Vehicle kinematics with smartphones for engineering students

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Abstract. Informal learning environments play a critical role to develop interest and capacities to pursue science, technology, engineering, and math (STEM) learning. Smartphones include a set of built in sensors (accelerometer, gyroscope, magnetometer, light sensor, microphone, …) that allow the design of a wide range of experiences outside laboratory. The proposed experiment, using the students' own devices, allows them to analyse, the movement of a vehicle, using simultaneously two smartphone sensors in order to understand basic concepts of automotive kinematics.

1 Introduction

Recent studies highlight the importance of learning science in informal environments and attest that these experiences can promote science learning and strengthen and improve school science (1). Nevertheless, it seems difficult to design physics experiments to be performed systematically outside the laboratory (informal learning environment) by a significant number of students of different levels. However, the development of mobile devices, with increasing measuring capabilities thanks to their built-in sensors, allows teachers to design physics, formal and informal, experiments alongside teaching strategies like BYOD (Bring Your Own Device (2).

The objective of this paper is to analyse one such experiment, the movement of a vehicle, using simultaneously different smartphone sensors in order to understand basic concepts of kinematics and automotive dynamics, and provide an exciting outdoor activity to study physics. The experiment was performed using a Samsung Galaxy S4 mini. The app used for data capture (including GPS position) is Sensor MobileNew

2 Measurements and results

The study has been carried out using two cars, a Jeep Grand Cherokee and a VW Golf. In order to study the behaviour of the rear and front parts of a car, a pair of smartphones were used placed in the center of the front and rear wheels axis, as can be seen in Fig 1.

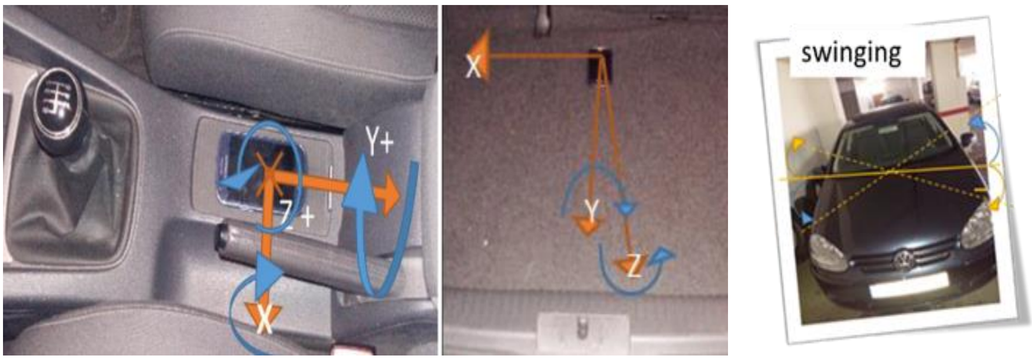

Fig.1. Left: location of smartphones in the vehicle (front and rear). Right: movement

In order to contrast results, several trips were taken in different types of routes, urban, interurban, etc. As examples, measurements in a trip including a flat urban road and a steeped interurban route, see Fig 2 (left), are shown. The accelerometer (Fig. 2 center) allows locating the places in which the car has stopped due to red traffic lights located in the urban part of the route. In addition, an increase in measured acceleration values in the interurban part of the route due to the unevenness of the road.

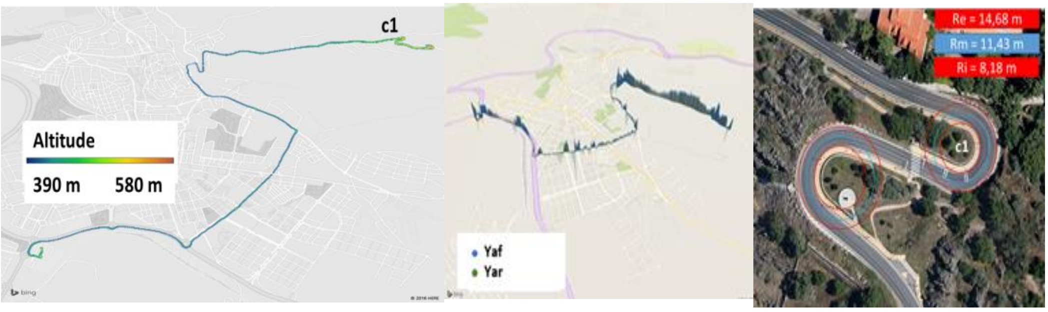

Fig. 2. Urban-interurban combined profile route (left); acceleration in the direction of the movement measured by the front (f) and rear (r) smartphone (center); curve c1 (right)

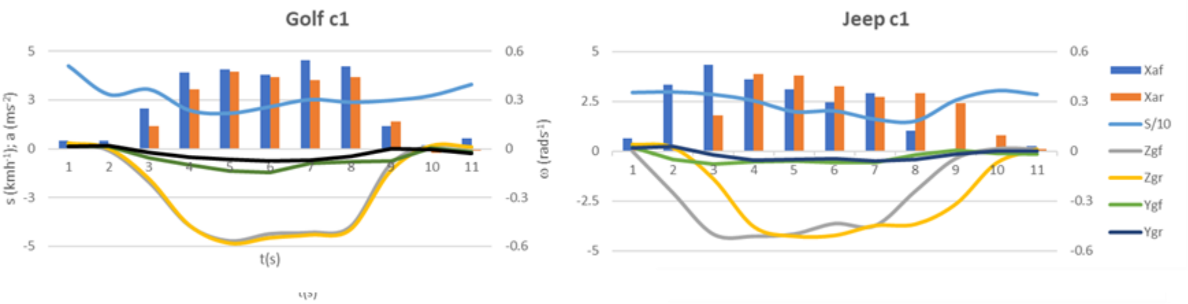

Fig. 3. Speed, centripetal acceleration, and rotation values in curve c1, in the front and rear (Golf, and Jeep).

In Figure 3, the values of the centripetal acceleration and the speed of rotation measured when describing the curve C1 (see Fig. 2) are shown. Comparing the values obtained by the front and rear sensors in both vehicles, an offset is found in the values measured by the Jeep. This difference is possibly due to the greater distance between the Jeep's axes and the lower speed (~5 km/h) with which it described the curve. The swinging is given by the values of the Z component of the acceleration, being somewhat higher in Golf, possibly due to the greater speed with which it describes the curve and the difference of the dampers of both vehicles.

3 Conclusion

Smartphone sensors allow engineering students to do measurements in outdoor environments. The obtained results allow a detailed description of the movement of a vehicle. The interpretation of the measurements can be adapted to the level of knowledge of the students. The use of their own devices can also increase the students' interest in physics

References

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