Development of Southern Research Recommendation System

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Abstract. The research was to identify needs on design and development of a research recommendation system for southern province groups in Thailand. The system employs semantic search function, research system structure and scope of knowledge during January 2008 to December 2017. 3,873 entries had been gathered from ThaiLIS, TNRR, and Southern universities research database by employing textual analysis and knowledge organization focusing on Classification Approach and categorization which main topics are sorted and categorized. To develop ontology, it applies knowledge engineering concept and using Protégé Ontology Editor version 5.5 beta to process the data for the accurate system development according to user-centered design concept. The study findings were the developed system is able to support information exchange, information retrieval, and research search and to decrease research redundancy and unnecessary budgeting. Moreover, the system could possible enhance conducting more innovations, confirming experts in the area, showing research trends, and showing research results on related fields, strategies, and problems which leads to the Southern developments extensively. After the implementation, the users' overall opinions and satisfaction was at a high level and information retrieval efficiency of system was at a good level with 0.70 accuracy, 0.78 recall, 0.88 precision, and 0.82 F-measure.

Keywords: Southern research recommendation · Southern Thailand · Research for development · Information and knowledge management · Ontology

1 Introduction

South of Thailand is coastal areas along Thai Gulf and Andaman Sea also it is closed to Malaysia border. Therefore, there are advantages on border trade and tourism [1]. Most of the South are forests and wetlands which is valuable for planting and eco-tourism [2]. Besides, the Southern economic structure consists of agriculture, industry, trade, and tourism, moreover, Southern culture portrays its own identity as uniqueness and diversity which could be conveyed as multiculturalism. In accordance to multiculturalism, the South welcomes all tourists as a hub of diversity [3]. These factors are strengths of the

South also relate to Thailand 4.0 concept in which the government encourages the people to have outstanding innovations along with creative culture, and to create services which lead to effective product development and tourism services [4].

Southern development policy and strategic plan and the Office of Strategy Management, Southern province group focuses on setting up Thailand stability and sustainable development framework under the sufficient economy concept. Moreover, international network has been brought to help on agriculture, food processing industry, and tourism development which based on economic expansions as increasing various types of business and employment rate also enhancing competitive man-power as to be ready for industry investment and marine transportation development like Joint Development Strategic for Border Area or JDS and Indonesia - Malaysia - Thailand Growth Triangle or IMT – GT [4].

Process on employing strategies into practice and driving the region is based on participation among the people, organizations, and departments in province group for the utmost development [5]. This drive and development pay attention to fundamentals, in other words, the developments on basic structures of economy, society, and community along with research and development on inventing innovations, gaining new knowledge, and solving problems systematically. In terms of development process and problem-solving, it employs needs and problem analysis as to gain findings which lead to practical research methodology [6]. Further research has been used as tools to reach body of knowledge, answers, explanations and systematic development, to reconfirm whether the knowledge is existing, and to see if the knowledge can be applied or solved problems [1].

Conducting research leads to freshly effective innovations which used for further development and precise solutions to strengthen the region and the nation. To conduct research for development in the South becomes an essential tool in constructing new knowledge which could lead to innovations especially agriculture and fisheries also research on multiculturalism. These 2 research topics included 5 targets which are encouraged and launched by the government [7]. Research procedure includes research problem, research statement, literature review, research framework, population and target group, research design, research tools, data analysis, research findings, and implement [8]. Each step needs information to be part of literature review and to support the ongoing research [9]. Gathering related information expands the area of knowledge to be multidisciplinary, yet due to information overload, it causes unreliability and unclear scope of knowledge.

To ease data search, confirmation, and support research in the South there should be a systematic knowledge management as categorizing and classifying data [10] which is easy to access. The knowledge has been categorized into tree structure according to the relationship of each concept [11] in accordance to policies, plans, strategies, problems context. These relationships are combined into the structure of information systems that the semantic web technology uses to search or recommendation system can understand, therefore, it helps on showing clear causes and effects also differentiating relationship in scope of related knowledge in the form of ontology [12] will serve to support the separation relationship process of knowledge scope relevant and not related to each other. Moreover, it helps users making decisions, gathering information, or continuing

further research for development in the South. Previous studies regarding recommendation system in Thailand show that there were systems developed for particular topics or areas, for example, a recommendation system for North Eastern Thailand, a system on collecting autobiography, a knowledge database on enhancing services for diabetic patient or a research database on rice. Yet the researchers did not find any research recommendation system for Southern part of Thailand even it is one of the main resources on economic and education in Thailand [1]. Consequently, 14 provinces of the South could not confirm or manage existing knowledge effectively [3]. Besides, the knowledge was scattered; it might need to be managed and shared systematically.

Therefore, this research aims to identify needs on design and development of a research recommendation system for 14 southern province Thailand development. The findings in this research will show the relationships and trends of knowledge based on research of Southern Thailand from the synthesized fixed data, additionally, it is beneficial to reflect gaps on some research points which can be resolved or reused. Identifying research knowledge relationships is to point out relationships between research and strategies, policies and needs which relate to problems. To resolve problems effectively a systematically research should be conducted according to existing research knowledge and grant. Further, this could explain more on relationships of information clearly, similarly, the system will help researchers scoping area of study, searching for information, reducing research redundancy, reducing costs on research redundancy and reconfirming existing knowledge, and creating innovations.

2   Research Objective

To identify needs on design and development of southern research recommendation system for southern province groups in Thailand.

3   Materials and Methodology

The search system development focuses on research and development methodology for innovation, new technology, and new knowledge [13] employing research-based development to be a framework for systematic research process as three phase as follows

3.1   To Scope and Categorize Knowledge Found on Research for Southern Development (Phase 1)

3.1.1   Underlying Concepts
Textual analysis and knowledge organization focusing on classification approach have been applied to sort main topics into tree structure. Approach and theoretical framework applied to this system development are based on classification theory or semantic relationship. To categorize knowledge is to sort and group similar content according to subclasses, meanings, purposes, durations, or locations for gathering proper amount of knowledge structure elements on developing the system [14–17].

3.1.2   Methodology

Mix method research has been brought to manage knowledge structure as using content synthesis to generate research contents and relationships, also using classification approach to classify data concerning meaning and content and then to synthesize research key points systematically.

(1.) The researchers to scope the knowledge 5 references had been used as follows;

1.1 7 strategies from the Ninth National Research Policy and Strategy (2017–2021) formulated by the National Research Council of Thailand.

1.2 10 strategies from the Twelfth National Economic and Social Development Plan (2017–2021) and the 20-year National Strategy framework (2017–2036) formulated by the office of the National Economic and Social Development Board.

1.3 11 strategies from 3 departments of administration and strategy planning of Southern province group development framework (2018–2021).

1.4 Synthesis on problems and needs of people in the Southern province group by the Office of Strategy Management.

1.5 Related research on TNRR, ThaiLIS and southern universities research database in the past 10 years from 2008–2017 then synthesizing the data according to 3 aspects of research knowledge structure: research documents, research basic information, and other related research information. Those research were carefully selected in terms of correctness, completeness, and conciseness, as a result, there were 3,873 entries from 78 departments.

(2.) Textual analysis and knowledge organization had been used to develop the system also focused on classification approach to categorize by analyzing contents to get concepts, relationships, and semantic groups of research data [18–20]. After analyzing the structure was developed based on *(1.)*. The structure had been evaluated by 7 experts (cover expert of policies and plan, information and knowledge management expert and research expert) using Index of item Objective Congruence. Lastly, the system had been fixed according to the experts' feedback and suggestions.

3.1.3   Result

After classifying and categorizing research for southern Thailand development, according to policy and strategy, problem and needs of community: the knowledge structure had been revised according to experts' suggestions in index, domain, concept issues and scope. The results of the knowledge structure had the concept, sub-concept and knowledge scope are as follows [21]:

(1) The overview on scopes of knowledge on Southern development research are as follows;

(1.1) Knowledge Structure consists of 2 domain; each domain consists of 20 class; each class consists of 139 concept; each concept consists of 327 Sub-concept.

(1.2) 2 domains consists of research aspects domain and research work domain.

(1.3) Research aspects domain refers to knowledge related to the research for development of Southern Thailand which consists of 3 knowledge sets: (1) research knowledge on policy, strategy, and management of Southern province group, and (2) research knowledge on problems and needs of Southern province people, consist of 17 class; each class consists of 113 concept; each concept consists of 215 sub-concept.

(1.4) Research work domain refers to knowledge related to the scopes of the research for development of Southern Thailand which consists of 3 classes such as: (1) research documents, (2) basic information and (3) other related information, each class consists of 26 concepts and each concept consists of 112 sub-concepts.

(2) Research synthesis on the Ninth National Research Policy and Strategy, the Twelfth National Economic and Social Development Plan and the 20-year National Strategy framework, administration and strategy planning of Southern province group development framework is classified into 6 classes, 31 concepts, and 95 sub-concepts on research aspects domain: such as research and development, infrastructure development, social development, economic empowerment, sustainable development, and production development.

(3) Research synthesis on the problems and needs of people in Southern province groups in (1) the Office of Strategy Management of Southern border provinces, (2) the Office of Strategy Management of Thai Gulf coast provinces, and (3) the Office of Strategy Management of Andaman coast provinces is classified into 11 classes, 82 concepts, and 120 sub-concepts on research aspects domain: such as safety system and welfare development, education development, career development, business development, tourism development, natural and environmental resources development, public health development, family unit development, agricultural area and innovation system development, transportation development, and solutions on immigrant worker.

(4) Research synthesis on the Southern university research database system, TNRR and ThaiLIS is classified into 3 classes, 26 concepts and 112 sub-concepts on research works domain:

(4.1) Research document – refer to the research documents, article and proceedings on southern development, consist of 2 concepts and 7 sub-concepts

(4.2) Basic research information – refer to Academic positions, qualification, researchers status, tools, population and research target, statistics, researchers contact information and research areas, consist of 8 concepts and 35 sub-concepts

(4.3) Related information – refer to affiliation of researchers, research type, research type divided by subject science and provincial group strategy, researcher region/province, research area divided by province group, southern regional development strategy office, research funding source, distribution model, source of research, research copyright and data source, data collection method, consist of 16 concepts and 70 sub-concepts.

3.2 System Needs of Researchers' on Southern Development Research (Phase 2)

3.2.1 Underlying Concepts

Quantitative research and user-centered design had been adopted to explore researchers' needs as follows;

Quantitative research and user-centered design had been brought to study the needs focusing on importance, needs, and satisfaction of users. The findings of this assessment are used in the system development process [22]. Moreover, the development uses system approach to construct an effective recommendation system in accordance with the needs and the Southern development strategies. The needs were from 327 researchers of 78 organizations who conducted research regarding Southern Thailand during January 2008 to December 2017. Those 10-year entries had been gathered from ThaiLIS, TNRR, and Southern universities research database which the researchers were able to access. The researchers employed rule of three to get 327 researchers of 78 organizations from the population. After that the researchers used simple random sample method as to get numbers of researchers from each organizations, then collected data from data based. The researchers were able to utilize needs of basic research data, related research data, and suggestions and recommendations on the next phase.

3.2.2 Methodology

(1.) Related data had been collected by reviewing literature focusing on online research database, research search, and research retrievals to compare and contrast the information for reinventing a needs assessment form. Consequently, the form was a 5-rating scale which divided into 3 parts; 7 items on background information, 40 items on needs in design and system development, and open-ended question on needs, opinions, and suggestions. The needs assessment had been sent by post and personally delivered to 327 researchers from 78 organizations to assess.

(2.) The quantitative data had been collected from June–August 2018 and analyzed quantitatively in terms of frequency, percentage, average, and standard deviation to set system development criteria according to the needs. Further, the research proposal and the collected data by quantitative process was confidential and approved by the Center for Ethics in Human Research, Khon Kaen University following the Declaration of Helsinki and ICH GCP.

3.2.3 Findings

Synthesized result of researchers' needs on research for Southern development, collected the data from the needs assessment form (quantitative), the results were the overall of system needs on the system design and development was at a high level as ($\overline{X} = 4.11$), additionally, each needs item portrays the same result as it is at the high level. The first two highest needs item were related research information and basic research information, on the basic research information aspect, it was found that overall needs on system design and development was at a high level ($\overline{X} = 4.07$), further, there were 3 highest needs items as a research area search function, a research population search function, and a search function on research statement or research problem. And the related research information aspect, it was found that overall needs on system design and development

was at a high level ($\overline{X} = 4.15$), further, there were 3 highest needs items as a search function showing research area regarding the Southern province group, a search function showing related research regarding research references, and a search function showing research related to its area and a search function showing research summary.

3.3 Developing the Research Recommendation System for Southern Thailand Development (Phase 3)

Phase 1 (3.1) and Phase 2 (3.2) findings had been brought to conduct in phase 3 (3.3) which are (1.) Ontology development base on knowledge engineering to gather basic knowledge structures (2.) system development to construct the system according to the needs and concepts on user-centered design and system approach.

(1.) Ontology development base on knowledge engineering

(1.1) Underlying concepts: To develop ontology for the system it was designed as a knowledge structure. This development is from 2 domains; research aspects domain referring to knowledge related to the research for development of Southern Thailand and research work domain referring to knowledge related to the scope of the research for development of Southern Thailand into concepts, classes, sub-classes, also systematically categorizing hierarchy of classes and sub-classes. Protégé Ontology Editor version 5.5 beta had been used to develop the ontology.

(1.2) Ontology development procedure: Protégé Ontology Editor Software had been selected as a tool to transfer and store knowledge in terms of ontology and to effectively support semantic search system in terms of knowledge sharing and reusing. The procedure is as follows;

(1.2.1) Developing ontology; related research knowledge had been analyzed and studied for gathering structures and relationships in detail and getting some as representatives and defining clear scopes of the study and setting the node Is-a relationships; labeling nodes based on the multiple levels of a hierarchy after that considering the relationships which reconfirmed by cross-checking sided and top levels of the instance.

(1.2.2) Considering Role Part-of (p/o) relationships; they should be changeable in terms of property, objection, core, and sibling. And considering Role Attribute-of (a/o); they should be filled or uncountable. Reconfirming every concept; having role physical and object containing Role (Part-of). Defining each concept before relating to others, p/o (Object property) refers to concept on ontology and a/o (Instance) refers to Data on Database or Data type Property and Categorizing semantic group and concept group search.

(1.3) Ontology of the recommender system: The designed ontology had been exported as Ontology Web Language or OWL. The ontology design and development of the recommender system consist of 2 domains, 5 concepts, 42 classes, 214 sub-classes, and 54 properties.

(1.4) Ontology evaluation: Ontology evaluation is one of ontology development procedures since it helps tracking the process also reconfirming its reliability, validity, and accuracy. The concepts on scope determining, class, sub-class, concept defining, properties defining, instance defining, application, and future trends on ontology development were used to generate 5-rating scale ontology development evaluation form. The ontology had been evaluated by 5 experts in the following fields; knowledge engineering, computer science, and information technology, the findings it was found that; the overall ontology was at a high level ($\overline{X} = 4.21$), yet there were 4 high level items as Determining Scope), Application and future trends on ontology development, Defining Properties, and Defining Classes, Sub-class, Concept. There was only 1 highest level as Defining Instance ($\overline{X} = 4.60$).

(2.) Developing the recommendation system

The system and a part of knowledge base system was developed based on the findings from Phase 1 (3.1), Phase 2 (3.2) and phase 3 (from ontology development base on knowledge engineering step)

(2.1) Underlying theories

2 theories were adopted to develop the system as (1) System Approach: using a system to manage information as scoping problems or suggesting solutions. (2) User-Centered Design: exploring problems and user's needs and interests [22]. Moreover, phase 2 findings were used to design user interface. The steps on developing are as follows;

Step (1) Designing database: MySql was used to design a server and database and PHP was used to design the system interface.

Step (2) Mapping Database to Ontology: To enhance search ability Apache Jena API which is an open source map tool framework for semantic search was used to get information from database and create Resource Description Framework or RDF. Then, SPARQL (SPARQL Protocol and RDF Query Language) was used to search for information through the designed ontology and show search results on the system.

Step (3) User Interface: JavaScript, PHP, and CSS were combined to design a beautiful friendly-user interface.

Role of the recommendation system is to suggesting useful research information to users as analyzing then selecting the information systematically.

(2.2) The system functions

(2.2.1) Storing aspect; the system could store the following items;

(1) Research information (2) Researcher information (3) Research category, (4) Related research primary and secondary policies (5) Related research primary and secondary problems (6) Research related to Southern province groups.

(2.2.2) Processing aspect

(1)   It is a combined system of relational database and ontology.
(2)   To search for information it is convenient to choose primary and secondary requirements as discipline, policy, problems, statistics used, or research area.
(3)   Processing data with relational database and ontology leads to effective search and shows semantic search results according to the design ontology.
(4)   Systematic processing leads to fast semantic search.

(2.3) The system development procedure

(2.3.1) Transcribing ontology data into Ontology Web Language or OWL by Protégé Ontology Editor Version 5.5 beta.

(2.3.2) Creating a database to store all the collected data by using MySql Database. There were 38 tables created according to data relationships and relational database system.

(2.3.3) Mapping Database to Ontology in OWL by using Apache Jena API to draft RDF (Resource Description Framework). Then, SPARQL was used to search for information through the designed ontology and show accurate results. After connecting the database and ontology further steps were continued as follows (1.) Mapping Class Table (2.) Mapping Property Column; Data type Property and Object Property and (3.) Mapping Vocabulary between words of data in data table to class inside ontology knowledge base.

(2.4) The system evaluation findings.

The result was the system shows search result according to keyword and/or other conditions. Then, the system recommends related research regarding the keyword and/or conditions and the search results also show relate the policies, strategies, problems, needs of community, basic information, and relate research information. The system had been developed in accordance with users' needs and it was evaluated and used by 28 experts in various academic fields were asked to evaluate the system regarding (1) information presentation and report (2) user support (3) information search (4) support system (5) overall system and (6) the usefulness of the system. The 5-rating scale on satisfaction survey was delivered to the experts along with the system link. Moreover, the search effectiveness was measured by studying all keyword searches in accuracy, recall, precision, and F-measure to study practical solutions for the system.

The results on Accuracy, Recall, Precision, and F-measure of the system was found at a good level (0.70–0.88); Accuracy is 0.70, Recall is 0.78, Precision is 0.88, and F-measure is 0.82 respectively. And The user's overall opinions and satisfaction from evaluated form it was found at a high level ($\overline{X} = 4.14$), further, 2 items are at a high level; support system and information search. The least preferred items are user support and overall system.

4   Results and Discussion

(4.1) Needs analysis on the research recommendation system's design and development

It was found that 327 users who were researchers, scholars, administrators of 78 organizations shared 2 system needs aspects as basic research information and related research information. These needs were considered as basic data which users are able to collect, refer, summarize, and apply to their further studies as follows:

Needs on basic research information is at a high level since researchers could use this data on stating the problems. Moreover, researchers could make research plans more effective as setting goals, exploring population and research area. The data is crucial for budgeting and time frame. Therefore, it is better if users could gather basic research information in advance.

Related research information is at a high level as same as needs on basic research information. Users need more information, for instance, specific research areas in the Southern border Thai gulf or Andaman Sea, references, or abstracts. Once users could access to secondary or tertiary sources, it is possible for users to conduct more productive research also create research network and community for future development [24, 25]. Besides, gathering references and abstracts is value-added to research [23].

(4.2) Scope of knowledge on research for Southern development

The scope consists of systematic knowledge structure, knowledge sets, categories, concepts and classes related to Southern research, strategies, guidelines, and management policies. The knowledge structure will be applied to use as a framework on setting Southern research or relate research topics, trends, grants, information system development or database, other further studies [11]. It could be used to setting subject, phrase, or keyword in categorizing information [9, 16] also the system keywords could be used with other databases or search engines. And the ontology could be further developed as a tool on semantic search system which could relate various aspects [12] and show the result in one search, for example, primary and secondary research topics, disciplines, strategies, problems, and needs. Besides, the system is able to show search results on research methodology, data collection, population and target groups, research area, and research province group area.

(4.3) Research recommender ontology for Southern development

The ontology was developed according to research knowledge structure for Southern development and it covered all important research knowledge related to the Ninth National Research Policy and Strategy, the Twelfth National Economic and Social Development Plan and the 20-year National Strategy framework, and 3 departments of administration and strategy planning of Southern province group development framework. Underlying concepts of the ontology are in hierarchy shown as primary and secondary relationships [18–20]. Therefore, the structure is new and could be used as follows;

(1) It is reusable by adding classes, for instance, disciplines, strategies, policies, problems, or needs and (2) It is a prototype of ontology development in region or province level.

(4.4) The research recommender system for Southern development

The final version of the system is similar to semantic web which stores data, runs by ontology, shows search results as relationship sets of information [11, 12] for example, shows research that relate to problems and strategies, research data collection area, population and target groups, or research tools.

The highlight aspect of this research is not only scopes and body of knowledge regarding situations, needs, strategies, and policies of the South which reflect gaps and lead researchers to acquire systematic plans and solutions but also it is able to disseminate on further effective recommender system developments as reducing search procedures, redundancy, and costs.

Additionally, the research findings could be applied in terms of policy area and national strategies, for example, the body of research knowledge on tourism and agricultural development which is crucial for national economic and resource. The government could take the knowledge into account the research or tourism policies, agricultural production as Start-up: Smart tourism and smart agro technology that supports production capacity and business value of products and services, responds to needs and expectations of customers, enhances competition capacity in nation level, or applies as a part of solutions. Further, it could also enhance long-term learning community.

5   Conclusions

The findings on identifying needs phase helps researchers to develop the system accurately and flexibly according to the needs and user center design, therefore, the system could be a prototype for students, researchers, administrators, or interested users to access and study the system structure individually. This system was developed from systematic ontology which could distinguish relevant or irrelevant data, therefore, this leads to research effectiveness as decreasing research topic and budgeting redundancy, saving search time, suggesting relevant research information or trends, and enhancing further studies. The knowledge structure inside the system allows us to see relationships among research, policies, strategies, disciplines, and problems and needs of Southern people so that researchers or interested people could use this structure to explore future research trends or use it as a resource for current studies. And the system is practical since it stores research data, saves time, and is easy access. On the contrary, there are 3 limitations on this development. First, diffusion of the model in the future in changing regarding needs, strategies, policies, or plans. Second, dissemination of the system within government sections might take time. Finally, distribution platforms could be more various for users as phone application.

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