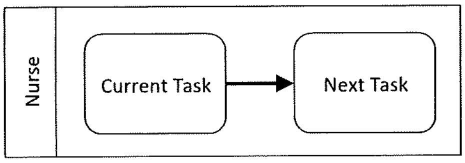
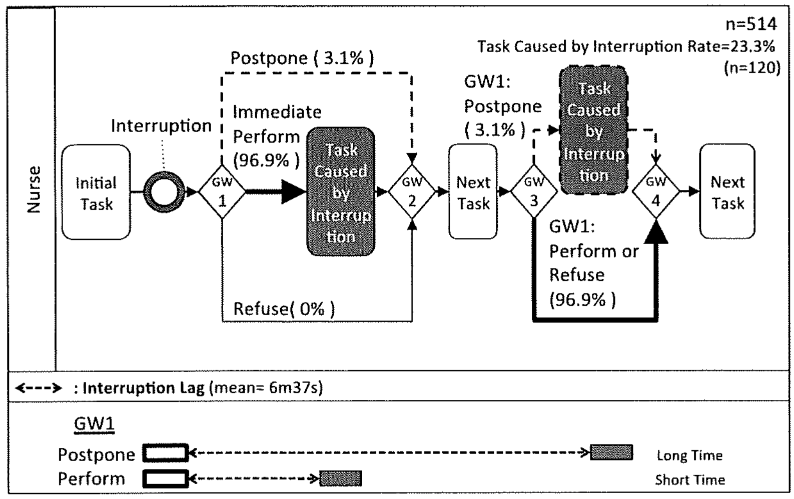
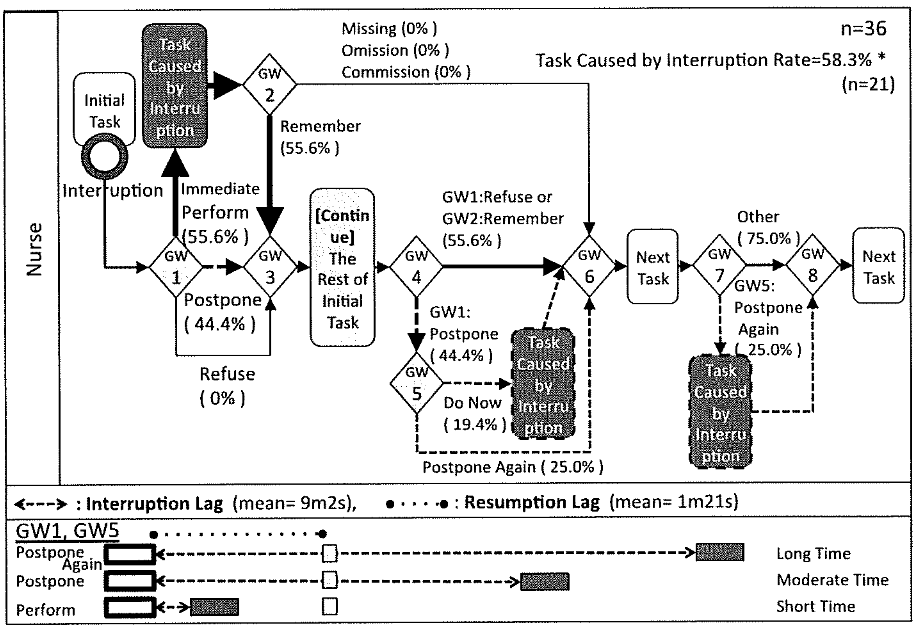


Figure 1. Normal workflow



Nurse makes clinical decision at GW1.

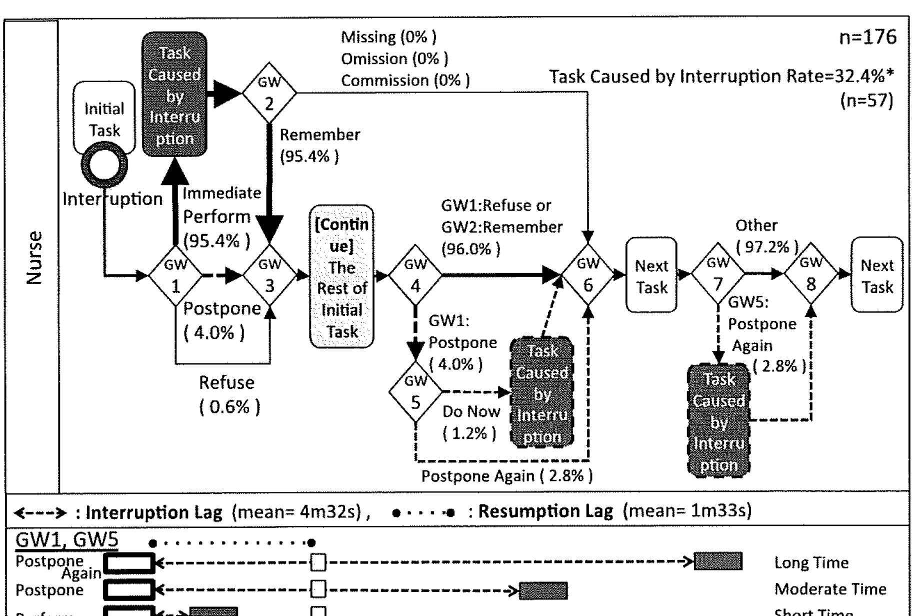
Figure 2. Workflow interrupted between tasks



Nurse makes clinical decision at GW1, GW2 and GW5.

* The difference in tasks caused by interruption is statistically significant (vs. Indirect care, Fisher's test, $p<0.005$)(vs. between tasks, Fisher's test, $p<0.001$).

Figure 3. Workflow interrupted in the middle of a task: Direct care



Nurse makes clinical decision at GW1, GW2 and GW5.

* The difference in tasks caused by interruption is statistically significant (vs. between tasks, Fisher's test, $p<0.05$).

Figure 4. Workflow interrupted in the middle of a task: Indirect care

Social Interaction in Risky Behavior by College Student in Japan

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Abstract

The prevalence of teenage smoking, drinking, and excessive diet have increased over the last 20 years in Japan. Although numerous literatures in sociology and psychology suggest that the influence of neighborhood on behavior of disadvantaged youths may be important in recent years, there are controversial evidences in econometric research.

The definition of influence of neighborhood, which is also called peer effects, is originally whose who suffer from the same problems. However, in these studies, the empirical strategy is carried out in the following way: peer effects are defined as the degree to which initial peer behavior predicts subsequent change in individual behavior.

For health policy, the potential existence and magnitude of peer effect is of interest, since peer effects may dominate the effects of policy interventions.

The primary contribution of this study is in its design, which allows for a more accurate assessment of peer group. We can identify the peer effect in three ways; individual's perception of class-level peer behavior, actual class-level peer behavior, and three best friend actual behaviors. Previous studies have set the peer effect on class-level.

This study employs a critically different strategy for identifying peer effects by using informative data and analytic method. We take advantage of a cross-sectional data set with unusually rich information on peer groups and individual risk preference. Besides information on substance use and background characteristics for all individuals between 18-22 years old in Japanese college students, the data reveals which school, class and reference group each individual participates in. We can identify the peer effect in three ways; individual's perception of peer behavior, actual peer behavior, and three best friend's actual behavior.

Instrumental variables regression and fixed effects-estimation were utilized. In all specification, significant peer effects were found for drinking, smoking, and dieting. The impact of peer behavior is larger among females. The results are applicable to social multipliers for adolescent health policies.

APAMI2009

The Efficiency of The Time Process Modeling Language in Hospital Job Analysis

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Abstract

This study aimed to examine the utility of the Time Process Modeling Language (TPML) as the way of analyzing the function of the cancer treatment in general hospitals. Time Process Modeling Language employs the outstanding visualization power of the UML (Unified Modeling Language) to extract the characteristics of the objective task and process. Based on literature and hearing investigation, we ascribed the outpatient chemotherapy department as a system and attempted to model it using TPML.

When we model the outpatient chemotherapy department as a system, the actor in this system consist of outpatients, doctors, nurses and pharmacists. Based on the use case diagrams, the following 4 functions represent the common functions of the system: 1)Implementation of chemotherapy, 2)Support for patients and counseling regarding chemotherapy, 3)Chemotherapy study groups and seminars as a part of medical staff education, 4)Discussion and approval of chemotherapy protocols. Both the approval of protocols and staff education functions can be shown on the boundaries of the system. Using activity diagrams, we found that there are 6 task groups regarding the implementation of chemotherapy which is a core function of the outpatient chemotherapy department: 1)examination, 2)prescription, 3)filling of prescriptions, 4)prior treatment, 5)administration of drugs to patients and 6)examination and instruction, and that it is possible to clarify the tasks and workflow.

Primary doctors determine prescriptions beforehand using common or department-specific protocols and employ either an electric ordering system or handwritten instructions to order the medication. This task is done physically by the ward or outpatient departments, however, regardless of where these tasks are performed physically, this must be included as part of the chemotherapy implementation process, which is the core function for any outpatient chemotherapy department system. There are also cases where outpatient care is handled by the primary doctor up until the day of the treatment followed by patient transfer to the outpatient chemotherapy department, and prior treatment based on prescriptions and their administration are performed by the physician at the outpatient chemotherapy department. Also, considerable variation exists in the performance of other tasks, both in the roles of primary doctors and doctors on duty, and in the location where the tasks are performed.

Building models using TPML makes it possible to organize and gather complex information regarding functions and tasks obtained through oral surveys and literature and also to use visualization for common understanding. Secondly, the gathering of information and visualization of system information may make the subject of evaluation and analysis more clear.

Development of Automatic Head-count method at Nurse Station using Omnidirectional Camera

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Abstract

It is very important to log the working hours of medical staff. There exists a close relationship between the workload of medical staff and medical accidents. It is also important to improve their working conditions. A time and motion study is a typical way of assessing the workload of medical staff. However, this method has several problems. It entails high human costs and long-term investigations, because the observer measure each action of staffs or the staff measure own action. Therefore, we considered that it is necessary to develop a low-cost method for performing quantitative measurements. In this paper, we propose an automatic head-counting method for nurse stations using an omnidirectional camera. We used the omnidirectional camera to obtain 360 degree video data and estimated the working hours of medical staff by performing difference image processing using a Gaussian distribution model. This method can deal with the noise of the imaging system and slight variations in the illumination condition. First, we estimated the number of staff working at a nurse station from images obtained using the camera. Further, we compared our results with the actual head count. We found that our proposed method gives highly accurate results. Thus, we consider that this method is useful to estimate the working hours of medical staff at nurse stations as an alternative method for the time and motion study.

Keywords: time and motion study, omnidirectional camera, nurse, Gaussian, image processing

1. Introduction

Recently, it is said that medical staff are overworked. However, the estimation of the workload is carried out subjectively. A method for estimating the working hours of medical staff is desired for ensuring the safety of patients and improving the quality of health care [1][2]. A time and motion study is used for managing the working hours of nursing staff. It is one of the effective methods used to obtain fundamental data for performing objective estimation and improving the quality of nursing care at hospitals. When observer is own, it is difficult to continue to record own actions but it is easy to record the purpose of action. At the same time, it is easy to continue to record each action of staffs but costs expense and takes labor when observer is second party. An automatic, cost-effective object detection system is desired. An active camera tracking system such as a surveillance and security system and video telephone system performs tasks that are tedious for humans. Further, it has been shown that tracking facilitates motion estimation [3]. A video surveillance system consisting of an omnidirectional camera is used for automatic object detection, people tracking, fall detection, and surveillance region classification for abnormal behavior detection [4].

We propose a new method for object detection using an omnidirectional camera to achieve a wide field of observation. In the conventional method, the background image does not include the target object. To detect the target objects, this method calculates the difference between the background image and each frame [5]. The proposed method can use although there is the target object or not. To detect the target object, this method uses Gaussian. First, its method calculate the brightness, the average brightness and standard deviation each pixel from all frames. Next, this calculates the difference between the brightness and the average brightness every one frame. Finally, we assume it the target object when the calculation result is more than five times the standard deviation. We assume it background image when the calculation result is less than five of the standard deviation. Then, we confirm the validity of the detection result by comparing it with the actual number of target objects.

2. Omnidirectional camera

An omnidirectional camera has a 360 degree field of view. This camera comprises a CCD camera and a hyperbolic curve mirror. The diameter of the mirror is approximately 50 mm, and the total height, including the CCD camera, is approximately 200 mm. This camera is manufactured by The Nara Institute of Science and Technology (NAIST). This is operated in the graphics mode with a resolution of 640 × 480 pixels at 29.97 fps. The video output is compatible with the NTSC system.

3. Method

3.1. Difference Image Processing

The conventional difference image processing is a technique used to extract the target object from an image. The target image is the result subtracted the background image from an image (Fig.1). Here, a background image stands for a set of motionless image pixels. Pixels do not include objects moving in front of the camera. The definition of a background image can vary with the object extraction technique. For example, if the depth map of a scene can be obtained, the background image can be determined as the static parts of the scene that are located far enough from the camera. While this technique has an advantage in that it enables high-speed processing, it has a disadvantage in that it reduces the extraction accuracy even in the case of small variations in the environment, such as the noise of the imaging system or slight variations in the illumination condition.

In general, the range of variations in the brightness differs depending on the image area. However, when one piece of the background image is considered, the conventional difference image processing cannot make arrangement with variation in the brightness to binarze the pixels of all frames with a constant threshold. To address this problem, there is the study about the difference image processing technique to define threshold of each pixel. That is, a background difference technique based on a normal model is used.

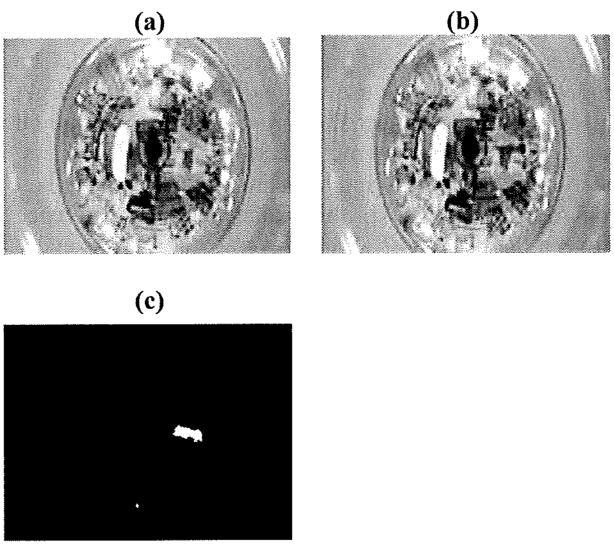

Fig. 1. Conventional difference image processing: (a) Background image, (b) One image of frames, (c) Target object.

In this study, we propose the new difference image processing technique used Gaussian assumed each image population to agree about statistic of each image. This technique stands up the calculation of the brightness, the average brightness and standard deviation for every pixel of each frame. The standard deviation is defined as the statistical in homogeneity and the contrast of an image. It can be used to reduce noise, which is generated by background pixels. We calculate the difference between the average brightness of all frames and the brightness of one frame. When the difference is less than five times the standard deviation, it is the background image. When the difference is more than five times the standard deviation, it is the target image. Fig.2 (a) shows one frame from the recorded video, Fig.2 (b) shows the image of the average brightness, and Fig.2 (c) shows the binaries image obtained by applying the background difference method.

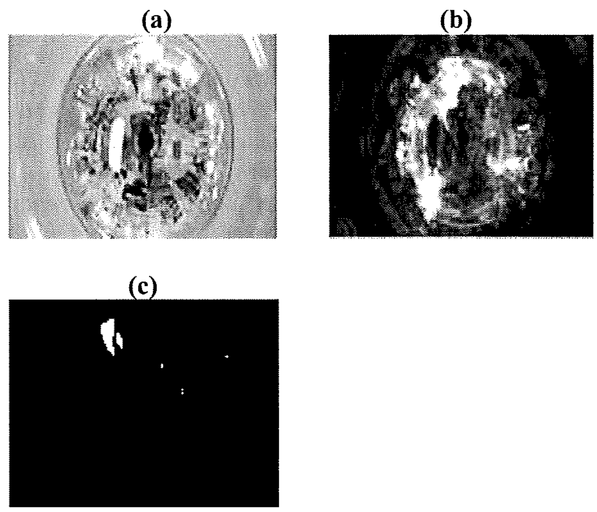

Fig. 2. Image using in the experiment: (a) Original image, (b) Average brightness, (c) Binary image applied background difference image processing.

3.2. Detection of Target Object

We could confirm that Fig.2 (c) is contaminated with noise. We use a median filter to filter the background noise. The pixel with the noise is removed by forming an array of nine pixels, which includes the background pixel and its neighboring eight pixels, in descending or ascending order and the central pixel value is denoted as a new pixel value. The filter smoothes the contour of an object, breaks narrow isthmuses, and eliminates thin protrusions (Fig.3). Processing is carried out to remove white noise found in a black image. The opening of set A by the structuring element B, denoted by $A \circ B$, is defined as

$$A \circ B = (A \Theta B) \oplus B \tag{1}$$

Thus, the opening of A by B leads to the erosion of A by B, followed by dilation. Erosion is a process replaced white pixels located along the border of the image with black pixel. In contract, dilation is a process replaced black pixels located along the border of the image with white pixel (Fig.4) [6][7].

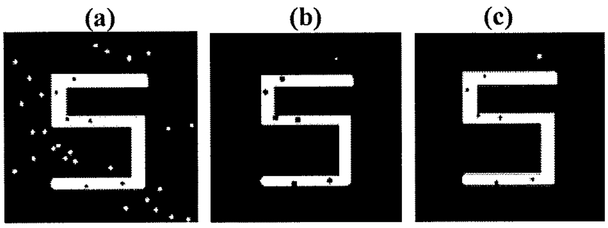

Fig. 3. Opening processing: (a) Original image, (b) Original image after erosion, (c) Image after dilation of (b).

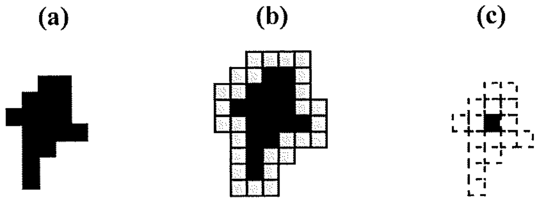

Fig. 4. Erosion and Dilation: (a) Original image, (b) Original image after erosion, (c) Original image after dilation.

Fig.5 (a) is the binary image of a single object. However, it is separated from other objects. We manipulate the image such that all objects are included in one single image. The processed image is larger than the binary image and contour processing is performed (Fig.5 (b)). The position of a person is expressed in terms of contour coordinates (Fig.5 (c)).

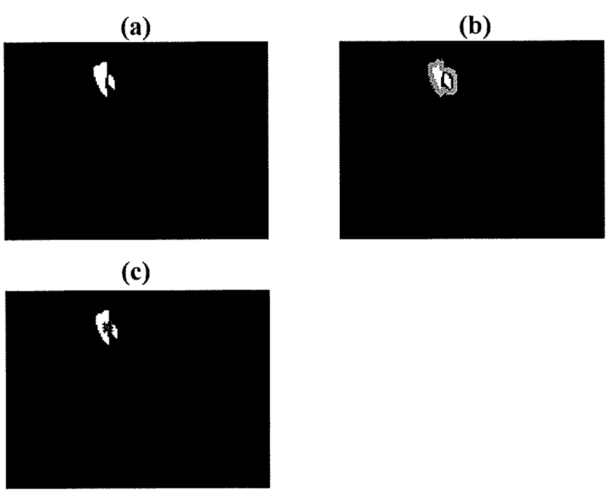

Fig. 5. Image Processing: (a) Image after denoising, (b) Image after contour processing, (c) Image after detection of average coordinates.

3.3. Assessment Protocol

3.3.1. Processed Video. In 2009, we recorded a 360° video at hospital A. The pixel size of the video is 512 × 384. The movie bit rate is 384 [kb/s]. The video frame rate is 15 [fps]. The length of the video is 60 [s].

3.3.2. Assessment Procedure. We estimate the number of persons from the coordinates and compare it with the actual number. Theil's U provides one of the best indications of the degree of heterogeneity in terms of two coefficients, and it is used as an alternate method for nonlinear regression analysis to estimate the coefficient of determination (r^2). The Theil's U inequality index (Theil 1961) is a measure of the degree to which a time series (X_i) differs from another (Y_i). X_i is the actual measurement value, and Y_i is the estimated value. The index is expressed as

$$U = \frac{\sqrt{\frac{1}{n}\sum_i (X_i - Y_i)^2}}{\sqrt{\frac{1}{n}\sum_i (X_i)^2} + \sqrt{\frac{1}{n}\sum_i (Y_i)^2}} \qquad (2)$$

U varies from 0 to 1, with 1 indicating maximum disagreement.

4. Results and Discussion

We describe the target detection results obtained by the proposed method. We calculated the head count in all the frames (Fig.6). Then, we compared the number of actual target objects with the number of target objects detected by the proposed method and the conventional method (Fig.7). We estimated Theil's U per 50 frames and confirmed the validity of the detection results per 50 frames (Figs.8 and 9). The total Theil's U was 0.322 in the case of the conventional method, and it was 0.191 in the case of the proposed method. We confirmed the validity of 37.8% of the results obtained by the conventional approaches and 66.7% of those obtained by the proposed method.

This method could be used to detect the target objects. However, the early detection rate of this method was not high. There are two reasons.One reason is that the pixels of the staff become reduced in size when the staff left the camera. Therefore, they are judged the noise and became processed by noise filter. The other is that a single object often separate from other objects when the target object was binarized. Then, the technique judge two or more objects when the results have broad space between each objects. The detection rate grows by setting a high resolution and expanding the detection screen.

Fig. 6. Original with pasted coordinate

5. Conclusion

The purpose of this study was to automatically estimate the working hours of medical staff by difference image processing. Noise could not be eliminated by the conventional calculus of difference. Therefore, a detection method superior to the conventional calculus of difference was required. We used the background difference method based on a Gaussian distribution model. After that, we detected noiseless target objects using a median filter. The new method gives better results as compared to the conventional method.
Further research is required to increase the response speed of the proposed method in detecting the target object. In future, we will examine the distribution of number of persons in a video for a longer period of time and show great dedication to continuous improvement the practice by time-varying image processing.

6. References

[1] RN Boyle CA. Using a Time-Flow Study to Identify Ambulatory Surgical Delays. Journal of PeriAnesthesia Nursing. 1996 April; vol.11 issue 2: p.71-77.

[2] Hendrich A, Chow MP, Skierczynski BA, Lu Z. A 36-Hospital Time and Motion Study: How Do Medical-Surgical Nurses Spend Their Time?. Permanente Journal. 2008 summer; vol.12 no.3: p.25-34.

[3] Fermüllerl C, Aloimonosl Y. Tracking facilitates 3-D motion estimation. Biological Cybernetics. 1992 July; vol.67 no.3: p.259-268.

[4] Wang M-L, Huang C-C, Lin H-Y. An Intelligent Surveillance System Based on an Omnidirectional Vision Sensor. IEEE Cybernetics and Intelligent Systems. 2006 June; p.1-6.

[5] Baumberg A, Hogg D. Learning flexible models from image sequences. Proceedings of the third European conference on Computer vision. 1994; vol.1: p.299-308.

[6] Gonzalez RC, Woods RE. Digital Image Processing. 2nd ed. New Jersey; 2002

[7] Davies ER. MACHINE VISION. 3rd ed. San Fransisco; Morgan Kaufmann Publishers; 2004

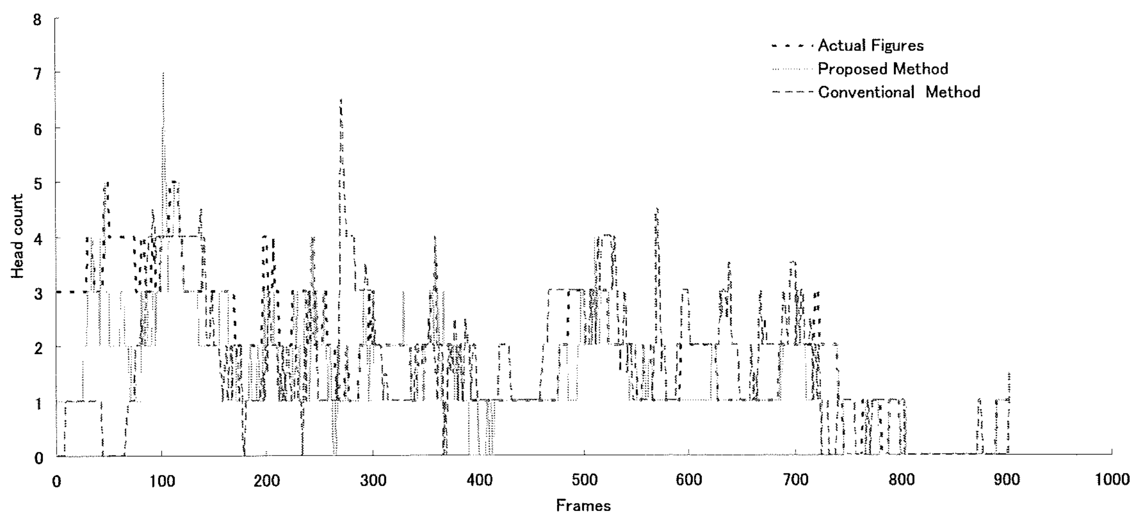

Fig. 7. Comparison between actual and experimental data: The dashed line represents the actual data of working staff, which was manually counted obtained. The continuous line represents the number of target objects detected by our method. The broken line represents the number of target objects processed by the conventional method.

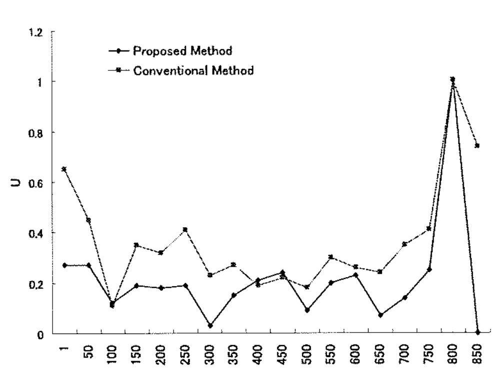

Fig. 8. Detection indicative of Theil's U

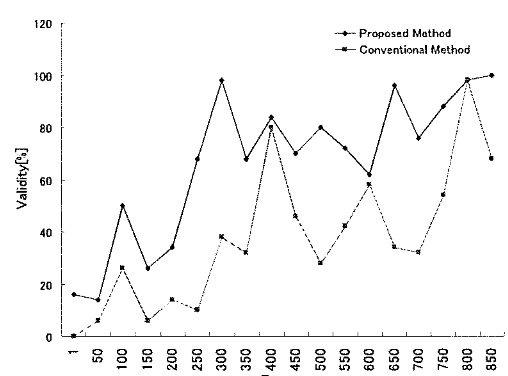

Fig. 9. Detection of validit

Proposal of Detection Procedure of ECG Monitor Alarm in Nurse Station by Frequency and Waveform Analysis

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Abstract

Nurses are exposed to various environmental sounds in nurse station all day. The environmental sounds include different kinds of alarm. Among them, the alarm for Electrocardiograph (ECG) monitor is calling when patient's condition sudden turn for the worse. It may lead to incidents or accidents in case nurses miss it. However, it is too difficult for nurses to keep paying attention to the alarm because it occurs frequently for computer miscalculations. Therefore, we think that it is very important to detect frequency of the ECG monitor alarm. And, it needs to attempt know how much time nurses have been exposed to the ECG monitor alarm.

In this paper we propose the automatically detection procedure of ECG monitor alarm using frequency and waveform analysis. At first, we identify the specific spectrum domain of the ECG monitor alarm from data which is recorded the ECG monitor alarm clearly and design band-pass filter which is passed principal spectrum band. Next, we describe also the present method to be extracted from audio data which is recorded by IC recorder in nurse station by applying the band-pass filter. Finally, we discuss as waveform analysis to count up the number of ECG monitor alarm and calculate alarm sound times by evaluating mean and median of sounds. As the results, we are able to extract the alarm clearly and to estimate number of the ECG monitor alarm and ECG monitor alarming times. Extracted ECG monitor alarm sounds are accurately, even if it is overlapped with other various environmental sounds.

Keywords: time study, ECG monitor alarm, nurse, frequency analysis, waveform analysis

1. Introduction

Telemetry EEG monitoring systems generate visual and audible alarm signals based on changes in patient physiologic conditions that exceed alarm limits established for a specific patient or a particular patient population [1]. Especially in the hospital ward related with cardiocirculatory disease, cardiac monitoring systems is essential for managing to risk. So, many patients are on telemetry cardiac monitoring systems [2]. They make practices cumbersome and complicated and to increase risk of error by oversight, because there is a large number of ECG monitors that should be checked by nurses. And more, it trigger an alarm that ECG waveform is identified as abnormal, due as patients turn over in them sleep, go to a restroom and have a poor reception on the telemetry cardiac monitoring systems from any cause [1],[3]. The alarm occurs frequently for computer miscalculations and nurses fail to hear the alarm easily. It might be lead to the situation that seriously incident or life-threatening mistakes for patients [3],[4]. Therefore, it needs to improve condition of practice. It is most important to measure actual condition accurately. Also, it is important as preliminary research to grasp and analyze the actual state of sonic environments for investigation of the nursing service accurately in the nurse station.

It is too difficult for nurses to keep paying attention to the alarm because it occurs very frequently for computer miscalculations. It needs to improve condition of practice, specifically, it is crucial to make an improvement of the sound environment in the nurse station. Therefore, it is very important to detect frequency of the ECG monitor alarm. And, it needs to attempt knows how much time nurses have been exposed to the ECG monitor alarm through a day work. And then, we consider that it is very important to research getting used to the alarm or attempt to improve existing condition of practice.

Generally, there are conduct surveys on the effect of the nurse services on the sound environment using time study by voice recorder as aims of the promotion of practices [5],[6]. You may think that it can be easy to survey using the output of EEG monitoring systems. However, the clinical practice of acute ward is too particularly. The method needs to be following consideration for monitoring the EEG alarm, even if it is lower detection accuracy.

At first, it can set up without some expertise in electromechanical. In some cases it is difficult to set up by technical expert in clinical practice. Therefore, the method is necessary to be able to easily set up and retrieve data by clinical nurse without some expertise in electromechanical. Also, it is necessary to be an easy-to-use method because it never cut the time of nursing services. Everyone can be easy to place a voice recorder and take only a few seconds. Also, it is easy to retrieve data. Next, it is not load on the clinical practice. It is not able to conduct verification experiments with the system down that is running for 24 hours. It could be a life-threatening of a patient, if it effect on EEG monitoring systems by any possibility. Furthermore, it needs to separate completely electrically from the system. Then voice recorder is absolutely separated [6].

In this study, we propose the automatically detection procedure in order to detect the ECG monitor alarm in the noisy environment by frequency analysis. It would be required the specific spectrum domain of the ECG monitor alarm from data which was recorded the alarm clearly. And we designed band-pass filter which was passed principal spectrum band. We were also extracted the alarm by applying the band-pass filter from sound data recorded by IC recorder in nurse station. Then, we discussed as waveform analysis to counts up the number of ECG monitor alarm and to calculate ECG monitor alarming times by mean and median.

2. Method

Our methodology is articulated in two steps: (A) the frequency analysis and (B) the waveform analysis. First of all, we show the frequency analysis that is able to extract the ECG monitor alarm from sound data that get mixed in with various sounds. Next we will explain the ECG monitor alarm identification step.

A. Frequency analysis with preprocessing

First, we provided six reference data that are recorded the ECG monitor alarm clearly while they are recorded by IC recorder in nurse station. Their power spectrums are showed in Fig.1.

There are three major frequency components and primary spectrum domains are between 1000 and 1200 Hz, 3200 and 3500 Hz and 4000 and 4200 Hz that are got the idea from the reference data. They showed strong spectral powers at from 1000 to 1200 Hz and 3200 to 3500 Hz within their three major spectral contents in all reference data. But we thought that spectrum at from 1,000 to 1,200 is mixed into low-frequency noises easily, in this paper, we assumed only frequency range of between 3,200 and 3,500 Hz as the alarm primary spectrum. Then, we designed band-pass filter that is pass band width between 3200 and 3500 by Fourier digital filter.

Next, we provided test data sets that are mixed in environmental sounds to any cases possible in nurse station. There was ECG monitor alarm, telephone call, another telephone call in a high tone, nurse call, speaking voice, other various noises as specific environmental sounds in nurse station. And, we provided test data that the sound data are overlapped with environmental sounds as in table.1. Regularized power spectrums of the test data are shown in Fig. 2.

The power spectrum of the alarm set off continuously is shown in Fig. 2.a. The data mixed with the alarm and phone called is shown in Fig. 2.b. Fig. 2.c is shown as only power spectrum of nurse call. The power spectrum to be shown Fig. 2.d is mixed the alarm, noise as speaking voices, phone and so on. Fig. 2.d is the alarm sounds overlapped with various environ-mental sounds. The spectrum of the phone call is shown in Fig. 2.e and the phone call in a high tone is shown in Fig. 2.f.

There are also not strong primary spectrums of the ECG monitor alarm. And the alarm in power spectrums of test data (shown in Fig.2.a, Fig.2.c, and Fig.2.d. Fig. 2.f) is included around same power spectrums with the other sounds. However, we could extract the ECG monitor alarm from test data using band-pass filter that is designed basis of reference data. There is a possibility that is able to detection accurately of the alarm simply by band-pass filter. Next, in this paper, we newly propose sound data analyzing method based on the waveform analysis.

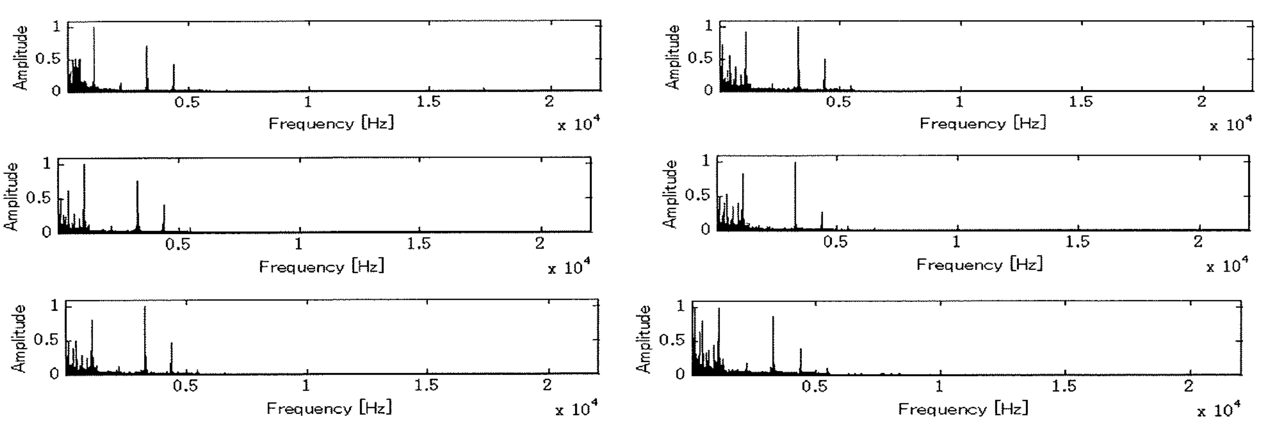

Fig. 1. Regularized power spectrums of the ECG monitor alarm: There are three major frequency components. First peak is from 1,000 to 1,200 Hz; Second peak is from 3,200 to 3,500 Hz; Third peak is from 4,000 to 4,200 Hz.

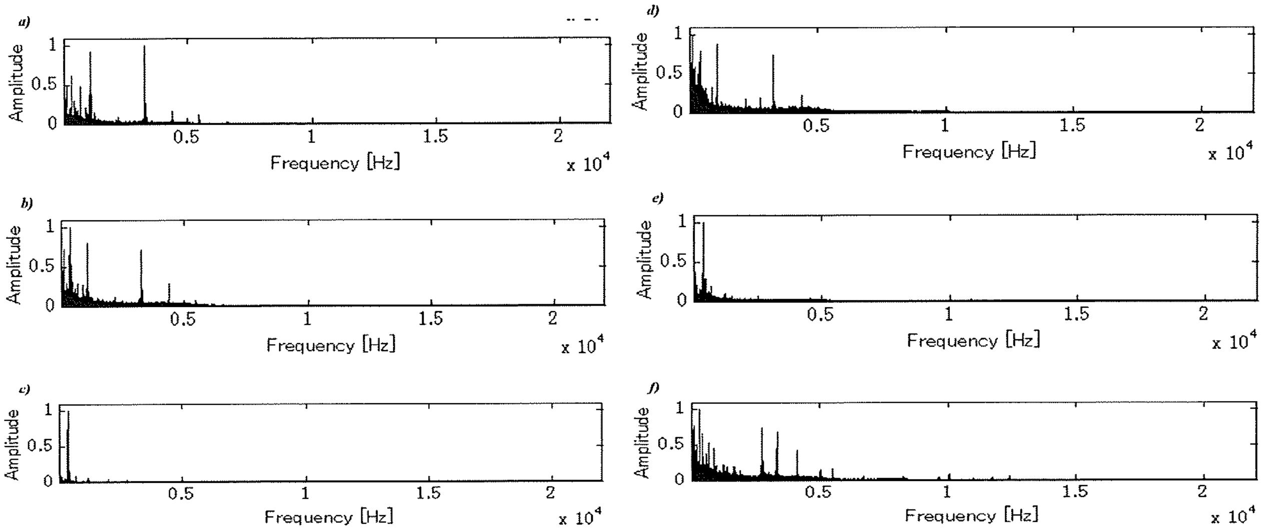

Fig. 2. Regularized power spectrums of the test data: (a) Alarm continuously, (b) Alarm and phone, (c) Nurse call, (d) Alarm with noise that mixed speaking voices, phone and so on various environmental sounds, (e) Phone call, (f) Phone call in a high tone.

B. Waveform analysis for automatic alarm detection

Our goal is to measure rate and times of ECG monitor alarm in nurse station. The wave patterns of the alarm that extracted the reference data by band-pass filter are shown in Fig. 3. We consider it is satisfactory to distinguish the wave patterns of the alarm to use waveform analysis. Because the wave patterns are distinctive and are shown constant interval and amplitude pattern. We analyzed data that was pre-processed by band-pass filter using waveform analysis to detection accurately of the alarm.

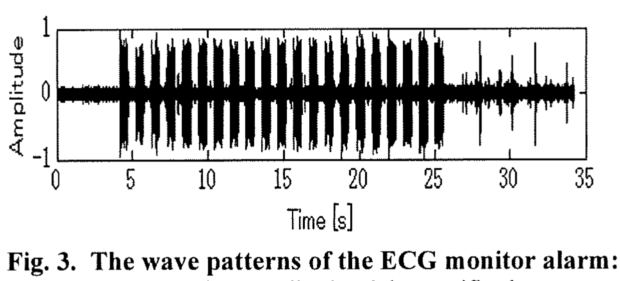

Fig. 3. The wave patterns of the ECG monitor alarm: This waveform data is normalized and the specific alarm wave patterns are shown from 5 to 26 [sec] and number of called the alarm is 21 times.

We proposed waveform analysis method that use first order amount of mean and median. First, we calculate mean and median from the reference data and decide threshold.

The threshold is defined as:

$$\rho = (\bar{x} + \langle x \rangle) \times \alpha \qquad (1)$$

Where $\bar{x}$ is the mean absolute value of the sound data and $\langle x \rangle$ is the median absolute value of them. The α is voluntary variable. The α value was decided it was optimized to detect the waveform of ECG monitor alarm accurately from the reference data. In this paper, the α value is 1.8. This result to be applied threshold is shown in Fig.4.

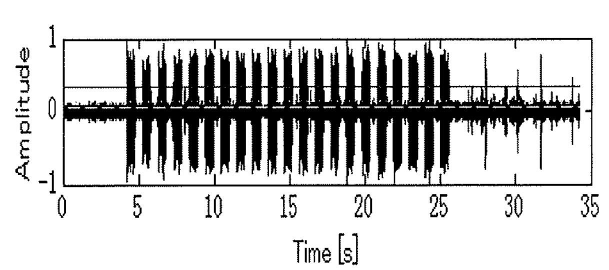

Fig. 4. Show the threshold on the wave patterns of the ECG monitor alarm: The full line (red color line) is threshold; the dashed line (aqua) is mean; the broken line (yellow) shows the median.

We assumed that it was impossible to detect the alarm accurately by only threshold because partly data without relating the alarm are under the threshold. Next, we show the way of detection for ECC monitor alarm intervals and terms.

First of all the data that exceed threshold were extracted. The intervals and terms of the ECC monitor alarm is around 0.5 ± 0.1 sec, we calculated optimum values of the parameters by steepest descent method to extract the specific wave patterns of the alarm accurately from each test data. Next, the call intervals and amplitudes span of the ECG monitor alarm were obtained from the reference data. And the specific waveforms were extracted from the data by the call interval. Finally, we estimated number of time or hours of calling the alarm based on amplitude span that the alarm called one. Though multiple alarm are set off continuously, amount of time of the alarm sound are calculated correctly.

C. Data Set

The waveforms of the each test data is shown in Fig. 5. We assumed that it was able to analyze accurately to process band-pass filter between 3200 and 3500 were, they did not show specific patterns, ex. the alarm waveform.

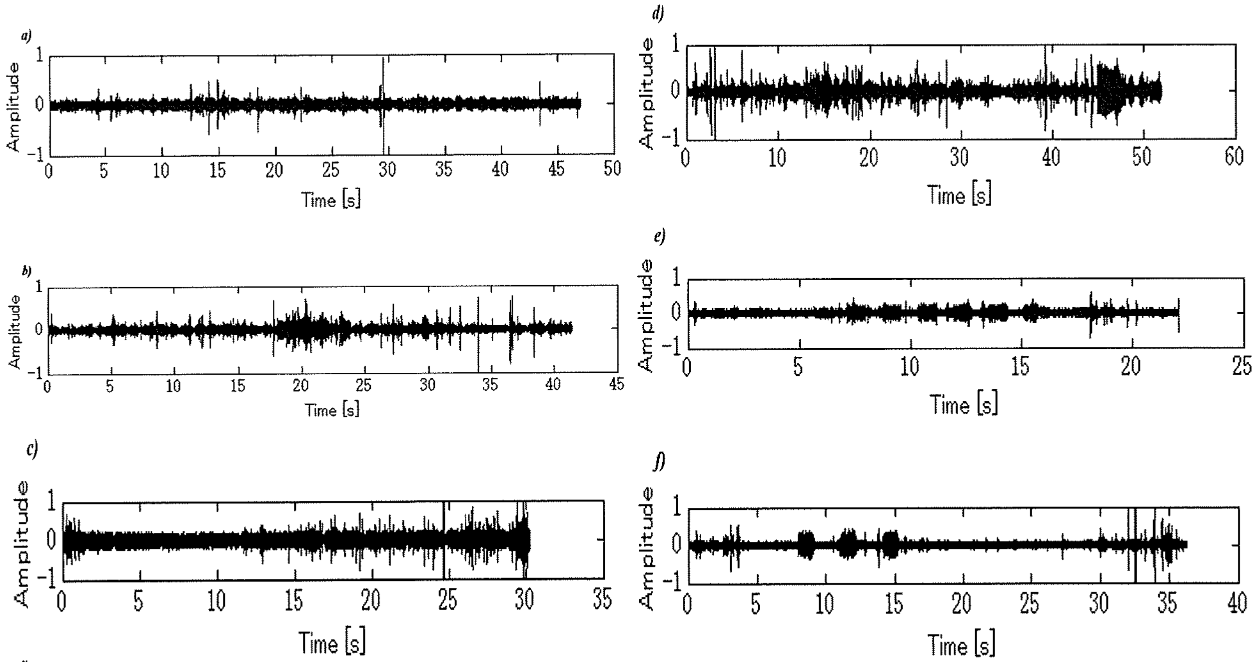

Fig. 5. The regularized wave patterns of the test data: (a) Alarm continuously, (b) Alarm and phone, (c) Nurse call, (d) Alarm with noise that mixed speaking voices, phone and so on various environmental sounds, (e) Phone call, (f) Phone call in a high tone.

3. Results and Discussions

The results of the each test data waveforms are shown in Fig. 6. The waveform set off continuously by band-pass filtered and waveform analysis is shown in Fig. 6.a. The wave patterns are shown specific patterns of the alarm calling between around 6 and 42 sec. Fig 6.b is the waveform of processed sound data to be mixed with the alarm and phone call. The wave patterns are also able to identify specific patterns of the alarm called between around 6 and 34 sec. Fig. 6.c is processed result that is nurse call calling. The waveform that is analysis result of sound data that set off the alarm with noise that mixed speaking voices, phone and so on various environmental sounds is shown in Fig. 6.d. The waveform of the analyzed the phone call is shown in Fig. 2.e and of the phone call in a high tone is Fig. 2.f. The wave patterns aren't able to identify significantly specific patterns of the alarm called in Fig. 6.c, Fig. 6.d, Fig. 6.e and Fig. 6.f. Therefore, we extracted the specific waveforms by the call interval as next processing and estimated number of times or hours of the alarm called based on amplitude terms that are calling the alarm. The result is shown in Table.1.

The data of only the alarm or alarm with few environmental sounds are able to be detected the alarm calling times completely (i.e. Alarm continuously or Alarm and phone). The data differed in frequency from the alarm such as nurse call or phone call is also detected completely. The analysis result data of the phone call in a high tone shown in Fig. 2.f is indicated same power spectrums with the alarm. Therefore, we considered that this analysis is possible to detect the alarm times and counts accurately, if the sound data are contaminated same frequency components.

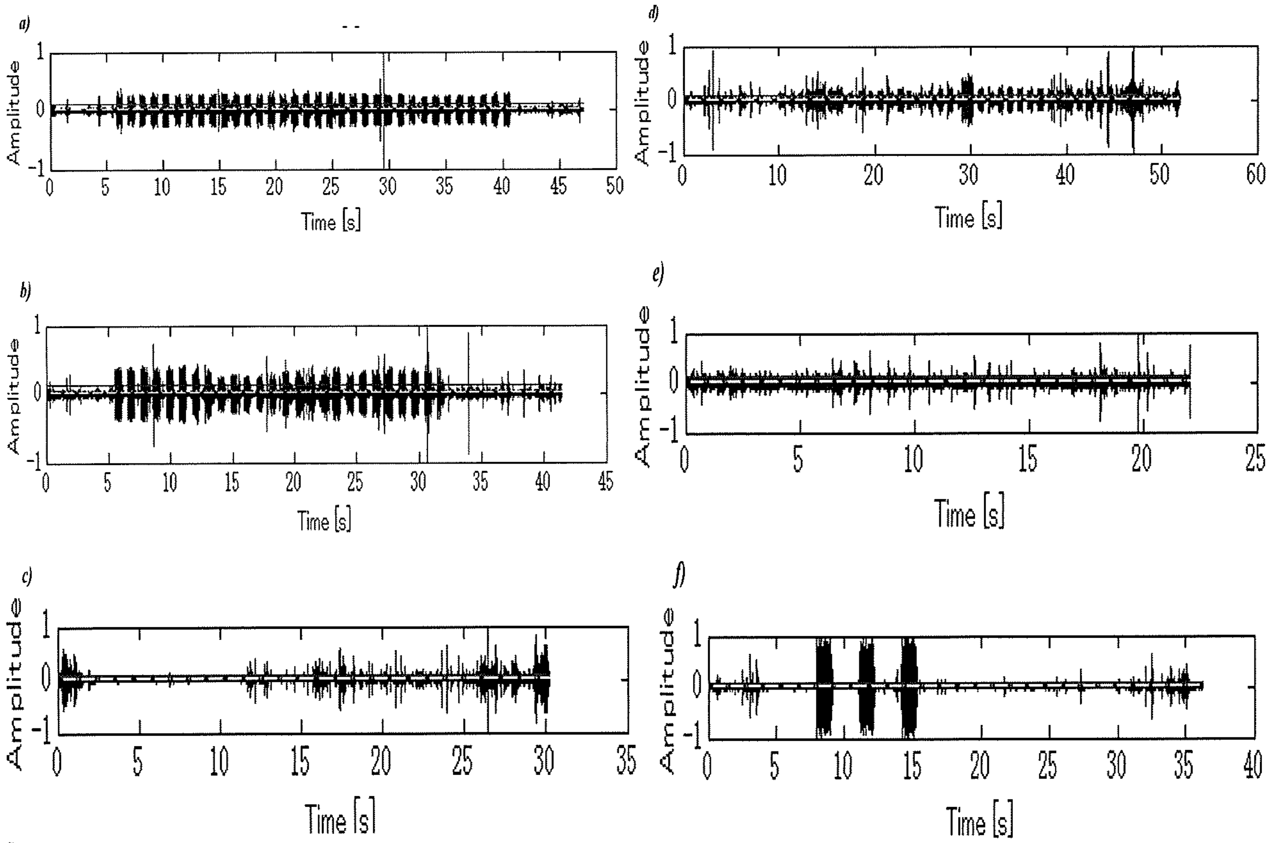

Fig. 6. The regularized wave patterns of the analysis result that is processed frequency analysis and waveform analysis: The full line (red color line) is threshold; the dashed line (aqua) is mean; the broken line (yellow) is median. (a) Alarm continuously, (b) Alarm and phone, (c) Nurse call, (d) Alarm with noise that mixed speaking voices, phone and so on various environmental sounds, (e) Phone call, (f) Phone call in a high tone.

Table. 1. The result of the estimated values and Detection Rate

	Sampled Values	Estimated Values	Estimated Times [sec]	Detection Rate [%]
Alarm continuously	36	36	19.2	100
Alarm and phone	27	27	14.5	100
Alarm with noise	34	45	23.7	76
Nurse call	0	0	0	100
Phone call	0	0	0	100
Phone call in a high tone	0	0	0	100
Sum	97	108	57.4	89.8

The data that the alarm are mixed with noises like speaking voices, phones and various environmental sounds were estimated 45 times call, but actual call times are 34. This estimation value is many false positive and detection rate is 76 %. We didn't detect successfully because it is too noisy and got interference continuously. However, detection rate was 89.8 % in total. It can be estimated too accurately the number and times of the ECG monitor alarm. Therefore it could be clarified the benefits of our analysis. Additionally, we considered that is able to estimate ECG monitor alarming time accurately, if we have clear reference data.

4. Conclusion

We proposed the automatically detection procedure of ECG monitor alarm using frequency and waveform analysis. At first, we identify the specific spectrum domain of the ECG monitor alarm from six reference data that are recorded the ECG monitor alarm clearly by IC recorder in nurse station. And, we designed band-pass filter that is passed principal spectrum band. Next, we extracted from audio data that are recorded by IC recorder in nurse station with environmental sounds by applying the band-pass filter.

Finally, the alarm waveforms are extracted form the basis for optimum values of the intervals and terms of the ECG monitor alarm that is obtained by steepest descent method. Then we estimated amount and number of times for setting the alarm.

In this paper, detection rate was 89.8 % in total and they can be estimated too accurately the number of and times of the ECG monitor alarm. Therefore, we consider that this analysis method is shown to be of benefit to detect the ECG monitor alarm automatically. And, the method can set up without some expertise in electromechanical and it is not load on the clinical practice. It only place IC recorder in nurse station. This study can be time study that is best suited to clinical practice and be useful as research for getting used to the alarm or attempt to improve existing condition of practice. In the near future, we are planning to develop the method that is more improved the accuracy.

References

[1] Patient Safety Authority, Alarm Interventions during Medical Telemetry Monitoring: A Failure Mode and Effects Analysis, Pa Patient Saf Advis, 5(Suppl. Rev.):1-50, Mar, 2008

[2] M Funk, JA Parkosewich, CR Johnson, and I Stukshis, Effect of dedicated monitor watchers on patients' outcomes, American Journal of Critical Care, Vol 6, Issue 4, 318-323, 1997

[3] Donita Semple, BS RN CPHQ; Linda Dalessio, RN APN CCRN, Improving Telemetry Alarm Response to Noncritical Alarms Using a Failure Mode and Effects Analysis, National Association for Healthcare Quality, pp. W5-13 to W5-19, Sept/Oct, 2004

[4] Emergency Room Nurses Faulted In Patient's Death, Legal Eagle Eye Newsletter for the Nursing Profession, p.4, May, 1996

[5] Ann Hendrich, Marilyn P Chow, Boguslaw A Skierczynski, Zhenqiang Lu, A 36-Hospital Time and Motion Study: How Do Medical-Surgical Nurses Spend Their Time?, The Permanente Journal,Volume 12 No. 3, p.p.25-34, 2008

[6] H.Kubota,Y. Kawata, H.Tanaka, T Takemura, Y.Sougawa, M. Hoshi, D. Onoduka, A. Kitagawa, N. Ashida, T. Hasegawa, C.Touge, M.Imamura, T.Komuro, H.Yamamoto, M.Uozawa, Y.Matsuura, K.Hasegawa, M.Irie, N.Moriguchi, H.Hamaguchi, R.Onishi, M.Oda, Time study for nursing by using voice recorders, Asia Pacific Association for Medical Informatics, p.p.1-8, 2000

[7] K. C. KIWIEL,K. MURTY, Convergence of the Steepest Descent Method for Minimizing Quasiconvex Functions, JOURNAL OF OPTIMIZATION THEORY AND APPLICATIONS: Vol. 89, No. 1, pp. 221-226, APRIL 1996

[8] L.M. Graña Drummond, B.F. Svaiterb, A steepest descent method for vector optimization, Journal of Computational and Applied Mathematics 175, p.p.395–414, 2005

The twelve-years' trend of the outpatients in the university hospital and its future projection

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1. Background

Aging brings many of goodness but also wear-out failure to human body. In 2025, 30.5% of the total population of Japan was estimated as the people aged over 65 years old. The ratio that the people over 65 years old occupy to the population at large is called aging rate. It is called aging that this ratio rises. The change of age distribution of population would effect on the distribution for patients too and that would have wide influence on the Japanese medical situation, for example, prolongation in hospitalization, change of the medical requirements and the number of medical specialists. Especially, the change would influence directly on the management of outpatient department in terms of waiting-time of patients and arrangement of medical staffs. It is important to investigate the recent trend of outpatients and the change of their characteristics for the planning of the hospital management in the future.

In this study, we focused the change of outpatients' age distribution in a university hospital. The university hospital takes a role to provide an up-to-date medical treatment in the northern part of Osaka, and plays the medical center role of the area.

2. Method

The period analyzed is June and October of the each year from 1996 to 2008, and we collected the patients' data of age, the visited department and the day of the first visit by using the data warehouse of the hospital. First, we investigated the change of distribution and average of outpatients' age over the period, then projected the age distribution for the next 5 years, from 2009 to 2013.

3. Results and discussions

All subjects were 856,968. The average number of the outpatients per month showed gradual increase during the period, 30,767 patients in 1996 and 39,086, patients in 2008. The average age of the patients increased apparently, from 48.6 in 1996 up to 55.1 in 2008. The aging rate of the hospital changed from 23.8% in 1996 to 39.1% in 2008. That was more rapid than those shown in Japan, 15.1% in 1996 and 21.5% in 2007. We drew the regression lines of outpatients and Japan's population between the changing aging rate and the year, setting the year to X, the aging rate to Y. The increasing inclination of the regression line in outpatient was 1.385, however, that of Japan was 0.5765. It is thought that the aging rate of outpatients rose earlier than that of Japan.

The projection for the next five-year was done by cubic model and the total number of the outpatients in 2013 was estimated as to be over 60,000 per month. The rapid increase of the patients was estimated in the age group of children and elderly person. The increase of the child patients was the different tendency from that of the population of Japan. One of the reason would be the decrease in the pediatrics department, namely the centralization of the pediatric medicine.

The investigation on the duration of a patient's consultation period would be also important to discuss the role of the medical institute in the regional medicine, because the patients' age would rise if they keep consulting to the medical department for a long time.

From a practical point, the number of the outpatients' units is limited and the number of the outpatients would not increase so much. The number estimated is thought as the potential needs for the medical treatment. And, how to respond to these medical needs would be an important question not only from the hospital management view, but also from the national medical policy view.

Fundamental Detection into Using Image Processing to The Consulting Behavior

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Abstract

In Japan, there is a word, "3 hours' waiting for 3 minutes' treatment". This is a sarcastic comment of patient on the long waiting time for the treatment followed by short consultations in many outpatient departments. There are 2.1 doctors per 1,000 people in the hospital of Japan, which is lower than those of average in the Organization of Economic Cooperation and Development (OECD), 3 doctors per 1,000 people. Most researchers have stressed that the major reason for long waiting times is the poor patient appointment system in place. Even in the university hospital, it is difficult to shift the consultation to advance appointment only and patients have common sense of taking almost a day to consult at the hospital even though clinic-hospital coordination has been advanced.

Introducing electronic medical record system (EMR) is expected to improve the efficiency of consultation in outpatient department, to decrease the waiting time of the patients, to increase the consultation time for each patient and to secure the examination time by improvement of medical care efficiency. Furthermore, EMR would lessen the time for seeking and/or transporting patient's file.

Meanwhile, it is worried that the consultation time to talk with patient with face to face might decrease in case of the doctor who isn't good at PC operation. Does the introduction of EMR contribute the prolongation of consulting time at the outpatient service? To overcome this problem, we proposed the system by video camera for the auto-time-motion study.

In this research, the extraction of the consulting behavior at the outpatient department was investigated experimentally. The behaviors to be discriminated are 1) doctor examine face to face with patient, 2) seeing the PC monitor in order to explain or input information for the patient, 3) seeing documents in order to explain or writing it for the patient, 4) talking to nurse or medical staff, 5) getting alarm or call, 6) others.

In the test bed, we constructed a virtual consultation room, a desk, a desktop PC with monitor and two chairs for the patient and the doctor were equipped. A color WEB-camera was set on the PC monitor for recording the situation of the patient's consultation. A subject in the role of a doctor sat behind the desk and performed several behaviors to be analyzed. It was examined the possibility of detecting the direction of the face from the image and the discrimination of the behavior.

The flesh-colored area was detected with the difference image and the possibility was suggested that we could detect the motion simply and quickly by the system. The privacy of patient and doctor was protected by leaving the difference image and getting rid of the ex-image. Moreover, the results suggested the possibility of direction of the face to be calculated by the difference image extracted. It would be necessary to consider the influence of the weather and sunshine to obtain stable result of the image processing.

Time Study for Nursing using Automatic Recorder Consisting of Ballpoint Pen and Stopwatch

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Abstract

The insufficient number of available nurses against their tasks is a serious problem. Nurses already have a considerable workload on a daily basis, and a shortage of nurses only worsens this problem. Therefore, there has been an increase in the number of medical incidents occurring due to inattentiveness from the nurses. To enable nurses to work effectively, it is necessary to estimate the stress they currently experience at work.

Determining the nurses' daily workload may help prevent medical incidents. The time study is commonly used to determine the nurses' daily tasks. A researcher follows a nurse during nurse's workday and records details about the nurse's tasks and the time required to complete the same. Ann Hendrich et al. reported that nurses' main tasks are documentation, medical administration, and care coordination. Among these three tasks, documentation required the longest time (35.3% of the total time). A method to record their task without their burden is required.

We developed an auto-recording device for the nurses' main task, namely, documentation. Our device is called Pen-Watch; it consists of a ballpoint pen with an attached stopwatch. We modified the stopwatch such that it could be used along with the ballpoint pen without restricting the nurses' ability to write. We installed a Start/Stop button on the top of the ballpoint pen. If a nurse presses the button before writing something, Pen-Watch begins recording the time. When the nurse presses the button again, Pen-Watch stops recording the time. Therefore, Pen-Watch can correctly record the time required to write something. Pen-Watch can record continuously for 24 h. Pen-Watch is a small device that is not affected by, e.g. people disturbing nurses during their work, and it eliminates the requirement for the installation of video cameras in rooms to record the working time of nurses. Pen-Watch is thus a novel and easy method for recording nurses' daily tasks easily.

Two experiments were performed: one to evaluate the accuracy of Pen-Watch and the other to determine the time required for documentation during daily work. In the first experiment, we asked a subject to perform deskwork, including documentation, for 30 min twice. In the first case, the subject was allowed to use Pen-Watch freely, whereas in the second case, the subject was asked to press the Start/Stop button. A camera installed on the desk was used to record the documentation time accurately. In the first case, the measurement error was approximately 2 min, whereas in the second, it was only a few seconds. This suggests that the measurement error occurred because the Start/Stop button was not pressed. It is necessary to become accustomed to using Pen-Watch to accurately record the time required for documentation. The second experiment was performed over two days. On the first day, the subjects were allowed to become accustomed to using Pen-Watch, and experiments were performed on the second day. The results of the second experiment revealed that Pen-Watch can be used to record the time required for documentation.

An Interactive, Multimodal Visualization and Analysis System for Time Motion Study

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Abstract

Time motion studies are used to measure on time utilization for medical profession. This can be performed either through continuous observation or work sampling, with continuous observation being more accurate than work sampling. Systematic coding is indispensable in order to analyze the time motion data, however, the framework and the contents of the systematic coding should be changed case-by-case to fit for the point of view of analysis. As the comprehensive data are collected in time motion studies, it is very hard to change the coding system to make a new system. Furthermore, the points to be investigated vary along with the change of the purpose of the time motion study. That is, it is desirable to develop a purpose-oriented interactive coding generation system equipped with the multimodal visualization request.

In this study, we proposed an interactive coding generation system with an automatic visualization and analysis program for the first step. This system is expected to reduce substantially time and effort to analyze the time motion study data.

For the development of the system, the time motion data obtained in an acute care hospital was used. The time motion study was remarked on the nurses' transportation jobs such as pushing a patient's wheelchair, pulling a patient's stretcher. The study was made with continuous observation method and the records were inputted code with text. Using these texts, we developed an interactive rule-generation system. In addition, interactive system to propose the purpose-oriented visualization was devised.

The total system consists of (1) input assistance systems, (2) check systems for incorrectly-inputs data, especially time parts, (3) retrieval support system, which extract a section of an action, (4) data coding generating system.

Based on the inputted text data, the coding rule adequate the purpose was extracted and composed by the response of the user. The investigation time was lessened in data coding, however, it required much more time to revalidate the coding.

The extracted coding rules were practical one but rather rough to apply to the general clinical job analysis. The more efficient selection and extraction logic would be needed.

Proposal of New Time and Motion Study for Work at the Nurse Station by Image Processing

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Abstract

The pharmacy operation is one of the important services that nurses have to do. Above all services, the pharmacy operation occupy a considerable amount of daily work. The nurse has to collect many data from time and motion study for improving pharmacy operation, but it gives the load to nurses. We proposed an automatic method for time and motion study by image processing. The method don't need the device that nurse have to be attached, and don't need wireless devices that affect telemonitoring system.

In this study, we recorded nurse doing pharmacy operation at the ward. One nurse wore red cardigan. After recording, we smoothed the image by using median filter, and extract the red cardigan. Then, the center of red area was calculated and tracked. In order to decide whether the nurse passed by the desk or she stopped to do pharmacy operation, the signal was recorded when she enter the area near the desk. As the results, we were able to measure her motion trajectory, and decide whether she did the pharmacy operation by the period of stopping at the desk.

Keywords: time and motion study, pharmacy operation, image processing, color extraction, moment feature

1. Introduction

Time and motion study for nursing is one of the effective methods to obtain a fundamental data for improvement of nursing at a hospital. The conventional method for time and motion study of nursing is onsite recording made by nurses, and there are two methods of recording: self recording, and recording by other person [1]. In the self recoding, nurses make dairy and researchers examine what kind of act took place from their dairy [2]. It is too difficult to completely know their works from dairies because of omissions or complexities [3]. In the recording by other person, the observer records nursing events with the time stamp by chasing a nurse all day. It is a heavy load for the observer. We encounter difficulties when we try to do the time and motion study because of a manpower problem, so it is difficult for doing it for a long time [1]. For this reason, it is needed that the method to do time and motion study automatically and not to need manpower.

In this study, we proposed an automatic method for time and motion study by image processing. The method don't need any device that nurse have to be attached, and don't need wireless devices that affect telemonitoring system.

Nurses have to do various services for nursing (e.g. nursing in neonatal intensive unit, nursing in intensive care unit, the pharmacy operation) [5][6]. In the pharmacy operation, the nurse labels the bottle of intravenous drip. So, in the services for nursing, we considered that the pharmacy operation is one of the important works, because it concerns life of patients. If nurses can improve the pharmacy operation, they can prevent medical accident, and they can concentrate on other important works. We proposed the automatically method for time and motion study of the pharmacy operation by image processing.

2. Method

A. Recording Images

We recorded two type of images by using a video camera (DCR-PC300NTSC, Sony, Japan). About the image1, the nurse wearing red cardigan went to the pharmacy operation desk, and did the pharmacy operation (Fig.1). About the image2, the nurse wearing red cardigan walked around the desk, and she went through without doing the pharmacy operation (Fig.2). The recorded sizes of images were 720 pixels in width and 576 pixels in height. The recorded frame rates of images were 30 fps.

B. Extracting the red cardigan

First, we extract a frame of the image, and smoothed it using median filter for the reduction of noise. Next, we extract the red cardigan by threshold tuning in color image. The extracted red cardigan image was converted to gray scale image, and then converted to binary format image.

From the binary format image of red cardigan, the center of the area of red cardigan was calculated by moment feature.

The moment feature is defined as:

$$m_{p,q} = \sum_{x}\sum_{y} x^p y^q f(x,y) \quad (1)$$

0th moment is defined as:

$$m_{0,0} = \sum_{x}\sum_{y} f(x,y) \quad (2)$$

0th moment means the area of the red cardigan because the image is binary format image.

The coordinates of image defined as Fig.3, and 1st moment of x and y coordinate defined as:

$$m_{1,0} = \sum_{x}\sum_{y} x f(x,y) \quad (3)$$

$$m_{0,1} = \sum_{x}\sum_{y} y f(x,y) \quad (4)$$

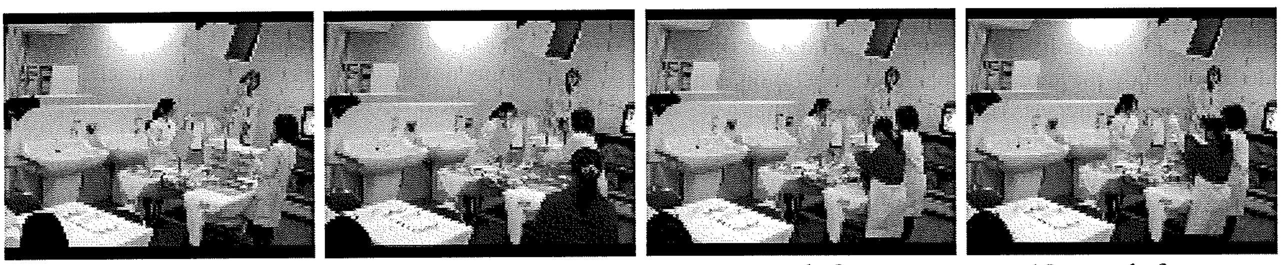
Finally, the center of the area of red cardigan was defined as:

$$(x_G, y_G) = \left(\frac{m_{1,0}}{m_{0,0}}, \frac{m_{0,1}}{m_{0,0}}\right) \quad (5)$$

After calculate the center of the area of red cardigan, we displayed blue circle to it.

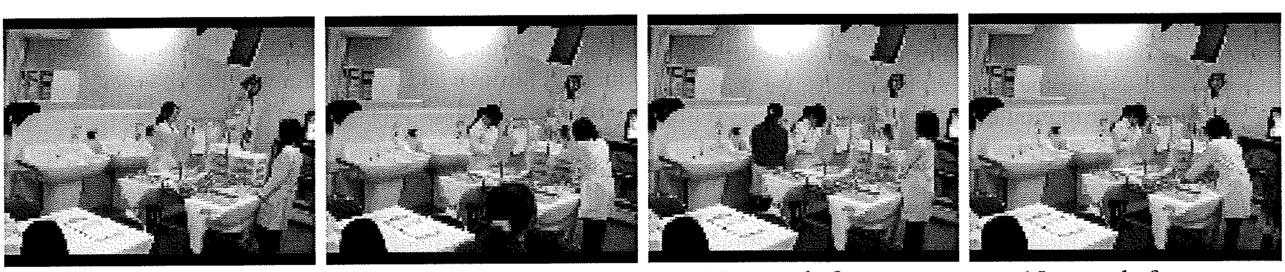
C. Recognition of intrusion into the area

In order to decide whether the nurse passed by the desk or she stopped to do pharmacy operation, the signal was outputted and time was recorded when she enter the area near the desk. The area was from 360 pixels to 660 pixels in X coordinate, and from 142 pixels to 280 pixels in Y coordinates (Fig.3).



Start of image | 5 second after | 10 second after | 15 second after

Fig. 1. Image 1. The nurse wearing red cardigan went to the desk, and she did the pharmacy operation



Start of image | 5 second after | 10 second after | 15 second after

Fig. 2. Image 2. The nurse wearing red cardigan walked around the desk, without doing pharmacy operation

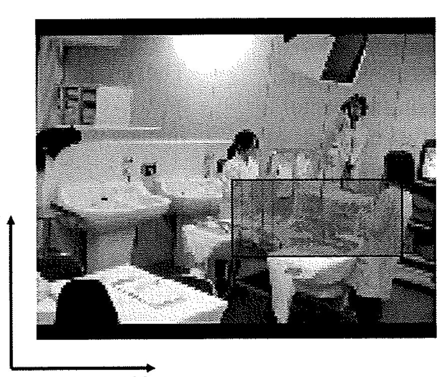
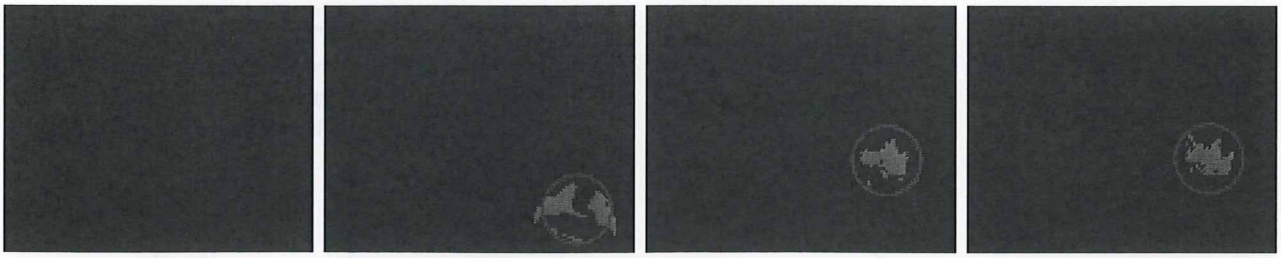


Fig.3 The coordinates of image and the area

3. Results and discussions

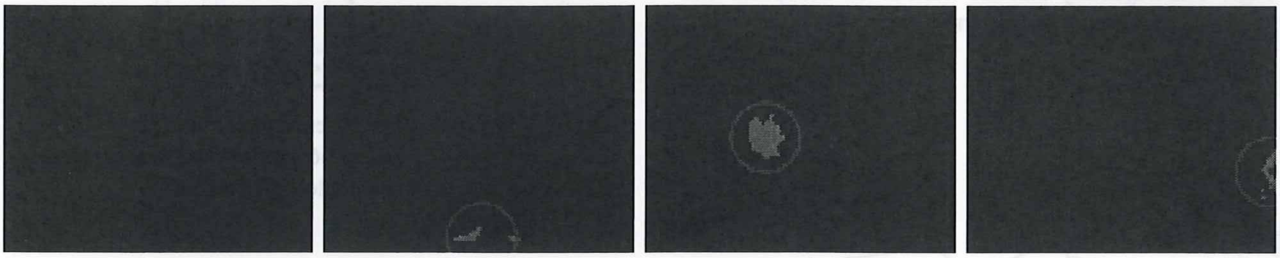
A. Images of tracking the nurse

The image of Fig.4 is the image that the nurse wearing red cardigan went to the desk, and did the pharmacy operation. The blue circle successfully tracked her, and from the image of 10 second after and 15 second after, we can confirm that she was stopping. The image of Fig.5 is the image that she walked around the desk, and she did not do the pharmacy operation. In this image, the blue circle did not successfully track her. When she passed behind other nurse, we lose sight of her and the blue circle disappeared (Fig.6). In order to solve this problem, we have to contribute the place of video camera, or we have to use two linked video camera and record her from her front and back.



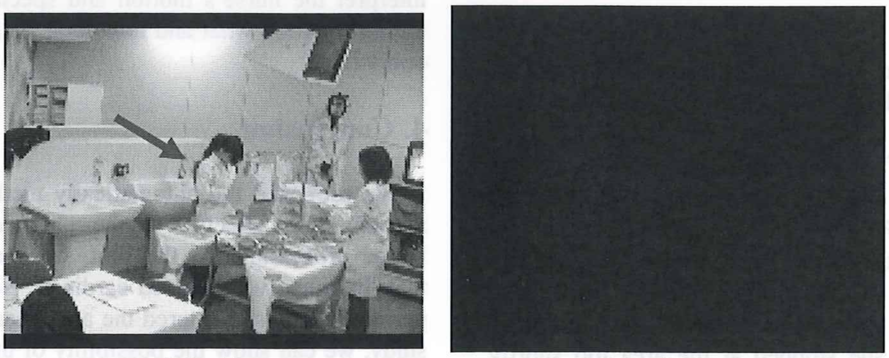
Start of image | 5 second after | 10 second after | 15 second after

Fig. 4 Image 1. The tracing of the nurse wearing red cardigan that did the pharmacy operation



Start of image | 5 second after | 10 second after | 15 second after

Fig. 5 Image 2. The tracking of the nurse wearing red cardigan that did not do the pharmacy operation



Original image | tracking image

Fig.6 Image 2. The nurse passed behind other nurse (11 second after)