ONTOLOGY-BASED DECISION SUPPORT SYSTEM FOR HYPERSENSITIVITY DISORDER ALLERGY

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ABSTRACT. *In general, the use of ontologies has become popular in many fields. The purpose of this study is to make people be more aware and concerned about their own allergies described in an application that can help to determine an allergy based on the health conditions of the carrier. As we know, the health problem is a complicated matter as a result of various environmental problems that are natural or not. Therefore, it is important to understand the concepts of health and illness, which can be divided as general or unavoidable diseases and others are allergic. Therefore, this research wants to develop a decision support system for hypersensitivity disorder allergy data searching using the ontology method. The Protégé tools are used to collect the data based on an ontology method. The ontology is applied to the system to helping the user find the allergy more quickly without having to consult their problem with the doctor. In this study, the system model gained from the ontology method is shown in the implementation by using an example.*
Keywords: Allergy, Ontology, Protégé, SPARQL, Expert system

1. **Introduction.** Allergy is a change of body reaction against germs. This phenomenon usually occurs when a person makes contact with certain substances that do not cause any reaction in others. That substance is called an *allergen*. Allergens are compounds that can induce immunoglobulin E (IgE). Hypersensitivity disorder is an allergy symptom, and when a person experiences excessive sensitivity to a certain chemical, it causes certain effects on the human body. This can cause changes in the conditions of the outer human body, such as skin, breath, and eyes [1]. In some studies ontology is used as the methodology to solve the problem, such as [2] showing an advancement in the research of diabetes diagnosis CBR by proposing a novel case-base fuzzy Ontology Web Language 2 (OWL). OWL 2 is the current standard web ontology language to represent fuzzy ontologies. This ontology can be considered as the first fuzzy case-base ontology in the medical domain. It is based on a case-base fuzzy Extended Entity Relation (EER) data model. The other paper is to integrate ontologies from food, health, and nutrition domains to help the personalized information systems to retrieve food and health recommendations based on the user's fitness conditions and food preferences [3]. One paper proposes research based on multiple ontologies to make information retrieval efficient by using the ontology method [4]. The last paper, based on the fuzzy ontology in supply partner matching research, was to find the right supplier in their supply chain network by using a matching system, which was based on fuzzy ontology to identify potential suppliers or partners and to pick

a partner or a supplier that had the biggest potential level of all [5]. The other paper describes a knowledge system for improving RFID recognition by using fuzzy ontology, too [6]. While other previous research is about allergies in general, this study argues about a treatment for people who are allergic to peanuts, which is Nambudripad's Allergy Elimination Techniques (NAET). NAET is a treatment for peanut allergy sufferers, combining traditional Chinese medicine with other nutrients. Treatment begins by giving acupuncture to the spine and surrounding muscles. After using NAET treatment, it was evident that the patient no longer suffered peanut allergic reactions, even after being given peanut concentrate [7]. As we know, the Semantic Web has in common with regular websites, which both implement the use of hypertext-based systems. Semantic Web intends to form a distributed knowledge-based system. The main focus of the Semantic Web itself is to share data, not the documents [8].

The purpose of this study is that the system model based on the ontology methodology lets people be more aware and concerned about their own allergies, which can help users search allergy data in the application. Section 2 addresses background of this research. Section 3 proposes the design and the implementation of the ontology. Section 4 implements the proposed model and the results. Section 5 describes conclusion and future research.

2. **Problem Statement and Solution Procedure.** The allergy data used in this research are used as a base for developing an ontology system for searching allergy data. Ontology consists of basic terms, the relationship between those terms, and rules that incorporate them. This can become knowledge that can be shared and used in multiple applications. Therefore, ontology can be a specification of a concept, which aims to facilitate knowledge sharing [9]. Ontology represents the real world in a more structured and systematic way. Ontology provides a reference model for ontology domains. A reference model is a set of terms that can be used to simplify communication among domain experts and to improve the understanding and knowledge sharing. The main components of ontology are Individuals, Class, Attributes, and Relationship [10,11].

The reason for using this method is because it is the most suitable way to perform data groupings and interclass entity relationships. Considering the object of this study, allergy, it was decided to use this method to do the classification of allergy types. The parameter that will be used in this research is the causes and effects of the allergies. The first step is gathering data. Data are collected by interview observations or using questionnaires. After that, the data can be analyzed, considering the need of the research, and this will be used as a reference to make Class and Subclass in the ontology. In this regard, the class and subclass creation process involves the use of Protégé tools.

The next step is the making of property, which contains object property and datatype property. These properties will be used as the attribute and relationship between data. Object property is created based on class and subclasses design, which has been made before, and each class can have its own object property. On the other hand, datatype property is used to give a name for each class and data entered into the ontology. Each data classification has a name for each identification, respectively. When classes and properties are created, data classification can occur.

Each data has at least one relation with other data so that it can be selected on the basis of these relationships. Allergy data have connections with data on the class Cause and Effect. After all data have their own relations, the data are ready to be stored in the form of OWL file, for later use in the system. The next step is to create a SPARQL query (Simple Protocol and Resource Description Framework Query). A SPARQL query is used to retrieve data from an OWL file [12]. To create a query, first, specification of PREFIX is needed, which is the name of where the data was taken. Next, the limitation is determined, in WHERE clause, by specifying the condition that must be fulfilled to

retrieve appropriate data. After that, there is a FILTER clause, which is used to classify further data retrieval. After query is completed, a website can be created. The Web-making phase starts from the design to the programming stage, making it a function to use the query.

Next, the connection between the OWL file and website must proceed using RAP, which is a software package for parsing, querying, manipulating, serializing, and serving Resource Description Framework models. Once the connection is completed, the website is ready to be used. On the basis of previous studies, this research developed an application based on the Protégé, JESS, and SWRL platforms. The ontology method was used to classify allergies based on the cause and effect with these data properties: hasEnvironment, hasFoods, and hasTemperature property, hasEye_Irritation, hasRespiratory_Problem, and hasSkin_Irritation. The results of this study can be described by an application that can help to determine an allergy based on the health conditions of the carrier.

3. **Design and Implementation.** The object of this research is allergy (hypersensitivity disorder). Interviews with different specialist doctors at different hospitals were done to obtain data. Therefore, this study includes data related to allergies from doctors who specialize in different fields at different hospitals. In order to handle ontology data, prior knowledge about the stages of making ontology is needed. The main thing to consider is the tools that will be used in mapping data ontology, which is Protégé. Protégé presents a display interface that tends to make it easy to understand and use. To use the Protégé, it needs to enter classes, properties, and individuals on the menu that has been determined. In addition, Protégé provides a SPARQL query feature that allows one to pretest the queries that have been created and to examine if the query is working properly. Also, Protégé provides an ontology graph feature that displays all the classes, properties, individuals, and relationships that have been previously inputted. On the basis of the object of this research, here are the types of hypersensitivity disorder shown in Table 1.

TABLE 1. Diseases of hypersensitivity disorder

No.	Diseases of Hypersensitivity Disorder
1.	Rhinitis
2.	Sinusitis
3.	Conjunctivitis
4.	Eczema
5.	Asthma
6.	Hypersensitivity pneumonitis
7.	Bronchiolitis
8.	Anaphylaxis
9.	Croup
10.	Urticaria

These are the steps to design the ontology with Protégé.

Step 1: Determining the class and property of the obtained allergy data. Class and property are created in order to properly group the data and to clearly classify relationships between the data.

Step 2: The obtained data will enter into classes and properties that have been made before, and the results of this allergy data mapping can be seen in graphical form.

Step 3: After the data are mapped, an OWL-shaped file can be created. This file serves as a storage place for variables and makes it as a special database for the ontology method.

Step 4: Create user interface design (UI) in the form of website.

Step 5: Create a function for the allergy data search menu, which starts by making a connection between the OWL file and programming website with PHP programming language, using RDF (Resource Description Framework) API for PHP (RAP). This RAP connection is created with the aim that the website can read the OWL file data that have been mapped in Protégé tools.

Step 6: The data can be retrieved by using a SPARQL query. SPARQL queries are used to retrieve and manipulate existing data in the Resource Description Framework (RDF) format or OWL. The OWL file is an output file generated from the designing step of class, subclass, object property, and datatype property. The result of the design can be seen in Figure 1. In this study, the main class is "Hypersensitivity_Disorder", which has two subclasses, "Cause" and "Effects": Class "Cause" has three subclasses, which are "Environment", "Foods" and "Temperature" while class "Effects" has three subclasses, which are "Eye_Irritation", "Respiratory_Problem" and "Skin_Irritation" respectively.
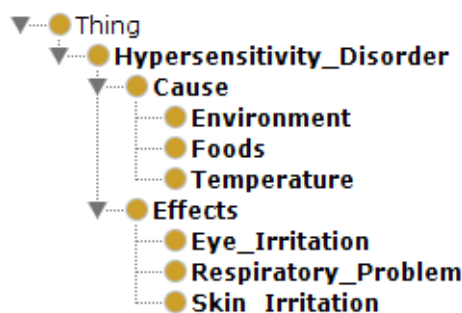

FIGURE 1. OWL file

Each class has its own properties, object property and datatype property. The design of object property from the OWL file can be seen in Figure 2. The design of this object property is similar to the class design. In this study, there are two main properties: "hasCause" and "hasEffects". The "hasCause" object property has three subproperties called "hasEnvironment", "hasFoods", and "hasTemperature" property. Meanwhile, the "hasEffects" property has three subproperties called "hasEye_Irritation", "hasRespiratory_Problem" and "hasSkin_Irritation" property. These object properties connect all Cause and Effects subclasses to Hypersensitivity_Disorder class.
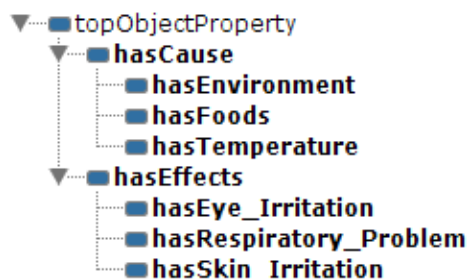

FIGURE 2. The design of object property

It is the same as the classes, which can be described in hierarchy. Properties can also be expressed as "subPropertyOf" with "RDFS: subPropertyOf". To provide limits to a property, "RDFS: domain" and "RDFS: range" are used. They are also called global restriction, which that applies in general, not limiting to a particular class. Figure 3 shows the data properties that were made by using protégé software. In this study, there are seven properties in DataType Property, which are "hasAllergy_Name", "hasEnviroment_Name",
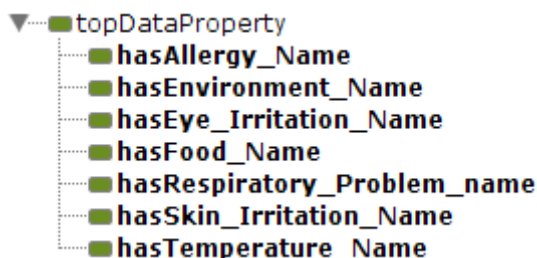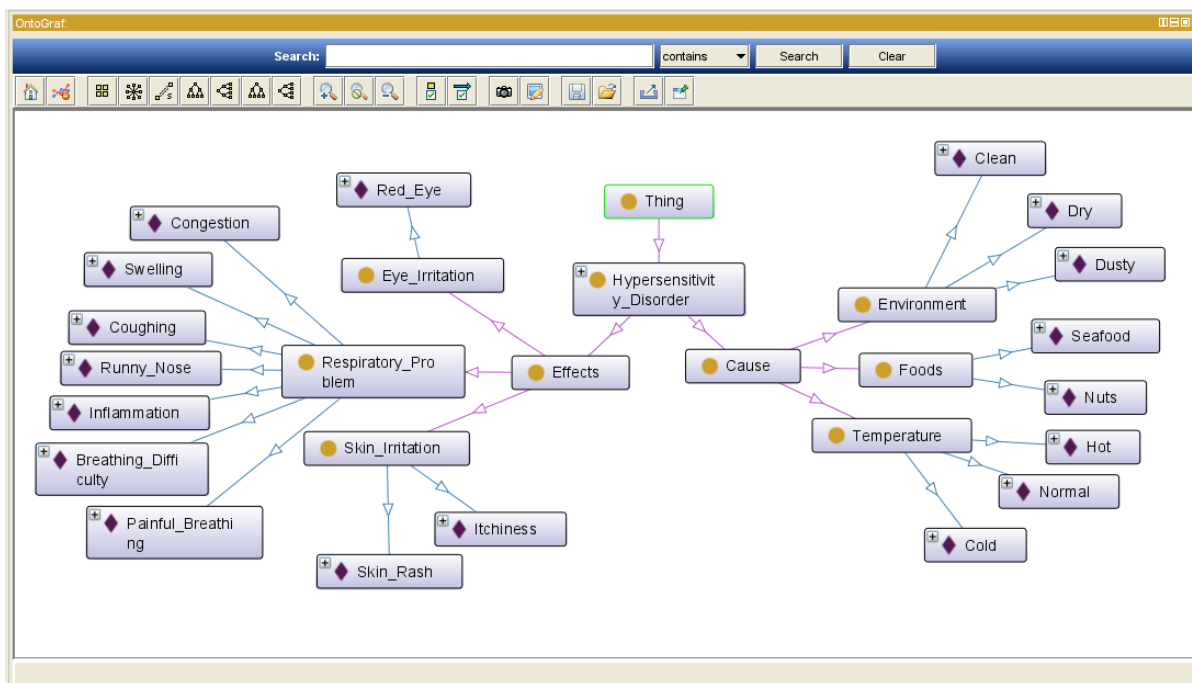
FIGURE 3. The design of data property

FIGURE 4. The design of the ontology

"hasEye_Irritation_Name", "hasFood_Name", "hasRespiratory_Problem_Name", "hasSkin_Irritation_Name", and "hasTemperature_Name".

In designing the ontology, there are some individuals contained in each class. Individuals of the class are denoted by blue arrows. Figure 4 shows the individual examples contained in the class "Hypersensitivity Disorder". Furthermore, in ontology design one can see the relationships between individuals and property, as well as the relationships between individuals by hovering the connecting arrows. Thus, individual relationships will appear in red boxes.

4. **Results.** The result of the implementation based on the ontology method is a system of test allergy that has been made previously using the OWL file and SPARQL query. In this application, SPARQL query is made to select data from OWL file, which has been made with PHP programming. The query applied in this research is used to select allergy data based on the Cause parameter and can be seen in Figure 5. Data are selected using the command SELECT DISTINCT * and are taken with the condition set on the WHERE clause, where the data are selected on the basis of the Cause parameter, which is Environment, Food, and Temperature. This clause can be classified with these variables: *?food*, *?envi*, and *?temp*. After that, the variables are stored in the FILTER clause and the data can be selected from the system input. The other query is used for selecting allergy data based on the Effects parameter. The data are selected using the same way,

```
$querystring = '
    prefix alergi: <http://www.owl-ontologies.com/alergi_bener.owl#>
    SELECT distinct *
    WHERE
    {
        ?alergi rdf:type alergi:Hypersensitivity_Disorder.
        ?alergi alergi:hasFood ?food.
        ?alergi alergi:hasEnvironment ?envi.
        ?alergi alergi:hasTemperature ?temp.
        FILTER
        (
            regex(str(?food),"'.$food.'","i") &&
            regex(str(?envi),"'.$environment.'","i")&&
            regex(str(?temp),"'.$temperature.'","i")
        )
    }';
```

FIGURE 5. Example of first query code

```
@$modelFactory = ModelFactory::getDefaultModel();
@$modelFactory->load(RDFAPI_INCLUDE_DIR . '../alergi.owl');
```

FIGURE 6. Connection code

```
@$result = $modelFactory->sparqlQuery($querystring);
```

FIGURE 7. Selecting code

which is through using SELECT DISTINCT *, and setting the conditions on the WHERE clause, which is categorized with these variables: *?effects1*, *?effects2*, and *?effects3*.

After making the SPARQL query, the connection between OWL file and the PHP programming can be made using RAP, which is described in Figure 6.

The last step is the processing and consideration of the OWL file as a database, so the data can be selected. The selecting process will be executed using the SPARQL query in the program, as shown in Figure 7.

Finally, after the connection is done, the website can be created as an expert system based on the ontology method. The design of the website is shown in Figure 8. This website contains three menus: Home, Test Your Allergy, and Allergy Info. The first menu is Home, which contains a slideshow and brief explanation about the website. The second menu is Test Your Allergy, which allowed people to search their own allergies by Cause or Effects using the given parameters in this menu. The last menu is Allergy Info. In this menu, the user can see the explanation of the allergy types in this part, considering the results gained from Test Your Allergy menu.

On this page in Figure 9, users can check their allergies by choosing the situation that best fits what has been felt. If they want to check for allergies based on a cause, they must choose Environment, Food, and Temperature in accordance with the condition when the allergy occurs. Three choices of Environment are 1) Clean, which means that the condition of the room can be said to be clean; 2) Dry, which means that the condition of the room is quite dry; and 3) Dusty, which means that the room is dirty and dusty enough. Then there are four choices of Food, namely Artificial Flavoring (artificial flavor), Junk Food, Nuts, and Seafood. The latter is Temperature, which has three options, namely Cold, Hot, and Normal. After selecting all three options, the user must press the Allergy Check
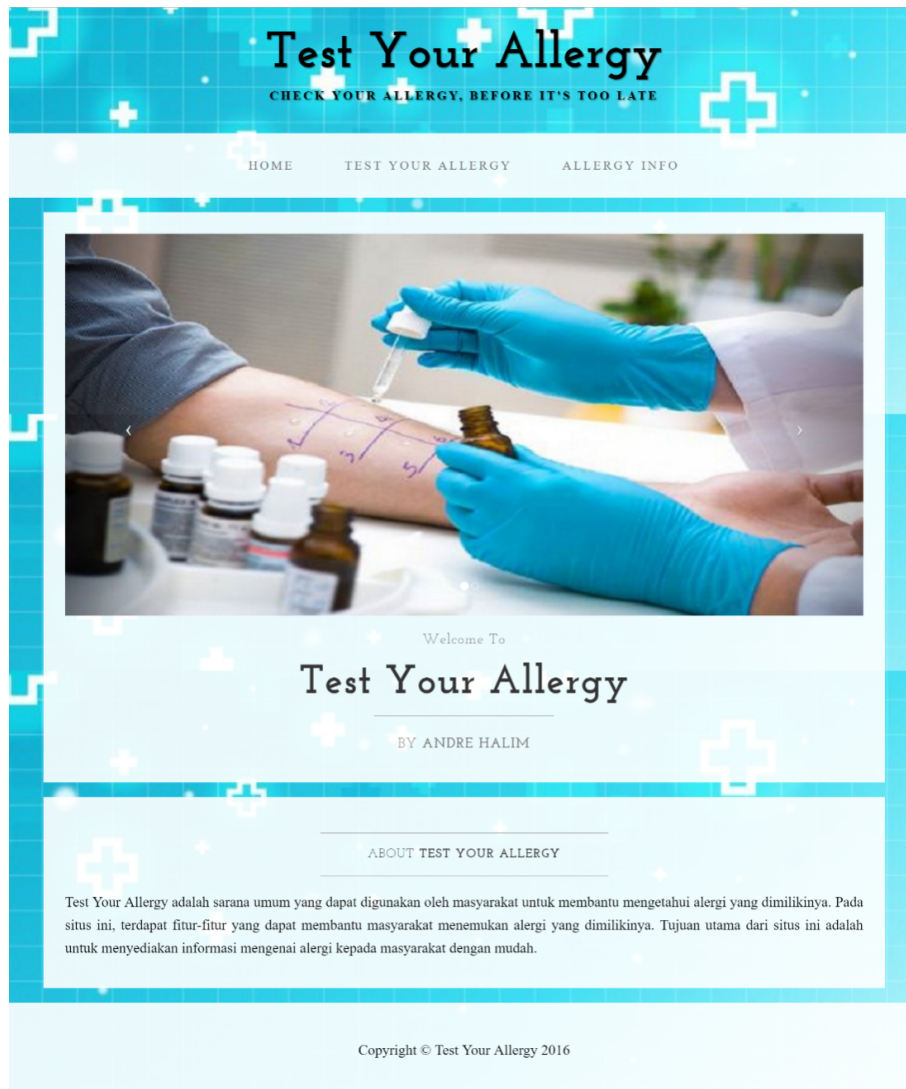
FIGURE 8. Home page

FIGURE 9. Results

button, so the system can give the appropriate result. For example: Example: (Cause) Environment: Dry, Food: Junk_Food, and Temperature: Normal" Result: Conjunctivitis.

According to this result, users can know the possibility of allergies they carry with their experiences, without needing to consult a doctor. Therefore, the users can save time and cost for consultations and treatments. With this system, users simply need to enter data about what triggers the allergies or the consequences of these symptoms. Thus, the system can provide outputs that can be served as a general description for the users to find out about the possibility of allergies they might hold.

5. **Conclusion.** This study represents the system for becoming more aware of the allergy, which can be used properly based on the ontology method. The searching process for each different kind of allergy is more effective and efficient based on the difference of the cause and effects in the application. This website application has been proven to work well, and it is also certain that the displayed data were accurate, according to the interviews with the doctors. In addition, the menu that contains the explanation about allergies helps people to understand more about their possessed allergies. For future research, the decision parameter scope can be extended to reach more complex issues and find better solution procedures.

REFERENCES

[1] A. B. Kay, Overview of allergy and allergic diseases: With a view to the future, *British Medial Bulletin*, vol.56, no.4, pp.843-864, 2000.
[2] S. El-sappagh and M. Elmogy, Fuzzy ontology modeling for case base knowledge in diabetes mellitus domain, *Engineering Science and Technology, an International Journal*, vol.20, no.3, pp.1025-1040, 2017.
[3] T. Helmy, A. Al-Nazer, S. Al-Bukhitan and A. Iqbal, Health, food and user's profile ontologies for personalized information retrieval, *Procedia Computer Science*, vol.52, pp.1071-1076, 2015.
[4] V. V. Rajendran and S. Swamynathan, MOSS-IR: Multi-ontology based search system for information retrieval in e-health domain, *Procedia Computer Science*, vol.47, pp.179-187, 2015.
[5] H. K. Lee, F. N. Ferdinand and T. Kim, Fuzzy ontology-based supply partner matching, *ICIC Express Letters*, vol.5, no.9(B), pp.3329-3334, 2011.
[6] H. K. Lee, C. S. Ko, T. Kim and T. Hwang, Fuzzy ontological knowledge system for improving RFID recognition, *International Journal of Industrial Engineering*, vol.20, nos.1-2, pp.60-71, 2013.
[7] N. Roy, Alleviation of peanut allergy through Nambudripad's allergy elimination techniques (NAET): A case report, *Global Advance in Health and Medicine*, vol.3, no.4, pp.40-42, 2014.
[8] B. Lee, H. James and O. Lassila, The semantic web, *Scientific American*, pp.29-37, 2001.
[9] T. R. Gruber, Toward principles for the design of ontologies used for knowledge sharing, *International Journal Human-Computer Studies*, vol.43, pp.907-928, 1993.
[10] T. Connoly and C. Begg, *Database System: A practical Approach to Design, Implementation, and Management*, Publisher Pearson, 2010.
[11] K. Aan and D. N. Eka, Visualization of ontology-based data warehouse for malaria spread incidences using Protégé, *Journal of Information System*, vol.12, no.1, pp.9-14, 2016.
[12] J. T. Pollock, *Semantic Web for Dummies*, Wiley Publishing Inc., IN, 2009.