Smart Survey Model of Average Daily Traffic (ADT) for Pavement Planning and Monitoring

Arthur Daniel Limantara[1*], Tjahjaning Tingastuti Surjosuseno[1] Bambang Subiyanto[2] Fauzie Nursandah[2] Sri Wiwoho Mudjanarko[3] Muhammad Ikhsan Setiawan[3] Nawir Rasidi[4]

[1]Department of Informatics, Sekolah Tinggi Teknologi Cahaya Surya, Kediri, Indonesia
[2]Department of Civil Engineering, Kadiri University, Kediri, Indonesia
[3]Department of Civil Engineering, Narotama University, Surabaya, Indonesia
[4]Department of Civil Engineering, State Polytechnic of Malang, Malang, Indonesia
[*]Corresponding author. Email: arthur.daniel@cahayasurya.ac.id

ABSTRACT
Daily traffic volume surveys for the planning and supervision of manual paving require work, time and are not cheap. Furthermore, the accuracy and speed of data collection are not timely. This study aims to bring a smart survey model that automatically collects and processes data on the daily volume of traffic in real time. The methodology used to model the survey process using smart devices, microcontrollers, sensors, Internet, cloud programming, and customer servers. The model survey process is divided into Part 1, Data collection and Part 2, to handle the axle load of each vehicle. The data is sent via the cloud access point; the cloud data are processed by the server. The model provides traffic volume data with speeds of up to 67.4 Mbps, 98 percent accuracy, and data processing results for monitoring the paving age in real time.

Keywords: *Traffic Volume Survey, Smart Survey Modelling, Internet of Things (IoT), Pavement Planning, and Monitoring.*

1. INTRODUCTION

Conventional pavement planning and design based on a survey of the average daily traffic volume of vehicles passing through a road. Usually, Macadam which done by recording the type of vehicle that passes through it, with the consequence that it requires a lot of survey personnel, costs, time, and lots of equipment (Figure 1) [1]. Also, the data analysed is past data, and the data is biased, and the accuracy cannot be justified [2].

Previous research to record Average Daily Traffic (ADT) uses a Video Image Vehicle Detection System, which is smarter than using an Image Processor system but can be more complicated when it is time to install CCTV specifically for VIDs [3]. A further study used the motion sensor (VIM) vehicle to accurately determine the weight and portion of weight on the body axle. The data gathered from these sensors are useful for road planners, designers, and law enforcement. The benefit of using this system is that it can easily be operated on multi-track roads. However, the initial investment costs are high [4]. This study focused on collecting average daily traffic data intelligently, then sending it via Wi-Fi and processing it to produce pavement planning and monitoring.

Figure 1 Conventional Survey of Average Daily Traffic (ADT) (Courtesy of Trans-Jakarta, Indonesia)

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2. METHOD

2.1. Average Daily Traffic (ADT)

The ADT, also called mean daily traffic, is the average number of vehicles traveling over a short period of time via a certain road point (often seven days or less). It is estimated by dividing overall daily volumes by the number of days in the period over a specified period [5].

$$ADT = \frac{1}{n}\sum_{i=1}^{n} VOL_i \qquad (1)$$

Where:

VOL_i = Daily volume on the day of ith and

n = the total number of days.

2.2. Axle Correction Factor (ACF)

ACF is the ratio of the number of vehicles divided by each type of vehicle by the number of axles. ACF is also referred to as the axle factor.

$$ACF = \frac{\text{Total number of vehicles of Class X}}{\textit{Total Number of axles of class X vehicles}} \qquad (2)$$

2.3. Wemos D1 Mini (chip ESP8266)

Wemos is a board module that can function with Arduino, especially for projects that carry the IoT concept (see Figure 2). Wemos can run stand-alone because a CPU is programmed via the serial port or OTA and wireless program transfer. Wemos has the ESP8266 Chipset, a chip with Wi-Fi features, and supports the TCP/IP stack. This small module allows a microcontroller to connect to a Wi-Fi network, make a TCP/IP connection using just a simple command, 80 MHz clocks, 4MB external RAM, and support the IEEE 802.11 b/g/n format, so it does not cause interference to others. Also, the CH340 Chipset converts a USB serial into a serial interface, such as a converter to IrDA application or a USB converter to Printer application. The CH340 sends a common link signal used in modems in serial interface mode. The CH340 is used to directly convert a standard serial interface to a USB bus. In the Wemos module, the digital pin is an input or output of the I / O ports in the Wemos module. The analog pin has a 10-bit resolution and a maximum of 3.2 Volt [6].

Figure 2 Wemos D1 Mini (chip ESP8266)

2.4. Arduino Uno

The Arduino Uno is an ATmega328 microcontroller board (datasheet). The system has 14 digital output input pins where 6 of these input pins are used as PWM output, six analog input pins and 16 MHz crystal oscillator connections (see Figure 3). To connect the Arduino Uno board to the computer with a USB cable or power with an AC-to-DC adapter or battery, the microcontroller is enough to be used [7].

Figure 3 Arduino Uno

2.5. Sensor Load Cell

A load cell is an electronic signal sensor or transducer which converts the load or force acting on it (see Figure 4). This electronic signal can change the voltage, the current, or the frequency change depending on the type of load cell and the circuit used. There are many loads cell types. Resistive load cells work on the principle of piezo resistivity. When a sensor is loaded/forced/strenghted, its resistance changes. This resistance change causes the voltage to change when the input voltage is applied. Single point charge cells are commonly used for weighing and for applications with unlimited space and off-center load compensation [8].

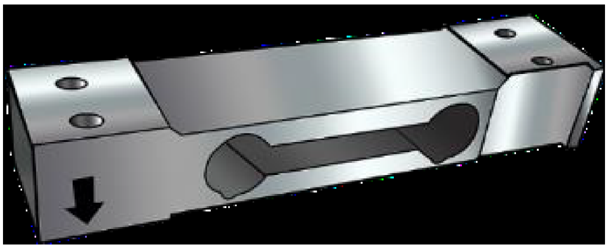

Figure 4 Single Point Load Cell

2.6. Modul HX711

The HX711 module makes it easy for us to read weight-measurement load cells, as presented in Figure 5. This module amplifies the sensor output signal and converts analog data into digital data. It is connected to a microcontroller so that we can read the load cell resistance changes. After calibration we get a measurement of weight with high precision [9].

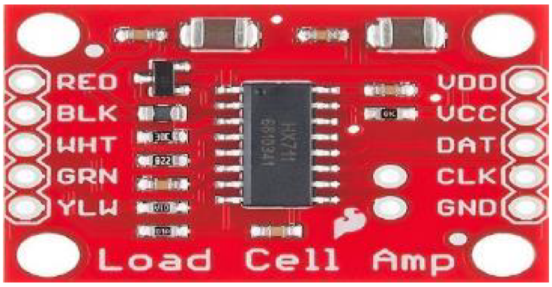

Figure 5 HX711 Load Cell Amplifier

2.7. Assumptions of Research

The assumption of this study is that *all vehicles* have *a Digital Vehicle ID on a Chip* based on some of our previous research published in the paper entitled “Pemanfaatan Internet of Things (IoT) sebagai Solusi Manajemen Transportasi Kendaraan Sepeda Motor” [10], “Solusi Pengawasan Kebijakan Mengatasi Kemacetan Jalan dan Parkir Kota Berbasis Internet Cerdas" [11], dan "A New Digital ID System on Indonesia Vehicle Using IoT" [12].

The digital vehicle ID on a chip contains vehicle data such as the vehicle plate number, vehicle type, and vehicle weight (Figure 6), which will be sent to the Cloud by an access point wirelessly, as shown in Figure 7.

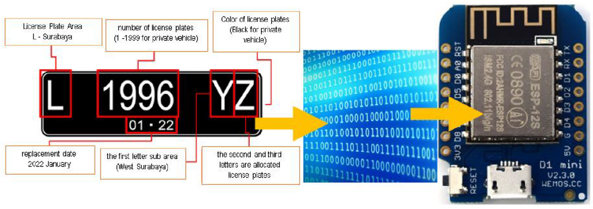

Figure 6 Digitizing Process of Vehicle License Plate

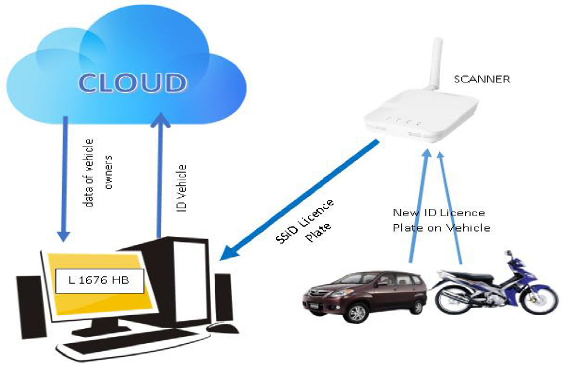

Figure 7 Vehicle Identification System with License Plate

Figure 8 shows vehicle type data used to classify vehicle axle loads for hardware and software designs discussed in point 3.2.

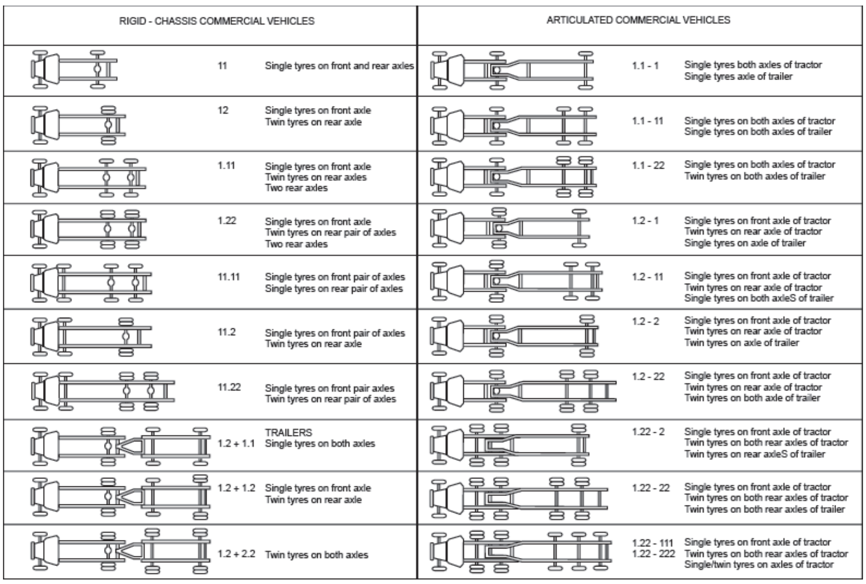

Figure 8 Typical axles configurations [13]

2.8. Hardware and Software Design for Obtaining Vehicle Weight Data

Vehicle wheel load identification built using a load cell sensor connected to the HX711 load cell as an amplifier and an Arduino Uno as a microcontroller, and an ESP8266 chip, which will send data to the Access Point and forward it to the server, as presented in Figure 9 [14].

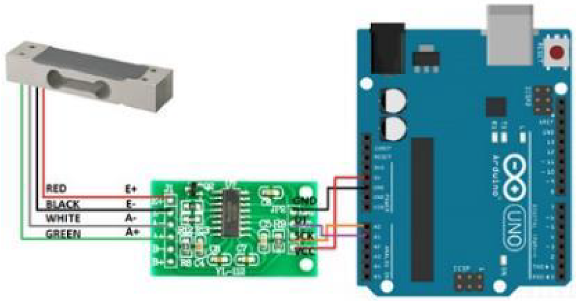

Figure 9 Schematic of Load Cell, HX711, and Arduino Uno Relationships

The hardware load cell sensor will be paired across the road and connected to the HX711 and Arduino Uno chips, which will be programmed with the Arduino IDE and transmitted continuously by a wifi signal [15]. The flowchart is presented in Figure 10.

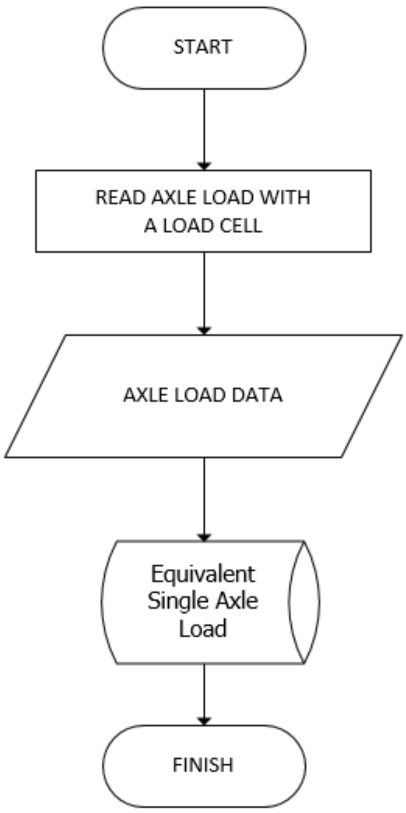

Figure 10 Flowchart of axle load reading by load cell

3. RESULT AND DISCUSSION

3.1. Delivery Speed Data Analysis

The data transmission speed measured is from reading the Digital Vehicle ID and the Axle load read by the Load Cell sensor then sent to Wemos D1 Mini to be uploaded to the Cloud and then received by the Web Server for data processing. The average speed of data transmission is 67.4 Mbps (read by the transfer rate software). In contrast, the accuracy of the data sent read 98%, and the 2% error that occurs does not affect the integrity of the data on time, as shown in Table 1.

Table 1. Transfer Rate Analysis Results and Data Accuracy.

Signal Quality (%)	Transfer Rate (Mbps)	Data Accuracy (%)
81 - 100	71.4	97
61 – 80	68.3	96
41 – 60	64.0	100
21 – 40	67.2	98
0 – 20	66.1	99
Average	**67.4**	**98**

4. CONCLUSION

Based on the above analysis, it can conclude that the model produces traffic volume data information with speeds of up to 67.4 Mbps, data accuracy of 98%, and real-time data processing results that can monitoring pavement age.

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REFERENCES

[1] S. Ji *et al.*, "Improvement of vehicle axle load test method based on portable WIM," *Meas. J. Int. Meas. Confed.*, no. April, p. 108626, 2020, doi: 10.1016/j.measurement.2020.108626.

[2] P. Falkowski-Gilski and T. Uhl, "Current trends in consumption of multimedia content using online streaming platforms: A user-centric survey," *Comput. Sci. Rev.*, vol. 37, p. 100268, 2020, doi: 10.1016/j.cosrev.2020.100268.

[3] B. T. Engineering, "Pemanfaatan kamera," pp. 1–8.

[4] F. Al-Turjman and A. Malekloo, "Smart parking in IoT-enabled cities: A survey," *Sustain. Cities Soc.*,

vol. 49, no. December 2018, 2019, doi: 10.1016/j.scs.2019.101608.

[5] FHWA, "Traffic Data Computation Method POCKET GUIDE," no. August, 2018.

[6] A. D. Triono *et al.*, "Utilization of Pedestrian Movement on the Sidewalk as a Source of Electric Power for Lighting Using Piezoelectric Censors," in *2018 3rd IEEE International Conference on Intelligent Transportation Engineering, ICITE 2018*, 2018, doi: 10.1109/ICITE.2018.8492624.

[7] C. G. Jones and C. Chen, "An arduino-based sensor to measure transendothelial electrical resistance," *Sensors Actuators, A Phys.*, vol. 314, p. 112216, 2020, doi: 10.1016/j.sna.2020.112216.

[8] G. Stano, A. Di Nisio, A. Lanzolla, and G. Percoco, "Additive manufacturing and characterization of a load cell with embedded strain gauges," *Precis. Eng.*, vol. 62, no. November 2019, pp. 113–120, 2020, doi: 10.1016/j.precisioneng.2019.11.019.

[9] W. Lapsomthop, N. Wongsirirax, A. Kitelteerakol, and W. Sawangsri, "Design and experimental investigation on 3- component force sensor in mini CNC milling machine," *Mater. Today Proc.*, vol. 17, pp. 1931–1938, 2019, doi: 10.1016/j.matpr.2019.06.232.

[10] S. W. Mudjanarko, S. Winardi, and A. D. Limantara, “Pemanfaatan internet of things (iot) sebagai solusi manejemen transportasi kendaraan sepeda motor,” *Pros. Semin. Nas. Apl. Teknol. Prasarana Wil. X*, no. August, 2017, doi: 10.17605/OSF.IO/6UE4B.

[11] A. D. Limantara, L. D. Krisnawati, S. Winardi, and S. W. Mudjanarko, “Solusi Pengawasan Kebijakan Mengatasi Kemacetan Jalan dan Parkir Kota Berbasis Internet Cerdas,” *Semin. Nas. Teknol. dan Rekayasa Inf.*, no. November, pp. 1–6, 2017.

[12] S. Winardi, S. W. Mudjanarko, B. Anindito, and W. M. Utomo, "A NEW DIGITAL ID SYSTEM on INDONESIA VEHICLE USING IoT," no. August, pp. 1–7, 2018.

[13] A. Nkaro, "Traffic Data Collection and Analysis," no. 99912-0-417–2, pp. 1–54, 2004.

[14] Z. Latif, K. Sharif, F. Li, M. M. Karim, S. Biswas, and Y. Wang, "A comprehensive survey of interface protocols for software defined networks," *J. Netw. Comput. Appl.*, vol. 156, no. July 2019, p. 102563, 2020, doi: 10.1016/j.jnca.2020.102563.

[15] S. Hankey, T. Lu, A. Mondschein, and R. Buehler, "Spatial models of active travel in small communities: Merging the goals of traffic monitoring and direct-demand modeling," *J. Transp. Heal.*, vol. 7, no. January, pp. 149–159, 2017, doi: 10.1016/j.jth.2017.08.009.