Knowledge Explication: Current situation and future prospects

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Abstract

Knowledge has power to improve human activities including industry and culture. Human workers acquire large amounts of knowledge from their experiences, but the knowledge is not systematized. Artificial intelligence (AI) cannot use this knowledge. Recent AI technologies such as machine learning and natural language processing support knowledge discovery, but they require big data. Knowledge engineering approaches such as interviews or protocol analysis are also useful to acquire knowledge from human workers, but such approaches are costly because many knowledge engineers must devote their efforts to each work site. Under those circumstances, we have proposed a new methodology to make knowledge, which is implicit in human workers, both explicit and systematized. We designate that methodology as knowledge explication. We applied the method to three service domains. Conclusions presented in this paper suggest future prospects for this research.

1 Introduction

Because of the progress of Japan's aging society, medical and long-term care costs are increasing ahead of the rest of the world. Discussion and activities are conducted to support elderly care services. The discussion and activities use technologies other than those of the elderly care field. As an example, a project exists to promote the development and introduction of robotic care devices to support elderly care services [1].

In general, sharing workers' knowledge supports business operations. This research specifically examines the sharing of procedural knowledge. The process here is a concept that includes actions necessary for businesses and the functions of tools to be used. We designate it as procedural knowledge.

Processes at an elderly care site are different from each other because of different skills of workers, states of elderly care receivers, and tools at care facilities. Furthermore, even for a single site, processes change, as do employees, elderly people, and the facility environment.

When care workers systematize such procedural knowledge and share it at the site, the systematized knowledge contribute to standardization of processes. Moreover, the systematized procedural knowledge is useful for care workers at new sites. It is also used as a checklist during care process execution. Then, care workers analyze records of care workers' processes appropriately with the systematized procedural knowledge. The analyses are useful to improve procedural knowledge.

Sharing such knowledge necessitates expression and systematization of the knowledge from workers, but expressing knowledge to and from workers is difficult because of the following features.

(1) Knowledge is accumulated by each care worker, but it has not become explicit.
(2) Because of variety, care workers cannot make global procedural knowledge.

For this study, we propose the methodology shown in Figure 1 for sharing procedural knowledge at elderly care sites. The emphasis of this proposed methodology is that workers describe site-specific procedural knowledge independently based on common procedural knowledge. It is meaningful for workers to play a central role. Therefore, we call it a worker-driven method aimed at achieving the following effects.

(1) By accepting stimulus of common procedural knowledge, workers can express and describe site-specific procedural knowledge that is accumulated among workers.
(2) Site-specific procedural knowledge can be described using a worker-driven method.

Such a methodology differs from conventional knowledge acquisition, such as interview and knowledge discovery from a large amount of data. In this study, this methodology is called knowledge explication. The methodology is not useful only for the elderly care domain, but for other human-centered industries such as education and R&D of autonomous vehicles.

[1] Robotic Care Devices Portal: http://robotcare.jp/?lang=en

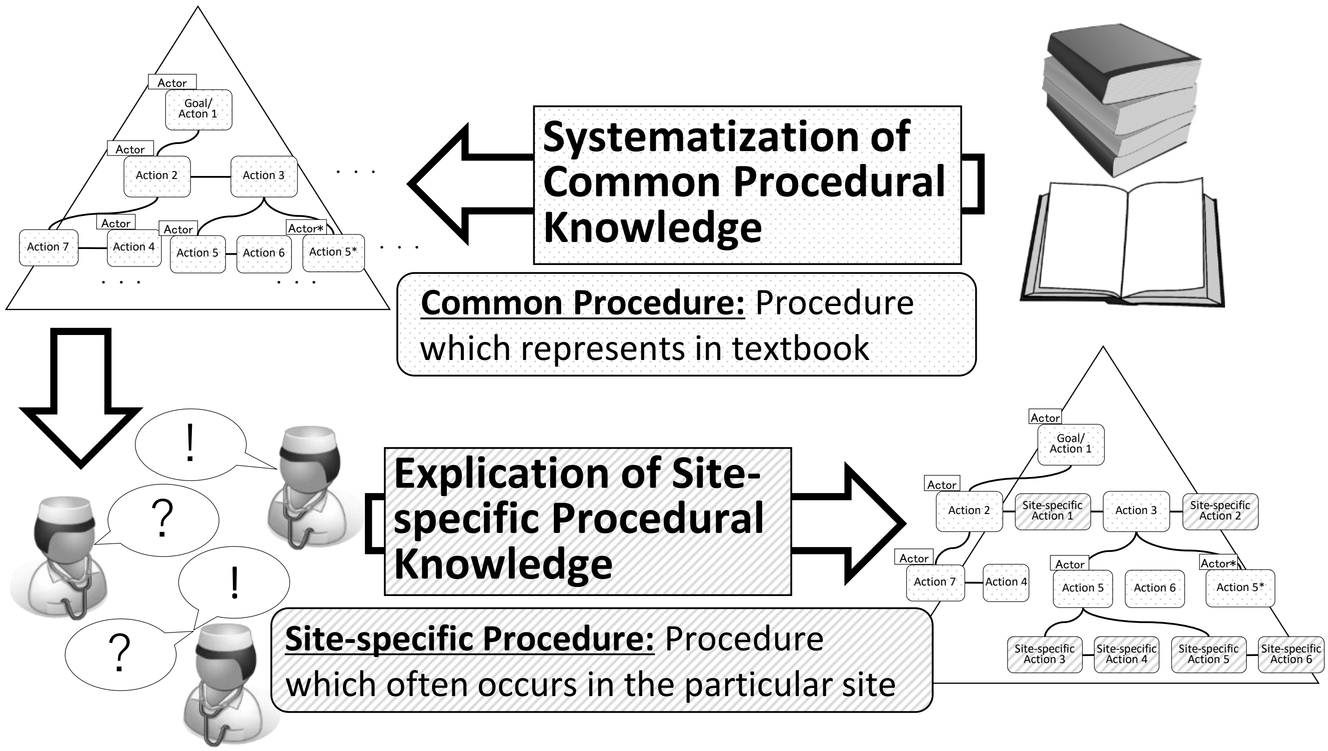

Figure 1. Overview of Knowledge Explication.

As described in this paper, we introduce the methodology and its application to elderly care services, education, and autonomous vehicles. We conclude with future prospects for related research areas of knowledge explication.

2 Related work

Some research has been conducted to share the knowledge. We classified the studies into two types. The first were conducted to elicit knowledge directly from domain experts, which has been developed in the knowledge engineering and knowledge management context. The second discovers knowledge from big data in a computational manner.

Research conducted by Schreiber et al. [2000] is classified into the first type. They provide methods to elicit knowledge from domain experts for expert systems, which imitates a domain expert based on a knowledge base. They enumerate methods to elicit the knowledge, such as interviewing, protocol analysis, laddering, and such methods involved in knowledge engineering. For example, during interviewing, the knowledge engineer generates questions and sometimes changes or generates new questions according to the expert's answers.

Gavrilova et al. classified related research from the perspective of knowledge management [Gavrilova 2012]. The classification is based on the key participant of knowledge elicitation. The first one is an "Analyst-leading" approach in which an analyst (similar to a knowledge engineer) plays an important role. The second one is an "Expert-leading" approach in which an expert plays an important role. The third one is "Expert–Analyst collaboration" in which both the analyst and expert mutually collaborate.

Especially in the medical informatics domain, as Peleg reported, computer-interpretable clinical guidelines (CIGs) have been developed [Peleg 2013]. Actually, CIGs are used as a knowledge base for clinical decision support systems (CDSSs), which support the daily work of medical doctor and co-medical staff. For example, CDSS produce an alert when the co-medical staff does not check the end of intravenous drip. CDSS might also provide the workflow according to the patient state. CIGs must have knowledge base to provide this information. Therefore, it is important to explicate the knowledge and know-how from the doctor and co-medical staff, but the explication method is not so new compared to a knowledge engineering approach.

Auer et al. provides DBpedia [2], which is structured knowledge developed in a computational manner [Auer, 2008]. They extracted the structure and the content from Wikipedia [3]. It is useful as corpus of natural language processing, as a linking hub among open datasets over the world, and for other purposes. The benefit of such an approach is its lower cost than a knowledge engineering approach. However, these approaches require big data or/and well-structured data such as Wikipedia. It is difficult to apply to work sites such as elderly care facilities.

On the other hand, the cognitive perspective is also related to this research because the knowledge of employees resulted from their cognition of the work-place. Lieto A. and Radicioni D. P. conducted Special Issue "From human to artificial cognition and back: New perspectives on cognitively inspired AI systems" [Lieto and Radicioni, 2016]. In the issue,

[2] DBpedia: http://wiki.dbpedia.org/
[3] Wikipedia: https://en.wikipedia.org/wiki/Main_Page

they provide cognitive approach to Artificial Intelligence which provide theoretical model from the perspective of Cognitive Science and use it explanatory from the perspective of Artificial Intelligence.

Bhatt et al., provides framework for the architectural designspace in [Bhatt et al., 2016]. They managed three different dimensions which are conception, computing and communication. Its focus is first class visuo-spatial objects of human who cognizes space of building. The framework has been used for pre-construction design post-occupancy analysis and education program. This framework is based on the research provided in 2014[Bhatt et al., 2014]. In the paper, Bhatt et al., provides a system for declarative narrativization of user experience in spatial design. We agree with their idea for human-centered design. It is important and necessary for human to represent the knowledge and/or data in understandable format. Our research focuses on more work-procedural knowledge rather than building design. Moreover, we focus on making knowledge explicit and systematized by employee themselves.

3 Knowledge Explication

3.1 Overview of Knowledge Explication

Figure 1 presents an overview of the proposed methodology: "Knowledge Explication." The procedural knowledge is produced according to the following steps. The first step is to systematize common procedural knowledge. The common procedural knowledge is knowledge that is included in textbooks and which is common among work sites in the same domain. The second step is to explicate site-specific procedural knowledge by workers themselves. Site-specific procedural knowledge is knowledge that often occurs at the site. The methodology costs less than a conventional knowledge engineering method. It also stimulates workers to explicate their knowledge, which has been accumulating through their experience. Therefore, this methodology can be useful in a domain that has little or no text data.

3.2 Systematization of common procedural knowledge

In the methodology, a worker who plays a knowledge builder role initially systematizes common procedural knowledge. For example, the knowledge builder extracts knowledge from a textbook or/and their common-sense knowledge. We do not care about the manner in which the knowledge is extracted. The knowledge builder can use a knowledge engineering approach and a knowledge discovery approach. In this step, the knowledge builder decomposes the knowledge to some parts and then links to others.

3.3 Explication of site-specific procedural knowledge

The next step is explication of site-specific procedural knowledge. Workers get together and discuss it based on the systematized common knowledge. The results of discussion are added to common knowledge. They become pieces of site-specific knowledge. We usually hold such group discussion as workshops. Furthermore, the knowledge builder systematizes the knowledge with pieces of site-specific knowledge. If the resulting knowledge is insufficient to represent the site's work process, then workers return to discuss it. When the knowledge is sufficient, the systematization result is useful as a manual for the work site.

4 Current application of Knowledge Explication

We applied the method to elderly care, education, and the autonomous vehicle domain.

4.1 Application to elderly care services

Application to elderly care services was done for two care facilities [Nishimura et al., 2017a]. The themes are prevention of pressure ulcers "which are injuries that break down the skin and underlying tissue [4]" and support of eating. Common procedural knowledge was extracted from textbooks. We confirmed the capability of explication of site-specific knowledge by care workers in the first theme. In the latter theme, we confirmed the capability of systematization of site-specific knowledge by care workers. The first case involved novice workers and veteran workers. Through discussion based on common knowledge and site-specific knowledge, the knowledge is transmitted from veterans to novices. After the third discussion, the procedural knowledge became sufficient for the facilities. The amount of the resulting knowledge is 1.8 times that of common knowledge.

4.2 Application to higher education

We also applied the methodology to higher education, specifically active learning classes at a university [Nishimura et al., 2017b]. In that case, we applied it for promotion of reflection by students. In the class, a teacher taught the Physiology of Kansei, which measures a customer's physiological feelings and needs for production improvement. The students also learned how to observe, think and present matters in their daily life. Reflection is important to memorize something and gain skills. The issue on the class is a lack of variety of reflection. For example, a student shares information about a restaurant. Information intrinsically related to the restaurant includes various information such as the table color, dish shape, food smell, background-music sound, and taste. However, the students merely share information related to the taste of food and also reflect the same information. It is good if the student can reflect deeper and deeper but the variety of information is also important. By virtue of the knowledge explication method, students can reflect on various information because the students can do reflection based on systematized knowledge, which helps students think about perspectives other than the intuitive one.

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[4] NHS choices, http://www.nhs.uk/conditions/Pressure-ulcers/Pages/Introduction.aspx

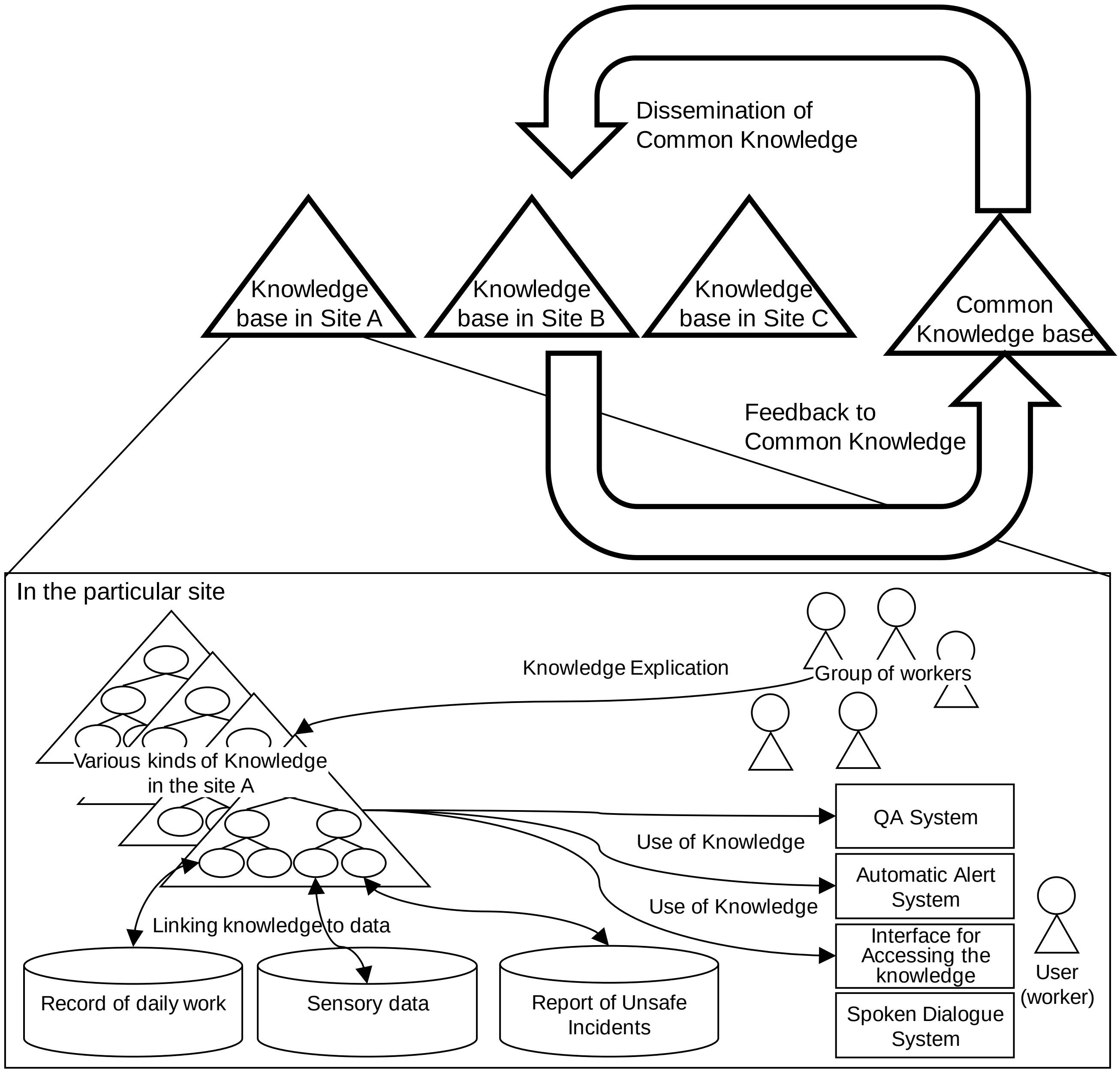

Figure 2: Future prospects of Knowledge Explication.

4.3 Application to autonomous driving

We also applied knowledge explication to the domain of autonomous driving [Nishimura et al., 2017c]. It is not an exact application, but we applied the first half step of it. For safe autonomous driving, the system must understand the law and actions according to the law. It is also important to share knowledge between the autonomous driving system and human beings. Sometimes the autonomous vehicle takes over the driving from a human driver. In such situations, the explanation by the autonomous vehicle system is helpful to understand the human driver situation. Therefore, explainable knowledge is important for an autonomous vehicle system. We applied the first half step of the knowledge explication method to achieve the goal. The driving actions are extracted from movies of unsafe incidents. We specifically examined incidents that occurred at an intersection where a vehicle almost collided with pedestrians. In all, 36 incidents were extracted. We analyzed the data manually. Consequently, we obtained systematized knowledge of the driving action, which is turning right.

5 Future prospects

Figure 2 presents future prospects of knowledge explication. We divide the prospects into two parts: knowledge circulation and knowledge use.

The first part is about the knowledge circulation in the upper side of Figure 2. The common knowledge base will be in public. Anyone can use the knowledge if they contribute to revise the common knowledge or to get feedback to common knowledge from site-specific knowledge. Once the common knowledge is disseminated to the respective work sites, the workers do knowledge explication. After building the site-specific knowledge, some of them get feedback to common knowledge base from their site-specific knowledge. Other work sites can use a revised version of common knowledge to their sites. Based on the feedback, users can compare knowledge among respective work sites. For example, a certain work site has 80% similarity of common knowledge, but the other 20% have unique knowledge of the work site. Therefore, a work site manager can understand which part of the knowledge is important or not. Comparing results is also useful for a worker who moves to other work sites. Circulation provides different parts of knowledge from knowledge of the prior work site.

The second part is about knowledge explication and use at each work site. As shown in section 3, the group of workers explicates and systematizes their knowledge with discussion. We will provide a support system for knowledge explication. Figure 3 portrays a screenshot of the support system which is under development. The systematized knowledge will be linked to various data such as record of daily work, sensory

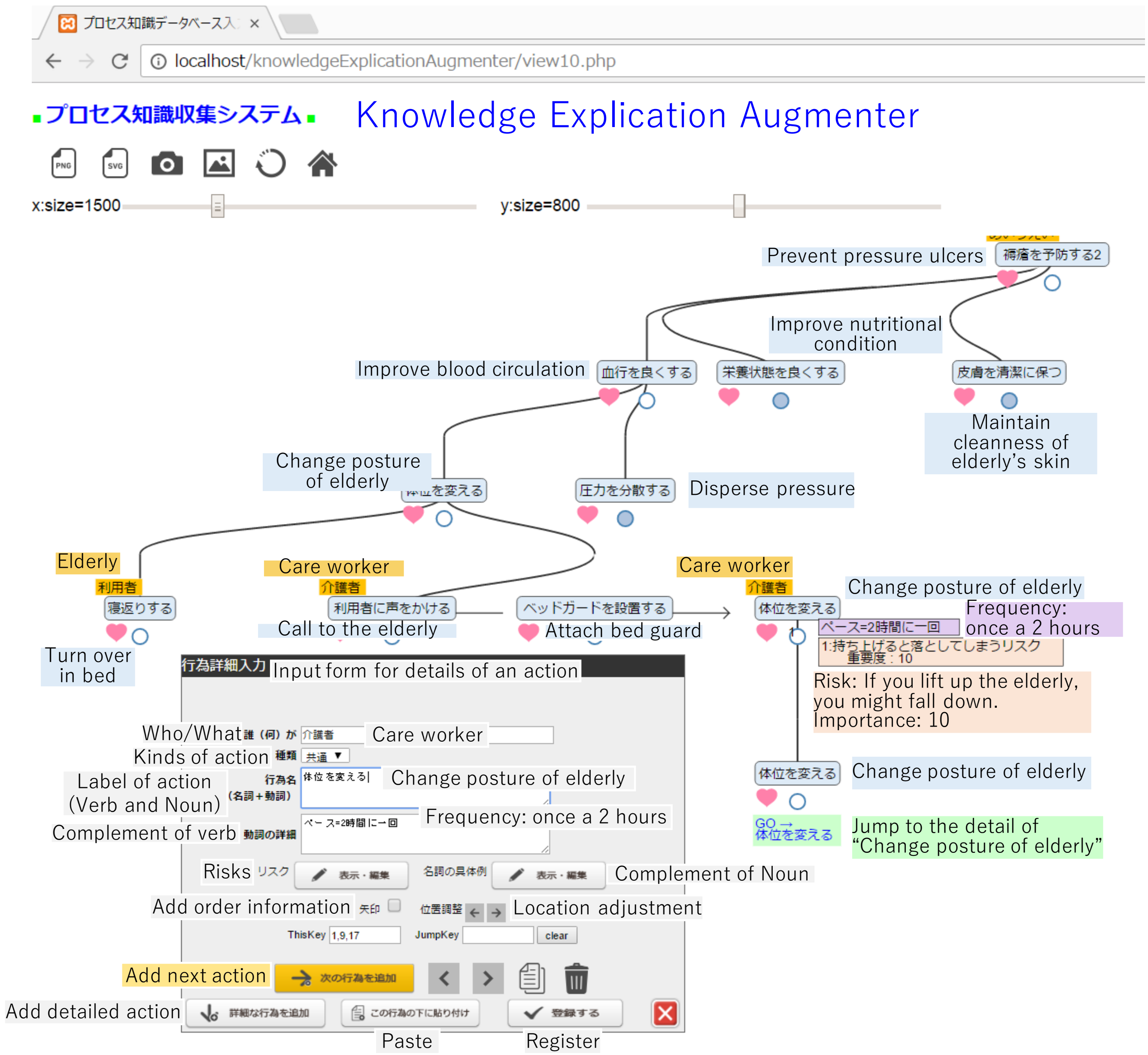

Figure 3: Screenshot of kNowledge eXplication augmenteR (kNeXaR).

data, and reports of unsafe incidents. Such data will be useful to support knowledge explication by presenting the data and to present it directly to workers with systematized knowledge. A machine learning approach will also be used. The systematized knowledge is useful as a label of data, so the amount of data required for machine learning will be small. In the use-phase, possible interfaces to retrieve the knowledge are the QA system, the spoken dialogue system, the automatic alert system, and some others.

We expect to apply this knowledge explication method to health promotion, training of music performance, and other industries for which knowledge is important.

6. Discussion

The role of artificial intelligence from the perspective of human-centered design is to support people's activities. As for “Artificial intelligence”, machine learning is currently in the spotlight. On the other hand, there is artificial intelligence research domain that qualitatively represents and uses human knowledge, such as expert system. This research is oriented toward the latter and focuses on representing the knowledge of human beings. It is also desirable that people who use something designed are involved in design process from the viewpoint of human-centered design. This idea comes from the idea of Participatory Design[Ehn 1991]. For instance, in the elderly care fields, it is the employees who know the care work well. If the employees are involved in the design process of what is used by themselves, participatory design contributes to making efficient tools. We can say that this research is to draw out the knowledge of employees with the above concept. We provided the methodology to explicitly design the business process that had been done implicitly so far.

7. Conclusion

7.1 Summary

We provide a method called knowledge explication to make knowledge explicit and systematized. The salient features of the method are the following.

(1) By accepting stimulus to common procedural knowledge, workers can express and describe site-specific procedural knowledge that is accumulated among workers.
(2) Site-specific procedural knowledge can be described using a worker-driven method.

We applied it to three domains: elderly care services, higher education, and autonomous driving. Based on the result, we present its future prospects.

7.2 Contributions

This research contributes to human-centered design from the perspective of human knowledge. The knowledge reflects human ideas. Therefore, it is useful for both AI and a human designer to consider the system from the human viewpoint.

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