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The Analytical Tools for Tourism Development through Social Media Data and Spatial Morphological Analysis

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ABSTRACT

In the tourism sector, social media data help elucidate the travel behavior and activities of travelers through images and reviews. However, geospatial studies with spatial analysis tools such as GIS are still required by researchers who hope to gain beneficial insight into tourism development from such social media data. In addition to spatial studies, Space syntax analysis is used to explain the spatial characteristics and accessibility of both pedestrians and vehicles; however, the method doesn't consider how people use the space. Therefore, using social media with space syntax analysis will help enhance the understanding of both tourism and spatial aspects. This research aims to develop analytical tools to support tourism studies with the GIS (graphic information system) process using social media data analysis and spatial morphological results from space syntax analysis. The study found that the accessibility potential of a destination does not enhance the popularity of tourist attractions as much as relevant images or attractions due to many popular tourist attractions being located in areas with low potential accessibility. While the image processing and text processing results can extract hidden traits and identities in each attraction, another result is that the analytical tool developed in the study can help quantify tourism activities and perform preliminary content analysis of the data from text and Image processing through the GIS software. It is also used to overlay tourism activities and spatial morphology results in order to recognize the tourism development potential of the area in terms of destination image tourism activities and accessibilities. The tool produces useful results and assists in decision-making for the development of tourist attractions.

Keywords: social media, big data, space syntax, GIS, tourism development

INTRODUCTION AND OBJECTIVES

Social media plays a huge role in today's tourism since tourists share their travel experiences through photos and comments on social media. This user-generated content data obtained from social media has the potential to be used to enhance understanding of travel behavior and perceptions of a destination from a tourist's perspective, which can be useful for helping the development of tourism. Therefore, the study of social media data should be carried out in combination with spatial studies in order to understand the spatial context, leading to appropriate spatial tourism management and development. In spatial studies, the most widely used tool is GIS, which helps in mapping and analyzing geographic data. GIS allows geolocation data from social media to be studied in spatial aspects, and understanding the spatial structure is essential. One of the concepts used to understand urban structure is space syntax methodology. Space syntax is a spatial morphological analysis tool that can indicate urban centrality and the accessibility of the area. However, morphological analysis is based solely on spatial data and requires demographic data to support the results. Thus, combining social media data with spatial morphological analysis may complement the results, leading to a better understanding of urban areas and the development possibilities for various tourist attractions. The results from the combined data will not only elucidate the development potential of tourist attractions but also help stakeholders to understand destination perception based on what people are interested in and what they mention in their social media activity.

This research, therefore, looks for a way to examine tourism potential and to assist in decision-making with respect to tourism development by using data obtained from major social media platforms. The research will utilize the results of spatial morphology analysis of tourist attraction areas to visualize and identify their spatial potential.

There are two objectives in this research: 1) Explore the use of social media data together with spatial morphological analysis by using the GIS overlay analysis process to generate spatial results for decision-making in tourism management 2) Develop an analytical tool to assist tourism spatial studies and improve decision-making related to tourism development and management.

First, the spatial morphological analysis was performed using segment analysis to focus on understanding the accessibility potential. Second, a quantitative study of social media data was carried out to understand the popularity of tourism activities in each area. Once the social media quantitative data had been studied, the contents of social media data were analyzed by image and text processing to further recognize the potential of tourist attractions with respect to user perception of the destinations. Third, social media data and spatial morphological analysis results were studied together with GIS to analyze the relationships that may indicate the potential of tourist sites. Finally, an analytical tool for tourism development was developed to aid the spatial studies process. The benefits of the use of social media data and spatial morphological analysis as a tool to assist in tourism development will be summarized and discussed.

LITERATURE REVIEW

Tourism Management & Development

Tourism relies on many factors and elements such as attractions, accessibility, public facilities, and activities to achieve its stakeholder's goals. Management and development, which depend on tourism policies and organizational requirements, are required in order to balance the tourism elements. Although the traditional approach can create stability for tourist attractions, it may not respond to current situations and social trends. With the current trends in tourism studies, attention is being paid to the following topics:

1) The influence of technology on tourism and tourism management - The use of technology plays an important role in tourism (Casado-Aranda et al., 2021; Volgger et al., 2021)

2) The impact of the development of tourist attractions causes some communities to

change their ways of life - The rural-to-urban transition from the development of tourism has an impact on the economy and culture and the preservation of local cultural identity (Mandic & Kennell, 2021; Rezvani et al., 2022).

3) The concept of sustainable urban development and responsible tourism (Li et al., 2021; Sigala et al., 2021; İnce et al., 2020) – This consists of sustainable tourist attraction management, and its practical applications

4) The coronavirus pandemic situation (Casado-Aranda et al., 2021; Sigala et al., 2021) -The pandemic resulted in lost tourism revenue and it affected the social sector.

Due to tourism's current issues regarding the influence of technology and tourism sustainability, it is necessary to increase the role of technology in supporting the tourism development process in order to the development to meet the tourist's expectations and create a balance between the community and tourism.

The Influence of Social Media on Tourism

Publishing photos and reviews on social media is a way that tourists share their tourism experiences, which affects tourist attractions. The increase in online photo publishing has resulted in strengthening perceptions of tourist attractions, especially for younger tourists (Sheungting et al., 2011). The popularity of many of these photos affects re-shoots in the same area due to the influence of memory or an image of the tourist attraction that occurs and affects future tourism in an ongoing cycle (Payntar et al., 2021). Also, microblogging has influenced the change of micro-tourism into major tourism, which may negatively impact residents in affected areas (Jang & Park, 2020). It can be seen that the reproduction of photos and microblogging reviews in social media influence the perception and promotion of tourism in real situations. Social media should be seen as an important factor in present-day tourism trends, and as a tool to help manage and develop tourism.

Social Media Study on Tourism

Nowadays, social media is being used to study various aspects of tourism due to its ability to reflect people's interests and opinions. Furthermore, social media geolocation data offers the potential to monitor changes in usage in an area by both tourists and local residents (Kádár & Gede, 2013). Mao (2015) found that popular social media comments and photos can be useful in understanding people and their travel habits and opinions. In addition to quantitative studies, social media studies also include analytical tools, such as image and text analysis using artificial intelligence, which is currently available as an online API service. Mirzaalian and Halpenny (2021) investigated the expressions of loyalty in TripAdvisor online reviews based on a list of keywords using text processing. Miah et al. (2017) analyzed keywords from social media texts to define tourists' interests and representative photo identification. Study of social media is a new alternative way of obtaining information that is different from traditional surveys. Information extracted from social media data helps identify and define popularity, perceptions, and emotions toward tourist attractions. Its use in tourism studies should be increasingly emphasized.

Spatial Morphology

A spatial morphological study helps create an understanding of tourist attractions in a spatial dimension to better understand the connection and potential of the tourist areas. Space Syntax Principle is a theory that can examine the relationship between people and space (Hillier & Hanson, 1984; Hillier et al., 1993) based on the principle of the structure of residential areas in many forms, including buildings, cities, and terrain levels. This is because people are roaming and adapting to the connections and layout of the urban area. The space syntax theory helps to explain how spaces are connected between separate cells, which in turn helps identify the nature and characteristics of each area (Bafna, 2003). Space syntax analysis is available through the Deptmap software, with two main methods that are widely used: axial

analysis and segment analysis (Crucitti et al., 2006). Fundamentally, space syntax analysis begins with Axial analysis by using a formula to analyze the connections between pedestrian and vehicle traffic paths. Important calculated values are (1) total depth value, calculating the connection of road lines from the entire network, (2) choice value, indicating the ability to move to another route, and (3) integration value, indicating the efficiency of access in each street. Segment analysis was developed to allow for more detailed analysis by splitting road lines into segments according to the intersection of road lines. This is done by taking the value from axial analysis and calculating 2 new main values: NAIN value (normalized angular integration), measuring the centrality of the area, and NACH value (Normalised angular choice), representing the priority and accessibility of the street. Space syntax is based on mathematical computation; consequently, limitations exist, in that many studies rely on demographic survey data that are as close to reality as possible to support their results.

Big Data and Spatial Analysis in Tourism Development

Big data has been increasingly used for tourism development due to the ease of data collection and the ability to get information that cannot be obtained from other sources. However, the use of big data in tourism spatial studies still requires specific tools. GIS (geographic information system) is a computer system that visualizes geolocation data and helps better illustrate and explain spatial patterns and relationships. Many studies use GIS to study geospatial data from big data, including spatial morphological analysis, for the benefit of tourism and urban development. Li et al. (2017) applied spatial morphological analysis together with a tracking system (GPS) to define tourism zoning and prevent negative impacts from affecting the local community. Mohamed and Stanek (2020) studied the location of sexual harassment along with space syntax analysis and found that incidents took place in the main traffic area during low traffic time. Park et al. (2020) explored visitors' moods based on opinions in tweets to recommend travel routes in a study of amusement park tourism. Ginzarly et al. (2018) studied the importance and value of historic sites by analyzing photographs posted on the Flickr website.

Clearly, relevant research demonstrates a variety of ways of using big data in tourism studies. Some research uses big data as a replacement for demographic surveys in combination with spatial morphological studies to explain the connections between people and space, including content analysis to extract hidden information from big data. It is evident that many studies have combined the use of big data with geospatial studies and also big data content analysis, but few have combined all of these processes to achieve multifaceted outcomes to aid the tourism development process.

METHODOLOGY

Development process of Spatio-Social Media Analytical Tools

This research aims to develop an analytical tool for supporting spatial studies in order to obtain results that will aid decision-making on tourism development. The researcher will create a spatial studies workflow and then develop it into an analytical tool with the QGIS graphical modeler function and Python scripts. The workflow consists of spatial morphological analysis, the study of tourist attractions' popularity from social media data, which includes social media content analysis, and the overlay analysis process. The tool is expected to help automate the spatial study workflow on QGIS.

Research Setting

This research uses Ayutthaya city center, Phra Nakhon Si Ayutthaya, Thailand as an experimental site. Phra Nakhon Si Ayutthaya is an "Old City" that is full of history and culture. The ruins of the old city are preserved in the Ayutthaya historical park as a World Heritage site.

Research Tools

The research tools consisted of a social media data collection tool, social media content analysis, spatial morphological analysis tool, and GIS tool.

1) The social media data collecting tool is a web-based social media data collector developed by the researcher using PHP, cURL, and Javascript computer language to collect data from Flickr and Instagram.

2) Social media content analysis consists of text processing from the AIForthai API service and Image processing from Google Cloud Vision API service. Both analysis tools use processing scripts developed with PHP and Python computer languages.

3) The spatial morphological analysis tool uses the space syntax method on Deptmap software to execute segment analysis. The researchers analyzed the traffic network of vehicles and pedestrian routes based on OpenStreetMap.

4) Geographic Information System (GIS) and additional statistical tools use QGIS software, an open-source GIS to perform spatial studies and to develop the analytical tool.

Data Collection Procedure

Data collection was divided into 2 parts.

1) Social media data collection - data were collected in an experimental site within a radius of 3 kilometers. The researchers retrieved photographs for 12 years (2010 – 2021) from the Flickr social media platform via the Flickr API data collection script. A total of 31,633 photographs were obtained with useful metadata such as geolocation, image URL, timestamp, owner name, views, and more. Instagram data were collected from Flickr for a total of 6 months (March to August 2021) using a different method. Instagram posts were retrieved using a URL search method to collect data directly from its website. Instagram data does not contain geolocation details; instead, it contains location information for a place. Researchers identified 130 places from Instagram location data collection, which were divided into 63 tourist attractions and 67 facilities and services.

2) Spatial data collection - we collected spatial data about experimental sites and tourist attractions consisting of tourist attraction locations, place boundaries, and street networks. A total of 353 locations were obtained, which were categorized as 117 attractions, 175 facilities, and 61 community areas. All tourism boundaries are based on building datasets that are classified as tourist attractions and tourist facilities from the OpenStreetMap.

Data Analysis Procedure

Data analysis was divided into 3 parts: a spatial morphological analysis, social media analysis, and overlay analysis.

1) The spatial morphological analysis follows the space syntax principle, starting with the construction of a street network of vehicle and pedestrian routes according to OpenStreetMap reference. The total depth and connections of the street network were analyzed using axial analysis on Deptmap software, and then segment analysis was used to determine the NACH value. Finally, the analysis results were shown through street color range visualization on QGIS. Color range visualization is based on the NACH (Normalised Angular Choice) value, which represents the accessibility hierarchy of street lines.

2) Social media analysis was used to study the popularity of tourist attractions and destination images. Before analyzing any image of a tourist attraction, a quantitative study was done by visualizing a 3D graph to understand its popularity. Then captions and image URLs were extracted from social media data, and 1000 texts and 100 images were randomly selected from each example tourist attraction site for further use in content analysis. Text processing was executed to perform tag analysis while image processing performed object detection and label detection developed with Python scripts. The results from text processing were visualized in Wordcloud, while results from image processing were visualized as analyzed images on a web-based application.

3) The overlay analysis was performed to study how social media data and spatial morphological analysis results are related and whether they can be used in examination of tourism development potential. The researcher first adjusted the CRS (Coordinate Reference System) of both data sets to be in the same CRS. Then the social media data and segment analysis results were converted into the form of a grid to allow the two data sets to be overlaid together. A QGIS joint attributes by location function was used to combine the data in the same position, and the results were visualized with the rule-based color range using the Natural Jenks method. Finally, the results were summarized in order to be further developed as an analytical tool.

Research Procedure

The research procedure was carried out in five stages. First, the spatial data was set up on QGIS software, and then the morphological structure was analyzed through the traffic network of vehicles and pedestrian routes in the experimental area using segment analysis from the space syntax method. Second, social media data were analyzed in terms of popularity related to tourist behavior and activities. Third, social media content analysis was conducted using text and image processing in order to support tourist activity and destination images. Fourth, the overlay analysis method was applied and the relationships between data were studied in order to understand how social media and spatial morphology are consistent. This may help to point out issues from data discrepancies and recommend guidelines for promoting tourist attractions based on activities and images of those attractions. Finally, the approaches and research results were summarized, and an analytical tool was developed from the process used in the study to help spatial study workflow and produce results that support decision-making for tourism management and development.

RESULTS

Spatial Morphological Analysis

The spatial morphological analysis results were generated following a space syntax principle through the street network on the map. NACH value results are generated on each street line through segment analysis. Hillier et al. (2012) explained that Normalised Choice (NACH) (1) aims to solve the paradox that segregated designs add more total choice to the system than integrated ones. This adjusts choice values according to the depth of each segment in the system, since the more segregated it is, the more its choice value is reduced by being divided by a higher total depth number. This would seem to have the effect of measuring choice in a cost-benefit way.

$$NACH = \frac{\log(\mathrm{ACH}+1)}{\log(\mathrm{ATD}+3)} \quad (1)$$

NACH value represents the accessibility potential of each street line by considering the connection of each line and analyzing how that streetway can lead to other streets (Figure 1). The results show that U-Thong Road, which surrounds the boundaries of the city center and other streets that connect to this road, acts as the core of the whole traffic system. The highest-value road is the one that connects the west and the east. In addition, it was found that many roads have low accessibility potential because of the dead-ends along the riverside and community areas. Overall, it is clear that traveling in Ayutthaya city center relies on the use of the main road, and that there are few alternative routes for traveling between places. Therefore, the Ayutthaya city center has high centrality since it acts as a key route for travel across the city.

Tourist attraction Popularity and Trends

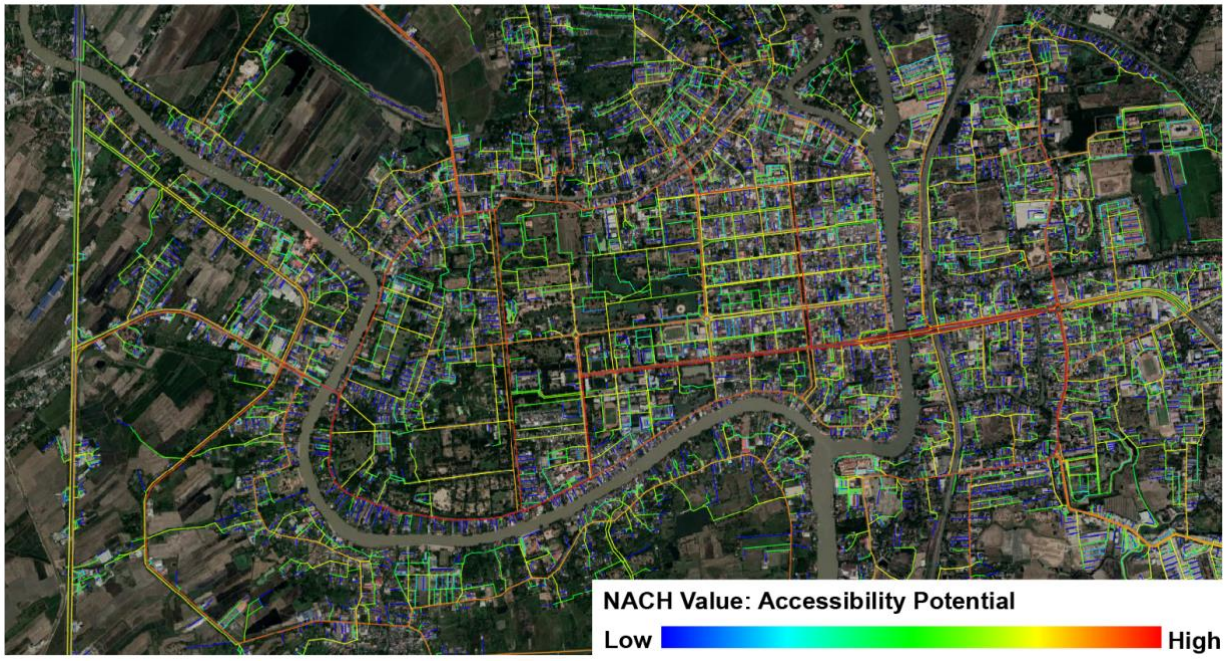
The researcher collected data from social media and visualized the geolocation data on QGIS for spatial visualization (Figure 2). We filtered out data with geographic anomalies and spammy data to minimize discrepancies. When visualizing

Flickr's photos from a time period comprising 11-years and 9 months on a map (Figure 3a), it can be seen that most of the photographs are concentrated around major tourist attractions such as temples and ancient monuments in Ayutthaya city center. When comparing the data over time, we found that the amount of data has decreased in the last 5-6 years due to Covid-19 and the decreasing popularity of the platform. In observing different periods, it was found tourists traveled more during the winter to early summer, and that their numbers decreased during the summer season. In terms of time, people tended to visit and take photos primarily during the morning and afternoon; they visited at a moderate level in the late morning, at noon and in the evening, and least travel during the nighttime.

While analyzing Instagram posts, we visualized spatial data about location based on pins (Figure 3b). The researcher divided these posts into 2 groups consisting of posts about general tourist attractions, and posts about tourist facilities and services. With respect to Instagram posts about general tourist attractions, most of these are archaeological sites located at the center of the city. Additionally, the area along the river also has many posts about religious sites. The evidence shows that the main tourist attractions attracted Instagram users, the same as was indicated by the results of Flickr analysis. There are several pins on Instagram posts collected from tourist facilities and services; most of them are cafés that are clustered next to ancient sites and along the east riverside, and only a few are located on the outskirts. When considering posts by month, the number of Instagram posts decreased from March to August corresponding to the low travel season, the same as was found in the Flickr analysis. Instagram also has a limitation with respect to dates. It does not provide data about the date the photo was taken; it only shows the upload time.

Figure 1

Results of Segment Analysis on the Ayutthaya City Center in 2021.



Note. Adapted from *Ayutthaya City Center*, by Google Map, 2022. Copyright 2022, by Google LLC.

Figure 2

The Study Process of the Tourist Attraction Popularity From Social Media Data

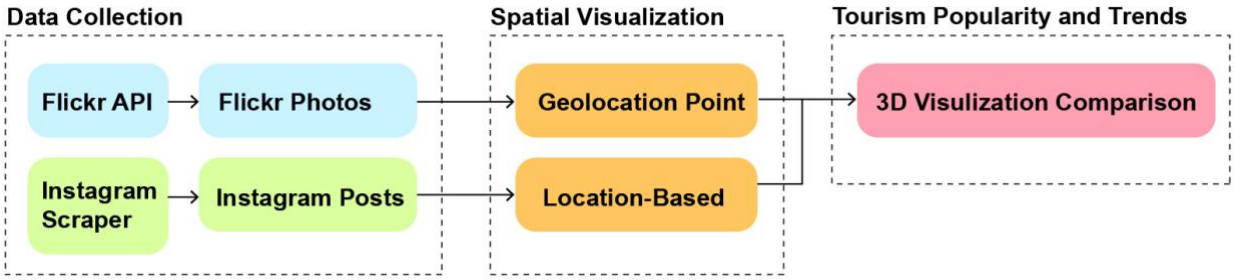
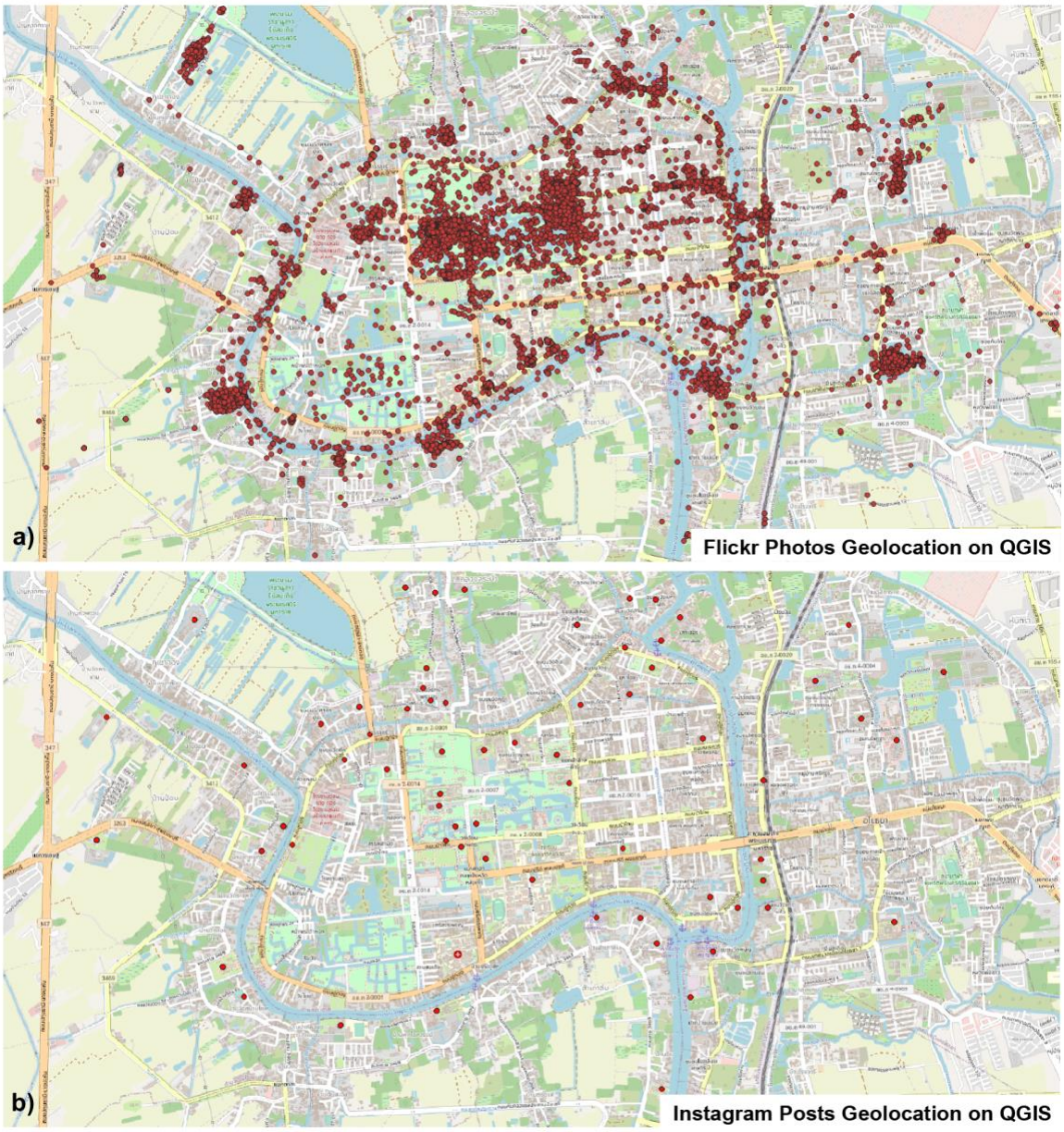


Figure 3

Visualization of a) Flickr Photos Geolocation and b) Instagram Posts Geolocation on QGIS.



Note. Adapted from *Ayutthaya City Center*, by OpenStreetMap, 2022. Copyright 2022, by OSMF.

It is necessary to understand the popularity and trends of tourism in order to understand the management priorities in the current situation. In this section, we summarize the popularity of each attraction according to the social media data. The results are visualized as a 3D bar graph based on the location of tourist attractions on the map (Figure 4a). According to Flickr analysis, the 4 most prominent attractions are Wat Mahathat, Wat Yai Chaimongkol, Wat Phra Si Sanphet, and Wat Chaiwatthanaram. Wat Mahathat ranks among the most photographed places, with a famous photograph of the Buddha's head in tree roots because the existing photographs influence the photographic view of tourists (Payntar et al., 2021), resulting in the taking of similar photographs. It can be seen that the tourists who use Flickr are very interested in the photographed attractions, which generates a high number of photos at this attraction. The gap in the number of photographs between the ancient tourist attractions is particularly high compared to other types of tourist attractions and tourist amenities.

Instagram analysis (Figure 4b) shows that pictures are posted in many major tourist attractions as well as Flickr, but Instagram has more postings about tourist facilities and services such as café and restaurants than about general tourist destinations.

In summary, the comparison demonstrates the contextual differences between platforms that can be useful in different situations. (1) Flickr shows the popularity and importance of major tourist attractions. Flickr's photography is ideal for identifying the predominant tourism trends for foreigners and those who are interested in iconic tourist attractions and (2) Instagram shows that its users are both tourists and local travelers. Instagram is suitable for showing the current trends regarding tourist attractions and tourism facilities and services. As a result, tourists are interested in the major tourist attractions of Ayutthaya, but identifiable trends in leisure tourism such as café-hopping have a higher post volume on Instagram. We also experimented with a popular café from Instagram and found that cafes near important tourist areas such as archaeological sites were given special attention, which affects the volume of posts in these cafes. Therefore, it can be seen that major tourist attractions and tourism facilities have to rely on each other because people want to enjoy both culture and leisure.

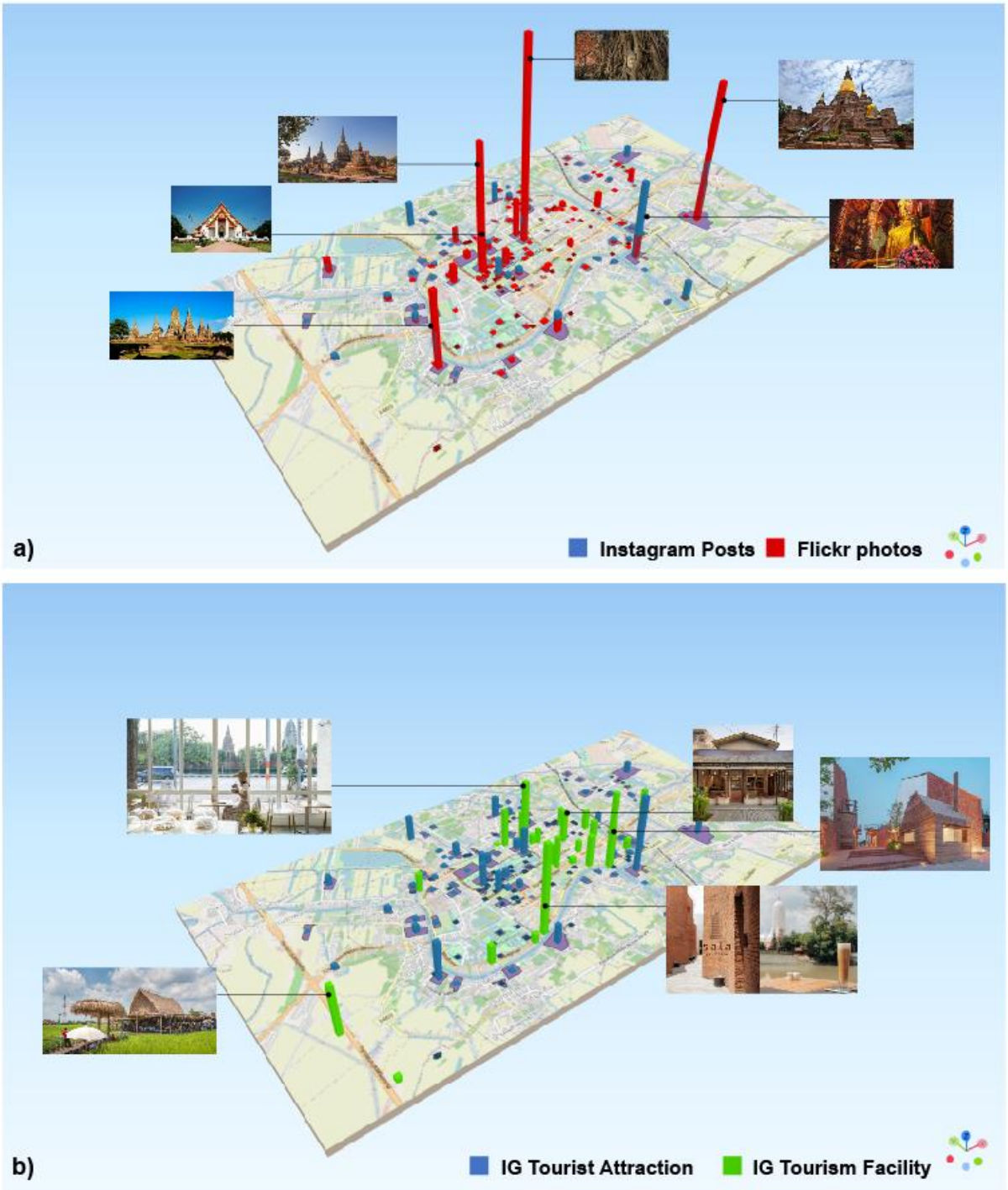
Destination Image from Text and Image Processing

In this section, content from social media is used to study destination images that are useful in supporting the development of tourist attractions. According to the research methodology, text processing and image processing are performed to reveal destination images in social media content. Text processing is a process used to find out people’s interests, while image processing is a process to analyze the elements of an image (Figure 5).

In this section, the researcher will give examples of both text and image processing results divided into general tourist attractions and major tourist attractions with high popularity based on analysis from the previous section. Wat Phra Ngam, an ancient tourist attraction was selected as the general attraction, while Wat Mahathat was chosen as the high-popularity attraction based on the number of Flickr and Instagram posts that rank among all the attractions. The first part is the analysis of tags from text processing to illustrate the important tags obtained by grouping texts mentioned in the photograph. The top tags for Wat Mahathat are *Thai travel*, *travel notes*, *visiting temples*, *temples*, *Phra Nakhon Si Ayutthaya*, etc. Collectively, these tags demonstrate that Wat Mahathat is an archaeological temple tourist attraction that is outstanding in tourism, and that it represents the perception of Ayutthaya. On the other hand, Wat Phra Ngam is a general archaeological temple that has gained a reputation through local television media. The top tags of Wat Phra Ngam are *science*, followed by *astronomy*, *sci-fi movies*, *travel in Thailand* and *traveler's notes*, etc. These tags results are unusual for archaeological sites, because of the influence of the TV series “Buppesannivas”, which mentioned the Gates of Time, resulting in the many fantasy and sci-fi tags. Text processing can indicate people’s interests from the results; as can be seen from these two examples, even similar attractions with different types of popularity can have different unique characteristics.

Figure 4

Visualization of Tourist Attraction Popularity From a) Flickr Photos Chart (red) With Instagram Posts Chart (blue) and b) the Comparison Visualization Between Instagram General Tourist Attraction Location Chart (blue) and Tourist Facilities and Service Location Chart (green).



Note. Adapted from *Ayutthaya City Center*, by OpenStreetMap, 2022. Copyright 2022, by OSMF.

Figure 5

Image Processing, From Importing Photos to Obtaining Analysis Results

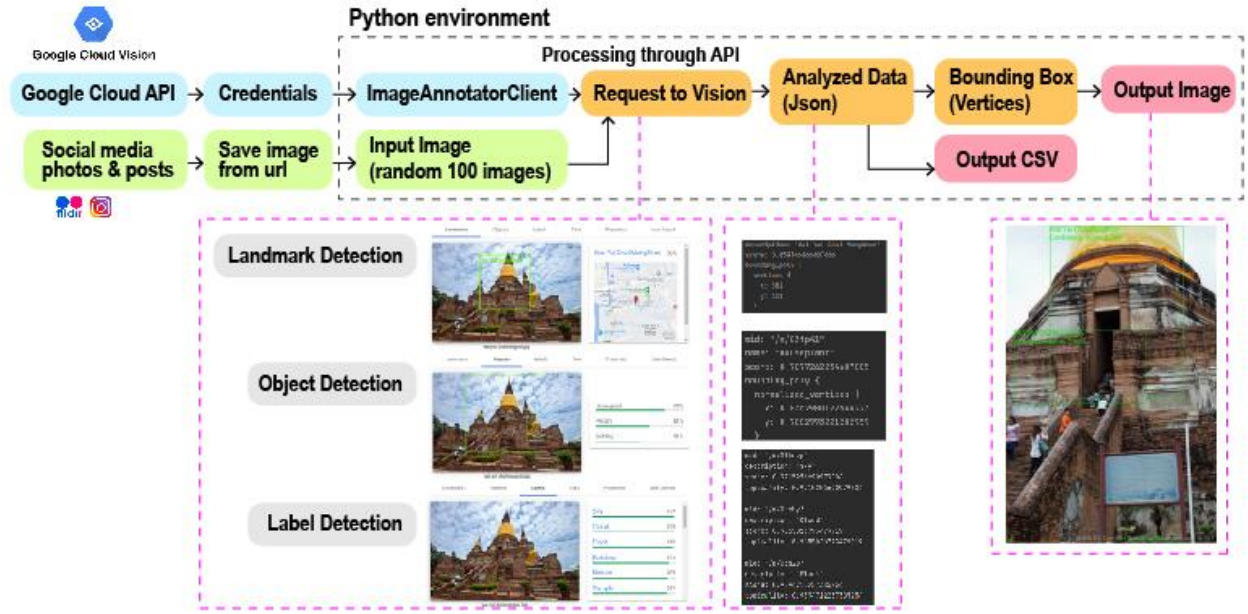


Figure 6

Image Processing Results Show Object Detection on Photos From Social Media. a) Represent Photos From Wat Phra Ngam b) Represent Photos From Wat Mahathat

In the image processing part, the results show the number of elements detected in the photograph using label detection. Analysis of Wat Mahathat identified labels such as *Temple*, *Sky*, *Trees*, *Plants*, *Ancient Sites*, and *Arts*. There are also labels related to brick materials and brick architecture. The labels show that Wat Mahathat is a temple-type ancient tourist attraction that has an image connected with nature, and that it also has elements of brick architecture. Wat Phra Ngam is considered one of the Unseen attractions (Figure 6a). According to label detection, 8 of the top 10 labels refer to trees, plants, grasses, natural scenery, and people in nature. It is quite clear that it is a tourist attraction that has a natural image of trees and plants rather than being an archaeological temple. There is also a connection between the location and the people who took photos there. If we compare the results from the two temples, it can

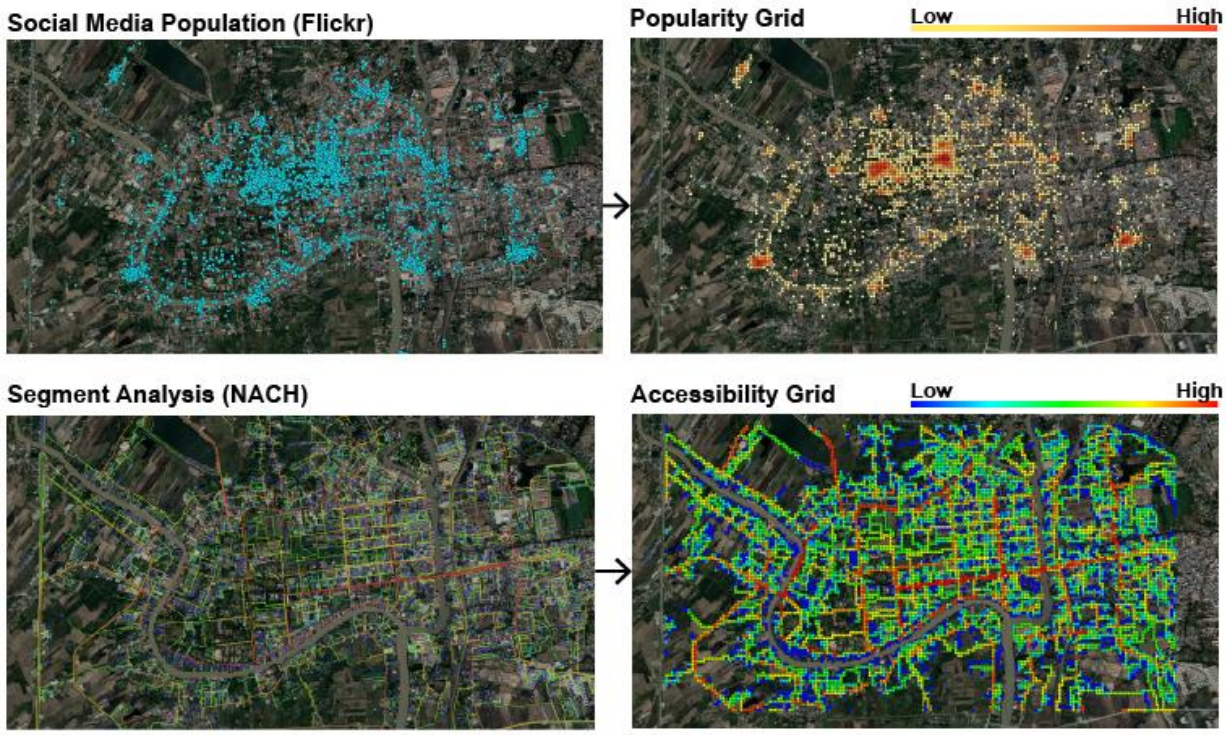
be seen that Wat Phra Ngam is attractive to people who are into nature, while Wat Mahathat is identified as a tourist attraction with unique architectural elements (Figure 6b). This implies that image processing can analyze an image in terms of its essential physical components as a tourist attraction. This is different from results from text processing that identifies people's interests and topics. The results of this stage can be used to interpret destination images in order to develop tourist destination image direction.

The Relationship Between Tourist Attraction Popularity and Accessibility Potential

Once the social media dataset was obtained and results from segment analysis were analyzed, both results through overlay analysis were used to study how these data sets can provided valuable information about tourism development potential and lead to better tourism decision-making aids to assist in management and development. In order to perform the overlay analysis, social media data and segment analysis results were converted into a 40x40 meter grid according to the research methodology. When the overlay analysis was performed, the results were visualized according to the color range, which is divided into 3 sub-levels that represent the density of the population and the accessibility potential. The color is based on the expression of the space syntax, with warm colors representing high values and cool ones representing low values.

Figure 7

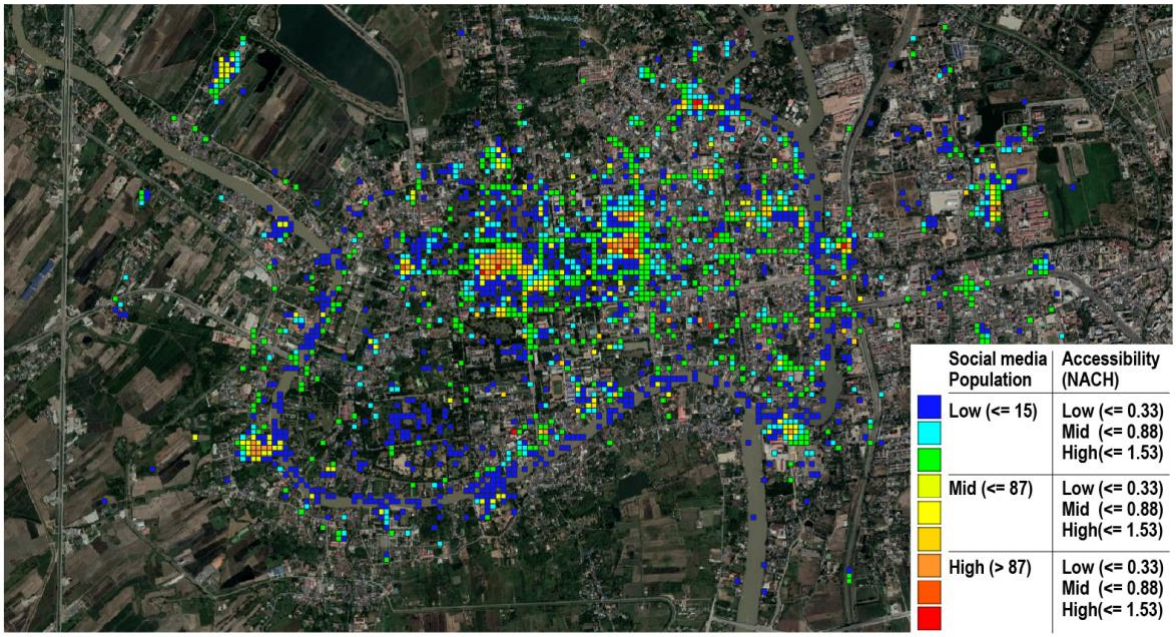
Conversion of Social Media Data and Segment Analysis Results Into a Grid Format



Note. Adapted from *Ayutthaya City Center*, by Google Map, 2022. Copyright 2022, by Google LLC.

Figure 8

The Relationship Grid Visualization Ranged From Cool Tones to Warm Tones



Note. Adapted from *Ayutthaya City Center*, by Google Map, 2022. Copyright 2022, by Google LLC.

Results from the social media data and segment analysis were displayed in a grid-based format (Figure 8) to check whether the volume of social media photos was related to the accessibility potential. The statistical correlation was analyzed and it was found that the Flickr data and NACH were not correlated. In this respect, it can be concluded that tourist attractions' accessibility and traffic potential do not directly encourage or decrease the number of tourism activities represented in social media data. Perceptions about the attraction and destination are more important to a tourist attraction. On the contrary, physical convenience is important due to the fact that the main tourist attractions with transportation and parking have a relatively high volume of posts, and it also helps to increase the potential of tourists want to visit those sites in the future. When we visualize a relationship grid or a grid of social media and accessibility potential, it shows tourism areas that are expected to have issues or potential.

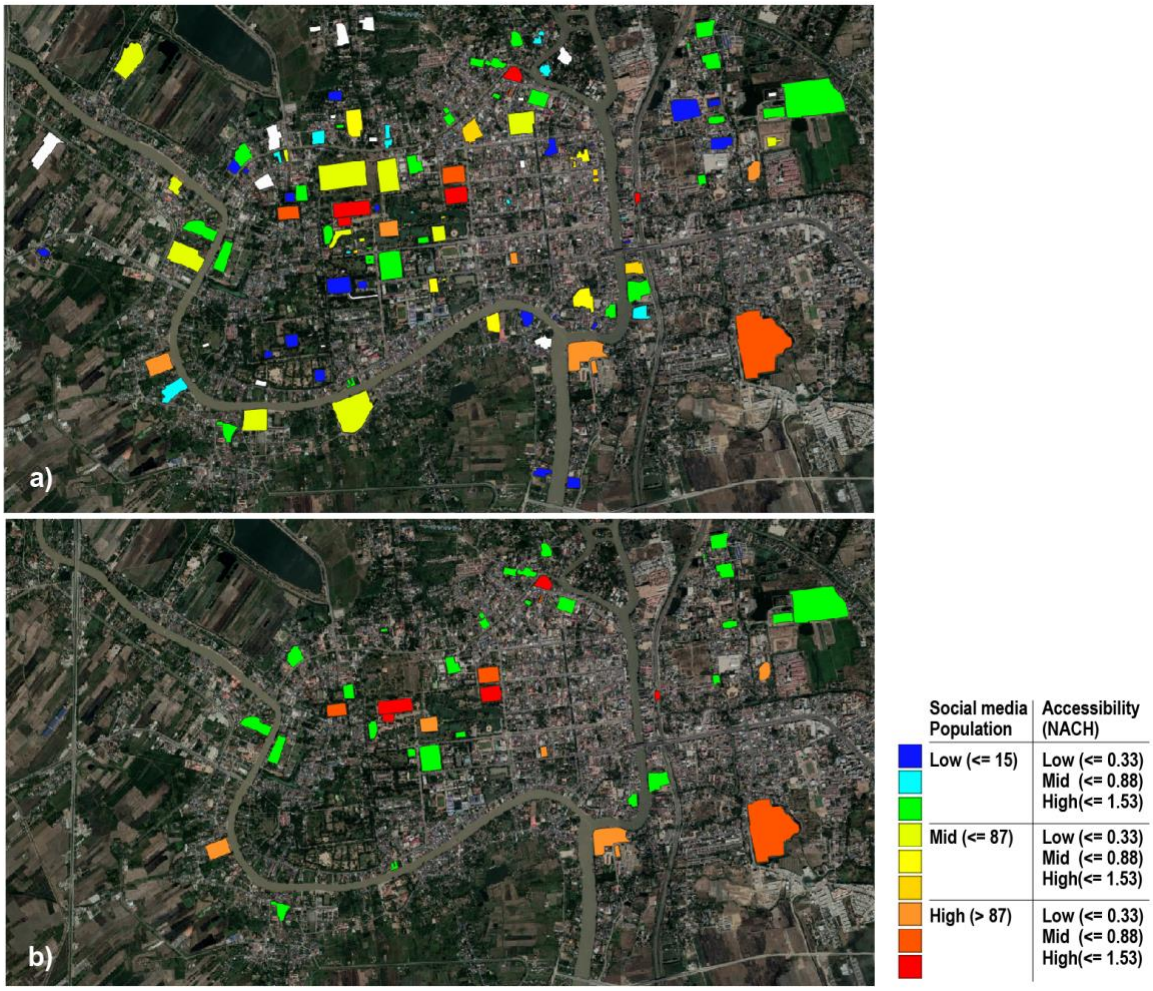
The researcher then applied the grid to create links with the locations of tourist attractions in order to visualize the results as a relationship map (Figure 9a), which provides the ability to differentiate the potential of each tourist area. When looking at the relationship map, the focus should be on the green and orange groups (Figure 9b).

As shown in figure 10, (1) The green color group identifies a tourism area with low posting and photographic activities, but one which is located in an area with high accessibility potential based on spatial morphological analysis. A green area comprises a group of attractions that are primarily located on the main road connecting to the surrounding city. This group of attractions has the potential to be developed due to good accessibility opportunities, but may not currently be attracting many people to visit and share experiences on social media. Therefore, destination image development should be considered in order to increase the likelihood of tourists visiting. An example of a tourist attraction in the green color group is the Chandrakasem Museum. The museum is located near U-thong Road, which is the main road in the city, but lacks the visual interest to attract tourists. However, the destination image extract from text and image processing found that this place is mentioned in terms of architecture and composition (Figure 10a). This provides opportunities to strengthen the destination image as an architectural photography attraction, which can be used to promote a group of similar tourist attractions, or

to create a new tourist route and (2) The orange color group identifies a tourism area with a high density of posts and photos, but one which is located in an area of low accessibility potential. It can be seen that each group has some different characteristics and surrounding contexts. This group is mostly located in the center of the Ayutthaya Island area where there is low accessibility potential due to the area having few alternative travel routes. On the other hand, it can be inferred that this group of tourist attractions has the potential to attract tourists without relying on traffic potential and accessibility. Unfortunately, areas with low accessibility may lead to overcrowding due to a lack of ability to choose routes. Most of the tourist attractions in this color group are major tourist attractions that can easily be overcrowded, especially tourist attractions like Wat Lokayasutharam (Figure 10b), which is an ancient temple with a large reclining Buddha located near the community area. The low accessibility has a negative impact on communities that may share the route, unlike other tourist attractions that may have separate routes available for accessing the area. Consideration of negative impacts should be given priority in these areas, and route management should be considered in order to reduce the chance of damaging the ancient sites. The results of this part are expected to identify areas that may have development opportunities, and they can be used to initially point out tourist attractions with conflicts, potentially leading to better decision-making on tourism management and development.

Figure 9

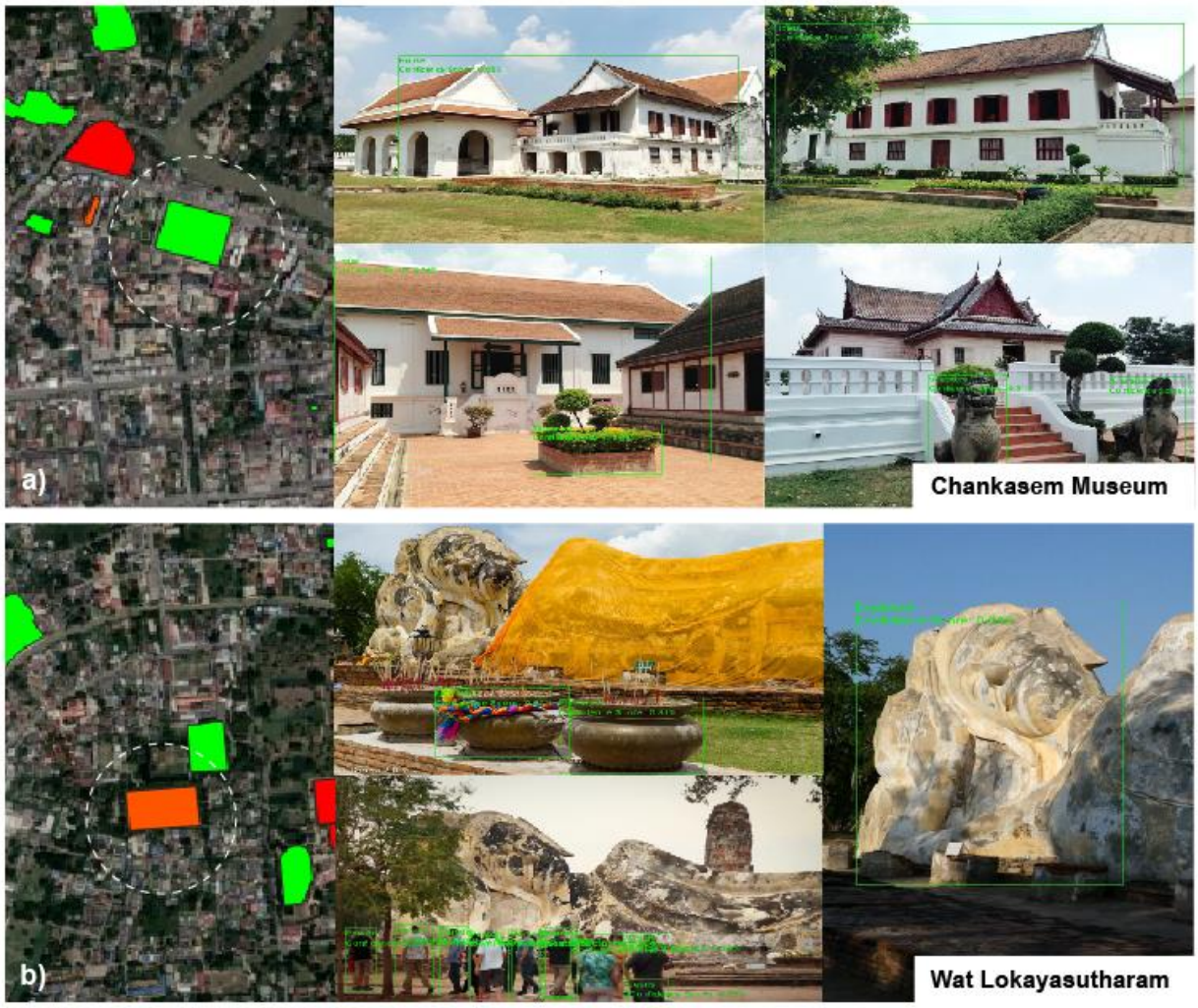
Visualization of a) Relationship Map in Each Tourism Area and b) Tourism Area Which Has a Development Possibility



Note. Adapted from *Ayutthaya City Center*, by Google Map, 2022. Copyright 2022, by Google LLC.

Figure 10

Examples of Destination Images of Tourist Attractions Categorized With the Relationship Map, a) Chandrakasem Museum and b) Wat Lokayasutharam.



Note. Adapted from *Ayutthaya City Center*, by Google Map, 2022. Copyright 2022, by Google LLC.

The Development of Spatio-Social Media Analytical Tools

This section explains the development of an analytical tool based on the study process from previous sections to create a GIS spatial studies workflow with a graphical modeler (Figure 11). All processes are integrated to use as spatial studies tools in QGIS. The development consists of 3 development parts: (1) Social media extraction and GIS visualization, (2) The overlay analysis process and GIS visualization, and (3) Social media content analysis and visualization.

Social media extraction and GIS visualization are used to extract information from social media and visualize it on the QGIS map. This tool was developed through the QGIS graphical modeler function, which can create QGIS spatial process workflow. First, a workflow model was created and exported as a Python script to communicate with the PHP script and retrieve social media data from Flickr. The script saves data in a CSV format and converts it into spatial data that can be visualized on the QGIS map. It can be used by filling in the parameters to customize the coordinate position, search radius, and upload date or creation date of social media posts. The second part is the spatial data overlay analysis section, which uses the graphical modeler tool to

bring the social media data obtained from the first part and space syntax value which must be analyzed by the users themselves and converted into a grid form. The tool combines the data using the *join attribute by location* function on QGIS to merge data and visualize it as a relationship map. The last part is social media content analysis and visualization, performs text and image processing to extract useful data from text and photos. It uses a PHP script executing a Python script to perform text and image processing, and saves data for visualization on web-based applications, and for further use in spatial studies. The overall process produces results that help explain details related to the popularity of tourist attractions, destination perception, accessibility potential, and the relationship between popularity and accessibility potential in order to identify areas with development potential and support decision-making on tourism management.

CONCLUSION

This research has carried out an analysis that meets the needs of present-day tourism management and development. First, spatial morphological analysis was performed through the space syntax method using Deptmap software with QGIS. The spatial results focused on accessibility potential to identify areas that offer good opportunities for tourists to easily access various tourist attractions. The results were useful in identifying the traffic characteristics and street orientation in the experimental area, and can be used with social media data. Also, a social media collection script was developed to obtain photos and posts from Flickr and Instagram; this is hugely advantageous in understanding the popularity of tourist attractions and current tourism trends. Also, social media content such as text and images can be interpreted by using Artificial Intelligence technology as text and image processing to understand the perception of destinations, which can be difficult to interpret using other study methods. The research also presents the exciting potential for use in real-time management of tourist attractions. The results can also be applied to other tourist sites that may have similar characteristics. In addition, the behavior of social media users between different platforms (Flickr and Instagram) is recognized.

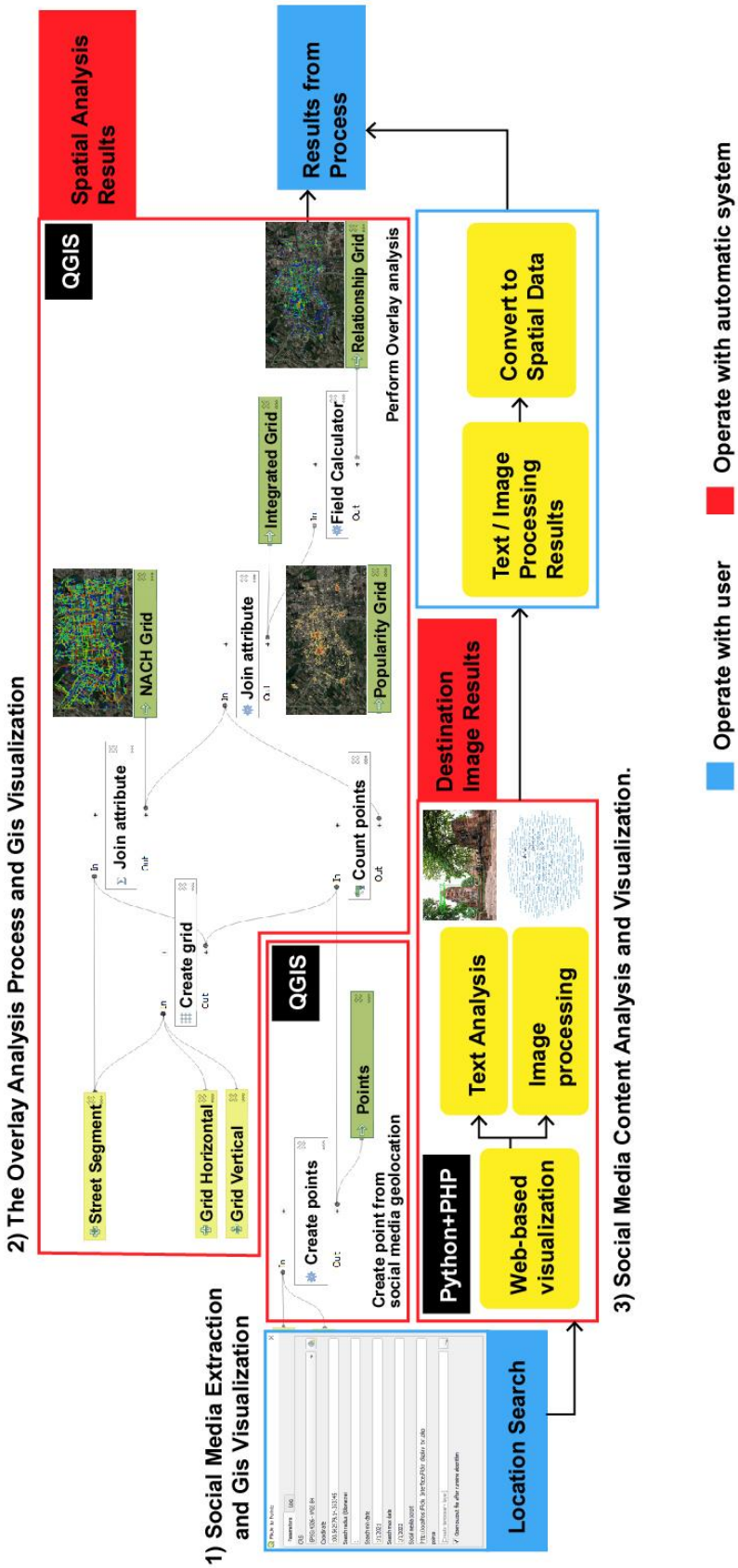
Second, an analytical workflow to aid decision-making on tourism development was studied, and the data on tourism activities represented on social media were combined with the results of spatial morphological analysis. The two tools have seldom been studied together, so this research may help contribute to the development of the spatial study. The results can be used to help make better decisions about examining and prioritizing tourist attraction sites that may have a conflict between the tourism activity and the spatial potential. Also, the social media content analysis results help explain perceptions of individual destinations, which can benefit destination image development. Therefore, the results obtained from social media data and morphological analysis are valuable and different from traditional data collection or the big data technique alone. In the last section, an analytical tool was developed to assist GIS workflow and social media studies to obtain results that will aid policymakers or stakeholders to manage tourist attractions in accordance with social trends and the potential of relevant areas.

There are a few limitations in this study. The first is the social data limitation created by the COVID-19 pandemic, which made real-time studies more difficult. The second is that this research only studied one experimental site. Therefore, if the process is implemented in other areas, additional factors may need to be taken into account. The third is that social media can easily deviate from online marketing. In order to reduce this deviation, it is necessary to use multiple platforms or additional data sources in conjunction with social media data in an effort to reduce the data discrepancy. The fourth is that the tools and processes developed in this research are still prototypes that may not be fully accurate and may require further evaluation of their applications and results.

In future studies, the analytical tool should be used to analyze other tourism areas that may have similar and different contexts. Also, other data sources should be applied to strengthen the accuracy of the results. From a technical standpoint, the user interface and back-end system should be developed to create a more continuous workflow.

Figure 11

An Analytical Tool for Tourism Development: A GIS Graphical Modeler Script for Social Media Data Collection, Content Analysis, and GIS Workflows



Finally, it is expected that results from both the study's process and the analytical tool will be useful to the tourism and urban community field, and will help drive the use of technology in tourism academics, including architecture and urban fields, leading to smarter tourism and smarter cities in the near future.

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