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Ontology-Based Nutrient Solution Control System for Hydroponics

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***Abstract*— This paper presents the Ontology-based Nutrient Solution Control System for Hydroponics with Protégé. We consider variables of electrical *conductivity* (EC), Potential of Hydrogen ion (pH), intensity of solution, species of plants and the relation of the device in the system for supporting to make the suitable decisions with the control system of hydroponics nutrient solution.**

Keywords*- *Hydroponics; Ontology; Nutrient Solution

I. Introduction

Nowadays, soilless culture is widespread more than before because of the limited space of cultivation including higher labor costs. Therefore, soilless culture is one of the solutions to the problem. The nutrient solution system is the essential of soilless culture that affect the growth of the plants. Typically, we control the capacity of nutrient solution by persons and found that is not consistent and accurate. Thus, we propose a nutrient solution system with automatic control based on ontology.

For this research, we use the principal of OWL (Ontology Web Language) and SWRL (Semantic Web Rule Language) with semantic rules for making parameter relational condition that affect the controlling of nutrient solution. We make ontology domain to control system using Protégé- OWL to write ontology. Protégé is the open-source and researched and developed by Standford Medical Informatics. OWL language is used for communicating in the Protégé.

II. Literature Review

A. Hydroponics

Hydroponics[2], the growing of plants specifically in water or nutrient solutions is one of the most rapidly expanding new areas of plant research esuaceb it is an economically and ecologically sound approach to field crop production and soil management.

Vegetable[4] in a hydroponics system are grown in nutrient solution, which consist of two variables, pH and EC. The volume of concentrated nutrient solution which is used for increase the EC, are calculated from equation (1) :

$$Q_U = \frac{Q_I(EC_F - EC_I)}{EC_U - EC_I} \qquad (1)$$

Q_u : volume of the concentrated nutrient solution which is used for increase the EC.

Q_i : volume of the nutrient solution in system before increase the EC

EC_u : EC value of the concentrated nutrient solution

EC_i : EC value of the nutrient solution in system before increase the EC

EC_F : EC value of the nutrient solution in system after increase the EC

Carruthers [8] and Jones [9] introduced the suitable values of EC and pH for crops as shown in the TABLE I.

TABLE I. The Suitable Values of EC and pH For Crops

Plant	pH	EC
Cauliflower	6.0-6.5	2.5-3.0
Cabbage	6.6-7.0	2.5-3.0
Broccoli	6.0-6.5	1.8-2.4
Carrot	5.8-6.3	1.8-2.2
Kana	6.0-6.4	1.5-3.5
Cucumber	5.5-6.0	1-2.5
Lettuce	6.0-6.5	0.8-1.2
Tomato	5.5-6.5	2.0-5.0
Rose	5.0-6.0	1.8-2.2
Strawberry	6.0-6.5	1.4-2.0
Apple	6.8-7.2	2.2-3.0

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B. Ontology

Ontology[1] gives the perfect semantic mean from the structure of relations, theories and logics that have benefits of controlling the attribute that make easier computing of ontology.

Ontology technology evaluation's main underlying idea is a mature concept and can be soon used for practical industry, We must evaluate and benchmark it to ensure a smooth transference. The evaluation should consider several factors—including interoperability, scalability, navigability, and usability.

C. Web Ontology Language (OWL)

OWL[3] is the language that is developed for response to support semantic web language and makes the level of logic in semantic web architecture. It is built on the basic of RDF(S).

Otherwise, OWL is a modern semantic language that is used to explain ontology. OWL defines ontology for the extension of knowledge. Ontology is based on OWL and is the group of axioms that has a definition of classes, properties and relationships between the related structures.

D. The Construction of Ontology

The prototype model[5] is an annular structure. It starts out by determining the scope in defining all the different concepts from the universal domain ontology in Fig.1

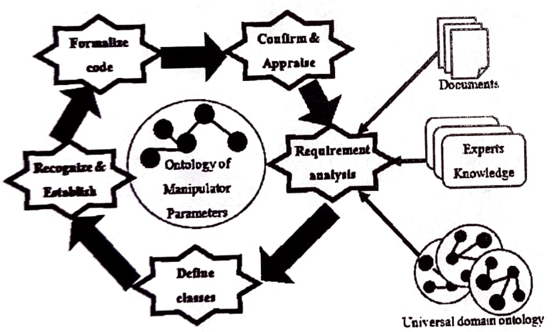

Figure 1. The prototype model of the construction of domain ontology for the manipulator parameters.

The procedure of the proposed prototype model is described below :

- Requirements analysis : Similar to the software developing method, we should capture information from its application scope, purpose as well as users from the beginning of constructing ontology, and the final goal of domain ontology is for the machine understanding.
- Define classes: Carrying on the detailed analyze and classifying the concept which is a collection of elements with similar properties from the requirement analysis. The properties would describe various features and attributes of the class.
- Recognize terms and establish the ontology framework: Evaluating the importance of every concept and selecting the key terms to remove the unnecessary concepts or exceed the domain scope. In this stage, the task complete the construction of target ontology structure which describes the concepts in the domain and also the relationships that hold between those concepts.
- Formalize code: After making evaluation, validation and refinement of the terms in the certain domain, we should formalize the good terms into codes in order to let the information has the machine intelligibility. Thus, the implicit semantic of the relational model must be mapped into explicit ontological structures. In the procedure of constructing ontology, it would use the "ontology reconfigurable" features and "ontology mapping" technologies.
- Confirmation and evaluation : The objective of this task is evaluation whether the existing ontology is conceptually rich enough to represent relational schemas completely and confirms whether all relational entities are mapped into corresponding ontological entities.

Because the knowledge domains are infinite, the domain boundary is fuzzy and the domains are overlap, we should continue communicating with professional expert after establishing the primary edition of certain domain ontology [6].

III. SYSTEM AND CONCEPT DESIGN

A. Nutrient Solution System

When the plants get water from the solution, the value of EC and pH will change. The changing value of EC is due to the absorption of nutrients in plants. The system is controlled by the EC, pH and water that flow away from the solution by controlling valve that opened-closed of solution A and B as Fig.2.

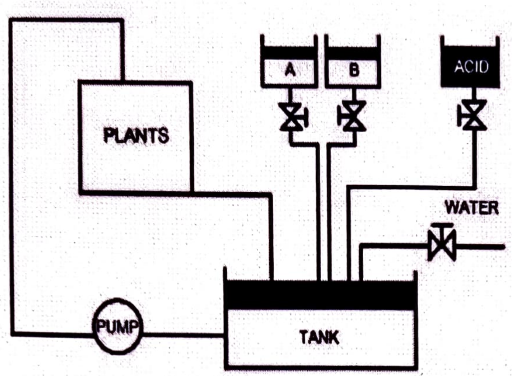

Figure 2. Nutrient Solution System for Hydroponics.

B. Ontology Design

This research, the automatic control system of nutrient solution is applied to use ontology which helps for making decision. We separate into 3 classes those are plant, parameter and tool for manipulator based on our approach following the overall prototype model as Fig. 3.

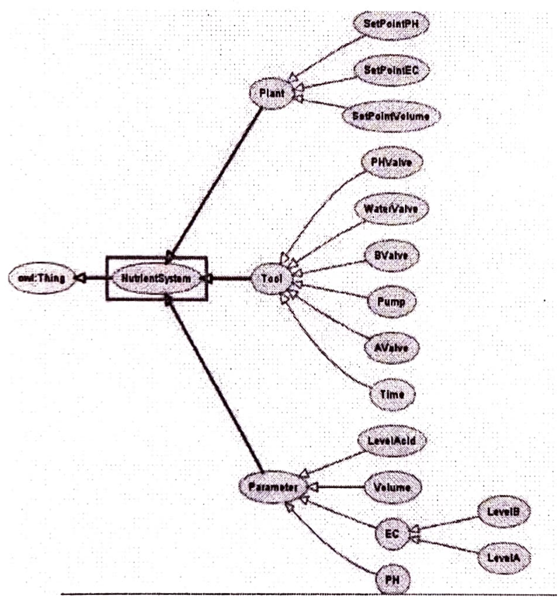

Figure 3. Hierarchy of Nutrient Solution System in Protégé

C. Protégé

The Protégé is a tool that supports knowledge acquisition and knowledge base development.[7] The user interface consists of several tabs that provide different views of the knowledge base. For example, tabs exist for ontology editing, form layout, knowledge entry, and knowledge base search. Protégé is implemented as an open-source Java application.

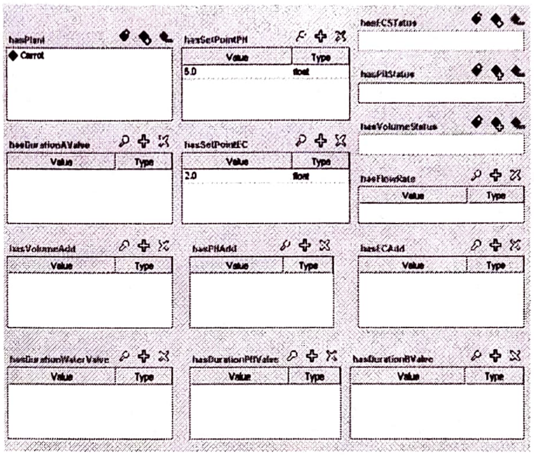

Figure 4. Nutrient Solution System for Hydroponics.

For Fig.4, the display screen using a protégé displays the relationships of the system and the user interface is also the inference rules to help for decision which will run through the plant to grow. Then the system will determine the setpoint of the plant in the database, the system will check the status of the solution to control the system to your preference.

IV. Conclusion and Future Works

Ontology is able to design structure and mechanism that makes the system more effective and can apply to the others control system using the relation of tools and variables. We also build an ontology of control variable from OWL and RDF (Resource Description Framework).

In the future, we will develop ontologies to be able to expand the extension of ideas and be able to apply to the remote control system together with the other development of ontology.

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