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Cloud-based Ontology Context Mining using Deep Learning in Healthcare

Ji-Won Baek, Kyungyong Chung, Jonghun Kim, Hoill Jung

Abstract ***With the development of information technologies, IT convergence technologies are being utilized in various fields. Human-oriented contents are continuously being developed to enjoy higher quality life through IT convergence technologies. Health care services resulting from the development of various smart IT devices in the health and medical field make more efficient health management possible for people. This study proposes a cloud-based ontology context mining method using deep-learning in health care. The user's static data and context data are saved in cloud, which is a high performance computing resource through ontology modeling and context mining is used to collect user health data with high similarity. The collected health data are applied to the algorithms and back propagation of artificial neural networks and deep-learning is conducted to provide more accurate health care prediction service. Furthermore, upon conducting a performance analysis to verify the validity of the learned user health data, it was found that the prediction accuracy that applied the proposed method was approximately 17% higher.***

Key words: Cloud Computing, Deep Learning, Healthcare, Ontology, Context Mining

I. INTRODUCTION

The rapid development of the IoT industry recently has promoted the application of medical data management and network systems in the health care industry. Among them, the medical industry is one of the fields in which the technologies are being applied in the fastest and largest scale [1]. Today's society is faced with the fourth industrial revolution due to the development of IT convergence technologies and entry into an information society. Humans have continuously developed research in the health and medical sector with the goal of living healthy lives and this has become more apparent through various health care services. Recently, hospitals have gone beyond the past patient information management system by using big data analysis technologies. Hospitals are now processing and analysing personal health records (PHR) based on IoT such as tablets and smart devices, thereby offering high quality treatment environments to patients [2]. As PHR include life information of individuals, data is continuously generated and when data is accumulated, issues arise in which there is lacking storage space or significant slowing of computing speeds. In order to address this issue, cloud computing is used to collect linear and nonlinear data in the server and then computes the similarity and adjacency between the mutual properties of objects to group them and provide integrated management [3-4]. By applying this, it is possible to provide advanced services such as potential health risk prediction service, solidification customized health improvement, preventive medical service for senior citizen welfare, early discovery of emergency patients, and to improve national health using a health platform that can collect, save and analyse massive amounts of medical big data. In addition, it is possible to improve medical service quality through user health status evaluation and risk prediction models through data mining and deep-learning in the cloud environment [5-7]. Therefore, this study proposes cloud-based ontology context mining using deep-learning in health care. It uses personalized data that integrates existing user health passive data and IoT-based user context data for ontology modeling and context mining to group users. Furthermore, deep-learning is conducted using the log data and health care data of grouped users. Back propagation of the neural network structure used in deep-learning is used to revise the weight and the accuracy of more precise predictions are computed. Moreover, performance assessment of F-Measure is conducted in the aspect of learning rate and accuracy to verify validity for the proposed method.

Composition of this study is as follows. Chapter 2 examines the context recognition ontology model and cloud computing and Chapter 3 describes the cloud-based ontology context mining method using deep-learning in healthcare. Chapter 4 conducts performance evaluations and Chapter 5 is the conclusion.

II. RELATED WORKS

2.1 Ontology Context Model

The ontology model is a tool that shows the concept and correlation. In particular, when expressing or explaining the daily life of humans, ontology is very efficient for digitalizing it or to show the data structure through computers. Figure 1 shows a healthcare-based ontology model for semantic network.

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Ji-Won Baek, Department of Computer Science, Kyonggi University, 154-42, Gwanggyosan-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16227, South Korea
Kyungyong Chung, Division of Computer Science and Engineering, Kyonggi University, 154-42, Gwanggyosan-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16227, South Korea
Jonghun Kim, Department of Software Convergence Engineering, Inha University, 100 Inha-ro, Michuhol-gu, Incheon 22212, South Korea
Hoill Jung, Department of Computer Software, Daelim University College, 29, Imgok-ro, Dongan-gu, Anyang-si Gyeonggi-do, 13916, South Korea. (correspond author)
*E-mail: hijung1982@gmail.com

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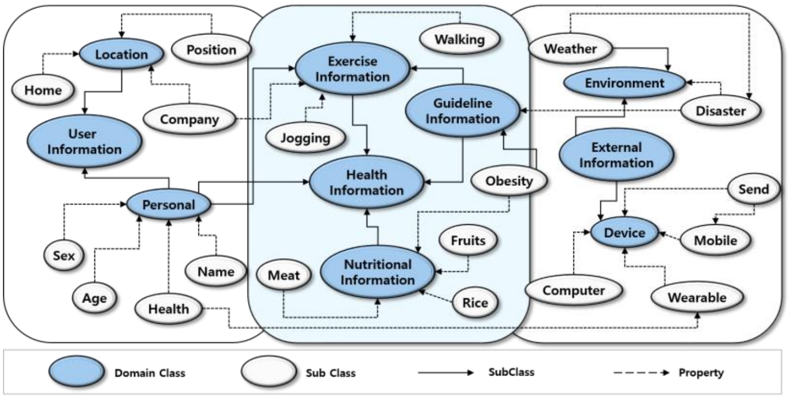

Fig 1. Health-based ontology model for semantic network.

Various recent context recognition studies commonly use ontology-based modeling methods and tools that support ontology are used to proclaim and express ontology language such as ontology web language, framework, etc. Ontology summarizes the concepts and relationships in biomedicine, bioinformatics, etc. and provides annotation information. It is also used frequently for sharing with human or computing agents. It also makes it possible to use domain knowledge or enables standardized analysis through a knowledge base using succession and knowledge binding or using computers. Ontology has become a core technology for context recognition modeling with the advent of semantic webs [7-8].

2.2 PHR based Cloud Computing Model

Cloud computing is a computing system that uses the backbone server to use services related to the storage of data and intelligent information systems [9-11]. This study collects dissimilar big data from various contact points and use high-performance cloud computing in which processing and analysis is possible. Nonlinear and linear data are integrated and processed from the collected medical big data, which are stored in cloud for managing the medical information. Efficiency for data search and management can be enhanced by grouping and it is possible to configure systems accessible by different hospitals through cloud computing. Also, efficient medical information management that overcomes existing weaknesses is available during data transfer and various emergencies at the hospital. Figure 2 shows a PHR based cloud computing model.

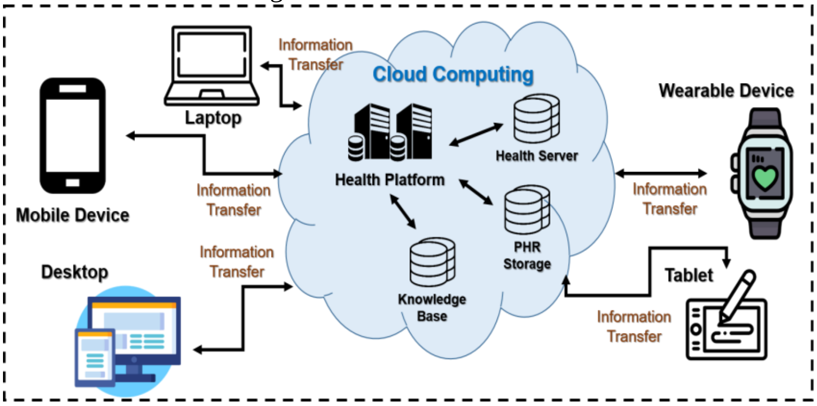

Fig 2. PHR based Cloud Computing Model.

III. CLOUD BASED ONTOLOGY CONTEXT MINING USING DEEP LEARNING IN HEALTHCARE

3.1 Cloud based Ontology Context

There can be various users, places, devices and services in the context information collection environment and service components must be able to exchange context information through the same semantic understanding. Context information modeling is necessary to use data categorized as context information. Context information uses the user as ontology to model as internal, external and service context information [12-13]. Furthermore, in order to enhance the modelled context information inference performance, physical dissimilar devices are integrated into a single virtual storage with software that offers virtualization functions. In the proposed method, the user enters and collects medical information in the cloud context model environment. Information integrated within the ontology context information storage performs similarity groups between users for more efficient services [14]. User groups used in cloud computing are grouped using the entropy weighting K-means algorithm as shown in Figure 3.

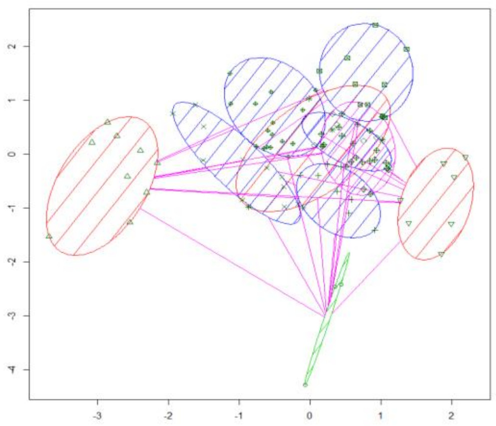

Figure 3 Entropy Weighting K-means Algorithm-based User Groups

The Entropy Weighting K-Means algorithm [10] measures the similarity of the mean values of the data and cluster and then groups data taking into consideration the entropy weight in the K-Means algorithm, which is a method for reassigning users in appropriate clusters [11-14]. At this time, the mean value uses the average value for the data vector of the cluster and using such algorithm, the grouped user information is encrypted to provide advanced services. This group's data in a physically limited storage space to process more information for more efficient management.

3.2 Cloud based Ontology Context Mining using Deep Learning

Deep-learning is a form that is more developed from the neural network model and it is a structure in which the hidden layers of the artificial neural network comprised of hierarchies are comprised of multiple stages [15-17]. The proposed model of deep-learning increment in the number of weights connecting nodes when there are more hierarchies. Therefore, when the number of nodes used in this hierarchy grows, it results in higher frequency for revising weights, therefore making it possible to draw up more precise results.

User context data saved in cloud shows groups with higher user similarity. The user context data can express each individual data as a vector, which is a sequential pair of numbers, and using the numerical relationship of two vectors, it is possible to find its semantic relationship. Artificial Neural Network (ANN), which imitates the human brain, can be applied in this vectoring work [17]. Cloud-based ontology context mining data digitizes its similarity relations through grouping per user, and it can thus be applied in the artificial neural network. Therefore, back propagation algorithms of artificial neural networks are applied to the cloud-based ontology context mining group data for deep-learning. Figure 4 shows the structure of cloud-based ontology context mining using deep learning.

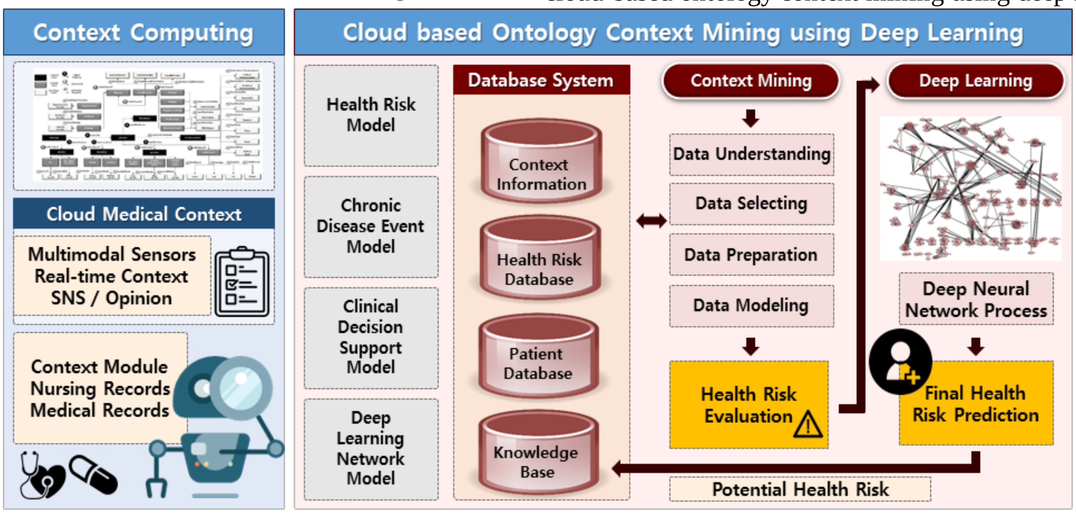

Figure 4 Structure of Cloud-based Ontology Context Mining using Deep learning

IV. PERFORMANCE EVALUATION

4.1. Context Recognition Model Environment

IoT is a spatial connection network between objects with intelligent relations that can send and receive information through sensor networks via mutual cooperation between things in an environment separated as humans, things and services. IoT-based context recognition technologies are used to collect context data according to the user's contexts for health care services. It collects user-environment information using IoT-based context recognition for ontology modeling [7]. Context recognition includes location information, sensing information, health data and PHR information using mobile devices or wearable devices for healthcare services of users. Weather is the biggest factor among the environment as external elements in IoT-based context recognition. Thus, through XML questions of RSS provided by the Meteorological Administration [18], user IoT-based GPS location information is applied to the context recognition model. Furthermore, temperature, humidity and illumination information are also applied according to the user's internal information based on IoT. Figure 5 shows the context recognition model environment.

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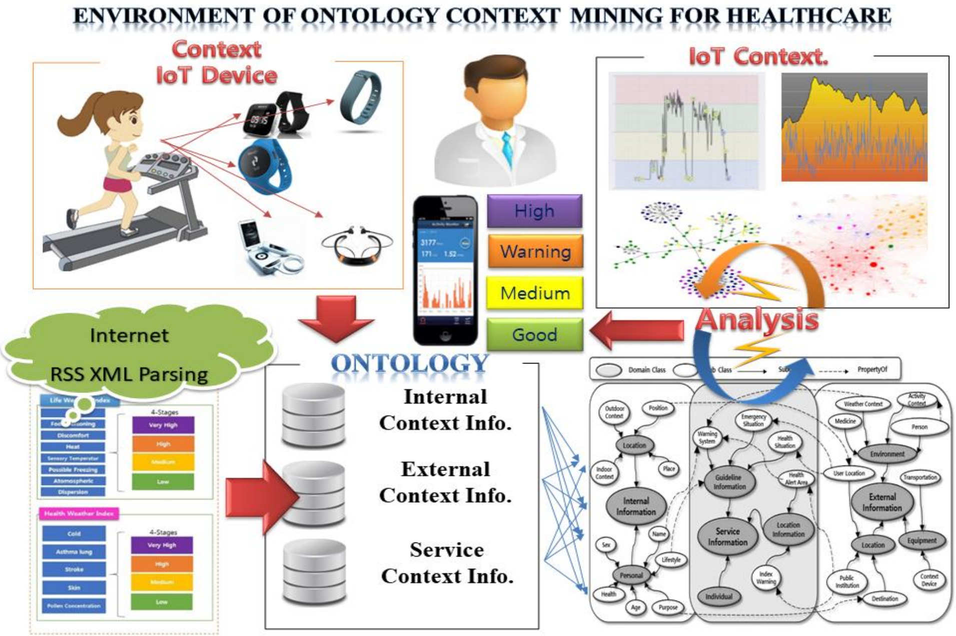

Figure 5 Context Recognition Model Environment

The IoT-based context information inferred from the collected data uses ontology [7-8] for modeling, which is a preceding study, to provide health care services to users. Ontology makes up the user-oriented internal, external and service classes and expresses the hierarchical relationship between classes in OWL format.

4.2. Performance Evaluation

The following experiments are conducted to assess the performance of the proposed method. The test data used are 23,125 records of web cloud context log data acquired over approximately three months from 139 users through IoT devices and 4,659 static records, which are the raw data from the national health and nutrition survey [19]. Performance evaluation first uses context information according to users and health care raw data records for deep-learning and evaluates performance according to learning rates. Second, the accuracy of predictions of use and non-use of the proposed method is assessed. Back propagation performance for computation in cloud-based ontology context mining using deep-learning showed difference in performance based on composition of learning rate. Therefore, before evaluating the accuracy of the prediction value, performance of back propagation according to learning rate is evaluated first to make it possible for more accurate predictions. Figure 6 shows the performance evaluation results of the deep neural network.

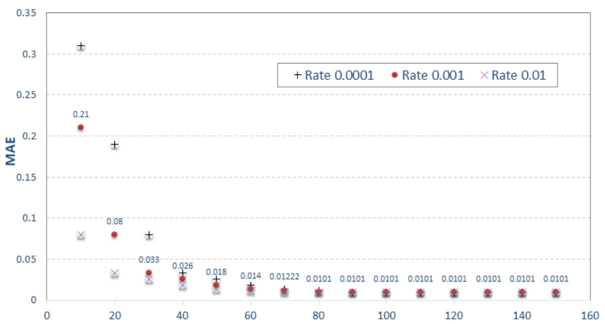

Figure 6 Performance Evaluation Results according to Learning Rates

Evaluations showed that learning rates from 0.001 to 90 or more learning times were the most effective. In order to verify accuracy according to whether or not cloud-based ontology context mining (CbOCM) using deep-learning proposed in the second test were applied, accuracy, recall ratio, and F-measure were compared and assessed [20-24]. After fixing the predicted risk rate for measurements, the inferred value for each inputted question and the value that should actually be inferred are compared and F-measure analysis [7, 23-24] is carried out. Figure 7 shows the results of F-measure according to the number of group.

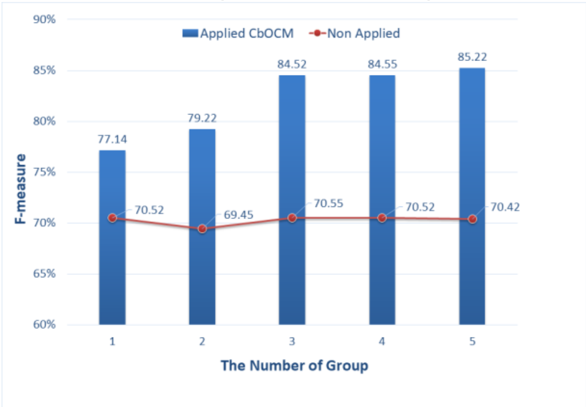

Figure 7 Results of F-Measure according to the Number of Group

V. CONCLUSION

This study proposed a cloud-based ontology context mining method using deep-learning in health care. The proposed method uses IoT devices to utilize user context information that can be acquired in everyday life and comprised the ontology. In addition, it was modeled to allow user-oriented services according to the location and environment of users that

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could impact health care. This uses cloud-based ontology context mining methods through medical big data groups and categorization for efficient management of static data and context data. The user's context data is managed as a knowledge base through ontology modeling and entropy weighting K-means algorithm is used for prediction and services according to user personalized information to categorize user context information into groups with high similarity. The categorized user group data apply back propagation algorithms of the artificial neural network through similarity computation between users and conducts deep-learning for more precise predictions and its validity was verified through performance assessment.

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