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Driving cycle tracking device development and analysis on route-to-work for Kuala Terengganu city

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ABSTRACT

Driving cycle is a series of speed versus time profile used to represent driving patterns of a vehicle. research in this field guides vehicle manufacturers and environmentalists to investigate air quality through emissions. Study on driving cycle also aids manufacturers to manage vehicle emissions and to save energy released through exhaust. Also, driving cycles can provide information on road condition and driving behaviour of an individual. For that, a proper data collection method is crucial as it is solely based on real world driving. This research is an initiative to construct a prototype of driving cycle tracking device (DC-TRAD) in which it was implemented with internet-of-things (IoT) to manage big number of collected data. U-Blox global positioning system (GPS) neo 7 M sensor was used to increase the accuracy of data capturing and it was used on route-to-work for Kuala Terengganu city (RTW DC for KT city) for analysis.

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1. INTRODUCTION

Driving cycle is defined as relationship of speed and time of a vehicle. Driving cycle is also commonly known as a cycle which relflects the condition of a certain route. Driving cycle is also defined the series of data points representing the speed of vehicle and time [1]–[9]. Driving cycle often varies according to routes and driving behaviour of the driver. Driving cycle is used as a tool to evaluate vehicle performances, emission of vehicle and vehicle design and development [10]. Also, driving cycle is used by manufcaturers and environmentalists as a tool of study for testing and certification of emission norms [11]. With regards to its importance, the information collected for the development must be accurate and of real world based to ensure the outcome of the driving cycle is accurate. Thus, there is a need for a device with an accurate global positioning system (GPS) sensor which can capture accurate information.

Driving cycle tracking device (DC-TRAD) was innovated for this purpose in which it was integrated with U-Blox Neo 7 M GPS sensor which can capture speed and time information with an accuracy of less than 1 meter compared to a sensor of a typical mobile phone which is 4.9-meter radius [12], [13]. However, the device must be improved from its previous release since internet-of-things (IoT) commonly known as pushingbox used in the device had been obsoleted [14]. This research gave an opportunity to explore on

reliable IoT platforms such as my structured query language (MySQL) database and to improve the accuracy of GPS sensor to enable the device to capture an accurate speed time information.

The objective of this research is to highlight the importance of an accurate data sampling as micro trips play an important role in driving cycle development in which a typical mobile phone GPS sensing is unable to capture the small changes during deceleration of vehicle. For this, speedview application which can be downloaded from playstore and certified by code sector developers was used as a comparison tool [15]. The device was then tested on route-to-work for Kuala Terengganu city (RTW DC for KT city) for analysis [16].

2. METHOD

Three steps are involved in this research which is component selection; prototype and database development; and data analysis with RTW DC for KT city. In the first phase, components needed was chosen precisely ESP32 microcontroller, U-Blox Neo 7 M GPS sensor, 3.5" thin film transistor (TFT) screen and jumper cables. In second phase, DC-TRAD prototype was developed as per Figure 1.

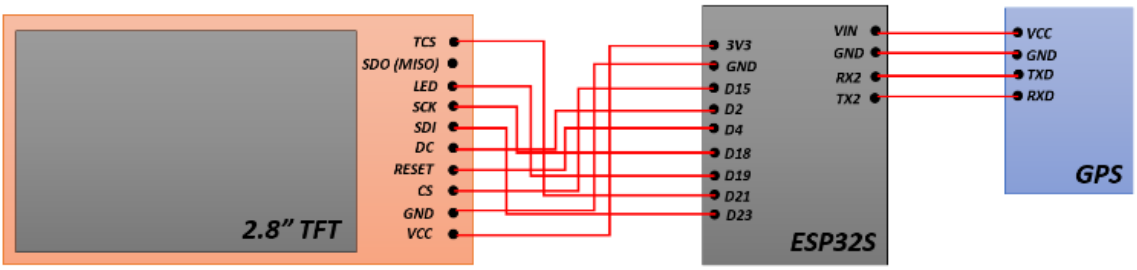

Figure 1. DC-TRAD connection

Table 1. Assessment of parameters for validation

No	Variable	Unit	Formula
1	Average speed, V_1	Km/h	$V_1 = 3.6\,\frac{dist}{T_{total}}$
2	Average running speed, V_2	Km/h	$V_2 = 3.6\,\frac{dist}{T_{drive}}$
3	Average acceleration, a	m/s^2	$a = \left(\sum_{i=1}^{n} \begin{cases} 1 & (a_i > 0) \\ 0 & (else) \end{cases}\right) - 1$ $\left(\sum_{i=1}^{n} \begin{cases} a_i & (a_i > 0) \\ 0 & (else) \end{cases}\right)$
4	Average deceleration, d	m/s^2	$d = \left(\sum_{i=1}^{n} \begin{cases} 1 & (a_i > 0) \\ 0 & (else) \end{cases}\right) - 1$ $\left(\sum_{i=1}^{n} \begin{cases} a_i & (a_i > 0) \\ 0 & (else) \end{cases}\right)$
5	Acceleration P_a, $v(t) \geq 3$ km/h, $a(t) \geq 0.1$ m/s^2	%	$\%\ acc = \frac{T_{acc}}{T_{total}}$
6	Deceleration P_d, $v(t) \geq 3$ km/h, $a(t) < -0.1$ m/s^2	%	$\%\ dec = \frac{T_{acc}}{T_{total}}$
7	Total distance travelled	Km	-
8	Total time taken	s	-

PhpMyAdmin platform which is a partner tool of MySQL is wellknown for its flexibility and versatility in handling huge amount of data points [16]. Besides, phpMyAdmin is a tool which is widely used by administrators and engineers to store and manage big amount of data in database as it can run queries easily and display multiple outcomes and results. It also supports import and export function in various formats in which databases can be imported, exported, and shared among other systems easily with a simpler configuration. Database setup of DC-TRAD is:

- Step 1: phpMyAdmin setup file was downloaded at https://www.phpmyadmin.net/downloads/
- Step 2: cross-platform, Apache, MySQL, PHP and Perl (XAMPP) webserver was downloaded at https://www.apachefriends.org/download.html

- Step 3: Apache and MySQL were started from the interface.
- Step 4: localhost interface was started at http://localhost/phpmyadmin. By default, the username is "root" with password space left blank. Upon successful login, it is highly recommended to change password to protect database. A new database was created with the name "gpsdata" and data named "gps_table". In this research, column named time, latitude, longitude, speed and time was initialized to data type "double".
- Step 5: a webpage was created which can be logged in anywhere by using localhost internet protocol (IP) address. Please take note that several security options must be enabled to ensure data privacy and protection plan. As per the name of the device defines, together with this, a separate Webpage was also created in which constructed driving cycle can be viewed instantly on the Webpage with the link provided.

In third phase, data collection was done on RTW DC for KT city by using developed DC-TRAD and speedview application simultaneously. Five routes of RTW DC for KT city was chosen as these routes are frequently used by Kuala Terengganu citizens to work and was authorized by [17]. There are three data collection techniques which are chase car, on-board and combination of both. In this research, car chase technique was chosen in which instrumented vehicle records speed point second-by-second as it follows the targeted vehicle. Figure 2(a) to Figure 2(e) show the chosen routes of RTW DC for KT city. To validate the results obtained, few assessment parameters were chosen; time, distance travelled, average speed, average running speed, average acceleration, average deceleration, acceleration percentage, deceleration percentage, idle percentage, and cruise percentage. Table 1 shows the formulas involved to calculate the assessment parameters.

Figure 2. RTW DC for KT city: (a) route A, (b) route B, (c) route C, (d) route D, and (e) route E

3. RESULTS AND DISCUSSION

DC-TRAD was developed by integrating ESP32 microcontroller, GPS Neo 7 M module and 2.8" TFT display screen. The connection was done as per Figure 1. Figure 3 shows the completed DC-TRAD prototype. In phpMyAdmin, a webpage entitled DC-TRAD was created and six parameters' columns were included in the database monitoring platform, which is number, latitude, longitude, speed, date, and time. The webpage was coded to be refreshed for every one second in which most of the driving cycles are being constructed by means of one second interval. Since the webpage constructed will be accessed by using confidential credentials or commonly known as IP address, it is recommended to protect the access link to ensure privacy. The database platform can be accessed through http://example-domain.com.ViewGpsVal.php and the constructed driving cycle which will be plotted instantly as soon as the data points are detected by the GPS sensor can be access via http://example-domain.com/SpeedTimeView.php in which "example-domain.com" will be replaced with IP address is corresponding machines. Figure 4 and Figure 5 shows DC-TRAD webpage interface and speed-time relation curve webpage respectively.

Figure 3. DC-TRAD prototype

Data collection was done on selected five routes of RTW DC for KT city and speed data was recorded for every one second through DC-TRAD and speedview application. Percentage error was calculated between DC-TRAD and speedview by obtaining the percentage difference between DC-TRAD and speedview application. According to [18]–[22], accuracy is well defined as the state of being truthful to ensure precision. A typical GPS sensor is more accurate than a mobile phone GPS sensor in which U-Blox sensor can capture information up to less than 1 meter radius. The accuracy of U-Blox GPS sensor can be seen during braking effect in which the speed of vehicle was detected and captured when then speed is at non-zero state. This is commonly known as vehicle cruising and idling where the speed of vehicle is more than zero when the acceleration is zero. Table 2 shows the accuracy comparison at non-zero state of U-Blox GPS sensor and mobile phone GPS.

Table 2. Accuracy of U-Blox sensor

Time	Mobile GPS	U-Blox GPS
414	15.6106368	16.1880094
415	11.2654080	11.8862329
416	8.0467200	8.6997318
417	5.3108352	6.2036392
418	3.2186880	3.5118956
419	1.7956289	1.8938160
420	0.0000000	0.0015894
421	0.0000000	0.0014895
422	0.0000000	0.0001890
423	0.0000000	0.0013256
424	0.0000000	0.0274518
425	1.5211897	1.4750790
426	6.1200000	7.0370790
427	19.4400000	20.7566790

According to [23]–[27], cruise control is when brakes are automatically applied to maintain the speed of the vehicle motor. GPS of a typical mobile phone is unable to capture this phase in which it records 0 km/h when the acceleration is zero. Through this, it is proven the speed recording of U-Blox sensor varies approximately 1.5 times higher compared to mobile phone GPS sensor. Vehicle cruising plays an important role in driving cycle development since it decides the number of microtrips on a certain route in which it directly affects clustering process of the cycle development.

Driving Cycle Tracking Device (DC-TRAD)

No	Latitude	Longitude	Speed (Km/h)	Date	Time
1	0	0	0	2022-01-19	10:25:45
2	0	0	0	2022-01-19	10:25:46
3	0	0	0	2022-01-19	10:25:47
4	0	0	0	2022-01-19	10:25:48
5	0	0	0	2022-01-19	10:25:48
6	0	0	0	2022-01-19	10:25:49
7	0	0	0	2022-01-19	10:25:50
8	0	0	0	2022-01-19	10:25:51
9	0	0	0	2022-01-19	10:25:52
10	0	0	0	2022-01-19	10:25:52
11	0	0	0	2022-01-19	10:25:53
12	0	0	0	2022-01-19	10:25:54
13	0	0	0	2022-01-19	10:25:55
14	0	0	0	2022-01-19	10:25:56
15	0	0	0	2022-01-19	10:25:56
16	0	0	0	2022-01-19	10:25:57
17	0	0	0	2022-01-19	10:25:58
18	0	0	0	2022-01-19	10:25:58
19	0	0	0	2022-01-19	10:25:59
20	0	0	0	2022-01-19	10:26:00
21	0	0	0	2022-01-19	10:26:01
22	0	0	0	2022-01-19	10:26:02
23	0	0	0	2022-01-19	10:26:02
24	0	0	0	2022-01-19	10:26:03
25	0	0	0	2022-01-19	10:26:04
26	0	0	0	2022-01-19	10:26:05

Figure 4. DC-TRAD webpage

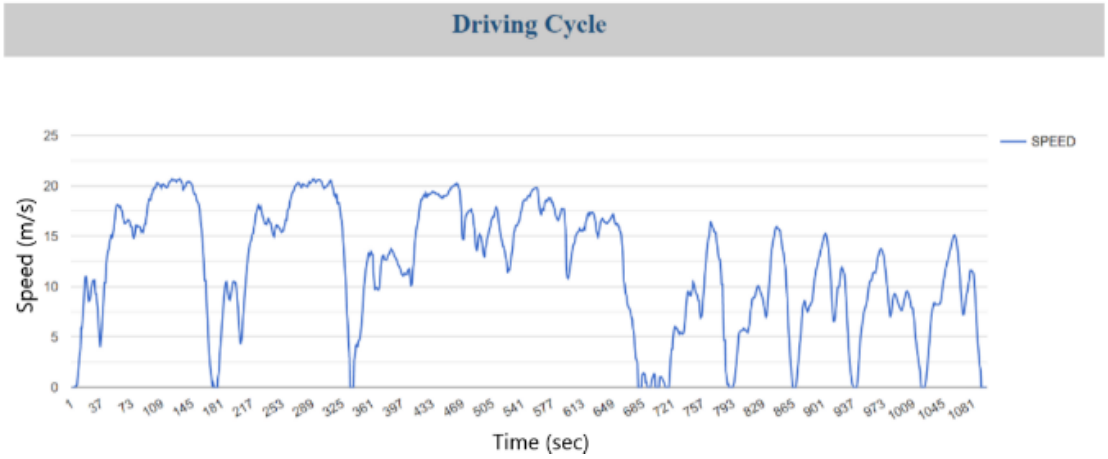

Figure 5. Speed-time relation curve webpage

4. CONCLUSION

DC-TRAD was successfully innovated with implementation of IoT which is in line with IR4.0 through the application of big data management. It is proven that the outcome of this research supports the idea of U-Blox GPS sensor being an accurate sensor with a detection radius of less than 1 meter compared to mobile phone GPS sensor which is 4.9-meter radius. This accuracy can be seen on cruising phases of vehicle on RTW DC for KT city in which speed of vehicle above zero can be captured when the acceleration is at zero. In this research, DC-TRAD was validated since it has less than 5% of error compared to speedview application and thus, can be used as a data collecting tool for future development of driving cycle.

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