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DRIVING CYCLE TRACKING DEVICE (DC-TRAD)

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Abstract

Driving cycle is commonly known as the relationship between a set of vehicle speed points and time and widely used by vehicle manufacturers, environmentalists and traffic engineers in the study of energy consumption and emissions of the transportation. In relation to that, energy consumption and emissions are directly affected by the driving behaviour of road users under different traffic conditions. Therefore, for an accurate driving cycle development, data based on real-world driving behaviour is crucial and brought up the idea of construction of driving cycle tracking device (DC-TRAD). This device benefits research on this discipline but not the user of the vehicle. Therefore, a built-in anti-theft tracking system is included in the system since vehicles stealing have been one of the major issues nowadays where there is lack of mix of security system and vehicle controlling which alerts the user on car thieves during his absence. The first objective of this research is to construct a schematic layout of DC-TRAD using Proteus 8 software. Second objective is to develop a prototype of DC-TRAD for cars and verify with existing route-to-work for Kuala Terengganu driving cycle and third objective is to develop anti-theft tracking system for cars and implementation of internet of things (IoT) technology for data controlling and monitoring of DC-TRAD. Generally, when DC-TRAD is powered up and initialized, the systems will be executed and TFT displays parameters collected and updates into google drive instantly and in case of car hijacking, the location of the vehicle will be sent to user through short messaging service (SMS) with the aid of GSM GPRS communication module. The average of the percentage errors between DC-TRAD and existing device is 7.55%. It can be concluded that DC-TRAD is verified with the other driving cycle device with error below than 10%.

Keywords: Anti-theft, Driving cycle, Electric vehicles, Hybrid electric vehicles, IoT implementation, Road profile, Tracking system.

1. Introduction

A few problems have been encountered lately which brings up the idea of constructing DC-TRAD. Firstly, constructing driving cycle is not simple perhaps needs a lot more time and manpower to get it done. Driving cycle plays a vital role in the production and evaluating the performance of the vehicle. Driving cycle is a representative speed-time profile of driving behaviour of specific region or city [1].

Driving cycle is the relationship of speed and time on a particular area and road which can be further used to draw out fuel consumption, road condition, fuel emission and fuel economy of car [2-4]. Other than that, it is very time consuming to record the speed of car and respective time of the travel in case of traffic and constructing driving cycle after data collection. An additional feature which comes along with DC-TRAD is the anti-theft tracking system.

Based on surveys done by the Zulkifli et al. [5], the price of a GPS based vehicle tracking system device falls in the range of RM82.98 - RM124.58 on monthly basis. To add to that, asset tracking device starts at the range of RM62.18 per month and installation of the device cost RM311.96-RM415.95 per vehicle. With DC-TRAD; a 2 in 1 device, the cost is said to be very much lower compared to existing anti-theft tracking systems available in market [6].

To make it more user-convenient, text messaging system is built into DC-TRAD and the device itself is connected directly to the motor of the car which starts up driving cycle and anti-theft tracking system instantly with the start of car motor which operates on Internet of Things (IoT).

2. Literature Review

Some of the existing projects and research conducted previously which directly and indirectly aids and contributes to the completion and success of this research **will be discussed in this section.**

2.1. Proteus 8

Proteus 8 is software used to simulate and to check connection between connections before hardwiring. According to Techulator (2016), breadboarding and creating a Printed Circuit Board (PCB) would be a good suggestion to test circuits but bigger circuits normally end up in complexities [7]. Therefore, simulating the circuit will be the best solution for this problem. Many components which are available in Proteus 8 software can be simulated. There are two ways of simulation which is “Run Simulator” and “Advance Frame by Frame”. “Run Simulator” executes simple circuits in normal speed whereas “Advance Frame by Frame” advances the execution and waits for the call for the next execution. This option is mainly used for digital circuit debugging according to Labcenter Electronic Ltd as mentioned in their official page of Proteus 8 (2016) [7]. To add to that, Proteus 8 also comes with an option of simulating microcontrollers such as PIC24, dsPIC33, 8051, Arduino and ARM7. According to Fan et al (2018), Proteus 8 software is a secure virtual environment that is convenient and quick to establish an experimental environment. Proteus can provide all the resources needed for the test, directly evaluate the correctness of hardware circuit design, directly debug the software with hardware schematic diagram, verify the function of the whole design, and test controllable, easy to evaluate and easy to implement [8]. Therefore, Proteus 8 software is used in this project.

2.2. Intelligent anti-theft car security system based on Arduino and GSM network

Car thief is co-related to carelessness of citizens and vehicle owners despite the intelligence of technologies which exist in 21st century. These issues brought up the idea of Intelligent Anti-Theft Car System based on Arduino and GSM Network which was proposed by Boskany et al. [9]. In the system proposed by ahmed et al. [10], the Arduino microcontroller, vibration sensor, GSM SIM 800L module and Bluetooth HC-05 are using to implement the system, the vibration sensor used the purpose of detecting the vibration resulting from the operation of the engine of the car when the vibration detected the message is sent through the GSM unit and the alarm whistle turning “ON” to alert the owner of the car. On the other hand, in the paper, this system was suggested to be used as a back-up system unit along with other conventional systems for a better security and safety to the car. In the proposed system, the setup can turn off ignition motor of the car through Short Messaging Service (SMS) and alerts the car owner through SMS if the car is started and brought over in owner’s absence. This existing system directly contributes to the advancement of DC-TRAD as DC-TRAD also comes with an Anti-Theft Tracking System which controls and monitors the state of ignition motor of the car and alerts the owner through SMS.

2.3. Advanced anti-theft and home safety system using GSM

Kansal et al. [11] proposed a system entitled Advanced Anti-Theft & Home Safety System Using GSM. This system is mainly for safety and security purpose which is said to be important in our day-to-day life.

Home security system which exists nowadays is standardized systems and this paper works on improvisation of the existing system with new techniques at a low cost. Kansal also highlighted in the paper that simple setup of the system enables user to design own hardware circuits which works well with various sensors, motors, lightings, alarms, relays and locking systems. The entire system is controlled by an Arduino and monitored at all-time which triggers the owner through SMS if it senses any security issue.

This proposed system also contributes a little in the research of DC-TRAD where reference code of GSM Network and sensor interfaces are obtained.

2.4. IoT based monitoring and control system

Bethapudi et al. [12] proved the vast application of IoT in monitoring and automation discipline in his proposed system. This project paper shows the efficient implementation of IoT for monitoring, controlling and automation system on portable and user interfacing devices. This research is closely related to the research of DC-TRAD because DC-TRAD works in similar principle as per this system as a portable single-handed system. Communication of sensors with networks through Internet gateway by means of low power communication such as Wi-Fi has been a great advantage of IoT implementation. System proposed by Prakash works in a way that home appliances such as door locking system, lighting and motors be controlled through smartphones or tablets using Wi-Fi as communication protocol with the aid of wed interfaces.

An extra feature of this system is the protection interface where any security issue alerts the user through web and smartphones. This research plays an important role in construction of DC-TRAD as DC-TRAD also works in the same way at which the data read from sensors will be updated into web interface and in this case, Google Drive Spread Sheet.

3. Methodology

3.1. Construction of schematic layout of DC-TRAD using Proteus 8

Schematic layout and simulation of DC-TRAD is done using Proteus 8 software to test the connection between the components. TFT screen lighting up and communication interface in virtual terminal using GSM module as per Arduino graphic code uploaded indicates the connection is proper and correct as shown in Fig. 1. Prototype is constructed accordingly after simulating connections.

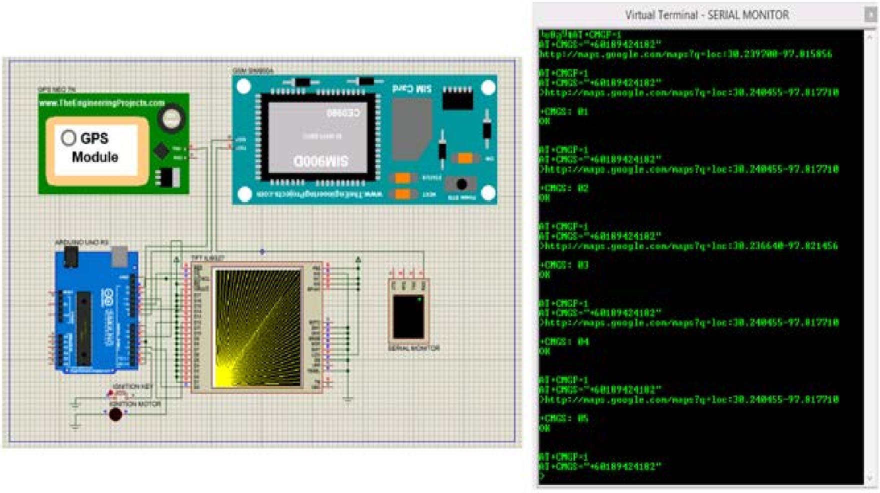


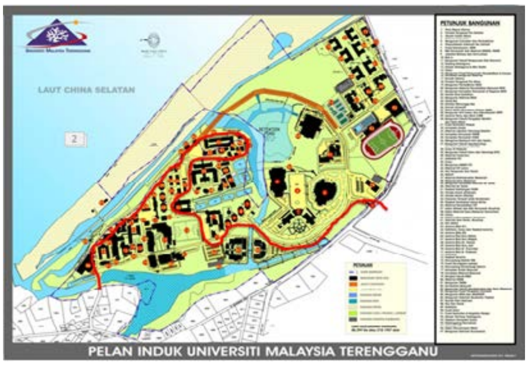
Fig. 1. Proteus 8 simulation result.

3.2. Testing DC-TRAD in UMT compound

The device is tested in 2 locations in University Malaysia Terengganu as marked “red” in Fig. 2(a and b).

3.3. Verification of speed-time data with developed route-of-work for Kuala Terengganu driving cycle

Data obtained through DC-TRAD was verified and validated with developed Route-of-Work for Kuala Terengganu driving cycle. Ten assessment parameters were chosen as key point for the validation and the results obtained through DC-TRAD was executed in Matrix Laboratory (MATLAB) software. Table 1 show the variables used.



(a) Testing route A.

(b) Testing route B.

Fig. 2(a and b). Testing route for 2 locations.

Table 1. Assessment variables.

No.	Variable	Unit	Formula
1	Average speed, V_1	km/h	$V_1 = 3.6\frac{\text{dist}}{T_{\text{total}}}$
2	Average running speed, V_2	km/h	$V_2 = 3.6\frac{\text{dist}}{T_{\text{drive}}}$
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	Idling Pi, v(t) = 0 km/h	%	-
6	Acceleration P_a, v(t) ≥ 3 km/h, a(t) ≥ 0.1 m/s^2	%	% acc = $\frac{T_{acc}}{T_{total}}$
7	Cruising P_c, v(t) ≥ 3 km /h , -0.1≤ $a(t) < 0.1$ m/s^2	%	% cruise = $\frac{T_{cruise}}{T_{total}}$
8	Deceleration P_d, v(t) ≥ 3 km/h, a(t) < -0.1 m/s^2	%	% dec = $\frac{T_{dec}}{T_{total}}$
9	Total distance travelled	km	-
10	Total time taken	s	-

3.4. Anti-theft system development and data storing using IoT

Coding for Anti-Theft Tracking System was developed at this phase and tested and IoT technology was used to store real-world data of Driving Cycle in Cloud using ESP8266 Wi-Fi Module. Data obtained was updated into Google Spreadsheet for every 5 seconds using PushingBox platform as shown in Fig. 3.

fx 2/15/2019 22:47:31

	A	B	C	D	E	F
444	2/15/2019	3.33	0	4.312279	101.1542	0.01
445	2/15/2019	4.57	0	4.312342	101.15427	0.09
446	2/15/2019	1.22	0	4.312297	101.15415	0.08
447	2/15/2019	0.26	0	4.312292	101.15414	0.01
448	2/15/2019	0.26	0	4.312292	101.15414	0
449	2/15/2019	0.26	0	4.31225	101.1541	0.05
450	2/15/2019	1.85	0	4.312242	101.15409	0.01
451	2/15/2019	0.74	0	4.31225	101.15411	0.01
452	2/15/2019	0.74	0	4.31225	101.15411	0
453	2/15/2019	0.74	0	4.312194	101.15401	0.08
454	2/15/2019	5.19	0	4.312133	101.15393	0.07
455	2/15/2019	4.93	0	4.312096	101.15389	0.04
456	2/15/2019	4.93	0	4.312096	101.15389	0
457	2/15/2019	4.93	0	4.312097	101.15382	0.03
458	2/15/2019	9.69	0	4.312076	101.15366	0.06
459	2/15/2019	13.54	0.01	4.312041	101.15347	0.08
460	2/15/2019	13.54	0	4.312041	101.15347	0
461	2/15/2019	11.76	0	4.31201	101.15337	0.05
462	2/15/2019	11.76	0	4.312018	101.15337	0.01
463	2/15/2019	4.87	0	4.31205	101.15338	0.03
464	2/15/2019	3.61	0	4.312059	101.15339	0.01

Fig. 3. Google drive spreadsheet sensor data updates.

4. Results and Discussion

Table 2 shows the result of the comparison of data and percentage error calculation by using the formulas as per Table 1. Through analysis stated in Table 2, the average running speed as per existing route A as shown in Fig. 4 (a and b) is 47.51 km/h and DC-TRAD obtained 46.8 1 km/h leaving an error of 1.47%. The key which influences the speed and running speed of vehicles are solely road conditions and driving behaviour of vehicle. As stated in Table 2, the average acceleration and deceleration is 0.51 m/s^2 and 0.55 m/s^2 respectively. This shows the behaviour of the drivers in Kuala Terengganu is ideal and not up to aggressive extent. Percentage error for all variables taking into consent is below 10% which falls in acceptable range to verify the usability of DC-TRAD.

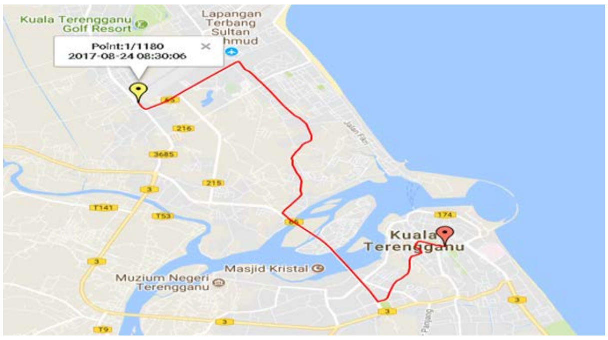
However, percentage cruise runs out up to 22.48% of error as it depends fully on driver behaviours. Percentage cruise is defined as the speed at which the vehicle is controlled. It is known as a servomechanism which takes control of the vehicle throttling to maintain a steady speed. Means that, as drivers in Kuala Terengganu does not maintain a steady speed of the vehicles as there might be obstacles on road and the road conditions are not up to par and satisfactory standard. The average of the percentage errors between DC-TRAD and existing device is 7.55%. It can be concluded that DC-TRAD is verified with the existing driving cycle device with error below than 10%.

To add to that, in anti-theft tracking system, the push button indicates the ignition key of the car and LED indicates the ignition motor of the car. After this system is installed in the car, the car should be started using mobile interface application where there will be three options; “ON”, “OFF” and “STOP”. User should click on “ON” option to start the ignition motor of the car, “OFF” to off the ignition motor and “STOP” to cut the connection of ignition motor to controller and to stop the car permanently in case of car theft.

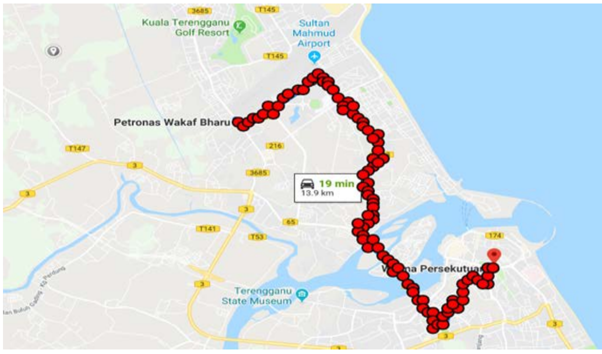
If the car is started other than using mobile interface application for instance, if any insertion to ignition key space of the car is detected, the system alerts the user through Short Messaging System (SMS) the current location coordinates of the car for every 5 seconds until the user clicks on the option “STOP”. Once “STOP” option is chose, the system sends the final location coordinates of the car. Figure 5 shows the SMS interface of the system.

Table 2. Percentage difference of DC-TRAD.

Parameters	Existing route A	Calculated route A	Percentage error (%)
Distance travelled (km)	13.11	12.41	5.34
Total time (s)	1004.00	961.00	4.28
Average speed (km/h)	46.34	48.51	4.68
Average running speed (km/h)	47.51	46.81	1.47
Average acceleration (m/s^2)	0.48	0.51	6.25
Average deceleration (m/s^2)	0.59	0.55	6.78
Percentage idle (%)	1.23	1.15	6.50
Percentage cruise (%)	4.36	5.34	22.48
Percentage acceleration (%)	52.32	48.65	7.01
Percentage deceleration (%)	42.10	38.53	8.48



(a). Navigation map.



(b). DC-TRAD.

Fig. 4. Route A using navigation map and DC-TRAD.

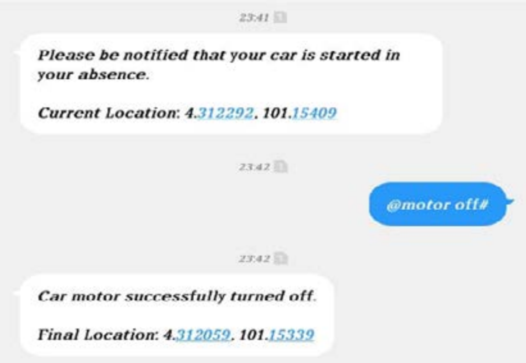


Fig. 5. SMS interface of anti-theft tracking system.

Conclusion

The DC-TRAD prototype is successfully developed and verified with the existing route-to-work Kuala Terengganu city driving cycle. The results of average speed, average running speed, average acceleration, average deceleration, idling, acceleration, deceleration, distance travelled, and total time taken to complete route sampling is within range except for cruising since it solely depends on driving behaviour of each individual. The average of the percentage errors between DC-TRAD and existing device is 7.55%. It can be concluded that DC-TRAD is verified with the other driving cycle device with error below than 10% and can be used to collect data and information to construct a proper driving cycle. The anti-theft tracking system also has been successfully implemented into the system via IoT. With DC-TRAD; a 2 in 1 device, the cost is very much lower compared to existing anti-theft tracking systems available in market. For the future research, the security encryption should be vital and improved in the system.

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