Mobile Application Based Parking System Control and Monitoring Model with Motor Vehicle Parking

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Abstract. Land transportation is an important component of the national transportation mode system, which encompasses provinces, cities, and districts, and has a significant impact on the economy and national development. Parking accumulation is necessary for determining the number of automobiles in a parking lot at a given time. Each parking space has a length of 3 m, a width of 12.5 m, and an area of 37.5 m^2. Each space can seat 15 motorcycles, an increase of 70 vehicles, or 87.5% above the previous capacity. The parking area can only accommodate 80 motorcycles with an effective area of 120 and 60 m^2 for vehicle circulation. By rotating parking spaces, an automatic parking system can increase parking capacity by 87.5% to 150 motorbikes without extending the parking area. Utilizes more optimal power and can park more motorcycles. It is suggested that the automatic parking system application can be enhanced with a variety of new functions.

Keywords: Parking System · Motorcycle Vehicle · Prototyping · PIECES Analysis

1 Introduction

Land transportation is part of the national transportation mode system that has an important contribution to improving the economy and national development, which includes provinces, cities, and districts. Areas that have a land transportation network will have faster economic growth that has a public impact than areas that are exclusive. Based on a survey published by the Central Statistics Agency (BPS) of the Republic of Indonesia Catalog Number 8302004 for the period 2017–2020 [1-5], given the importance of the availability of land transportation in order to support economic growth activities at the national level. This survey is needed to provide information to data users, government, and private parties, concerning land transportation facilities and infrastructure. The object discussed or used in the literacy study research is the mode of land transportation, especially motorized vehicle drivers (two-wheelers). Miro (2008) classifies transportation modes in general into two major groups of transportation, namely (1) Private, a

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Table 1. Comparations Development of Number of Motorized Vehicles in National and DKI Jakarta Province (%).

Type of Motor Vehicle	Development of Number of Motorized Vehicles by Type (Unit)			
	2020	2019	2018	2017
Passenger car	21.30%	21.23%	20.79%	20.24%
Bus Car	15.12%	15.07%	14.99%	14.81%
Freight cars	13.37%	13.34%	13.16%	12.95%
Motorcycle	14.03%	14.07%	14.10%	14.11%
Amount	14.85%	14.88%	14.85%	14.79%

Resource BPS survey data recapitulation for 2017–2020

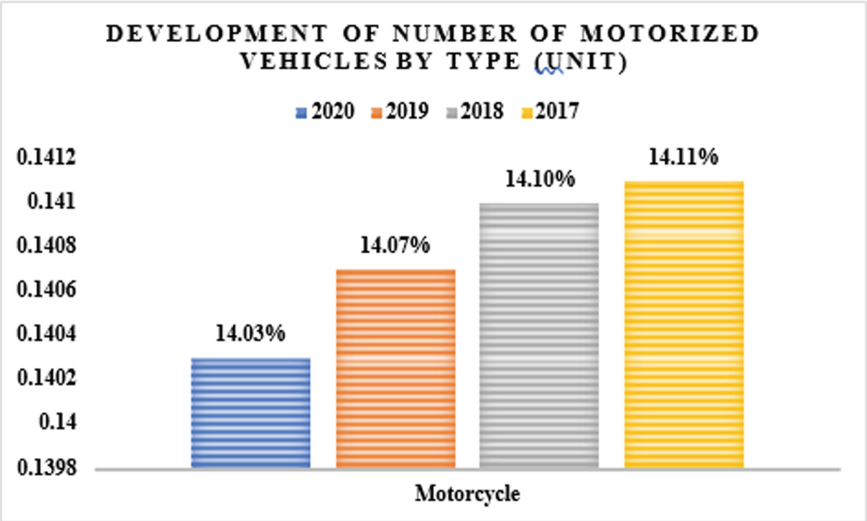

Fig. 1. Visualizayions Comparative Development of Number of Motorized Vehicles in National and DKI Jakarta Province (%).

mode of transportation that is devoted to a person's personal needs (2) Public, modes of transportation that are intended for common (people), common interests, receive shared services, have the same direction and purpose. The average results (Table 1 and Fig. 1) of the development of the number of two- wheeled motorized vehicles at the provincial level of DKI Jakarta against the National is 14.08%.

2 Research Methodology

2.1 Prototyping Method

The research methodology in this final project uses the prototyping method [15], which can be explained as follows:

1. Identification of problems that describe the condition of the problems that are being experienced in each process related to the need for parking spaces and parking systems.
2. Analysis of the problem that describes the problems that occur and have an impact on the business process of the motorcycle parking system at Train Station XYZ (sample). The analysis used for the process describes all the problems that exist at Train Station XYZ related to the motorcycle parking area using PIECES analysis.
3. Needs analysis, namely analysis of system requirements and collecting data or information on the application to be made. At the design stage of the motorcycle parking application, in order to get results in accordance with the system requirements for parking vehicles at Train Station XYZ.

   - Functional Needs [13, 17].

     a. To determine the features that exist in the motorcycle parking system application.
     b. To determine the role of parking attendants and motorcycle users in using the motorcycle parking system application.
     c. To determine the information to be provided regarding the availability of motorbike parking lots at Train Station XYZ.

   - Non-Functional Needs [13].

     a. To support the design of motorcycle parking system applications.
     b. To process data and implement a motorcycle parking system in the form of applications and miniatures.

4. A quick design, namely making general designs for further development. In the software development process, to In order to create apps that are suited to consumers' needs, interaction To produce applications that are tailored to the needs of users, the interaction between the system and humans is needed. At this stage, it is related to applications and miniatures that will later be used by motorcycle users.

   - Use Case Diagrams
     Discussion about the process and actors of parking attendants and motorcycle users in parking vehicles and picking up vehicles.
   - Activity Diagrams
     Discussion about the application flow process with several features and functions that have been designed in the motorcycle parking application.
   - Class Diagrams
     In this phase, the class diagram only describes the structure and class description in the database design and the packages that exist in the system/software that we are currently using.

5. Formation of prototypes, namely the manufacture of prototype devices, including testing and refinement. At this stage, the appearance of the motorcycle parking

application regarding the suitability of the initial design was made with the mockup. In addition to software development, there is the manufacture of a miniature design as a place to park vehicles. This miniature design only depicts an imitation of automatic motorcycle parking on a reduced scale and can be seen from all directions, namely in three dimensions.

6. Evaluation of the prototype, namely evaluating the prototype and refining the analysis of the needs of motorcycle users. This motorcycle parking application helps motorcycle users in parking vehicles and picking up vehicles by utilizing Automation technology and the Internet of Things. At this stage, evaluate the results of the application and the miniatures that have been completed with the system programming process.
7. Prototype improvement, namely, making the actual type based on the results of the prototype evaluation. The final production, namely producing the device correctly so that it can be used by motorcycle users. At this stage, black box testing is carried out. If implemented, it is expected to be useful and make it easier for motorbike users to park their vehicles and can make solutions to solve parking problems at Train Station XYZ.

2.2 UML Model Approach [16, 17]

Identification of problems that describe the condition of the problems that are being experienced in each process related to the need for parking spaces and parking systems.

1. Use Case Diagram
   The roles of each actor in the Use Case Diagram (Fig. 2) are as follows: (1) Motorcycle users, before parking, first open the application to register and then log in. After logging in, motorcycle users can park by selecting a parking lot, then scan the QR Code for the parking token so that they get an E-Karcis and place the vehicle; (2) Motorcycle users who want to finish parking, first provide the QR Code E-Kartis. Then make payment according to the bill and pick up the vehicle; (3) Motorcycle users in topping up their balance by providing a QR Code and nominal money; (4) The parking attendant, before confirming login first, then scans the QR Code Transaction No and provides the total parking payment; (5) The parking attendant in doing a balance top-up, first scans the UID QR Code and receives money, then selects the balance top-up nominal.
2. Class Diagram
   The Class Diagram describes the structure of the system in terms of defining the classes that will be created to build the system. The class has three main parts, namely attribute, operation, and name. The classes that exist in the system structure must be able to perform functions according to system requirements (Fig. 3).
3. Activity Diagram
   In the Activity Diagram process, adjustments are made between parking attendants and motorcycle users when parking the vehicle (Figs. 4, 5 and 6). The design of the activity diagram in the motorcycle parking system at Train Station XYZ is divided into six sub-activities, namely motorcycle user registration activities, login activities,

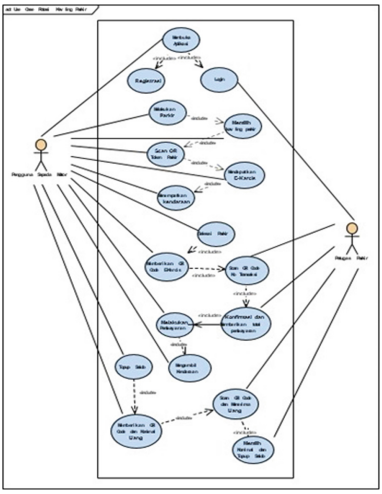

Fig. 2. Proposed Use Case Diagram Design.

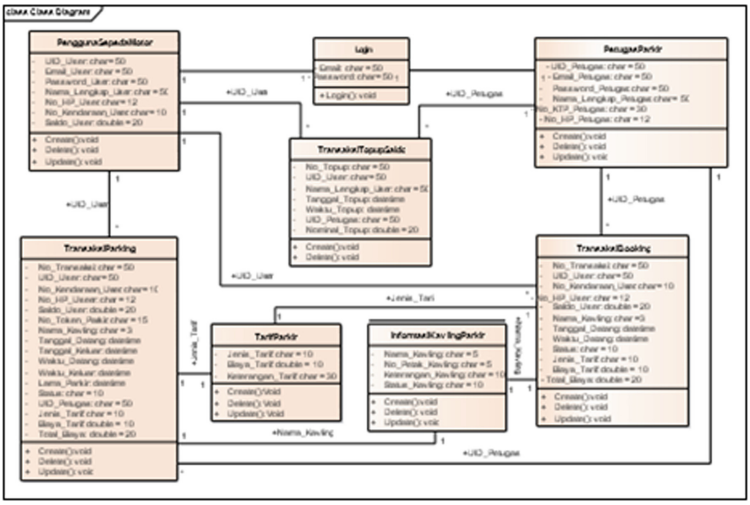

Fig. 3. Proposed Class Diagram Design.

parking entry, parking exit, parking bookings, parking booking confirmations, and balance top-up.

2.3 Parking System Problem Statement with PIECES Analysis

In this step, it will be explained about the current motorcycle parking system at Train Station XYZ, problem statements based on PIECES analysis, system users, all limitations (time constraints, parking attendants, technology, data, and parking processes), and the development of a parking system by utilizing Automation technology and the Internet

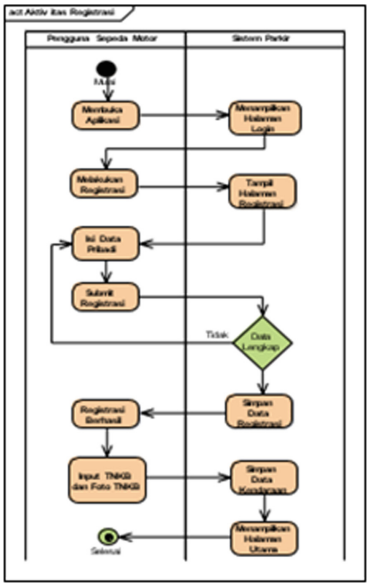

Fig. 4. Registration Activity.

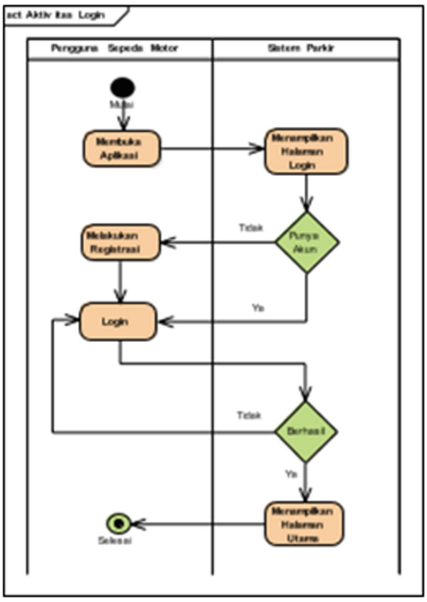

Fig. 5. Activity Login.

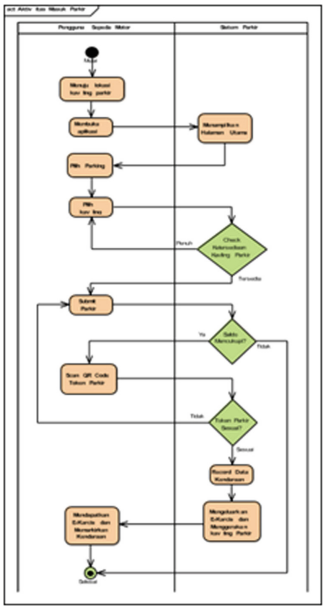

Fig. 6. Entry Activity.

of Things. Explanations of inefficiencies or other problems related to business processes are stated in the PIECES analysis TABLE. Then, the purpose of system improvement is defined, which is obtained from the definition of scope and problem analysis and defines the inputs, processes, or outputs.

- Motorcycle User Registration Activities.
- Motorcycle User Login Activity.
- Parking Entry Activities (Fig. 6).
- Parking Exit Activities (Fig. 7 and Tables 2, 3, 4, 5, 6 and 7).

2.4 Parking System Problem Statement with PIECES Analysis

Parking characteristic parameters should generally [6-9] Accumulation Is the information needed to find out the number of vehicles that are in a parking lot at a certain time interval, equations

$$\text{Accumulation} = E_i - E_x + X \tag{1}$$

1. Duration
   Is the information needed to know the length of a parking motorcycle vehicle? Parking duration is obtained by observing the time the vehicle enters and the time the vehicle leaves.

$$\text{Duration} = \text{Extime} - \text{Entime} \tag{2}$$

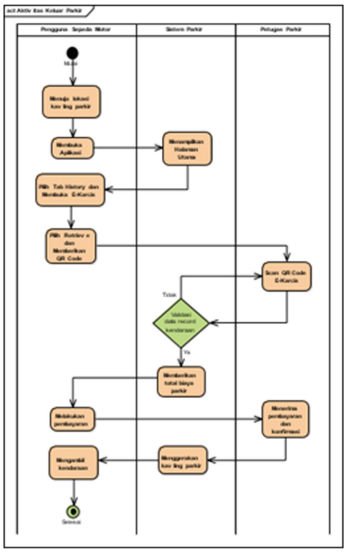

Fig. 7. Exit Activity.

Table 2. Performance Analysis.

Parameter	The Core Problem	Cause of Problem
Throughput	Tn calculating the parking fee, itis only done at the time of the transaction when exiting the parking lot.	Motorcycle users cannot prepare money according to parking fees and increased transaction time.
Response Time	The parking exit only has one exit for motorbikes and cars.	So, when making transactions out of parking, there are often long gueues of parking, there are often long queues

2. Volume
   The number of vehicles that have used the parking space in a certain parking lot in a certain time unit (per day).

$$\text{Volume} = E_i + X \tag{3}$$

3. Index
   The parking index is a percentage of the accumulation of the number of vehicles at a certain time interval divided by the available parking space x 100%.

$$IP = \frac{\text{Accumulated}}{\text{Available parking space}} * 100\% \tag{4}$$

Table 3. Performance Analysis.

Parameter	The Core Problem	Cause of Problem
Accurate	The core problem There is no information on the availability of vacant parking lots	Motorcycle users do not know whether there is still vacant parking available.
Punctuality	Motorcycle users are only given information on parking entry signs	Motorcycle users parking their vehicles need more time to find vacant parking lots
Irrelevant	Motorcycle users only know how long the parking duration is at the time the transaction is exiting the parking lot	Motorcycle users do not know for sure the parking costs incurred based on parking duration in real-time.

Table 4. Economic Analysis.

Parameters	The core problem	Cause of Problem
Cost	In the procurement of equipment, investment costs are still small.	There is only a maintenance fee for the ticket dispenser and automatic doorstop.

Table 5. Controlling Analysis.

Parameters	The core problem	Cause of Problem
System access rights	Only administrators and officers can access the system.	Motorcycle users do not know the history of parking transactions.

Table 6. Efficiency Analysis.

Parameters	The core problem	Cause of Problem
Resource	Lack of coordination of parking attendants in managing vehicles at the time of parking transactions.	In the transaction queue, out of the car and motorbike parking, there is a long queue.

4. Turnover rate

$$Turnover = \frac{\text{Parking Volume}}{\text{available parking space}} * 100\% \tag{5}$$

where;

Table 7. Services Analysis.

Parameter	The Core Problem	Cause of Problem
Services	There is no service officer to arrange for parking the vehicle	Motorcycle user park their vehicles not in the right place provided

Ei Number of vehicles entering the parking location.
Ex Number of vehicles leaving the parking location.
X Number of vehicles that have been in the parking location before observation.
Extime time when the vehicle exits the parking location.
Endtime time when the vehicle enters the parking location.

This study only focuses on motorcycle parking areas; with this, the motorcycle parking plan has a length of 6 m and a width of 30 m, so the parking area is 180 m2. From the parking area, only 120 m2 can be used with a length of 4 m and a width of 30 m as a place to park motorbikes, and 60 m2 with a length of 2 m and a width of 30 m as circulation in and out of vehicles for parking.

2.5 Requirements, Applications and Circuits Design

1. Specifications
   The non-functional requirements needed when making applications and miniature motorcycle parking system prototypes are:

   - Software Requirements

     a. Windows 10 Home Operating System
     b. Ionic Framework SDK
     c. Visual Studio Code
     d. Fritzing
     e. Arduino IDE
     f. Marvel app Mockup

   - Hardware Requirements

     a. ASUS Laptop Processor Intel® Core i7-6700HQ
     b. 2.60 GHz, 12 GB RAM
     c. NodeMCU ESP 8266 Microcontroller.
     d. Limit Switch sensor and 5mm green LED.
     e. 28BYJ-48 Stepper Motor and Motor Driver f). ULN2003
     1. Application User Interface (UI) (Figs. 8, 9, 10 and 11)

2. Electronic Circuit Design (Figs. 12, 13, 14, 15 and 16).

Fig. 8. Registration.

Fig. 9. Login.

2.6 Blackbox Testing

See Table 8.

3 Results and Discussion

The result of the calculation of parking capacity is the total capacity according to the parking system design using parking lot rotation. From the observations, the length of the parking area is 6 m, the width of the parking area = is 30 m, and the parking area is 180 m^2. The design of the parking building has a length of 6 m, a width of 15 m, and an area of 90 m^2 so that later there will be two parking buildings. In 1 parking building, there are five parking lots, and each parking lot has a length of 3 m, a width of 12.5 m, and an area of 37.5 2, which can accommodate 15 motorcycle vehicles,

Fig. 10. Main Menu.

Fig. 11. Parking Location.

Fig. 12. Ionic *Architecture* [10].

according to the Motorcycle Parking Space Unit. Parking building capacity = 5*15 = 75 motorcycles, and Overall capacity = 2*75 = 150 motorbikes. From the calculation of the overall capacity, the parking system design can accommodate 150 motorcycle vehicles, an increase of 70 vehicles, namely 87.5% from the previous capacity. The

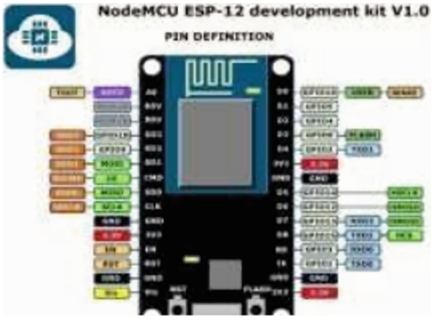

Fig. 13. NodeMCU *Board V 1.0* [11][14].

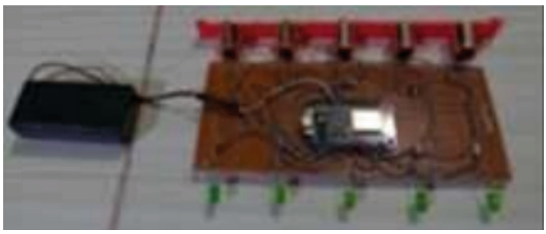

Fig. 14. Vehicle Detection Sensor.

Fig. 15. Parking Lot Rotation Drive.

parking area can only accommodate 80 motorcycle vehicles with an effective area of 120 m^2 and 60 2 as circulation in and out of vehicles for parking. According to the parking needs analysis above, the design of this parking system with a capacity of 150 vehicles can meet the parking needs of 120 vehicles every day (Tables 9, 10 and 11).

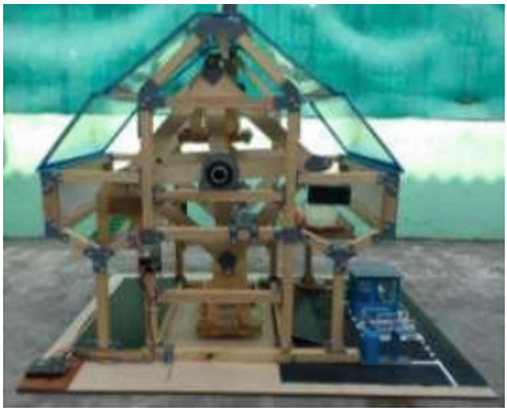

Fig. 16. Miniature Parking System Prototype.

Table 8. Black-Box Test.

System Scenario Result	Tested Part	Test Action	Function Test	Which are desired	Status
Login Page	Registration Button	Click the Registration Button	Enter to the Registration page	Showing Registration page	Success
Registration Page	E-mail password and data line personal	Entering e-mail password and data line personal	e-mail password and data line personal filled	Display e-mail password and data line personal	Success
	Registration Button	Click the Registration Button	To process account registration (new)	Display information successfull	Success
Login Page	E-mail and password line	Enter E-mail and password	E-mail and password filled	Show E-mail and password	Success
	Login Button	Click Login Button	For entering to main page applications	Display main page	Success
	Information on parking rates and on the availibilty of parking lots	Scroll the page and slide the plotting tables.	To view Information on parking rates and on the availibilty of parking lots	Display Information on parking rates and on the availibilty of parking lots	Success

(*continued*)

Table 8. (*continued*)

System Scenario Result	Tested Part	Test Action	Function Test	Which are desired	Status
Main page	Parking Button	Click Parking Button	To enter Parking Button	Views page parking	Success
	Booking Button	Click Booking Button	To enter Booking Button	Views booking page	Success
Menu History	History Button	Click History Button	To enter History Button	Views History Button	Success
Menu Profiles	Profiles Button	Click Profiles Button	To enter the Profiles Button	Views page Profiles	Success
Menu Home	Home Button	Click Home Button	To enter the Home Button	Views page Home Button	Success
History Page	Booking Transaction Button	Click Booking Transaction Button	To see Booking Transaction Button	Views page Booking Transaction Button	Success
	Parking Transaction Button	Click Parking Transaction Button	To see Parking Transaction Button	Views page Parking Transaction Button	Success
	Top-up Balance Transaction Button	Click Top-up Balance Transaction Button	To see Top-up Balance Transaction Button	Views page Top-up Balance Transaction Button	Success

Table 9. Parking Accumulation and Volume.

Number	Time	In	Out	Accumulated	Volume
1	07:00–07:30	16	2	14	16
2	07:30–08:00	20	7	27	35
3	08:00–08:30	19	5	41	55
4	08:30–09:00	13	7	47	68
5	09:00–09:30	18	4	61	86
6	09:30–10:00	12	3	70	98

(*continued*)

Table 9. (*continued*)

Number	Time	In	Out	Accumulated	Volume
7	10:00–10:30	13	5	78	111
8	10:30–11:00	15	2	91	126
9	11:00–11:30	14	6	99	140
10	11:30–12:00	12	5	1	152
11	12:00–12:30	10	2	1	162
12	12:30–13:00	8	1	1	170
13	13:00–13:30	9	5	124	179
14	13:30–14:00	10	3	131	189
15	14:00–14:30	9	7	133	198
16	14:30–15:00	5	11	127	203
17	15:00–15:30	8	25	110	211
18	15:30–16:00	8	19	99	219
19	16:00–16:30	4	20	83	223
20	16:30–17:00	8	19	72	231
21	17:00–17:30	5	13	64	236
22	17:30–18:00	3	30	37	239
23	18:00–18:30	2	22	17	241
24	18:30–19:00	3	20	0	244

Table 10. Parking Change Calculation.

Time Interval		Volume [1]		Capacity [2]	Accumulated [3]	Turnover [4]	% Level Customer [5]
From	Until	From	Until				
07.00	10.00	80	98	80	70	12,250	87.50
10.00	13.00	80	72	80	120	0,9000	150
13.00	16.00	80	49	80	99	0,6125	123.75
16.00	19.00	80	25	80	0	0,3125	0
				Amount	289	30,500	

4 Conclusion

The conclusions obtained in the analysis above are: making a motorcycle parking system application based on a Mobile Application, it is hoped that with this application, motorcycle users will know information about the availability of empty parking lots before committing parking. Make development system parking bicycle motorcycle use

Table 11. Cumulative Percentage and Parking Duration.

Number	Duration Parking	Middle Value (x)	Number of Vehicle (f)	Percentage (%)	Cumulative Percentage (%)	f * x
1	0–15	7,5	I	0,41%	0,41%	7,5
2	15–30	22,5	I	0,41%	0,82%	22,5
3	30–45	37,5	4	1,64%	2,46%	150
4	45–60	52,5	3	1,23%	3,69%	157,5
5	60–75	67,5	3	1,23%	4,92%	202,5
6	75–90	82,5	I	0,41%	5,33%	82,5
7	90–105	97,5	3	1,23%	6,56%	292,5
8	105–120	112,5	9	3,69%	10,25%	1012,5
9	120–135	127,5	10	4,10%	14,34%	1275
10	135–150	142,5	6	2,46%	16,80%	855
11	150–165	157,5	10	4,10%	20,90%	1575
12	165–180	172,5	6	2,46%	23,36%	1035
13	180–195	187,5	5	2,05%	25,41%	937,5
14	195–210	202,5	4	1,64%	27,05%	810
15	210–225	217,5	2	0,82%	27,87%	435
16	225–240	232,5	8	3,28%	31, 15%	1860
17	240–255	247,5	10	4,10%	35,25%	2475
18	255–270	262,5	15	6,15%	41,39%	3937,5
19	270–285	277,5	10	4,10%	45,49%	2775
20	285–300	292,5	14	5,74%	51,23%	4095
21	300–315	307,5	13	5,33%	56,56%	3997,5
22	315–330	322,5	15	6,15%	62,71%	4837,5
23	330–345	337,5	16	6,56%	69,26%	5400
24	345–360	352,5	14	5,74%	75,00%	4935
25	360–375	367,5	10	4,10%	79,10%	3675
26	375–390	382,5	16	6,56%	85,66%	6120
27	390–405	397,5	9	3,69%	89,34%	3577,5
28	405–420	412,5	8	3,28%	92,62%	3300
29	420–435	427,5	6	2,46%	95,08%	2565
30	435–450	442,5	6	2,46%	97,54%	2655

(*continued*)

Table 11. (*continued*)

Number	Duration Parking	Middle Value (x)	Number of Vehicle (f)	Percentage (%)	Cumulative Percentage (%)	f * x
31	450–465	457,5	*5*	2,05%	99,59%	2287,5
32	465–480	472,5	I	0,41%	100.00%	472,5

automation technology that can rotate parking lots, thereby increasing parking capacity by 87.5% to 150 motorcycles without expanding the area parking. Creating parking conditions with a neat arrangement so that motorcycle users are easy to park vehicles. Suggestions for the automatic parking system application are that it can be developed with various additional features and various types of vehicles that can make it easier to park the vehicle. Uses more optimal power and can accommodate more parked motorbikes.

References

1. Badan Pusat Statistik: Statistik Transportasi Darat 2016. Badan Pusat Statistik Republik Indonesia. DKI Jakarta (2017).
2. Badan Pusat Statistik: Statistik Transportasi Darat 2017. Badan Pusat Statistik Republik Indonesia. DKI Jakarta (2018).
3. Badan Pusat Statistik: Statistik Transportasi Darat 2018. Badan Pusat Statistik Republik Indonesia. DKI Jakarta (2019).
4. Badan Pusat Statistik: Statistik Transportasi Darat 2019. Badan Pusat Statistik Republik Indonesia. DKI Jakarta (2020).
5. Badan Pusat Statistik: Statistik Transportasi Darat 2020. Badan Pusat Statistik Republik Indonesia. DKI Jakarta (2021).
6. F. D. HOBBS.: CHAPTER 1 - Administration and Planning in Traffic Engineering. In: Pergamon International Library of Science, Technology, Engineering and Social Studies, F. D. B. T.-T. P. and E., Second E. HOBBS, Ed. Pergamon, pp. 1–41 (1979).
7. F. D. HOBBS.: CHAPTER 2 - Traffic Studies. In: Pergamon International Library of Science, Technology, Engineering and Social Studies, F. D. B. T.-T. P. and E., Second E. HOBBS, Ed. Pergamon, pp. 42–93 (1979).
8. F. D. HOBBS.: CHAPTER 4 – Parking. In: Pergamon International Library of Science, Technology, Engineering and Social Studies, F. D. B. T.-T. P. and E., Second E. HOBBS, Ed. Pergamon, pp. 173–209 (1979).
9. F. D. HOBBS.: CHAPTER 7 - The Traffic Stream and Capacity. In: Pergamon International Library of Science, Technology, Engineering and Social Studies, F. D. B. T.-T. P. and E., Second E. HOBBS, Ed. Pergamon, pp. 332–382 (1979).
10. B. Dunka, E. Emmanuel, and Y. Oyerinde.: HYBRID MOBILE APPLICATION BASED ON IONIC FRAMEWORK TECHNOLOGIES. Int. J. Recent Adv. Multidiscip. Res. 4, pp. 3121–3130 (2017).
11. Zeroday.: A lua based firmware for wifi-soc esp8266. Github (2015).
12. ESP8266 Technical Reference, Version 1.7. Espressif Systems (2021).

13. K. Matsumura, H. Mizutani, and M. Arai.: An Application of Structural Modeling to Software Requirements Analysis and Design. IEEE Transactions on Software Engineering 4, pp. 461–471 (1987).
14. M. P. Sharma and M. Parveen Kantha: 'Blynk' Cloud Server based Monitoring and Control using 'NodeMCU,'. Int. Res. J. Eng. Technol. 7(10), pp. 1362–1366 (2020).
15. A. I. Wasserman.: Software engineering issues for mobile application development. Proceedings of the FSE/SDP workshop on Future of software engineering research - FoSER '10. ACM Press (2010).
16. C. Simons and G. Wirtz.: Modeling context in mobile distributed systems with the UML. Journal of Visual Languages & Computing 18(4), pp. 420–439 (2007).
17. J. McDermid: review: Software Engineering: A Practitioner's Approach. 10(6) (1995).