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EVALUATION OF ECO-DRIVING USING SMART MOBILE DEVICES

ABSTRACT

The methods of measuring driving behaviour and the quality of drive in road transport are important factors in data acquisition and subsequent analysis of driving. The prevalence of smart terminal devices and cost effectiveness of On-Board Diagnostics (OBD) sensor devices provide great potential and the availability of the aforementioned technologies. This study shows the possibility of using information and communication technologies (ICT) and sensor devices for measuring the effectiveness of eco-driving. The ease of implementation of ICT elements, the accuracy of collected data and their storage for later data analysis offer a number of possibilities to use. This study shows the technical solution of the system and analysis of collected data on actual driving samples. By comparing normal and eco-driving modes, the advantage of using eco-driving modes is demonstrated through reduced fuel consumption and CO_2 emissions amounting to almost 23% and 31%, respectively.

KEY WORDS

eco-driving; smartphone application; On-Board Diagnostics; fuel consumption; CO_2 emission;

1. INTRODUCTION

The increase of global energy demand has encouraged the development of strategic objectives aimed at energy efficiency and reduction of greenhouse gas emissions. In the context of energy and climate efficiency, the European Union adopted three objectives that need to be achieved by 2020: to reduce greenhouse gas emissions (by 20%), to increase the share of renewable energy (by 20%) and to improve energy efficiency (by 20%) [1]. Furthermore, the greenhouse gas emissions are expected to be reduced by 24% until 2020 and by 32% until 2030, based on the current reduction measures. As far as the energy efficiency is concerned, the latest projections show that energy saving in the European Union by 2020 could be at least 17% [2]. Energy efficiency is essential for sustainability and competitiveness of the EU members, being the pillar of growth and economic stability.

If CO_2 emissions fail to be reduced, climate changes could stop global GDP by 1.5% and by 5% in South East Asia by 2060 [3]. The European transport sector is currently responsible for over 28% of the CO_2 emissions level in the EU [4]. Furthermore, the European transport sector must reduce the level of CO_2 emissions, approximately 60%, by 2050 (compared to 1990) [5].

At the same time, the levels of CO_2 emissions are directly related to fuel consumption. Emissions of CO_2 from the combustion of fossil fuels are the main cause of global warming, while road transport is almost entirely dependent on oil as fuel [6]. The reduction of CO_2 emissions on a global scale is of common interest worldwide. The European Union has set legally-binding objectives for newly manufactured cars: CO_2 emissions by 2020 must not be greater than 95 [g/km] [7]. Globally, the European Union has the most rigorous regulations concerning car CO_2 emissions by 2020.

Historical records, as well as future plans indicate that there is a need for sustainable road transport worldwide. As result, the governments of the EU Member States have increased efforts aimed at reducing CO_2 emissions and increasing energy efficiency in all sectors, including transport. This comprises a variety of initiatives, one of which is the use of eco-driving performance in road traffic. Eco-driving techniques are practical and cost effective, which further increases the attractiveness of their application.

Eco-driving technique involves the use of intelligent and safe driving that leads to a reduction in fuel consumption, greenhouse gas emissions, the number of traffic accidents and noise of internal combustion engine vehicles [8]. It can be considered as a smarter and more efficient way of driving that optimally uses the possibilities of modern technologies while simultaneously increasing traffic safety. Eco-driving includes more efficient driving practices and vehicle maintenance. The impact of vehicles on the environment in terms of fuel consumption and CO_2 emissions is determined by the interaction of the technical characteristics of vehicles and driving modes [9]. Even a small reduction in fuel consumption can significantly reduce greenhouse gas emissions and increase fuel economy [10].

Increasing awareness among drivers about the impact of their activities on the reduction of fuel consumption and levels of CO_2 emissions can yield significant results. The advantages of using eco-driving are shown in *Table 1*.

Table 1 – Categories and the impact of eco-driving advantages [11]

The area of activity	Impact
Safety	a Increase in road safety b Improvement of driving skills
Environment	a Reduction of greenhouse gas emissions (CO_2) b Reduction of harmful gas local emissions c Noise reduction
Driving economics	a Reduction in fuel consumption (5-15% in the long term) b Reduction of maintenance costs c Cost reduction due to traffic accidents
Social responsibility	a Contribution to responsible driving b Stress reduction while driving c Increase in ride comfort for drivers and passengers

Driving behaviour change is one of the factors which commonly influences the reduction of fuel consumption. Energy-saving driving style is based on the driver's situational awareness and ability to predict near-future traffic demands. Aggressive driving technique with hasty and frequent acceleration/braking intermittent actions has generally negative impact on consumption.

There are different systems that enable the analysis of eco-driving effectiveness. This study shows the cost-effective and publicly available elements of the system for measuring the effectiveness of eco-driving, based on ICT technologies.

2. PREVIOUS RESEARCH

Many studies on the regional and global level show significant benefits of eco-driving modes both in financial and economic terms. The possible fuel savings by using eco-driving behaviour were studied by many authors, and in accordance with the analysis of some of them, potential savings range from 5% to 32% (*Table 2*).

Table 2 – Fuel savings according to various authors [12]

Reference	Fuel saving
(Barkenbus, 2010)	10%
(Kolman, 2009)	30%
(Mele, 2008)	26%
(Walden, 2008)	25%
(Onoda, 2009)	5 – 15%
(Barić, Zovak, Periša, 2013)	32%
(Barth & Boriboonsomsin, 2009)	10 – 20%
(Hitchings & Ward, 2010)	18%
(OECD, 2010)	25%
ECOWILL (2013)	14 – 18%

Although these studies suggest that the fuel savings and reductions in CO_2 emissions are the consequences of eco-driving, it is important to accurately measure the specified fuel savings and reductions of CO_2 emissions. In this context there are different measurement systems of eco-driving evaluation.

In accordance with the research [9], eco-driving style enables fuel savings in the amount of 32%. In this study, Key Driving Training System (KDTS) is used as a measuring system for collecting driving style data. This system is a professional solution that allows interpretation of driver behaviour as well as the subsequent analysis of driving. However, it is necessary to mention the inability of in-system satellite positioning, as well as demanding purchase costs, as a downside.

In the study [13], in order to collect vehicle trajectory and eco-driving data, a portable Global Positioning System (GPS) receiver and fuel consumption sensors installed in test vehicles were used. In many studies, a professional measurement system designed specifically for the specific parameters acquisition of the vehicle condition and post-process analysis, is commonly used [14]. A possible drawback of such measurement method is temporary lack of satellite signal which could unexpectedly occur thus preventing vehicle positioning. In the study [15], the possibility of potential fuel savings by using eco-driving mode is given through experimental results that have been processed through driving simulator as one of the methods of data collection and analysis.

More sophisticated approach to education and the use of eco-driving mode is shown in the study [16], which demonstrates the possibility of using smartphone applications for education in using eco-driving. A disadvantage of that application is the missing connection with Electronic Control Unit (ECU) engine vehicles and thus lacking real data acquisition of fuel consumption and CO_2 emissions of gases. The aforementioned drawback is evident in research [17], where an overview of applications of mobile terminal devices that provide feedback to the driver on driving quality and the degree of adaptation of eco-driving is given.

With a GPS receiver and inertial sensor system, there is no connection with the ECU and thus other methods are used to calculate fuel consumption and CO_2 emissions, which does not offer a complete solution.

The study [12] shows the technical solution of data acquisition through modern ICT devices and technologies. The convenience of applying this model to drivers of road entities is noteworthy due to the relatively low implementation cost and the high level of usefulness of all the constituent elements of the system. Quick installation, simplicity of use and storage of collected driving data are the biggest advantages of this solution. The continuation of the above research, by means of collecting real data on fuel consumption and CO_2 emissions of gases, as well as the comparison of two driving modes (Normal driving and eco-driving), is the focus of this paper.

In the Republic of Croatia, within the framework of the Intelligent Energy Europe, a project of the mass popularization and implementation of eco-driving has been started (Eco-driving - Widespread Implementation for Learners and Licensed Drivers - ECOWILL), as one of the cheapest, fastest and easiest energy efficiency measures in transport. The project lasted three years, from 2010 to 2013. The aim was to save energy, reduce fuel consumption and reduce greenhouse gas emissions. During the project, short 500 eco-driving trainings for drivers of vehicles of category B were held, offering training for the application of the rules of eco-driving. Training with drivers was conducted in the theoretical and practical part. The parameters were measured and compared regarding fuel consumption during the freestyle and during eco-driving style. The results of the training indicate that average fuel savings of 0.8 to 1.2 l/100 km were realized, or from 14% to 18% [18]. Also, four high traffic schools for the education of students being educated for the occupation of drivers of category C vehicles, implemented the project "Eco-driving is the law" [19].

3. METHODOLOGY AND RESEARCH ELEMENTS

The research includes specific elements (OBD diagnostic device, smartphone powered by the Android operating system and diagnostic application package TorquePro – OBD 2 & Car) and methodological procedures required for proper operation of the system, as described further in the text.

3.1 Test vehicle

Generally, vehicle characteristics which are important for measuring fuel consumption and CO_2 emissions are: OBD-II connector in the vehicle, type of engine (petrol, diesel, hybrid), engine displacement (ccm) and engine power (hp). The vehicle in which all measurements and data acquisition for research purposes were performed was Renault Megane 1.5 dCi, produced in 2006, with 105 [hp] and diesel engine. The basic parameters of the car measured just prior to the ride (air pressure level in the tyres, the number of people in the car and the fuel level in the fuel tank) in both types of drive were identical.

3.2 Test driving route

The length of the test route for research purposes amounted to 89.5 [km]. The starting point is rural area at the address Žarovnica 102, 42250 Lepoglava, while the point of destination was urban area with the address Vukomerec Street 20, Zagreb (*Figure 1*). Each type of driving (normal driving and eco-driving) was tested three times with approximately the same results for the measured parameters. In the presented driving results the average values of the measured parameters in both driving types have been achieved. Comparisons of driving results of both types of driving (normal driving and eco-driving) are shown in *Table 3*.

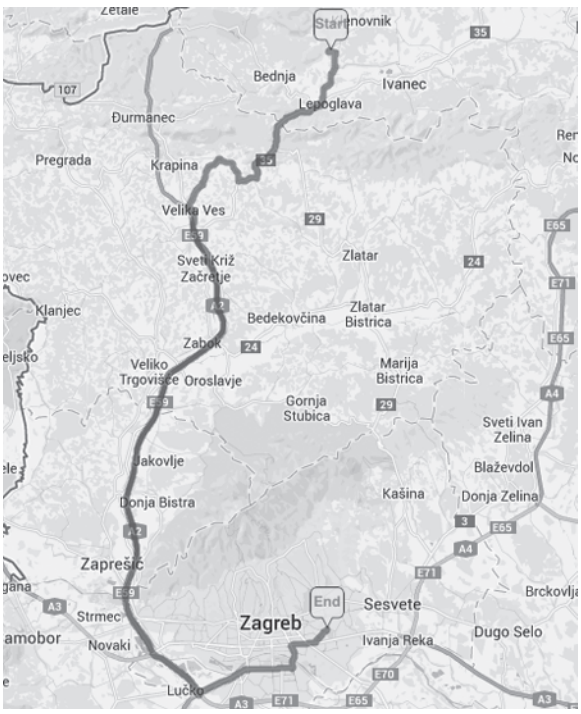

Figure 1 – Drive route used for research purposes

Both runs were performed on Tuesday at almost identical departure time (06:40 h a.m.) in order to achieve similar traffic driving conditions in both tests as closely as possible. The first and the second test drive were carried out on March 4 and March 11, 2014, respectively. The important feature of the selected driving route is the inclusion of three driving modes: freeway, highway and city driving, which gives more significance to the collected data that simulate real driving environment.

3.3 Eco-driving

Eco-driving presents a set of rules which are developed in order to reduce fuel consumption. According to studies [6] and [8], there are two stages of eco-driving modes: before the trip and during the trip. Within each stage, drivers are advised on how to ensure efficient driving. The methods which are relevant for the efficiency of eco-driving can be seen in Formula (1). The applied methods, regardless of the stage of driving, are relevant factors that influence the efficiency of eco-driving and provide the difference between normal driving styles. Accordingly, it can be quite generally written:

$$E = f(S, T, O, P, I, B, U, R)_{s,t} \qquad (1)$$

where:

- E – efficiency of eco-driving;
- S – vehicle maintenance in accordance with the standards of the manufacturer;
- T – reducing the amount of transported cargo;
- O – maintaining proper tyre pressure;
- P – relaxed acceleration and braking, while ensuring safe distance between vehicles;
- I – avoiding idling while driving;
- B – closing windows at high speeds;
- U – slight deceleration using car engine;
- R – maximum reduction in air conditioning (cooling and heating).

It is important to note that the methods *S*, *T* and *O* are used prior to travel (first-leg drive), while methods *P*, *I*, *B*, *U*, *R* must be used during the journey (the second stage of driving). In order to achieve the best results, the most important methods the driver uses and cares about during eco-driving were methods *T*, *O*, *P*, *I*, *B*, *U* and *R*, while not caring much about them in normal driving style.

3.4 Smartphone application used for the measurement

The acquisition and storage of driving data were performed using modern ICT devices and technologies that include OBD diagnostic device, smartphone powered by the Android operating system and diagnostic application package TorquePro (OBD 2 & Car). Smartphone powered by the Android operating system is used because it is the most growing OS with 81.1% of the global market in Q1 2014, according to [19]. Application package TorquePro (OBD 2 & Car) is the most popular OBD reader app which defends its reputation with a laundry list of features and sensors it can follow [20]. Mode of each segment of the system for data collection and processing as well as the architecture of technical solutions are presented in study [12].

Driving and vehicle data were collected during the entire trip and stored on a web application, which allows data retrieval at any time and their adjustment according to the research requirements. The example of driving data can be seen in *Figure 2*.

The data shown in *Figure 2* represent a fraction of data collected by the application Torque Pro (OBD 2 & Car). The collected data are stored in MS Excel file and can be used for later analysis of driving. *Figure 2* shows some of the collected data, such as device time, longitude, latitude, speed, average CO_2 and engine RPM, which is collected in every second of driving.

The progression of events and processes within the application Torque Pro (OBD 2 & Car) is shown by a flowchart (*Figure 3*).

Figure 3 shows the activation process of application Torque Pro (OBD 2 & Car) and its connection to the vehicle's ECU. Furthermore, the application defines the type of vehicle and the possibility of data collection and display of the measured results. All data are collected on a web server which enables their further analysis.

	B	C	D	F	G	I
1	Device Time	Longitude	Latitude	Speed (OBD)(km/h)	COâ,, in g/km (Average)(g/km)	Engine RPM(rpm)
1816	09-ruj-2013 07:15:44.259	15.889463871717453	46.13141058012843	42	51.17636871	1306
1817	09-ruj-2013 07:15:45.251	15.889407293871045	46.13131205085665	40	50.87053299	1272
1818	09-ruj-2013 07:15:46.265	15.889358595013618	46.131217838265	38	50.56652832	1209
1819	09-ruj-2013 07:15:47.264	15.88931174017489	46.13112953491509	36	50.26433945	1020
1820	09-ruj-2013 07:15:48.265	15.889267064630985	46.13104697316885	35	49.86422729	936

Figure 2 – Partial view of collected driving data, an example

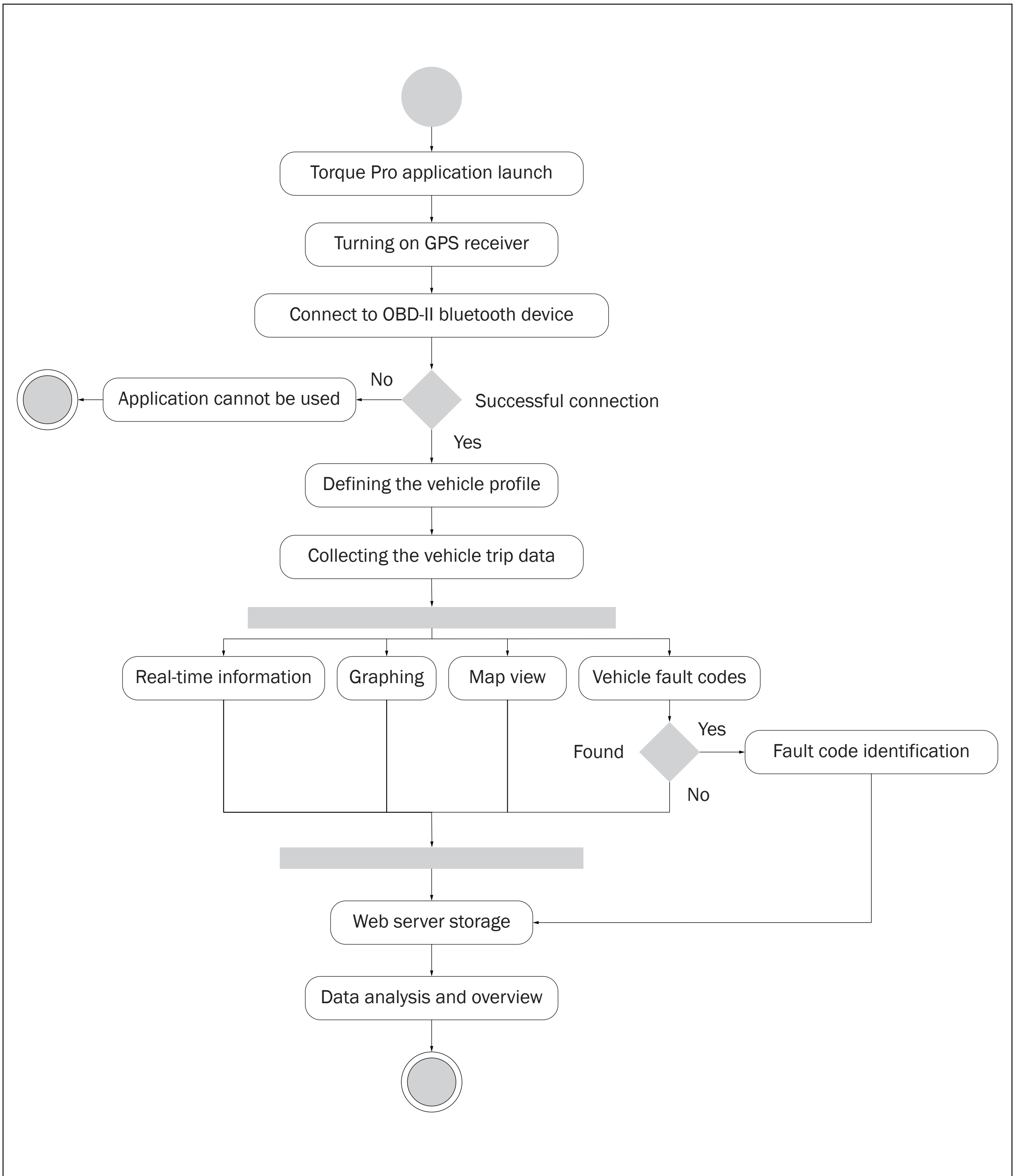

Figure 3 – Torque Pro (OBD 2 & Car) flowchart

4. COMPARISON OF THE MEASUREMENT RESULTS

The aim of this study is to efficiently collect data for comparing the fuel consumption and CO_2 emissions through two different driving modes, by using ICT. The driving modes performed are: normal driving (Drive 1) and eco-driving (Drive 2). All measurements are executed in almost the same meteorological conditions (sunny and dry, temperatures 10 to 12°C) on the road and with nearly the same traffic situation (regular traffic density and normal speed in traffic flow) on the identical route driving, according to the aforementioned measurement methodology in Chapter 3.3. The comparison of the main parameters that affect driving has shown prospective financial and environmental benefits in reducing fuel consumption and CO_2 emission levels.

4.1 Fuel consumption measurement and analysis

The measurement parameters and the results obtained in both driving modes are shown in *Table 3*. It is important to point out the differences in the amounts of fuel consumed when comparing the two driving modes. This offers the assessment possibility of the advantages and disadvantages of various methods of driving and their evaluation.

The difference of driving parameters in *Figure 3* is obtained by using the formula: Difference = Drive1 – Drive2. *Figure 4* shows the trends in fuel consumption in the time domain.

By comparing the fuel consumption for Drive 1 and Drive 2 in *Figure 4*, it is important to highlight the increasing differences in fuel consumption respective to the length of the ride.

4.2 CO_2 emission measurement and analysis

Carbon dioxide (CO_2), particularly from transport and industry, is one of the leading greenhouse gases that contributes to global warming, and thus climate change [21].

Emissions of carbon dioxide are proportional to fuel consumption, i.e. carbon content in the fuel consumed, and determined from the known stoichiometric ratios. For a complete overview of CO_2 emissions it is necessary to analyze the total energy chain, from fuel production to its burning within a motor vehicle. In every step of energy conversion certain losses appear, which in turn, on a larger scale, have an impact on the final CO_2 emissions.

Table 3 – Measurement and comparison of driving parameters that affect fuel consumption

Measurement parameter	Unit	Drive 1	Drive 2	Diff.	Diff. [%]
Total length of distance travelled	[h:mm:ss]	1:23:15	1:28:56	-0:05:41	6.39
Total duration of the trip	[km]	89.56	89.49	0.06	0.07
Average engine RPM	[RPM]	1,753.33	1,562.83	190.50	10.87
Average speed	[km/h]	54.70	48.15	6.55	11.98
Maximum speed (GPS)	[km/h]	143.78	121.95	21.83	15.18
Average fuel consumption	[l/100km]	4.68	3.61	1.07	22.78
Total amount of fuel consumed	[l]	4.19	3.23	0.96	22.83

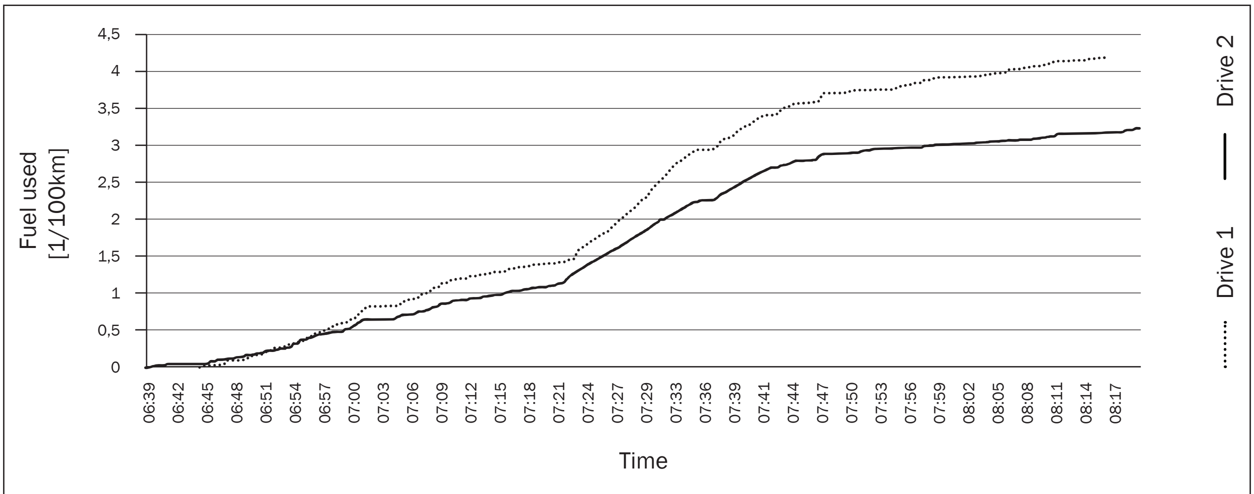

Figure 4 – Comparison of fuel consumption for Drive 1 and Drive 2

Table 4 – Comparison of the driving parameters that affect CO_2 emission

Measurement parameter	Unit	Drive 1	Drive 2	Diff.	Diff.[%]
Average CO_2 emissions	[g/km]	72.69	50.17	22.52	30.99
Maximum CO_2 emissions	[g/km]	896.68	750.23	146.46	16.33
Average engine RPM	[RPM]	1,753.33	1,562.83	190.50	10.87

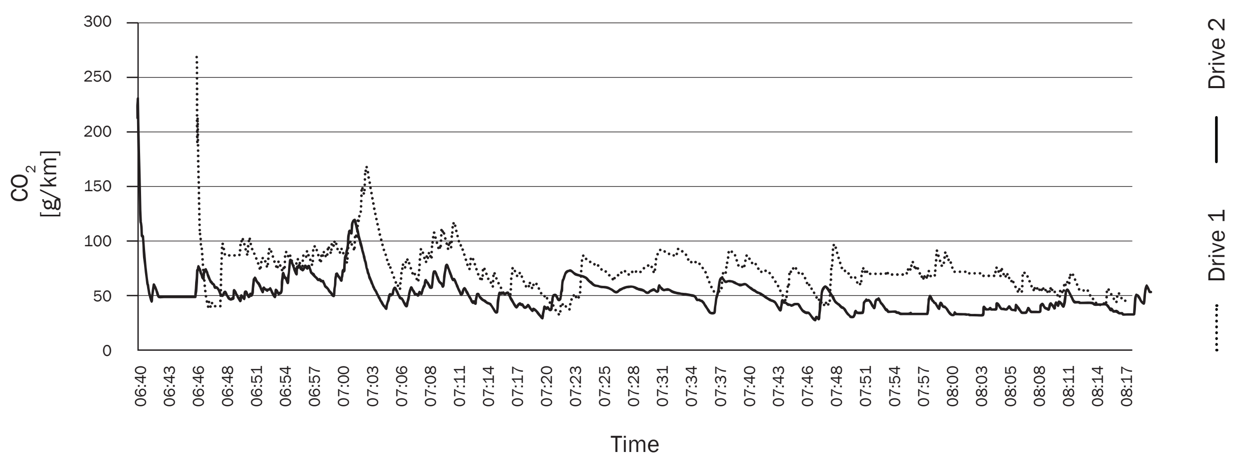

Figure 5 – Comparison of CO_2 emissions in Drive 1 and Drive 2 cases

Levels of CO_2 emissions when comparing the two driving modes are shown in *Table 4*. The differences that emerged when comparing emissions allow assessment of the advantages and disadvantages of various methods of driving and their evaluation.

Comparative overview of CO_2 emissions during each trip and different driving modes (Drive 1 and Drive 2) is shown in *Figure 5*. In the case of Drive 2, the average CO_2 emissions have been reduced, compared to Drive 1.

5. DISCUSSION

By using appropriate hardware and software tools modern mobile devices can be upgraded from their basic functionalities. This paper presents the simplicity and the ability of using ICT as a link between mobile devices, application Torque Pro (OBD 2 & Car) and bluetooth OBD-II device for easy collection of data on individual driving styles, and thus the comparison of different driving styles – eco-driving and normal driving.

When defining the input parameters for further simulation of savings in fuel consumption, the measured fuel consumption with respect to the driving mode was taken into account. Also, the number of kilometers travelled on a daily, monthly and annual basis is considered as the real value, provided the vehicle is travelling on the route which was investigated in this study (*Table 5*). The cost of fuel in *Table 5* is determined by the actual price of INA Eurodiesel fuel on April 15, 2014.

Table 5 – Input parameters for fuel saving simulation

Input parameter	Unit	Drive 1	Drive 2
Average fuel consumption	[l/100km]	4.68	3.61
Travelling distance on a daily basis	[km/day]	200	200
Travelling distance on a monthly basis	[km/month]	4,000	4,000
Travelling distance on an annual basis	[km/year]	48,000	48,000
Price of fuel	[kn/l]	10.01	10.01

Regarding the results of this research it is necessary to mention that they are based on vehicles of category B with a diesel engine, manual transmission (6-speed transmission) and according to used route with urban, rural areas and a highway. Further results will be obtained in the context of the vehicles with petrol engines and vehicles with automatic transmission, vehicles with 5 or 6-speed transmission, and a new series of vehicles that have "Eco Indicator", which helps the driver to adopt the rules of eco-driving (proper gear selection, economic or non-economic driving).

5.1 Fuel consumption

As the total length of distance travelled is concerned, there is just a slight (0.07%, or 60 [m]) difference between Drive 1 and Drive 2 due to GPS positioning error followed by computer car distance miscalculation.

According to the data from *Table 3*, in Drive 2 case, the lower average speed (6.55 [km/h] slower), and the lower engine RPM (by 190.5) were measured. This caused an increase in total duration of the trip in Drive 2 by 5 minutes and 41 seconds. Considering that Drive 1 achieved higher average RPM, the comparison shows a higher maximum speed of the vehicle (by 15.18%) and higher average speed (by 11.98%) in Drive 1 case, which affects fuel consumption.

The comparison of fuel consumption shown in *Table 3* demonstrates significant savings in Drive 2 case. The measurement results have shown that the average fuel consumption is reduced by 22.78%, which was additionally validated by the confirmation of reduced total quantity of fuel used on the test route by almost 23%.

Based on the comparison of fuel consumption and the average number of kilometers travelled in a given period, a simple simulation of potential savings if eco-driving is implemented was performed. Simulation savings were obtained by using the formula: Save [kn] = Drive 1 [kn] – Drive 2 [kn].

According to *Table 6*, the savings from the use of eco-driving modes amount to 22.86%. The above indicates a reduction of the cost of 21.42 [kn] on a daily, or 5,141.14 [kn] on an annual basis.

Table 6 – Fuel savings for various time periods

Time period	Drive 1 [kn]	Drive 2 [kn]	Savings [kn]	Savings [%]
1 day	93.69	72.27	21.42	22.86
1 month	1,873.87	1,445.44	428.43	
1 year	22,486.46	17,345.33	5,141.14	
5 years	112,432.32	86,726.64	25,705.68	

According to [22], the average monthly net wage in Croatia in June 2014 amounted to 5,558 [kn]. The amount of savings shown in *Table 6* is very close to one average net wage in Croatia in 2014.

5.2 CO_2 emissions

The analysis of CO_2 emissions in different driving modes shown in *Table 7* shows the reduction in average CO_2 emissions of gases in the amount of 31% in favour over Drive 2. Moreover, the research results show that the maximum CO_2 emissions were less by 16.33% in Drive 2. Due to the proportionality of the engine RPM and the amount of CO_2 emissions, it is not surprising that in Drive 2 case the average engine RPM was 10.87% lower.

These reductions in CO_2 emission levels can be applied to different periods of time, thus providing the potential savings and environmental benefits, as shown in *Table 7*.

Table 7 – Reduction in CO_2 emissions for different time periods

Time period	Drive 1 [kg]	Drive 2 [kg]	Savings [kg]	Savings [%]
1 day	14.54	10.03	4.51	30.99
1 month	290.76	200.66	90.10	
1 year	3,489.06	2,407.96	1,081.10	
5 years	17,445.32	12,039.80	5,405.52	

The percentage of savings in CO_2 emissions is 30.99%. This indicates that by changing the driving behaviour CO_2 emissions could be reduced by 4.5 [kg] per day on the specified route. If applied to an annual period, the reduction of CO_2 emissions amounts to 5,405.52 [kg].

6. CONCLUSION

There are numerous methodologies and principles of measuring driving efficiency. Previous studies have shown that most solutions for measuring the effectiveness of eco-driving modes comprise deficiencies in various forms (high cost, measurement complexity, professional measuring equipment, etc.), depending on the system.

The development of ICT allows customization according to various human activities, such as driver's behaviour in the traffic environment. The high efficiency and ease of application of ICT and sensor technologies in measuring the effectiveness of eco-driving have been demonstrated in this research. Real-time feedback allows prompt evaluation of driving. The shown methods offer the possibility of improving driving through the reduction of CO_2 emissions and fuel savings, which additionally contributes to improving road safety and reducing the number of traffic accidents. It is necessary to emphasize the importance of evaluating the capacity and competence of drivers for the use of mobile ICT technologies and sensors for eco-driving and use in everyday real driving conditions.

The results and methodological procedures indicate the simplicity, acceptable quality and relatively inexpensive model solutions for measuring driving parameters. In this research, a comparison of collected data, depending on the driving style, was outlined. The advantages of using eco-driving modes are consistent with previous research. Aditionally, savings in fuel consumption amount to almost 23%, while reduced CO_2 emissions yield 31%.

The proof of potential implementation of the presented solution is reflected through the availability and applicability of technical elements, relatively low cost of both ICT and sensor technologies, and the quality of the measured results. It has been proven that the increase in the number of users of such technical solutions results in reducing fuel consumption and CO_2

emissions. Further research will explore the development of new mobile ICT technologies and their practical application to vehicle safety, the total cost of implementation and economic opportunities for the drivers.

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SAŽETAK

EVALUACIJA EKO VOŽNJE PRIMJENOM PAMETNIH MOBILNIH UREĐAJA

Metode mjerenja načina i kvalitete vožnje u cestovnom prometu bitan su faktor prilikom prikupljanja podataka i naknadnoj analizi vožnje. Visok stupanj korištenja pametnih terminalnih uređaja te relativno niska cijena senzorskih On-Board Diagnostics (OBD) uređaja osiguravaju veliki potencijal i laku dostupnost navedenih tehnologija. Ovim istraživanjem prikazuje se mogućnost korištenja informacijsko-komunikacijske tehnologije (ICT) i senzorskih uređaja za potrebe mjerenja učinkovitosti eko vožnje. Jednostavnost implementacije informacijsko-komunikacijskih elemenata, točnost prikupljenih podataka i pohrana u vidu kasnije analize podataka nudi brojne mogućnosti upotrebe. U istraživanju je prikazano tehničko rješenje sustava i analiza prikupljenih podataka na realnim primjerima vožnje. Usporedbom normalnog i eko načina vožnje dokazana je prednost korištenja eko načina vožnje kroz smanjenje potrošnje goriva u iznosu od gotovo 23% i emisije CO_2 plinova u iznosu od 31%.

KLJUČNE RIJEČI

eko vožnja; aplikacija pametnih mobilnih uređaja; On-Board dijagnostika; potrošnja goriva; CO_2 emisija;

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