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MONITORING FOR VEHICLE VELOCITY AND ACCELERATION USING AN ACCELEROMETER

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Abstract-- Vehicles play a major role in this globalization era and their increasing use in everyday life comes with greater risks for accidents. On the other hand, people are not really aware of the necessity for safe driving, as evident in the number of people breaking traffic regulation. This research is aimed at building a system of vehicle velocity and acceleration monitoring using an accelerometer with ADXL345protocol and Raspberry Pi minimum system. The program in Raspberry Pi is written using Python. Programming is initialized with SMB (system management bus) function, followed by setting for data transfer velocity and command program to read the accelerometer, as well as a command to display data output. For validation purposes, output from the accelerometer sensor system is compared to that of accelerometer sensor embedded in cellular telephone using accelerometer analyzer software. Sensor readings are kept in files of text format.

Keywords: movement orientation, speed, acceleration, accelerometer sensor, gyroscope sensor

I. INTRODUCTION

Vehicles play major roles in this globalization era, starting from their core function as transportation means, distribution of goods, down to vehicle modification for specific purposes such vehicles for heavy duty work, firefighter trucks, and even to race cars that become a sport. Increasing number of vehicle use in everyday life lead to more accidents. This is made worse by the fact that people are not yet really aware of driving safety, with many of them still breaking traffic regulation. Traffic accidents are caused by the arrogance and ego of drivers (human error), lack of road infrastructure and vehicle conditions, among other things. One of the ways to prevent accidents is by making a vehicle velocity and acceleration monitoring instrument. This is meant to know vehicle condition on the road and whenever an accident takes place. Vehicle velocity and acceleration can be detected to determine exactly when an accident may take place and the possible extent of the resulting impact.

II. THEORY

Motion, Speed, and Acceleration

Motion or displacement of a point takes place at a certain time. There are two types of motion, translation and rotation. Translation happens on a straight plane, while rotation occurs on a circular plane. Velocity is the distance or displacement a point covers at a certain time and it is a vector [1]. Final velocity is defined as initial velocity plus acceleration at a certain time and is written in the following formula:

$$V_t = V_0 + at \qquad (1)$$

Where V_t is the final velocity in meters per second (m/s), $V_0$is initial velocity in meters per second (m/s), a is acceleration in meters per squared second (m/s^2), and t is time in second (s). Based on that definition, angular velocity is defined as displacement of the angular position of a point per time. Meanwhile, acceleration is changes in velocity at a certain time. It is also a vector and is written mathematically as:

$$a = \Delta V/\Delta t \qquad (2)$$

Where a is average velocity in meters per squared second (m/s^2), ΔV is changes in velocity in meters per second (m/s), and Δt is changes in time in second (s).

Accelerometer

Accelerometer is a sensor that can measure velocity, detect and measure vibration, and measure acceleration due to gravity. One of its uses is to detect motion, such as feet when people are walking. It is also used to detect hand motion for game consoles, as accelerometer sensors can be attached to a hand and detect the velocity of that hand motion. Distance and direction of a movement can be measured from the velocity detected by an accelerometer. This measured acceleration is the result of recorded object movement related to changes in mass the accelerometer sensor detects [2].

Raspberry Pi

Raspberry Pi is a microcomputer with a credit card size. Its exact dimension is 85 mm x 56 mm and it functions like a normal computer [3, 4]. This means that Raspberry Pi can do just about anything an ordinary computer can. It is developed by The Raspberry Pi Foundation that focuses on education for people of all ages. Raspberry Pi comes with a system of Broadcom BCM2835 chip (SoC), covering ARM1176JZF-S 700 MHz processor, Video Core IV GPU, and was initially marketed with a 256 megabyte RAM, but then later upgraded to 512MB. It also has a built-in hard disk or solid-state drive, but it takes an SD card for both booting and long term data saving. One advantage Raspberry Pi over an ordinary PC is its general purpose input output (GPIO) that allows it to be easily connected to another device [5, 6].

III. METHOD

The data acquisition system consists of some parts including an accelerometer as the motion sensor, Raspberry Pi as a data processing computer, and a micro SD card as the data storage device. The block diagram of this system is shown in Figure 1.

Figure1. Block diagram.

Accelerometer ADXL345 consists of four (4) main pins; Vcc, ground, SCL, and SDA. The Vcc pin is connected to a 5V DC output voltage from the Raspberry Pi minimum system circuit,, the ground pin is connected to the Raspberry Pi ground, the SCL pin of the accelerometer is attached the GPIO 1 pin of the Raspberry Pi. SCL and SDA pins serve to communicate I2C data. In principle, accelerometer sensors read orientation values of acceleration and by using an integral calculation, velocity values at certain times are obtained.

IV.RESULT AND DISCUSSION

Data obtained when vehicles accelerate are given in Table 1, while the resulting velocity and acceleration calculations are shown in Figure 2. Data obtained when vehicles decelerate are given in Table 2, whereas the resulting velocity and acceleration calculations are given in Figure 3. Meanwhile, data for vehicles who were initially stationary, and then slowly moved, and finally stopped, are provided in Figure 4.

Table1. Data of accelerating vehicles

A (G)x	ay (G)	az (G)	vx (Gs)	vy (Gs)	Vz (Gs)
0.004	-0.004	-0.026	0.004	-0.004	-0.026
0.015	-0.014	0.031	0.019	-0.018	0.005
0.025	-0.012	-0.015	0.044	-0.03	-0.01
0.009	-0.013	-0.015	0.053	-0.043	-0.025
0.011	-0.013	-0.01	0.064	-0.056	-0.035
0.021	-0.012	-0.018	0.085	-0.068	-0.053
0.016	-0.012	-0.022	0.101	-0.08	-0.075
0.021	-0.023	-0.026	0.122	-0.103	-0.101
0.018	-0.007	-0.023	0.14	-0.11	-0.124
0.019	-0.015	-0.022	0.159	-0.125	-0.146

Table2. Data of decelerating vehicles

ax (G)	ay (G)	az (G)	vx (Gs)	vy (Gs)	vz (Gs)
-0.008	0.005	0.002	0.07	-2.132	-0.221
-0.009	0.005	0	0.061	-2.127	-0.221
-0.012	0.007	-0.002	0.049	-2.12	-0.223
-0.004	0.005	0	0.045	-2.115	-0.223
-0.01	0.005	0	0.035	-2.11	-0.223
-0.006	0.005	-0.003	0.029	-2.105	-0.226
-0.012	0.005	0.001	0.017	-2.1	-0.225
-0.01	0.007	0	0.007	-2.093	-0.225
-0.003	0.004	0.002	0.004	-2.089	-0.223
-0.004	0.004	0.001	0	-2.085	-0.222

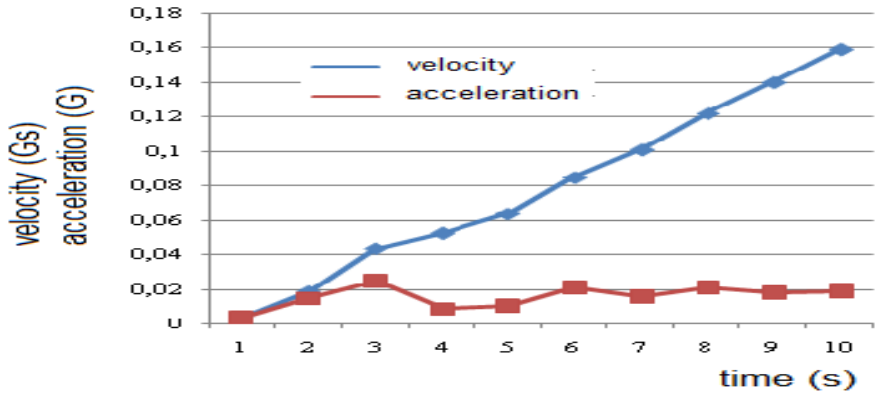

Figure2. Vehicle velocity and acceleration upon accelerated.

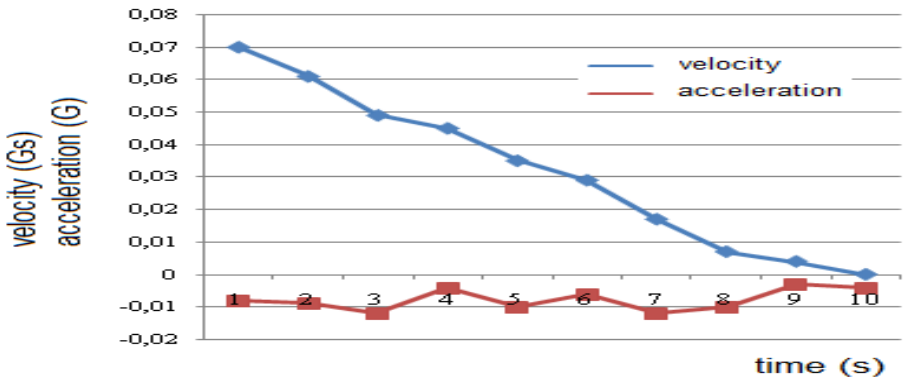

Figure 3.Vehicle velocity and acceleration upon decelerated.

It can be seen in Figure 4 that the vehicle is initially motionless with an initial velocity of 0. Once acceleration is applied, its velocity gradually increases and it is positive. Meanwhile, in Figure 3, when the vehicle undergoes deceleration, the acceleration value read by the accelerometer on the x-axis is negative. This is because the vehicle is moving against the normal direction of the x-axis. The vehicle is initially in motion, but when acceleration in the opposite direction is given, it slows down and finally stops.

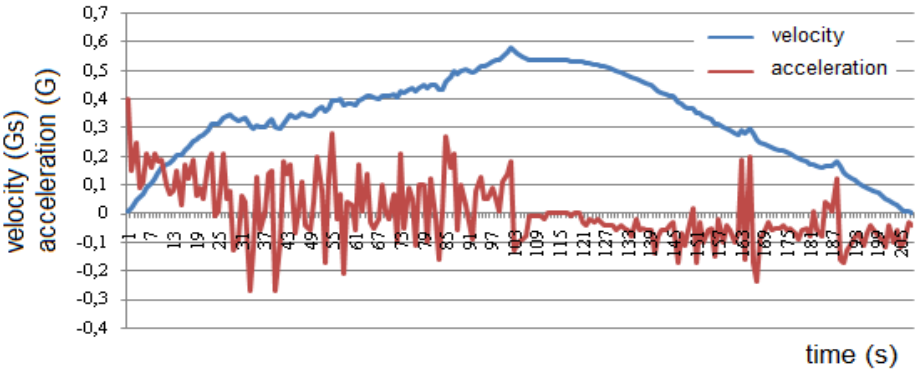

Figure 4. Vehicle velocity from being stationary, moving slowing, and being stopped

On the other hand, for the vehicle that is initially stationary, then moved, and finally stopped (Figure 4), the initial velocity and acceleration are both zero, but then they increase in value into positive, and then upon being decelerated, the velocity is still positive, but the acceleration is negative. As this deceleration process progresses, the velocity and acceleration values approach zero. Finally, the vehicle stops, and both velocity and acceleration values are now zero.

V.CONCLUSION

Results show that monitoring for velocity and acceleration can be realized by combining a ADXL345 accelerometer sensor with a Raspberry Pi with the help of I2C data communication. Data obtained from this system are time, velocity, and acceleration. These data are saved in the external memory of the Raspberry Pi, in the form of an SD card in the txt. File format.

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