Human Interaction with Systems in the Vehicle Technology

Zlatko V. Sovreski[1,2], Petr Bouchner[2], Stanislav Novotný[2], Misko Dzidrov[3] and Elizabeta Hristovska[4]
[1,2]University "St. Climent Ohridski" Bitola - Faculty of Technical Sciences
Department of Traffic and Transportation Sciences- Czech Technical University in Prague
Faculty of Transportation Sciences - Czech republic
zlatkosovre@yahoo.com[2] and zlatko.sovreski@uklo.edu.mk

[2]Petr Bouchner and Stanislav Novotny
Czech Technical University in Prague
Faculty of Transportation Sciences1- Czech republic
xnovotny@fd.cvut.cz

[3]Misko Dzidrov is with the University "Goce Delcev" Stip
Faculty of Mechanical Engineering
Republic of N. Macedonia
misko.dzidrov@ugd.edu.mk

[4]Elizabeta Hristovska is with the University "St. Climent Ohridski"Bitola
Faculty of Technical Sciences
Republic of N. Macedonia
elizabeta.hristovska@uklo.edu.mk

ABSTRACT: *In electric vehicle technology, the functioning of humans with cars is challenging as it requires efficient human interaction with system. We have analysed many human-machine interaction systems in this paper. We have addressed the in-vehicle interaction in this work. The use of eco-mode and influences are tested in experimentation.*

Keywords: HMI, Electric Vehicle, Hybrid Car, IVIS

Received: 19 November 2022, Revised 3 March 2023, Accepted 9 March 2023

DOI: 10.6025/jcl/2023/14/2/43-49

1. Introduction

One of the main problems of electric vehicles is limited battery capacity and longtime of battery recharge. Unlike in case with conventional cars energy management system is crucial for EV, where it is not a problem of ecology of driving, but it is also essential for general utilization of the EV. The range may vary on driving style and driving conditions in several tens of presents (for contemporary cars the difference is of 100 km). Most of the general rules of ecodriving can be applied to electrical vehicles too. Similarly to conventional cars, the eco-driving techniques may be applied in EV:

• To monitor the fuel use.

• To drive smoothly and mind the traffic ahead.

• Not to use the break and gas pedals aggressively.

• Try to avoid speed oscillations when possible, i.e. on highways. Turn on cruise control when possible.

• Not overuse air conditioning.

• Use the air conditioner smartly – not under- or overuse.

• Check the tire pressure.

• Not to overload car with unnecessary load and not to increase aerodynamic drag like one from the roof rack, or open windows.

This problem could also be solved with the help of application of automated vehicle systems.

2. Systems Currently in Use

According to time scaling by the IEA (International Energy Agency), we are now living the third age of electrical vehicles. Quite a variety of HMI (Human-machine interaction) systems have been developed since the beginning of development of electrical vehicles by now. Let us assume that vehicle-to-driver (and vice versa) communication can be subdivided into display systems (the information displays and gauges), starter system, pedaling and charging system. Display systems are usually a wide variety of designs. Besides the intuitive design, interface needs to provide useful and relevant information sufficient to keep driver confident in car functioning.

2.1. Different aspects of EV driver-car interaction

There two main streams in approaches to design. The first one pursuing the goal to make the appearance of the systems maximally similar to those in ordinary fuel car with exploitation of mechanical gauges with arrows where and displaying EV systems operation related information instead. The familiar appearance makes the interaction intuitive and transition from fuel to electric cars more comfortable. Placement and manner of delivery of information is to be carried out on the assumption of the general knowledge and standards. According to ANSI (American National Standards Institute) [2] the indicators standardization is not electric vehicle specific, general rules for car displays apply here. Thus, instead of tank fuel level, there is an indicator of battery capacity, energy use and recuperation is usually associated with the revolutions counter, and navigation display usually contains map of refueling stations. The location of the gauges is usually as it were in a fuel car (Mitsubishi I Miev, Nissan Leaf).Sometimes the gauges location varies, like in Tata Vista EV, where the main meter is located at navigation panel place, and in Smart for two Electric Drive energy use and battery controls are above the navigation panel. Also design of indicators can be different (Ford Focus Electric). In those systems the information representation differs – battery charge can be expressed in percent, in km or in scale value. Another approach is quite forward in design, different in location of interface components and even uses the external and portable devices as in-vehicle display (BMW i3).Most of electric vehicles have also a display showing info related to eco-ing.

2.2. Propulsion System Interaction

Due to regenerative breaking vehicle feedback from pressing the pedals in EV is different. Vehicle decelerates (with possibility to even stop at intersections) by depression of drive pedal only and starts on after idling by its pressing thus making it possible to drive with one pedal only. There is no clutch, to there are only two pedals which can be rather inconvenient for drivers who are used to mechanical gear.

2.3. Audio Feedback

We know the importance of audio stimuli, car engine in particular, which is described in relation to automobile simulator engine in [3] and [4]– for driver and, in our context, also for pedestrians', cyclists 'and blind people safety. There exists quite a variety of possibilities for improvement of car to human interaction quality due to possibility of computer simulation of car engine sound. Through proper legislation, it is possible to regulate the sound volume inside and outside the car, solve the problem of sound proofing and make adaptation to electrical vehicles in general more gradual. Obligatory simulation of engine sound in electrical and hybrid vehicles has already been implemented in the USA [5] and in Europe and is referred to as Electrical Vehicle Warning Sound. According to legislation, the sound (Approaching Vehicle Sound for Pedestrians System – Nissan leaf) is activated while driving bellow the certain speed (50 km/h or 20 mph range in city) and is deactivated at higher speeds, when enough noise is generated by tire friction and aerodynamic drag. Being a necessary solution for pedestrians' safety, it does not intrudeinto the car cabin acoustic, which is an asset for driver and passengers comfort. Manufacturers of applied systems suggest pedestrian warning and in-cabin sound modules, the later can be switched on and off with possible volume adjustment (Electrical Vehicle Electronic Sound System by EVEESSTM, Sound Box by S.M.R.E. Engineering etc.).

Figure 1. Examples of EV charging stations: corporate station at Transportation Faculty, CTU in Prague (left),Tesla public charging station with solar energy source (upper right), home charge station by Easy charge (bottom right)

2.4. Charging

In electric vehicles, visual interface is concentrated around efficient energy consumption. The basic reason of it is the range anxiety phenomena, which is a fear of electric vehicle driver to run out of "fuel" and not be able to charge the vehicle in time. The network of charging stations is not as dense as one of the fueling stations. Users, while switching from fuel cars, are to change their habits of route planning. The possibility of driving right after refueling is not available in case of EV, where recharging takes hours while driving electric vehicle requires certain route planning. That is why the infrastructure of charge stations is a very important factor for convenience of vehicle exploitation. Besides, the proper delivery and management of information regarding the charging stations is very important as the factor influences driver's route planning. Charging station solutions for EVs are proposed by special companies (General Electric, Eaton, Siemens etc.) as well as by electric cars manufacturers (Tesla Motors etc.) and can be available on the market as public charge stations, corporate stations for companies supporting the development of green technologies, and for private use at homes. The architecture of station can imitate the fuel station (public solution), parking spot (corporate and public solution) or look like a socket (more or less private solution). For reference please see Figure 1. EV battery can be charged manually at the station or remotely via existing remote control applications for cell phone having your car connected to the socket.

3. Related Research

3.1. Audio Feedback

Experimental assessment of EV or hybrid HMI has been conducted by researchers from Sweden [6]. The selected group of participants had no, or little experience of driving electric or hybrid car. Goal of experiment what functional information should be in EV, how it can be presented and what approach of the interface (i.e. traditional, or innovative) should be preferred. Both stationary and while driving interface testing was performed. Probed were allowed to provide comments and opinion during the tests, relevant notes were made for analysis. Besides, number of errors and driver surveying were collected. The tested systems were: battery charge symbol and need of charge, message about limited performance of vehicle, eco meter. Two phases of experiment covered testing of two different concepts. During the first phase the classical (similar to fuel car) approach of HMI was presented for testing, while in phase 2 the one was developed and enhanced according to the reflections collected from participants in phase 1. Interface design changed from imitation of classical gauges, location of information changed too with moving of speedometer to the left and adding more information in the bottom and on the right. The interface looks more like battery device interface. During the experiment drivers related to information by habit and at first understood it intuitively as if they were in a fuel car. Among the compared systems were battery charge level, eco meter, distance to goal indicator, and readiness of EV electric consumption, warnings and some others. The information characteristic to EV (or hybrid) only was accepted better by drivers in the second phase. While in the first they were looking more to where the things should be. The most familiar systems in both cases were the battery level, distance to goal (and empty) and speedometer, which is quite understandable as the first is familiar from mobile devices and the second – partially, from navigation system interfaces.

Don Norman in his book specifies for basic principles of development of sound of electric cars and hybrids: it shall convey an alerting function (vehicle is somewhere near), it shall serve for orientation regarding vehicle direction of movement, it shall not be annoying and it shall be designed in the terms of certain standards so that it is able to be interpreted as a car sound in relation to the term of skeuomorphic [7].

Cooperative research by a Laboratories Vibrations Acoustique, INSA-Lyon, France and Institute für Psychologies, Technische Universität Darmstadt, Germany was made to compare sound perception by sighted (100 participants) and blind people (53 participants) of diesel and electric car sound [8]. Nine variants of electric car sound were proposed to propends. The task set for participants was to determine from which direction the vehicle was coming in pedestrian crossing in dry and rainy weather (rain sound added) with traffic noise simulation. Better results in response time of vehicles detection were detected in dry weather, and for EV some respondents could identify the approaching car at unsafe (under 7.5 m) distance. There was not a big difference between responses of blind and sighted people.

Visual interface for electric vehicle Efficiency of interface in motivating driver for eco-driving can be assessed in laboratory with the help of vehicle simulator. The emissions, pedals use, acceleration/deceleration can be measure in simulated driving environment.

One of the proposed approaches described in [9], where a system providing static and dynamic feedback is developed. The system will provide voice notifications (warnings) when driver is not driving in eco-mode and driver will be given recommendations on driving after the measurement. In experiment five non-eco types of driving were predefined: rapid acceleration and deceleration, high engine revolutions rate, high speed with high amplitude on highways or freeways and idling while being parked. Visual interface of the proposed system indicated CO2 emissions. The experiment results showed decrease in CO2 emissions. There were three tests run, both static (3.43%) and dynamic (5.45%) feedback showed CO2 emissions reduction.

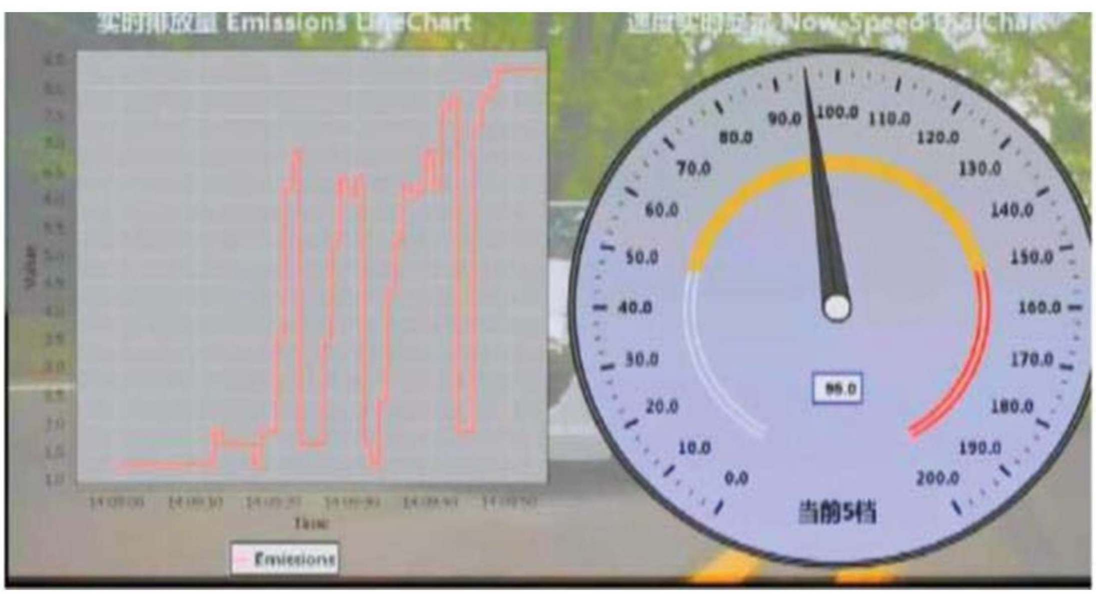

Figure 2. Proposed eco-driving mode notification [11]

Another research proposes interface with notifying driver about eco related information in trucks (Figure 3) [10].In this experiment drivers were testing a notification system and were to evaluate the kinds of notifications. The design of experiment was to identify which of the presented information was found useful and helpful for the drivers. There were two types of information on display – permanent (average fuel meter, speed guidance, acceleration/deceleration guidance, and coasting guidance at crests and changing (speed, feed forward advice and performance feedback indicating how well the driver performed in the last event (the stars and text under the speedometer). After the experiment drivers chose the most useful among the presented information – see Figure 4.

Other than visual types of notification have been tested by [11]. There were three systems proposed: Two hap tic accelerator pedal systems (hap tic forced and hap tic stiffness) and one multimodal visual–auditory. The system suggested information about fuel efficiency and position of acceleration pedal. Depending on the section speed limit, probed were advised to select acceleration pedal position angle: increase (15% depression), decrease (0% depression) or maintain their speed (7% depression) – see Figure 5 for reference. Three system notification types showed comparatively similar outcomes, where all systems have successfully improved Eco manner of driving, with the only difference for deceleration with hap tic force system, which was more efficient. Visualvocal interface was considered more loading by the drivers' subjective opinions.

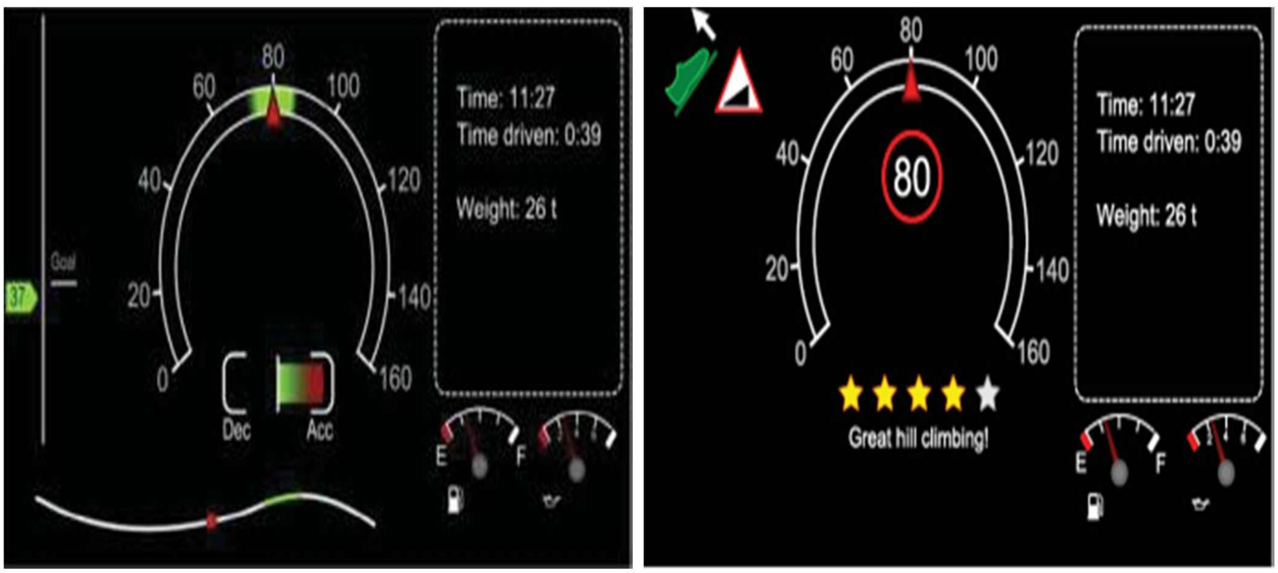

Figure 3.Permanent and changing information about eco-driving [10]

Number of participants who selected the different eco-driving constituents.

Eco-driving constituent	Number of participants
Speed guidance (continuous)	12
Average fuel meter (continuous)	14
Coasting guidance at crests (continuous)	9
Acceleration/deceleration guidance (continuous)	9
Speed alert (intermittent)	8
Feedforward advice (intermittent)	15
Performance feedback (intermittent)	13

Figure 4. Notification selection by propends [10]

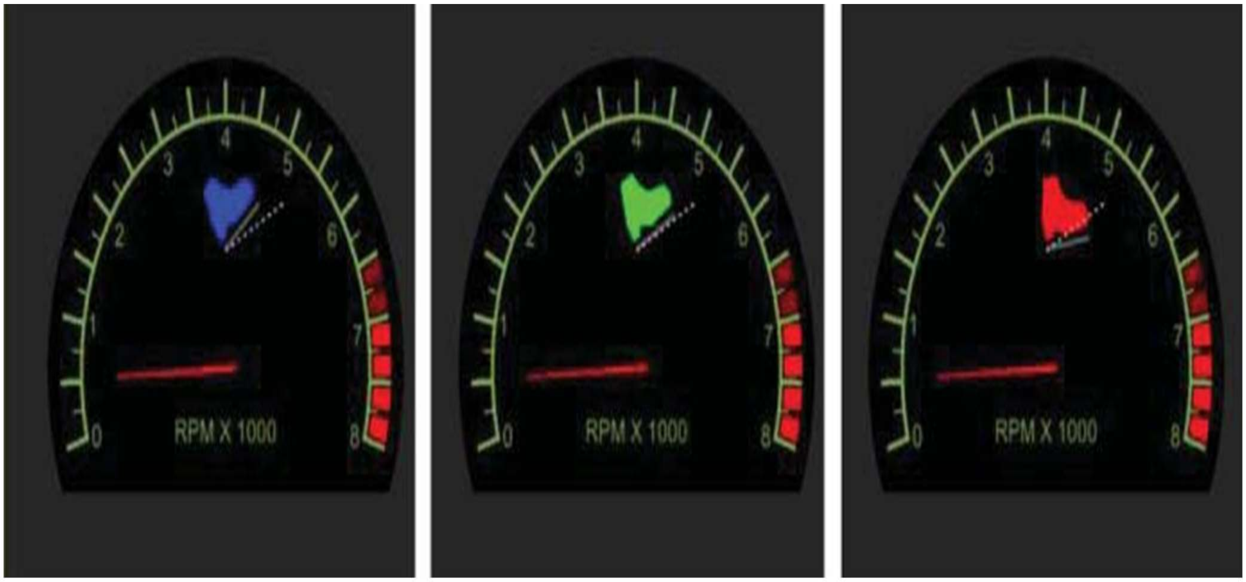

Figure 5. Acceleration pedal advise in [7] - left is insufficient, right is excessive, middle is normal

4. Conclusion

Motivation of eco-driving is proved to be efficient method of overall driver awareness of necessity for driving smartly, save natural resources and decrease contamination of the ecosphere. Real-time dynamic feedback appears to be more efficient method for motivation of eco-driving. Efficiency of notification and study of the target audience of such systems is very important. Average consumer on a vehicle market will be found to be used to classical outline of the in-vehicle system interface. For many drivers over 50 the visualization is found to be unclear or distracting due to vision issues with age. That is why it is important to perform sufficient research on visual design and representation of useful information: more types of notifications (like hap tic an acoustic) shall be considered for design by car manufacturers.

References

[1] Yoshizawa, S., Tanaka, Y., Ohyamaguchi, M., Kitazaki, S., Kuroda, K., Sato, S., Obata, T., Hirokawa, Y., Iwasaki, M., Maruyama, K. (2011) Development of HMI and telematics systems for a reliable and attractive electric vehicle. SAE Technical Paper Series.

[2] Electric Vehicle Standards Panel. Standardization Road Map for Electric Vehicles, version 2.0. American National Standardization Institute (2013).

[3] Hajný, M. (2006). Module of Audio Subsystem of Car Simulator,(in Czech) [Diploma Thesis], FEE CTU. Prague.

[4] Ing. Bouchner, P. (2007). Driving Simulators for HMI Research, PhD [Thesis], Institute of control and Telematics. Chienkuo Technology University: Prague.

[5] U.S. Department of Transportation Proposes, New Minimum Sound Requirements for Hybrid and Electric Vehicles [Press release] (2013) (source. www.nhtsa.gov/. last accessed on 29 May, 2015).

[6] Strömberg, H. et al. (2011) Proceedings. Driver Interfaces for Electric Vehicles, AUI, 2011.

[7] Norman, D. (2013). The Design of Everyday Things, rev. and expanded edn. Available from Basic Books, a member of the Peruses Books Group. U.K. MIT Press.

[8] Parizet, E., Ellermeier, W., Robart, R. (2014) Auditory warnings for electric vehicles: Detestability in normal-vision and visually impaired listeners. *Applied Acoustics*, 86, 50–58.

[9] Zhao, X., Wua, Y., Rong, J., Zhang, Y. Development of a driving simulator based eco-driving support systém. Transportation research part C: Emerging technologies. Elsevier Ltd. Contents Lists Available at Science Direct.

[10] Fors, C., Kircher, K., Ahlström, C. (2015) Interface design of eco-driving support systems – Truck drivers'preferences and behavioural compliance. Transportation Research Part C. Elsevier Ltd: *Amsterdam,* 58, 706–720.

[11] Ing. Sovreski, Z.V. PhD (2013). Study and Application of Hydrogen as an Alternative Propulsion in Vehicles in Urban Mass Transportation [Doctoral Dissertation]. Chienkuo Technology University in Prague.