American Journal of Engineering Research (AJER)
E-ISSN: 2320-0847 p-ISSN: 2320-0936
Volume-7, Issue-12, pp-139-144
www.ajer.org
Research Paper Open Access

Combining OBD Technology with Acceleration Sensor to Analyze Aggressive Driving Behavior

Shu-LinHwang, Yen-Jen Chen
Department of Electronic Engineering, Ming Chi University of Technology, New Taipei City, Taiwan
*Corresponding Author: *Shu-Lin Hwang*

ABSTRACT: *Nowadays, both the transportation of a large amount of cargo and private transportation are relying on use of automobiles. Generally, many transportation-related industries and commodities would use the Vehicle Fleet Management System (FMS) to learn about the conditions of the vehicles under management through the data from the Internet of Vehicles (IOV). Apart from the vehicle conditions, developers hope that they can reach effective fleet management for vehicles and drivers by learning more about whether drivers have good driving habits. This study attempts to use smart phones to capture OBD-II (On-Board Diagnosis) data and integrate the acceleration sensor on the mobile phone itself to detect, record, quantify and visualize the driving behavior through the Aggressive Driving Behavior Featuring Model that can easily judge whether the driver has the habit of Aggressive Driving.*

This study elaborates how to use the acceleration sensor dedicated for the smart phone provided by OBD-II for integration of the vehicle information, analyze the driving behavior, classify various events and set the Threshold to help assess if the driver has the habit of Aggressive Driving.

Keywords: *Driving Behavior, OBD, Accelerometer, Vehicle Fleet Management*

Date of Submission: 01-12-2018 Date of Acceptance: 31-12-2018

I. INTRODUCTION

Traffic safety is an important issue in past. In addition to property losses, car accidents have clearly accounted for a large proportion of fatal accidents around the world. According to the statistics of the top ten causes of death of Ministry of Health and Welfare of the Republic of China [1], accident injuries are ranked as the No. 6 and 45% of the deaths from transportation accidents.The death of accidental injuries was the first cause of death from the age of one to twenty-five years. According to the statistical analysis of traffic accidents as reported by the Police Department of the Ministry of the Interior [2], traffic accidents caused by the driver up to 77%.

Driving-related traffic accidents can be roughly classified into the following situations: one is improper driving behavior, such as: changing lanes or improper direction, overspeed out of control, and not keeping a safe distance from traffic; the other one is poor driving conditions, such as: drunken driving, fatigue driving and the situation of not paying attentionsuch as: not paying attention to the state of frontal car. These conditions can be observed through the speed of the car, the accelerator pedal, the turning condition and the braking condition. The aggressive driving may have some bad driving habits when driving usually. If there is careless attention, serious accidentsmay occur. In addition, professional driving often drives for long periods of time, and easy to cause serious traffic accidents due to poor mental state, excessive irritability, overconfidence and driving too fast or not paying attention.

OBD-II (On-Board Diagnostics ver.2) [3] has been in use for many years since its official launch. The US-standard vehicles manufactured after 1996, the Japanese-made vehicles manufactured after 2000, and the domestically produced vehicles made from Taiwan after 2008 are all required to install OBD-II vehicle diagnostic system by law. Most of the on-road vehicles are currently loaded with the OBD-II system.

In fleet management, because the OBD-II system provides a large amount of vehicle data, how to use the information provided by the OBD-II system to help the fleet manage the vehicle status has become a topic. The application developers of fleet management usually develop special hardware device with back-end server computing to achieve cloud management systems, there are already many products that are beneficial to managers.

In terms of insurance, UBI (Usage-Based Insurance) telematics insurance is also extended. The difference betweentelematics insurance mode and the general insurance mode is that the car dealers collect the insurer's driving information through relevant devices and adjust the insurance premium of the policy according to their driving conditions. Insurers with good driving conditions can renew at a preferential price and with poor driving conditions will increase their premiums substantially. This kind of insurance mode is not only an incentive for the driver to implement safe driving, but also beneficial to the insurance company, and achieve a win-win situation between the insurance company and the insurer. [4]

The analytical methods proposed in this study hope to help to observe the driver's driving habits.They can be used not only for fleet management, insurance products, but also for drivers to review their driving habits and prevent potential failures due to overconfidence. Therefore, it can avoid the occurrence of traffic accidents.

II. BACKGROUND KNOWLEDGE

2.1 Driving behavior analysis related literature

Jia Di Yu [5] et al. proposed "Fine-Grained Abnormal Driving Behaviors Detection and Identification with Smartphones" paper to use the acceleration sensor and direction sensor to judge the driving behavior of the vehicle as a reference. It can be used to detect six driving behaviors include snakes, sudden steering, taxiing, fast turn, corner and urgent car. This paper refers the calculations of the accelerometer and the classification and definition of dangerous behaviors, which is helpful for the test plan. JIE HU [6] et al. proposed the paper titled "Abnormal Driving Detection Based on Normalized Driving Behavior". In the paper they used the vehicle speed, throttle opening, and brake pressure to calculate the module as a referenceto make judgment for four driver states: normal driving, mobile phone use, aggressive and drunk/fatigue driving.

Our studies refer to [6] for the application of vehicle speed and throttle opening and behavioral modules for abnormal driving behavior, which can help us formulate for poor driving state detection and testing. Taiwan’s National Central University, Kuo-Chu Hu and Din-Chang Tseng [7] proposed “Driver Behavior Analysis based on The Multi-Sensor Fuzzy Decision”. The study uses gyroscope and acceleration sensor associated with fuzzy theory and attribution function to achieve identifications of vehicle left and right turn, acceleration and deceleration and road bumps. In our paper referencesits definition of driving behavior events, it can effectively classify the basic driving behavior and further propose a reasonable threshold.

2.2 OBD-II on-board diagnostic system

OBD-II (On-Board Diagnostics ver.2) [3] has been used for many years since its official launch. The US-standard vehicles manufactured after 1996, the Japanese-made vehicles manufactured after 2000, and the domestically produced vehicles made from Taiwan after 2008 are all required to install OBD-II vehicle diagnostic system by law. Most of the on-road vehicles are currently loaded with the OBD-II system.

OBD-II has multiple diagnostic criteria, and SAE's J standard is particularly suitable for driving performance or emissions diagnostics. SAE-J1962 [8] defines a standardized data connection interface and connects the data lines with each communication protocol to this interface to provide a connection for diagnostic device. SAE-J1979 [9] defines a standardized diagnostic test mode, defines nine diagnostic modes (MODE1-MODE9) and data formats of OBD-II, in which each mode sub-item is distinguished by PID. Fig. 1 illustrates the format of the MODE1 send request message andfig.2 illustrates the return data format of MODE 1, where the data portion is divided into four parts and each part is 1 byte (8 bits).

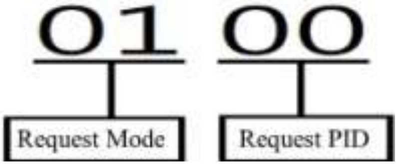

Fig. 1.OBD-II request message format

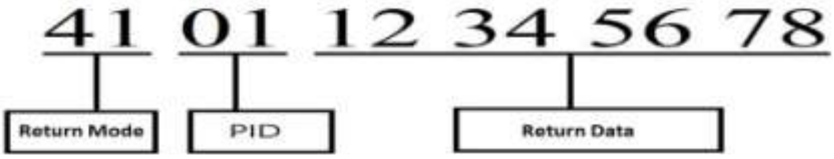

Fig.2.OBD-II return data format

SAE-J2012[10] defines a standardized fault code consisting of 2bit Space, 2bit error code public, private label, 4bit Type and 8bit description. It is used to describe the vehicle failure position when the vehicle warning light is on. SAE-J1930 [11] sets standard terms, which can be understood by comparing the proper nouns and abbreviations in the agreement documents.

The SAE J1962 [8] specification provides two standardized hardware interfaces called Type A and B. Both are concave, 16-pin (2 x 8), use a D-type connector and have a groove between the two rows of pins. The B-type has a groove interrupt in the middle. It is used to prohibit the insertion of the Type A plug while still allowing the Type B plug inserted into the Type A socket. Type A connectors are for vehicles that use a 12V supply voltage, while Type B is for 24V vehicles and needs to be marked in blue. Figure 3 shows the hardware interface.

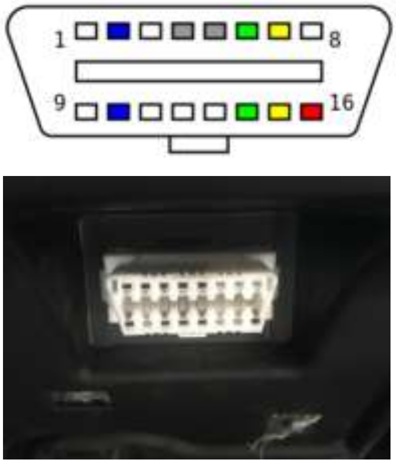

Fig.3. OBD-IIhardware interface

III. SYSTEM ARCHITECTURE ANDEXPERIMENTAL METHOD

3.1 System Architecture and Hardware

The system architecture in this study is shown in Figure 4. The specific app of the smart phone is connected to the OBD-II diagnostic device via Bluetooth to exchange data. The app will issue the UART command to request itto send the relevant data commands. After taking the data of the driving computer, the diagnosis result is returned to the smart phone[12].On the other hand, the app detects the accelerometer data built in the mobile phone, records it with the OBD-II data, and analyzes the status. During the driving process, if the app determines the driving behavior is a radical driving behavior, a message is sent to notify the driving state.After the driving event is end, the system will analyze the driving record to give a rating, and it can distinguish whether the driving vehicle is Excessive.

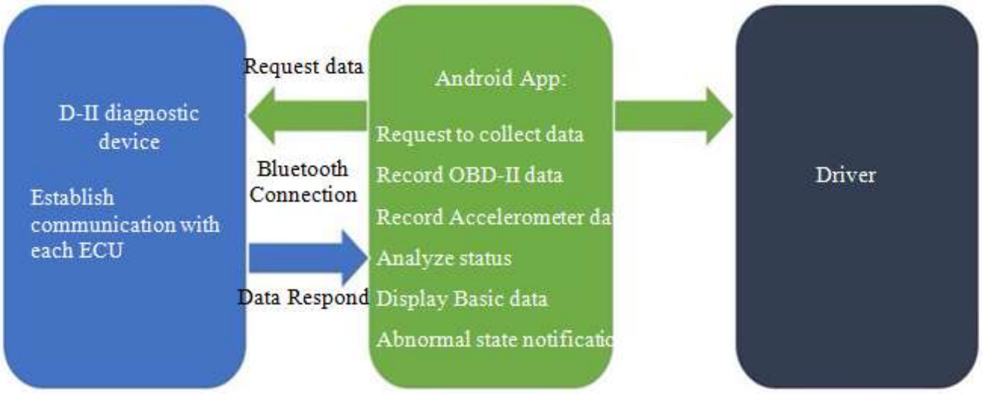

Fig.4. Testing system architecture

3.2 Android Testing App

The data exchange architecture diagram oftest app is shown in Figure 5. It is mainly divided into main program, OBD connection processing module, OBD data conversion module and record analysis module. This app was developed by Paulo Pires. The data conversion module API [13] and the application program [14] are modified and produced as follows:

Main program: Responsible for data display, assign tasks to each module, display warning notices, and display driving scores.

OBD connection processing module: Responsible for Bluetooth-related processing such as Bluetooth connection establishment, Bluetooth data transmission and Bluetooth data reception.

OBD data conversion module: Converting AT command required by the UART, including the command requesting and the data command responding.

Record Analysis Module: This module captures vehicle and sensor data from the OBD data conversion module and the accelerometer of the mobile phone.Then,the main program can know the data status from the module bydoing data analysis, processes and storing.

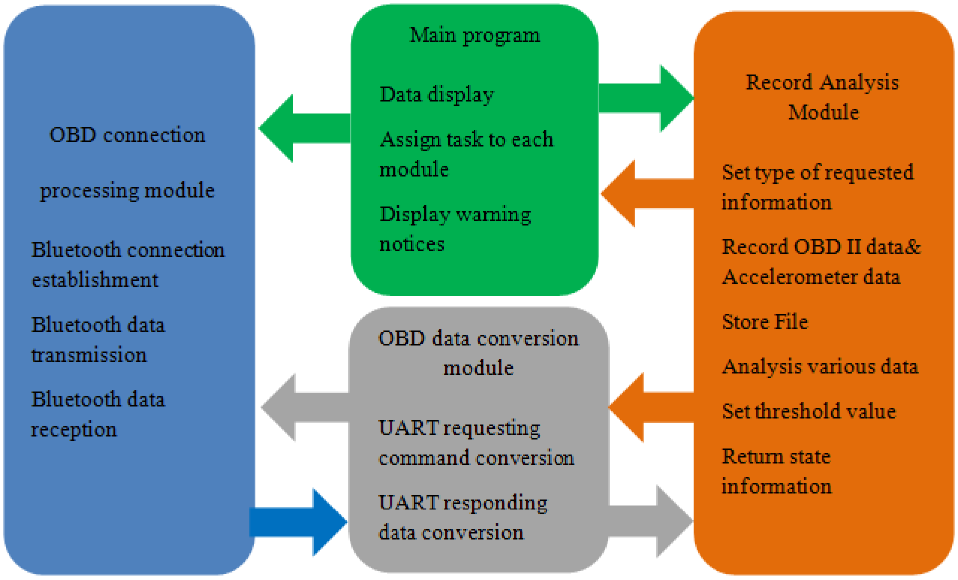

Fig. 5. Data exchange architecture diagram

At the beginning of the program, if the user decides to start the connection, the main program will enable the OBD connection module. The connection module will establish a Bluetooth connection and send four AT commands required to initialize the OBD-II diagnostic device. Then, the main program will enable the record analysis module, which can set the type of data to be collected and use the OBD data conversion module to convert the request command of collecting data to the OBD connection processing module to send a request to the OBD- II Diagnostics.After OBD-II diagnostic device receives the request command, retrieves the data of the driving computer through OBD-II and sends back the diagnostic message to the OBD connection processing module. The OBD connection processing module will deliver the command to OBD data conversion module performs data conversion and returns to the record analysis module. The module records and analyzes and stores the data as a file. The main program periodically queries the module for status, and it responds to the status. The main program displays the status on the main screen of the app. If necessary, a warning notice will be displayed. After the end of the record, the driving score of the record will be displayed.

3.3Experimental Method

This study elaborates how to use the acceleration sensor dedicated for the smart phone provided by OBD-II for integration of the vehicle information, analyze the driving behavior, classify various events and set the Threshold to help assess if the driver has the habit of Aggressive Driving.

For smart phones, we use the three-Axis of the accelerometer to observe driving habits. The test is fixed in the car in an upright position.Vehicle direction definition of three-Axis is shown in Figure 6.The X-Axis represents the left and right movement of the carbody, and the driving actions such as left and right shaking and turning affect the X-Axis. When turning left, the X-Axis is positive; when turning right, the X-Axis is negative.The Y-Axis represents the up and down movement of the carbody. When the vehicle passes the bumpy road, the body will sway up and down. In this case, the value will be reflected. In addition, this value is also affected when the vehicle turns too sharply.The Z-Axis represents the front and rear movement of the car body, which will affect this value when the vehicle is suddenly accelerating and decelerating. When braking, the Z-Axis is positive; when accelerating, the Z-Axis is negative.

Fig. 6. Vehicle direction definition

This study uses five sources for sampling data and records at the speed of 0.4 seconds per data entry, including: (1) the Vehicle Speed, (2) the Throttle Gate, (3) the Acceleration Sensor X-Axis, (4) the Acceleration Sensor Y-Axis, and (5) the Acceleration sensor Z-Axis.Experiments are conducted over the 5 riving behaviors, including (1) stepping on the accelerator, (2) decelerating, (3) left-turning, (4) right-turning, and (5) bumps in the road.

Normal drivers step on the throttlefrom shallow to deep. The aggressive driver may step on the depths when stepping on the throttle, which may cause the vehicle to accelerate too fast. In order to detect whether the pedal throttleis normal or not, the following formula is proposed to determine the dynamic threshold:

$$\overline{\mathrm{T}(t)} = \alpha \cdot \mathrm{T}(t) + (1-\alpha) \cdot \overline{\mathrm{T}(t-1)} \tag{1}$$

$$\begin{cases} \mathrm{T}(t) \le \beta \overline{\mathrm{T}(t)}, Normal \\ \mathrm{T}(t) > \beta \overline{\mathrm{T}(t)}, Abnormal \end{cases} \tag{2}$$

In the above-mentioned formula, T(t) represents the throttle gate value at that specific point. After$\alpha$is used to adjust the proportion of the current throttle gate value to previous throttle gate values, a Threshold can be obtained based on the sum of the current and previous throttle gate values as adjusted. α(0.1、0.3) and β(1.1、1.2、1.3) are obtained after over 10 times of experimental testing, analysis and comparison, and the relationship between $\alpha$and β is used to judge whether the step is overly aggressive.

In order to find out the safety thresholds for various values, we conduct the tests on the five driving behaviors, including (1) aggressively stepping on the accelerator, (2) aggressively pulling the brakes, (3) aggressive left-turning, (4) aggressive right-turning, and (5) driving on bumpy roads without deceleration at normal vehicle speeds, to obtain the results shown in the table 1.

Table 1. Safety thresholds setting

Original Data	Threshold
the throttle gate	$\overline{\mathrm{T}(t)} = \alpha \cdot \mathrm{T}(t) + (1-\alpha) \cdot \overline{\mathrm{T}(t-1)}$ $T(t) \le \beta \overline{T(t)}$ $\alpha = 0.1$ $\beta = 1.2$
Accelerometer -X-Axis(the left and right of the vehicle body)	$-0.5 \le a_x \le 0.5$ Unit: g
Accelerometer -Y-Axis(the upper and lower of the vehicle body)	$5 \le a_y \le 1.5$
Accelerometer -Z-Axis(front and rear of the vehicle body)	$-0.5 \le a_z \le 0.5$

Then, using the data in the above table as the benchmark, General/Aggressive Driving is tested 15 times on the open-space roads for the same type of vehicle.

IV. EXPERIMENT RESULTS

The OBD-II data used in this study is recorded in 0.4 sec/sample. Because we found that the more data detected with OBD-II, the slower the sampling speed will be. At setting the proximity limit, the speed of sampling is also unstable. Under the premise of both effective records and stable sampling, we chose to use 0.4 seconds/sample for detection.

During the test, if the Threshold is exceeded, it will be recorded as a behavior exceeding the Threshold (hereinafter referred to as the Threshold-Exceeding Behavior). And, after the driving is completed, the ratio of the total driving time to the threshold-exceeding driving time is calculated. As shown by the results in the following table, TSER represents the threshold-exceeding ratio of the throttle gate value, AXER represents the threshold-exceeding ratio of acceleration X-Axis, AYER represents the threshold-exceeding ratio of acceleration Y-Axis ratio, and AZER represents the threshold-exceeding ratio of acceleration Z-Axis.

Table 2. Analysis of road driving test data for Normal/Aggressive driving style

Driving Conditions		SPEEDAvg.	TSER	TSER Avg.	AXER	AXER Avg.	AYER	AYER Avg.	AZER	AZER Avg.
Gentle Driving	Max	34	9%	6.21%	0.1%	0.093%	0.3%	0.1%	1.9%	0.96%
	Min	30	4%		0.08%		0.05%		0.3%	
Aggressive Driving	Max	43	27%	21.2%	4%	1.58%	0.9%	0.4%	10%	5.93%
	Min	36	17%		0.3%		0.1%		3%	

The table 2 shows that when the driver likes to aggressively step on the accelerator, it can be easily detected by comparison of the throttle gate value(21.2%/6.21%)and the data of the Acceleration Meter Z-Axis(5.93%/0.96%). The data of the Acceleration Meter Z-Axis can also be used to observe the brake condition. By observation of the data over the Z-Axis, thethreshold-exceeding ratio can be detected to observe the brake condition.

If the driver does not have the habit of slowing down in time when turning, the vehicle body can very often be unstable, which can be discerned from the data of Acceleration Meter X-Axis(1.58%/0.093%). The data of Y-Axis(0.4%/0.1%) can be used to observe the response when the vehicle encounters bumpy roads.

The research results can help analyze the driving habit of the driver, so that the observer can easily know the problem of the driver. By observation of the driving behaviors such as stepping on the accelerator, pulling the brake, turning, bumpy roads or so, the driver can receive notifications to the driver and help the driver improve the driving habit on his/her own.

V. CONCLUSION

In the future, the research will use the data advance to determine the more precise driving behavior. The five dangerous driving behaviors mentioned in this paper—rapid acceleration, rapid deceleration, sharp right turn, emergency pullback, and sharp turn. We have found that in the future we can distinguish these behaviors by some features. In the case of rapid acceleration, the throttle value will be accompanied by the accelerometer Z-axis negative excess value and in the behavior of sudden deceleration Accelerometer Z-axis positive excess value.If the X-axis of the accelerometer exceeds 1.5 m / s2 in the turning behavior, the excess value behavior in the sharp turn behavior (X-axis exceeds 5 m / s2) will account for 10-30% for the entire turning behavior, and the excess value behavior in the sharp turn accounted for about 75-85% of the total sharp turning behavior, Observing this ratio can be used to distinguish the two different dangerous driving behavior.For the behavior of emergencypulling back, there will be a case where the turning behavior is accompanied by a positive or negative excessvalue of the Z-axis of the accelerometer.

The observation of the above behavioral characteristics needs to be carried out more experiments to verify the classification, which can be used as the direction of future research. In addition, more vehicle resources are expected to be used for testing and further optimizing the threshold value.

References

[1]. Ministry of Health and Welfare of Republic of China, in https://www.mohw.gov.tw/mp-1.html

[2]. National Police Agency, Ministry of the Interior of Republic of ChinaPolice Political Safety Ball Information Network - Accident Statistics, in https://www.npa.gov.tw/NPAGip/wSite/lp?ctNode=12744&CtUnit=2543&BaseDSD=7

[3]. OBD-II, in https://en.wikipedia.org/wiki/On-board_diagnostics

[4]. National Association of Insurance Commissioners, Usage-Based Insurance and Telematics, Report of National Association of Insurance Commissioners, 2015, in http://www.naic.org/cipr_topics/topic_usage_based_insurance.htm

[5]. J. Yu, Z. Chen, Y. Zhu, Y. Chen, L. Kong&M. Li(2016),"Fine-Grained Abnormal Driving Behaviors Detection and Identification with Smartphones", IEEE Transactions on Mobile Computing

[6]. Jie Hu,Li Xu&Xin He,"Abnormal Driving Detection Based onNormalized Driving Behavior", IEEE Transactions on Vehicular Technology, Vol.66, no.8, pp. 6645 – 6652, Aug. 2017

[7]. Kuo-Chu Hu, Din-Chang Tseng, "Driver Behavior Analysis based on The Multi-Sensor Fuzzy Decision", Taiwan's National Central University Master Thesis, 2015

[8]. Diagnostic Connector Equivalent to ISO/DIS 15031, SAE Standards J1962-2001.

[9]. E/E Diagnostic Test Modes, SAE Standard J1979-2006.

[10]. Diagnostic Trouble Code Definitions, SAE Standards J2012-2002

[11]. Electrical/Electronic Systems Diagnostic Terms, Definitions, "Abbreviations, and Acronyms", Standard J1930-2008

[12]. Yen-Jen Chen, Ching-Chuan Liu. "Design and Implement of App Based OBD-II Vehicle Tracking System", Tokyo, Japan: 2016 The 4th International Conference on Information Technology and Science (ICITS 2016)

[13]. OBD-II Java API, in https://github.com/pires/obd-java-api

[14]. Android OBD Reader, in https://github.com/pires/android-obd-reader

[15]. Accelerometer, in https://en.wikipedia.org/wiki/Accelerometer