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Author(s)	佐藤, 薫
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Situation Recognition from Behavior Logs in Caregiving Services

Kaoru Sato (1310026)
School of Information Science,
Japan Advanced Institute of Science and Technology
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In Japan, age-population ratio has been shifted to more elderly one, and the ratio of young people decreases rapidly in the population. In such aging society, while demands for caregiving services are increased, the number of employees who provide the services is insufficient. Thus, improvement of both efficiency and quality of the services are a critical issue for the society. Recently, use of ICT devices in caregiving fields is considered for supporting communication among care staffs, and some experiments show that this attempt improves their communication efficiency. Moreover, use of ICT devices brings another benefit that use logs of the devices are automatically collected into database. In the use logs, operation records of the services are included, and therefore, proper analysis of the use logs might help the care staffs to improve efficiency and quality of the services.

Previously, there are two studies that utilize the use logs for improving their operation efficiency. In the Nursing-care service space visualization and evaluation system, the use logs are used to visualize changes of operation areas of each care staffs by animation. This reproduction of the past operations is used during conferences for improving work operations. However, it takes quite a lot of time to manually find out information valuable for the improvement from the animation. Thus, applying some data mining techniques, so as to automatically extract the valuable information, may contribute to improving their user experience. As another study, on the other hand, an automatic information extraction technique is applied to the use logs. The study mainly focuses on individual behaviors of care staffs, and suspicious activities in these behaviors are extracted from the use logs by constructing a probabilistic model. This type of techniques that unusual events are extracted from a large amount of event logs is eagerly studied in the research field of Outlier Detection(OD).

One of the other related research fields in data mining is Situation Awareness (SA). According to Endsley, SA is a cognitive process, and defined by the following three levels: Perception, Comprehension, and Projection. In this paper, we focus on not only individual behaviors of each staffs but also the entire caregiving service space, and apply the concept of SA to analysis of the use logs. Therefore, operation situations as the entire service space are extracted from the use logs of ICT devices in caregiving services. We assume that the derived results are applied to an automatic extraction of anomaly situations. This OD technique might be used during conferences of the past work operations.

Field experiments were conducted in a nursing home for the purpose of evaluating communication effectiveness when Smart Voice Messaging System is introduced in the nursing home. In the experiments, 5 or 6 care staffs waring smart devices were working on the floors. As a result of the experiments, voice messages and location information are

collected and stored in a database. In this research, however, we just focus on location information of care staffs. Also, members of our research group observed features of 4 types of operation situations. This observation is used for the Post-processing stage of the proposed method.

As an operation situation recognition method, we proposed the method consisting of 5 stages though a general data mining technique consists of 3 stages. Those 5 stages of the proposed method are described as follows.

(1) Pre-processing 1

As the first step, distribution information of care staffs is extracted from the behavior logs, and represented by a vector format (we call this “Place vector”). To generate the place vector, we first divide the nursing facility into 10 areas. The 10 areas correspond to components of the place vector, and each component represents the number of care staffs staying in each area. If there are some staffs who are moving from one area to another area, the values of the moving staffs are added in half to the components of areas that the staffs leave from and go to. As the output of this stage, time series of place vectors is generated.

(2) Clustering 1

Once time series of place vectors is generated, all types place vectors are clustered into some classes based on their similarities. In this way, Hierarchical clustering as the clustering technique, and Ward method as the similarity metric are used. The clustering in this stage just focuses on distribution information of care staffs. We do not care about any temporal information at all.

(3) Pre-processing 2

In this stage, graphs are constructed from the derived clusters in the previous stage. The constructed graphs are intended to represent movement information of care staffs by connecting the derived clusters at successive timestamps. As a result of this stage, adjacency matrices of all generated graphs at all of time intervals are lined up on the time axis. The concept of the graph generation is comes from the research field of Graph similarity

(4) Clustering 2

A large part of this stage is the same as the second stage of this method. In this stage, all types of adjacency matrices are listed up from the time series, and clustered into some classes. Hierarchical clustering and Ward method are also used in this stage as used in the Clustering 1 stage. The number of clusters is decided based on analysis of the derived dendrogram.

(5) Post-processing

In the last stage of the proposed method, derived clusters in the fourth stage are mapped into operation situations appear in the caregiving service. The mapping is conducted by comparing features of derived clusters and operation situations. The mapping is conducted based on the analysis of time series and center vectors of derived clusters, and the analysis of observed features of 4 types of operation situations in the field experiments.

To evaluate the effectiveness of the proposed situation recognition method for real caregiving services, the proposed method is applied to the use logs obtained in the field experiments. By analyzing time series graphics of derived clusters in the first clustering stage and second clustering stage, we confirmed that the second clustering phase contributes to solving the problems occurred in the first clustering phase.

Two applications of the proposed operation situation recognition method are assumed. The first one is a human decision making support system. This system might substitute the perception and comprehension phases for the entire operation situation instead of human' s brain. By using the system, each care staff can be aware of the entire operation situation. Another one is for automatic extraction of anomaly situations. This application might be used during staff conferences reviewing the past work operations.