It can be observed that parameter \((c_1, c_2) = (0.05, 0.15)\) has the highest efficiency.
Highly-gradating of Ultra-low-gradation Image Using Spatial Features

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Keywords : spatial features, low-bit image, highly-gradating, tone restoration

1. Introduction
In recent years, high quality imaging was advanced by spread of display and digital camera. Demand of highly-gradating was growing for false contour removal, gradation interpolation or gradation restoration from quantization compression image.

2. The Conventional Methods and Purpose of the Proposed Method
Such as the method using piecewise histogram equalization (PHE) and the method using e-filter (EPSF) was proposed. Because PHE using only edge strength, the center of the big area didn’t get better result. For this reason, PHE couldn’t apply ultra low gradation image that included big area. Because filter size of EPSF was not variable, EPSF was unnatural result depending on the size of the area. Therefore, we proposed highly-gradating method could obtain a natural result image by using spatial feature even ultra low gradation image.

3. Highly-gradation of Ultra-low Gradation Image using Spatial Features
Area of same gradation value containing attention pixel as attention area G. To be smoothing when gradation value of adjacent pixel with G was continuous with gradation value of attention pixel. On the contrary, to be edging when gradation value of adjacent pixel with G was discontinuous with gradation value of attention pixel. From this premise, G could be classified six pattern. According to the pattern, got currate distance of attention pixel and candidate pixel adjacent to G. And From this information, estimate to gradation value of attention pixel. In this way, by estimate to gradation value of all pixel, ultra low gradation image could highly-gradating.

4. Experiment
As the original image, prepared the different types of 256 gradation image of 18 pieces. Those image was transform to 8, 16 gradation image. And those image was highly-gradating to 256 gradation from 8, 16 gradation by PM (Proposed Method), PHE and EPSF. Fig. 1 was shown example of processing result by PM. Fig. 1 (a), (b) was original image of 256 gradation. Fig. 1 (a) was portrait image and Fig. 1 (b) was geometric pattern image. Fig. 1 (c) was ultra low gradation image of 16 gradation get from Fig. 1 (a). Fig. 1 (d) was ultra low gradation image of 8 gradation get from Fig. 1 (b). Fig. 1 (e), (f) was result image each from Fig. 1 (c), (d) by PM.

From quantitative evaluation experiment, PM was showed to have effectiveness by average of MSE. Table 1, Table 2 showed average of MSE each from 8, 16 gradation image. From Visual assessment experiment, PM was showed to have effectiveness by average ranking from 10 people. Table 3 was shown average of ranks of visual assessment from 8, 16 gradation image.
Efficient Learning Method for Human Detection based on Automatic Generation of Training Samples with the Negative-Bag MILBoost

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Keywords: 3D Human model, Negative-Bag MILBoost, Human Detection, Generative Learning

Statistical learning methods for human detection require large quantities of training samples and thus suffer from high sample collection costs. Their detection performance is also liable to be lower when the training samples are collected in a different environment than the one in which the detection system must operate.

In this paper we propose a generative learning method that uses the automatic generation of training samples from 3D models together with an Negative-Bag MILBoost learning algorithm (Fig. 1).

In this study, we use a three-dimensional human model to automatically generate positive samples for learning specialized to specific scenes (Fig. 2). Negative training samples are collected by random automatic extraction from video stream, but some of these samples may be collected with incorrect labeling.

When a classifier is trained by statistical learning using incorrectly labeled training samples, this can impair its recognition performance. Therefore, in this study an improved version of MILBoost is used to perform generative learning which is immune to the adverse effects of incorrectly labeled samples among the training samples (Fig. 3, Fig. 4).

In evaluation tests, we found that a classifier trained using training samples generated from a 3D human model was capable of better detection performance than a classifier trained using training samples extracted by hand. The proposed method can also mitigate the degradation of detection performance (Fig. 5) when there are images of people mixed in with the negative samples used for learning.
Evaluation of Volume Tiering Method and SSD Cache Method in Tiered Storage System

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Norihisa Komoda  Fellow  (Osaka University)

Keywords: Tiered Storage, Volume Tiering Method, SSD Cache Method, I/O Response Time, SSD

1. Introduction

With recent improvements in information technology, solid state drives (SSDs) which provide higher performance than hard disk drives (HDDs) have become popular. Since SSDs are more expensive than HDDs, it is difficult to replace all of the HDDs with the SSDs. Figure 1 shows the storage system in this paper. The followings are the 2 methods to utilize SSD on the storage having both SSD and HDD.

(1) Method dividing and locating data to SSD or HDD (Volume Tiering Method)

(2) Method locating all data to HDD and coping partial data to SSD (SSD Cache Method)

The volume tiering method improves I/O performance by allocating hot areas to SSD. However, because this method optimizes data location every 1 hour to 24 hours, when the hot areas moved, it takes 1 hour to 24 hours to improve the I/O performance. Since the SSD cache method caches accessed area to SSD immediately, it improves the second and subsequent accesses to the area. When cached data is ejected frequently, however, the SSD cache method needs to write the data to HDD, therefore, there is a possibility to increase HDD load which leads to lower storage I/O performance.

We consider that utilizing both methods simultaneously addresses the problems above. We assume that appropriate number of SSDs for tier and appropriate number of SSDs for cache may differ on the basis of the number of I/O, read-write ratio, and I/O locality. In this paper, we evaluate the effects of these methods by I/O simulation and clarify conditions when these methods are effective.

2. Evaluation

We evaluate the effects of these two methods by simulating I/Os using I/O trace log captured in a real production environment. These two methods can be applied simultaneously. We also evaluate these effects by adjusting the number of SSD used as the fast tier and as cache as a parameter.

Figure 2 shows the simulation result of the storage I/O response time. The vertical axis shows the normalized storage I/O response time where the storage I/O response time with the SSD cache method is 100%. The horizontal axis shows SSD cache capacity rate to total capacity. F1 and F2 show the simulation condition in Financial 1 and Financial 2 respectively. F1 is write-intensive workload and F2 is read-intensive workload. “rw” means the condition that swaps read requests for write requests. Number in condition shows the rate of the number of SSDs to the number of HDDs.

The simulation result shows that the volume tiering method improves the storage I/O performance in write-intensive and low I/O locality workload with small SSD capacity. The SSD cache method is effective in read-intensive and high I/O locality workload with large SSD capacity. Utilizing both methods simultaneously with write-intensive workload is the most effective. The storage I/O response time is reduced by up to 20% utilizing both methods simultaneously compared to using the volume tiering method or the SSD cache method separately.

Fig. 1. Overview of storage system

Fig. 2. Storage I/O response time utilizing volume tiering and SSD cache method simultaneously