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Vehicle service reservation system and crowd-prediction feature using ARIMA method

Karto Iskandar[a*], Bismo Asyura Widianto[a], Muhammad Alvito Kuntjoro[a], Rayhan Ardiya Dwantara[a] and Maria Grace Herlina[b]

[a]*Computer Science Department, School of Computer Science, Bina Nusantara University, Jakarta 11480, Indonesia*
[b]*Management Department, BINUS Business School Undergraduate Program, Bina Nusantara University, Jakarta 11480, Indonesia*

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A B S T R A C T

This study begins with a literature review to observe current problems surrounding vehicle service centers and the use of the ARIMA method to resolve similar cases. Researchers then conduct the observation process by collecting user needs through surveys and questionnaires. Next, researchers use the Scrum methodology to develop a web-based application enriched with the ARIMA method. Afterward, researchers obtain user feedback using surveys and questionnaires to evaluate the user experience towards the application. Conclusively, based on the results of the questionnaires, the average respondent believes that the web-based application can simplify respondents in making vehicle service reservations with a score of 8.85 out of 10. In addition, the average respondent believes that the web-based application can assist respondents in planning vehicle service. They visit with shorter queue times through a crowded time prediction system on a web-based reservation application with the ARIMA model with a value of 8.9 out of 10.

1. Introduction

The automotive industry in Indonesia is experiencing a rapid increase in growth from 2021 – 2022 (Setiawan, 2021). This was caused by a new tax program introduced by the government, which reduced vehicle tax (PpnBM), which brought a 758% increase to the number of vehicles on the road (Wahab et al., 2021). Therefore, the growth from 2021 – 2022 was a major increase compared to the previous year, which only had a rise of 17.89%, according to (Veza. et al., 2021). A vehicle service center is where vehicle owners can perform various kinds of vehicle maintenance. Those services are periodic checks, engine overhauls, bodywork repairs, etc. The number of service centers throughout Indonesia varies around 165, 46 of which are official service centers, and the other 119 are general service centers (Budiono et al., 2021; Ismail & Mulyaman, 2021). Also, according to the Indonesian Republic Police, every year, there has been an increase in the number of vehicles. For example, in 2018, there were 14.830.698 cars, which further increased in 2019 to 15.592.419 vehicles; in 2020, it grew more to 15.797.746 cars.

Due to the rapid advancement of the automotive industry, there has been a growing demand for vehicle service centers. To maintain their vehicle's health, owners must regularly visit a service center for general repairs or maintenance (Escobar-Falcón et al., 2021). Busy hours at service centers can indicate whether a client would book a service for their car at that service center in the future. Customers prefer a service center with no big queue, especially on weekends when service centers usually have more customers than on weekdays. Customers typically contact the service centers to gain information about the kinds of services they offer, the time needed for the service, and the price of the service. That takes a bit of time and effort to get information about the service center (Çetinkaya et al., 2021).

* Corresponding author.
E-mail address: karto_i@binus.edu (K. Iskandar)

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Service centers usually have 4 working areas for the mechanics to work on cars. Hence, customers must wait at least 30 minutes for light services like regular checkups and oil changes (Cuellar-Usaquen et al., 2021). The services can affect the time of work and queue for the next customer. If the vehicle needed more severe treatment, finishing it would take more time (Bajegani et al., 2021). The number of mechanics can also affect the work time; service centers with many mechanics can usually finish their work faster than those with fewer mechanics. Just from the mechanics alone, the queue time can be predicted until the next customer (Allahverdi at al., 2022).

2. Literature review

2.1 Workshop

A workshop or vehicle repair shop is a business engaged in maintenance services and the automotive sector, such as vehicle repair (Macedo, 2021). Some of the services provided by workshops are servicing, engine maintenance, bodywork repair, chassis repairs, and specialist repairs such as repair of suspension parts, painting, and welding of cars. All these services are provided to keep customer vehicles roadworthy and meet technical requirements (Aryadi et al., 2018; Khariwal et al., 2021).

2.2 Forecasting

Forecasting is a process of making predictions based on data from the past or present. In this context, Time Series Forecasting is an application to regression problems in developing deep-learning architectures specifically designed to handle indexed data over time. Those theories are from (Torres., et al., 2021; Yildirim & Kuvvetli, 2021).

2.3 ARIMA method

ARIMA model, which stands for Auto-Regressive Integrated Moving Average, is a class of analytical models used to describe time series-based data. ARIMA uses past and present values to produce accurate short-term predictions. ARIMA uses lags or certain chronological times based on past values (Siami-Namini et al., 2018). ARIMA assumes future data will be similar to trend data. The ARIMA model has three components: p, d, and q. P defines the term AR, i.e., the value of the lags that occur in the observation model also called the lag order. D is the number of times the observations are distinguished or the minimum number of differentiations required to make the sequence stationary. Q defines the term MA, i.e., the size of the moving average window or the number of errors left in the forecast, which must be entered into the ARIMA model. Those theories are from (Al Amin & Hoque, 2019; Khan & Gupta, 2020; Schaffer et al., 2021).

2.4 SCRUM

A Software Development Life Cycle (SDLC) is needed to develop any application. An SDLC consists of several phases: planning, analysis, design, and implementation. Several SDLC models are in use in the industry, including Waterfall, Spiral, and V-model. However, one SDLC model is prevalent and stands out among the others. The Scrum methodology is the name given to this SDLC. Scrum is an application development approach that adheres to the agile framework concept. A Scrum team consists of a Product Owner, a Scrum Master, and several Developers. The Product Owner is directly responsible to the business owner and stakeholders. While a Project Manager or Scrum Master is in charge of spotting difficulties throughout project development and proposing a solution to be adopted in the following iteration so that the problem does not reoccur. A project manager is also responsible for leading the sprint planning and the sprint retrospective. The final role in a scrum team is that of developers. According to (Mahalakshmi & Sundararajan, 2013; Gaborov et al., 2021), developers are responsible for executing the backlogs discussed at the sprint planning stage.

2.5 Black box testing

Black Box Testing is a testing technique that focuses on the specification of the functions that exist in an application. This testing technique will uncover several things, such as incorrect functionality, data structure, database, performance, or other errors that may occur. The advantage of using this testing technique is that the tester does not need knowledge of a particular programming language. Testing is also carried out from the user's point of view. Therefore, there will be no ambiguity or inconsistency in the requirements specification (Rahadi, 2020; Rawat et al., 2020).

2.6 Forecasting of Manufacturing Demand Using ARIMA Model

In the competitive environment of the manufacturing industry, and the need to respond quickly in an ever-shifting industry demand, organizations are moving towards a more effective demand-driven supply chain. Therefore, demand forecasting has been crucial to avoiding unnecessary spending on stocks that do not have the demand. However, a further complicating issue is that some demands can be intermittent. It means there is a time when we have no demand and other times when we have successive demands. To counteract this, scholars (Fattah et al., 2018) developed an AI model based on historical data using the Box-Jenkins series procedure. The models developed from this process were selected based on 4 performance criteria:

Akaike Criterion, Schwarz Bayesian Criterion, Maximum Likelihood, and Standard Error. These models were then compared with historical data from the real world with the same conditions and parameters. The results obtained proved that the model can be used to forecast future demands in the manufacturing industry. Furthermore, these results will provide these manufacturing managers with reliable guidance in making crucial business decisions in the future.

2.7 Forecasting Tourism Market Demand in Hunan Province using ARIMA

A mountainous province in the People's Republic of China is home to a significant position in the country's economic development thanks to its enormous tourism resources. According to (Quan Qin, 2021), in recent years, Hunan province has been going through a critical phase in transitioning from a significant tourist province to a staggering tourist province with a large sum of money entering the economy. Because of this, it has become of great significance to analyze and predict the development trend of the future tourism market demand in Hunan Province and provide the government and tourism enterprise managers with scientific market decisions. Scholar (Quan Qin, 2021) aims to use time-series data from 2000 to 2019 on the number of domestic visitors in Hunan Province. It seeks to build a prediction model (ARIMA) to anticipate the number of tourists in Hunan Province over the following four years. The author chooses a time series model based on the linear characteristics of the number of domestic tourists in Hunan province. The author also combines qualitative and quantitative analysis methods and comprehensively analyzes the factors influencing the number of tourists in Hunan province in China. The results proved that the ARIMA model can accurately predict the dynamic trend of domestic tourists in Hunan Province. However, the ARIMA model has some limitations, such as requiring a long time series. Therefore, the predictions provided by this technology also still have several uncertainties.

3. Method

This study explores the problems people experience when ordering vehicle services to repair shops around Jakarta, Indonesia. The ARIMA method helps them schedule the right time to service their vehicles. This study uses qualitative design using surveys to get feedback and the problems faced by the community in ordering vehicle service. The rest of the data is obtained by visiting the workshops around Jakarta. The data is about the workshop conditions on specific days and how long the service would take. It includes the workshop procedure of dealing with clients so that it can be translated into the basis for application development. The development method used for this study is the SCRUM method. The SCRUM method is one of the Software Development Lifecycle (SDLC) and the development method that uses the agile framework concept (Mahalakshmi & Sundararajan, 2013; Gaborov, 2021). The testing methods used for this study are Black Box Testing, 8 Golden Rules of Interface Design, and 5 Measurable Human Factors. Black Box Testing is used by developers to test the program, including all features, to ensure that everything works properly (Rahadi, 2020). The 8 Golden Rules of Interface Design are used for User Interface (UI) design so that the UI meets the standards of a proper UI (Shneiderman et al., 2016). The 5 Measurable Human Factors are used to measure applications performance and the time a user spends on the application. The solution to helping people schedule their vehicle service reservations better is to use the ARIMA method by showing the busy hours of each workshop in Jakarta, Indonesia.

4. Results and discussion

This web application project development process takes about six months. It is developed remotely by a developer in Greater Jakarta, Indonesia. Researchers use UML Method and a Use Case Diagram to design web applications, as shown in Fig. 1. The Use Case Diagram design for this web application involves 2 actors who use the system: The user and Service Centre Admin. The user has 11 use cases, and the service center admin has 9 use cases. The following is an explanation of the use cases that will be used in the web application system:

- Use Case See List of Service Centres by the user to see the list of service centers
- Use Case Service Centre Detail the user to see the detail of the service centers
- Use Case See Busy Hours (ARIMA) by the user to see the busy hours of the service centers
- Use Case Pick Time by user and service center admin to pick the time of the reservation
- Use Case Pick Service Type by user and service center admin to pick the service type for the reservation
- Use Case Book Reservation by the user to book the reservation for their vehicle service
- Use Case Fill Car Information by user and service center admin for filling the vehicle information
- Use Case Cancel Reservation by the user and service center admin to cancel the reservation
- Use Case See Reservation List by user and service center admin to see the reservation list
- Use Case Add Rating and Review by user for adding rating and review for the service center
- Use Case See Service Centre Review by the user to see the ratings and reviews of the service center
- Use Case Add Reservation Manually by service center admin to add a reservation manually if the customer came without booking a reservation
- Use Case Provide Service Type by service center admin to provide the service type on the web application
- Use Case Accept Reservation by service center admin to accept the user's reservation

- Use Case Begin Service by service center admin to begin the user's service
- Use Case Finish Service by the service center admin to finish the user's service

Fig. 1. Use Case Diagram

The ARIMA method is a combination of 3 parts, namely: AutoRegressive (AR), Integrated (I), and Moving Average (MA) (Khan & Gupta, 2020). ARIMA is a convenient notation for the ARIMA model (p, d, q). Here p, d, and q are the levels for each of the AR, I, and MA parts. Each of these three parts is an effort to make the final residuals display a white noise pattern. The first pass of the ARIMA model is to subtract the time series from its lagged series to extract trends from the data. Differencing is the most used technique to extract trends. The following process is to extract the influence of the previous period's values on the current period. After the time series data is stationary through the integrated (I) pass, the AR part of the ARIMA model gets activated. As the name auto-regression suggests, here we try to extract the influence of the values of previous periods on the current period. The third and final pass of the ARIMA model is to extract the impact of the last period's error terms on the current period's error. Fig. 2 below explains how the ARIMA model in the web application processes data and performs predictions as necessary in a flowchart.

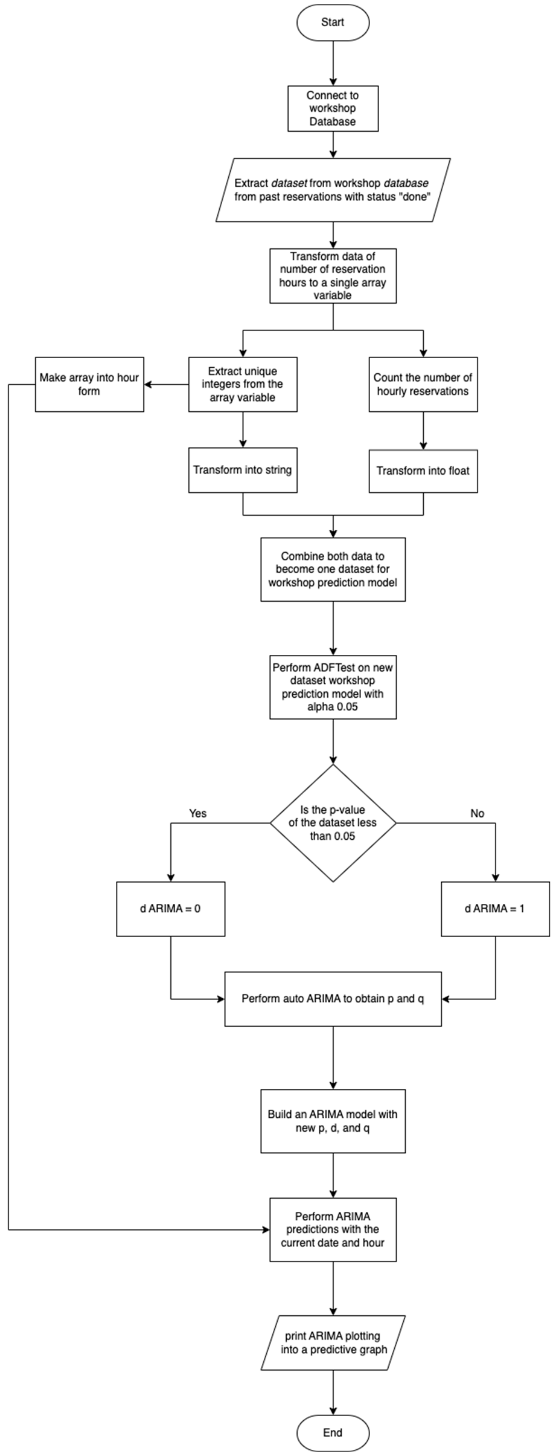

Fig. 2. ARIMA Method Flowchart

The following pseudocode explains in more detail how the ARIMA method works. This pseudocode explains how ARIMA processes data and makes predictions as necessary in a comprehensive manner. First, we connect to the database so we can pull data and we can make predictions. We pull data from past service reservations with the status "done," indicating that the reservation has been finished. Then, we retrieve the hour from the dataset and store it in a unique number so we can use them to predict the hours later. Then we loop over the number of hours to get a number for the dataset later. And that way, we can make a new dataset with the number of reservations in that hour. This new dataset can be used to predict the dataset, but first, we have to check some things for ARIMA to work correctly. Then we do the ADF Test to determine whether the data is stationary. It takes the p-value of the dataset and checks if greater than the alpha (0.05). If it is less than 0.05, it is stationary; otherwise, it is not stationary. If the dataset is stationary, then it means the d parameter is 0; else, it is 1. After finding the d parameter, we use the function auto_arima to find the p and q parameters to complete the ARIMA prediction. Then we use the new dataset to do predictions with the ARIMA to get the prediction value. The prediction value will allow us to plot a visualization onto a graph, and this graph will be the result that will be sent to the website using the Rest API call. Algorithm 1 shows the pseudocode of the ARIMA method solution.

Algorithm 1. ARIMA Method

```
SET FUNCTION plot_png():
        SET 'dataset' and 'newHours' from benerinDataset()

        from pmdarima.arima IMPORT ADFTest

        SET 'adf_test' EQUALS TO ADFTest with p-value alpha of 0.05
        SET 'value' EQUALS TO ADFTest value of 'dataset'

        SET 'train_' to 85% of 'dataset'
        IF (first index of 'value' is less than 0.05)
                SET 'diff' EQUALS TO 1
        ELSE IF
                SET 'diff' EQUALS TO 0

        from pmdarima.arima IMPORT auto_arima

        SET 'model' EQUALS TO auto_arima using dataset from 'train_', range of value p and q is 1 to 8,
            value d is 'diff' and no seasonal data, and 50 iterations to find the perfect p, d, q value

        SET pdq EQUALS TO order p, d, and q of 'model'

        from statsmodels.tsa.arima.model IMPORT ARIMA

        SET ‘newModel’ EQUALS TO ARIMA(with parameters of p = pdq[0], d = pdq[1], q = pdq[2])
        SET 'trainned_model' EQUALS TO 'newModel' to fit the relations between predictors and outcome
        SET 'date_time' EQUALS TO 'newHours' set datatype to date and time
        SET 'data_forecast' EQUALS TO prediction values of 'trainned_model'

        SET 'fig' and 'ax' EQUALS TO plotting with size of 11 length and 5 width
        SET 'fig' and 'ax' plotting subplot
        SET 'hh_mm' EQUALS TO date formatter to "hour:minute"
        SET ‘ax’ EQUALS TO dates on x axis with date formatter ‘hh_mm’
        SET 'ax' EQUALS TO plot bar with 'date_time' as x axis and 'data_forecast' as y axis
        SET plot bar colour based on number of customers
        DISPLAY all 'date_time' on plot
        DISPLAY plot graph

        from io IMPORT BytesIO

        SET ‘img' EQUALS TO BytesIO() to turn into a binary data
        SET plot of 'ax' to be saved as figure TO 'img' with format 'png'

        SET img.seek(0) to get the binary value
        SET 'plut_url' EQUALS TO encoded string of 'img'
        RETURN 'plot_url' AS 'pictureData' in json
ENDFUCNTION
```

Fig. 3 below shows the result of the prediction model. Most importantly, a graph is present to show the prediction of the crowd at a specific time of day. The vertical axis represents the predicted crowd or the prediction of the number of reservations, and the horizontal axis represents the current hour of the day. This plot graph can be used by users to search for the desired workload time (Londono et al., 2021).

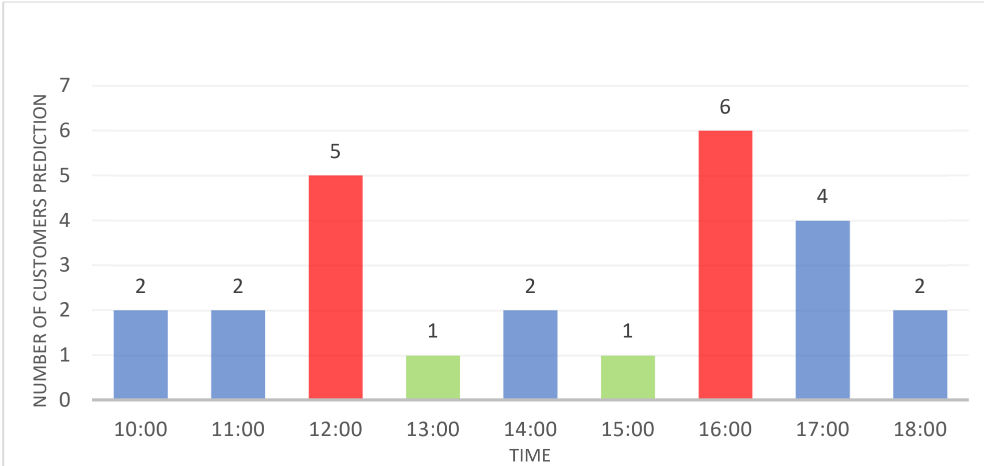

Fig. 3. Prediction Plot

After the development process, several evaluations are carried out to ensure the quality of the project. First, user feedback was collected from 200 respondents via a survey questionnaire containing 16 questions focused on the web application's usability and functionality. Second, to ensure the functionality of the features in the project, Black Box Testing is carried out. Finally, the 8 Golden Rules of Interface Design ensure that the User Interface (UI) meets good UI standards. Also, the 5 Measurable Human Factors are used to measure app performance and user time in using the app.

From the questionnaire results, it was found that the majority of respondents believed that the web application was easy to use, with 50% of respondents getting a score of 10 and 25% of respondents getting a score of 8. On the other hand, only 10% of the respondents believed it was pretty easy to use, scoring 7 out of 10. The online application was to be easily comprehended by users. It is mentioned that 40% of respondents gave a score of 10, and only 5% gave a score of 7 out of 10. In addition, it was found that the web application was beneficial for respondents, with 55% of respondents giving a score of 10 and only 5% saying the web application was slightly valuable, scoring 7 out of 10. Most importantly, it was found that using the web application can significantly reduce one's waiting time to visit a service center. It is shown that 40% of respondents scored 10. Then 30% scored a score of 9, and only 15% scored a score of 7 and 8 out of 10. In addition, according to respondents, the web application can help them plan their schedule for den vehicle services, gan 40% scored 10, 35% scored 9, and 30% scored 8 out of 10. In addition, showing the service center's peak hours helps users plan their vehicle's service schedule with a 30% score of 8, 35% score of 9, and 30% with a score of 10 out of 10. The information displayed on the web application helps users to decide which service center is best for them. With 35% a score of 8 and 9, and 25% a score of 10 out of 10. The estimated time of each service helps users schedule their vehicle service better. They scored 30% on 8 and 9 and 35% on 10 out of 10. In addition, the web application helps users schedule their service time better, with 15.8% scoring 8, 21.1% scoring 9, and 57.9% scoring 10 out of 10. The Estimated price of each service helps users schedule their service time. They scored 35% score of 8, 30% score of 9, and 20% score of 10 out of 10. Overall, the web application meets user expectations, with 20% scoring 7 and 8, 45% scoring 9, and 15% scoring 10 out of 10. The web application will also be used by users, with 20% scoring 8, 40% scoring 9, and 35% scoring 10 out of 10. Finally, users will also recommend this web app to their friends, with 25% scoring 10, 40% scoring 9, and 25% scoring 10 out of 10. Fig. 4 below summarizes that the average respondent believes the web-based application can simplify respondents in making vehicle service reservations, scoring 8.85 out of 10. Moreover, the average respondent believes that the web-based application can assist respondents in planning vehicle service visits. It provides shorter queue times through a crowded time prediction system on a web-based reservation application with the ARIMA model with a value of 8.9 out of 10.

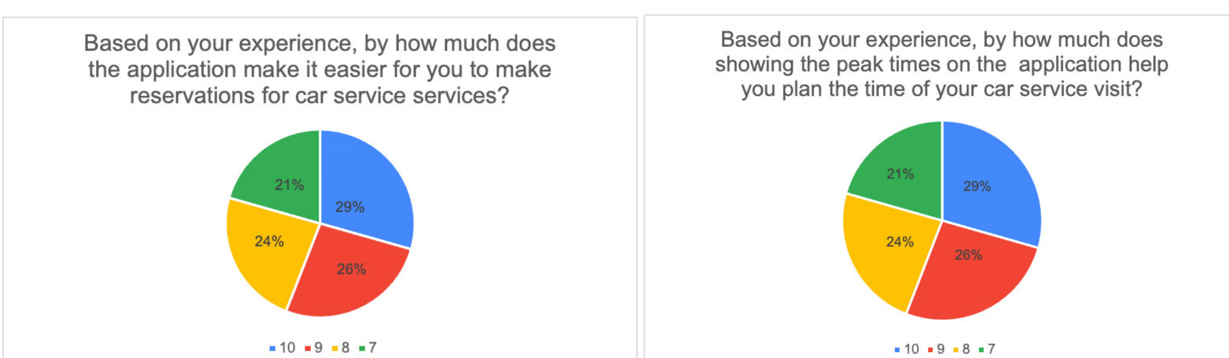

Fig. 4. Results of the Evaluation Questionnaire

To evaluate the User Interface and User Experience of the web application, several principles developed by Ben Schneiderman were used. The first principle in Ben Schneiderman's 8 Golden Rules is consistency. This principle prioritizes consistency so that new users can still recognize that the page they are viewing is still within the scope of the same website. This gives users comfort when exploring pages without fear of switching sites. The web application has proven to follow this principle where every page on the web application uses a consistent font, namely Raleway Sans-Serif. Not only that but there is also a consistent color palette that only contains 4 primary colors. The second principle is to cater to universal usability. This principle explains that a user interface must be usable to users with various backgrounds and preferences. Therefore, the interface must use copywriting or elements that are simple and common to find. The web application has proven to follow this principle by using commonly seen icons to accompany texts displayed on the website. The third principle is to offer informative feedback. This principle explains the user must be able to understand the action that was just performed by the user has been received and executed by the system. As an example of implementing this principle, the web-application system will respond to the user if the user presses the "Save Review" button but has not filled out a review or given any rating to the workshop. The feedback given to the user is in the form of an error message describing the user's error. The fourth principle is to design dialogs that yield closure. This principle explains that when a user has successfully submitted a reservation without any mistake, the system will display a response in the form of an alert. The alert above is displayed so the user knows there is no longer a process that must be passed to submit a reservation because the user has entered the data correctly. The fifth principle is to design an interface that prevents errors. The web application has proven to follow this principle by providing a button where the user can see the password that has been typed. At first, the password typed by the user cannot be seen, but when the "View Password" button is pressed, the user can view and recheck the password that has been typed. The sixth principle is to permit easy reversal of actions. As an example of implementing this principle, when a user wants to cancel a reservation, the system will show a modal page that aims to confirm that the user really wants to cancel the reservation. If the user decides not to cancel the reservation, the user can press the "No" button on the open modal. The seventh principle is to design an interface that keeps the user in control.

When a user wants to make a reservation for a vehicle service, the user is free to tell any complaints experienced by the user while driving their vehicle. This will help the repair shop to better understand the state of the vehicle that will be serviced at that time. The final principle is to reduce short-term memory load. There is a Reservation List page. It contains the reservation submitted by the user to reduce the burden on the user's memory when using the website. It is completed with the name of the workshop and the services to be performed. With this, the user will still remember the information regarding the reservation submission made by the user without fear of misinformation caused by memory loss. All in all, according to Ben Schneiderman's 8 Golden Rules of Interface Design, the web application has met the standards of a good interface design.

Apart from evaluating the User Interface, the User Experience of the website also needs to be assessed. For this, Ben Schneiderman's 5 Measurable Human Factors were used to measure the application's performance and the user's time. The first measurable human factor is the time to learn about a website. The time required by the user to understand the design of the user interface to perform an action desired by the user depends on several factors. The most crucial factor that determines the small amount of learning time that must be spent by the user is the simplicity of the user interface design and the consistency between the pages. Based on the questionnaire done to collect user feedback, users need about 5-10 minutes to get used to and learn how the website works.

The second measurable human factor is the speed and performance of the website. After the development process was completed, it was found that the website could help users make reservations for vehicle services in a shorter time. This can be supported by the time it takes for the user to see the busy workshop time with a duration of under 30 seconds. The next measurable human factor is the rate of errors done afflicted by the users. The presence of several features on the website aims to prevent the mistakes made by users. Those are confirmation modals to ensure that the user really wants to cancel, the view password button to contain password input errors, and also validating personal data formats, the error rate that occurs due to user negligence will be reduced. The fourth factor is the user's retention over time. The consistency of the user interface design on the website helps users better understand how the website works. Not only that, but the Reservation List page also allows users to recall detailed information about the reservation they submitted. The final human factor is the user's subjective satisfaction with the website. According to the results of the questionnaire conducted regarding the user interface design on the website, it can be concluded that respondents who have tried the website stated that the website has an attractive design, was easy to use and understand

The accuracy of a model is crucial to its use in helping users make the essential decision. Therefore, a model evaluation metric called Mean Absolute Error was used to assess the accuracy of the ARIMA model. The mean absolute error of a model concerning a test set is the mean of the fundamental values of the individual prediction errors on all instances in the test set. For example, each prediction error is the difference between the true and predicted values. From using this metric, it was found that the prediction model had a mean absolute error of 13%. Therefore, an overall accuracy of 87%.

5. Conclusion

Due to the rapid advancement of the automotive industry, the demand for vehicle service centers is increasing. Therefore, for vehicle owners to maintain their vehicle's health, they must regularly visit the service center for repairs or general maintenance.

However, the increasing number of cars in Jakarta has raised several issues among vehicle owners. The main thing is the long queues at the vehicle service centers on several occasions. From this basis, quantitative research was done by distributing questionnaires to uncover user requirements. After the user requirements are collected, a web-based application is developed to solve the issues discussed.

According to the results of several evaluation parameters, there are several points that can be concluded regarding the web application after evaluating 200 respondents. First, based on the questionnaire results, the average respondent believes that the web-based application can simplify respondents in making vehicle service reservations, scoring 8.85 out of 10. Second, the average respondent believes that the web-based application can assist respondents in planning vehicle service visits. Third, it will serve with shorter queue times through a crowded time prediction system on a web-based reservation application with the ARIMA model with a value of 8.9 out of 10. However, improvements can still be made to further enhance the quality of the web-based application. Based on the results of the development and evaluation of the web-based application thus far, the authors propose several improvements that can be used for growth in the next iteration. First, the respondents would like to develop a feature to call a mechanic to the house for minor services such as oil changes and vehicle checks. Second, respondents also want the system to be able to estimate the cost of their service. It is accompanied by the cost of replacing spare parts, which is then paid through an online payment gateway. Finally, the respondents would like the web application to be available in a mobile version with a reminder system for service times.

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