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Herb and Medicinal Properties Information Services with AI and NLP

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Abstract

The objectives of this research are: 1) to gather information on the properties of herb plants from the herb garden of Plak Mai Lai Temple, located in Tung Kwang subdistrict, Kamphaeng Saen District, Nakhon Pathom, and 2) to develop and evaluate the efficiency of an information system for herb and medicinal properties. The system utilized artificial intelligence (AI) based on natural language processing (NLP) concepts. The research methodology comprises the development of research tools, an experiment tool, and subsequent analysis and evaluation. The experiment tool is an information system designed according to system development life cycle, and hosted on the Apache web server. The user interface was created using HTML5, CSS and Bootstrap, with data management handled by jQuery and AJAX. The responsive web application is linked to a MySQL database through PHP scripts. Data collection tools include a system performance evaluation form and a user satisfaction form, both of which successfully passed an assessment conducted from two panel of five experts.

The findings of the research are as follows. Through the survey and data collection of herb and their components properties from 508 herb plants found in the Plak Mai Lai Temple herb garden spanning within an area of 92 rai, 1 ngan, 97 square wa (approximately 156,800 square meters), along with the analysis of 373 cases containing sentences describing symptoms, the accuracy of NLP concepts was determined to be 82.35 percent. Regarding the performance evaluation of the information system for herb and medicinal properties utilizing AI based on NLP concepts: 1) the overall performance was rated at the highest level ($\bar{X}$ = 4.68, $S.D.$ = 0.47), and 2) the overall satisfaction also scored at the highest level ($\bar{X}$ = 4.70, $S.D.$ = 0.50).

Keywords: information service, herb, medicinal property, artificial intelligence, natural language processing, AI

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1. Introduction

According to the national strategic plan for Thai wisdom development, Thai-style healthcare, issue 3, and the national master plan for Thai herb development, issue 1 (B.E. 2560-2565), Thai traditional medicine, folk medicine, and alternative medicines were designated as primary services running paralleled to modern medicine in creating wellness. Moreover, the benefits of Thai herbal products and services were widely promoted to enhance competitiveness in both Thai and international markets. As people trust and recognize the advantages of herbal usage, the wisdom of Thai herbal medicines will be safeguarded and preserved [1][2].

During the COVID-19 pandemic, there has been a notable surge in the popularity of herbal medicines, particularly for alleviating basic symptoms and providing fundamental treatments. Nevertheless, the lack of knowledge on the usage of herbal medicines can potentially lead to harmful or side effects. Therefore, it is crucial to exercise caution when selecting herbal remedies, ensuring that the chosen herbs are suitable for addressing specific symptoms [3].

Nowadays, AI is becoming increasingly integrated into information services, facilitating effective user communication. NLP stands out as one of the most widely used AI technologies for enabling interactive communication. Through machine learning, AI is trained to comprehend conversations and frequently asked questions, enabling it to automatically and efficiently provide users with the most relevant information. Consequently, this leads to the generation of faster and more convenient services.

Hence, the researchers conceived the idea of developing an information system for herb and medicinal properties, utilizing AI based on NLP concepts. The goal is to facilitate the transfer of knowledge on various herbs, including their properties, benefits, and potential risks of misuse. For this purpose, we incorporated information from the Plak Mai Lai Temple herb garden in Nakhon Pathom, along with insights from experts and traditional healers well-versed in medical plants, as documented in the daily use memos.

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Accessible through the Internet, this platform allows people to conveniently explore and inquire about this information. Not only does it serve as a source of knowledge and understanding of their significance, but it also empowers users to make informed decisions about the use of herbs.

2. Materials and Methods

2.1 Objectives

2.1.1 Collecting property information for herb plants located in the herb garden of the Plak Mai Lai Temple, Tung Kwang Subdistrict, Kamphaeng Saen District, Nakhon Pathom, Thailand.

2.1.2 Developing and assessing the efficiency of an information system for herb and medicinal properties, employing AI based on NLP concepts.

2.2 Reviews of literature and related works

2.2.1 Natural language processing (NLP) facilitates computer comprehension of human languages by converting communication languages into interpretable structures that can be processed. The five key stages of NLP are as follows: 1) Morphological analysis: This involves analyzing words based on their constituent meaningful parts. 2) Syntactic analysis: Here, the structure of the given sentences is identified, determining whether they function as subjects, verbs, objects, or phases to convey logical meaning. 3) Semantic analysis: This process entails extracting meaning from texts that might have correct syntax but could be ambiguous, nonsensical, or impossible. 4) Discourse integration: Considered within the broader context of nearby sentences, this stage examines how some texts relate to previous or subsequent sentences. 5) Pragmatic analysis: This phase involves reinterpreting the true meaning of sentences [4] [5] [6]. NLP is closely linked to text analytics, which entails classification and categorization to automatically extract meaning and identify structures with in large volumes of data. Text analysis is a technique used to explore data sets in text format, defining new and previously unseen variables from the data.

2.2.2 The Thai text structure theory emphasizes the elements of consonants, vowels, tone marks, and their associated meanings. Thai sentences adhere to a distinct language rule where words are arranged in the order of subject, verb, and object. Texts commonly comprise a series of multiple sentences. Grammatical relations in Thai for forming sentences include: 1) Word order relationship: This refers to the arrangement of words to form phrases or sentences according to language rules, creating meaningful sentence structures. Word order follows syntax rules based on word categories, such as subject (actor), verb, and object (undergoer). 2) Grouping relationship or hierarchical relationship: This involves organizing words in interconnected sentences and segmenting words into related subgroups to construct a cohesive grammatical structure [7].

2.2.3 During model testing and performance evaluation, a test set was utilized to assess algorithm efficiency. The results were presented in the form of a confusion matrix table, outlining a positive class pertaining to the interested class and a negative class representing the non-interested class. Accuracy is expressed as a percentage of correct predictions compared to the entire predicted data set [8], calculated using equation (1).

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN} \tag{1}$$

In the evaluation of data classification performance, various standard criteria are incorporated for accurate measurement and assessment. This included the True Positive Rate, also known as Recall which is determined by the number of true positives divided by the sum of true positives and false negatives, as depicted in equation (2).

$$\text{Recall} = \frac{TP}{FN + TP} \tag{2}$$

The True Negative Rate, also referred to as Specificity, is the ratio of genuinely negative samples that yield negative results. It is determined by dividing true negatives by the sum of false positives and true negatives, as illustrated in equation (3).

$$\text{TNR (True Negative Rate)} = \frac{TN}{FP + TN} \tag{3}$$

Precision refers to the closeness of measurements to each other, or the ratio of correct positive predictions out of all positive predictions made as shown in equation (4), where precision equals true positive divided by the sum of true positives and false positives.

$$\text{Precision} = \frac{TP}{TP + FP} \tag{4}$$

When True Positive (TP) is the number of cases correctly identified positive. The model predicts positive and it is actually positive.

True Negative (TN) is the number of cases correctly identified negative. The model predicts negative and it is actually negative.

False Positive (FP)is the number of cases incorrectly identified positive. The model predicts positive, but it is actually negative.

False Negative (FN) is the number of cases incorrectly identified negative. The model predicts negative, but it is actually positive.

2.2.4 Related works

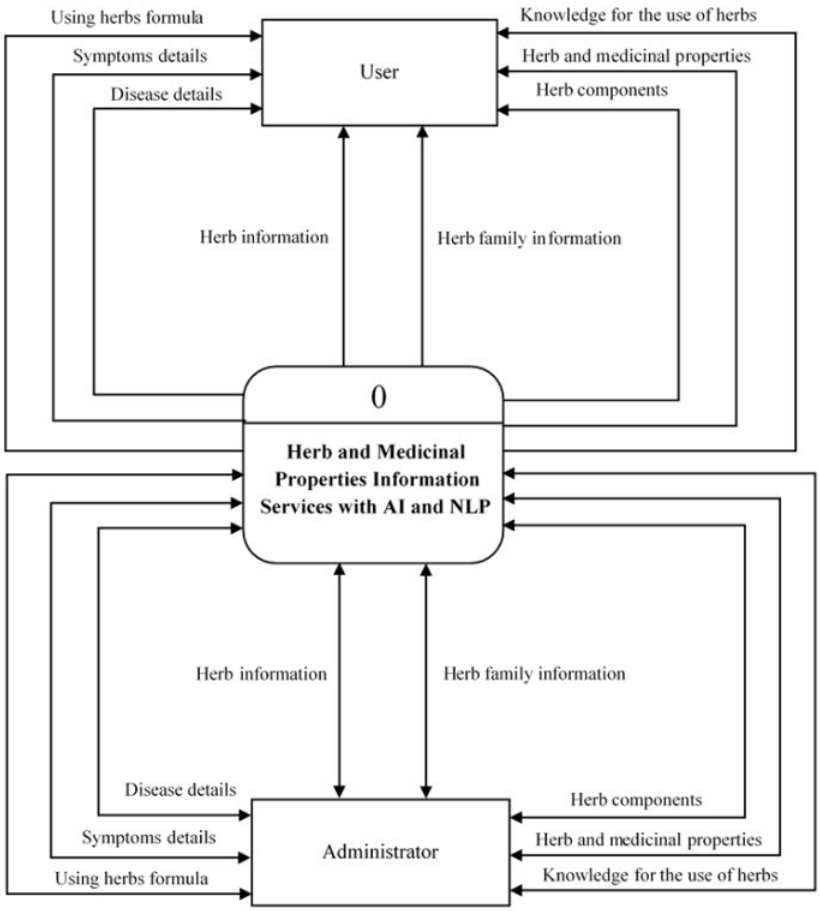

Figure 1: Data Flow Diagram

1) Research on the collection of herbs and their properties has revealed their utilization as both food and treatments for various symptoms, contributing to health nourishment [9]. The influential factors guiding the use of herbs in healthcare include access to herbs, media literacy concerning herbs, knowledge and comprehension of herbs, communication skills in selecting herbs, decision-making skills in choosing appropriate herbs, self-management in herb selection [10], attitudes, perceptions, access to health services, and the realization of the advantages of herbs in fundamental healthcare, thereby reducing reliance on the costs associated with modern medicines [11]. However, only a small fraction of the population possessed knowledge about the use of herbs. Thus, the dissemination of herbal knowledge in healthcare can empower individuals to make informed choices in their self-healing journey [12].

2) Research focusing on the development of information service systems using AI has highlighted the creation of a management system for medicinal plants and their properties. This was achieved by implementing concepts from the system development life cycle and conducting system performance evaluations [13]. Furthermore, automatic Thai text classification using machine learning, coupled with NLP, involved the extraction of extensive data from the Internet, followed by thorough data analysis and computer processing. However, the complexity of Thai language processing, owing to intricate sentence structures and syntax, necessitates the analysis of its language structure, the implementation of Thai text classification, and the storage of machine learning data for future applications [14]. Configuring variables and operations in the NLP model has been instrumental in enhancing accuracy [15]. Thai sentence examination by NLP techniques is swiftly validated by subjecting sentences or texts to a pre-processing phase. This involves word tokenization, the removal of duplicate words and gaps, and the identification of nouns and classifiers to ensure precise information retrieval [16]. The process of tokenizing words from main sentences involves grouping alphabets, vowels and tone marks to form words, which are then compared to keywords in databases [17]. Following the extraction of meanings through NLP, the system can present data in textual, pictorial and video formats alongside providing links to related resources [18] [19]. NLP finds practical application in the healthcare domain by establishing connections between symptom data and corresponding treatment data [20] [21].

From the literature review, it can be indicated that

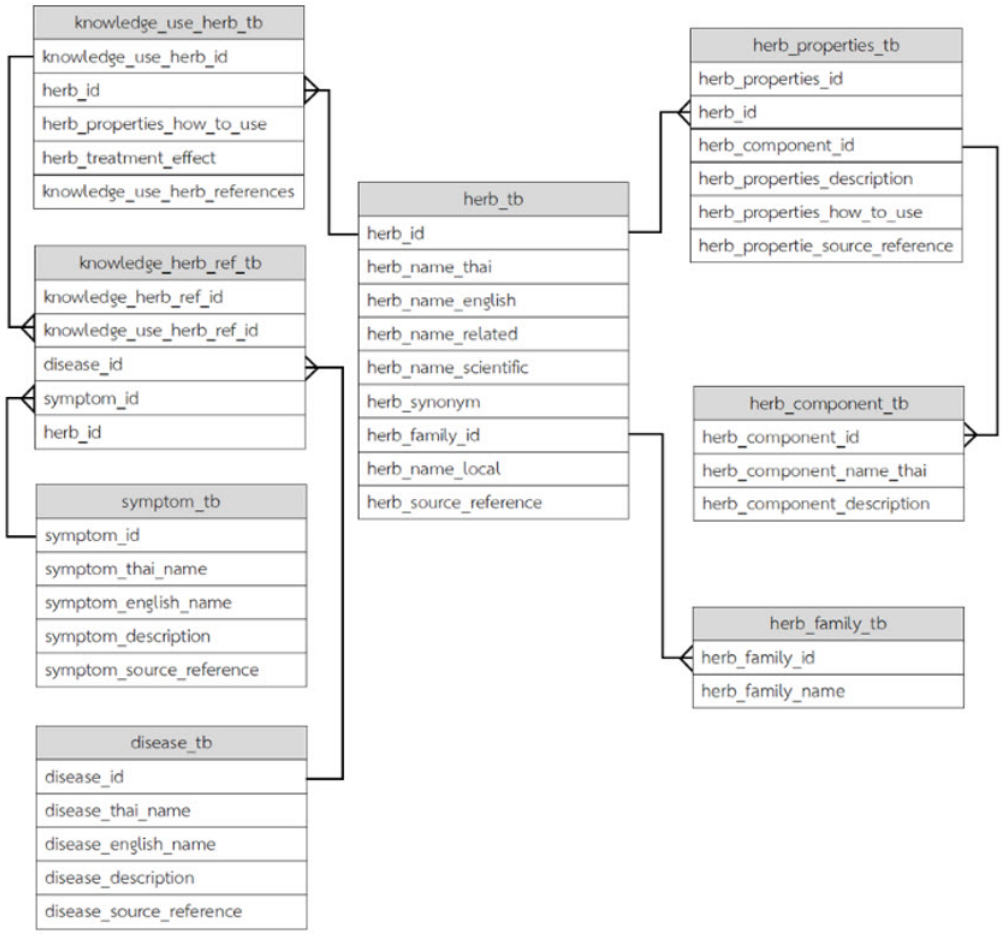

Figure 2: Data Flow Diagram

Thais widely use herbal remedies for self-care. Providing information services about herbal plants and their medicinal properties is crucial, and it has been observed that the use of AI can effectively facilitate human communication and automated services. Furthermore, Thai people use Thai language as their primary means of communication. The application of Thai language in the context of herbal plant information and medicinal properties is still relatively limited. Consequently, researchers propose the integration of AI based on NLP concepts to provide information services on herbal plants and their medicinal properties, aiming to meet the growing demand for such information services in the future.

3. Research Methodology

3.1 Research tool

The research tool is an information system for herb and medicinal properties, employing AI based on NLP concepts. It has been developed using PHP, jQuery, JavaScript, HTML, CSS, Bootstrap, and Ajax, and integrated with a MySQL database. The data collection tools comprised a system performance evaluation form and a user satisfaction form.

3.2 System development

The proposed system was developed according to five steps of System Development Life Cycle (SDLC).

1) Investigation and collection of medicinal plants from the Plak Mai Lai Temple herb garden, Tung Kwang subdistrict, Kamphaeng Saen District, Nakhon Pathom were conducted to gather information about their medicinal properties. The requirement definition was identified, which included herb data, parts of herb with their medicinal properties, and medicinal properties with their related treatment power. Information was gathered from various reliable documentation and online sources [22].

2) Analysis and design of the information system for herb and medicinal properties were conducted using AI based on NLP concepts as depicted in the data flow diagram (DFD) and Entity Relationship (ER) diagram in Figure 1 and Figure 2.

3) Development of the proposed information system.

3.1) Development Tools were as follows:

3.1.1) The information system development tool was Sublime Text 3.

3.1.2) The web server service was Apache server.

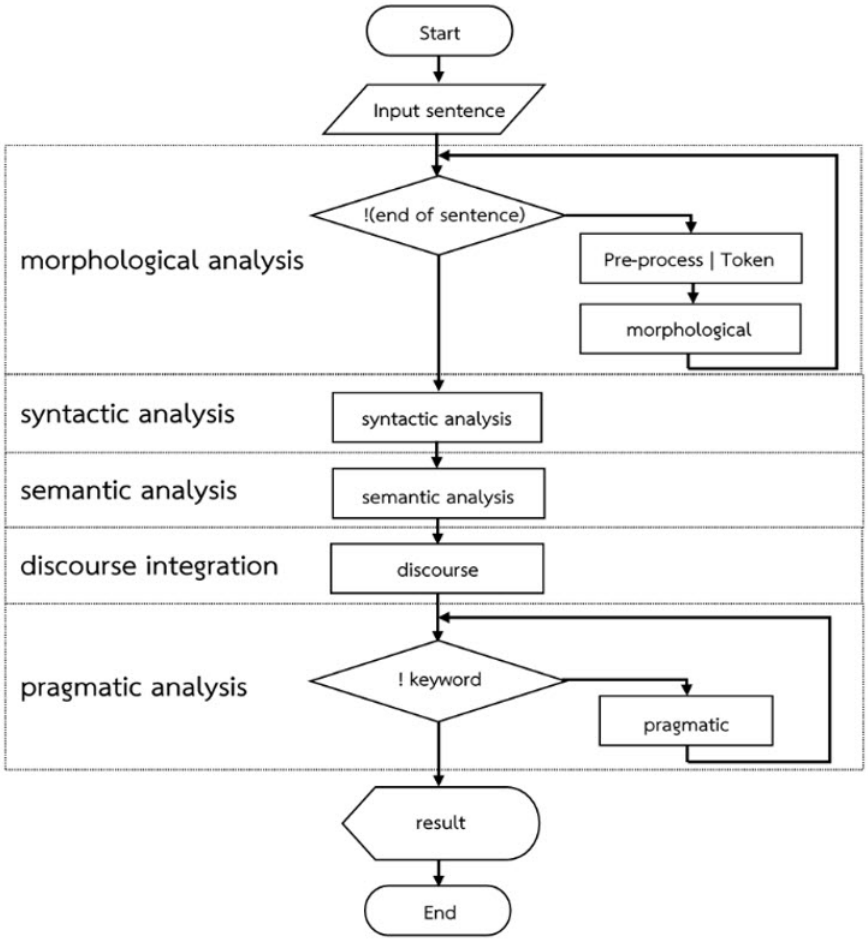

Figure 3: NLP concept

Table 1. System testing results

System testing	Result
Administrator identification to access the system	passed
Medicinal plant properties data management through database operation including insertion, updating, deletion, and viewing data	passed
Frequently asked questions and answers of herbs and their medicinal properties data management through database operation including insertion, updating, deletion, and viewing data	passed
Medicinal properties of herb search using web applications connected to the Internet	passed
Question and answer services on web applications, using AI for herb medicinal properties, connected to the Internet	passed
The processing of herb and medicinal properties information service, based on AI, enables the retrieval of medicinal plant properties according to users' needs	passed

Table 2. Examples of herb medicinal properties

Herb	Components of Herb	Properties
Acacia tomentosa	Root	Snake venoms counteracting
Indian gooseberry	Fruit	Diuretic and phlegm-expelling
Naringi crenulata	Leave	Epilepsy healing
	Root	Intestinal disease healing
Crinum	Tuber	Laxative
	Seed	Menstruation healing
Soap Pod	Root	Anti-inflammatory
	Flower	Tendon deformation
Chebulic	Overripe fruit	Cough and vomit healing
	Crust	Heart nourishment
Mulberry	Leave	Cough and sedative healing
	Fruit	Kidney caring and throat soothing

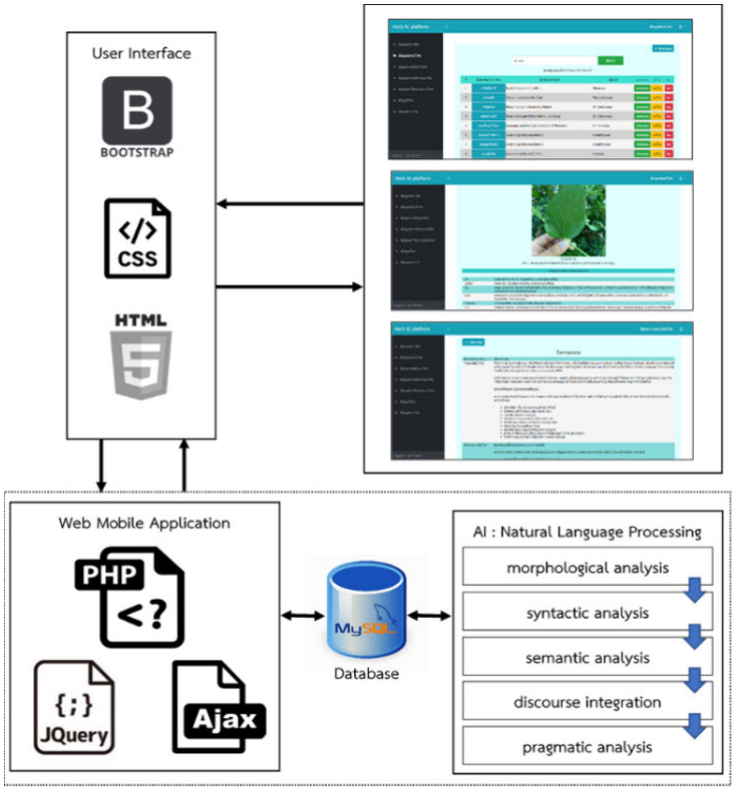

Figure 4: System architecture of the information system

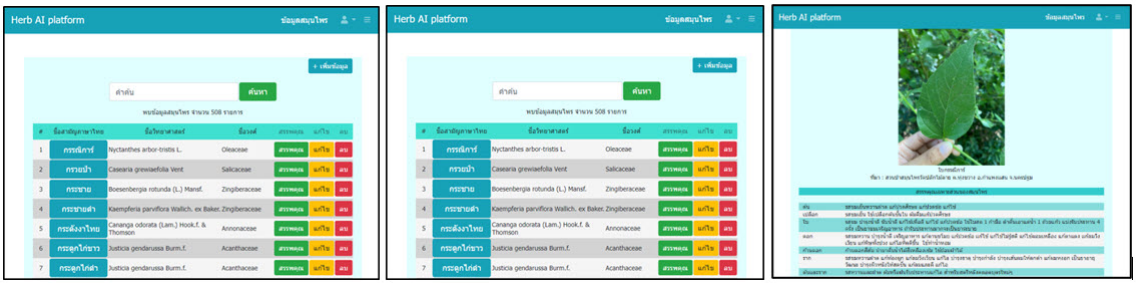

Figure 5: Results from the development of the proposed information system

3.1.3) The database management tool was phpMyAdmin, providing access to MySQL database.

3.1.4) The system development languages and techniques included PHP, Bootstrap, jQuery, Ajax, CSS, and HTML5.

3.2) System development process

3.2.1) Install and configure the web server.

3.2.2) Install and create the database, and define users' rights and authentication.

3.2.3) Utilize HTML5, CSS, and Bootstrap to design and develop the user interfaces.

3.2.4) Use PHP to develop the web application that connects to the database.

3.2.5) Utilize jQuery along with Ajax to develop parts that automatically reload data.

3.2.6) Convert herbs and their properties data into the digital form and import them into the information system for medicinal plant and medicinal properties information services using AI based on NLP concepts.

The system architecture of the information system depicted in Figure 4 illustrates that the herb data, along with reference data, was imported to the system via the user interface developed using HTML5, CSS, and Bootstrap. The web application, constructed using PHP, jQuery, and Ajax, facilitated the connection to the database. Furthermore, data retrieved from the database could be visualized on the geographic map by integrating the system with the Google Map API.

The NLP concept utilized in this research involves five fundamental steps, including morphological analysis, syntactic analysis, semantic analysis, discourse integration, and pragmatic analysis, as illustrated in Figure 3.

The system architecture, depicted in Figure 4, showcases the information system of herb and medic-

Table 3. Results of the System Performance Evaluation

	Performance issues	$\bar{x}$	S.D.
1	**Functional requirement**	**4.72**	**0.40**
1.1	Ability to access the database system	5.00	0.00
1.2	Ability to insert data	4.80	0.45
1.3	Ability to update data	4.40	0.55
1.4	Ability to present data	4.60	0.55
1.5	Correctness of database	4.80	0.45
2	**Functional accuracy**	**4.72**	**0.49**
2.1	Accuracy on data classification	4.60	0.55
2.2	Completeness on insert data	4.80	0.45
2.3	Completeness on update data	4.80	0.45
2.4	Completeness on present data	4.60	0.55
2.5	Overall completeness	4.80	0.45
3	**Usability**	**4.68**	**0.51**
3.1	Convenient to use	4.80	0.45
3.2	Appropriateness of screen design	4.60	0.55
3.3	Clarity of text on screen	4.60	0.55
3.4	Ease of understanding data	4.80	0.45
3.5	Overall usability	4.60	0.55
4	**Performance**	**4.64**	**0.51**
4.1	Web link loading speed	4.80	0.45
4.2	Database connection speed	4.60	0.55
4.3	Storing or updating data speed	4.40	0.55
4.4	Presenting data speed	4.80	0.45
4.5	Overall speed	4.60	0.55
5	**Security**	**4.63**	**0.46**
5.1	Right and permission	4.80	0.45
5.2	Network security	4.80	0.45
5.3	Data access security	4.80	0.45
5.4	Accuracy of user right control	4.60	0.55
5.5	User right and permission verification	4.20	0.45
5.6	Virus and intruder protection	4.20	0.45
5.7	Supporting requirement and application	4.80	0.45
5.8	Consulting and problem esolution	4.80	0.45
	Overall performance	**4.68**	**0.47**

Table 4. Evaluation results of the model

Diagnostic	Value
Sensitivity	77.47%
Specificity	83.91%
Accuracy	**82.53%**

Table 5. User general information

General Information	Quantity (persons)	Percentage
Gender		
Male	28	52.83
Female	25	47.17
Total	**53**	**100.00**
User type		
People	12	22.64
Student	38	71.70
Teacher/Professor/ Academic officer	3	5.66
Total	**53**	**100.00**
Age		
Less than 20 years	29	54.72
20 - 29 years	19	35.85
30 - 39 years	3	5.66
40 years or upper	2	3.77
Total	**53**	**100.00**
Education level		
Lower than bachelor degree	37	69.81
Bachelor degree	11	20.75
Master degree	2	3.77
Higher than master degree	3	5.67
Total	**53**	**100.00**

inal properties. It employed AI based on NLP concepts. This architecture illustrates that user input sentences are imported from a user interface that has been developed by HTML5, CSS, and Bootstrap. These sentences were then connected to the database in a web mobile application format, which has been created using PHP, jQuery, and Ajax. These sentences were further analyzed by the system based on the NLP concept.

4) System testing involves evaluating the information system to provide herbal and medicinal information services through AI, based on NLP principles. The testing was divided into two parts: subsystem testing and integrated system testing. The system testing was considered ”passed” when the subsystem testing was able to function as specified. The test results and system usage testing results are presented in Table 1.

5) Implementing and maintaining the information system of herb and medicinal properties information services using AI in line with testers' recommendations, and launching the system via the Internet.

3.3 Analysis and Evaluation

Likert's five-level rating scale was utilized for the evaluation of system performance and user satisfaction. Mean ($\bar{x}$) and standard deviation (S.D.) are were calculated and the results are were interpreted based on the specified levels [23].

Table 6. Results of users' satisfaction

	Satisfaction issues	$\bar{x}$	S.D.
1	**Information system usage**	**4.75**	**0.43**
1.1	Usability, uncomplicated	4.81	0.39
1.2	Correctness of information	4.79	0.41
1.3	Information system corresponds to user requirements	4.57	0.53
1.4	Appropriateness of data volume on each page	4.79	0.41
1.5	Correctness and completeness of text, picture, table	4.81	0.44
2	**Information system administration and performance**	**4.71**	**0.47**
2.1	Correctness of administration and fast processing	4.81	0.39
2.2	Correctness, completeness and reliability of data	4.47	0.74
2.3	Benefits to users	4.70	0.46
2.4	Speed of data retrieval	4.62	0.48
2.5	Performance and readiness to serve	4.77	0.42
2.6	Up-to-date information	4.79	0.41
2.7	Convenience and usability for use	4.75	0.43
2.8	Overall satisfaction of usage	4.77	0.42
3	**Information system usage**	**4.62**	**0.59**
3.1	Usability to access the system	4.72	0.49
3.2	Network security	4.64	0.52
3.3	User identification before using the system, such as username and password	4.53	0.77
3.4	Privacy	4.66	0.55
3.5	Safety upon logging out after usage	4.55	0.63
Overall users' satisfaction		**4.70**	**0.50**

4. Results and Discussions

1) The survey and data collection of herbs and the properties of their components were conducted on 508 herb plants found in the 92 rai, 1 ngan, 97 square wa (equivalent to 156,800 square meters) of the Plak Mai Lai Temple herb garden. The survey included mapping the medicinal properties of herb components, for example, leaves, flowers, roots, crusts, and seeds, to herbs and their properties, as examples identified on Table 2.

2) The information system of herb and medicinal properties employing AI based on NLP concepts was developed in web application format as illustrated in Figure 5.

3) Based on the performance evaluation of the information system for herb and medicinal properties, utilizing AI based on NLP concepts, the results can be summarized as follows:

3.1) The information system's performance evaluation form and the user satisfaction form passed the IOC assessment conducted by a panel of five experts, including three information system development experts, one plant and agriculture expert, and one herbal expert. Subsequently, the system performance was evaluated by another group of five experts, three information system development experts, one plant and agriculture expert, and one herbal expert. The results of the evaluation presented in Table 3.

The results of the evaluation of the processing model for providing information on herbal plants and medicinal properties using AI based on NLP concepts were obtained from a sample group of sentences used for testing, consisting of general terms combined with terms indicating symptoms of diseases, totaling 373 cases. The Split Test evaluation technique was used, dividing the group into a learning data set of 60% and a testing data set of 40%. It was found that the sensitivity value was 77.47%, the specificity value was 83.91%, and the accuracy value was 82.53%. The evaluation results are presented in Table 4.

3.2) Users of the information system of herb and medicinal properties, utilizing AI based on NLP concepts, amounted to 53 individuals. User general information is presented in Table 5.

The results of users' satisfaction are presented in Table 6.

5. Conclusions

The results indicate that, from the survey and data collection of herb medicinal properties associated with 508 medicinal plants discovered in the Plak Mai Lai Temple herb garden, along with the medicinal properties of herb components when applied in conjunction with sentences containing words describing symptoms, in a split test technique comprising 60% learning data and 40% testing data, the accuracy of NLP concepts is 82.53%. This could be incorporated into the information system for herb and medicinal properties information services, utilizing AI based on NLP concepts.

During the development of the information system of herb and medicinal properties, leveraging AI based on NLP concepts, a responsive web application format was adopted, connected to an online database. This setup enables users to conveniently access the system

from various devices, such as computers, tablets, and smartphones, providing flexibility in usage from any location at any time.

According to the performance evaluation of the information system for herb and medicinal properties, using AI based on NLP concepts, the overall performance is at the highest level ($\bar{X}$ = 4.68, $S.D.$ = 0.47). Specifically, the system exhibited the following performance levels: 1) Functional requirement: highest level ($\bar{X}$ = 4.72, $S.D.$ = 0.40) 2) Functional accuracy: highest level ($\bar{X}$ = 4.72, $S.D.$ = 0.49)

According to the results of users' satisfaction, the overall satisfaction level is also at the highest level ($\bar{X}$ = 4.70, $S.D.$ = 0.50). Specifically, users are highly satisfied with information system usage: highest level ($\bar{X}$ = 4.75, $S.D.$ = 0.43).

References

[1] National Health Local Knowledge Development Committee, National Health Commission Office, National Strategic Plan for the Development of Thai Wisdom, Thai Health, Issue No. 3, https://www.thaihof.org/ 16766-2/ (accessed 1 July 2022). (in Thai)

[2] Ministry of Public Health, National Master Plan for Thai Herbal Development, No.1 (2017-2021), https://www.dtam.moph.go.th/images/download/dl0021/MasterPlan-Thai herb.pdf (accessed 1 July 2022). (in Thai)

[3] Thai Traditional Pharmacy Academic Group, Information about the involvement of traditional Thai medicine practitioners in the battle against COVID-19, The Institute of Thai Traditional Medicine, https://ittm.dtam.moph.go.th/index.php/knowledge-1/163-knowledge-3(accessed 1 July 2022). (in Thai)

[4] Kijsirikul, B. Artificial Intelligence, Bangkok: Computer Engineering, Chulalongkorn University, (2005). (in Thai)

[5] Nongnuch, K., Zahao, A., Tumthong, S. Literature Analyzed Using Natural Language Processing, The 1st Rajamangala University of Technology Suvarnabhumi National Conference, Rajamangala University of Technology Suvarnabhumi, (2016) 472-479. (in Thai)

[6] Masdisornchote, M. Constructing Thai Opinion Mining, Sripatum Review of Science and Technology, 6 1 (2014) 120-128. (in Thai)

[7] Wimonsathitphong, S. The Study of Thai Language according to Linguistics, Faculty of Humanities and Social Sciences, UdonThani Rajabhat University, (2015). (in Thai)

[8] Markham, K. Simple guide to confusion matrix terminology, 2014, https://www.dataschool.io/simple-guide-to-confusion-matrix-terminology (accessed 1 July 2022).

[9] Phondee, N., Thokeaw, W. Local Wisdom of Medicinal Plants for Health Care in Ban Hin Haw Community forest, Ban Phang District, Khon Kaen Province, Research Reports, Rajabhat Maha Sarakham University, (2017). (in Thai)

[10] Khattiya, S., Fongkerd, S. Santayakorn, P. Health Literacy Factors Affecting Herbal Use Behavior Towards Self-Care Among Patients with Chronic Diseases Who Come to The Services at Huai Koeng Hospital, Udonthani Province, Udonthani Rajabhat University Journal of Humanities and Social Science, 10 1 (2021) 127–144. (in Thai)

[11] Woradet, S., Chaimay, B., Salaea, R., Kongmee, Y. Factors Associated with Herbal Used Behavior towards Self Care among Village Health Volunteers in Phatthalung, Journal of Health Science, 24 1 (2015) 50-59. (in Thai)

[12] Anekpunyakul, P., Sirilak, S., Damee, P. Herbal Use Behavior in Health Care among the People in Receiving Service at Naresuan University Hospital, CUAST Journal, 9 2 (2020) 76–90. (in Thai)

[13] Wisanjittarat, N., Simalaotao, P. Sirisukpoca, U. The Development of the Prototype of Thai Herbal Management Information System and Providing Properties Data Services for the Treatment of 2D Barcode. Proceedings of the 11th NPRU National Academic Conference, Nakhon Pathom Rajabhat University, (2019) 283-292. (in Thai)

[14] Sornjapo, N. Thai Text Automatic Clustering Model Using Machine Learning by Unsupervised Learning with Natural Language Processing, Sripatum Chonburi Journal, 14 4 (2018) 96-106. (in Thai)

[15] Arntong, P. Sequential Model-Base Optimization for Natural Language Processing Data Pipeline Selection and Optimization, Master of Science (Business Analytics and Data Science), School of Applied Statistics, National Institute of Development Administration, (2021). (in Thai)

[16] Chumnankit, T., Siriborvornratanakul, T. Thai Fake News Detection Using Natural Language Processing, KMUTT Research and Development Journal, 45 2 (2022) 275-287. (in Thai)

[17] Poonphon, N., Sirisukpoca, U. Simalaotao, P. Development a Prototype of The Interactive Kidney Disease Consultation System using Natural Language Processing, Proceedings of the 14th NPRU National Academic Conference, Nakhon Pathom Rajabhat University, (2022) 807-818. (in Thai)

[18] Therjanthruk, N., Simalaotao, P. Sirisukpoca, U. Development of a Prototype of The Interactive Diabetes and Hypertension Consultation System with Web Mobile and Web Application, Proceedings of the 14th NPRU National Academic Conference, Nakhon Pathom Rajabhat University, (2022) 797-806. (in Thai)

[19] Yao, Y. Wang, Z., Li, L., Lu, K., Liu, R., Liu, Z., Yan, J. An Ontology-Based Artificial Intelligence Model for Medicine Side-Effect Prediction: Taking Traditional Chinese Medicine as an Example, Computational and Mathematical Methods in Medicine, 2019, https://doi.org/10.1155/2019/8617503 (accessed 1 July 2022).

[20] Wang, N., Li, P., Hu, X., Yanga, K., Peng, Y., Zhu, Q., Zhang, R., Gao, Z., Xu, H., Liu, B., Chen, J., Zhou, X. Herb Target Prediction Based on Representation Learning of Symptom related Heterogeneous Network, Computational and Structural Biotechnology Journal, 17 (2019) 282-290.

[21] Zhang, T., Schoene, A. M., Ji, S. Natural language processing applied to mental illness detection: a narrative review. npj Digital Medicine, 5 46 (2022), https://doi.org/10.1038/s41746-022-00589-7 (accessed 1 July 2022).

[22] Jongwutiwes, K., Nillapun, M., Chalongsuk, R., Thammetar, T., Sangwattanakul, W. A little guide takes a tour of the herbal forest of Wat Plak Mai Lai, Nakhonpathom: Phetkasem Printing Group, 2-17. (in Thai)

[23] Srisa-ard, B. Preliminary Research, (10th edition), Bangkok: Suwiriyasan (2017). (in Thai)