

An Ontology-Based Content Provision System to Advance Child Obesity Management Platforms

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Abstract

The 2014 National Health and Nutrition Survey of Korea reported that child/teenager obesity rates are 11.5% in 6-18 year olds, 5.9% in 6-11 year olds, and 15.5% in 12-18 year olds. Child obesity is a disease caused by changes in social environment structure and may become a chronic disease that leads to adult obesity; thus, prevention and management are becoming increasingly critical. Education and policies for obesity prevention are in place in Korea, but their effects are limited and temporary because no personalized education is provided. Therefore, this study proposes a service using data to set up obesity-related guidelines by using an ontology-based JENA engine to provide content tailored for child obesity. The goal of this study is to aid in obesity prevention and management by providing customized obesity-related content as contextual information for obese children and teenagers through ontology-based guidelines.

Keywords: Child obesity, ontology modeling, awareness model, mobile platform

1. Introduction

Child obesity has recently been emerging as a major social issue. Major causes of child obesity that have been highlighted include the increase in high-fat and high-calorie diets due to wealthier lifestyles changing culture following the development of social economy, insufficient exercise caused by use of automobiles and electronic media, and lack of management of children due to increased numbers of nuclear and double-income families [1-2]. These causes drive the current trend of increasing child obesity.

The child obesity rate is growing annually, and its growth is expected to be sustained [3]. Additionally, the 6th Period, 2nd Year National Health and Nutrition Survey of Korea (2014) reports that child/teenager obesity rates are 11.5% in 6-18 year olds, 5.9% in 6-11 year olds, and 15.5% in 12-18 year olds. The child/teenager obesity rate is higher in girls than in boys. The survey also reports that male teenagers have a higher obesity rate than male children, while no difference was found between female children and female teenagers [4].

Obesity, emerging as a serious health issue for children, is reported to result in various complications including cardiovascular abnormalities in children as well as to lead to adult obesity that causes major chronic diseases and a higher rate of death [1,5]. Also, during the school age, a process is needed that forms appropriate body image to establish a positive personality and self-awareness, adaptive behavior, and correct sociality. However, obese children are more dissatisfied with their figures than children of normal weight. These dissatisfactory figures may cause psycho-social issues such as loss of self-esteem and depression and are highly likely to lead to inferiority and loneliness complexes and other psychogenic mental disorders [6].

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Many issues have also been identified in Korea while preventive education policies and programs for obese children are conducted. Education in Korean schools focuses on college entrance and does not properly train or teach skills for healthy lives, including obesity prevention. As most obese child management programs focus on elementary schools, highly obese children only participate voluntarily due to low self-esteem, so that the program effects are limited and temporary [10].

Mobile healthcare services are currently available in Korea and overseas. The 'Health On' service provided by SKT in the Korean market offers health care with input diet and exercise information as well as health-related programs [7]. 'Let's Move!' is another service offered in the United States to manage child obesity. 'Let's Move!' provides beneficial information for parents to help their children consume healthy food and establishes an environment to select healthy foods while supporting and recommending healthy foods to be supplied in school [8-9]. An additional mobile service for child obesity management has been developed for Korea and is the subject of this study. The service manages child health and obesity with 5 types of information entered on the screen regarding children's meals, exercise, mood, sleep and others. This service provides content related to children's health and obesity. This study presents the application of ontology to content provision to advance this service.

This study includes research using context-based ontology for this application. Furthermore, it proposes a system that delivers tailored content to provide adequate information to obese children in each case. The proposed ontology model in this study is designed to provide tailored content with consideration for children's diet, behavioral habits and physical information for accuracy and to benefit obese children. Guidelines are constructed based on context for obese children with this model, and the study proposes the service up to the inference stage.

This study comprises the following: Chapter 2 describes related research; Chapter 3 defines the system architecture and ontology model; and Chapter 4 describes a guideline inference model based on context to offer suggestions for future studies.

2. Related Research

2.1 Guidelines for Child Obesity

Obesity has recently been highlighted as a social issue due to better quality of life and the westernization of most children's/teenagers' diet. Obesity refers a state in which there is more fat tissue than normal due to accumulation of excessive fat. Obesity is recognized as a risk factor for various diseases such as diabetes and hypertension as well as for earlier death and also as a health risk factor resulting in serious health issues in modern society and simultaneously influencing an individual's behavior patterns and psychology. Obesity during the child/teenage period when most physical growth occurs is reported to lead to adult obesity about 80% of the time [8].

If a child/teenager's body mass index (BMI, kg/m^2) was in the 85-94th percentile for his/her height and age, he or she was classified into the overweight group as a subject for tracking and monitoring. If the BMI was 95 percentile or 25 kg/m^2 more, the child or teenager was classified into the obese group. The degree of obesity [Obesity Degree(%) = (Actual Body Weight - Standard Body Weight of the Height) / Standard Body Weight of the Height \times 100] was calculated for each gender, age and height based on the 50th weight percentile as the corresponding standard weight. Degrees of obesity of 20% or higher were defined as Obesity while 20-29% were classified as Mild Obesity, 30-49% were classified as Moderate Obesity and 50% or higher as Extreme Obesity [15]. According to the child obesity guidelines provided by U.S. CDC, BMI within the 5-84th percentile is classified as Normal, BMI within the 85-94th percentile is classified as Overweight, BMI within the 95-98th percentile is classified as Obesity, and BMI at the

99th percentile or higher is classified as Extreme Obesity [16]. This study proposes a service providing tailored obesity content for children.

2.2 The Context-Aware Model

Context-aware computing is defined as “technology that produces information on context in reality in a virtual space by connecting the reality and the virtual space and provides user-centric intelligent services by using the information” [11]. Based on this technology, context awareness and contextual characteristics were deduced, and learning, reasoning, and other intelligent techniques are applied for a human-centric autonomous service.

Active research on the context-aware field includes research on recommendations using service ontology-based context-aware modeling. A data acquisition module based on the OSGi framework was built to establish a heterogeneous device and an ontology-based context information model was developed [12]. Research was carried out to propose a tailored exercise prescription service model based on context awareness for effective exercise prescriptions. This is the proposal of a tailored service made through reasoning by using users’ static context information and dynamic context information entered using various measurement instruments [20].

As above, major global research in the context-aware field has focused on development of a core engine followed by development of devices and services applying the core engine [13].

2.3. Ontology

Ontology can be defined as “the formal specification of a shared concept”. The term ontology defines relations between terms [14]. In ontology, words related to a certain domain are expressed in levels as enabling a web-based knowledge process or sharing and reusing knowledge between programs.

OWL and other languages have been developed for computers to process this ontology. OWL is a RDF-based meaning-centric language designed to express and directly process information in the form of ontology [14].

In this study, context information was defined using OWL and an obesity management service tailored for children through rule reasoning using a JENA engine was proposed.

3. Mobile Service for Child Obesity Management

3.1. Mobile Platform for Child Obesity Management

Child obesity and health issues are becoming more serious. Lifestyle and health management with BT-IT fusion technology is required while the access to and the use of such technology must be convenient for children’s health improvement and management. Therefore, a child obesity management service has been developed aiming to develop obesity-related data measurement and analysis technologies based on BT-IT fusion technologies with consideration for user convenience.

After analyzing the user’s lifestyle and psychological state by using a BT-IT fusion technology-based emotion modeling service, a remote diagnosis and wearable bio recognition modeling technology, input and a UI/UX service with consideration for user convenience were ultimately provided. This study is expected to help resolve issues of child/teenager obesity, to save medical costs and to improve national health.

The current child obesity management service operated by a general hospital located in Seoul comprises platforms for diagnosis, treatment and management of child/teenager obesity as in Figure 1. This service manages children’s obesity through cooperation among the child/teenage patient, the patient’s guardian and a group of experts including a doctor, dietitian, sport therapist and coordinator.

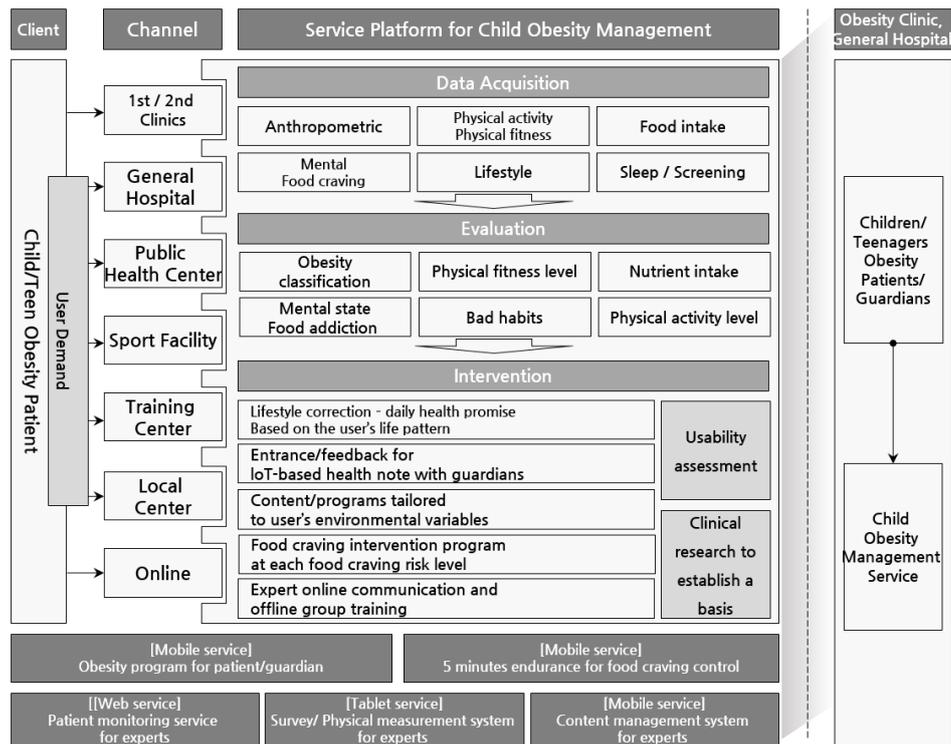


Figure 1. Mobile Platform Architecture for Child Obesity Management

The service includes processes to enter meals, activity and other information for a child through the mobile application and to manage the child's status by experts through the web. This service platform for child obesity management manages obesity through intervention at each stage of a child's obesity in conjunction with the obesity clinic of the university hospital.

3.2 Ontology System Architecture

The existing mobile service for child obesity is depicted as a case model in Figure 2 below. After a user signs in and answers the questionnaire, the content recommendation process begins by analyzing the data acquired from the questionnaire and the health notes entered by the user when he/she joins the service

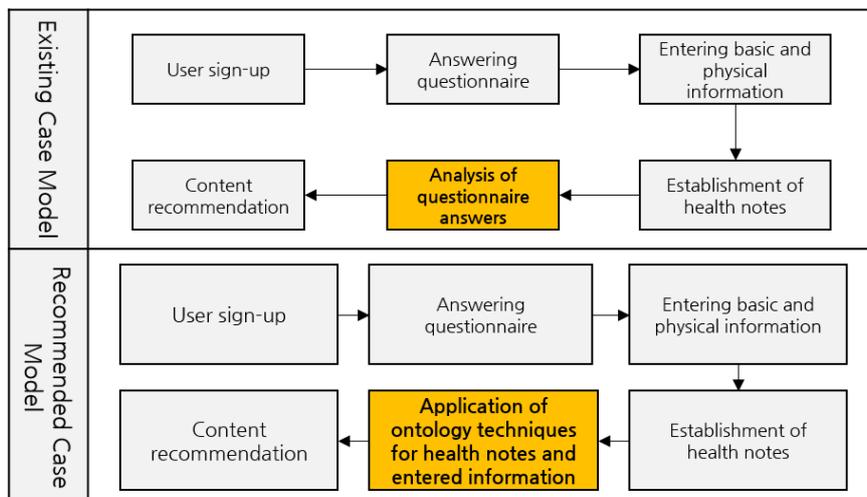


Figure 2. Mobile Service Process for Child Obesity Management

To detect context and provide a suitable service, the system should be able to process any change in context in real time. Context-aware modeling technique, context management and context reasoning are required to allow this [16]. The system architecture proposed by this study is shown in Figure 3. After context and activity data on the child are collected, the context-aware engine converts the information collected by the local context monitor into forms allowing for reasoning and sends the converted information to the context-aware interface. This context-aware interface then processes reasoning for the context information.

The local context monitor receives context data through “context and user activity data” and converts the received data into the OWL format. The context reasoner receives data from the LCM and processes reasoning, referencing context ontology. Reasoning is processed through guidelines after creating SPARQL queries to process within ontology. The child’s obesity guidelines are determined depending on the results of reasoning. The activity reasoner then processes reasoning for the service according to the service rules after creating SPARQL queries by referencing the context ontology model. A content recommendation service tailored for the child obesity patient is offered based on the reasoning results.

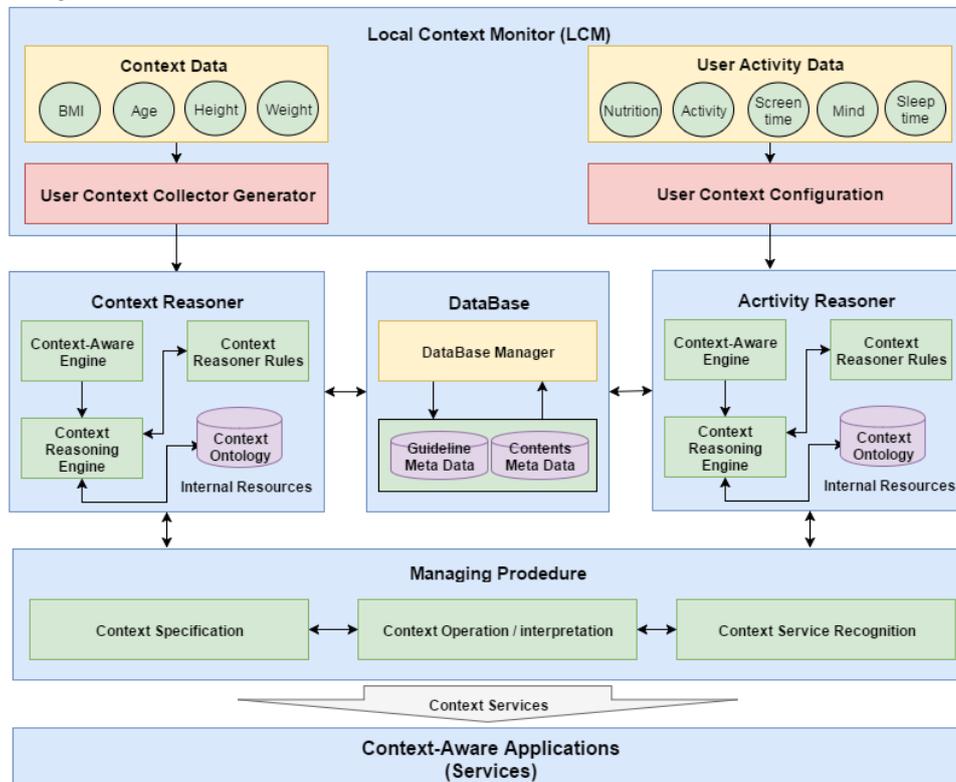


Figure 3. Ontology-Based System Architecture

3.3. Ontology Model

Context-aware modeling is required to use the data classified as context data to recommend personalized content. The ontology may express the knowledge possessed by a human as information shared between human and computer or between computers. The knowledge possessed by a human is expressed in forms that can be processed and understood by computers. Spatial context information and device context information created from common context information are processed into the ontology model to use for the personalized recommendation service [11]. The ontology model proposed by this study to provide ontology-based tailored contents to obese children is depicted in Figure 4.

3.3.1 Guideline Ontology Model

Figure 5 displays the guideline ontology model. The model's main classes are guideline, content and context. Each main class has subdomain classes as in the defined relationships. The health data class, a subclass of the context class, has 4 data types in total that include the child's physical information. Each result value has a data type to be constructed as context data. The medical class measures the child's obesity degree based on the height, weight, BMI and age of the child acquired from the health data class. The guideline class produces guidelines for each child's obesity degree determined through that child's context data. The appropriate guidelines for the child's context are determined through the medical class.

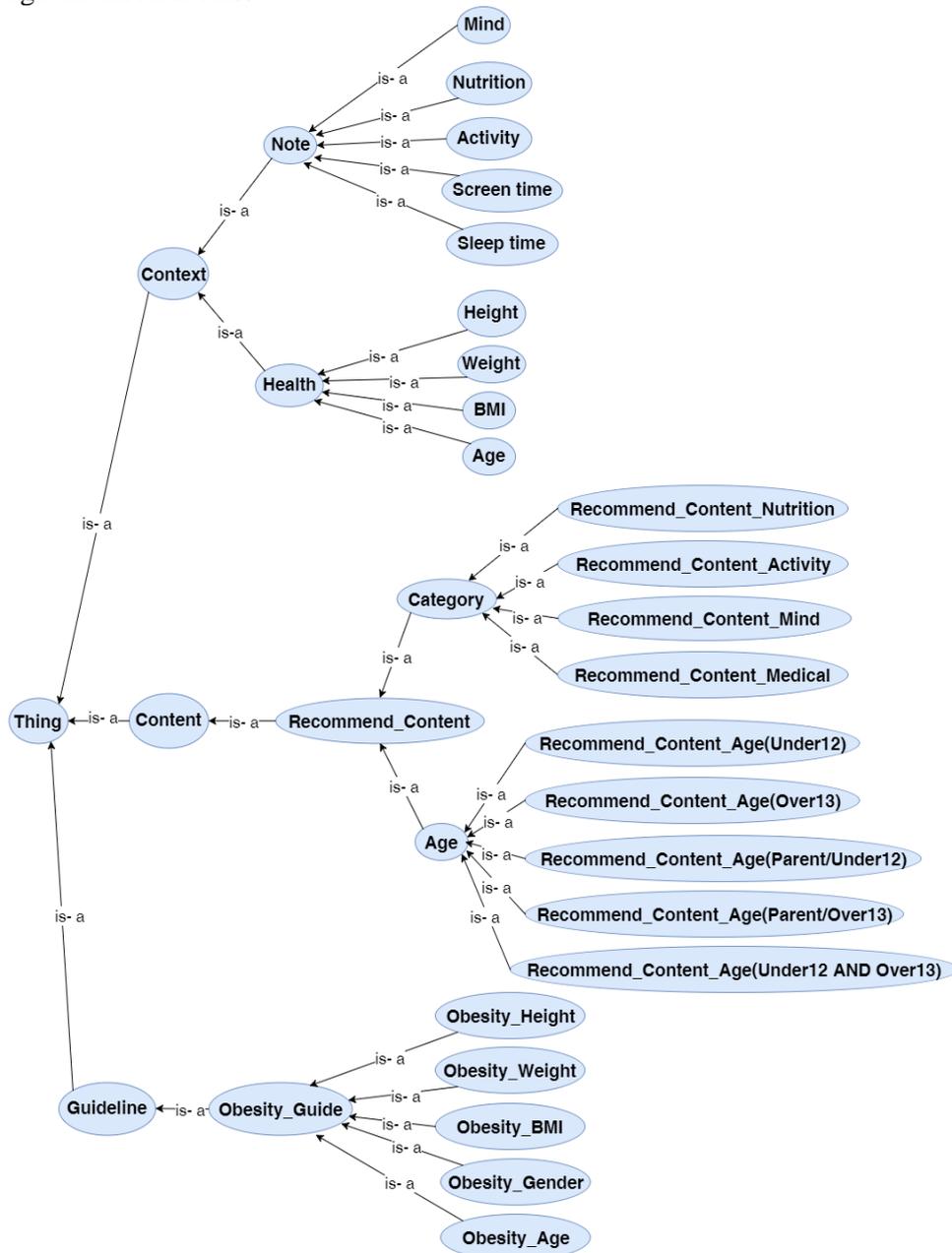


Figure 4. Ontology Model

3.3.2 Service Ontology Model

After the guidelines for a child are determined by guideline ontology, service based on the child's context data and guidelines should be provided. Figure 6 shows the ontology model defining the context information for the service. Provision of the service is determined by identifying risk factors according to the child's context data received from the health data class. If service is to be provided, it follows the guidelines for the child's obesity. The subclasses of the user note class are mental state, activity, sleep time, nutrition and screen time, and they support service management by allowing a child to enter his/her mental state, activity, sleep time, nutrition and screen time. Personalized content for each child is recommended based on the child's obesity according to the child's context data while management is provided following the child obesity guidelines.

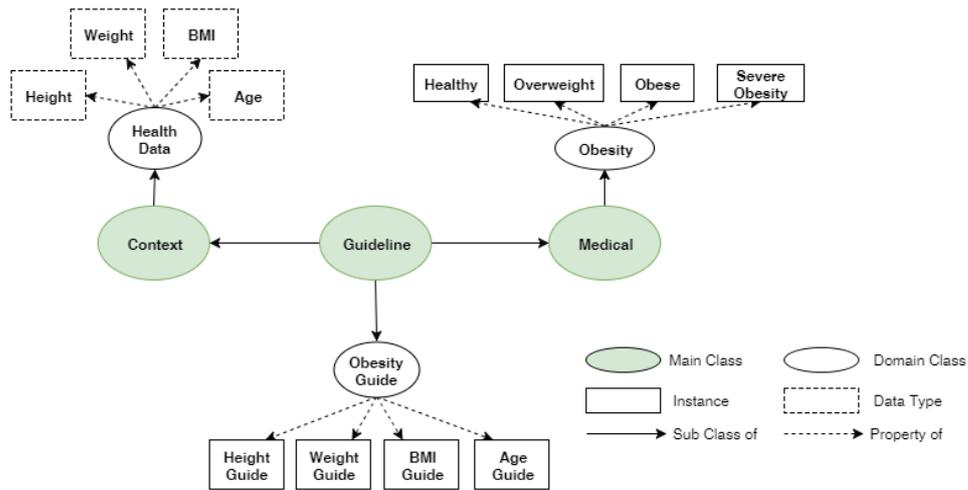


Figure 5. Guideline Ontology Model

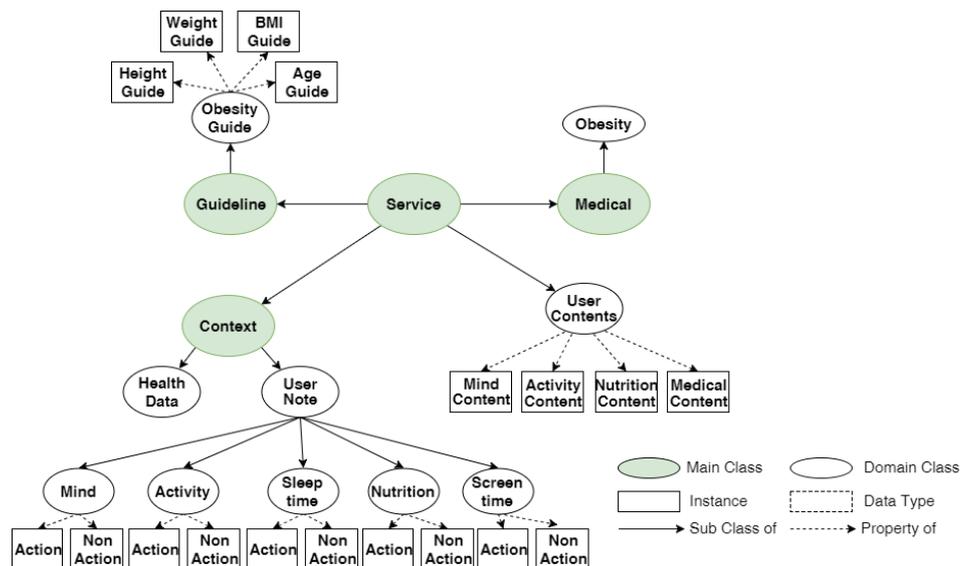


Figure 6. Service Ontology Model

4. Results

The results of the ontology model proposed by this study were determined as follows: Protégé was adapted as a system model to use OWL [18]. The Jena reasoning engine was used for guidelines and service reasoning. Reasoning through rules was done after creating SPARQL queries [19].

4.1. Obese Child Context-Based Guideline Reasoning

Table 1 shows SPARQL queries for reasoning the guidelines personalized through the context data and the guideline ontology for each child's context information. Reasoning for the guidelines was according to Jena rules after creating SPARQL queries with the entered context data converted to OWL.

Table 1. Queries for Guideline Reasoning

SPARQL Queries
SELECT ?Customer ?Property ?Guideline WHERE ?Customer hasRecommend ?Guideline. ?Customer ?Property ?Guideline
Jena Rules
[GuidelineRule: (?Customer hasObeisty ?Obesity) \cap (?Obesity hasGuideline ?Guideline) \cap (?Customer hasBMI ?BMI) \cap (?BMI hasGuideline ?Guideline) \cap -> (Customer hasRecommend ?Guideline)]

4.2. Guideline-Based Service Reasoning

Table 2 shows SPARQL queries and Jena rules for reasoning to develop the personalized content recommendation service for a child through the guidelines and the service ontology. After the determination of guidelines for the child, SPARQL queries were created again following the context data and reasoning was according to the rules to provide tailored content based on the determined guidelines.

Table 2. Queries for Service Reasoning

SPARQL Queries
SELECT ?Customer ?Property ?Service WHERE ?Customer hasRecommend ?Service ?Customer ?Property ?Service
Jena Rules
[ServiceRule: (?Customer hasObesity ?Obesity) \cap (?Obesity hasService ?Service) \cap (?Customer hasObesity ?BMI) \cap (?BMI hasService ?Service) \cap (?Customer hasUserNote ?UserNote) \cap (?UserNote hasService ?Service) \cap -> (?Customer hasRecommend ?Service)]

5. Conclusion

Obesity is now confirmed to be a very critical disease not only for adults, but for children as well. Various programs are offered to set criteria to classify child obesity and to cure the disease; however, services to manage child obesity are still insufficient.

The authors have developed a mobile platform for child obesity management and used ontology as the research proposal method to advance the platform. A previously used method for content provision was redesigned based on ontology and proposed for this purpose.

This study presents an ontology model for such a content provision system through context data of child obesity patients and data entered through the mobile service. The model provides content based on guidelines tailored for the content provision service through physical information and basic and activity data entered by the child obesity patient. The method using ontology can be used more effectively than existing methods using surveys since the mobile service adequately provides the necessary content to patients.

The proposed ontology technique is not limited only to use in content provision, but was determined to have extensive usability in various fields. Moreover, since the ontology model was specifically designed for child obesity, the guidelines are different from those for adult obesity, and the model is considered to have high value.

Finally, if the ontology technique proposed by this study is applied to all areas of service related to child obesity, the quality of this service can be expected to improve. Research that directly applies the ontology technique to a mobile service for child obesity management to improve usability is planned for the future. This ontology-based content provision system is proposed to help manage child obesity, which is emerging as a social issue.

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References

- [1] S. H. Yoon, H. J. Kim and K. W. Oh, "Prevalence of Obesity among Children and Adolescent in Korea", Korea Centers For Disease Control & Prevention, vol. 8, (2015), pp. 1050-1059.
- [2] "The Ministry of Health and Welfare", <http://health.mw.go.kr/>.
- [3] S. J. Yang, S. H. Jang and S. J. Kim, "Physical Activities and Health Belief of Elementary School Students for Obesity Prevention and Management among Elementary School Students", Korea Society of public Health Nursing, vol. 26, no 2, (2012), pp. 227-238.
- [4] B. G. Yang, "Korea Health Statistics 2014", Korea Centers For Disease Control & Prevention, (2014), pp. 1-470.
- [5] "Korea Medical Association", <http://www.kma.org/>
- [6] E. G. Shim and Y. K. Yang, "4th-grade elementary-school children's body image and dietary habits according to body mass index", Journal of Nutrition and Health, vol. 47, no. 4, (2014), pp. 287-299.
- [7] "Health On", <http://www.health-on.co.kr/>
- [8] H. Yoo, "A study on the prevention of childhood obesity - focusing on the physical education at school", Korean Journal of Sports Science, vol. 20, no. 1, (2011), pp. 273-283.
- [9] "Let's Move!", <http://www.letsmove.gov/>
- [10] E. Y. Noh and S. J. Eun, "The policy support plans of obesity prevention and management for childhood and adolescent", The Seoul Institute, (2013), pp. 1-185.
- [11] "Context-Aware Computing", Telecommunications Technology Association.
- [12] J. K. Ryu, K. Y. Chung, J. H. Kim, K. W. Rim and J. H. Lee, "Recommendation using Service Ontology based Context Awareness Modeling", Journal of the Korea Contents Association, vol. 11, no. 2, (2011), pp. 22-30.
- [13] B. M. Lee, Y. H. Lee, K. M. Yu, J. Y. Park and U. G. Kang, "Ontology-based Customized Health Management Service for Metabolic Syndrome Patients", Journal of the Korea Society of Computer and Information, vol. 17, no. 1, (2012), pp. 41-52.

- [14] O. H. Kweon, J. S. Park and K. H. Yeom, "An Approach to Selecting Ontology Model for Inferring Situation-Awareness Services in Mobile Environments", *Journal of KISS: Software and Applications*, vol. 39, no. 8, (2012), pp. 646-654.
- [15] M. K. Kim, W. Y. Lee, J. H. Kang, J. H. Kang, B. T. Kim, S. M. Kim, E. M. Kim, S. H. Suh, H. J. Shin, K. R. Lee, K. Y. Lee, S. Y. Lee, S. Y. Lee, S. K. Lee, C. B. Lee, S. C. Chung, I. K. Jeong, K. Y. Hur, S. S. Kim and J. T. Woo, "Clinical Practice Guidelines for Overweight and Obesity in Korea", *The Korean Journal of Obesity*, vol. 2, no. 4, (2014), pp. 217-221.
- [16] "Centers for Disease Control and Prevention", <http://www.cdc.gov/>
- [17] J. H. Kim, M. G. Hwang and H. M. Jung, "Context Information Modeling Method based on Ontology", *Journal of Digital Contents Society*, vol. 12, no. 4, (2011), pp. 437-447.
- [18] "Protégé", <http://protege.stanford.edu/>
- [19] "Apache Jena – Home", <https://jena.apache.org/>
- [20] B. M. Lee, J. K. Kim, J. H. Kim, Y. H. Lee and U. G. Kang, "A Customized Exercise Service Model based on the Context-Awareness in u-Health Service", *Journal of Korean Institute of Information Technology*, vol. 9, no. 2, (2011), pp. 141-152.

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