Implementation of Care Records Automatic Generation Function in a Care Record Application

Haru Kaneko, Tahera Hossain and **Sozo Inoue**

Graduate School of Engineering, Kyushu Institute of Technology, Fukuoka, Japan

{haru| tahera|sozo}@sozolab.jp}

Abstract

The number of elderly people is increasing in the world. Especially in Japan, the shortage of nurses has been a problem in recent years. So far, we had developed a mobile application to make nursing care records. In addition, we are also experimenting with the introduction of this application to nursing homes. In this paper, we design an automatic generation function of the nursing care record into our mobile nursing care record application. In this paper, we implement an automatic generation function of the recorded contents in this care record system. we aim to simplify the work of making care records. To do so, we make a machine learning model for estimating the feature nursing care records in the server. And, we design new UI on our application to make care records using estimation result. As a result of the evaluation, we know it is possible to reduce time that making care records using our application with automatic generation function of care records.

Keywords: *Nursing care record, Machine Learning*

1. Introduction

Currently, Japan is facing a shortage of human resources in the nursing care industry. For this purpose, researchers are extensively working to improve automated nursing care facility center [1]. It is important for healthcare monitoring center or assisted living facility center. Worldwide elderly peoples are increasing and it requires a large amount of nursing care staffs to support and help these elderly peoples. Due to the shortage of human resources, nursing care industries turnover rate is higher than other industries. One of the main reasons is the increase of elderly population and healthcare issues, surveillance, fall detection, etc. [2]. Analysis by the Ministry of Health, Labor and Welfare [3], the turnover rate for care workers in the FY2016 survey was 16.7% (national average: 15.0%), which is about 4.9% from the 21.6% turnover rate for care workers in FY2007. Despite improvement, the turnover rate is 1.7% higher than the national average, and the problem that it is difficult to acquire new care workers is considered to be the cause of the shortage of human resources in the care industry. [4].

In this regards, advancement of technology can help to monitor patient activity in healthcare center. As a measure for this human resource shortage problem, attention has been focused on improving the productivity of nursing care business using ICT [5]. For example, the status of the care recipient is acquired and managed from the non-contact sensor mounted on the bed. Few systems use motion sensors [6], mat type sensors, etc. to centrally manage daily activity information such as toilets and sleep [7]. Also, several mobile apps are suggested for human activity recognition [8]. At the same time, researchers are also conscious of real time applications for hospitals and nursing homes [9]. This technology can be used to recognition of patient activity record, nursing care activities, nursing care work along with resident's care [10]. Analysis of this care records data can improve the support of the nursing facility center [1] and able to provide better life to patient. It helps to evaluate elderly people's day to day health status. For this purpose, either sensor/video-based system can help us to collect these types of patients' regular life data and clinicians will able to analyze those data for behavior prediction. In this regard, it is always challenging to capture appropriate amount of real field data to predict patient behavior [11].

In our laboratory, we focused on the utilization of technology in this nursing care site. We developed a nursing care recording system which is mobile based application and conducted an experiment of introducing it to nursing care facilities [1]. This care record system allows each care staff to enter a care record from the mobile application and view all care record data recorded from the WEB application. We are aiming to shorten the work time and simplify the work by using the mobile app to create the care records. In addition, this care record system collects the acceleration sensor data at the same time as the care record data. Using the collected care record data and acceleration data, there is also a function to estimate the behavior of care staff on the next day. In this paper, we implement an automatic generation function of the recorded contents in this care record system. By using the automatic generation function of the recorded contents, we are aiming to shorten the work time and simplify the work by using the mobile app to create the care records. In addition, this care record system collects the acceleration sensor data at the same time as the care record data. Using the collected care record data and acceleration data, there is also a function to estimate the behavior of care staff on the next day. In this paper, we implement an automatic generation function of the recorded contents in this care record system. By using the automatic generation function of the detail of records, we aim to further simplify the work of making care record. In this paper, we make machine learning model to estimate detail of care records in the server, and we designed application UI to input care record using estimation result.

The organization of the paper is as follows: after providing a brief introduction in Section 1, we present related work in Section 2. In Section 3, we analysis the requirements of this system. In Section 4, we present the system design and details of the experimental setup. In Section 5, we elaborately explain

the evaluation and results of our experiment. Finally, we conclude the paper in section 6 with some analysis and future work guidelines.

2. Related Work

The increase of older people is a global trend. Especially in Japan, the percentage of people who are 80 years old or above is expected to increase from 8.6% in 2017 to 21.9% in 2065 [12]. Increasing numbers of the elderly people require everyday life support. Throughout Japan, there are different types of residential care facilities for the elderly, including nursing homes with limited medical competency. The main purpose of these nursing homes are take care of daily living requirements of elderly peoples. For this purpose, a large number of care staffs are required. As elderly population are increasing so shortage of human resource has been observed to support this large number of elderly populations. To address this problem, automated nursing care center or partially automation in nursing care center are now introduced in different research. As well as the work load balance of nursing care stuff is also important in this regard. However, it is not a straightforward job to implement IT systems into nursing care facilities. Most importantly, there are no specific standard for nursing care recording system like hospital. Consequently, each nursing care has their own requirements of care recording system.

Obayashi et al. [13] focused on reducing the burden of night work in nursing homes, proposed a system that combines a monitoring system and an interactive robot conducting an experiment of introducing it into a nursing care facility. The monitoring system recognizes the state of the resident on the bed, and notifies the care staff when it detects rising or getting out of the bed. This is an example of a study aiming to introduce the advance technology to nursing homes. During using this system an interactive robot speaks when the monitoring system detects getting up and getting out of bed for any residence. In order to improve nursing-care services, a location tracking based system has proposed by Hirabayashi et al [14]. The proposed Visualization and Evaluation System collects location information and twittering of nursing-care staff and integrates record of nursing-care and nurse call. As a field experiment, the system is effective to improve nurse care service. Inspired by their work, we designed a care record application with an automatic generation function to simplify making care record process.

3. Requirement Definition

In chapter 3, we define requirements for care records automatic generation function in a care record application. Requirements definition is a detailed definition of the functions and performance that the system must be satisfy.

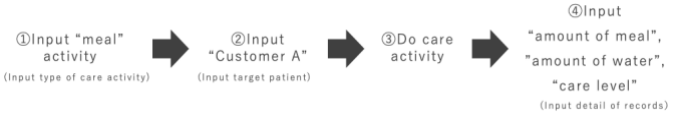

Figure 1- Image of the use case of the care record application when nurses assist eating meal.

The care record application described in this paper is designed to improve the efficiency of making care records in nursing facility. Nurses are required to carry a smartphone during work hours. Then, they make care records using this app.

3.1 Business Requirements

First of all, we define how nurses use the care record application during their work. In a nursing facility, nurses carry their smartphones with them while they work. When a nurse do a care activity, she first records the type of caregiving activity and the target patient from this application. After that, they do a caregiving activity. After the nursing activity is completed, the nurse records that details of care record from this application. Fig. 3 shows an example of the care activity for "providing meal support to Customer A". Indicates the steps in the use of this application.

Next, we define how nurses use the automatic generation of care records of our care record application. The application displays the estimated care activity. When a nurse do a care activity, the nurse chooses the correct care activity among the estimated care activities in the application and converts them into a record of the actual care activity. The contents of the care activity are inputted based on the estimated results and the miss in the estimation are corrected.

Lastly, we define the level of systematization using care record applications in nursing facilities. The care record application described in this paper takes the place of the nursing care records which are recorded on paper or in other systems in nursing facilities. The care record is a record of which patients are cared, who and when. The system also records the amount of food intake and amount of excretion and vitals, and is use for the health management of the patients or report to family.

3.2 Functional Requirements

In this section, we define the functional requirements for the care record application. The functional requirements are a list of the functions that the system should have in order to satisfy the business requirements. The functional requirements of the care record application described in this paper are described below.

(1) It can make care records.

(2) Care records can be shared.

(3) It can see all care records when we need it.

(4) It can output to traditional paper care record format

(5) All records can be entered from a smartphone

(6) It can enter care records even when smartphone is not connected to the network.

(7) Personal information is not leaked to the outside world.

(8) It can to input data in between nursing work and other duties.

(9) It can easily see the estimated results

(10) It can create a record easer based on the estimation results

(11) It can edit the inputted care activity

(12) It can edit the inputted target patient.

(13) It can edit the estimated detail of records.

(14) It can edit the estimated time.

(15) It can input care record using estimation results even when not connected to the network

(16) Estimates that have not been confirmed by nurse does not record in the formal records.

(1) to (8) are functional requirements for the care record application. (9) to (16) are the functional requirements for the automatic generation of detail of care records. (6) and (15) are based on our experience that it is sometimes difficult to install the Wi-Fi system in every room of a nursing facility. (8) the reason why the system is able to input the data in between nursing tasks is that the nurses have to input the data in between their daily tasks.

3.1 Non-Functional Requirements

This section defines the non-functional requirements for care record systems. Non-functional requirements are requirements other than functional requirements, such as performance, reliability, scalability, and operability. The non-functional requirements of the care record application described in this paper are described below.

(1) Even users who have never used to using a smartphone can use.

(2) Using automatic generation function make the recording process easier.

(3) It reduces time using function which automatic generation of detail of records.

(1) is a requirement for the care record application. (2) to (3) are requirements for the automatic generation of detail of care records.

4. System Design

In this chapter, we will design the automatic generation of detail of records in the care record application based on the definition of requirements described in Chapter 3. First, we describe our care record application that we have developed in our laboratory. After that, we design the ML server (machine learning server) and mobile application UI.

4.1 Our Care Record Application

First, we will give an overview of our care record application. Figure 2 shown the relationship between the care record mobile application and servers. This system has already been completed and we have experiment using this application[1]. In this paper, we add an automatic generation function to this system.

Nurses use the application to make care records. This application can make care records even when the network is not connected. The entered records are sent to the app server (application server) when the network is connected. Therefore, this application can be used in nursing facilities that are equipped with Wi-Fi only at the nurses' station.

The entered care records data are sent to the app server. The app server built by Laravel. The app server records the care records data to a DB (database). In addition, care records can be checked from browsers. And care records data can be output to the form format specified by the nursing facility.

In our system, the ML server has already estimate once a day using care records data. In this estimation, we estimate which nurse, which care activity, what time on the next day. The data used for estimation is delivered from the application server to the ML server via an intermediate server. The results of estimate are also sent to the app server from ML server via an intermediate server. In this paper, we add a new machine learning model for estimating the detail of care records. Estimation is once in a day. And send estimation result to mobile application before start nurses work.

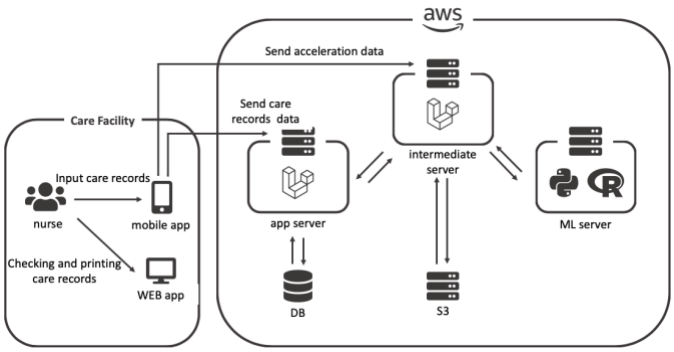

Figure 2-The relationship between mobile applications and servers in care record applications.

4.2 Machine Learning Server

The ML server has already estimate once a day using care records data. In this estimation, we estimate which nurse, which care activity, what time on the next day.

In this paper, we estimate the detail of that care activity. For example, in our system, it is already estimated that “UserA” will eat and take medicine at 12:00 pm on the next day. The new estimation model that we describing in this paper estimates the target patient and detail of care records for this estimated care activity. For example, Detail of care records are "amount of food intake", "amount of excretion" or "level of meal assistances".

4.2.1 Estimate Target Patient

In another paper we have already created a machine learning model for estimating the target patient [15]. In this paper, we have reworked this model for the server.

This model using Random Forest [16]. Random Forest is a machine learning algorithm that ensemble learning using decision trees as weak learners.

For the characteristics, "start time", "nurse id” and "types of care behaviors" are used. We use "start time", “nurse id", and "activity class" as explanatory variables. Target variables are which patient are the target of this care activity.

4.2.2 Estimate Detail of Records

In this section, we describe the method for estimating detail of care records.

As in the previous section, In another paper we have already created a machine learning model for estimating the detail of care records [15]. In this paper, we have reworked this model for the server. This model using Random Forest [16].

For the characteristics, "start time", “nurse id", “activity class”, “type of record”, and "previous recorded values of same type" are used. We use "start time", “nurse id", and "activity class" as explanatory variables. The target variable is the recorded value in the care records.

4.3 Mobile Application

In this section, we design the user interface (UI) of care record mobile application that displays estimated care records.

The UI of our care record mobile application made so far is shown in Figure 3. (A)-(G) shows the UI when nurses make a care record.

(A) is the first screen displayed when the mobile application is opened. There are three columns in (A). The left column shows the type of care activities, the middle column shows the target caregivers, and the right column shows care records.

When a nurse do care activity, nurse select the type of care activity and the target patient before to start care activity. In (B) to (C), the type of care activity and the target patient are selected. In (C), nurse click the red button, the care record is created. In (D), the button at the top of the right column is a care record. By tapping this button, the screen change to (E). The nurse do care activity on (E). After the care activity is completed, nurse tap the care record button at the top right of the screen again. Then, by long tap the button, the screen change to (G). At (G), the nurse input the detail of the care record like the amount of food intake and water intake and so on. This is the UI for recording the care record without using the automatic generation function.

Figure 3-UI of a mobile application for a care record application that does not use an automatic generation function. (A):Initial screen,(B):The type of care activity is entered, (C):The target patient is entered, (D): The state in which the care record was created, (E):doing care activity, (F):Care activity completed, (G):Input the details of records.

Next, Figure 4 is the newly designed mobile Application UI.

(A) is the first screen displayed when the mobile application is opened. There are three columns in (A). The left column shows the type of care activities, the middle column shows the target caregivers, and the right column shows care records.

In (A), the estimated care records are shown by gray buttons in the right column. To click this button, the screen changes to (B). In (B), the estimated type of care activity and the estimated target patient is selected. If the wrong target patient is selected, nurse can correct the errors on this (B) screen. Then, by clicking the "create a record" button (red button), the screen changes to (C) that care record is created. The steps from (C)-(E) are the same as the UI of without using the automatic generation function. In (E), by long tap the button, the screen changes to (F). (F) is UI to input detail of records. In (F) is already input estimated value. If the wrong value is selected, nurse can input right value. If the estimated results are correct, nurse tap button to complete recording on bottom of (F).

Figure 4-UI of a mobile application for a care record application that using automatic generation function. (A): Initial screen. The estimated care records are shown by gray buttons in the right column, (B): The type of care activity and target patient is entered that was estimated. (C): The state in which the care record was created, (D): doing care activity, (E): Care activity completed, (F): Input the details of records. (F) is already inputted estimated value.

5. Evaluation

In this chapter, we evaluate the system that designed in chapter 4. In chapter 3.1, we first define the flow of creating a care record using a mobile application. As shown in Figure 4, the designed mobile application is able to make care records in accordance with the defined business requirements.
In section 3.1, this care recording system is defined as a replacement for traditional care records using paper in nursing facilities. The care record system designed in this paper is capable of creating care records and It is possible to output the traditional care records on paper. Therefore, this requirement is fulfilled.

5.1 Evaluation of Business Requirements

The first, we evaluate whether the designed system meets the Functional Requirements defined in section 3.2. Among the functional requirements defined first, (1)It can make care records, (2)Care records can be shared, (3)It can see all care records when we need it, (4)It can output to traditional paper care record format, (5)All records can be entered from a smartphones, (6)It can enter care records even when smartphone are not connected to the network, (7)Personal information are not leaked to the outside world, (8)It can to input data in between nursing work and other duties, which already meets the requirements of the existing care record system. Considering (8), the automatic generation function is designed to allow nurse to continue the input work afterwards even if you interrupt the input work.

Next, (9) it can easily see the estimated results, (10)It can create a record easer based on the estimation results, the designed UI is similar to care records that does not using automatic generation function, and filled the requirements of (9) and (10).

Secondly, we describe (11) the confirmed presumed record can be modified later, (12) the presumed subject can be modified (13) we can modify the estimated content, (14) we can modify the estimated time. The UI designed in the chapter 4 can edit or delete the target patient, the detail of record, and the time. Therefore, the requirements of (11)-(14) are satisfied.

Next, we describe (15) it can input care record using estimation results even when not connected to the network. Application download the all estimation results for the day from the ML server at once by one day. We can change time when download the estimation results by setting. So we set up time when download the estimation results in night when

nurses are not working, but we can also set up evening for night shift. Also, in nursing facilities where there is a sufficient network, it may be possible to use estimation like real time estimation, such as estimates and downloading estimation once an hour. Therefore, requirement (10) is filled.

Lastly, we describe (16) estimates that have not been confirmed by nurse does not record in the formal records. The UI designed in chapter 4 can not record without tap a button for complete recording on bottom of screen to input detail of records. So nurse need check the estimated result to record detail of records. The requirements of (16) are filled.

5.2. Evaluation of Function Requirements

The first, we evaluate whether the designed system meets the Functional Requirements defined in section 3.2. Among the functional requirements defined first, (1) it can make care records, (2) care records can be shared, (3) it can see all care records when we need it, (4) it can output to traditional paper care record format, (5) all records can be entered from a smartphones, (6) it can enter care records even when smartphone are not connected to the network, (7) personal information are not leaked to the outside world, (8) it can to input data in between nursing work and other duties, which already meets the requirements of the existing care record system. Considering (8), the automatic generation function is designed to allow nurse to continue the input work afterwards even if you interrupt the input work.

Next, (9) it can easily see the estimated results, (10) it can create a record easer based on the estimation results, the designed UI is similar to care records that does not using automatic generation function, and filled the requirements of (9) and (10).

Secondly, we describe (11) the confirmed presumed record can be modified later, (12) the presumed subject can be modified (13) we can modify the estimated content, (14) we can modify the estimated time. The UI designed in the chapter 4 can edit or delete the target patient, the detail of record, and the time. Therefore, the requirements of (11)-(14) are satisfied.

Next, we describe (15) it can input care record using estimation results even when not connected to the network. Application download the all estimation results for the day from the ML server at once by one day. We can change time when download the estimation results by setting. So, we set up time when download the estimation results in night when nurses are not working, but we can also set up evening for night shift. Also, in nursing facilities where there is a sufficient network, it may be possible to use estimation like real time estimation, such as estimates and downloading estimates once an hour. Therefore, requirement (10) is filled.

Lastly, we describe (16) estimates that have not been confirmed by nurse does not record in the formal records. The UI designed in chapter 4 cannot record without tap a button for complete recording on bottom of screen to input detail of records. So, nurse need check the estimated result to record detail of records. The requirements of (16) are filled.

5.3. Non-Evaluation of Function Requirements

Finally, we evaluate whether the designed system meets the non-functional requirements defined in section 3.3.

First, we describe about (1) even users who have never used a smartphone or have not use a smartphone so much. This application is designed to reduce the number of screen transitions as much as possible. In the experiments that we have conducted in our laboratory, we found that users who are not used to using smartphones are perplexed by the screen transitions. So there are only 2 screen (initial screen, inputting detail of records screen). In addition, nurses can use application only tap and long tap, and nurses does not need use swipe or flick. This is also based on knowledge from the experiment that we have conducted in our laboratory. Thus, in this paper, we try our best to make the system easy to use for users who are not used smartphones.

Secondly, we describe about (2) using automatic generation function make the recording process easier and (3) it reduce time using function which automatic generation of detail of records. In this paper, it is not possible to evaluate the time spent by real nurses for inputting data, so we evaluate a number of tap to input a care record. There are 3 types of inputting contents using automatic generation function, “Input type of care activity”, "Input the target patient" and "Input the detail of records". we evaluate a number of tap each types of inputting contents using automatic generation function.

First, we evaluate about "Input type of care activity". To input type of care activity does not use automatic generation function need one tap. If accuracy of estimation is higher, to input type of care activity using estimation also need only one tap. But if the estimation accuracy is 0%, nurse need check if there are estimated care record button. And then enter the type of care activity same as input type of care activity does not using estimation. Therefore, if the estimation accuracy of the type of care activities is low, it may take more time than input does not using automatic generation.

Next, we evaluate about "Input the target patient”. To input target patient does not use automatic generation function need tap that number of target patient. If accuracy of estimation is higher, to input target patient using automatic generation function does not need tap. Because when input type of care activity using automatic generation function, target patient also input automatically. But if the estimation accuracy is 0%, nurse need delete inputted target patient by automatic generation function, and input correct target patient. Therefore, if the estimation accuracy is lower than 50%, nurse need more tap than when input target patient does not using automatic generation function.

Finally, we evaluate about "Input the detail of records”. To input detail of records does not use automatic generation function need tap that number of detail of records. If accuracy of estimation is higher, to input detail of records using automatic generation function need only one tap a button to complete recording on bottom of screen. If the estimation accuracy is 0%, to input detail of records need only input correct value. In other words, nurse does not need delete incorrect input which inputted by automatic generation function. So, if the accuracy is higher than a little, we can reduce a number of taps.

From these results, the higher the accuracy of the estimation, we can reduce the number of taps. As for the "input detail of record", even if the estimation accuracy is a little, we can reduce the number of taps. However, if the estimation accuracy of "Input type of care activity" and "Input the target patient" is low, the number of taps increase than input does not use automatic generation function.

6. Concludion

In this paper, we designed a care record application with a automatic generation function to simplify making care record process. To do so, we define system requirements, and design care record application. We make tow machine learning model that we had made our related work on server. And we make system that send estimation result on server to application. And, we designed application UI, to input care record using estimation result.

As a result of evaluation, we know it is possible to reduce time that making care records using our application with automatic generation function of care records. Now, we have experiment using our application without automatic generation function on nursing facilities. We would like to introduce the automatic generation function to this experiment in the future, and we would also like to evaluation experiments of the automatic generation function.

References

[1] S. Inoue, P. Lago, T. Hossain, T. Mairittha, N. Mairittha, "Integrating Activity Recognition and Nursing Care Records: The System, Deployment, and a Verification Study", Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, Vol. 3, No. 86, pp. 24 pages, 2019-09-09.

[2] S. Abbate, M. Avvenuti, P. Corsini, J. Light, and A. Vecchio,"Monitoring of Human Movements for Fall Detection and Activities Recognition in Elderly Care Using Wireless Sensor Network: a Survey", INTECH, 2015.

[3] Ministry of Health, Labor and Welfare: Labor Market Analysis Report, Retrieved from https://www.mhlw.go.jp/content/11600000/ 000340639.pdf (2018).

[4] Ministry of Health, Labor and Welfare: About the current status of care areas, etc. Retrieved from https://www.mhlw.go.jp/content/12602000/000489026.pdf (2019).

[5] Ministry of Health, Labor and Welfare: Regarding the promotion of ICT and care efficiency in the nursing field (online), https://www.kantei.go.jp/jp/singi/keizaisaisei/miraitoshikaigi/ suishinkaigo2018/health/dai6/siryou4.pdf⟩ (2019).

[6] Paramount Bed: Smart Bed System, Retrieved from https://www.paramount.co.jp/sbs/index.html.

[7] Econavista Co., Ltd.: Life rhythm Navi + Dr., Retrieved from http://info.liferhythmnavi.com./

[8] Lara, D. Oscar, and A. Miguel, "A mobile platform for real-time human activity recognition." Consumer Communications and Networking Conference (CCNC), 2012, IEEE, 2012.

[9] N. Mairittha, T. Mairittha, S. Inoue, "FonLog - A Mobile App for Nursing Activity Recognition", ACM Int'l Conf. Pervasive and Ubiquitous Computing (Ubicomp) Demo, 2018.

[10] N. Mairittha, T. Mairittha, and S. Inoue. 2018. A Mobile App for Nursing Activity Recognition. In Proceedings of the 2018 ACM International Joint Conference and 2018 International Symposium on Pervasive and Ubiquitous Computing and Wearable Computers (UbiComp'18). 400-403, 2018.

[11] P.Lago, S. S. Alia, S. Takeda, T. Mairittha, N. Mairittha, F. Faiz, Y. Nishimura, K. Adachi, T. Okita, F. Charpillet, and S. Inoue. 2019. Nurse Care Activity Recognition Challenge: Summary and Results. In Adjunct Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2019 ACM International Symposium on Wearable Computers (UbiComp/ISWC '19 Adjunct).

[12] National Institute of Population and Social Security Research. (2017). Population projections for Japan. Retrieved from http://www.ipss.go.jp/pp-zenkoku/j/zenkoku2017/db_zenkoku2017/db_s_suikeikekka_9.html

[13] K. Obayashi, S. Masuyama, The Effects of Introducing Communicative Robots with Infra-red Radiation Monitoring System on Night Shift Duties of Nursing Facility Care Worker, Journal of the Robotics Society of Japan, vol. 36, no. 8, pp. 537-542.

[14] Y. Hirabayashi, N. Uchihira, K. Torii and Y. Ikawa, "Verification of effectiveness of the nursing-care Service Space Visualization and Evaluation System: Field experiment aiming to improve nursing-care services," 2013 Proceedings of PICMET '13: Technology Management in the IT-Driven Services, pp. 1567-1571, 2013.

[15] H. Kaneko, S.Inoue, Estimation of Record Contents for Automatic Generation of Care Record, Research of Report Mobile Computing and Pervasive Systems (MBL), vol. 2020-MBL-94, no. 41, 2020.

[16] Breiman, L.: Random Forests,Machine Learning,Vol. 45, pp. 5–32 (2001).