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# Usage of Smartphones in the Education Process of MADI during Vehicle Road Tests Conduction

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**Abstract**

The article discusses the possibility of modern smartphones sensors usage during vehicles road tests performing in educational process of the Moscow Automobile and Road Construction State Technical University (MADI) in teaching students of evening classes of specialty "Automobiles and automobile industry".

**Keywords:** pedagogy, specialists training, road vehicles, sensors of smartphone, road tests

## 1. Introduction

Modern information technologies in a greater degree are oriented and influence the younger generation, to which students, undoubtedly, belong to. Increase of student's interest in studying any discipline at the institution of higher education is one of the most important problems for a teacher, and its solving is possible with maximum usage of modern materials, devices and technologies, including information ones at the education process.

At Moscow Automobile and Road Construction State Technical University (MADI) there was conducted the following experiment: the two student groups obtaining evening classes education on specialty "Automobiles and automobile industry" during the semester there was suggested to accomplish a laboratory-based work with conducting a personal or public vehicle road test based on the suggested methodology with further processing and comparison of the experimental data. Meanwhile, a smartphone of a student served as the measurement instrument.

## 2. Road Test Conduction

The modern smartphone sensors make it possible to log various parameter data in real time mode [1], among which there are kinematic parameters of movement of the device itself, as well as navigation data. By the statistic data, the percentage of smartphone usage among cellular network subscribers in Russia is already more than 40%, and in future it is forecasted only the growth of the current index. In the practice it has been revealed that 100% of students in the chosen groups use smartphones and many of them have tablet computers, which also could be used in the laboratory-based work. Accordingly, all the mobile devices had operating system either iOS or Android.

Within the scope of the laboratory-based work the students were suggested to independently choose and accomplish any of the suggested tasks, presented in the Table 1, besides, all the associated methodological materials were explained at the lessons and provided to the students in electronic form.

Table 1. Laboratory-based work task on "Cars" course

| Task | Testing types | Experiment aim |
|---|---|---|
| By a personal car: | | |
| 1.1. | Acceleration from rest on a straight line with the maximum rate up to 100 km/h and further braking with the constant rate until the full stop. | To identify the trajectory and indexes of car's accelerating and braking dynamics. |
| 1.2. | Relaxed driving from p. A to p. B (it is desirable to have turns to different sides, time of turning 1-3 minutes, along | To identify the trajectory and evaluative indexes of safe car driving on the road. |

| | | |
|---|---|---|
| | the running road). To repeat the turning with a higher movement rate. | |
| 1.3. | To follow the random route in the city (driving time 2-5 minutes). | To identify the trajectory and evaluative indexes of car movement conditions while performing random maneuvers in the city. |
| By public transport: | | |
| 2.1. | To drive one station (smartphone is to be fixed stationary relative to the vehicle body). | To identify the trajectory and estimated indices of ground public transport driving conditions. |
| On foot: | | |
| 3.1. | To put smartphone into the pocket and walk 1-2 minutes along the MADI corridor (including walking up/down the stairs). | To follow the trajectory of smartphone movement in the space during its owner walking. |

Consequently, during the road test conducting, smartphones were used in the capacity of measurement devices [2], personal computers were used for experimental data processing. As test objects there were used personal vehicles, including motorcycles [3] and ground public transport (autobuses and taxi-buses). During the tests procedure there were recorded the following data [4, 5]: acceleration (longitudinal, lateral, and vertical); angular velocities (by three axes); geographic longitude; geographic latitude; vehicle velocity by the GPS/Glonass data. All the road tests were conducted on the dry smooth asphalt covering without driving regulations breaching and with the precaution measures following.

Out of 34 students from the two groups, 29 students tested personal vehicles and 5 students worked with the public transport. Task 3.1 assumed to use more powerful MatLab calculating framework while processing the experimental data. Besides, it was not directly related to vehicles. That was the reason for none of the students chose it.

During the road test conducting, the recommended frequency of data recording rated from 10 till 100 Hz [6]. Owners of the iOS powered smartphones were suggested to use free “SensorLog” software for recording device sensor data, correspondingly, for Android powered smartphones – free “AndroSensor” software. The testing data was recorded either in the CSV format with separators or in the table view and further it was exported to the personal computers. The data processing was taught separately for MS Excel and MatLab frameworks. The report execution for laboratory-based work was done in accordance with the suggested sample in electronic form, the report was submitted via electronic mail.

In the issue of the laboratory-based work accomplishment, the students accomplished the following vehicle road testing:

- motor cars: Audi Q7, BMW 116i, BMW 118i, Fiat Albea, Ford Focus 2, Hyundai Accent, Jeep Grand Cherokee, Kia Seed, Mazda 323, Mitsubishi Lancer, Opel Astra GTC, Opel Insignia, Saab 9-3, Skoda Fabia, Volkswagen Polo, Volkswagen Golf, Volkswagen Golf GTI, Volkswagen Passat, Volkswagen Tiguan, Volvo S60, AZLK-21412, VAZ-21093;

- motorcycles: BMW R 1100r, Yamaha fz400;

- buses: LiAZ-6213, Volzhanin-3290, LiAZ-5292.

**3. Experimental Data Processing**

For all task variants, except 3.1 (table 1), the students accomplished the following:

1) Velocity function graphing from time, continuous function constructing (Figure 1);

2) Graphing actually recorded projections of acceleration in time function;

3) Identification of turning angles of smartphones coordinates for their combination with axes, parallel to the central axes of car;

4) Graphing acceleration projections in the coordinates, parallel to the central axes of car;

5) Motion path construction on the plane by the geographical coordinates;

6) Motion path construction in maps.google.ru;

7) Covered distance calculation by geographical data.

For the task 1.1 there were additionally identified the following parameters: acceleration time up to 100 km/h, covered distance during acceleration, maximum acceleration, average velocity during acceleration, maximum deacceleration, average deacceleration during braking, braking distance [7, 8].

Correspondingly, for the task 1.2 there were additionally identified for each test the following parameters: time of driving, average velocity on the rout, separately the indexes of longitudinal and lateral acceleration of the car (average, maximum, minimum, average of positive indexes, average of negative ones).

For the tasks 1.3 and 2.1 there were additionally identified the following parameters: time of driving, average velocity on the rout, separately the indexes of longitudinal and lateral acceleration of vehicles (average, maximum, minimum, average positive indexes, average negative ones).

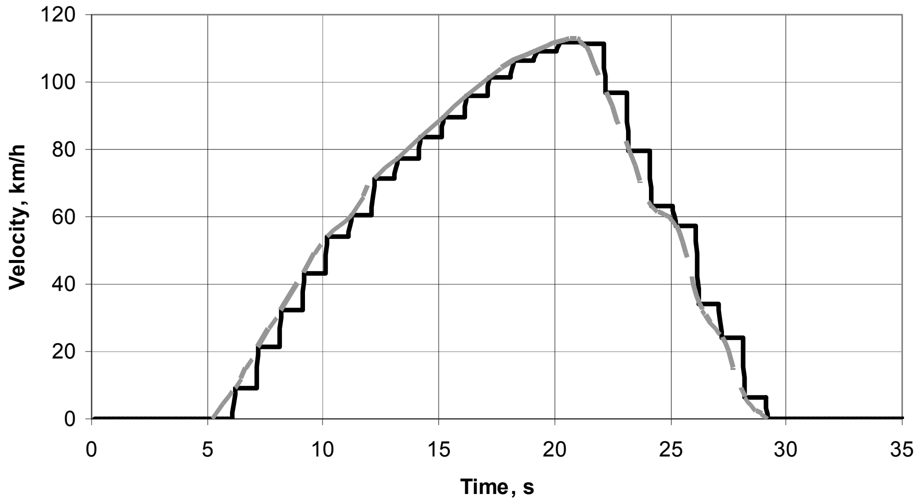


Figure 1. Acceleration and further braking of AZLK-21412

While road test conducting, the smartphones were fixed stationary relative to the objects of the tests. Thereby, the projections of acceleration vector were recorded relatively to coordinates of smartphone. For identification of smartphone orientation relatively to the acceleration vector of free fall $\vec{g}$ according to the record data at the initial time instant, when the vehicle was motionless, the following dependencies were used:

$$\begin{cases} \alpha = \arccos(g_x / \sqrt{g_x^2 + g_y^2 + g_z^2}) \\ \beta = \arccos(g_y / \sqrt{g_x^2 + g_y^2 + g_z^2}) \\ \gamma = \arccos(g_z / \sqrt{g_x^2 + g_y^2 + g_z^2}) \end{cases} \tag{1}$$

Further, there were performed the smartphones coordinates turnings up to the condition achievement, under which, the considered axes of measurement tools became parallel to the central coordinate axes of testing object, that is:

$$\begin{bmatrix} a_x^{NSC} \\ a_y^{NSC} \\ a_z^{NSC} \end{bmatrix} = M_i(\theta) \cdot \begin{bmatrix} a_x^{OSC} \\ a_y^{OSC} \\ a_x^{OSC} \end{bmatrix} \tag{2}$$

where:

NSC – New system of coordinates;

OSC – Old system of coordinates;

$a_i$ – Projection of acceleration vector on the relevant axis;

$M_i(\theta)$ – Matrix of rotation around relevant axis by angle $\theta$.

The rotation matrixes by angle $\theta$ around coordinates $x, y, z$ are presented by the following dependencies:

$$M_x(\theta)=\begin{bmatrix}1 & 0 & 0\\ 0 & \cos\theta & -\sin\theta\\ 0 & \sin\theta & \cos\theta\end{bmatrix};\quad M_y(\theta)=\begin{bmatrix}\cos\theta & 0 & \sin\theta\\ 0 & 1 & 0\\ -\sin\theta & 0 & \cos\theta\end{bmatrix};\quad M_z(\theta)=\begin{bmatrix}\cos\theta & -\sin\theta & 0\\ \sin\theta & \cos\theta & 0\\ 0 & 0 & 1\end{bmatrix}$$

Figure 2 shows the sample of geographic representation of accelerations, recorded relative to the smartphone axis (a_i_sm), and calculated longitudinal car acceleration.

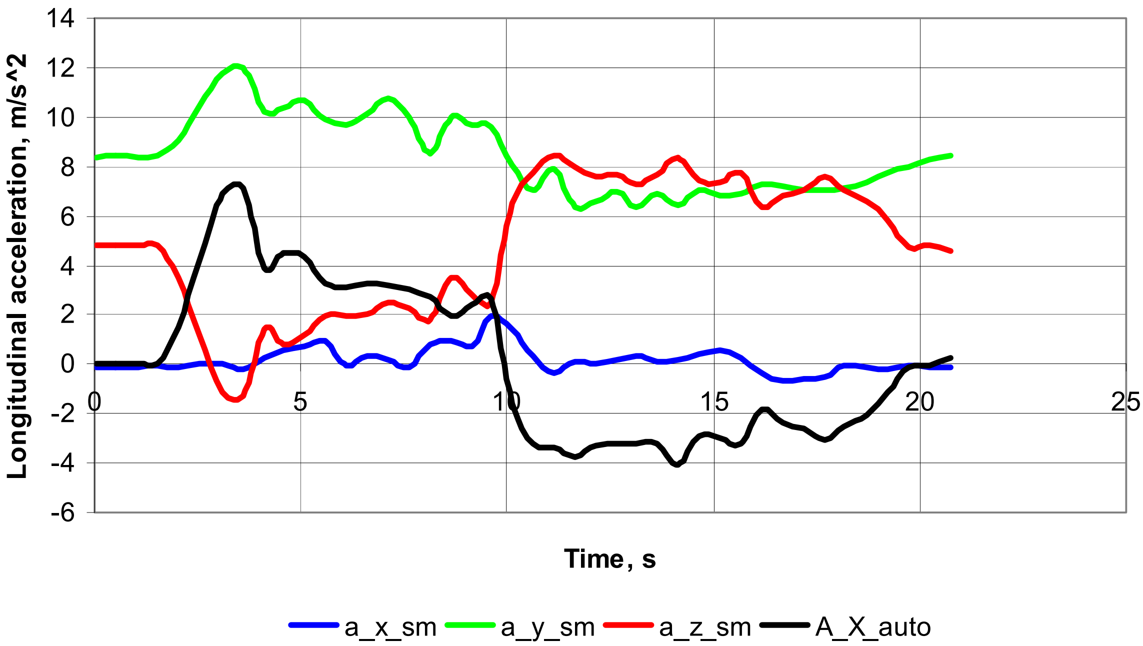


Figure 2. Calculation of longitudinal VW Tiguan car acceleration during acceleration and further braking

Figure 3 shows the example of index comparison of two rides lateral accelerations of different intensiveness (task 1.2) during the car passing identical areas of movement trajectory.

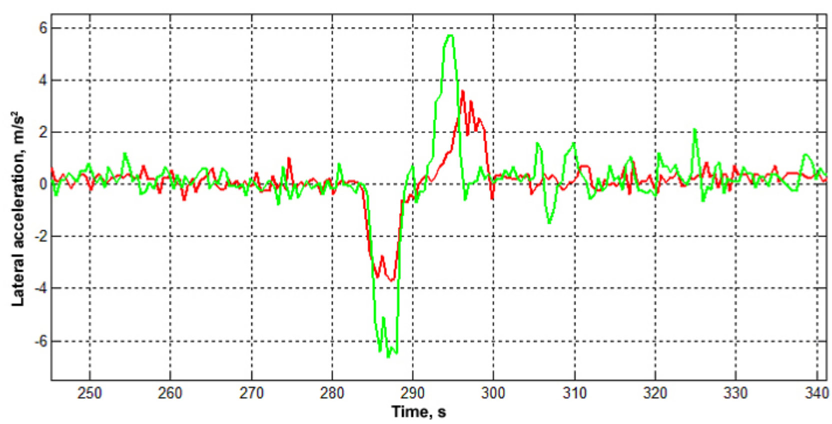


Figure 3. Example of data fragments comparison of lateral accelerations of two rides with different intensiveness

During the test conduction, geographic placement of vehicle was identified by the data of GPS/Glonass satellite navigation: there was performed recording of longitude, latitude, ellipsoidal height and other parameters in the real time [9]. Taking into account the circumstance that the rides were carried out on the grounds, incommensurably smaller by the sizes of the Earth's surface scales, drawing of the trajectories of the considered rides was presented in the following way: for the coordinates of abscissa axis there were accepted indices of the measured longitude, and for coordinates by ordinate axis - indices of geographic latitude, being corrected by the related scale coefficients. For Moscow region the scale coefficients were identified in [10] and were the raw data for the students:

$$\begin{cases} \mu_x = 62547.1826 \ \ m/^\circ \\ \mu_y = 110595.5433 \qquad m/^\circ \end{cases} \tag{3}$$

The example of the result of movement trajectory construction on the plane by geographic coordinates with usage of scale coefficients (3) and comparison of constructed movement trajectory with area map is shown on Figure 4.

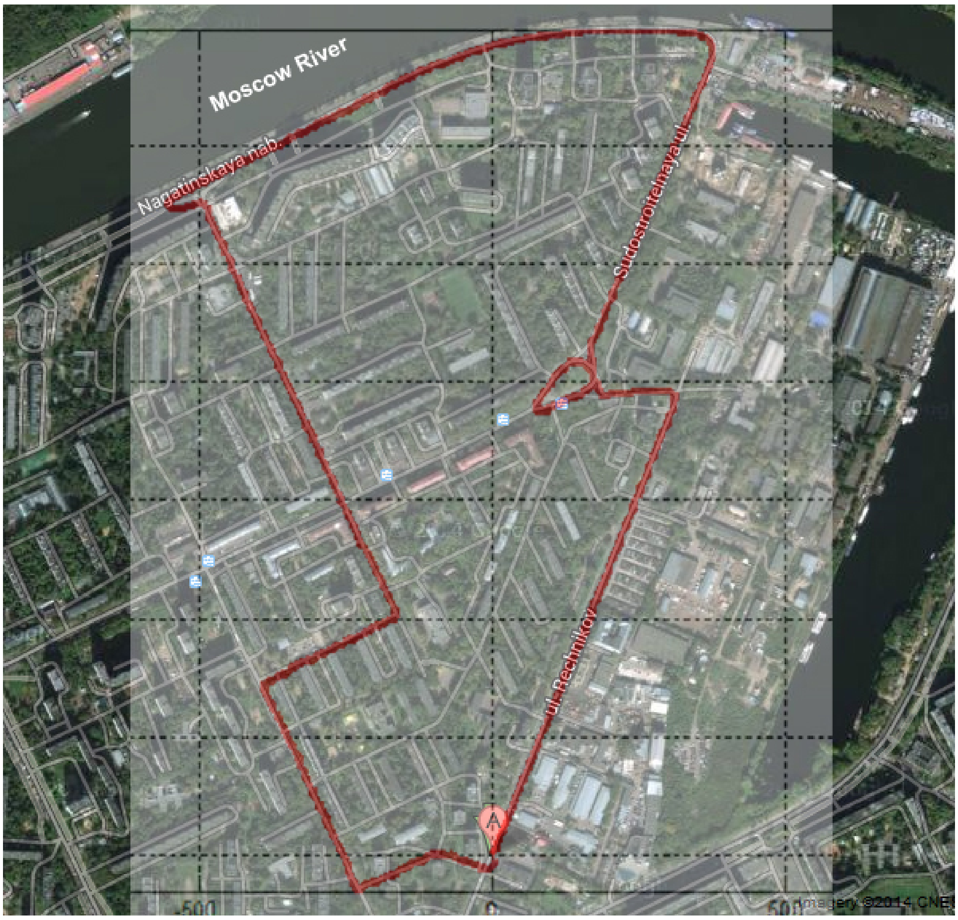

Figure 4. Movement trajectory construction on the area map (task 1.3)

## 4. Results and Conclusion

Heated interest and motivation of students toward study of the discipline increased by the combination of the following factors:

1) Study of exploitation features of real vehicle or personal car;

2) Interest toward own smartphones opportunities;

3) Competitive effect among students while comparing measures results;

4) Practical skills of working with computer software, increasing total "computer competence";

5) Obtaining interdisciplinary knowledge on the car theory, experiment theory, mathematics analysis, theoretical mechanics, mathematic statistics, navigation and cartography, psychophysiology.

Thus, we consider the conducted experiment being successful and working on opportunities of implementation of the suggested approach into studying process, as the increase of involvement level of students into study disciplines is becoming obvious.

The suggested approach in the perspectives can be finalized and used while preparing laboratory-based works on different disciplines related to study of exploitation features of vehicles [11], dispatching of public transport, task of intellectual transport systems [12], logistic and others.

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