Cases of non-signalized engine braking

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Abstract. According to statistics approximately 30% of all road traffic accidents occur because of improper vehicular distance in a traffic flow which is a result of imperfect stop signaling system. Stop signaling system does not signal when such types of braking as engine braking, step-by-step braking and some other types of braking take place. Currently the majority of vehicles are equipped with monitoring systems, and starting from 2017 all production vehicles will have a warning alarm button connected to ERA-GLONASS system. This article suggests a new technique of detection of vehicle non-signalized braking cases implemented with the help of a standard element base of a vehicle monitoring system.

1. Introduction
Since the number of vehicles moving in a traffic flow increased, the distance between them decreased. At the same time, speed limits have significantly increased [1,2]. Therefore, the split seconds at the moment of braking became of vital importance. When a sudden unplanned braking takes place, vehicles following the stopping car often simply have no time to brake. We predetermined the situation by the fact that we received the information about some danger on the road only by a foregoing vehicle (“the leader”), but the drivers going after the leader can orient themselves in a traffic flow concerning awaiting road dangers only by stop-signals of a leading vehicle [3]. While driving some danger situation may appear unexpectedly [4, 5] and, as a rule, it can be of different kind, which may result in a driver of a foregoing car choosing the way to brake more appropriate to this particular situation. Such ways to brake may include application of brakes or engine braking. The engine braking vehicles going behind will get no visual information about the foregoing braking because engine braking does not presuppose any signal to switch on.

One of A. Zagorodnikh's co-authors N. Sevryugina has proved imperfection of stop-signal system of a vehicle which produced a signal only if a braking system appeared [3, 6, 7]. Clever use of different ways of braking combined can increase the road traffic safety together with longevity and reliability of a braking system.

Analysis of statistics related to road traffic accidents for the period from 2014 to 2015 [7] shows that the number of road accidents caused by improper vehicular distance makes 24% out of all road accidents, and 56 % out of this belongs to head-end, front and rear-end collisions. Collision of two or more vehicles mainly occurs because of disregard of vehicular distance [8-11]. Untimely informing of drivers about the beginning of foregoing vehicle's braking is one of the main causes of collisions. Scott E. McIntyre in his paper analyzes the degree of drivers' reaction to yellow and red lights of vehicular stop-signals [12]. Nevertheless, the article states that psychological aspects of stop-signals perception do not play the main role, while timely signaling does. A moment of braking starts exactly when a
vehicle being a material object slows down as a result of deceleration [3,6,7]. More attention should be paid to identification and signaling of a real moment of braking.

The target of the experimental study is detection of moments of non-signalized engine braking and estimation of deceleration magnitude at the mentioned moments.

2. Theory

We conducted the experimental study on Orel public roads using Volkswagen Jetta of 2014 production year with automatic transmission. We chose it because only it could help detect moments of engine braking while a car was moving [13]. In order to detect moments of non-signalized engine braking and to measure deceleration of a vehicle we used a modified terminal programmable device UTP-M-21-3.314 (further UTP) produced by GK «NAVIGATOR» [14].

UTP is a computing device created as a terminal station with GLONASS/GPS global positioning system and GSM-modem connected to a sensor registering car body’s vibration in three axes. The sensor is created as an integrated triaxial accelerometer capable of measuring vertical car body’s vibration and acceleration and deceleration of a vehicle along two other axes.

The UTP used for the experimental study comprised an integrated triaxial accelerometer based on MMA7456L microchip (created by Freescale company). Functional circuit of the UTP is presented in Figure 1.

![Figure 1. Functional circuit of the UTP.](image)

Functional capabilities of the device are: identification of a car driver; identification of a vehicle's location; control over motion parameters including measurement of a vehicle's acceleration magnitude in three interperpendicular axes; storage of information by a memory card; read-out of gathered data via USB or data transmission to monitoring servers via GSM.

The device is tightly fixed inside a car (figure 2) and connected to a vehicle's power system and stop-signals (figure 3).

When engine starts, UTP device switches on, plots geographical position of a vehicle, checks functioning of the sensors, measures acceleration magnitude of a vehicle and records the data into non-volatile memory. While this vehicle is in motion, the device monitors the mentioned parameters. At this, recording of these parameters is done repeatedly depending on the time interval which is preliminary set or when some event like acceleration or braking takes place.

UTP controller software allows capturing changes of acceleration according to data gathered by a triaxial accelerometer. At this, current status of sensors connected to the device is registered into its memory. When we mounted UTP inside a car as a sensor connected to the 15-th connector pin of external UTP interfaces (sensor 3), a wire connecting positive contact of stop-signaling lamps was linked up (fig.3). When acceleration magnitude changed, sensor 3 actuation was registered; that meant that a message «Sensor 3 actuation» signified voltage supply to stop-signaling lamps of a vehicle and, consequently, UTP registered deceleration of a vehicle as a result of braking by application of a braking system (signalized braking). But when deceleration was registered without actuation of sensor 3 that
meant that a vehicle started engine braking. Microcontroller software (UTP) was modified in order to implement the operation algorithm of the device depicted in figure 4.

Figure 2. Location of the UTP inside a vehicle.

Figure 3. UTP connection diagram.

Figure 4. Algorithm of deceleration detection.
### Table 1. Some piece of experimental data.

| Date and time | Sample number | Longitude (measured in degrees) | Latitude (measured in degrees) | Speed, km/h | Application of a brake pedal | Acceleration along X axis, m/s² |
|---------------|---------------|---------------------------------|--------------------------------|-------------|-------------------------------|--------------------------------|
| 04.12.2016 17:20:23 | 2600 | 36.03053284 | 52.98228455 | 7 | Yes | 0.000 |
| 04.12.2016 17:20:25 | 2601 | 36.03058624 | 52.98225784 | 6 | No | 0.000 |
| 04.12.2016 17:20:26 | 2602 | 36.03058624 | 52.98225784 | 0 | No | 0.274 |
| 04.12.2016 17:20:27 | 2603 | 36.03058624 | 52.98225784 | 0 | No | 0.000 |
| 04.12.2016 17:20:29 | 2604 | 36.03065491 | 52.9822733 | 0 | Yes | 0.000 |
| 04.12.2016 17:20:32 | 2605 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:20:34 | 2606 | 36.03065491 | 52.9822733 | 0 | Yes | 0.001 |
| 04.12.2016 17:20:39 | 2607 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:20:41 | 2608 | 36.03065491 | 52.9822733 | 0 | Yes | 0.000 |
| 04.12.2016 17:20:45 | 2609 | 36.03065491 | 52.9822733 | 0 | No | 0.129 |
| 04.12.2016 17:20:47 | 2610 | 36.03065491 | 52.9822733 | 0 | Yes | 0.000 |
| 04.12.2016 17:20:52 | 2611 | 36.03065491 | 52.9822733 | 0 | Yes | -0.001 |
| 04.12.2016 17:21:00 | 2612 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:21:02 | 2613 | 36.03065491 | 52.9822733 | 0 | Yes | 0.000 |
| 04.12.2016 17:21:05 | 2614 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:21:07 | 2615 | 36.03065491 | 52.9822733 | 0 | Yes | -0.264 |
| 04.12.2016 17:21:16 | 2616 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:21:19 | 2617 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:21:20 | 2618 | 36.03065491 | 52.9822733 | 0 | No | -10.856 |
| 04.12.2016 17:21:22 | 2619 | 36.03065491 | 52.9822733 | 0 | No | 0.069 |
| 04.12.2016 17:21:27 | 2620 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:21:32 | 2621 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:21:35 | 2622 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:21:44 | 2623 | 36.03065491 | 52.9822733 | 0 | Yes | 3.921 |
| 04.12.2016 17:21:45 | 2624 | 36.03065491 | 52.9822733 | 0 | No | -3.223 |
| 04.12.2016 17:21:46 | 2625 | 36.03065491 | 52.9822733 | 0 | Yes | 0.000 |
| 04.12.2016 17:21:47 | 2626 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:22:34 | 2627 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:23:34 | 2628 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:24:34 | 2629 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:25:27 | 2630 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:25:34 | 2631 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:26:34 | 2632 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:26:47 | 2633 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:27:34 | 2634 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:28:34 | 2635 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:29:34 | 2636 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:29:51 | 2637 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:30:34 | 2638 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
| 04.12.2016 17:31:34 | 2639 | 36.03065491 | 52.9822733 | 0 | No | 0.000 |
Information about a vehicle's location, parameters of motion and status of UTP connected sensors were stored binary into non-volatile memory of the device. To process the mentioned data we used the following software: “AVIGATOR-S2016”, GLONASS/GPS satellite vehicles monitoring system. “NAVIGATOR-S2016” automated monitoring system is a software technical complex which main task is monitoring of a vehicle. Basic capabilities of “NAVIGATOR-S2016” are gathering and storage of data received from monitored objects (data concerning location of objects, changes of status of connected sensors, etc.); execution of queries about the latest status of objects or status within any time period; display of location of monitored objects on an electronic map; generation of reports concerning parameters of vehicle's motion and their export into different data formats.

3. Results
We conducted experimental study within a period from 1.10.16 to 20.12.16. Driving took place on public roads of Orel. On average about five rides a day took place. Average length of a ride was 30 minutes. Data about motion parameters within reported period was gathered by monitoring system of vehicles “NAVIGATOR-S2016” in Orel Department of Unified National Dispatching System of the Russian Federation and exported in Excel format. Table 1 shows some data concerning vehicle motion parameters obtained during the experimental study.

Analysis of results of the experimental study showed that the average number of non-signalized braking moments for 30 minutes of continuous driving makes 30% of all registered moments of braking (fig.5).

Figure 5. Average ratio of types of braking within 30 minutes of continuous driving.

Figure 6 shows different acceleration magnitudes (samples) in the form of a graph within 30 minutes of continuous driving which means moments when braking pedal was not used by a driver.

Figure 6. Sample of experimental data.
4. Discussion
After the analysis of received experimental data within a reported period we arrived at the following conclusions:

- Driving style can be called moderate [15].
- Average number of cases of engine braking within 30 minutes of continuous driving is 14.
- Average number of cases of signalized braking within 30 minutes of continuous driving is 42.
- Maximum deceleration magnitude of a vehicle in case of engine braking is \(-3.223 \text{ m/s}^2\).
- Maximum deceleration magnitude of a vehicle in case of signalized braking is \(-10.856 \text{ m/s}^2\).
- Average deceleration magnitude of a vehicle in case of engine braking is \(-0.395 \text{ m/s}^2\).

As Figure 8 shows, if the driving style is moderate, then the number of cases of engine braking is similar to the number of cases of acceleration. At this, magnitudes of these parameters are in the same range.

5. Conclusions
The number of road traffic accidents caused by improper vehicular distance makes 24% out of all the road traffic accidents. 56% of road traffic accidents caused by improper vehicular distance belong to head-on, front and rear-head collisions.

Analysis of experimental data showed that average number of engine braking cases is 14; average deceleration magnitude in case of engine braking is \(-0.395 \text{ m/s}^2\), and maximum deceleration magnitude is \(-3.223 \text{ m/s}^2\) which means that it is necessary to signal about that kind of braking to vehicles going behind.

Signaling about engine braking to drivers of going behind vehicles will reduce the number of road traffic accidents.

To reduce the number of rear-dead collisions and, thus, decrease the number of road traffic accidents in general, it is reasonable to create a device (without alterations in the design) signaling about deceleration of a vehicle.

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