Easy Knowledge Engineering and Usability Evaluation of Longan Knowledge-Based System

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Abstract. Longan has been regarded as an important economic fruit for export of Thailand. In order to support Thai longan growers, the Thai government has set a strategic plan to enhance longan production and knowledge distribution by funding research and development, and constructing of Longan Knowledge-based System (LKS). This paper presents the construction process of LKS called 'easy' knowledge engineering, involving ontology modeling for construction of longan knowledge structure and preparation of data instances. LKS provides (1) unsophisticated tools with usability for searching some related knowledge concepts, and (2) 'easy' knowledge that was compiled, according to the designed ontology, into different basic core data representation. In addition, this paper demonstrates a usability study in evaluation of LKS based on ISO 9241 usability standard. The results show that LKS has a usability, and users highly satisfy with searching interaction and retrieving 'easy' knowledge.

Keywords: Ontology, Knowledge-based system, Data representation, Usability evaluation, ISO 9241, User satisfaction, Longan

1 Introduction

Longan has been regarded as an important economic fruit for export of Thailand. The Thai government has expedited and promoted longan export and marketing to nearby countries. In order to support Thai longan growers, the Thai government action plan has been geared to increasing the production efficiency, funding research and development, and constructing of Longan Knowledge-based System (LKS).

The knowledge-based systems are commonly used to support some group of users in order to solve their problems in a specific domain. To comply with the action plan, we

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focused on the development of LKS for Thai longan growers. The challenge of LKS design is the knowledge structure, data representation, and user interaction.

- **Knowledge structure:** The processes of knowledge acquisition from longan domain expert, and implementation of ontology as a data model to represent the unstructured knowledge are concerned to construct a longan knowledge structure or longan ontology that contain knowledge basically corresponding to user needs.
- **Data representation:** The benefit of longan ontology is to support the data extraction and capturing that domain expert can easily assemble a core longan knowledge into three basic kinds of data representations. Three forms of data representations provided in LKS are Wikipedia, video clips, and images. We note that each data representations can support a large group of users with different user's interacting natures and limitations. Wikipedia supports quick scanning through knowledge contents, and flexible to choose to focus on or skip some contents. Video clips support incremental learning. Related knowledge contents are combined and represented in one video clip. Images are used for illustration to increase users understanding. It is good to know what kind of data representations users would prefer, and whether longan knowledge can be transferred to users or not.
- **User interaction:** Simple user interface is designed for easy to contact with, because users have different levels of computer skills. A large group of users can usually interact with hyperlink as a familiar interface style commonly used for accessing to online knowledge-based system. Hyperlink provides simple point-and-click interaction to users for navigating through some complex and unstructured data.

In addition, the usability evaluation of LKS, based on International Organization for Standardization (ISO) 9241, is necessary to determine whether LKS is easy to use, and longan knowledge is easy to understand, interesting, and practical. The users of LKS are the primary subjects who directly use the knowledge. Hence, we conduct the experiment with users contributing to find user satisfaction and feedback on LKS design further than common validating LKS by domain expert or knowledge engineer. ISO 9241 is a widely used basic usability standard and provides a flexible implementation. Usability evaluation can provide user satisfaction and feedback concerning sophisticated interaction with LKS.

Therefore, the paper is organized into 3 parts. The first part explains the overall system architecture of longan knowledge engineering called 'easy' knowledge that is the concept behind the LKS. The second part describes a usability evaluation of LKS, and analysis of results. The third part presents some discussion, and finally conclusion and recommendation.

2 Easy knowledge engineering and system architecture of longan knowledge-based system

We built the LKS to share easy longan knowledge mainly to Thai longan growers and agricultural extension officers. It was challenging to design LKS, because most users of LKS have low levels of computer skill, and require easy knowledge explaining step-

by-step guide of longan production. LKS provides unsophisticated tools and data representation to avoid user overwhelming.

We designed a framework for knowledge construction and representation in order to define the scope of data to be collected. First, the knowledge structure was designed and organized by using ontology [1] with a collaborative work of knowledge engineers and experts in different area of longan. Many possible questions concerned about longan knowledge were pooled from longan growers who had levels of experiences in longan planting from beginner to expert. The critical thinking with Nominal Group Technique (NGT) [2] allows a group meeting of longan experts to find some answers to the pool of questions and present them as a set of required longan concepts. A group questionnaire was constructed to validate the longan concepts, and then used for ontology construction. Fig.1 summarizes a framework for longan ontology modeling.

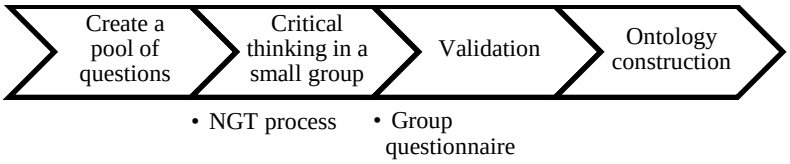

Fig. 1. A framework for longan ontology modeling

The longan ontology contained the interested primary knowledge that was organized as a node where each node was divided into sub nodes in a hierarchical structure. This structure was essential because (1) it was used as a searching knowledge structure in LKS, and some relationships between nodes described a semantic of related knowledge concepts (2) it was used as an outline for the scope of knowledge domain for preparation of data instances in a form of data representation. We used longan research data as our primary source of data instances.

Second, in order to classify the type of knowledge and source of information for gathering data, we further defined the source of domain into two categories: implicit and explicit knowledge [3, 4]. For the source of data for explicit knowledge mainly came from publication papers, research reports and books; whereas data that was collected for implicit knowledge came from interviewing with the longan local experts.

Third, the collected data was extracted and captured according to the scope of knowledge structure that was designed. One of the approaches we found to be efficient was while the data is being collected, the representation of knowledge should also be designed. We also need to design the type of media and which format is suitable for our users. Knowledge is scattered and needs to be collected in a form of data representation. The contents were then divided into three categories: textual information as Wikipedia, images and video clips. The video clip had been designed for 3 minutes long, because a presenting knowledge was digested to a simple and easy knowledge, then the story proceeding of this easy knowledge could concisely explain. Since human concentration is short, a 3-minute video clip could be attractive. Finally, the final output of data representation in different form of media will be approved by the expertise before presenting to the users. Fig.2 summarizes our framework for easy knowledge engineering.

LKS was built on a simple architecture. Ontology RDF file was transformed to a relational database. DotNetRDF, C#, and .Net Library is used to connect ontology structure with relational database structure. LKS provides web interface and accessing with URL (called ThaiLonganWiki) [5]. LKS provides users to access easy longan knowledge via hyperlink which each links are concepts or nodes on longan ontology. Each links can also lead users to some related concepts and data instances semantically based on longan ontology. Users can also enter a keyword in the search box and select some specific data representations whether Wikipedia, video clip, or image to directly get some data instances as shown in Fig.3 and Fig.4. From data instances, users can easily connect to other related concepts. LKS also provides some functions for blog communication and posting page according to the longan knowledge structure.

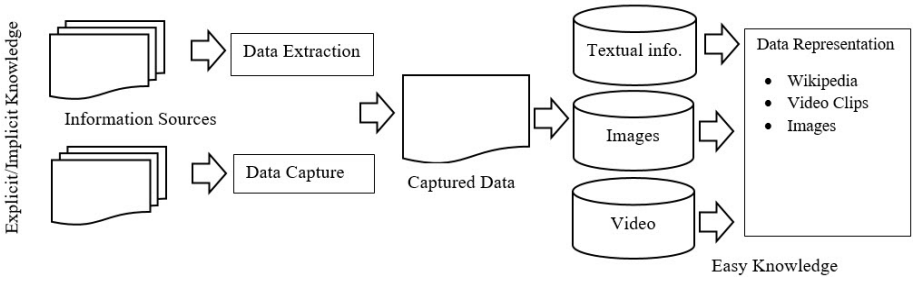

Fig. 2. A framework for easy knowledge engineering of LKS

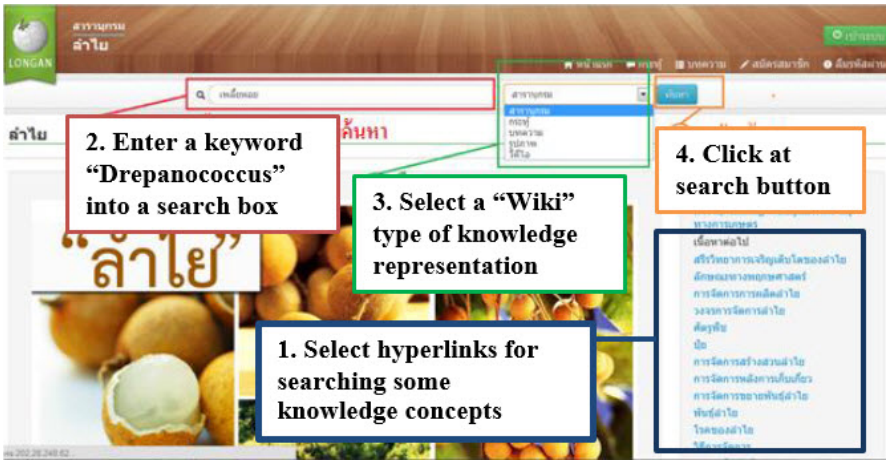

Fig. 3. A screenshot of LKS main page

Fig. 4. A screenshot shows the results after entering a keyword “Drepanococcus” representing in Wikipedia of LKS

3 Usability evaluation

The objective of this usability evaluation is to study user satisfaction and feedback of using LKS with 3 kinds of data representations (Wikipedia, Video, and Image). It can be determined from usability indexes and overall satisfaction. LKS was evaluated by using ISO 9241 usability standard [6, 7] consisting of efficiency, effectiveness, and satisfaction. This standard is a basis of usability evaluation that can generalize its implementation to many kinds of evaluated object and is flexible to define our own set of measuring indexes.

3.1 Measurement of ISO 9241

ISO 9241 requires 3 measurements. Hence, we defined our methods for usability evaluation.

Efficiency measurement. We focused on and recorded user’s time to complete some assigned tasks, which followed general information retrieving tasks. The individual recorded time then was statistically processed and interpreted.

Effectiveness measurement. We studied a percentage of completed task by recording the successful number of tasks to complete. In order to be successful a user must complete some assigned task and gives some correct answer corresponding to some questions. We focused on a successful proportion of tasks that users interacted with each data representation.

Satisfaction measurement. We measured user satisfaction from a questionnaire with 5 measuring indexes as follows.

- Ease of use: the extent to which LKS is easy to learn, easy to use, and easy to complete user's task.
- Comprehensibility: the extent to which user understands the longan knowledge that propagates through LKS.
- Interesting: the extent to which a presentation style of each data representation in LKS is interesting.
- Practical use: the extent to which user obtains longan knowledge, and then can implement and deploy it in reality.
- Overall satisfaction: the extent to which user satisfies overall of LKS.

3.2 Evaluation variables

From above measurement, we defined variables for our study as follows.

- Independent variables: (1) Wikipedia (Wiki) (2) Video clip (VDO) (3) Image.
- Dependent variables: (1) Time to complete the tasks (2) Frequency score from correctly completing the assigned tasks (3) Satisfaction score from using Wiki, VDO, and image.

3.3 Subject and process

Subjects were Thai longan growers, agricultural extension staff, agricultural students, and agricultural academic staff. They were recruited from a group of participants attending in several longan lecture training. Evaluation process started from (1) training subjects to use LKS (2) giving a paper of assigned tasks and allowing them to work on their own by recording their working time (3) filling in evaluation questionnaire when they finished all tasks. The evaluation was completed in a computer laboratory.

3.4 Assigned task

Users were asked to complete the assigned tasks that followed some general tasks of searching on the Internet. For searching task with Wiki, we assumed the topic of "Fruit thinning" that users were interested in, asked them for navigating to its detail, and answered a question. Finally, they were asked to navigate some related contents such as "Fruit wrapping for a good skin tone" and answered a question. For searching task with

VDO and image, we specified some topic and asked them to navigate to those specified VDO and image.

3.5 Questionnaire

Our questionnaire was based on our objectives and measuring indexes. The questions [8] were categorized into 2 groups, background information and user satisfaction. The questionnaire was conducted by using a multiple choices for answering questions of background information, and a Likert scale with 5 scales of satisfaction (Excellent = 5, good = 4, fair = 3, poor = 2, and very poor = 1) for answering questions corresponding to measuring indexes.

3.6 Pilot study and final survey

We conducted a pilot study with 11 subjects to test our questionnaire and sequence of evaluation process before a final survey was carried out. We found that subjects were confused on some parts of LKS, descriptions of assigned tasks, and questions in a questionnaire. Therefore, we modified some system functions of LKS, added user's expected knowledge, reduced a number of tasks, rewrote the description of assigned tasks, and used simple language in a questionnaire before doing a final survey.

The final survey was conducted in 5 sessions independently with 106 subjects. We analyzed a measurement of user satisfaction from all subjects, but measurement of efficiency and effectiveness from 32 subjects. We chose both parametric and nonparametric statistics for data analysis. Means, frequency, percentage, Chi-Square test, and F-test were used. We accepted a significance level at $p=0.05$ which suitable for this kind of survey which was accurate and highly reliable.

3.7 Usability analysis of results

The followings present some results from each measurements.

Efficiency measurement. We studied separating user's working time with 3 data representations, Wiki, VDO, and image. We would like to know the efficiency of interaction to access each data representations. Table 1 shows maximum, minimum, and average of time that all 32 subjects could complete their tasks. It was interesting that there was a big difference between maximum and minimum of working time (seconds). There were some reasons that subjects have a big difference of levels of computer and internet skill. The more computer skill, the less time to complete the task.

We studied more to the significance of difference with ANOVA and F-test. We found that the average of time using VDO was significantly different from Wiki, and average of time using Image was significantly different from Wiki. However, average of time using VDO was not significantly different from Image with $p=0.528$ (> 0.05). Therefore, we can combine VDO and Image into one data representation for the later studying of user satisfaction.

Table 1. Average of time (seconds) to complete the assigned tasks

Data representations	N	Mean	Std. Deviation	Minimum	Maximum
VDO	32	143.59	113.015	3	420
Image	32	101.47	89.660	2	360
Wiki	32	256.94	213.081	39	852

Effective measurement. We studied the success of the tasks to complete by using 3 data representations. We defined a meaning of success that subjects must complete the assigned tasks and give all correct answers. The result shows that all 32 subjects can complete the assigned tasks by using VDO and Image. Only 30 subjects could finish the assigned tasks and give all correct answers by using Wiki. We use Chi-square (X_c^2) for significant testing of successful proportion. We found that the successful proportion by using each data representations was not different with X_c^2=4.09 and significance p=0.057 (>0.05).

Satisfaction measurement. Based on the result from efficiency measurement, we combined VDO and Image (VDOIMG) into one data representation to decrease a number of independent variables and make the evaluation simple to our subjects. Therefore, we studied a percentage of frequency of user satisfaction from using 2 data representations, Wiki and VDOIMG. We determined which level of user satisfaction mostly agreed in each measuring indexes for Wiki and VDOIMG was. The result was analyzed based on our 5 measuring indexes as follows.

Ease of use. The statistical results show that the most subjects (43.4% of all subjects) agree that VDOIMG is easy to use, and (48.1% of all subjects) agree that Wiki is easy to use as shown in Fig.5a. None of the subjects agree at a poor level. We analyzed that LKS used hyperlink with a point-and-click interface style. It required a basic interaction familiar to subjects. Even though, they did not have much computer skill, they could learn how to use Wiki and VDOIMG in a short time.

Comprehensibility. The most subjects (48.1% of all subjects) agree that they have a good understanding of contents on VDOIMG, and (55.7% of all subjects) agree that they also have a good understanding of contents on Wiki as shown in Fig.5b. We analyzed that both data representations could highly pass on longan knowledge concepts to many subjects.

Practical use. The most subjects (53.8% of all subjects) agree that they can have a good practice after watching a VDOIMG, and (63.2% of all subjects) agree that they also have a good practice after looking up on Wiki as shown in Fig.5c. We found more than 5% of difference from the result percentage. However, a group of subjects (29.2% of all subjects) agree that they have an excellent practice after watching a VDOIMG. As the video clip presentation was 3 minutes and quickly proceeded, some subjects might not be able to extract knowledge and focus on it within a short time. However, if they

could watch a video clip again, they might be able to follow and focus more. It mainly depended on individual concentration. Some subjects could follow and grasp some knowledge for their own practice.

Interesting. Most subjects (70.8% of all total subjects) agree that both VDOIMG and Wiki were interesting as shown in Fig.5d.

Overall satisfaction. The most subjects (53.8% of all subjects) agree that LKS has "good" level of satisfaction, and (33% of all subjects) has "excellent" level of satisfaction as shown in Fig.5e.

We now conclude in this section that the most percentage of user satisfaction in each measuring indexes is in a "good" level of satisfaction for both Wiki and VDOIMG. The results from 3 measurements show a high usability of LKS based on ISO 9241.

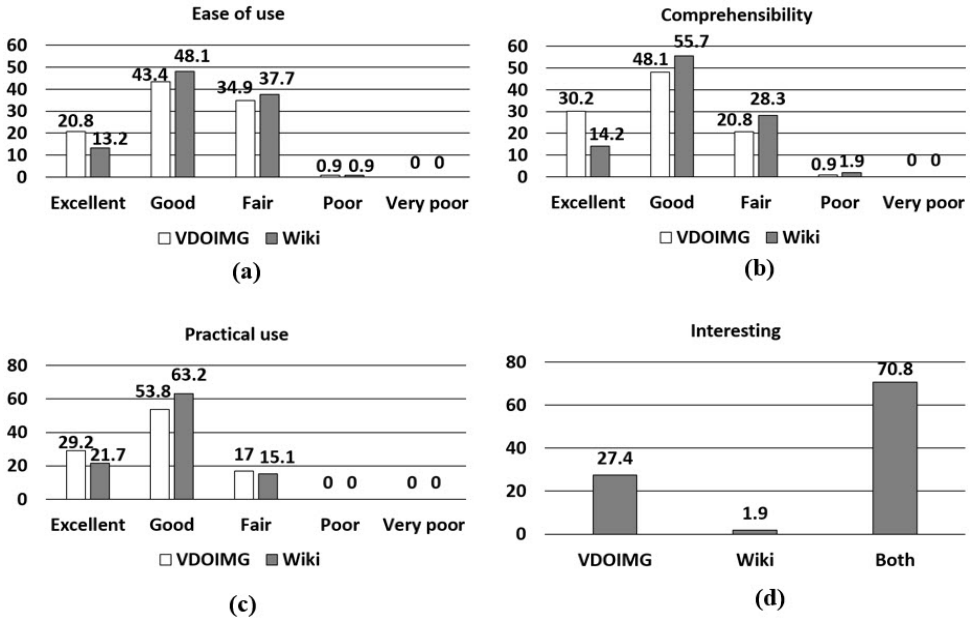

Fig. 5. Percentages of frequency for user satisfaction in each measuring indexes

Fig. 5. Percentages of frequency for user satisfaction in each measuring indexes (Continued)

3.8 Average analysis of user satisfaction score

We found an interesting result in Fig.5 that a group of subjects agree that VDOIMG has "excellent" level of satisfaction in Ease of use (20.8%), Comprehensibility (30.2%), and Practical use (29.2%). This shows a big proportion that affects the average of user satisfaction score as shown in Fig.6. We found that VDOIMG has higher average of user satisfaction score than Wiki in Ease of use, Comprehensibility, and Practical use. A big space with a solid line shows a high average of user satisfaction score for VDOIMG, especially, in Comprehensibility. It means most subjects agree that knowledge in VDOIMG is easier to understand than Wiki. VDOIMG can be transferred to them and its knowledge content is easy to understand. Therefore, they can practically use this knowledge. This is similar to Wiki, because the average user satisfaction score of Practical use for Wiki and VDOIMG are very close.

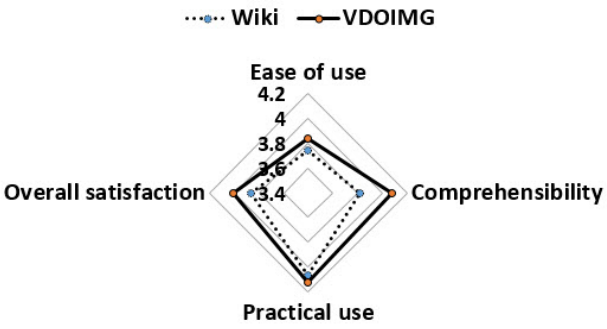

Fig. 6. Average of user satisfaction in each measuring indexes for Wiki and VDOIMG

3.9 Correlation analysis of results

A correlation analysis was carried out between each variable of background information and user satisfaction levels (very high, high, medium, low, and very low). We applied Chi-square test for independence and p-value to check whether there is some background influence in each measuring indexes of user satisfaction. If p-value is less

than 0.05, we can conclude that each considering pairs will be correlated. We can conclude as follows.

- Sex affects level of satisfaction in Ease of use for both Wiki and VDOIMG. Female tends to have higher satisfaction than male.
- Age affects level of satisfaction in Ease of use for VDOIMG. Age ranging from 21 to 30 tends to have "high" level of satisfaction and more than 60 tends to have "medium" level of satisfaction. In addition, age affects level of satisfaction in Interesting. It means that all age ranges are interested in both Wiki and VDOIMG. Especially, a large number of subjects with age 21-30 tends to interest in VDOIMG. We can conclude that users with age 21-30 can well response to VDOIMG.
- Education level affects level of satisfaction in Practical use for VDOIMG. Most subjects have bachelor degree or higher, and tends to have "high" level of satisfaction. They agree that knowledge from VDOIMG is highly practical use.
- Computer experience affects level of satisfaction in Ease of use for both Wiki and VDOIMG. The more computer experience, the higher level of satisfaction.
- Sources of knowledge: Relatives affects "high" level of satisfaction in Comprehensibility for Wiki. Friends and neighbors affect "high" level of satisfaction in Practical use for VDOIMG. We found that relatives, friends, and neighbors are some good sources of knowledge, because familiarity and reliability can lead to knowledge transferring and sharing.
- Interesting data representation: Training and discussion with agricultural academic staffs affects "high" level of satisfaction in Ease of use for Wiki. Internet and digital media affect "high" level of satisfaction in Practical use for VDOIMG. In addition, Internet and digital media affect "high" level of satisfaction in overall satisfaction. It means that Internet and digital media are the most interested tools of knowledge transferring. Most subjects agree that they can practically use knowledge from Internet and digital media.

4 Discussion

An interesting result shows that VDOIMG has obviously higher average of user satisfaction score in Comprehensibility than Wiki. Even though, knowledge content in Wiki and VDOIMG is the same, it is much different in a presentation and story proceeding, which are both important factors of user's comprehensibility. VDOIMG provides users a visualization of longan knowledge in a video clip. It can demonstrates many action methods such as how to do water management on a longan crop, and how to use Potassium Chlorate for flower induction. It also uses easy language, and present concise story proceeding with core knowledge concept.

Additionally, while VDOIMG has average of user satisfaction score in Comprehensibility much higher than Wiki, the average of user satisfaction score in Practical use of both VDOIMG and Wiki are very similar. It shows an independence of Comprehensibility and Practical use. Less understanding does not contribute to less practical use. We analyze that when users access to their knowledge, they needs time to interpret and analyze data before execution. It is very clear that VDOIMG can reduce user's time.

However, users does not stop interpreting and analyzing, and they can do data execution later on with Wiki. The most important thing supporting users is 'easy' knowledge. It is practical and represented on LKS. We note that this demonstrates some advantage of easy knowledge engineering with ontology modeling to provide usability of LKS.

In addition, we interviewed the same group of subjects after 3 months later. We found that 93% of all subjects revisited to access knowledge in LKS. The result from interview [8] shows an appreciation on LKS and 23.34% of revisiting subjects had informed their known people to access LKS for easy longan knowledge.

5 Conclusion and recommendation

We conclude that LKS has a usability based on ISO 9241. The usability study shows a "high" user satisfaction and "good" interaction between users and LKS. The result of usability evaluation implies some advantage of our easy knowledge engineering with ontology modeling. Searching through knowledge structure based on longan ontology enhances a high understanding and practical use of longan knowledge. User evaluation is very important to measure user satisfaction and gain feedback of LKS design. It assures that 'easy' knowledge has been transferred to users. For future work and more powerful search for knowledge, semantic with reasoning search can be further implemented.

6 Acknowledgement

This work is a part of research project funded by Agricultural Research Development Agency (Public Organization): ARDA, Thailand. (PRP5505010760)

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