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Development of a Semantic Ontology for Knowledge of Ancient Lanna Documents

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ABSTRACT

This study is a research and development project aimed at developing a semantic ontology for ancient Lanna documents. It focuses on building a structured relationship of knowledge by analyzing information from various documents and databases, including the research database, the online information resource database (OPAC), the Northern Thai Information Center of the Chiang Mai University Library, the online information resource database of Rajamangalaphisek National Library, Chiang Mai, the online information resource database (OPAC) of the National Library of Thailand, the Office of Arts and Culture, Chiang Mai Rajabhat University, and the online database from Sirindhorn Anthropological Center. This research tackles inefficiencies in retrieving and managing information on ancient Lanna documents through the development of a semantic ontology. The aim is to enhance the organization, classification, and accessibility of these documents, thereby improving search capabilities and knowledge dissemination. The innovation of this research lies in the development and evaluation of a semantic ontology specifically tailored for ancient Lanna documents. This ontology facilitates more effective grouping, categorization, and retrieval of information, significantly enhancing access to and utilization of ancient knowledge. A key innovation of this research is the application of ontology and semantic web technologies to the study of ancient Lanna documents. The research presents a structured approach to developing and validating the ontology, utilizing tools like Protégé and involving expert evaluations to ensure accuracy and relevance. The research process is divided into three stages. Stage 1 involves determining the need for an ontology by analyzing online data and grouping related keywords and phrases through the study of various information resources, including digital collections of ancient Lanna documents. Stage 2 focuses on developing the ontology using the Protégé program, which involves designing classes, setting main classes, subclasses, hierarchies, and properties to create data relations within each class. Stage 3 encompasses the ontology assessment, which is divided into two parts: evaluating the appropriateness of the ontology structure by experts through a questionnaire on class correlation validity and assessing word grouping in ancient Lanna documents. The study's findings indicate that the identification of definitions, scope, and development objectives is appropriate (mean score = 0.88), with high scores in class grouping and ordering (score = 0.90), naming relationships and properties (score = 0.90), and the overall preciseness and appropriateness of the ontology development for ancient Lanna documents (score = 0.89).

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1. INTRODUCTION

The National Library is a major information institution housing a vast collection of ancient documents. Its objective aligns with Thailand's 4.0 policy, which aims to transform libraries into bookless institutions, enabling users to read and search for information through digital technology. The library offers search services across multiple databases, including the National Library of Thailand's bibliographic database, a digital library database, rare books, and electronic ancient documents [1].

The National Library's Digital Library (D-Library) contains over 10,000 full-text resources classified into 14 categories, such as rare books, old newspapers, ancient documents, local books, historical photographs, and national knowledge books. Ancient documents serve as historical records in the form of linguistic and textual artifacts created through traditional writing and drawing techniques. These documents preserve knowledge about Thai ancestors, national history, cultural heritage, literature, ethics, and moral values [2]. Furthermore, future generations can study cultural heritage as evidence for transmission to various groups of people nowadays, and it is also a product of the ancestors' wisdom that has been chronicled in writing in the form of books, manuscripts, and inscriptions. Ancient documents, which are recorded evidence and valuable academic documents, can be found in every region of Thailand. It is used as primary data for research on several topics as well as for documenting stationed in local areas across the country in the form of letters, and languages, and as evidence in history, literature, religion, art, and literature. Regarding a rare book, it is one that is distinctive in one or more characteristics, including physical characteristics such as book designs and printing materials, content specialties such as authorship and publishing purposes, and production characteristics and methods such as special typefaces, etc. The term "rare books" refers to older books that have been in print for a long time as well as newly published books that are considered valuable and rare in the future and that book collectors and libraries strive to preserve so that they can be used as reference documents for studies and research. Additionally, rare books are advanced research books that people desire to research. They are not commonly found in libraries and cannot be acquired through publishers or bookstores [3, 4]. The storage of ancient documents, including rare books, are maintained, and preserved at ancient sites, temples, local libraries, and university libraries, with higher education institutions and national libraries having the most [5, 6].

The preservation of ancient documents, including rare books, is maintained at historical sites, temples, local libraries, and university libraries, with higher education institutions and national libraries playing a significant role in their conservation [5, 6]. The Rajamangalaphisek National Library in Chiang Mai is the northern branch of the National Library, established to safeguard Thailand's wisdom heritage. It serves as a repository of ancient documents, rare books, and intellectual property and facilitates knowledge dissemination and preservation. This library is responsible for 14 provinces in northern Thailand, including Chiang Mai, Mae Hong Son, Chiang Rai, Nan, Phayao, Phrae, Lamphun, Lampang, Sukhothai, Tak, Phitsanulok, Uttaradit, Kamphaeng Phet, and Phetchabun [7].

Each institution's library selection includes criteria for determining and evaluating the value of rare books, which can be grouped into eight categories: 1) ancient and rare books that were printed in the era before humans could figure out how to typeset (rarity); 2) books that record each country's or region's printing history (local rarity); 3) limited edition books (limited editions); 4) books made as mementos for the auspicious occasion; 5) first edition book (first edition). 6) The book's prominence (reputation) as a specific work or a limited number of books that differ from the majority of the notable author's works and books are forgeries and fakes that are made, written, or produced with the intent of deceiving as the work of a famous author (Fakes and forgeries). 7) A book in decent condition or a beautiful book; and 8) A book has a history of ownership (provenance) that it belonged to previously, was the property of the library, or was purchased from a bookshop, as well as evidence that makes the history of book ownership known [3, 8-10]. According to the above-mentioned criteria for determining and evaluating the value of rare books, rare books have academic value in various fields of study, such as history, politics, and culture, and reflect the wisdom of the ancestors, the history, and the evolution of the country from the past to the present through the characters appearing in the book. Every rare book is precious; its charm resides in its antiquity, and it should be highly preserved [8, 10-12]. Nevertheless, rare books and ancient documents' accessibility remains highly restricted, and their usage and service are limited by the scope and context of these information providers.

Despite the significance of these historical documents, their accessibility remains highly restricted due to limitations in document management, classification, publication services, and search tools. Users face challenges in locating relevant information due to regulatory constraints, inadequate search systems, and the lack of standardized classification methods [13,14]. Ontology, as a structured framework, addresses these challenges by systematically organizing concepts, definitions, restrictions, and categorizations within a specific knowledge domain. By utilizing semantic relationships and linked data principles, ontology enables more precise retrieval of information and enhances the overall user experience [15-17]. The

application of ontology to ancient Lanna documents offers a solution for knowledge organization, supporting efficient search and retrieval through structured relationships among different document types, languages, and historical contexts [18], using the concept of grouping and segmentation to create hierarchical relationships [19-21]. The concept of knowledge organization includes a wide range of schemes established to support knowledge storage and retrieval. It is concerned with the retrieval of information within the library, Informatics Institute, and archives as well as the solution of issues in retrieving Lanna fabric knowledge using keywords that are technical terms or Lanna fabric terminology because Lanna fabric is known by many names in different parts of the world. Also, there is ambiguity with homophones in Thai. In some cases, spelling errors occur due to translation from one language to another [22]. For data collection and association in an ontological hierarchy, it is a semantic terminology used to describe specialized knowledge. It is a hierarchical group of words used to represent areas of interest and can be applied to a variety of systems, including information collection, document categorization, information extraction, etc. [23], [24]. The development of a semantic ontology of Lanna ancient document knowledge differs from the general use of keywords in search engine. An ontology, on the other hand, uses relations to describe all relevant information in each class of semantically related data structures. Placing all classes' relations across all dimensions allows one to study the relations in many different ways and compare or extract some characteristics that are similar in each data field.

According to the aforementioned problems, the researcher gathered the various knowledge found in the ancient documents of rare books to design and develop the ontology for retrieving information and knowledge of rare books in Lanna by integrating information according to the concept of ontology, which is a category of knowledge organization system that has a significant role in semantic explanations, in an attempt to establish a common understanding in a specific area of knowledge. Therefore, this study aims to design and develop an ontology for retrieving information from rare ancient Lanna documents. The knowledge management technology, various methods have been employed to address the development of domain-specific ontologies for retrieval, stemming from different knowledge sources. These methods fundamentally tackle three issues: 1) aggregating general terms used in domain description, 2) organizing terms to form a hierarchical relationship of classes, and 3) explicitly expressing all conceivable relationship constraints [25]. Similarly, in the development of Lanna document ontologies, the linkage of knowledge contained within Lanna documents can be demonstrated across different types of ancient documents. This study identifies or develops a terminology for representing knowledge that can be used as a semantic search base for the future development of a knowledge-based system and the semantic search system of a specific information system related to the knowledge of rare books of ancient Lanna documents.

2. LITERATURE REVIEW

Ontology is a term for representing knowledge and a tool for representing concepts and connecting semantic relations between them. As a result, ontologies can be employed to clarify specific knowledge as well as to integrate disparate knowledge to form a relationship. Furthermore, it can be used to search for information acquired through information extraction and can be integrated into a search system [26], [27] such as a document grouping system or the use of ontology technology to recommend food products.

Additionally, ontology has been employed in knowledge management, whether in agriculture, healthcare, tourism, ethnic groups, education, or law [28-31]. For example, there is research on the design of Thai rice ontology [29] that has a grouping of data that can define 3 classes of Thai rice ontology, namely: 1) characteristics 2) rice varieties 3) the source of production, and the knowledge of Thai rice ontology have been verified through retrieval and search efficiency measurements. According to research on the semantic data retrieval of palm-leaf manuscripts for use in retrieving old heritage in ancient documents [32], the following subjects were discovered in palm-leaf manuscripts: Astronomy 2919 items, Astrology 6794 items, Medicine 1286 items, Veterinary Science 146 items, Chemistry 166 items, Physics 326 items, Botany 8 items, and Architecture 599 items. Besides, rare book and manuscript research in libraries and professional organizations has addressed ACRL/RBMS storage standards as well as rare book lexicon formats [33], [34]. Based on the use of traditional medicine knowledge gained from traditional medicine textbooks and rare books, which has taken advantage of the wind illness guidance system [35], as well as research on Thai herbal medicines recorded in ancient documents. There are 12 main classes, namely: herbal medicine, pharmacy class, drug flavor class, drug preparation class, potion making class, drug use class, side effects class, caution class, spell class, disease class, people Class, and palm-leaf manuscripts class [36]. There is no correlation among all the data that can be used to retrieve related words contained in ancient documents or rare books in every research project. Only certain types of ontological associations are established in relation to retrievable terms, as summarized in Table 1.

3. CONCEPTUAL FRAMEWORK

The purpose of this research was to design, develop, and evaluate an ontology for information retrieval of ancient Lanna documents. The researcher

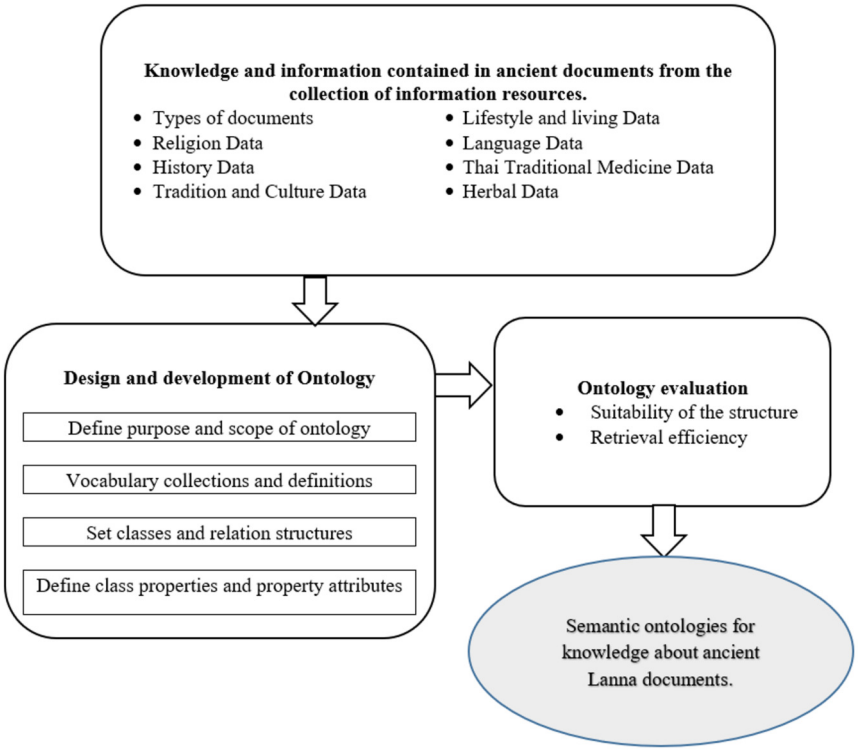


Fig.1: *Conceptual framework.*

Table 1: *Table Type Styles.*

Name	The creation of relations among groupings of knowledge in diverse domains			
	Data Segmentation	*Data Relation*	*Implementing Relations as a search system*	*Ontological Relations*
Mining the treasure of palm leaf manuscripts through information retrieval techniques	Yes	Yes	None	None
Rare Books and Written Documents: Libraries and Professional Organizations	N/A	Yes	Yes	None
The Development of the Wind Disease Recommendation System Using the Knowledge Base of Folk Medicine	Yes	Yes	Yes	Yes
Ontology Development for Thai Herbal Medicine Recorded in Ancient Documents	Yes	Yes	Yes	Yes

conducted the research according to the research conceptual framework as shown in Fig. 1.

4. METHODOLOGY

4.1 The concepts and theories of research

This study employs Ushold and King [37] method to ontology development, with the principle of domain ontology development serving as the primary framework for development in three steps as follows:

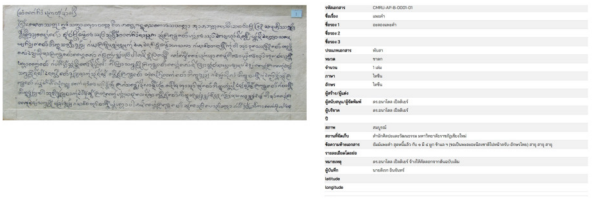
1) The task involves compiling transliterated ancient documents and analyzing their classification based on the criteria established by the National Library, which are recognized and aligned with international standards, as illustrated in Fig. 2 and 3. This process is closely tied to the purpose of ontology determination, which aims to study ontology requirements derived from online data sources, including keyword search data and grouped terms from research databases. These sources encompass the online information resource database (OPAC) of the Northern Thai Information Center at Chiang Mai University Library, the online information resource database of Rajamangalaphisek National Library in Chiang Mai, the OPAC of the National Library of Thailand, the Office of Arts and Culture at Chiang Mai Rajabhat University, and the online database from the Sirindhorn Anthropological Center. Through the examination of ancient documents from these repositories, the documents were systematically categorized based on the definitions and classifications of archival systems.

Following this, the metadata of the ancient documents were organized, and the relationships among these documents were established. These relationships were then analyzed using ontology in subsequent steps, ensuring a structured and comprehensive approach to understanding the historical, cultural, and contextual significance of the documents. This integrated methodology not only aligns with international archival standards but also enhances the accessibility and interpretability of the ancient documents for scholarly research and preservation.

2) The analysis of data organization was conducted based on the Dublin Core theory [55], wherein data was grouped according to content relationships using

(a) (b)

Fig.2: *Images from the National Library: (a) original manuscript, (b) transliterated version.*



(a) (b)

Fig.3: *Images from the ancient document database of Chiang Mai Rajabhat University: (a) original manuscript, (b) transliterated version.*

the thesaurus con RDF framework, as proposed by Lacasta et al. [56]. This process involved the creation of top-level classes and sub-classes, categorized according to the relationships among various aspects of the documents. These classifications included:

- Document type: Palm-leaf, stone inscriptions.
- Content: Religion, history, law, literature.
- Language and script: Lanna Tham script, Khom Lanna script.

This structured approach ensured a systematic organization of the documents, aligning with established theoretical frameworks and facilitating efficient retrieval and analysis.

3) Defining Relationships: The relationships between classes were explicitly established to create meaningful connections within the data. For instance:

- "Lanna ancient documents" written in "Lanna Tham script."
- "Palm-leaf manuscripts" pertain to "Buddhism."

These relationships were categorized into two main types:

1. Object Properties: These describe relationships between entities, such as "written by," "refers to," or "translated from."

2. Data Properties: These describe attributes or characteristics of entities, such as "creation date," "discovery location," or "script type."

4) Ontology development was developed by employing the Protégé program correlation structure to correlate terms and information included in documents related to ancient documents.

5) The ontology evaluation was separated into two parts: evaluating the suitability of the ontology structure by 5 experts using the correlation validity questionnaire (2 ontology experts) and evaluating the data of Lanna ancient documents (3 experts in ancient documents).

The ontology development process applied the ontology development approach based on the knowledge engineering methodology of Noy & McGuinness [38] as a framework for developing the ontology. The procedures are as follows: 1) define the ontologies' domain and scope; 2) define terminology; 3) define classes and class hierarchies; 4) define relationships; 5) define properties; 6) define a perspective of class properties; and 7) create sample data within that class.

4.2 Process of research development

The development of ontology in three stages:

Stage 1 Determine the ontology's objectives and scope in order to present a set of terms and concepts related to ancient Lanna documents for a total of 1,153 items from the research database, the online information resource database (OPAC), the Northern Thai Information Center of the Chiang Mai University Library for 687 items, the online information resource database of Rajamangalaphisek National Library, Chiang Mai for 50 items, the online information resource database (OPAC) of the National Library of Thailand for 5 items, the Office of Arts and Culture, Chiang Mai Rajabhat University for 31 items, and the online database from Sirindhorn Anthropological Center for 380 items. These are to analyze the phrases and use them in the design and development of ontology appropriately, along with the words that were used in structured interviews. Three experts on Lanna ancient documents have been interviewed and their knowledge transcribed in order to verify the accuracy of the information obtained from the process of analyzing the content, concepts, and terminology for the classification of knowledge (knowledge classification approach) of Brugton [21] from the document and preparing it as a system before proceeding to the next step.

Stage 2 From terminology collection in stage 1, ontology development consists of terminology grouping, defining a main class and subclasses, defining properties and characteristics of classes, and creating representative data within classes to define the values of terms and data attributes. The tool was the Protégé program that was used to design and develop the ontology, define main classes, subclasses, hierarchies, properties, and technical relationships between classes.

Stage 3 An ontology evaluation is intended to get verified the academic accuracy of the experts' assessments of the contents of the ancient Lanna documents and to allow for appropriate adjustment of the evaluation results. The ontological evaluation is divided

into two parts: the evaluation of Lanna terminology and the evaluation of class relations. The researcher led the Lanna ancient document terminology group in designing the structure and invited three Lanna ancient document experts to evaluate the relationship grouping's consistency. Two ontology experts evaluated classification, class relations, and class properties using methods to assess the validity, consistency, and suitability of the structure and vocabulary relationship through consistency determination. Following that, the researcher gathered expert recommendations, grouped them, and summarized the assessment results for future correction and improvement.

Research tool is the Protégé program. It is a free, open-source knowledge management system program created in 1987 by Musen and a team at Stanford University [39]. In addition, Obrst et al. [40] evaluated ontological evaluation guidelines, which consisted of: 1) the process of identifying the definition, scope, and objectives of the development 2) the process of defining the concept or class 3) the process of determining the properties of the class 4) the sampling or representative generation process, and 5) its application and future development suggestions. Data analysis, the researcher used data analysis by analyzing the index of congruence, or IOC (Index of Item Objective Congruence), with acceptable criteria and considered to be consistent or appropriate, i.e., scores from 0.5 and up, and if less than 0.5 points, they need to be improved [41]. The researcher obtained experts' analysis and advice, then gathered suggestions from three ontology and semantic web specialists, as well as three Lanna ancient document experts, for a total of five people. The researcher sought professionals who are qualified as academics or researchers in related fields and who have had continuous publication of research results, academic papers, or other works, or a person with a national or international reputation, or a person with experience in research or teaching in a related field. Evaluating the appropriateness of the technology framework by experts using an assessment of the accuracy of the relationship between classes and assessing the data grouping for Lanna ancient documents by Lanna ancient document experts regarding keyword search and keyword relationships. In cases where assessments from both sides of expertise are accurate and reliable.

5. RESULTS

The aim of the ontology development for information retrieval from Lanna documents is to design, develop, and evaluate the ontology for information retrieval from Lanna documents. The researchers grouped the research results into 3 parts, which are as follows:

5.1 The development of semantic ontology for knowledge about ancient Lanna documents

The result of the study revealed that knowledge about Lanna ancient documents can be divided into nine areas of knowledge, namely: 1) types of Lanna ancient documents; 2) topics; 3) recording format 4) use; 5) letter or character; 6) written language; 7) relevant location; 8) relevant ethnicity; and 9) wisdom types. These can be used to structure the knowledge of ancient Lanna documents, which can be divided into 9 main classes, 35 subclasses, and 61 subgroups. Examples of knowledge structures are shown in Tables 2 and 3.

Table 2: *Class Structure and Main Class Description of The Ontology of Ancient Lanna Documents.*

No.	Name	Description
1	Types of ancient Lanna documents	Thai book, palm-leaf manuscripts
2	Topics	Religion, arts and culture, way of living, pathology, astrology, history, architecture, literature, politics, government
3	Recording format	The use of natural materials, such as stone, Lan Ngern and Lan Tong inscription, Bai Lan, pattern, metal, Thai book
4	Use	Advantages or disadvantages of the ancient documents' records
5	Letter or character	Letter or character shown in representing data or texts on that document, such as Tai Khoen, Tai Lue
6	Written language	The language used to record in ancient documents such as Tai Yuan, Pali
7	Relevant location	The discovery place, storage place, place for ancient document
8	Written language	A group of people, an ethnic group that contributes to the record or is mentioned in ancient documents
9	Wisdom types	Knowledge, abilities, and skills arise from the accumulation of experience through the processes of selection, learning, and passing on to solve problems and develop a way of life that is balanced with the environment and suitable for each era

Table 3: *Ontology Design for Ancient Lanna Documents.*

No.	Main classes	Subclasses	Subgroups	Properties
1	Types of ancient Lanna documents	Thai book	Black Thai traditional book	A book made by making paper from various types of materials, such as Khoi bark, hemp bark, and mulberry bark
			White Thai traditional book	
			Khoi paper	
			Mulberry paper	
		Palm-leaf manuscripts	Palm-leaf manuscripts	Palm-leaf manuscripts, category, bind, bundle, recording format, letter writing, handwritten lettering
2	Topics	Law	Law	Law, prohibitions or regulations of people in society
			Prohibitions/Regulations	
		Archives	Myth	Ancient documents, myth, chronicles, history of the summary work of ideas
			Chronicle	
		Religious matters	Lanna script	Thai traditional books recorded in the Tham Lanna, the Khmer Thai, and the Pali language
		Myth/Tale	Myth/Tale	Name
				Story
		Chronicle	Chronicle	Lanna documents that mention city building, people groups, and immigration
		Royal ceremony	Royal ceremony	Information on documents mentioning ceremonies in the ruling class and governor
		Literature	Literature	Documents referring to folk songs, folk tales, and chants
		Warrants	Warrants	A document that issues an order from the ruler to the person who holds the position according to the schedule of ceremonial staff, state ceremonies, other ceremonies
		Literature	Literature	Importance and form of knowledge of literary arts in Lanna documents
		History	History	The history of each city, each ethnic group, and the importance and form of historical knowledge in Lanna documents
		Inscription	Inscription	Ancient Lanna documents written or engraved in the form of letters or pictures on stone, metal or clay
		Miscellaneous	Miscellaneous	General stories that are not clearly divided into categories of knowledge or write a general story
		Book	Astrology	Ancient Lanna documents on astrology, fortune telling
			Superstition	Ancient Lanna documents about superstition, magic, and the use of offerings
			Pathology	Lanna ancient documents on medicine, health treatment
			Mathematics	Ancient Lanna documents on mathematics, calculations, measurements of distance
		Religion/belief	Religion	Types of belief sectarian division Creeds and beliefs
			Sect	
			Creed	
			Belief	
3	Recording format	Inscription	Stone inscription	Writing inscriptions on various types of materials
			Lan Ngern inscription	
			Lan Tong inscription	
			Tinplate inscription	
		Writing patterns	Writing patterns	Writing with an ink, gold, and silk
		Writing	Writing	White pencil lines, black pencils, straight lines with yellow and gold lines

No.	Main classes	Subclasses	Subgroups	Properties
4	Use	Advantages	Advantages	The application of knowledge
		Disadvantages	Disadvantages	from ancient Lanna documents in both good and bad ways
5	Letter or character	Letter or character Thai traditional books recorded in the Tham Lanna, the Khmer Thai, and the Pali language	Tham Lanna characters	Lanna, Tai Khoen, Tai Lue, Tai Yai, Burmese characters
			Tai Khoen characters	
			Tai Lue characters	
			Tai Yai characters	
			Burmese characters	
6	Written language	Origin of languages	Thai Yuan	Origin of languages used for recording are Pali, Thai Yuan, Tai Yai, and Burmese
			Pali	
			Tai Yai	
			Myanmar	
		Origin of characters	Thai	Origin of characters used for recording are Thai, Sanskrit, Pali, Mon, Khmer, or others
			Pali	
			Sanskrit	
			Mon	
			Khmer	
			Others	
7	Relevant location	Discovery place	Discovery place	Records relating to the place of
		Important place	Name of place, province, district, location	discovery and places mentioned in documents located in Lanna or outside Lanna
8	Relevant ethnicity	Ethnic groups in Lanna	Ethnic groups in Lanna	Ethnic groups mentioned in documents located in Lanna or outside Lanna
		Ethnic groups in the non-Lanna region	Ethnic groups in the non-Lanna region	
9	Wisdom types	Agricultural wisdom	Agricultural wisdom	Classification of various aspects of wisdom appearing in ancient Lanna documents
		Economic wisdom	Economic wisdom	
		Religious wisdom, morality, ethics, values, beliefs	Religious wisdom, morality, ethics, values, beliefs	
		Wisdom in resource management and village development	Wisdom in resource management and village development	
		Wisdom in art	Wisdom in art	
		Environmental management wisdom	Environmental management wisdom	
		Language and literary wisdom	Language and literary wisdom	

Table 2 shows the main classes and explanations for dividing the main classes into nine classes, each of which has subclasses, subgroups, and properties to explain the relationship to the main class in detail. Table III depicts the division of the 35 subclasses, 62 subclasses, and 29 class properties.

Table 3 demonstrates the main classes and their subclasses as well as descriptions of the subclasses and properties to show the relationships after the design of the ontology and then establish the relationship with the Protégé program. An example of an ontology design showing the relationship between a main class and a subclass of an ontology is shown in Fig. 4-5.

5.2 The results of ontology evaluation for information retrieval of ancient Lanna documents

This research divided the evaluation into two sections: an expert evaluation of the ontology structure and an evaluation of the data analysis using a concordance index. The details are as follows:

1) An expert evaluation of the ontology's suitability of structure for information retrieval of ancient Lanna documents overall found that the ontology has a suitability of 0.93 by grouping classes within the ontology, ordering classes within an ontology, the name of the classes within the ontology, property names, relationships between classes, and names of relationships between classes. The validity of the ontology content and the ontology overview are suitable as 1.00, followed by classes of ontologies and class properties or attributes that are appropriate, equal to 0.66, respectively, as shown in Table 4.

Table 4: *The Results of Ontology Evaluation for Information Retrieval of Ancient Lanna Documents.*

Items	IOC	Results
1. grouping classes within the ontology	1.00	suitable
2. ordering classes within an ontology	1.00	suitable
3. classes of ontology	0.66	suitable
4. name of the classes	1.00	suitable
5. class properties or attributes	0.66	suitable
6. property names	1.00	suitable
7. relationships between classes	1.00	suitable
8. names of relationships between classes	1.00	suitable
9. accuracy and suitability of the ontology content	1.00	suitable
10. overview of ontology	1.00	suitable
Total	0.93	suitable

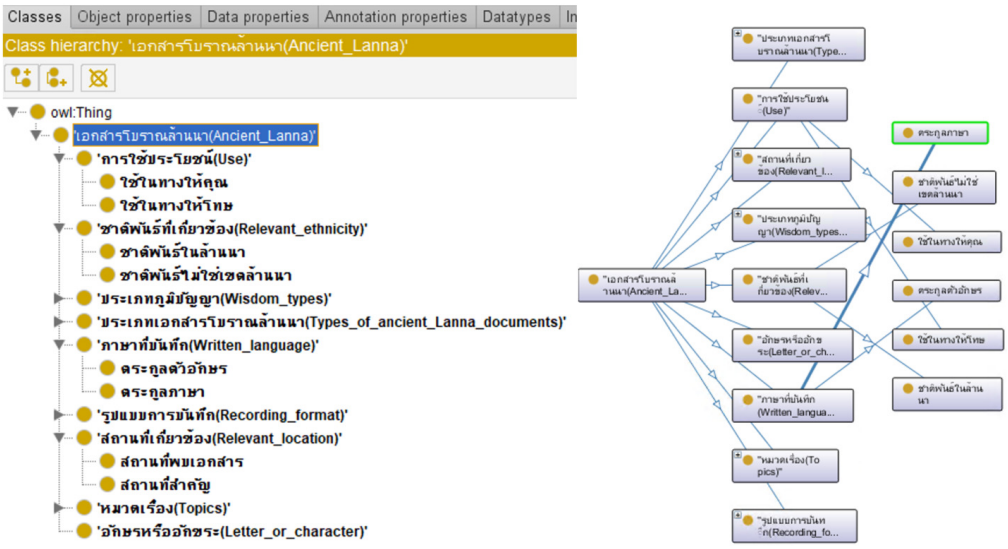


Fig.4: *Ontology design. (Thai language).*

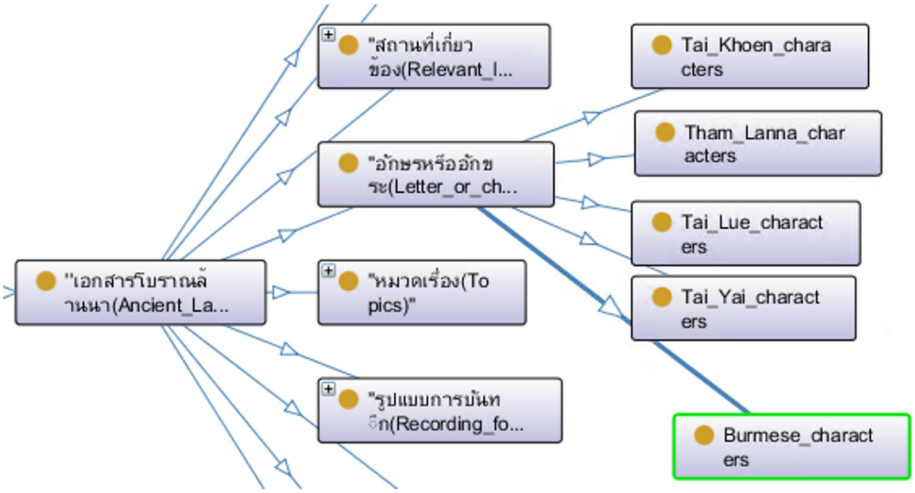


Fig.5: *Ontology relationship of main and subclass of ancient Lanna documents (demonstrated in the subsection of letter or character).*

2) The results of evaluation were obtained by finding the index of congruence, or the IOC (Index of Item Objective Congruence), and obtaining an acceptable mean score. If the value is 0.50 or higher, it means that the content is consistent and usable [42]. The evaluation by three experts in Lanna ancient documents is an evaluation of data analysis by finding the consistency index used for linking and grouping information about Lanna ancient documents. The overall evaluation found that the ontology structure is consistent with the definition value. The development scope and objectives show consistency (mean score = 0.89) in three areas: class naming, relationships, and properties (score = 0.88); class grouping and ordering within the ontology (score = 0.90); and accuracy and suitability of the overall ontology content (score value = 0.90), as shown in Table 5.

The results of the evaluation can be used to design classes, relationships between classes, and class properties within the ontology for information retrieval of ancient Lanna documents. This makes the developed ontology suitable for and consistent with the needs of data retrieval

6. DISCUSSIONS

The design of an ontology for information retrieval of ancient Lanna documents applies a classification structure of knowledge derived from a classification structure based on the knowledge found in the information resource and the expertise of a Lanna ancient document, which is based on the principle of grouping and includes the sub-elements of the knowledge of ancient Lanna documents, which cover all and reflect the contents of the ancient Lanna documents. For instance, this is in line with the study of Somprasertsri [43], which states that the process of document

Table 5: *Results of The Ontology Consistency for Retrieving Information From Ancient Lanna Documents.*

Items		IOC	Results
Relationships and class properties naming	1. The name of the class within the ontology	0.88	consistency
	2. Class properties or attributes	0.86	consistency
	3. properties name	0.89	consistency
	4. relationship between classes	0.89	consistency
	5. names of relationship between classes	0.86	consistency
Average of consistency		0.88	consistency
Grouping and ordering of classes within an ontology	1. Grouping classes within an ontology	0.92	consistency
	2. Ordering classes within an ontology	0.93	consistency
	3. Classes of ontology	0.86	consistency
Average of consistency		0.90	consistency
Accuracy and suitability of the ontology content	1. Accuracy and suitability of the ontology content	0.91	consistency
	2. Overview of ontology	0.89	consistency
Average of consistency		0.90	consistency
Total		0.89	consistency

retrieval based on document content uses the principle of graph association, the ordering of results from retrieval measurement, and results of document retrieval performance based on document content. According to Unnankat *et al.* [13] there was a problem in accessing information on ancient documents in terms of search tools, the use of catalog cards, and register books that users had used in the writing and inscription book at service rooms at the National Library of Thailand. Hierarchical structure analysis is used to group the details regarding the structure of the ancient Lanna documents as well as other factors such as retrieving and accessing Lanna fabric information sources in the upper northern region [22]. When it comes to sequencing, grouping, and knowledge-based retrieval, which consists of knowledge that comes from wisdom and culture, including religion, art, and cultural landmarks that can be applied to knowledge from other fields, there are various methods of accessing such information that depend on the structured relations of the retrieved information [44]. The ontology concept is a novel concept that reuses knowledge retrieval and assists in storage and retrieval in order to produce a tool to support the retrieval of knowledge of ancient Lanna documents. Moreover, several researchers have used the concept of ontology to help store and retrieve knowledge in various fields, such as the ontology of agricultural wisdom [45], [46] and the development of ontology for a dietary recommendation system based on personalized nutrition [29], [47]. Therefore, the ontology idea allows service users to obtain and access particular knowledge in an accurate and comprehensive manner.

In the final step, the researcher synthesized a guideline derived from the conceptual process of studying the knowledge of ancient Lanna documents, yielding a model of a semantic ontology of knowledge about ancient Lanna documents that can use the concept of ontology as a data source and retrieve information using the SPARQL language rather than a relational database system. According to Nithiyuwit with Treenuntharath [48] and Idrissi *et al.* [49]. The development of a robust ontology through the establishment of relationships among primary classes, subclasses, and various properties of ontology components can be effectively applied to the construction of retrieval systems using SPARQL language, as demonstrated by studies Majeed *et al.* [52], Patel *et al.* [53] and Bangkhomned *et al.* [54].

7. CONCLUSION

This study focuses on the development of an ontology for knowledge retrieval from ancient Lanna documents. The research follows a structured methodology comprising three stages: requirement identification, ontology development, and ontology evaluation.

Stage 1: Determining Technology Requirements

This involves establishing the objectives and scope of knowledge extraction from terms and content associated with Lanna ancient documents from the research database, online information resources database (OPAC), Northern information from the library of Chiang Mai University (687 items), online information resources database of National Library Rajamangala Chiang Mai (50 items), from the National Library's online information resources database (OPAC) (5 items), from the Art and Cult database (100 items), and from the National Library's online information resources database (OPAC The resulting word groups are then used in the design and development of the technology. They are formed into Ontology after categorization. The information is then evaluated by three specialists in ancient Lanna documents and technology. The results indicated that the Ontology is 0.93 suitable. The classification of classes within the Ontology, the ranking of classes within the Ontology, the names of classes within the Ontology, the properties, the relationships between classes, the terms of relationships between classes, the correctness and suitability of the Ontology's content, and the overview of the Ontology are

all appropriate. Following these are the classes and properties or attributes of the classes, each of which has a suitability of 0.66.

Stage 2: Development of Ontological Knowledge about Lanna Ancient Documents

This phase entails research to develop Ontological knowledge regarding ancient Lanna documents, utilizing a program to develop the Ontology structure. The outcome is nine categories of information regarding ancient Lanna documents. 1) Ancient Lanna documents from materials such as Toothbrush tree bark, Jute tree bark, and Paper mulberry tree bark share characteristics with Thai books made from these same substances. The attributes include scripture, binding, recording, inscribing, and writing. 2) Subjects include knowledge groups about law, prohibitions, or social rules that penalize various characteristics, ancient documents, legends, chronicles, operational reports, dialogues, and summaries of differing opinions, Thai books recorded in Lanna Dhamma and Khom Thai characters, Pali language, titles, and stories. Lanna documents mentioning city building, ethnic groups, relocation, information in documents about various ceremonies in the ruling class, city owners, regional rulers, mentioning folk songs, local tales, playing songs, documents of orders from the rulers to those in position to do or not to do as scheduled, officials conducting royal ceremonies, state ceremonies, various ceremonies, the importance and forms of knowledge in the field of literature in Lanna documents, history of each city, each ethnic group, the importance and forms of knowledge in history in Lanna documents, Lanna ancient documents written or inscribed as characters or images on stone slabs, metal or clay, general stories that do not clearly separate knowledge categories or write general stories, Lanna ancient documents on astrology, prediction, horoscope, Lanna ancient documents on occultism, magic, use of worship items, Lanna ancient documents on medical science, treatment, health, and Lanna ancient documents on mathematics, calculation, distance measurement. 3) Recording formats feature various types of inscriptions or writing on various content materials, including writing ink lines, gold-coated lines, gold silk lines, white pencil lines, black pencil lines, bell lines, yellow lines, and gold lines. 4) The advantages of applying knowledge from ancient Lanna documents. 5) Characters or character groups consist of Lanna, Tai Kheun, Tai Lue, Thai Yai, and Burmese characters or character groups. 6) The recorded language is a language family used for recording in Pali, Thai, Thai Yai, and Burmese. Thai, Sanskrit, Pali, Mon, and Khmer are the character families used for recording. 7) Related locations have historic properties related to the discovered location, and the locations mentioned in the documents are in Lanna or outside the Lanna area. 8) The documents in Lanna or outside of Lanna contain information about the nationality of the related nationality. 9) Type of wisdom has classified various aspects of wisdom that appear in Lanna ancient documents; this classification can be used to organize the knowledge structure of Lanna ancient documents. It is divided into 9 primary classes, 35 subclasses, and 61 minor groups.

Stage 3: Ontology Evaluation

At this stage, the semantic ontology evaluation of knowledge about ancient Lanna documents is performed, dividing the evaluation into two parts: an evaluation of the structure by ontology experts and an evaluation of data analysis by experts in ancient Lanna documents by looking for consistency index. 1) The result of the evaluation of the appropriateness of the ontology structure for the retrieval of information from ancient Lanna documents was appropriate (0.93), and 2) the result of the evaluation of the consistency analysis of the content was consistent and usable. The average score for the development's definitions, scope, and objectives was 0.89, indicating that the ontology structure was consistent overall.

In addition, the research discovered that the semantic ontology of knowledge about ancient Lanna documents is derived from the integration of knowledge in various disciplines of group organization to link the knowledge of the tools used in recording, knowledge about geography and places that appear in ancient Lanna documents, and the history of Lanna. Therefore, ancient Lanna documents cannot be defined as a single body of knowledge. Thus, the knowledge of ancient Lanna documents demonstrates the linkage of knowledge content in various dimensions, connecting dispersed knowledge in classes and various knowledge groups by defining semantic relationships, and can be used to determine search terms or controlled vocabulary used to explain knowledge and knowledge relationships, presenting as knowledge categories [50, 51], by developing a linkage system of relationships using ontology methods.

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AUTHOR CONTRIBUTIONS

Conceptualization, P. Julrode and P. Jarusawat; methodology, P. Julrode; software, P. Julrode; validation, P. Julrode and P. Jarusawat; formal analysis, P. Julrode; investigation data, P. Julrode and P. Jarusawat; data curation, P. Julrode; writing-original draft, P. Jarusawat; preparation, P. Julrode and P. Jarusawat; writing-review and editing, P. Julrode and P. Jarusawat; visualization and ontology creation, P. Julrode. All authors have read and agreed to the published version of the manuscript.

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