Analyzing Driving Behavior Based on Vehicle Information Logging Using MPU6050

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ABSTRACT

The most important factor in car accidents and even traffic congestion is the driving behavior of human. Analyzing the driving behavior and applying restrictions on risk-making drivers can reduce probable causalities and improve the transportation safety. A hardware can collect the data related to the driving conditions and processes that information that may be useful in this regard. By analyzing the information recorded by the hardware, one can obtain an approximate prospective of the driving behavior. This prospective can distinguish a careful driver from a careless one. By collecting various data in different conditions, the accuracy of this criteria will be improved. On the other hand, the accuracy of different components of the hardware is crucial since the unexpected noises deteriorates the performance of data collection. In this research, a data analysis module is developed to record the acceleration and angular velocity of a sample vehicle to identify the driving behavior and propose quantitative criteria to distinguish aggressive and cautious drivers. In this way, one can figure out if his/her driving habits are dangerous or not.

KEYWORDS

Driving accidents, Driving behaviour, Vehicle data logger module, Driving criteria.

1. Introduction

Iran ranks first in the world with more than 800,000 cases of car accident annually, which causes almost 6-billion-dollar financial loss and irrecoverable human casualties as well. Reported studies state that there are 3 factors contributing to an accident: Driver, Vehicle and Road, whereas the first one is the most important factor. Each driver has his/her driving behavior. Cautiousness, driving skill, personal characteristics and driver's mood may have effect on the driving behavior. Driving behavior would affect vehicle dynamics, especially speed and acceleration. Hence, it can be concluded that observing acceleration-deceleration (A/D) profile and speed pattern, will give us useful data about drivers' behavior model and recognize different drivers even if they are drunk. Based on this model we can find standard criteria of acceleration and speed for cautious driving.

Studies show that the absolute amount of linear acceleration or deceleration should never exceed 0.5g and proper angular lane change acceleration is under 0.1g [1]. Most of the studies are focused on brake deceleration due to high probability of occurrence in a crash. Table 1 summarizes the suitable brake deceleration that is recommended by some researches. Subscription of all recommended acceleration and speed ranges may guide us to access good criteria for analyzing driver behavior. Present study aims to verify universal cautious driving criteria for the Iranian drivers to develop a data-gathering hardware which can be installed on each vehicle to observe and judge driver behavior based on collected data.

Table 1. Recommended braking deceleration threshold by studies

Author	Year	Speed (km/h)	Deceleration rete
Bennett [2]	1995	90-100	0.23g
Akcelik [3]	2001	60	0.3g
Wang [4]	2005	80-90	0.26g

2. Methodology

Some studies use GPS data to analyze driver behavior [2] while others employ mobile phone accelerometers to gather data [3]. The objective of this work is to develop a simple practical data-logger to gather A/D and speed data. For this purpose, Arduino Uno R3 board was used as the processor and MPU6050 chip was chosen as its accelerometer and gyroscope. Table 2 and 3 show brief characteristics of the chip.

Note that many modules use MPU6050 chip for data collection and their final extracted data may differ based on their quality of production. We compared GY521 and GY86 acceleration and angular speed data with LIS2HH12 accelerometer and gyroscope chip produced by ST which is used in SAMSUNG mobile phones like GALAXY S6.

Table 2. MPU6050 accelerometer characteristics [4]

Acc range (g)	Sensitivity (LSB/g)	Logic supply	Operating supply (v)
±2	16384	VDD	2.375-3.46
±4	8192		
±8	4096		
±16	2048		

Table 3. MPU6050 gyroscope characteristics [4]

Gyro range (°/sec)	Sensitivity (LSB/°/sec)	Noise rate (dps/√Hz)	Operating supply (v)
±250	131	0.005	2.375-3.46
±500	65.5		
±1000	32.8		
±2000	16.4		

We conducted several experiments on both GY521 and GY86 in different ranges in the same condition to find out which one follows the reference (LIS2HH12) in the best way. The method was setting modules next to each other beside the mobile phone and installing the package on the car's middle console and finally running them simultaneously. As it is depicted in the figure 1, GY86 shows more inertia in following the reference acceleration. Finally, we find GY521 extracted data more reliable. Subsequent experiments were done by using GY521.

After selecting the accurate module, finding the best range of data gathering for accelerometer and gyroscope is the next level. Clearly wide range of data may result in noises and outlier data. Same technique for data collecting as the previous experiment was held. As expected, ±2g and ±250°/s were the most accurate range. Table 6 compares mean squared error of GY521 and GY86 in different acceleration ranges. The Range with the least value suits our work.

On final step we asked a random driver to do 6 driving maneuvers while data logger was running. Driver was 24-year-old man with 6 years of driving experience. The vehicle was chosen from the Iranian domestic produced car with commonly used engine, domestic produced car with commonly used engine, chassis and gear box. Of course, testing different cars and drivers leads to various results, but in this case reaching to the right criteria would satisfy this work's purpose. However, repeating the experiment in other conditions with different variables will be a good challenge to reach more precise results.

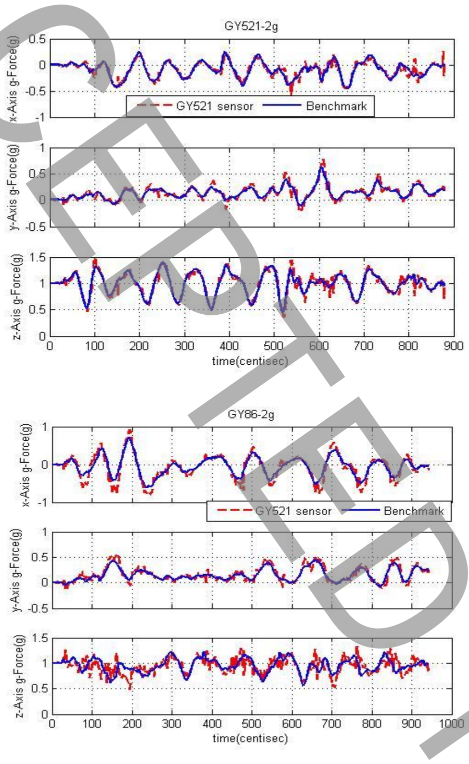

Fig. 1. GY521 and GY86 acc data ±2g

Table 6. GY521 and GY86 Acc MSE based on Reference

Module	GY86	GY521			
Acc range	±2g	±2g	±4g	±8g	±16g
X	0.119	0.059	0.076	0.087	0.054
Y	0.058	0.053	0.126	0.103	0.068
Z	0.128	0.067	0.106	0.117	0.081

We installed the data logger in the middle of center console to get rid of conversion calculations. We should set GY521 coordinate parallel to the chassis assigned axes. The proper position and direction of data logger is shown in the figure 2. Before each experiment, GY521 coordinates were calibrated with the chassis axes. We used a mobile holder to reduce induced noises from engine and road. In addition, a low-pass filter was used in the Arduino code to extract smoothened data.

All experiments were conducted in a deserted asphalt road in downtown with enough space to do maneuvers. The driver was asked to do all 6 maneuvers in two style, the former cautious driving style and the latter in aggressive driving. The driver was free to accelerate or decelerate the car to do the maneuver by his own experience. Here are maneuvers:

- Speeding up from 0 to 60km/h in linear direction
- Braking from 60km/h to 0 in linear direction
- Left and Right lane change at 60km/h
- Left and Right turn at 30km/h

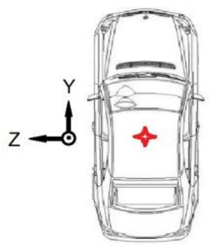

Fig. 2. Proper position and direction of data logger

3. Results and Discussion

Figure 3 depicts the result of maneuvers. As it is illustrated, acceleration and angular velocity charts give us clear useful information about how the carful driver's profile differs from the careless drivers'. Even gear shifts and chassis swings caused by the suspension system are evident in the A/D and the velocity chart. To form driving criteria, maximum amount of each chart is significant. Table 7 summarizes these extracted maximum quantities from the charts.

Table 7. Driving criteria

Maneuver		A/D		Gyro	
		Axis	Max(g)	Axis	Max(°/s)
Speed up	Cautious	y	0.23	z	-3.5
	Aggressive		0.34		-5.6
Brake	Cautious	y	-0.16	z	1.9
	Aggressive		-0.68		3.5
L Lane change	Cautious	z	0.1	(x,y)	(5.3)
	Aggressive		0.42		(19,11)
R Lane change	Cautious	z	-0.1	(x,y)	(-5,-3)
	Aggressive		-0.42		(-19,-11)
L Turn	Cautious	z	0.2	x	29
	Aggressive		0.5		50
R Turn	Cautious	z	-0.2	x	-29
	Aggressive		-0.5		-50

To validate our extracted data, we have compared them with other references. There are some standards here that can help us in this regard. Traffic Engineering

Handbook of United States mentions that deceleration rate of 0.346g is suitable to stay in line and maintain steering control [5]. AASHTO declares deceleration rate greater than 0.458g is for sudden brakes when driver faces unexpected object on the road [6] which is really dangerous and may result in accident. ISO15622, standard for designing adaptive cruise control systems, knows -0.357g maximum rate for deceleration, 0.2g maximum rate for acceleration and 0.234g maximum lateral rate for turning curves of road to keep driver in comfort [7]. In [1], Fazeen and Gozick have proposed that safe acceleration and deceleration never exceed the g-force of more than ±0.3g and sudden rates approach ±0.5g. Safe left/right lane changes produce an average g-force of less than ±0.1g. By comparing all aforementioned data with table 7, the accuracy of our results will be determined.

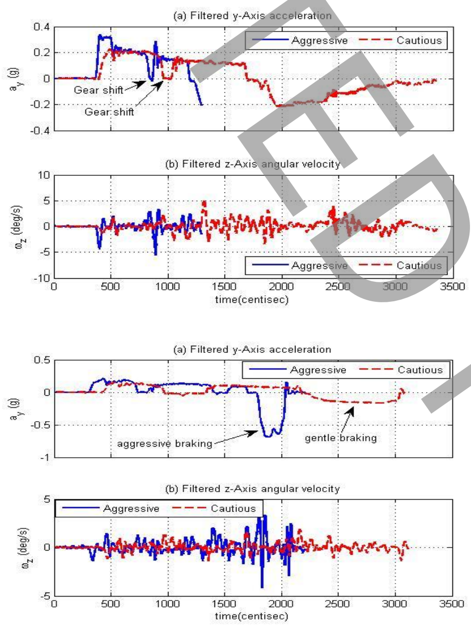

Fig. 3. A/D and angular velocity charts

4. Conclusions

Driver behavior monitoring can be extremely effective on reducing accident rate by recording high risk actions of each driver and giving them driving manner correction procedure. Aggressive drivers will be revealed easily and controlling actions can be applied on them. There are several methods to monitor driver behavior. In this work we have tried to monitor driver behavior by using simple data logger in order to find best driving criteria to define a suitable standard of driving for Iranian drivers based on universal standards.

5. References

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