Smart Application for Car Parking System at Nakhon Ratchasima Rajabhat University

Wiyada Yawai*

Faculty of Science and Technology, Nakhon Ratchasima Rajabhat University

Email: wiyada.y@nrru.ac.th

Abstract

This smart application, namely "CarPark", was developed to solve vehicle parking problems at Nakhon Ratchasima Rajabhat University. Because, at present, there are many cars travel around Nakhon Ratchasima Rajabhat University each day, but parking at the university is limited. Therefore, it takes a long time to find parking, and sometimes drivers need to park in prohibited areas. This blocks entrances and exits. The "CarPark" application can be used to find a parking lot, a parking space, a car and a car owner. It can also be applied to motorcycles and expandable for users to use with many parking lots, parking spaces for an unlimited number of cars and motorcycles. Actual trialed users used parking spaces at all 30 buildings at Nakhon Ratchasima Rajabhat University. A total of 44 users, including executives, lecturers, students, staffs and external personnel, were assessed. The average application satisfaction score was 4.06, which is quite high. This smart application can also be used in any parking lot of any organization for any registered vehicle.

Keywords: Mobile application; car parking system; parking space.

1. Introduction

Many cars use the parking lot at Nakhon Ratchasima Rajabhat University each day. Because parking on campus is limited, it can take a long time to find a parking space. Sometimes drivers have to park in a prohibited area. This causes a problem in which entrances and exits of parking lots are blocked, and new cars are unable to enter. This application is specifically designed to solve this problem. However, in educational institutions there has been no development of a mobile application that identifies parking spaces in a building, along with collecting parking data in each building where vehicles were parked. How many cars are currently parked, and how many more cars can be parked in each building? This application can be used for both cars and motorcycles. The user registers in the application with an emergency contact number. We developed the application with the following objectives:

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* Corresponding author.

- To solve the problem of finding a parking place at Nakhon Ratchasima Rajabhat University.

- To help in tracking the owner of a car when he or she has parked in the wrong place.

- To help in finding a car in case the owner forgot where the car was parked.

2. Previous Research

The application "Find My Car eLibera Parking System" [1] helps to find parking by using the current location, car owner's location, and GPS positioning. Google Navigation is used to navigate to the parked car. The user location can be shared with friends of users, or a picture of the parking spot can be taken and sent in an SMS as an emergency message. The application is compatible with the operating system Android 2.2 and higher, and is used for general locations. Thailand Highway Traffic [1,2] is an application that displays traffic information about the highways in Thailand by showing a current picture from CCTV cameras installed along the highways with the user's vehicle speed data (km/h). The flow rate of the user's vehicle (veh/h) is recorded on a graph for the past 24 hours and displayed in color. The user can search for service points such as restrooms and drinking water, along with a map showing the travel time. The application is available for both Android and IOS. OBD, Car Doctor by PNN Soft [1], is an application that helps to check cars and shows various details about the engine's status by working through the Bluetooth system when there are defects. Car Doctor also recommends solutions for Waze users [1] as an application that reports traffic using current technology. By crowdsourcing with real-time traffic reports, along with traffic reporting in map format and chat rooms for users using Waze in the same area, the user can chat and share real-time traffic reports. The HUDWAY-GPS Navigation HUD [1] is an easy-to-use 3D navigation app. The user can choose a route to help calculate the distance speed.

Worapon Pongphet [3] developed an application to help inspect parking buildings and empty spaces in parking buildings using the Android operating system and Google Maps. (The Parking Building and Available Space Application uses the Android Operating System and Google Maps.) Pongphet's application to provides building recommendations and finds suitable parking spaces for vehicles using a mobile phone. The system is connected to the GPS system and Google Maps through sensors and microcontrollers (Arduino) used in buildings and parking lots at Dhurakij Pundit University.

Montasinee Homwan and his colleagues [4] developed a Parking lot Searching System by WAP Service via mobile phone. This application works with parking areas in buildings or in shopping centers. Optical electronic sensors are used to detect cars. Then, the data are sent via an ET-PC 8255 card into the database system in the server. The database system was developed by using Visual C ++, Nokia WAP Toolkit, and Professional Home Page. The screen display is text mode. The user must enter the site to view whether the parking position is free. This research is only a simulation of a parking search system.

Ittipol Homhoun and his colleagues [5] attempted to find free parking spaces and parking spaces close to areas required by visitors. To save time in finding a parking space and reducing traffic problems within Naresuan University. Data were collected from this research, including building names and parking locations. Then, the data were managed by using the QGIS program, which created a database. Then, a set of instructions was written to create a Web Map Interface in JavaScript, PHP, and HTML. The location system was connected to

OpenLayers, Geoserver, and the Database Management System. To show the location of the parking place in the database. The position results were calculated every time the user searched according to specified conditions. jQuery mobile was used to develop a system to update the parking information in the smartphone system. Based on the results of the experiment, by allowing a user to choose conditions according to his or her needs, a system can support the decision of the carriage location within the dog. Colleges can help make choices more easily. All research papers mentioned above can be concluded their objectives, scopes, services, OS, tools, techniques and limitations as shown in Table 1.

Table 1: The conclusion of the previous research objective, scope, service, OS, tool, technique and limitation.

System/ Researcher(s)	Objective(s)	Scope(s)/ Service(s)/OS	Tool(s) /Technique(s)	Limitation(s)
Find My Car By eLibera [1]	1. To locate a car. 2. To search for the parking position of his/her own car.	1. Anywhere using. 2. Android.	1. GPS. 2. Android.	1. Unable to search for other car owners. 2. Unable to search for a parking lot and space.
Thailand Highway Traffic [2]	1. To show traffic pictures. 2. To show vehicle-speed information. 3. To find a service point.	1. Anywhere using. 2. Android/IOS.	1. GPS 2. Android/I OS	1. Unable to search for other car owners. 2. Unable to search for a parking lot and space.
OBD Car Doctor by PNN Soft [1]	1. To help users check their car statuses. 2. To give recommendations users to solve various problems related to their cars.	1. Blueto oth.	1. Bluetooth	1. Unable to search for other car owners. 2. Unable to search for a parking lot and space.
Waze [1]	1. To report the real-time traffic status.	1. Use chat rooms to introduce customers.	1. Use Crowdsourcing Technology.	1. Unable to search for other car owners. 2. Unable to search for a parking lot and space.
HUDWAY- GPS Navigation HUD [1]	1. To help drivers to navigate in 3D. 2. To search for points of interest and select routes with sound. 3. To calculate car speed and distance.	1. Anywhere using.	1. GPS	1. Unable to search for other car owners. 2. Unable to search for a parking lot and space.
Worapon Pongphet [3]	1. To help drivers to check parking buildings	1. Available for a car only.	1. GPS 2. Google Map	1. Available for car only. 2. Able to use

System/ Researcher(s)	Objective(s)	Scope(s)/ Service(s)/OS	Tool(s) /Technique(s)	Limitation(s)
	and empty spaces.	2. Able to use only at Dhurakij Pundit University. 3. Androi d. 4. Google .	3. Sensor and Microcontroller (Arduino)	only at Dhurakij Pundit University. 3. Unable to search for other car owners.
Montasinee Homwan and his colleagues [4]	1. To find a car park through the WAP service on a mobile phone and send a vacant position.	1. Able to use with car only. 2. Use simulation techniques to simulate a parking search system.	1. Use light sensors to detect cars.	1. Able to use with car only. 2. Unable to search for other car owners. 3. Still not be practical, available only in the parking simulator.
Ittipol Homhoun and his colleagues [5]	1. To help drivers to find vacant parking spaces within Naresuan University.	1. Able to use with car only. 2. Able to use with Smartphone.	1. Use QGIS program to import data into PostgreSQL/PostG IS database.	1. Able to use with car only. 2. Unable to search for other car owners. 3. Available only at Naresuan University.

3. Research Theory and Methods

3.1. License plates in Thailand

This research uses Thai license plates for cars and motorcycles.

3.1.1. Car License plate [6,7]

In everyday life, people may not even notice license plates. That classified cars by Today, Asia Direct will take an example of each type of license plate that friends see each other in a variety of colors on the road what kind will that be? How are they different? License plates issued by the Department of Transport at present are made of aluminum in a standard size of 13.5 "X 6" with a number of embossed stamps on the license plate and the Department of Transport logo on the bottom right corner as shown in Figure 1.

Figure 1: License plate in Thailand [8].

3.1.2. Motorcycle license plate [7]

The font style of the new motorcycle license plates, as shown in Figure 2, is the same as that of the license plates that replaced the old category beginning in 2012.

Figure 2: Current motorcycle license plate [6].

This version of the moped still has 3 lines like its predecessors. By using the principle of running numbers in the same way as a car license plate, the characters of letters and numbers have changed as well. The Department of Transport seal has been moved from the bottom right corner to the top right corner of the nameplate.

The category on the first line begins with a number, followed by 2 digits of Thai characters, such as 1 กก, 1 กข, 1 กค and so on. Like cars, the second line is the name of province and the last line has been changed from a 3-digit to 4-digit number (which means each category can hold 9999 nameplates).

3.2. Mean [9]

For a given set of numbers $\{x_1, x_2, x_3, ..., x_n\}$ of sample size n, the most familiar and useful measure of the center is the mean, or arithmetic average, of the set. Let x_i be a representative number of the valid observation samples. We often refer to the arithmetic average as the sample mean and denote it by the sample mean $\bar{x}$ of observations $x_1, x_2, x_3, ..., x_n$ is given by equation 1.

$$\bar{x} = \frac{x_1 + x_2 + x_3 + ... + x_n}{n} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad (1)$$

3.3. Sample Standard Deviation (SD) [9]

Let the sample consist of n elements $\{x_1, x_2, x_3, ..., x_n\}$ taken from the population, with mean $\bar{x}$ as in Equation 1. The standard deviation of the sample, denoted by *s*, is the square root of the average of the squared deviations from the sample mean.

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n-1}} \qquad (2)$$

which means $\bar{x}$ as in Equation 1.

3.4. Euclidean Distance [10]

Figure 3 is the Pythagoras' theorem applied to distances in two-dimensional space, by given a vector $x = [x_1\ x_2]$ is the sum of the squares of its coordinates (see triangle *OPA* in Figure 3 or triangle *OPB* – $|OP|^2$ denotes the squared length of *x*, that is, the distance between points *O* and *P*.) The squared distance between two vectors $x = [x_1\ x_2]$ and $y = [y_1, y_2]$ is the sum of squared differences in their coordinates. (Figure 3 $|PQ|^2$ denotes the squared distance between points *P* and *Q*). To denote the distance between vectors x and y, we use the notation $d_{x,y}$ so that this last result can be written as equations (4):
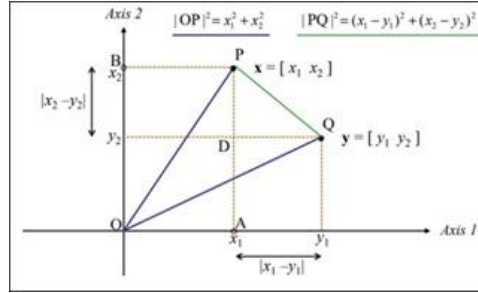
Figure 3: Pythagoras' theorem applied to distances in two-dimensional space.

$$d_{x,y}^2 = (x_1 - y_1)^2 + (x_2 - y_2)^2 \qquad (3)$$

That is, the distance itself, $d_{x,y}$, is the square root as in Equation 4.

$$d_{x,y} = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2} \qquad (4)$$

3.5. Study and Data Collections

Initially, the researcher collects the coordinates of all parking spaces. (A square is drawn.) The maximum number of cars in each parked building is counted. Separate from cars and motorcycles, the coordinates are based on the latitude and all four longitude values in each parking space per car in each building area where parking is possible.

3.5.1. Collect data for the area of the parking building in each building (Building Table). The fields are as follows:
3.5.1.1. Building Code
3.5.1.2. Building Name
3.5.1.3. Beginning Latitude
3.5.1.4. Ending Latitude
3.5.1.5. Beginning Longitude
3.5.1.6. Ending Longitude

3.5.2. *Set codes and coordinates for each building.* The coordinates of each building indicate the total area of each building that can be used for parking.

3.5.3. The car data are set as follows*:*

3.5.3.1. License Plate

3.5.3.2. Car Type

3.5.3.3. Car Color

3.5.3.4. Car Company

3.5.3.5. Province Code

3.5.3.6. Car Year

3.5.3.7. Car Category

3.5.4. Set the car owner information as follows*:*

3.5.4.1. Owner Code

3.5.4.2. Owner Name

3.5.4.3. Name of the agency

3.5.4.4. Telephone number

3.6. Development and Working Design

The design workflow for users of this application is shown in Figure 4. The user logs in to find an available parking space in each building or to find a parked car. The user can also find the owner of a car in case of double parking or parking in the wrong space. The user can find the owner of a car using the license plate, and can then call the car owner. Every screen in the parking system application uses audio commentary in English to help users and provide advice when something goes wrong.
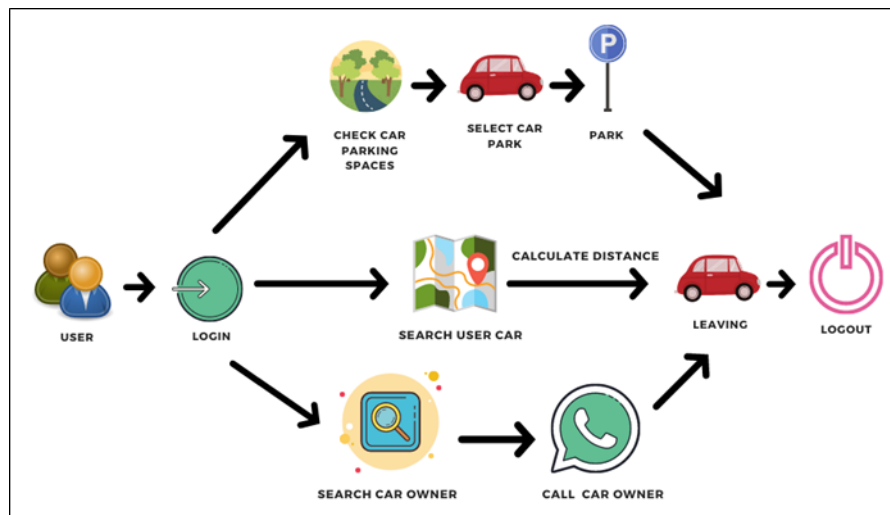
Figure 4: Application workflow.

3.7. Tools for Development

3.7.1. MIT App Inventor 2.0 was used for development [11].

3.7.2. Data was stored on the Airtable Cloud platform [12].

3.7.3. The operating system is based on Windows 10.

3.8. System Requirements

3.8.1. Android operating system.

3.8.2. Internet accessible.

3.8.3. Requires 6.1 MB of installation space.

3.9. Application Design

1. The application, namely "CarPark", size is 6.1 MB. The user must allow the application to access GPS functions, as shown in Figure 5.

Figure 5: CarPark application icon.

2. Thus, the application can display an appropriate size of the screen. The user can adjust the font size to be standard or normal.

3. After that, users click on the icon , as shown in Figure 6, and enter the application. A voice announcement accompanies the screen, as shown in Figure 6. Then, users can click the icon to log into the system, or click to exit.
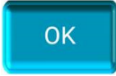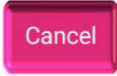
Figure 6: Logging into the application.

4. After clicking the login button , the login page is shown for users to enter the username and password which users have already entered in the system, as shown in Figure 7. The user completes the information and presses or .
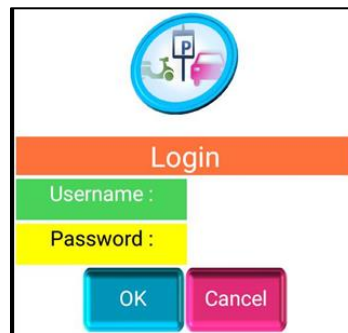
Figure 7: Log in and access.

5. The user has logged in and will come to the screen as shown in Figure 8. This is the main menu with various buttons. The meaning of each button is explained in Table 2.

Figure 8: Main menu to access application.

Table 2: Meaning of each button.

Button	Meaning
	primary portion of user data
	description of each button
	part that stores information about the car
	parking button
	parking spot
	search for parked car
	search for the car owner using the license plate
	exit from application

.6When the user presses , the screen appears as in Figure 9 to allow users to view details about the car owner, and the user can edit, then presses the button to save edited data or presses the button to exit.
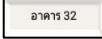
Figure 9: Owner information screen.

7. Pressing displays the car information screen, as shown in Figure 10. Users can edit the information and press the button to save edited data or press the button to exit.

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Figure 10: Car information screen.

.8When the user presses the button , the application shows the number of parking spaces available in each building. The user can press to display information on the number of parking lots in 30 buildings, as shown in Figure 11. The user can press to display the next page or to show the previous page. Additionally, the user can press buttons for each building. For example, pressing shows a picture of the 32nd building. The user can press to calculate the distance from the user's location to the 32nd building)in meters) and display the result, as shown in Figure 12, and press the button to exit.


Figure 11: Number of parking spaces for cars and motorcycles that are vacant in each building.

Figure 12: Thirty-second building, number of parking spaces for cars and motorcycles, and distance from user to 32nd building)in meters).

9. When the user presses the button , the application shows the user entering the parking lot. This is shown in Figure 13. The user must be outside the building because the GPS location (latitude and longitude) is required to determine the parking spot. If the user is outside the building, then an error of approximately +/- 10 meters will occur. The user may have to press the Parking button repeatedly when unable to find the location. Until he or she can find the parking position, as shown in Figure 14, the building name will show as any building.
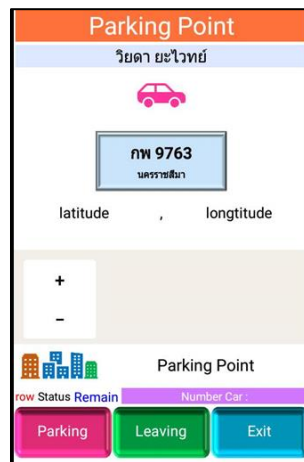
Figure 13: Waiting to press the parking button to park the car, or leaving the parking lot.

Figure 14: Image of car appears on display. When user presses Parking button to park the car, the application shows the parking lot.

Figure 15: User riding a motorcycle. After pressing Parking button to park, application shows a parking lot.

If the user is outside the building area when the nearby building cannot be determined, or the user parks outside the university, the building name will not be displayed but will display a message; parking point, which the user can use outside the university. To help determine the parking spot and to prevent forgetting the parking lot.

10. In case a user presses a button, it will display a screen to help locate the user parked car, as shown in Figure 16.
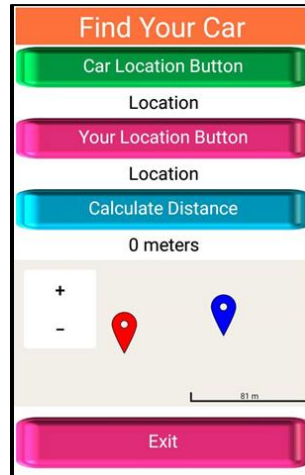
Picture 16: Finding a user's parked vehicle.

The user must press a button to determine where the car is parked. If the user has not parked the car, the application will display a message saying "You did not park the car." And if the user presses the button, the application will not be able to calculate the distance between the points where the user is. Because the user did not park the car and did not specify where the user is, as shown in Figure 17.
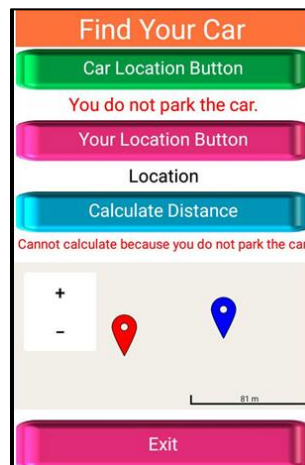
Figure 17: Error when user does not park the car and wants to find a car.

If the user wants to find a vehicle, he or she presses the to locate his or her vehicle,

and presses the [Your Location Button] to locate the user. Under this situation, the user should be outside the building. Because it will find the position of the user well. If the location cannot be found, the application will say "Press button again." The user must press the button repeatedly until the user is located, and press the [Calculate Distance] button to calculate the distance from the user to the car.

11. When a user presses [xx 9999], the screen displays a page, as shown in Figure 18, to find the owner from the license plate as in the picture. In this case, the user must fill in the full license plate number (xx 9999), by which the license plate number must already be registered with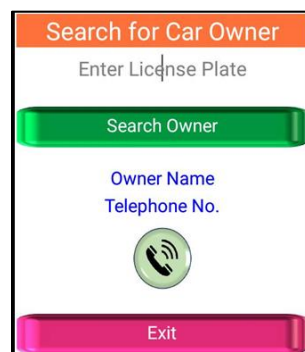 the Smart Car Parking system. After pressing the [Search Owner] button, if there is information in the system, it will show the car owner name. By ringing a phone number with which the user can call a car owner by pressing a button, the owners of cars blocking an entrance or exit or parked in the wrong place can be contacted.

Figure 18: Picture of finding owner of car.

5. Results

5.1. User evaluation results

This research was conducted by test users using the actual application at 30 buildings within Nakhon Ratchasima Rajabhat University. Using both cars and motorcycles, the total number of user assessors was 44 including executives, lecturers, students and external personnel. By gender, as shown in Table 3, divided by the type of users, as shown in Table 4, the average application satisfaction rating was 4.06, which is a high level. By referring to the Chakri Thamman and his colleagues [13] evaluation criteria, details are shown in Table 5.

Table 3: User data by gender.

Gender	Percent
Male	59.09
Female	40.91

Table 4: Data by user type.

User Type	Percent
1. Executive	2.27
2. Lecturer	20.45
3. Staff	6.82
4. Student	43.18
5. External Personnel	27.27

Table 5: Evaluation results from users of application.

Topic	$\bar{X}$	SD
1. The beauty, modernity and interesting nature of the application.	3.65	1.24
2. Easy-to-use menu.	3.89	1.17
3. It is easy and convenient to access information quickly.	3.93	1.07
4. The language used is correct. Able to convey meaning and understand correctly.	4.05	1.01
5. The accuracy of the information.	4.09	0.86
6. Find a park space.	4.30	0.79
7. Find the location of a parked car.	4.27	0.90
8. Find the owner of the car.	4.32	0.80
Average	4.06	0.98

4.2. The statistics used in the research were the percentage, mean and standard deviation. The statistics were compared (dependent t-test) [13] by using the results and the following evaluation criteria.

The mean range; 4.51-5.00, indicates the highest level.

The mean range; 3.51-4.50, indicates a high level.

The mean range; 2.51-3.50, indicates the average level.

The mean range; 1.51-2.50, indicates a low level.

The mean range; 1.01-1.50, indicates the lowest level.

6. Conclusions

Even though, the average application satisfaction assessment, from 44 users, results at the 4.06 level were high. However, because the usage system has limitations on positioning, it must be used outdoors via the GPS system only to locate the parking space. Even so, GPS positioning has a discrepancy of 1-5 meters, it is still in a range of sight for the user to find a parking space or find his or her vehicle. Thus, this application is suitable for using outside the building only. Because indoor parking space locating, the GPS signal may be blocked by a parking building. However, this application can be applied to any parking lot of any organization and also serve any registered vehicle.

7. Discussion

7.1. The application should encourage Internet-of-Things technology to be developed to accurately locate a car's location, especially for indoor parking.

7.2. Language capability should include Thai, English and other languages such as Chinese.

7.3. The application should include a system to log in via Facebook, Google Account and others.

7.4. The application should have an automatic registration system.

7.5. The application should be used by other organizations such as schools, universities and private organizations.

Acknowledgements

References

[1] Roojai.com. (2019, April 6). *5 Must-have Apps for Car Lovers! Definitely good*. [On-line]. Available: http://www.roojai.com/article/car-parts-and-car-accessories/5-app-for-car/

[2] Bureau of Road Maintenance Administration. (2022, March 4). Department of Highways. *Thailand Highway Traffic* [On-line]. Available: http://bmm.doh.go.th/website/index.php/2-uncategorised/190-thailand-highway-traffic#.

[3] Woraphon Pongphet. "Parking Building and Available Space Application using Android Operating System and Google Map." *Veridian E-Journal Science Group*. Vol. 5 no.3, pp. 492-507, 2012.

[4] Montasinee Homwan, et al. "A Parking Lot Searching System by WAP Service via Mobile Phone." *Bangkok University Academic Review Journal*. vol. 5 no. 2, 2006.

[5] Ittipol Homhoun, et al. "Real-time parking decision support system in Naresuan University." *Master's thesis*, Naresuan University. 2015.

[6] Thai Car License Plates good. (2022, March 4). [On-line]. Available: https://driving.information.in.th/license-plates.html.

[7] Vehicle registration plates of Thailand. (2022, March 4). [On-line]. Available: https://www.wikiwand.com/en/Vehicle_registration_plates_of_Thailand.

[8] Including License Plates of Each Type. (2022, March 4). [On-line]. Available: https://www.asiadirect.co.th/adbnewsdetail.php?newId=62.

[9] Jay Devore. "Probability and Statistics for Engineering and the Sciences." *Eighth Edition. California Polytechnic State University*, San Luis Obispo, 2010.

[10] Michael Greenacre. (2008, April 26). *Correspondence Analysis and Related Methods.* [On-line]. Available: http://www.econ.upf.edu/~michael/stanford/maeb4.pdf.

[11] MIT App Inventor. (2021, January 15). [On-line]. Available: https://appinventor.mit.edu/.

[12] Airtable [Internet]. (2021, January 15). [On-line]. Available: https://airtable.com/.

[13] Chakri Thamman and Manit Asanok. "Study results of information system components to promote research and academic services." Faculty of Information Technology Rajabhat Maha Sarakham University. *Journal of Information Technology and Innovation Management*, vol 5 no. 1, pp. 122-132, 2018.