Ontology Driven K-Portal Construction and K-Service Provision

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Abstract

Knowledge has been crucial for the country’s development and business intelligence, where valuable knowledge is distributed over several websites with heterogeneous formats. Moreover, finding the needed information is a complex task since there has been lack of semantic relation and organization. Even if it has been found, an overload may occur because there is no content digestion. This paper focuses on ontology-driven knowledge extraction with natural language processing techniques and a framework of user-centric design for accessing the required information based on their demands. These demands can be expressed in the form of Know-what, Know-why, Know-where, Know-when, Know-how, and Know-who for a question answering system.

1. Introduction

In order to understand a situation, a decision-maker needs data, information and knowledge. The knowledge consists of data items and/or information organized and processed to convey understanding, experience, and expertise that are applicable for problem solving (Turban et. al., 2005). However, sources of these data are scattered at several locations and websites with heterogeneous formats that offer structured information to large volumes of unstructured information. Moreover, the needed knowledge has been too difficult to find since the traditional search engines return ranked retrieval lists that offer little or no information on the semantic relationships, and even if it has been found, often overload since there is no content digestion. Accordingly, the users or knowledge workers must spend time browsing and reading to find out how various information are related and where each falls into overall structure of the problem domain.

In this paper, we present a systematic attempt to construct the knowledge portal, which aims to integrate and organize the data/information resources dispersed across web resources in a manner that makes them useful, and a framework of user-centric design for accessing the requested information. Since the web consists of a large extent of unstructured or semi-structure natural language text, several techniques both in language & knowledge engineering and ontology engineering are applied to the knowledge portal construction. These include named-entity recognition (Chanlekha and Kawtrakul, 2004), discourse processing (Grosz et. al., 1995; Kongwan and Kawtrakul, 2005; Wattanamethanont et.al., 2005) information extraction, knowledge discovery (Bloom, 1956; Prather et. al., 1997; Wah, 1999; Pechsiri and Kawtrakul, 2005) and ontology maintenance (Kawtrakul et. al., 2004).

The experiment is set-up in Plant Knowledge portal such as Rice. The related information about rice dispersed across web resources consisting of varieties, disease, pest, rice exporter, harvest technology, weather forecast, etc.

2. System Overview

This paper focuses on ontology driven information extraction and integration. At extraction level, task-oriented and real-world taxonomy ontology are used to construct information schema and scenario construction. At integration level, demand-driven or pragmatic-oriented ontology is used to aggregate information from multiple heterogeneous sources. The developed system is consisted of three main components as shown in Figure 1.
Distributed Information Gathering. The information, both unstructured and semi-structured documents are gathered from many sources. Periodic web crawler and HTML parser (Thamvijit et al., 2005) are used to collect and organize related information. Domain-specific parser (Kawtrakul and Yingsaeree, 2005) are used to extract and generate metadata for interoperability between disparate and distributed information. The output of this stage is represented in RDF format.

Knowledge Portal Construction. Ontologies are used as a key to facilitate both information extraction and integration. There are two types of integration: summarize into relational database; such as <Rice varieties and yield, Disease dispersion, Pest characteristics >, and document hyperlink such as Product processing, Cultural practice and Fertilizing. Additionally, the process of knowledge extraction from text is needed to pursue the goal of generating useful knowledge, such as general symptoms of plant diseases, from the large amount of text. The output of this stage is structured knowledge and rules.

Knowledge Service Provision. Four different target users groups, i.e., farmers, researchers, SME and Intelligent Command Centre, are distinguished by different viewpoints that are characterized by each user’s interest. At this stage, knowledge tracking and summarization are applied for knowledge service provision. Moreover, K-service in the form of Know-what, Know-why, Know-where, Know-when, Know-how, and Know-who has been also provided.

Three multidisciplinary areas: Language Engineering such as word segmentation (Sudprasert and Kawtrakul, 2003), named entity recognition (Chanlekha and Kawtrakul, 2004), shallow parsing (Satayamas et al., 2005), shallow anaphora resolution and discourse processing (Kongwan and Kawtrakul, 2005), Knowledge Engineering such as knowledge extraction (Pechsiri and Kawtrakul, 2005), representation and Ontology Engineering such as ontology construction and maintenance (Kawtrakul et al., 2004; Kawtrakul et al., 2005), are applied to each component of knowledge portal construction.

3. Ontology driven K-Portal Construction

Knowledge portal construction is not a trivial task since information is distributed in various information sources. For example, the related information about rice dispersed across web resources consisting of varieties, disease, pest, harvest technology, weather forecasting, disaster warning, etc. Hence, knowledge portal construction is a combination model that refers to the creation of new explicit knowledge by extraction, integration, reasoning and synthesizing existing explicit knowledge to help users accessing interrelated knowledge in a well-organized form. This paper presents a method for automatically constructing knowledge portal from electronic documents by using two types of ontology which are pragmatic-oriented ontology and task-oriented ontology.

3.1. Pragmatic-oriented Ontology for Macro-Knowledge Construction

Pragmatic-oriented ontology means systemic and related topic map applied to aggregate expected information from multiple heterogeneous sources. The example of rice ontology in pragmatic point of view for aggregating information for one stop accessing is shown in Figure 2.

![Figure 2 Ontology Driven Rice Portal](image-url)
3.2. Frame-based Ontology for Micro-Knowledge Extraction

Although most of agricultural knowledge is contained in electronic document, manually reading and digesting these documents is time consuming. To solve this problem, information extraction using task-oriented ontology has been developed to extract relevance information from those documents and reorganize it into a well-defined structure format. In this system, task-oriented ontology is represented in a frame and slots scheme (Figure 3). Manually designed extraction rules are also required to guide the extraction process.

By using this predefined knowledge together with natural language processing techniques, the information extraction process contains two main steps as the following:

- **Pre-processing:** This process performs language processing consisting of word segmentation, name entity recognition, noun phrase analysis, and heuristic-based anaphora and ellipsis resolution (Kongwan, 2005).

$$\text{<Rice\_variety>:=}$$

- Variety\_name: list value
- Rice\_type: \{ข้าวเหนียว/Rice, ข้าวเหนียว/Sticky Rice\}^\wedge
- Farming\_system: \{ข้าวเหนียว/off-season rice field, ข้าวเหนียว/in\_season rice field\}^\wedge
- Harvest\_time: numeric value -
- Average\_yield: numeric value -
- Irresistible\_pest\_disease: symbolic value *
- Resistible\_pest\_disease: symbolic value *
- Area\_condition: symbolic value *

Note: ^ represents only one value
- represents only one value or the optional value.
* represents zero value or many values

Figure 3 An Example of Rice\_Variety Frame and Slot Scheme

- **Information extraction:** The objective of this step is to extract required information based on task-oriented ontology and predefined extraction rules. The example of extracted information is shown in Figure 4.

$$\text{<Rice\_variety>:=}$$

- Variety\_name: ข้าวเหนียว\_นท.1/Khao Yipun DOA1, ข้าวเหนียว\_นท.2/Khao Yipun DOA2
- Rice\_type: ข้าวเหนียว/Rice
- Farming\_system: ข้าวเหนียว/off-season rice field
- Harvest\_time: 90^\text{day} -
- Average\_yield: 500^\text{kg}\_1600\text{m}^2 -
- Irresistible\_pest\_disease: 0
- Resistible\_pest\_disease: Bakanae
- Area\_condition: high land

Figure 4 An Example of Extraction Result

3.3. Knowledge Extraction

In this work, our knowledge extraction system will mainly focus on causality knowledge, existing between causative antecedent and effective consequent discourse units. Mining Know-Why or explanation knowledge will induce a knowledge of reasoning that is beneficial for our daily use in diagnosis.

**Framework for Causality Extraction**

To extract a causative unit and its effective information unit in the form of an intra-causal EDU or an inter-causal EDU, there are three main tasks as the following (Chaveevarn, et.al., SNLP 2005):

- **Pre-processing:** This process provides word segmentation, part of speech tagging, including Named entity recognition, word-formation recognition (Pengphon et. al., 2002) to solve the boundary of Noun phrase and EDU segmentation (Chareonsuk et. al., 2005).

- **Causality Learning:** This task is to learn cause-effect expression between causative events and effective events from the corpus. This expression can be expressed by the combination of verb pairs from different EDUs or by a lexical pair from a lexico syntactic pattern within one EDU. In the verb pair expression, one event verb is the causative verb(vc) from a causative EDU. The other event verb is the effective verb or result verb(ve) from an effective EDU. For the lexical pair, the causative and the effective events are determined from the noun phrases presented in the lexico syntactic pattern of one EDU.

- **Causality recognition and extraction:** The objective of this task is to extract the cause-effect relation from an input text. There are two main steps as in the following:
  - **Cause-effect Identification:** This step is to identify the causative unit by searching any element in Vc from the cause-effect verb pairs (for the inter-causal EDU) and any element in the verb-phrase cue set along with lexical pairs (for the intra-causal EDU) from the causality learning step. For the basic EDU that contains an embedded EDU, paraphrasing is required before searching.
  - **Cause-effect Boundary Determination:** This boundary determination will be applied only in the inter-causal EDUs. The determination contains 2 main approaches, applying the cue phrase and the centering theory. Cue phrase is used for identifying a causality boundary. There are 2 kinds of the cue phrases, as the verb-phrase cue set and the discourse-marker cue set, as shown below. The centering theory will be applied when the implicit cue phrase is recognized.

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This theory relates to the focus of attention within a discourse segmentation (Grosz et al., 1995) to determine the smooth shift occurrence.

To evaluate the system, we use documents containing 3000 sentences from the Department of Agricultural Extension corpus. Our model of causality extraction shows the precision and recall of 86% and 70% respectively, where our evaluation is based on the expert’s results.

4. K-Service Provision

Four different target users group are distinguished from the different points of views depending on their objective, interest, affectionation and benefit.

- The farmers require some useful information, i.e. how to analyze the type of pests, or symptom of plant diseases and how to protect plant from diseases,
- The researchers prefer to track the problems and literate the previous researches,
- Small and Medium Enterprise requires to follow up the state of business,
- Intelligent Command Center of the Government needs portal of Executive information, cross sector analysis, and Intelligent Real-time warnings/alerts or event tracking.

Accordingly, K-service provision consists of Question-Answering and Knowledge Tracking.

4.1 Question Answering

Unlike normal information retrieval systems or search engines, QA can supply users with the satisfy information instead of providing just a list of searching result. Moreover the QA is an effective technique to solve the task of patterns and templates processing that were driven by ontology. In this research QA is applied for the applications below.

4.1.1. Know-what

In Agricultural domain, the Object-Property knowledge, such as pest’s characteristics (color, size, and etc), is a useful knowledge that serves the “What” question for a farmer or an agriculturalist, for example “What is kind of the insect, that its body is black, size is about 2 millimeter long?”

In order to answer the question effectively, the system needs to handle the fuzzy value of the object’s properties such as “approximately 2 millimeter”, “light green”, “dark red”. To handle these problems, we use the fuzzy concept for representing the property value in Object-Property knowledge. In order to answer the query, we use the similarity function to retrieve the answer (Kongkwan et al., 2005). Based on 440 sentences experiment, the precision of the system is 88.88% and the recall is 47.05%.

4.1.2. Know-who

Finding an appropriate person for solving some specific problems is a complicated task. For example, when a farmer wants to find an expert who knows how to control a rice blast, he/she may ask the system with the query “Who is rice blast expert?” The system will process that query and return a list of rice blast experts to him/her containing expert’s name, position, affiliation, area of expert, and contacting address. The example of the output from the system may look like this:

Name: Theerayut Toojinda
Position: Research Scientist
Affiliation: Kasetsart University
Email address: Theerayut@dna.kps.ku.ac.th
Expert field: RICE BREEDING/ MARKER AIUED SELECTION

Name: Ladha, J.K.
Position: Senior researcher
Work place: IRRI India Office, NASC Complex, DPS Marg, Pusa, New Delhi 110012, India
Email address: j.k.ladha@cgiar.org
Expert field: Soil fertility, plant nutrition, biological N2 fixation, rice-wheat system.

Name: Barman, Bhubaneswar
Position: Chief Scientist
Affiliation: Assam Agricultural University, RARS, Shillongani, Nagaon, Assam, INDIA
Email address: brrihq@bdonline.com
Expert field: cereals and grains

Figure 6 An Example of Know-who result
4.2 Event Tracking

In order to fulfill knowledge service provision, we also provide tracking system called Event Tracking. Figure 5 shows the example of “dispersal” and “prevention” Frame of disease that modified from (http://framenet.icsi.berkeley.edu/).

To track the events, we need to know n-tuple information including time dimension such as the dispersal of rice blast, we need to know 3-tuples information consisting of place, time and result.

\[ E = \{ < p_1, t_1, r_1 >, < p_2, t_2, r_2 >, ..., < p_n, t_n, r_n > \} \]

Where:
\[ p_1, ..., p_n = \text{place} 1 \text{ to } n \]
\[ t_1, ..., t_n = \text{time} 1 \text{ to } n \]
\[ r_1, ..., r_n = \text{result} 1 \text{ to } n \]

5. Conclusion and Future work

This work is the research on-demand that we got the requirement from the end-users. To construct knowledge portal, two type of engineering is required as basic elements, which are language engineering, and ontology engineering. For the current prototyping, ontology is modified from Frame net and predefined manually. For the next step, ontology will be semi-automatically constructed by using a variety of terminological resources, such as raw text, dictionaries and thesauri.

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