Ontology Model for Dietary of Children with Autism Spectrum Disorders

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***Abstract*—Autism is a developmental disorder involving communication, social interaction and imagination activities. One of the therapies used to reduce autism in children is diet therapy. Dietary therapies require special knowledge for parents of children with autism in order to know which foods and drinks are recommended or avoided. Therefore, in this study, the authors intend to build a food and drinks ontology for dieters in autism sufferers based on semantic web technology that using protege. The ontology built contains 50 foods and drinks for three types of autism diet therapy. Ontology testing uses SPARQL query to get answers from the questions asked. The results of the built ontology model can be used as a knowledge base on foods and drinks to facilitate autistic dieters in choosing a diet that fits the type of diet.**

***Index Terms*—Autism; Diet; Ontology; Semantic Web.**

I. INTRODUCTION

Autism is a developmental disorder involving communication, social interaction and imagination activities. Children with autism generally experience disorders of play patterns, sensory disorders, behavior and emotions [1]. Autism can occur in all children from different social and cultural levels. Data from UNESCO in 2011 mentioned that recorded 35 million people with autism worldwide. This means an average of 6 out of 1,000 people in the world suffers from autism. In Indonesia, it is not certain exactly how many autistic children in Indonesia, but the government released data on the number of children with autism can be in the range of 112 thousand inhabitants [2].

Symptoms of autism vary, so it takes some type of therapy to handle it. One of them is with diet therapy [3]. Diet can't be done by eliminating certain foods and drinks just like that, should be added food and other drink that are allowed as a substitute for the child's nutritional needs remain met. There are three kinds of popular diet therapy for children with autism that are gluten-free and casein diet, Feingold and failsafe diet, and diet specific carbohydrate [4]. After a diet, the development of children monitored whether or not there are improvement and reaction changes that arise. When the child gets food and drink is seen the increase in autism behavior then allegedly children suffer from allergies to food and drink [5].

To be able to know what foods and drinks that should be avoided and substitute special knowledge needed so that parents of autistic children easily in running diet therapy. One way to represent a knowledge domain can use ontology. Ontology is a representation of terms used to describe and represent a domain of knowledge [6]. Ontology in the food and drink domain for autistic child dieticians will help parents to do diet therapy for children with autism well.

Based on the above explanation, in this study will be done ontology development of food and drink for dieters in children with autism. Ontology to be built can provide information to parents about foods and drinks to avoid and substitutes based on the type of diet therapy run by the child. This ontology model can then be accessed using SPARQL queries to search for parent-required information.

II. LITERATURE STUDY

This section consists of four parts. The first section discusses diet therapy for children with autism. The second part deals with ontology. The third section deals with SPARQL which is the query language for ontology model testing. Finally the fourth section on the related research discussed in this study.

A. Diet for Children with Autism Spectrum Disorder

Diet has a meaning as a regulation of the pattern and the consumption of food and drink that are limited in number to a certain amount for the purpose of treatment of illness or health. For people with autism, there are three types of diets that are applied are gluten and casein-free diet, Feingold and failsafe diet, and specific carbohydrate diet. The effects of each of these diet therapies can be different for different children. A diet therapy may be useful for a child with autism but is not beneficial to other children [7].

Gluten and casein-free diet is avoidance of food and drink containing gluten and casein. Gluten is a protein compound in some foods such as wheat while casein is a protein compound in milk. Feingold Diet and Failsafe Diet is avoidance of artificial food additives (dyes and preservatives), salicylates, and flavor enhancers. Initially, this diet is intended for hyperactive children, but when people with autism follow this diet turned out to produce improved conditions better. Specific Carbohydrate Diet is a diet that limits carbohydrates that are consumed only from monosaccharide types. This diet aims to control the growth of excessive or unbalanced microbes in the gut, avoidance of carbohydrate-containing foods [8].

B. Ontology

In informatics, an ontology is a dictionary of terms in canonical syntax with generally accepted definitions designed to produce lexical or taxonomic frameworks in knowledge representations that can be shared by different information systems communities [9].

The ontology model has five components: class, relation, formal axiom and instance [6]. An ontology can be characterized as:

$$O = (C, R, I, A)$$

where C is a set of class representations we want for the purpose of thinking within a domain. Classes can represent abstract concepts (intentions, feelings, etc.) or specific concepts (people, computers, etc.).

R is a set of relations connecting the class. Relationships represent a type or association between concepts within a domain. The first argument is known as the domain of the relation and the second argument is the range.

I is a set of instances, where each instance can be a derivative of one or more classes and can be linked to an instance and through relation. The Instance is used to represent elements or individuals in an ontology.

A is a set of axioms. Formal axioms are useful for modeling the correct sentences. Axioms are used to represent knowledge that is not formally defined by other components.

Ontology is an important element in semantic web implementation. With the ontology the meaning can be created into the data representation. In the semantic web architecture, these data will be stored in RDF (Resource Description Framework) format. Then the semantic context is built in OWL (Web Ontology Language) format [10].

C. SPARQL

SPARQL is an RDF query language, it can be used to query a lot of RDF data. A query language is required to refer to information from a semantic web application. SPARQL Protocol and RDF Query Language is a protocol and query language for semantic web resources [11].

To obtain information from an RDF graph a query is required. SPARQL is a query language that can be used to access data on the semantic web [12]. Results from SPARQL queries can return values in several data formats, among others: XML, JSON, RDF, and HTML. The sample SPARQL that can be used is shown in Figure 1.

```
PREFIX foaf:   <http://xmlns.com/foaf/0.1/>
SELECT ?name ?address
WHERE {
   ?person foaf: page ?address
   ?person foaf: page ?name
   }
```

Figure 1: The Example of SPARQL

D. Related Work

Research on autism has been developed before. Chakkrit Snae and Michael Brucks [13] developed a healthy food recommendation system for dieters and non-diets for restaurant or hospital-based patient Ontology Web Language - Description Logics (OWL-DL). Ontology was built by taking data from interviews of several nutritionists and observation of eateries in the city of Bangkok. This system helps in recommending food and snacks that match the nutritional profile of the customer.

Another study was conducted by Michelle Ann Suarez and Kristin Maria Crinnion [14] to find out foods that can be used for the autistic child's diet and compare compositions with children who do not have autism. This study took primary data in the form of the direct survey of parents who have children with Autism to collect information on food selection. The results of this study indicate that children with autism who have fewer foods (less than 20 vegetables and fruits) in the diet process have a percentage of empty calories more, which will disrupt their health later. This study also contains recommended food information for autistic patients, thus helping the first treatment for people with new autism.

Another study was conducted by Mugzach et all [15] who built an ontology on autism spectrum disorder (ASD). This study updates the autism ontology that has been built before by adding 443 classes and 632 rules that represent phenotypes, synonyms, environmental risk factors and frequency of comorbidities. This ontology can be used as a knowledge base that contains knowledge about autism.

III. METHODOLOGY

The research methodology consists of several steps: Data collection, Ontology Building and Evaluation. Figure 2 shows the research methodology applied in this study.

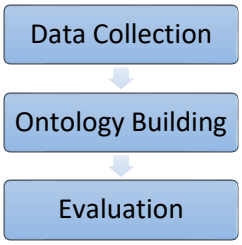

Figure 2: The Methodology of Research

A. Data Collection

In this step, the authors collected data from various sources, namely Autism and Diet book [8] and Alergon Diet Autism website [16]. The data collected includes foods and drinks that can be consumed by children with autism, foods and drinks that should not be consumed by children with autism, types of food and drink, food and drink sources, and types of diets for children with autism.

B. Ontology Building

In this step, the authors build an ontology of the knowledge collected using the Protégé 4.3 tools. Several stages are used in ontology development [17].

a) Determine the scope of ontology
b) Consider the use of an existing ontology
c) Determine and define key terms in ontology
d) Defines the class and hierarchical structure of the class
e) Defines a property or slot
f) Define the facet in the slot
g) Create an instance

C. Evaluation

The purpose of this stage is to ensure the ontology model built into this research is correct. Evaluation of results will be done by looking at the relevance between search queries that use SPARQL with search results against ontology models built. Here are some questions that will be tested on the ontology model.

a) Show all the food!
b) Show all diets and explanations
c) What kind of food X should not be eaten by dieter Y?
d) What kind of Diet X should not eat anything?
e) What kind of Food with X source that can be eaten by dieter Y?
f) What kind of foods X may eat by dieter Y?

g) Show all drinks!
h) Show all drinks that X dieters cannot drink!

IV. Result and Discussion

A. Data Collection

Ontology development is done by using data and knowledge taken from various sources. The data collected a total of 50 foods and drink recommended and not recommended for people with autism. Each food and drink data has a component name, description, type of food and source. In addition, the data collected also contains three types of autism diet associated with foods and drinks consumed by people with autism.

B. Ontology Building

The ontology model in this study has several classes, including classes Food, Drink, and Diet. The explanation of each class on the ontology model in this study as follows:

1. Food Class - Food is a material derived from animals or plants that are eaten by living things to get nutrition and energy. In general, in the construction of this ontology, Food is divided into foods that can be consumed and foods that should not be consumed. The food class has a property data relation in the form of food, source and type names. Example instances of this class are apples, spinach, wheat, corn, and yogurt.
2. Drink Class - The drink class is a class that describes drinks that can be consumed and can't be consumed by people with autism. The drink class has a property data relation in the form of the name of the drink, the source, and the type. Example instances of this class are cow's milk, water, and apple juice.
3. Diet Class - The Diet Class describes a class that describes the various types of diets that autism sufferers can do. On the ontology built this autism diet is divided into three kinds, namely Gluten and Casein Free, Feingold and Failsafe, and specific carbohydrate. The food class has a data relation property of nama_diet and description. Instances of this class are specific_carbohydrate, gluten_and_casein_free and Feingold and failsafe.

To enrich the information in this ontology, we add some relation or property ie object property that connects between classes or between instances. The data property that connects the instance with the data. For detail properties in the ontology model are shown in Table 1.

After the ontology model is built, the next process is to add an instance. The instance is a member created from a class or subclass. Examples of instances that have been added are gandum_hitam instance is a member of the Food class, which has the object property relation not Allowed and the data property name, type, and source as shown in Figure 3.

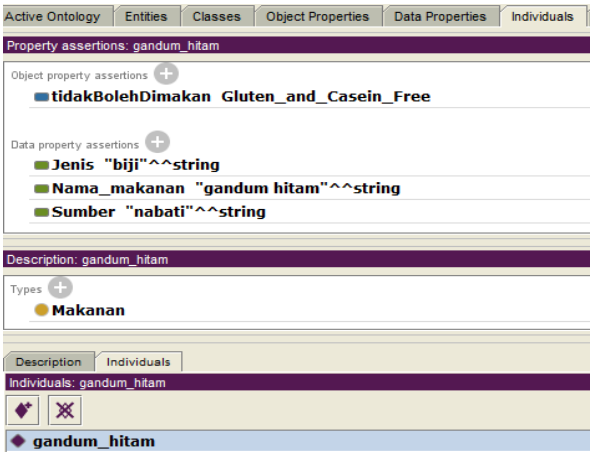

Figure 3: The Example of Instance in Ontology

Table 1
Property List in the Ontology

No	Property	Tipe Property	Domain	Range
1	may_be_eaten	object property	Food	Diet
2	may_be_drunk	object property	Food	Diet
3	may_eat	object property	Diet	Food
4	may_drink	object property	Diet	Drink
5	not may be eaten	object property	Food	Diet
6	not may be drunk	object property	Drink	Diet
7	not may eat	object property	Diet	Food
8	not may drink	object property	Diet	Drink
9	diet_name	data property	Diet	String
10	Description	data property	Diet	String
11	food_name	data property	Food	String
12	drink_name	data property	Drink	String
13	type	data property	Food, Drink	String
14	source	data property	Food, Drink	String

C. Evaluation

After implementation ontology and addition of instances in each class, the next stage is the evaluation of ontology knowledge already built. This test is done by giving some questions using SPARQL query. The example of a question tested using the SPARQL query as shown in Figure 4. Question: What foods should not be consumed by specific carbohydrate dieters?

Query SPARQL:

```
  PREFIX                                          diet:
<http://www.semanticweb.org/dietautism/ontologies
/2016/11/diet-autism#>
  SELECT ?Nama_makanan ?Nama_diet
  WHERE {
  ?Makanan diet:Nama_makanan ?Nama_makanan .
  ?Makanan diet:tidakBolehDimakan ?Diet .
  ?Diet diet:Nama_diet ?Nama_diet .
  ?Diet      diet:Nama_diet      "Diet      spesifik
karbohidrat"^^xsd:string
        }
```

Figure 4: The Example of Evaluation with Query SPARQL

The Result:

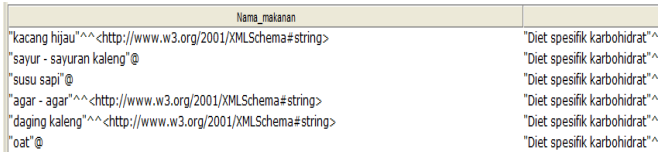

Figure 5: The Evaluation Result with Query SPARQL

The result of a SPARQL query has a string data type indicated by description after the name of the food and the name of the diet is displayed. Then all questions used for ontology model evaluation can be seen in Table 2. The X and Y marks on the question can be filled with certain data, such as "Gandum", "Susu kedelai", "Gluten and Casein Free" and the others. If the question is answered correctly then the correct answer will be added in the answer column, but if the question is answered wrong it will be added the wrong description.

Table 2
The Evaluation Result Ontology with SPARQL Query

No	Question	Answer
1	Show all the food!	true
2	Show all diets and explanations!	true
3	What kind of food X should not be eaten by dieter Y?	true
4	What kind of Diet X should not eat anything?	true
5	What kind of Food with X source that can be eaten by dieter Y?	true
6	What kind of foods X may eat by dieter Y?	true
7	Show all drinks!	true
8	Show all drinks that X dieters cannot drink!	true

V. CONCLUSION

Food and drink information for autism dieters can be represented in an ontology-based knowledge model. The ontology built contains 50 foods and drinks that can be consumed and can't be consumed and contains three types of autism diets. Food and drinks data consists of name, description, type and source data. While, diet data consists of data of diet name and description. The results of ontology model testing using SPARQL query generate answers to all questions posed correctly. So from the test results, ontology model built on this research can be used as a knowledge base on food and drinks to facilitate the autism dieters in selecting a diet that suits the type of diet.

Suggestions for further research is to add the amount of food and drinks data so that complete information in the ontology model. As well as expanding the properties used in ontology, so that more and more conditions become a reference in providing food and drinks recommendations for the user. Furthermore, ontology model can be developed as the knowledge base of Semantic Search application to facilitate information searching on food and drink domain for the autism patient.

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