System Monitoring Traffic Density Application based on Neural Network Algorithms

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ABSTRACT— ***The increase in vehicle traffic density in a city correlates with increasing private vehicle usage. This problem is caused by the lack of public transport services. In other side, the volume of private vehicles increases the traffic density and cause problems are jammed in rush hour traffic. Use of the application can help road users to know the traffic conditions at real time. The research has developed a mobile application of information about traffic condition. This application is created using Android software programming, Android Development Tool (ADT) integrated with Google Maps so it can display information points from jammed location. The information presented in the form of the location name, location coordinates (latitude, longitude), the average vehicle speed (Km / h) which pass through the area and the traffic status in the form of a solid, jammed or smoothly. The data was predicted by Backpropagation Neural Network. The performance has seen on the size of MSE (Mean Square Error). The result is the smallest MSE are 8,91x10^{-24}, it means the chosen method has a predictability that is very close to the actual conditions of traffic situation.***

Keywords— Android Development Tools, Backpropagation neural network, MSE

1. INTRODUCTION

At last decade, with the increasing population density in metropolis city impact on congestion, accidents and traffic violations. Therefore, It takes a transportation information system to solve various traffic problems.[1] There have been many applications to support the problems solving related to traffic jams to avoid traffic location or traffic areas. The accuracy is a problem for the provision of traffic congestion data, where the information is still relying on the user to feed congestion information.

There are several studies that have been done previously about application development such as Waze, dan Google Maps [2]. The distinguish idea comes from the application of campus assistant on android platform where are illustrated for Florida Atlantic University – Boca Raton Campus [3]. This apps serves the detail maps inside the campus building for new student a visitor which are not support by Google maps. The similar situation appears in developing country roads such as Surabaya Indonesia. The most problems are crowded situation early morning and in the end of the noon when the public mobility flows from business district area to resident area. The government serves traffic information using static web [4]. Base on the main problems in urban area traffic condition, the regulations are followed to solve these problems [5].

The paper is organized as follows. In section 2 is the parameter of traffic information design such as stage of processing in server and client. Section 3 present the backpropagation neural network algorithm to predic the traffic condition in future. The next section gives simulation result and performance analysis achieved and finally, section 5 concludes the paper result.

2. PARAMETER DESIGN

The application is built using the Android programming softwareAndroid Development Tool (ADT) This application is integrated with Google Maps so that it can display information points which location is jammed, solid or smooth traffic in Surabaya. The information presented in the form of the location name, location coordinates (latitude, longitude), the average vehicle speed (Km / h) which pass through the area and the traffic status in the form of a solid, jammed or smoothly. That information is stored in a MySQL database that is connected with the application, so that at every hour application will update the information based on the database. In this research, data location and the average speed of vehicle is obtained from the Department of Transportation Surabaya, where every day traffic conditions are monitored. Overall system block diagram shown in Figure 1.

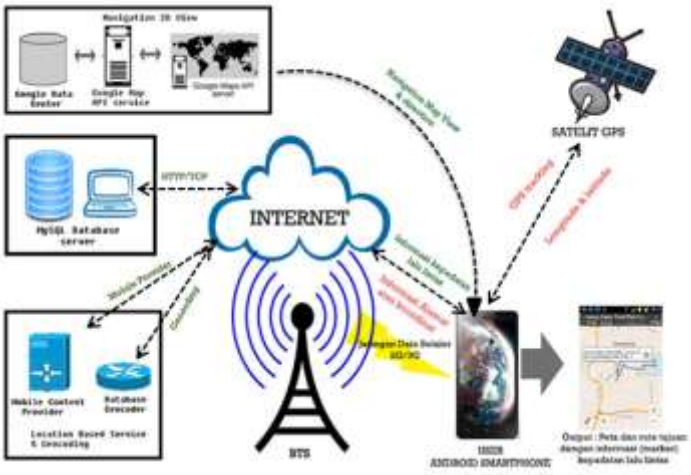


Figure 1. Blok diagram all system

Figure 1 arranged stages of processing system into two parts, the server and client. Details present in Figure 2 as follows:

1. Server
   On the server side, there are several stages of processing, among others:
a. Data collection
b. The data processing method of prediction with Backpropagation Neural Network and for the accuracy of the data by the method of Mean Square Error (MSE)
c. manufacture Database
d. Making the Web as a server
2. Client
   On the client side, the work done is the creation of applications based on Android which is used in the application on the user's smartphone. Several stages of making the application are:
a. Configuring Google Map API Key
b. Displaying Google Map
c. Displays the user's position using application
d. Featuring dense traffic information

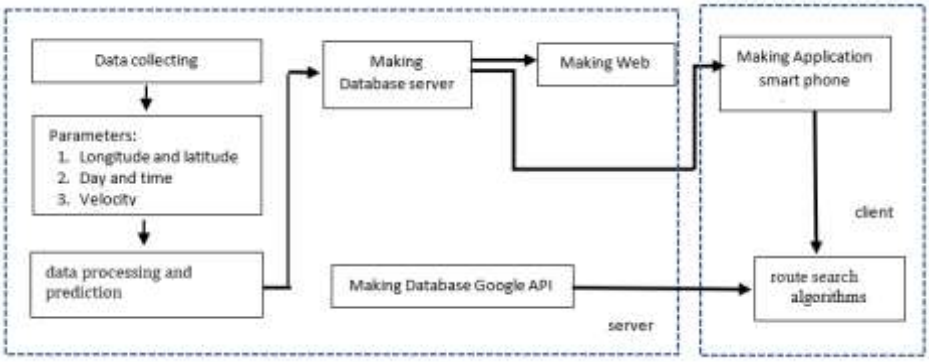


Figure 2. Blok diagram of processing system

At the end of the research, an application to navigate congestion traffic information based on Android will be presented.

3. BACKPROPAGATION NEURAL NETWORK ALGORITHM

This section describe the data processing for backpropagation neural network algorithm take two steps as follows

A. Data Collection

At this stage of data collection, where data is obtained based on statistical data the average density of traffic at the junction of the Department of Transportation Surabaya Surabaya. Data obtained from 20 CCTV cameras were installed at a crossroads. The data show the number of vehicles crossing the area. Data location of a camera mounted at the intersection are presented in Table 2. Base on the captured data from the crossroads in front of the camera, the average of the vehicle numbers are change daily in every minute at each junction and will be used as a reference number for category of traffic conditions. The standardization of traffic category such as standstill, solid or smooth, base on the Regulation of the Minister of Transportation No. KM 14, 2006 Chapter III, Article 7 Planning Traffic on the level of service on roads, as shown in Table 1.

Table 1. Average Density Traffic Parameter [5]

Parameter	Kecepatan Rata-rata (*Km/h*)
Traffic jams	≤ 25 *Km/h*
Congested traffic	30 *Km/h* s/d25 *Km/h*
Smooth traffic	≥ 30 *Km/h*

Table 2. Data Layout Camera Mounted at the crossroads [4]

Camera	Location	Latitude	Longitude	Address
1	Al Falah	-7.294637	112.73926	Tm Mayangkara
2	Ciliwung	-7.29234	112.73708	Jl Ciliwung
3	Dr.Sutomo	-7.284583	112.73329	Jl. Raya Dr Soetomo
4	Sahid Hanamasa	-7.26634	112.75114	Jl Pemuda
5	Samsat kertajaya	-7.279433	112.7622	Jl Manyar Kertoajo
6	Siola	-7.255784	112.73698	Jl Genteng Kali
7	Mustopo	-7.265713	112.75741	Jl Prof Dr Mustopo
8	Ngagel Jaya-Utara	-7.286847	112.75587	Jl Kalibokor
9	Kedung Doro	-7.266077	112.73006	Jl Kedung Doro
10	Embong Malang	-7.258396	112.73314	Jl Embong Malang
11	Jembatan Rolak	-7.307032	112.72061	Jl Gunung Sari
12	Mayjen Sungkono	-7.29059	112.71432	Jl Mayjen Sungkono
13	Margorejo	-7.316253	112.73402	Jl Raya Margorejo
14	Dinoyo	-7.279584	112.74394	Jl Dinoyo
15	Jagalan-Peneleh	-7.247861	112.74238	Jl Peneleh
16	Praban	-7.255973	112.7342	Jl Praban
17	Tembaan	-7.246942	112.73682	Jl Tembaan
18	Kutai	-7.294353	112.73186	Jl Kutai
19	Kertajaya	-7.278376	112.75582	Jl Kertajaya
20	Wapo	-7.270664	112.76066	Jl Karang Menjangan

B. Data Prediction using Backpropagation Neural Network

Prediction data is done using Backpropagation Neural Network consists of architectural design, design of input-output data and the process of training and testing process as describes below

i. The design of System Architecture

System architecture used in the Neural Network is made up of three layers, inpu tlayer, hidden layer and output layer. Figure 3 shows Architecture of weekly sessions contain 24 input layer, one hidden layer with number of nodes are 20 and number of output layer are 7. In Figure 4 shows Architecture of daily sessions contain 24 input layer, one hidden layer with number of nodes are 20 and one output layer.

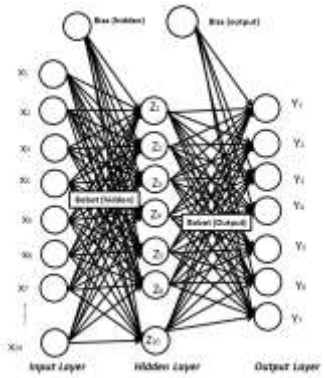


Figure 3. Neural Network Algorithm architecture weekly sessions (24,20,7)

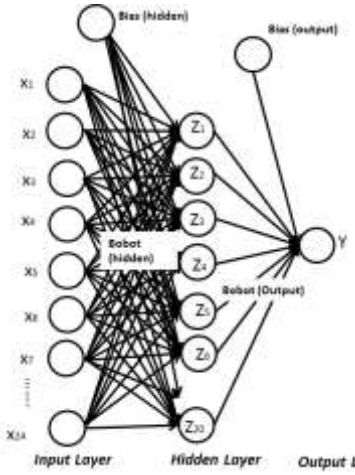


Figure 4. Neural Network Algorithm architecture dayly sessions (24,20,1)

There are two architecture scenarios for this research , weekly sessions and daily sessions. For second session the architecture of the input layer and output layer are different, the similarity happend on the hidden layer.

The units for input layer is a lag value Xt of target data, while in the hidden layer is a similar value from the target data Zt lag. When the output layer in scenario 1 (weekly sessions) unit is a lag Yt value and the target data in the second scenario is a unit of Yt value too.

The flow of information systems in Neural Network algorithm is to predict traffic density data. First data set come from the inclusion of the amount of data that will be in training. Data were obtained from data collection along 4 months, i.e. data for March, April, May and June 2015. Those data become initial input and function for the target data as use as a parameter for the computation process in neural Network Algorithm. Another parameter used is the learning rate (α), tolerance error (θ) and the number of units in the hidden layer.

ii. Training Process

In the training process, there are several other parameters that are in addition to input the data traffic density and the target which is the reference for the training process, the parameter is the learning rate (α), tolerance error (θ), the number of nodes in the hidden layer and the activation function used. These parameters more details can be seen in Table 3.

Table 3. Training process parameters on method of Backpropagation Neural Network

Parameter	Keterangan
Neural Network Method	*Backpropagation*
The number of nodes in the hidden layer	1 *layer*, 20 *nodes*
Activation function in the hidden layer	Sigmoid Bipolar
Performance function	*Mean Square Error* (MSE)
Learning rate	0.0001
Maximum Iteration	10000

In the training process, the input data will be normalized so that the output data will be generated to describe the pattern of data as before. Afterwards, the training process then generate the values of the most optimal weight neural network algorithm stored for testing process.

iii. Testing Process

In the process of testing the input or the input variable is a data training results and data testing. In this process the data is normalized at denormalization training process so that data values can be restored with post std function in matlab.

In this process will result in the output of the forecast data in accordance with the architecture of each scenario. Wherein the first scenario i.e. weekly sessions, will be produced 7 series output data is the data for one week (Monday - Sunday).

C. Making Database server

In making this database, data entered as traffic density data is data predicted results by the method of Backpropagation Neural Network has been done. making this database may take a few variables needed for the data from this database can be well informed on the user.

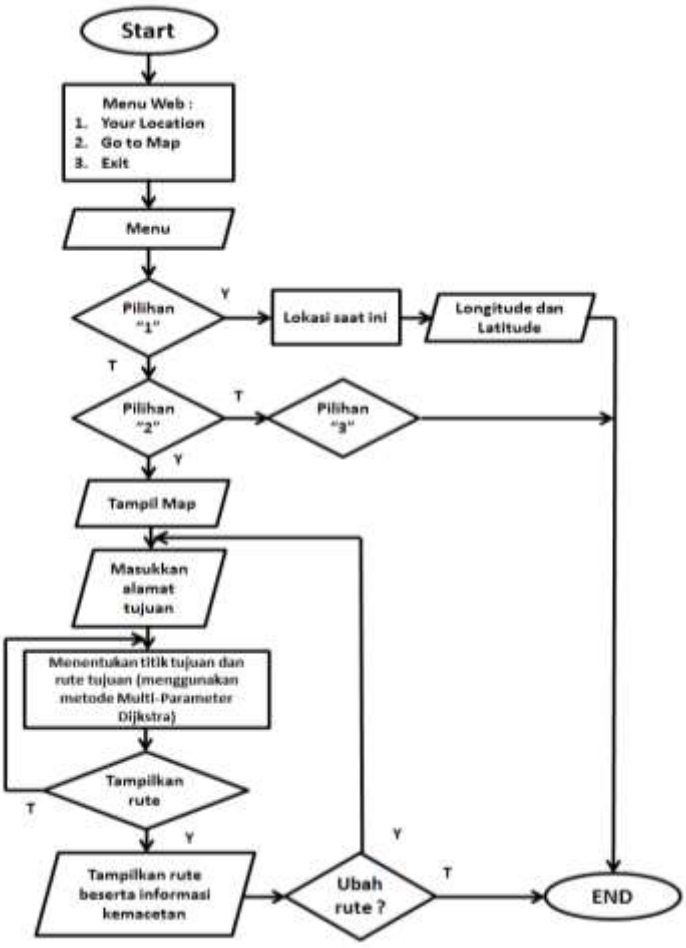


Figure 5. Flowchart application system

D. Preparation System Applications "Traffic Monitor" based on Android

Making the application system "Traffic Monitor" is made with Android Java language, which is that this application can be used by users in the handset (smartphone) that uses the Android OS. This application will show where the current user position on the map of Google Maps that is already integrated with the application. Additionally, it will be displayed predictive traffic data in Surabaya at points indicated location dense, smooth jams or traffic, which is where the information data is obtained from a database that has been created. System flowchart applications created can be seen in Figure 5. Whereas display applications like Figure 6.

4. SIMULATION RESULTS AND PERFORMANCE ANALYSIS

After the process of designing and manufacturing of complete systems, is the process of testing the system to obtain data that will be analyzed. System testing and parameter is passed with the following provisions:

A. Backpropagation Method

i. Scenario 1: Weekly Session

From the results of the training process can be seen the difference the training process at one location to location 20. The results of training can be seen in Table 4. From the acquisition of the training results obtained how many iterations occur, performance and time computing network system. After the training process, then the data in testing to obtain the desired prediction data, namely in Table 5

Table 4. Results of the training process on a weekly session

Location	Result of training process on a weekly session		
	Iterasi (Epoch)	*Performance* (MSE)	Computation time
C1	11	$1{,}73x10^{-22}$	9 second
C2	13	$1.28x10^{-22}$	22 second
C3	10	$1{,}73x10^{-14}$	13 second
C4	20	$2{,}13x10^{-13}$	20 second
C5	12	$1{,}98x10^{-14}$	24 second
C6	13	$3{,}24x10^{-16}$	19 second
C7	21	$2{,}05x10^{-7}$	56 second
C8	14	$2{,}73x10^{-15}$	20 second
C9	10	$1{,}34x10^{-14}$	12 second
C10	11	$1{,}79x10^{-18}$	17 second
C11	11	$3{,}71x10^{-14}$	30 second
C12	26	$2{,}26x10^{-23}$	55 second
C13	15	$3{,}32x10^{-13}$	42 second
C14	12	$4{,}20x10^{-15}$	36 second
C15	11	$1{,}73x10^{-14}$	12 second
C16	11	$5{,}05x10^{-16}$	21 second
C17	10	$2{,}82x10^{-17}$	19 second
C18	13	$4{,}08x10^{-15}$	25 second
C19	11	$1{,}73x10^{-16}$	20 second
C20	10	$5{,}00x10^{-14}$	19 second

Table 5. Results of the testing process (data prediction)

	Hasil Prediksi - Kecepatan rata-rata (Km/h)						
Jam	28 Juni 2015	29 Juni 2015	30 Juni 2015	1 juli 2015	2 Juli 2015	3 Juli 2015	4 Juli 2015
0	52	57	50	50	50	45	52
1	36.3569	38.4146	37.7377	33.577	38.939	34.166	38.973
2	52	57	60	57	55	55	47
3	55	46	57	50	55	45	52
4	50	54	55	55	55	55	50
5	49	44	55	54	50	50	47
6	38.264	40.6507	29.2239	36.693	32.158	37.205	38.81
7	43.4523	43.0799	26.5376	34.344	28.559	29.11	31.441
8	35	34	27	33	30	29	35
9	34	35	32	31	31	29	30
10	30	32	35	31	35	30	31
11	37	32	35	32	35	29	31
12	37.006	38.4746	35.4804	39.786	34.8	40.14	35.983
13	30	34	32	34	31	31	31
14	31.3206	32.1237	33.4921	31.618	31.183	28.153	27.826
15	37.8593	22.8255	29.1276	24.532	26.84	23.813	25.567
16	35	25	34	30	30	29	27
17	29.7531	25.5087	28.7124	27.481	26.91	28.175	26.225
18	33.1069	41.3528	30.4486	28.969	31.557	27.421	29.76
19	35	43	35	34	35	31	29
20	36	43	35	35	35	33	35
21	30	47	40	35	35	37	35
22	40	47	47	48	45	45	45
23	45	50	50	50	45	45	45

ii. Scenario 2: Dayly Session

Table 6. Results of the training process on a daily session

Location	**Result of training process on a dayly session**		
	Iterasi (Epoch)	***Performance* (MSE)**	**Waktu komputasi**
C1	4	$1{,}12x10^{-20}$	5 second
C2	4	$4{,}28x10^{-15}$	5 second
C3	4	$4{,}23x10^{-15}$	5 second
C4	4	$4{,}96x10^{-18}$	5 second
C5	4	$8{,}36x10^{-16}$	5 second
C6	4	$4{,}41x10^{-15}$	5 second
C7	4	$1{,}53x10^{-17}$	5 second
C8	4	$2{,}23x10^{-20}$	5 second
C9	4	$1{,}34x10^{-23}$	5 second
C10	5	$1{,}75x10^{-20}$	6 second
C11	4	$2{,}68x10^{-15}$	5 second
C12	4	$1{,}65x10^{-12}$	5 second
C13	4	$5{,}19x10^{-17}$	5 second
C14	4	$2{,}39x10^{-16}$	5 second
C15	15	$1{,}46x10^{-15}$	25 second
C16	5	$5{,}36x10^{-23}$	6 second
C17	4	$6{,}69x10^{-17}$	5 second
C18	5	$9{,}48x10^{-19}$	5 second
C19	4	$3{,}60x10^{-16}$	5 second
C20	5	$8{,}91x10^{-24}$	6 second

From the test results of data prediction system using Backpropagation Neural Network, carried out on two scenarios, namely Scenario 1: weekly sessions and scenario 2: daily sessions.

In scenario 1, it can be seen that the most excellent performance dianatra 20 location point is at the location of the C12 with the value of MSE of 2,1x10-23 with many iterations as many as 26 epochs and computation time for 55 second. In the training process, the number of iteration / epoch has no effect on long computation time, the cause of many iterations since the system is still not able to find the weights and bias values corresponding to the target data and the value of the error (MSE) is small, so the iteration will continue to run until it finds The smallest error and in accordance with the target data. Once the training process is done, then the process of testing, where the input or the input is the result of the training process within the extension * .mat. In addition, testing of data is the data that will be simulated to produce the output of the data input. Data from this testing process which is the final output data (prediction data) for 1 week (7 days) as shown in Table 5. From the results of these predictions, compared with actual

data, ie data on the predicted date, on which they are carried out on June 28, 2015 to July 4, 2015. This test was conducted to test the correctness and performance of the back propagation method.

Similar to the first scenario, the scenario 2: Daily sessions also done the same thing. But the difference is the target data and output. Data output on a daily sessions just one row of data that represents prediction data one day. From the training results in Table 6, the most excellent performance with the smallest MSE value is 8,91x10-24 in location C20.

iii. Testing and Analysis Comparative Testing Data Full (24 hours) and not full (not 24 hours)

In this test done testing and comparison of data is not full (data not 24 hours) in the testing process. This test aims to get the full 24-hour prediction data, or is unable to predict the data with the data testing that is not full. Testing the data used are full of data (24 hours), the data ¾, ½ ¼ data and data from the full data (24 hours). In Table 7 are shown the data from the prediction of each data testing.

Table 7. Results of prediction data from the data testing different

Time	Result of data prediction (Km/h)			
	Data testing : Full	Data testing : ¾ data	Data testing : ½ data	Data testing : ¼ data
0	48	47.8658	48.0006	48.4146
1	48	47.8794	48.0014	48.1308
2	48.354	49.4311	48.0012	47.8449
3	48.1093	50.2122	48.0024	47.9933
4	45	44.9465	45.0024	45.2755
5	45	45.0515	45.0004	45.0021
6	38	38.0178	38.544	37.9622
7	32.7882	35.0207	35.0005	33.4035
8	33	32.9872	32.3941	33.1833
9	34.9221	32.9674	33.0004	33.8175
10	32.9527	32.977	34.3276	33.7179
11	33.6034	31.7343	32.9248	30.5637
12	30	30.9846	30.0012	30.9016
13	30	29.9537	30.9402	30.8252
14	30	29.969	30.0007	30.8723
15	30	29.9276	30.0014	30.8461
16	34.6902	33.9727	34.0007	32.0742
17	35	35.0105	32.8561	34.8377
18	43	43.0194	42.9999	43.0654
19	40.1821	43.014	42.9996	42.986
20	42	42.0049	42	41.0885
21	45	45.826	46.3027	44.9866
22	45	45.0348	45.0012	43.6507
23	50	47.8125	51.1181	49.8368

B. Result of Aplication

Results display on the traffic menu folder of the application is made is shown in Figure 6.

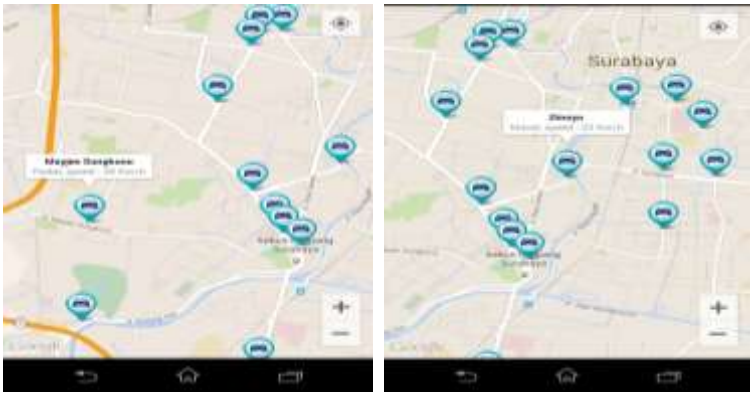


Figure 6. Display location point with traffic information

C. The results of data access information of the application based on data from the database

Results of information access data from a database that Traffic Monitor application can successfully retrieve data from the database as user access times that are using the application. Results of data access is done at 20 locations at 07.00 and 12:00. In Table 8 and Table 9 takes some sample results on the data information access.

Table 8. Results of the data access information from the database at 07.00

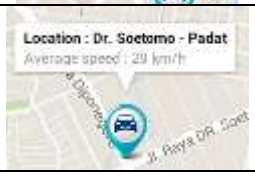
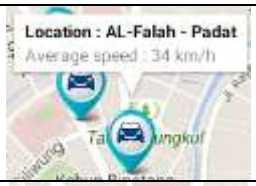
Location	Display on Aplication	Data in *Database*	Description
C1		27,6 Km/h	Successful data retrieval
C2		25 Km/h	Successful data retrieval
C3		29 Km/h	Successful data retrieval

Table 9. Results of a data access information from the database at 12.00

Location	Display on Aplication	Data in *Database*	Description
C1		34 Km/h	Successful data retrieval
C2		31 Km/h	Successful data retrieval
C3		32,5 Km/h	Successful data retrieval

From Table 8 are the results of the comparison display of information on the application and the data from the database at 07.00, it can be seen that the results of the data display information such as location, average speed and traffic indications on the 20 point locations with the data on the database. that applications can retrieve data from the database according to user access time. In Table 9 are the results of the comparison display of information on the application and the data from the database at 12.00 also shows the same result between the display of information to the database.

5. CONCLUTION

Based on the results of the implementation of the manufacturing and testing of the data prediction system using Backpropagation Neural Network and the creation of applications for monitoring traffic, some conclusions can be drawn as follows:

1. These parameters in accordance with the Regulation of the Minister of Transportation No. KM 14 Year 2006 on Management and Traffic Engineering on the Road with indications: traffic conditions ≤ 25 Km / h, solid conditions between 30 km /h / d 25 Km / h and substandard conditions ≥ 30 km / h.
2. From the results of prediction data, obtained Backpropagation best performance in scenario 2, namely at locations C20: Wapo, the Mean Square Error (MSE) of 8,91x10-24. The performance of the method Backpropagation seen from the MSE value, the smaller the MSE value, the better the performance and accuracy of data input.
3. Information on application "Traffic Monitor" has been able to show traffic congestion prediction information, the location with indication jammed, congested and smooth traffic with the description of the average speed of vehicles that pass through the area.

6. ACKNOWLEDGEMENT

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