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A Development of Supporting System for Historical Heritage Based Tourism

Salinun Boonmee[1], Suwit Somsuphaprungyos[2], Parinya Natho[3], Sangtong Boonying[4]
[1,2,3,4]Department of Business Administrator and Information Technology, Rajamangala University of Technology Suvarnabhumi, Thailand

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ABSTRACT

Tourism is a major economic contributor in Thailand. With the richness of historical heritage recognized as world heritages, Phra Nakhon Si Ayutthaya province is a famous destination for tourists who enjoy historical and cultural tourism. This work presents a development of a supporting system for tourism in Phra Nakhon Si Ayutthaya province in regarding of historical and cultural aspects of heritages. This work designs an ontology to represent a relation network of properties from tourist attractions based on historical and cultural relationship among them. Instances which are the heritages hence are related and can be visualized in a form of a graph. The suggestion module is designed to provide related tourist destination following the relations from the generated knowledge graph based on the initial query of a user. The experiment results signify that the system revealed hidden historical relations of destinations to users and made them learn the values of history lied within heritages. Furthermore, 87.5% of participants decided to make a tour plan following the suggested destinations since they found the linking in historical values to be more meaningful and interesting.

Corresponding Author:

Sangtong Boonying,
Department of Business Administrator and Information Technology,
Rajamangala University of Technology Suvarnabhumi,
19 Moo 3, Thawasukri, Phra Nakhon Si Ayutthaya, Phra Nakhon Si Ayutthaya 13000, Thailand.
Email: sangtong.b@rmutsb.ac.th

1. INTRODUCTION

Tourism is a major economic contributor in many countries including Thailand. In 2017, Thailand adopted its smart city concept called Thailand 4.0 in which tourism is one of the targets to be enhanced with smart solutions. The concept of Smart Tourism was emerged in a recent decade for applying information and communication technology in assistance of tourism [1, 2]. Smart tourism refers to innovative tools and approaches developing to improve tourism [1, 3]. The information and communication technology used for smart tourism is a combination of Internet of Things, mobile communication, cloud computing, and artificial intelligence. The core concept of smart tourism is to improve the efficiency of resource management and to increase tourism experience for tourists. Thus, most of the smart tourism applications thus aim to distribute information and facilitate efficient allocation of tourism resources to match users' interests [4-7] and optimize their traveling plan [6, 7].

In the existing work of smart tourism applications, their main tasks are to provide information, to help making choices and to assist in finding and contacting accommodations including making reservations, translation services and direction guidance. Some may include the use of augmented reality to let tourists experience augmented things in a real-world environment via smart phone. These applications thus are helpful and result in boosting the trend in tourism. However, most of the existing applications are useful on optimizing the route and providing necessary information for traveling, but not focusing on connecting values of the

attraction. Thus, tourists are guided to places based on fame and a beauty of the explicit nature or architecture without learning the hidden relation of connectable historical and cultural values from attraction.

Tourism can be grouped based on aspects such as culinary tourism, historical tourism, cultural tourism, nature tourism and religious tourism. While these aspects can be combined in tour planning, the most popular ones are nature tourism and cultural tourism. Nature tourism refers to a travelling to enjoy a beauty of the natural attractions of an area while cultural tourism involves travelling to see a culture of a particular country or region. The cultural tourism involves the enjoy of learning history of a region, exquisite architecture, local festivals and cuisine. In Thailand where is rich of cultural and historical heritages, many visitors can choose to enjoy historical sites and learn about Thai culture along with history in every major province.

Phra Nakhon Si Ayutthaya province (Ayutthaya for short, henceforth) is one of the major tourist destinations. It is a combination of an ancient capital and modern city in the Central Plains of Thailand, about 80 km north of Bangkok. It boasts numerous magnificent historical ruins indicating its most prosperous history in the 17th Century in which has been a UNESCO World Heritage Site since December 13, 1991 [8]. There are several attractions including ancient temples, museums, ruins and local markets. Tourists thus commonly visit Ayutthaya for short stay (1-2 days) for sight-seeing.

In this work, we aim to develop a smart tourism application on mobile platform to facilitate cultural and historical tourism planning for Ayutthaya province. An ontology is developed as a schema to link relevant concepts in tourism such as heritage attractions, accommodations and travelling methods. The rest of this paper is organized as follows. Section 2 provides background knowledge related to Phra Nakhon Si Ayutthaya province, an ontology representation and existing smart tourism systems. Section 3 describes the design of the proposed system including ontology design and recommendation. In Section 4, experiments are explained as setting, result and discussion. Section 5 gives a summary of the paper and a plan on future work.

2. LITERATURE REVIEW

2.1. Importance of Phra Nakhon Si Ayutthaya Province

Ayutthaya was the second capital of the Siamese Kingdom and was founded in 1350. From the 14th to the 18th centuries, it was grown as one of the world's largest and most cosmopolitan urban areas and became a center of global diplomacy and commerce. Ayutthaya located on an island which were surrounded by three rivers connecting the city to the sea. Presently, the old capital city is located in Phra Nakhon Si Ayutthaya District, Phra Nakhon Si Ayutthaya Province. With the glory of the past, the province contains several archaeological ruins, such as the remains of tall prang (reliquary towers) and Buddhist temples.

Ayutthaya was a center of economics and trade at both the Asian and global levels, since it connected the East (China and Japan) and the West (French, Portugal, and England). As evidence of foreign influences, a trace of mix cultures can be noticed in the form of arts seen in the architectural ruins. The ruins are consolidated, preserved or reconstructed as tourist sites. The great cultural value of Ayutthaya's ruins was officially recognized in 1991, when the Historic City became an UNESCO World Heritage Site.

Its distance from Bangkok makes tourists considering Ayutthaya a popular trip destination for travelers from Bangkok for a trip of 1-2 days. Ayutthaya province is a common choice of destination for both Thai and foreigner tourists who like historical site and Thai cultural value. Travelers can travel to Ayutthaya by car, train, bus and boat while they can get around by many means including bicycle, rental car and hired tuk-tuk (a motorized 3-wheeler with a chauffeur). There are many attraction locations including ruins, temples, museum, markets, and foreign settlements.

2.2. Ontology Background

Ontologies in information science are semantic data models that define the types of things existing in a domain and their properties that can be used to describe them as to represent the relation of things in a formal schema readable by both human and machine [9-11]. Thus, ontologies are often regarded as a domain-based knowledge representation. Ontologies are generalized data models, meaning that ontologies only model general types of things that have common properties to schematize the similarity and dissimilarity of things in a domain, but do not include information about specific individuals with identity. Within an ontology, there are two main components as follows:

Classes: the distinct types of things in a conceptual level.

Relationships: the connectors between classes or a class and individual data.

- Is-A: relationships that define hypernymy-hyponymy between classes.
- Part-of (Object property): properties that connect two classes.
- Attribute-of (Data property): properties that link a class to data value.
- Instance-of: relationships that indicate a link of a class to its individuals.

An ontology is stored in a specified marked-up format, called OWL (Web Ontology Language) [12]. OWL is a semantic-web computational logic-based language, designed to represent rich and complex knowledge about things and the relations between them [12]. It specifically provides detailed, consistent and meaningful distinctions between classes, properties and relationships. OWL enriches ontology modeling in semantic graph databases, called RDF triple stores. Ontologies are capable to extend in which results to spanning of coverage and usability with the growth of data. In fact, ontologies function like a 'brain' of the system in which they 'work and reason' with classes and relationships similarly to humans perceive interlinked concepts. With an ontology, applications including recommendation [13], semantic search [13] and personalized supporting system [11] can be implemented regarding provided knowledge efficiently.

2.3. Existing Smart Tourism Researches

Tourism industry is an important source of income for many regions and even for entire countries as it plays a crucial role in the economics growth in countries. In Thailand, according to the secretary-general of the Office of the National Economic and Social Development Council speaking in 2019, they expect that the tourism sector will account for 30% of Thailand's GDP by 2030, up from 20% in 2019. The demand for smart tourism systems have thus increased and resulted in many smart tourism projects worldwide. In this part, existing supporting tools for tourism are reviewed.

First, Soo and Liang [4] proposed a tool for planning and arranging trips in the city of Taipei, Taiwan. Tourist is asked to select accommodation. The system will automatically suggest nearest place of interest (POI) to visits by considering visitor's available time slot. INteractive TouRist Information GUidE (INTRIGUE) are proposed by Ardissono et al. (2003) [5]. The tool aims for planning the trip in Torino, Italy. A fuzzy logic was used as a core to link sites' information. It allows user to search for tourist attractions and accommodations according to different viewpoints, such as the historical period, artistic current, types of monuments, and so forth. In 2004, Sun and Lee introduced multi–agent tourist advisor [6] to provide personalized routes using a vector-based recommendation technique. The system works by using a shortest path algorithm to minimize a cost in the road network and consider user personal interest values to calculate personalized point–to–point routes. A tourist trip is calculated using a model concerning the POI selection problem as a prize collection TSP. Maruyama et al. [7] presents P-Tour system, a device for a personal navigation in touring. Their main concern is to minimize travel cost with remaining of users' interest POI. The condition to select the POIs applied the P-tour routing algorithm to select and route POIs. POIs in this work are marked with factors including a location, a visiting duration, an importance score and an optional constraint on arrival time.

Castillo et al. [14] presented a multi–agent-based system for planning tourist visits. In their work, user's interest, POIs operation hours, user's preference, price of meals and transports, location and multi-modal mean of transport are requirement factors. In use, the planning relies on Predicate logic AI using tree search for finding a plan and route. Lee et al. [14] applied ontology based multi-agent technique to provide personalized travel planning in Tainan City, China. In this work, concepts in the ontology is matched to the tourist's requirements. Fuzzy logic is then used to select and sort a top three of historic sites and a top five of local gourmet food stores. Their disadvantage in this work is that the system makes a distinction between selection and routing. Yu and Chang [16] introduced a framework for the personalized recommendation of hotels, restaurants and POIs for the city of Taipei, Taiwan. The system is designed to recommend a tour based on the user's current time and location with given interests. The main approach is to use Bayesian network technique along with the analytic hierarchy process (AHP) method. Huang and Bian [17] presented the system providing personalized recommendations of tourist attractions in an unfamiliar city based on a tourism ontology. The major objective of this work is to consider a POI based on similarity of user behavior and of other users. Moreover, GIS functions is available since it applies Spatial web services technology. The system also provides an interactive geographic interface and getting users' feedback as input for further recommendation. Bahramian and Abbaspour [18] presented a system using ontology to infer the users' preferences from their histories of viewing the tourism resources from users. A context-aware semantics-based recommendation strategy is chosen to determine the users' preferences and the interests of like-minded individuals. The benefit of inference mechanism is used to discover similarity point of interest.

From existing work, their main objectives are to provide information, to help making choices and to assist in finding and contacting accommodations including making reservations, translation services and direction guidance. These applications thus are reliable and result in boosting the tourism. These applications are useful on optimizing the route and providing necessary information for traveling, but not focusing on connecting values of the attraction. Unfortunately, special purpose tourism such as historical and cultural tourism has their specific characteristic to be considered. Tourists focus more on values of the heritages that they can learn, experience and enjoy. Values of tourism sites should be the main constrain in the trip planning process aside of distance, budget, popularity, etc. The trip plan should be used as the guideline to create an environment for support visitors to follow relations between historical heritages.

3. METHOD

To provide a service to support tourism in Phra Nakhon Si Ayutthaya District (Ayutthaya henceforth for short) regarding to cultural values and historical link of destinations, an ontology is developed as a core knowledge-base. The focus of the ontology is to connect tourist attractions based on historical relation and to systematically store information of the attraction. For suggestion module, we design the system to be browsable from initial query. With the initial query, all related sites in all aspects are given as a graph to connect tourist destination sites regarding historical and cultural relation. Thus, users will learn how a site connect to other sites and can decide a plan following their own interests. In addition, this system will not only let users find beautifulness of historical heritages, but also learn insight history from them. As an overview, an architecture of the system is illustrated in Figure 1

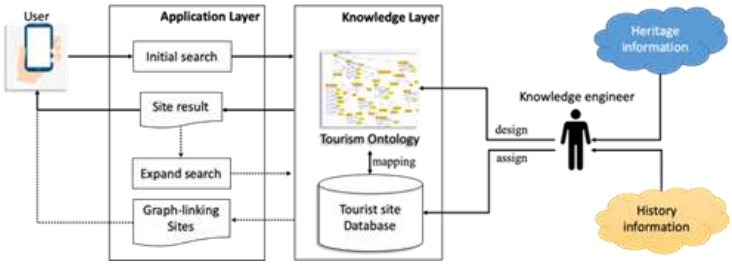

Figure 1. An overview of the system

In the system shown in Figure 1, there are two system layers as an application layer and a knowledge layer. The application layer is to connect between user and knowledge layer. It also processes to the query from user's initial search and expends the query for extended search results. In knowledge layer, an ontology, which is mapped to the database, provides a graph-based linking of concepts to get the relevant instances. In development of the ontology and data, knowledge engineer manually extracts knowledge from information sources and store them in the knowledge layer.

3.1. A of historical tourism ontology for ayutthaya

This paper focuses on a design of tourism supporting tool for Ayutthaya province regarding cultural and historical aspects hidden in tourist sites. Hence, not only a name and location of tourist sites are kept, but we also collect historical and cultural details of the sites to link them. The values of sites should let travelers understand the relation of each site and should impress traveler for the cultural value more deeply along with beautifulness of the architecture.

With several aspects, we design an ontology to cover all related concepts as a schema to control necessary information used in a reasoning process. The main classes of the designed ontology with some of their properties are given in Table 1.

Table 1. Main Classes of The Designed Ontology With Some of Their Major Properties

Ontology Class	Definition	Property: A/o (attribute-of) and P/o (part-of)
Travelers	Persons who travel for sight-seeing and visit a place	A/o: Amount_of_tourists (number) P/o: Preference (Tourism Type) P/o: Traveling Method (Transportation)
Tourist Site	A place for visiting and sight-seeing	A/o: Name (string) A/o: Location (string) P/o: Site type (Location Type) P/o: Get_to_by (Transportation) P/o: Made_by (Historical Person) A/o: Made_in_Year (number) P/o: Contain (Object) P/o: Nearby_location (Tourist Site) A/o: Opening hours (string)
Historical Person	Persons who interacted with tourist objects such as creator, maintainer, owner, etc.	A/o: Name (string) P/o: Role (Occupation) P/o: Family Relation (Historical Person) P/o: Friendship Relation (Historical Person) P/o: Hostile Relation (Historical Person)
Object	Items which are an attracting heritages or goods related to history	P/o: Made_by (Historical Person) A/o: Made_in_Year (number) P/o: Past_location (Tourist Site) P/o: Transfer_by (Historical Person)

The main focus of this ontology is to create a network of tourist sites based on history and cultural value. Thus, there are concepts related to person in a history and how they are related to another. However, we also keep common information from other works such as location of the site, parking availability, transportation accessible route, etc. These data will facilitate the plan maker to make more comfortable traveling around Ayutthaya.

The ontology however is a schema to connect concepts with meaning, but it requires real-life data to complete a relational graph of instances. For instances of this ontology, we collect data of tourist sites within Ayutthaya province as well as accommodation places including hotels and restaurants. According to a schema of the designed ontology, all of the data are filled for the best reasoning result in the later process. Additionally, we extract information of heritages and historical persons by reviewing Thai history and interviewing history experts. Examples of instances of Tourist site are given in Table 2.

Table 2. Examples of Instances for The Major Class "Tourist Site"

ID	Name	Type of	Made in year	Built by	Located in	Near by	Contain
1	Wat Phutthaisawan	Active Temple	1353	Somdet Phra Chao Uthong (King Ramathibodi I)	Samphao Lom	Tamnak Phra Phutthakosajarn Hall	Mount Meru Prang
2	Wat Yai Chai Mongkhon	Restored Ruin	N/A	N/A	Phai Ling Sub-district.	N/A	N/A
3	Tamnak Phra Phutthakosajarn Hall	Palace	N/A	Somdet Phra Chao Uthong	Samphao Lom	Wat Phutthaisawan	N/A

With ontological schema as a representation, the instances thus are related to another and can be considered as a knowledge graph of historical items. We draw a graph to demonstrate how items are meaningfully connected in Figure 2.

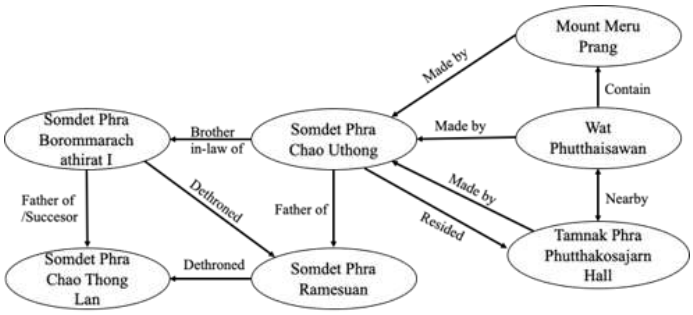

Figure 2. A Knowledge Graph Generated from Instances of Ontology Schema to Connect Tourist Sites

3.2. Suggesting module

With the knowledge base, suggestion can be made based on users' query. The suggestion in this work is in mixed initiative interaction. Users are responsible to provide the first query. The knowledge stored in the ontology then realize the request and provide all related options following the assigned properties of the concepts exemplified in Table 2. By selecting some of the returned suggestions, the system takes that as additional queries to expand the suggestion further as shown in Figure 2.

The system can generate a different type of outputs as shown in Table 3. First, the instance level is the same as normal semantic search which get a query as criteria from a user then return relevant results by directly matching them. This level suits for those who want to get specific details of the sites or completely realize their own interest. Second, for the extended instance level, not only directly matched results are returned, but also their related sites. The extension is considered by using values assigned in ontological properties as another query. For example, 'Site A', which is a direct-matched result of user's query, has two values of its properties as X and Y. Then, X and Y are used to extend the search and should gather more relevant results to 'Site A'. Last, a knowledge-graph level refers to using the initial query result to generate a graph of relations between all relevant concepts as shown in Figure 2. Users can gain information of every generated node in the graph by hovering the node for short summary or clicking it to set it as another focus for graph expansion.

Table 3. Level of Results from The System

Level of generated output	Outputs
Instance Level	A list of tourist sites that are matched to the user's query with the property value details including class range of object properties and data value from data properties (address, image and opening hour)
Extended Instance Level	Details of matched tourist sites and their related sites by using data property of the matched sites to be other queries.
Knowledge-graph Level	All relevant concepts from the initial query are generated into browsable graph with an understandable connection.

4. RESULTS AND DISCUSSIONS

4.1. Experimental setting

To evaluate usability of the proposed system, an experiment was set as follow. 120 Thai participants were volunteered as samples to test the system. For details of participants, they are in between the age of 25 to 45-year-olds while the gender ratio for male and female is 56:64 respectively.

Each participant was requested to create a 2-day tourism plan for cultural tourism in Ayutthaya, Thailand. The objective of the plan is for the participant to take his friend who never visit Ayutthaya to enjoy a series of attraction sites based on connection of historical sites. There are a total of 153 selectable sites including temples, palaces, museums, and ruins which publicly opened for tourism. Participant can choose of tourist sites following preference regardless of travelling cost, entry cost, travelling time, and transportation limitation.

In details of plan making, there are 2 phases as 1. Plan design, and 2. Plan adjustment. The plan design is for the design of the plan without using the system. In this phase, participants must select 2 to 5 sites to visit per day without a help of the system. Hence, the 2-day plan should consist of 4 to 10 selected tourist sites. After obtaining the starter plan is the adjustment phase. In adjustment phase, participants were asked to use the system and allow to make change to the plan by re-selecting the tourist sites. However, every adjustment made requires the reason for the change. We randomly separated participants into three groups of 40 participants each regardless of gender or age as follows:

Group 1: Participant in this group was provided with system output in instance level, namely, a common information that can be easily found in a website.

Group 2: Participant in this group was given with the extended information level that provided the link between destinations.

Group 3: Participants in this group was provided with knowledge-graph level which shows all relevant attraction that culturally and historically related to the initial query.

Thus, we have the starter plan and final plan after using the system for comparison. Furthermore, participants answered questionnaire to reveal their feeling of using the system.

4.2. Experimental results and discussions

First, we would like to see the effect of using the system. Hence, we calculated a number of participants who made an adjustment in their plan since the adjustment reflected their thought on destination sites. The adjustment results are given in Figure 3.

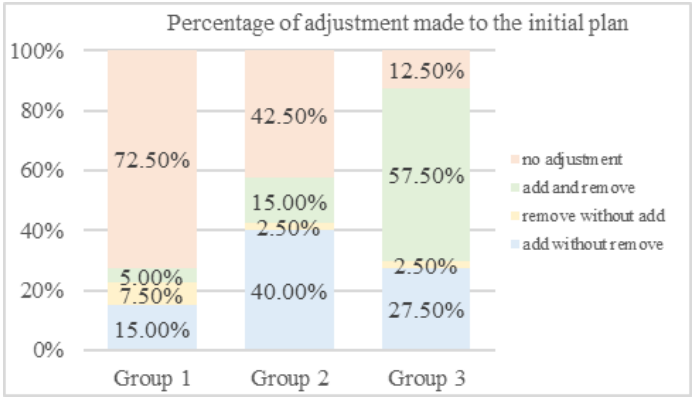

Figure 3. Results of Participants Making Adjustment After Using the System

Furthermore, we also interested in a number of added sites or removed sites after using the system. The results of a number of added sites or removed sites after using the system are provided in Table 4 and Figure 4.

Table 4. Number of Added Sites or Removed Sites

Group	Average of sites in starter plan	Average of added sites	Avearage of removed sites	Average of sites in a final plan
1	5.93	0.23	0.15	6.00
2	5.98	0.83	0.18	6.63
3	5.98	1.78	0.98	6.78

Figure 4. A Number of Added Destination Site After Using the System

We then inspected them on how they made an adjustment by adding from the starter plan and found the reasons for all the changes made to the tourist plan were grouped and resulted as given in Figure 5.

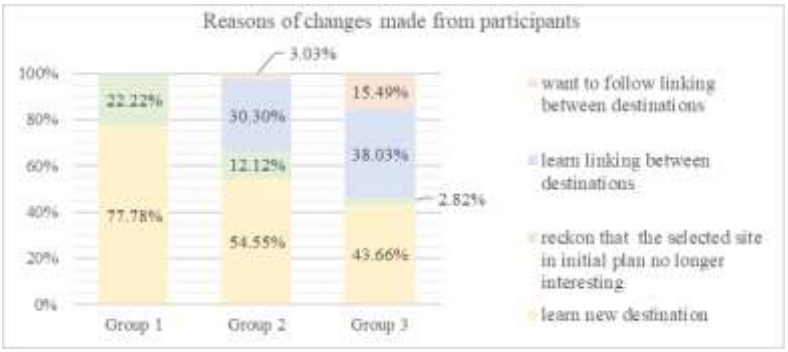

Figure 5. Reasons of Making Adjustment form Participants

By analysis of the chosen tourist sites, the starter plans from all participants comprised of well-known tourist sites. According to questionnaire results, the reason of choosing such location for tourism planning was because these tourist sites are popular for beautiful landscape and architectures such as famous temples and ruins. The use of system thus changed the mind of participants as the results in Figure 3 indicate that the changes were made in all groups, but the number of changes was noticeably different based on the difference of information based on the group criteria.

Based on grouping, there were 11, 23, and 35 participants (27.5%, 57.5%, and 87.5%) who made changes of the plan, respectively. Thus, it is conclusive that the difference of information provided effectively affect participants' decision making on planning. By analyzing based on grouping, we found that participants in Group#1 found the obtained basic information of related sites gave them little to none power to change their mind. For Group#2, most of participants who made change of the plan chose to add more tourist sites (16 persons) while 6 persons removed some and added some tourist sites. the number of sites added was 1 to 3 sites as shown in Figure 3. The adding was the effect of providing details of tourist sites and their related sites by using data property, so participants found some relation among two sites and decided to add them for connecting the site in more meaningful way. Group#3 was the group that had the most participant changing the plan. The participants in this group were provided with the full details of relationship between tourist sites in the aspect of historical and cultural insight. Thus, 35 out of 40 participants in this group made an adjustment to their starter plan. This can be concluded that the given relationship that making tourist sites connecting to one another can intrigue interest from users. Moreover, we found that participants from Group#3 mostly added more destination sites while moderately removed chosen sites. This can indicate that applying historical insight has an effect to users to learn interesting relations between the sites and learn of new sites with meaningful linking. Furthermore, results of questionnaires from this group participants pointed out that the sites that are

connected such as two temples that related to the same king based on the given lore are more interesting to visit more the two sites that lack historical connection.

5. CONCLUSION

This paper presents a supporting system for promoting historical tourism in Phra Nakhon Si Ayutthaya province, Thailand. Since the province is the former capital city of Thailand, the tourist sites were full of hidden historical and cultural values. To emphasis the values, an ontology is developed as a schematic network to link the historical and cultural importance between tourist spots and remaining heritages. Instances of the ontology thus can be related via a knowledge graph regarding history and culture. For the suggestion module, it is designed for users to initially provide their first query to signify their points of interests. Then, the suggestion will provide related tourist sites following the relations from the generated knowledge graph. The graph hence reveals implicit value of the sites from the cultural and historical aspects that can let users enjoy and experience tourism for both explicitly beautiful architectures and implicit cultural and historical values of the tourist sites.

From experiments, we asked 120 Thai persons to initially make a tour plan for their foreigner friends. The participants were split into groups with different information provided. The results indicated that the participants with historical and cultural knowledge graph decided to change the plan for 87.5% while those with commonly found information rarely made change in their plan. This revealed that those that learned the implicit values of tourist sites from the provided knowledge graph were more intrigued with the obtained knowledge and found it was more meaningful to travel following the historical linking. From an interview after experiment, participants pointed out the reasons to their change of tourist sites in the plan is that they obtained new historical relation among sites from the system and learned of unknown locations by following the generated knowledge graph to another in their preferable aspect. Thus, it is conclusive that connecting tourist sites in a meaningful aspect such as cultural aspect and historical aspect can influent tourists to enjoy more of tourism regarding hidden cultural/historical value instead of sole appreciation of beautiful physical landscape and stunning architecture.

To further improve the system, we plan to expand coverage of tourist sites to other nearby provinces to cover some of related heritages. In addition, other tourist types such as markets and nature-based spots will be included to expand a scope of destinations. Lastly, we plan to extract relations of all historical heritages in Thailand as a knowledge graph to expedite a learning of Thai history via heritages.

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BIOGRAPHY OF AUTHORS

Salinun Boonmee is currently an assistant professor and a lecturer of the Department of Information System and Business Computer, Faculty of Business Administration and Information Technology, Rajamangala University of Technology Suvarnabhumi (RMUTSB). She received her Ph.D. in Computer Education at King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand. Her research interests include IoT, machine learning, data analytics and artificial Intelligence (AI). She can be contacted at email: salinun.b@rmutsb.ac.th

Suwit Somsuphaprungyos is currently a lecturer of the Department of Information System and Business Computer, Faculty of Business Administration and Information Technology, Rajamangala University of Technology Suvarnabhumi (RMUTSB). He received his Ph.D. in Management of Information Technology at the School of Informatics, Walailak University (WU), Thailand. He received an M.Sc. in Internet and Information Technology from the Naresuan University (NU), Thailand. His research interests include Internet Technology, Internet of Things, Smart Technology, Data analytics and Ontology. He can be contacted at email: suwit.s@rmutsb.ac.th

Parinya Natho is currently a lecturer of the Department of Information System and Business Computer, Faculty of Business Administration and Information Technology, Rajamangala University of Technology Suvarnabhumi (RMUTSB). He received his Ph.D. in Information Technology at the Faculty of Information Technology, King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand. He received an M.Sc. in Computer Science and Information Systems from the National Institute of Development Administration, Thailand. He received his B.Sc. in Computer Education from Rajamangala University of Technology Thanyaburi, Thailand. Parinya has also obtained a Digital Literacy Certification Certificate (IC3) to his name. He can be contacted at email: parinya.n@rmutsb.ac.th

Sangtong Boonying is currently an assistant professor and a lecturer of the Department of Information System and Business Computer, Faculty of Business Administration and Information Technology, Rajamangala University of Technology Suvarnabhumi (RMUTSB). He received the Ph.D. degree in Education Technology from Burapha University, Thailand. His research interests include IoT, machine learning, image processing, data analytics and artificial Intelligence (AI). He can be contacted at email: sangtong.b@rmutsb.ac.th