CHARM Pad: Ontology-Based Tool for Learning Systematic Knowledge about Nursing

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Abstract. Japan is no exception among developed countries facing healthcare system problems due to aging and low birthrate as the number of patient increases and health care worker numbers shrink. The introduction of high tech medicine has increased the amount of knowledge to be learned by novice nurses. Although vast amounts of implicit knowledge have accumulated among nursing practitioners, this knowledge needs to be communicated when hospitals train younger generations of nurses. In this paper, the authors have proposed an activity model called CHARM (the Convincing Human Action Rationalized Model) and CHARM Pad, tablet PC with browsing software for CHARM models. CHARM explicates multidimensional purpose-oriented procedure relations often existing as implicit knowledge. For this reason, CHARM supports the training and education of novice nurses. We developed CHARM models according to nursing guidelines of hospitals and applied them to training of the nurses in two hospitals. CHARM and CHARM Pad are being evaluated at these hospitals and positive responses are coming from nurses.

Keywords: CHARM, CHARM Pad, nursing process, knowledge representation, activity model.

1 Introduction

Along with the progress of medical treatment technique, knowledge about nursing process which nurses must learn is rapidly increasing. Furthermore, the process contains much implicit knowledge which does not appear on manuals in hospitals.

Although training of the nurses relies on the manuals, conventional manuals have the problem. Some of the nurses who have learned using these guidelines lack

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flexibility in a changing situation. In order to improve the efficiency of medical care, it is therefore important to train nurses to be able to deal properly with unforeseen incidents.

In this paper, we focus on solving issues about the training of nurses. To support nurses learning the process, the authors have developed CHARM Pad, an ontology-based tool on tablet PC (Figure 1). CHARM Pad displays a purpose-oriented process model of nursing care in a tree structure in which not only explicit activities written on the manuals but also implicit knowledge such as purpose of each care process are represented. In addition, the CHARM pad shows various treatment approaches for each disease condition which supports learning alternative ways of nursing care, which are very important knowledge for creative nursing care.

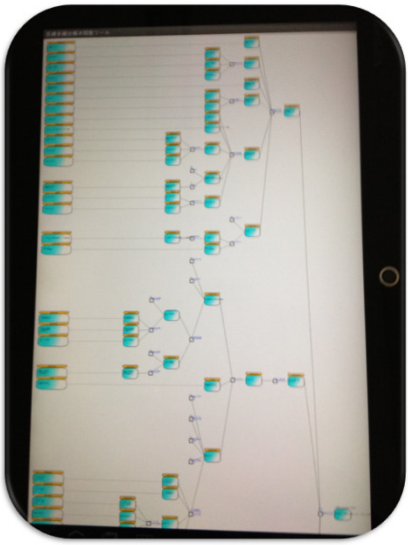

Fig. 1. CHARM Pad

2 CHARM and Modeling Procedure

2.1 Modeling Procedure

The CHARM pad is based on a modeling framework called CHARM (Convincing Human Action Rationalized Model) which is an ontology-based generic representation model of human activities.

The origin of CHARM is hierarchical functional modeling method investigated in the authors' laboratories. In the field of engineering design, knowledge pertaining to functions that express design intent - this is called functional knowledge - is shared and used. Research pertaining to the improvement of sharing and reusing knowledge is known as ontology engineering [1]. The authors have used ontology engineering to

explicitly state concepts of functional knowledge, hereafter called a functional knowledge sharing framework [2, 3]. This framework is based on device ontology that defines devices from a modeling perspective. Device ontology was used to create functional decomposition trees for expressing individual functions. The functional decomposition tree also demonstrates the purpose of the function. Because the tree describes the purpose of the function from its mechanics, the use of the device can be changed to suit different situations. This framework has also been put to practical

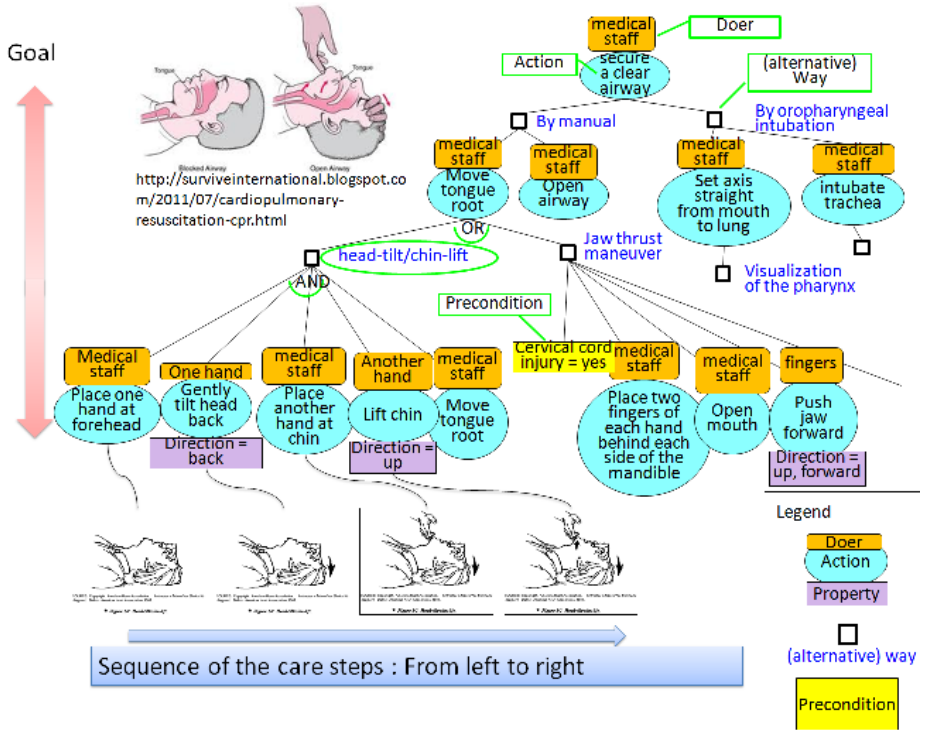

Fig. 2. CHARM for "Secure a clear airway" (part)

use, for example, in normal work in production technology at Sumitomo Electric Industries, Ltd. [2]. In this example, the framework succeeded in enabling implicit knowledge to be externalized and shared.The CHARM represents such activities in a tree structure like Figure.2. On the instruction manuals or guidelines, they describe important/right sequence of actions. First, the designer of the CHARM describes the actions on the manuals at the bottom level of the tree. Next, the designer put the actions together to make part of the CHARM tree from the view point of the goal, which is achieved by the actions. For example, a sequence of five actions constitutes the "head-tilt/chin-lift way" which achieves the goal "Move tongue root" (left lower part of the figure 2). At the same time the goal activity is a part of the activities which achieve higher goal, "Secure a clear airway" in turn. On this manner, we develop a CHARM tree which achieves an ultimate goal "Recover a victim in cardiac or

respiratory arrest". The CHARM represents one activity from two viewpoints (Figure.2). The vertical viewpoint represents a hierarchy of the goal and sub-goals (goal oriented viewpoint). The horizontal viewpoint represents order of the activities to achieve goals (sequence oriented viewpoint). The goal oriented viewpoint is important because the nurses have to abstract "problem" of his/her patient to find alternative treatment method when he/she cannot cure by one method. The sequence oriented viewpoint is also important for novices who have to learn right order of care process. The CHARM Pad equips with two modes corresponding to the both viewpoints.

2.2 Evaluation Comments on CHARM

We obtained comments on CHARM from nurses who are co-researchers of this project and from member of Nursing College. Their comments suggested that CHARM is a valid method for describing medical procedures.

Because CHARM is able to explicate relationships between actions, there are high expectations for its applicability in nursing training. Nursing staff members who are responsible for educating newcomers at Miki City Hospital commented that CHARM is useful in teaching students and inexperienced newcomers. They also commented that CHARM explicates multiple possible procedures and makes optimal decisions easier to make. They further commented that although it may be difficult to use CHARM in a clinical setting, the method is useful in basic and postgraduate training.

Comments from nurses such as "(CHARM) explicated possible choices of procedures" indicate that CHARM has ability to represent the procedures with consistency. Comments such as "(CHARM) explicated purposes of actions" indicated that CHARM was able to describe relationships between actions and purposes. We expect that CHARM will help learners to optimize decision making.

Members of the College of Nursing faculty commented that CHARM externalized implicit knowledge that was not available in guidelines. In conventional guidelines, the relationship between actions and causes of potential problems was not described clearly, making it difficult for nurses to understand guidelines. Faculty members stated that CHARM made it possible for even new nurses to understand procedures.

3 Nurses' Training by CHARM Pad

3.1 CHARM Pad

To support nurses learning the process, the authors have developed CHARM Pad, an ontology-based tool on tablet PC. As is shown in Figure1, CHARM Pad displays a purpose-oriented process model of nursing care in a tree structure in which not only explicit activities written on the manuals but also implicit knowledge such as purpose of each care process are represented.

By simple gestures, users can browse nursing care processes at various levels of granularity. When a user wants to know more detail about a process, for example, he/she can expand the corresponding node to see its sub-processes by just tapping the

node. Some processes are linked with movies or pictures which support understanding about the process through multi-media. On the nursing care manuals, for example, they just say “Perform cardiac compression 100 times per a minute” which is difficult for novices to do at the spot. With an instructional movie, the novice intuitively understands the right pace and rhythm for the compression. In addition, the CHARM pad shows various treatment approaches for each disease condition which supports learning alternative ways of nursing care.

CHARM Pad has other 2 modes to support learinig. One is “Sequence-oriented view mode” in which minimum and essential steps form a line like left side of the screen of Figure 1. For novices, it is hard to learn all relationships represented in the tree structure of the CHARM, since their first requirement is to learn right sequence of the care process. Sequence-oriented view mode is especially for novice nurses.

Another mode is “Lens mode” which is designed for finding necessary nodes in a big CHARM tree. Such a big CHARM tree is displayed in a small scale (Figure 3), and the Lens-mode shows a part of the tree with a readable scale.

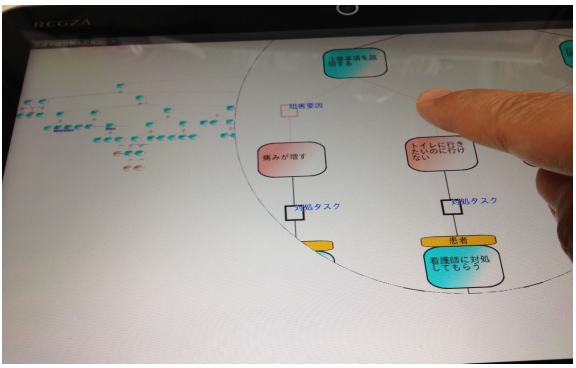

Fig. 3. Lens-mode of CHARM Pad

3.2 Application of CHARM to Nurses’ Education

The authors applied the CHARM modeling method to the manuals for nursing care to support training and education of the novice nurses in the real hospital. The authors have described CHARM models in the CHARM pad based on the nursing care manuals which are currently used in the ICU unit of the Nursing Department of Osaka Kouseinenkin Hospital, Osaka Prefecture, Japan, under the supervision of the trainers of nurses and professors from the Kobe City College of Nursing. The ICU unit of the hospital uses 30 materials including manuals and guidelines for the training [4].

Nursing care procedures are written in the new nursing staff training guidelines provided by the nursing department in Osaka Koseinenkin Hospital. These Guidelines cover a half of the technical items of the guideline, which targets all new nursing staff within the first year and provided by the Ministry of Health, Labor, and Welfare [5]. In other words, CHARM pertains to all new nursing staff and therefore the model can be potentially used in other hospitals. A total of 54 CHARMs were written with 4600

nodes. The modeling procedure took about 3.2 man-months. Validity of content was confirmed by the members of the Kobe City College of Nursing and nurse-educators of the ICU department who coauthored this CHARM. Guidelines outside of the scope of ICU training were also written in CHARM in case other departments decided to use this CHARM.

They use the manuals for 8 months training course for novices in which about 50 novice nurses participate every year. We developed 54 CHARMs which cover all of the training materials on the CHARM Pad. We handed the CHARM Pad for each of the participants of the training course for evaluation from June 4th, 2012 to February 1st, 2013. Before the training, they learn the care process at home with lecture materials and CHARMs.

Fig. 4. Use of CHARM Pad at Osaka Kouseinenkin Hospital

On the simulation training, the authors record their actions and set the recorded movie back on their own CHARM Pad. After the simulation training, participants compare their action to that of the trainer's on the CHARM Pad to review themselves (Figure.4).

4 Related Work

Research presented in this paper is compared with research pertaining to computer interpretable modeling of medical guidelines.

Boxwala et al. have proposed a model called GLIF that is used to standardize and share guideline models from different organization and different medical systems [6].

GLIF was used to model 12 different procedural guidelines, which included injections for influenza and examinations of lower back pain [6]. GLIF was also used in writing guidelines for nurses [7]. GLIF uses flowcharts to describe procedures. Nodes of flowcharts are defined into 5 types: Patient_State_Step, Action_Step, Decision_Step, Branch_Step, and Synchronyzation_Step. Patient State Step describes the state of a patient such as "in a state of suffering from a chronic cough" and “cough condition was cured.” Action Step describes a recommended action such as “get cough history,” which describes the obtaining of information from an electronic medical record, or “take an X-ray of the chest,” which describes action taken by a health care worker. Decision Step describes the process of deciding on treatment. As in Action Step, Decision Step nodes describe actions pertaining to systems such as “Is the pH of the esophagus above or below normal values?” and actions taken by health care workers such as “do you suspect that the cough is caused by gastroesophageal reflex disease?” Links for the Decision Step node branch into 2 or more directions, which differentiates this node from the Action Step node. Branch Step and Synchronization Step nodes show actions following in parallel. Branch Step is the origin of multiple parallel methods and Synchronization Step is the end point at which parallel methods reintegrate. The node structure of this flowchart clarifies, for the modeler, knowledge that needs to be extracted from guidelines.

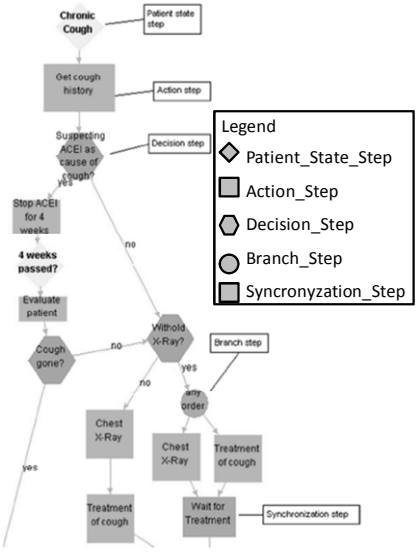

Fig. 5. Example by GLIF ([6]. Common examples were added by the authors)

Fig. 5 shows a flowchart for chronic cough treatment modeled using GLIF. The beginning of the flowchart shows the assumed patient state. GLIF uses UMLS, which is a system of medical term, in order to share information with other systems. Action Step describes the obtaining of cough history after a patient arrives at the hospital. The doctor determines if ACEI is the cause of the cough, and actions thereafter

branch off according to examination results. In this way, GLIF models procedural guidelines, and then it is computer interpretable.

CHARM as proposed by the authors focuses on modeling purposes of procedures. Models that focus on the flow of procedures, like GLIF, are useful for knowledge builder because he/she needs to understand only the flow of procedures. From the aspect of use in knowledge management and education, however, our model is more efficient. Externalizing the implicit knowledge of veteran staff members can increase the understanding of procedures, thereby facilitating guideline integration. Newcomers can also easily understand purposes behind procedures. These are the differences between GLIF and CHARM.

5 Concluding Remarks

Since several managers of hospitals and trainers of the nurses admit our idea, projects are running in 3 hospitals and one university. For now, CHARM Pad has been adopted in two hospitals for training nurses.

Fundamental research projects related to CHARM modeling are running in other two hospitals for management of clinical path and analysis of electronic health records. Furthermore, CHARM Pad is adopted for a lecture at Osaka University, Japan for education of fundamental nursing skill from the next April. The authors aim at wide range of the users from university students to the professional nurses.

References

1. Mizoguchi, R.: ”Ontology Engineering”, Ohmsha publishing (2005) (in Japanese) ISBN4-274-20017-5
2. Kitamura, Y., Mizoguchi, R.: Ontology-based description of functional design knowledge and its use in a functional way server. Expert Systems with Application 24(2), 153–166 (2003)
3. Kitamura, Y., Mizoguchi, R.: Organizing knowledge about functional decomposition. In: Proceedings of 14th International Conference on Engineering Design (2003)
4. Sasajima, M., Nishimura, S., Kitamura, Y., Hirao, A., Hattori, K., Tarumi, S., Takaoka, Y., Mizoguchi, R.: CHARM Pad: Ontology-based Software on Tablet PC for Learning Systematic Knowledge about Nursing. In: WHO 2012, Kobe, Japan (2012)
5. Technical items of the guideline for all new nursing staff within the first year by the Ministry of Health, Labor, and Welfare (2011), http://www.mhlw.go.jp/shingi/2009/12/dl/s1225-24a.pdf
6. Boxwala, A.A., Peleg, M., Tu, S., Ogunyemi, O., Zeng, Q.T., Wang, D., Patel, V.L., Greenes, R.A., Shortliffe, E.H.: GLIF3: a representation format for sharable computer-interpretable clinical practice guidelines. Journal of biomedical informatics 37, 147–161 (2004)
7. Peleg, M., Boxwala, A., Tu, S., Wang, D., Ogunyemi, O., Zeng, Q.: Guideline Interchange Format 3.5 Technical Specification, http://mis.hevra.haifa.ac.il/~morpeleg/Intermed/guidelines/GLIF_TECH_SPEC_May_4_2004.pdf