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Effect of Human Response on the Effectiveness of Advanced Vehicle Control Systems (HR_{AVCS})

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***Abstract*— This work aims to investigate the effect of driver response to relayed messages through Human Machine Interface (HMI) on the effectiveness of Human-Vehicle Interface (HVI) and to enable the optimized design of HMI. The investigation and mathematical modeling cover vehicles with Advanced Vehicle Assistant System (ADAS), which operates using Advanced Vehicle Control System (AVCS). The presented model uses driver response time and machine (electronics, sensors, processors) processing time to measure vehicular efficiency and driver interaction, which is also a function of the HMI design, and the way messages are passed to the driver. The produced model uses a probability function that can be used in the design and testing process to assess the effect of failure on the designed interface and relates the function to the driver's response time ratio and the vehicle electronics' processing time. The presented work concluded that as the driver response time increases, effective interaction decreases as a probability function. Also, as the driver response time deviates from the specified threshold, the effective interaction decreases, which also applies to the processing time. In addition, as the time ratio between the driver responses to the machine processing (Time Ratio) increases, the effective interaction parameter (R) value decreases. The work also proved that a more adaptive model is possible using a probability function correlated to the response time ratio to processing time.**

***Keywords*— HMI; ADAS; AVCS; HVI; probability; mathematical modeling; driver reaction; processing time.**

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I. INTRODUCTION

Many vehicle accidents result from human errors divided into recognition, response, reaction, and decision errors. Over the past 20 years, road vehicle technology has revolutionized thanks to electronics technology advancements incorporated into the automotive sector. Over 100 microsystems in modern and advanced vehicles serve the driver by assisting with operation, comfort, and safety. Most of the vehicle's operations are controlled by electronics, and efforts are being made to coordinate vehicle- to vehicle (V2V) and V2I (vehicle-to-infrastructure) information sharing.

The motivation behind vehicular development and its automated assistance systems is to reduce accident frequency and severity, energy conservation, and dangerous exhaust emission reduction with the advancement of technology and the implementation of sensors in vehicles, and the development of Advanced Driver Assistance Systems (ADAS) that relies on Advance Vehicle Control Systems (AVCS) and the importance of interaction with the driver.

Electronic networked driver assistance systems significantly improve road safety, as human factors, mainly the driver, cause most road accidents. A driver's poor decision, an incorrect assessment of the situation, or a lack of consideration are the main causes of vehicular accidents, in addition to the insufficient technical state of a particular vehicle, due to the owner not carrying out scheduled maintenance for the vehicle. If the driver is in a poor physical or mental state, such as tired or otherwise unfit, the likelihood of making poor decisions increases [1]–[5].

Technical solutions are available to warn the driver of late recognition in cases of losing vehicle stability, unintentional lane departure, or pileups occurring from behind. If this is insufficient, assistance systems automatically intervene in the management of the vehicle, greatly reducing the severity of the accident's effects. A last-second emergency stop could be used as an intervention, greatly reducing the vehicle's kinetic energy before impact. Driver assistance systems may also make up for any potential driver errors in judgment [6]–[8].

Highly automated driving systems will promote sustainable and safe mobility by relieving drivers of stressful or distracting activities. The complexity of modern road vehicles already prevents some driver segments from utilizing new driver-aid systems. New ADAS features must be integrated into driver education programs so that they are understood and get accustomed to by drivers. The application should be very simple and seamless to encourage such functions.

Driver overload or underload conditions are two examples of traffic situations where drivers particularly need assistance. Driver stress may cause a decline in performance when the driver is required to complete several activities at once while also paying attention to other vehicles (such as in demanding scenarios like turning at junctions or driving in the congested lanes of construction zones). Driver underload occurs when very few impulses reach the driver during repetitive driving, which causes drowsiness (such as in boring situations like traffic jams or long-distance driving). In normal driving situations, the driver is engaged in enough driving to keep him alert and focused but not enough to get confused or disoriented [9], [10].

Informing drivers about potentially harmful scenarios is the first step in helping them drive safely. The motorist is only given a warning at this point, with no additional assistance or involvement. The decision to act after receiving the warning is entirely up to the driver. The second degree of assistance goes beyond simple warnings and helps the driver by showing him how to operate the vehicle safely in potentially dangerous circumstances. This level presupposes that the driver is aware of the potentially dangerous situation (warning), and additional guidance is given to the driver, pointing him toward the appropriate action.

Automated vehicle control intervention is the final level of driver assistance. There are classifications for semi-automatic and highly automated driving, depending on the intervention degree. While the vehicle's longitudinal movement is controlled automatically during semi-automated driving, longitudinal and lateral movement are controlled automatically during highly automated driving [11], [12].

Advanced Driver Assistance Systems (ADAS) and Vehicular Information Systems are only two examples of the many new in-vehicle technologies available today. Additionally, the use of portable computer devices inside vehicles is growing quickly. These new technologies have enormous potential to improve life, work quality, and road safety, for example, by giving in-vehicle access to cutting-edge communication and information sources. However, unforeseen behavioral responses to the technology, such as system over-reliance and safety margin compensation, may dramatically reduce or even cancel the safety gains of ADAS.

Engineers and researchers have designed human-machine interfaces (HMIs) for many years to ensure and improve the optimum interaction between drivers of conventional vehicles and their vehicles. The creation of concepts for human-machine interaction had to take a user-centered approach. The main components of an automotive HMI are output channels, which inform the driver about the system's status through displays, and auditory and haptic messaging [13], [14].

A critical aspect of vehicle safety is Human-Machine Interface (HMI). HMI acts as a mediator between the driver and the rest of the vehicle dynamics in terms of carrying out decisions made by the driver as a result of messages relayed to the driver through it.

The human-machine interfaces specify the bidirectional link between the driver and the vehicle. Good HMI device design is a difficult engineering endeavor. The development of an interface that is easy to use, intuitive, and ergonomic requires extensive knowledge [15], [16], [17]. Designing HMI should be based on the following requirements:

- Ability to read displayed messages easily.
- Clarity of displayed messages.
- Ease of access and use of vehicular functions.

The requirements listed above are intended to improve traffic safety. These arguments support the idea that the driver should not be distracted by the vehicle's handling.

HMI design and message delivery implementation can affect driver response and could lead to driver distraction [18], [19], [20]. Accidents can also occur as a combination of driver and HMI errors, which could be a result of:

- Message processing delay
- Message display delay
- Incorrect data delivery
- Out-of-order message delivery

Thus, driver interaction can be affected by the design and means of message delivery and by the driver's mental and psychological condition, physical condition, exhaustion, and fatigue.

Optimized HMI, together with AVCS, can provide drivers with an interactive, proactive system that supports their decisions by informing them, advising them of the best course of action to be taken, and under critical conditions to act on behalf of the driver to avoid traffic incidents and fatal accidents [21], [22], [23].

Implantation of HMI interacting with AVCS in the form of ADAS should be a help, not a hindrance to the driver, as in distracting or disturbing the driver from carrying out proper driving, and not be very complex in its interface. Hence, the driver finds it difficult to understand and use.

Thus, the design of HMI needs to facilitate readability and orderly delivery of messages to the driver with the driver's ability to respond and react to such delivered messages with the best decision based on provided data. Hence, human factors must align with machine parameters to enable the safe driving of today's advanced vehicles [24], [25].

Cooperation between humans and vehicles is necessary for automation to operate correctly. If the partnership functions as intended, the human driver may give up some. In that case, all, or even some portion of control of the vehicle, may similarly need human takeover in the event of failure or system awareness that it cannot handle the situation at hand or one that is about to arise. Alternatively, the vehicle can agree to the human's request to take control [26], [27].

HMI cannot be viewed solely as a collection of audiovisual displays communicating data and settings back and forth. It also covers the vehicle's controls because they serve as conduits for driver feedback and human input into the vehicular environment.

Feedback may include not only the conventional feel of the vehicular controlling techniques, such as the steering wheel, but also the vehicle's dynamics about a particular environment and extra haptic aspects, such as resistance, pulses, vibrations, and physical assistance. In this context, the term HMI will broadly refer to all explicit and implicit communication between a human operator and a vehicle [28], [29].

Drivers of vehicles with automatic features may be unaware of the limitations of these systems. Because these functions change over time, there is a vital necessity for the HMI to assist humans in understanding their capabilities. According to the HMI, humans must be made aware of what is expected of them regarding active participation and monitoring. Such comprehension is necessary for well-calibrated trust and safe and comfortable functioning. False expectations about what the human will notice on the part of the system, as well as an overreliance on system capabilities on the part of the human, could result from a vehicle and human's miscommunication about what the other party will do [30], [31]. With these automatic features, the vehicle and the driver can be considered a single cognitive system that must work together to provide safe and comfortable driving. This work presents mathematical modeling of the interaction between the driver and the provided vehicular interface and its effect on the effective use of such advanced designs in ADAS and AVCS-based vehicles. The work models driver response time and processing time as the parameters for assisted driving. This work aims to support more optimized driver-vehicle interactive designs through HMI by considering human and processing variables. This will correlate the human factor to sensors, electronics, and processing technologies used in the HMI, thus contributing towards safer and more comfortable driving [32], [33].

II. MATERIALS AND METHOD

The structure and dynamics of a person's personality, experience and competence, age, gender, sociodemographic traits, health-threatening habits, exhaustion, illness, and other factors all impact how they behave in traffic. The capacity of the sensory organs, mental abilities, and psychomotor abilities are those of a person as a participant in traffic and as a factor in traffic safety. Human ability disparities can be seen in how quickly people react to danger, perceive it, and how well they can get beyond it. The person's psychophysical capacities, the vehicle's technical qualities, the road's characteristics, and the local environment must all be in harmony for safe traffic operation [34], [35].

Both predictable and unforeseen elements (incentives) that influence drivers' behavior can be found in the traffic environment. The most hazardous factors for traffic safety are unpredictable and have no clear classification. The man responds to danger using his psychophysical, uniquely human abilities, including perception, comprehension, reasoning, response, and reaction [36], [37].

Information is accepted and used as a basis for an event's experience in the human body. Environmental events that happen suddenly and unforeseen call for swift response and resolution. When a problem is resolved correctly and on time, it can be safely resolved, but when a problem is solved incorrectly and late, it can immediately become dangerous for traffic. The essence and seriousness of the event's course and duration are determined by how quickly it occurs and how long it lasts [38].

Both the subjective traits of the driver and the conditions of the objective environment affect the driver's response time. This is the time it takes for the driver to recognize the threat and decide whether to halt the vehicle or veer right or left. Receiving, analyzing, and coming to judgments regarding forced information is the process of perception.

A driver's awareness is a crucial aspect that needs to be constantly evaluated. On highways, drowsy driving can result in several accidents and incidents that can cost lives, money, and even physical harm. Additionally, slower decision-making due to the drivers' greater reaction times can lead to a collision or a traffic accident. The average reaction time value is crucial in actual practice since it serves as a standard in many transportation calculations, such as accident reports when forensic experts reconstruct the sequence of a traffic collision [39], [40].

When a crash occurs at a fast speed, there is a considerable danger of fatalities or serious injuries. To design a vehicle that ensures the highest degree of road user safety, for example, or to develop new autonomous systems, it is required to assume the proper level of the driver's reaction time. The safety distance between the vehicles should also be explained using this figure for instructional purposes. Additionally, the theoretical level of reaction time should be used, whether planning the flow of traffic, placing variable traffic signs, or simulating various traffic circumstances.

Driver response time often refers to how long it takes a driver to react after receiving an emergency signal because of their functional limitations. The motorist does not consider the need to take appropriate steps until after making a judgment, at which point they begin. While operating a vehicle, drivers experience various emotions, and their reactions to unexpected situations vary.

The most frequent distractions are talking to fellow passengers, managing the behavior of traveling children and animals, using a cell phone, and using automobile electronics, including the radio, air conditioning, and navigation systems. Other affecters, such as hand, fatigue, stress, alcoholism, drug use, illness, or malaise, can all considerably lengthen reaction times and cause accidents.

Applying ecological principles when creating an HMI is important. The intention is to avoid Regarding potential progression to higher cognitive control, i.e., to keep the person at their talents and location necessary, the levels of the rules, and to prevent the slower and less efficient knowledge that may be more dangerous.

The mentioned components, essential for automated HMI design vehicles, are each covered in this study independently. Give the necessary knowledge about the automated vehicle's capabilities to enable the following:

- Minimizing driving mode errors.
- Establishing the proper trust calibration.
- Encouraging the right amount of attention and action.
- Minimizing automation surprises.
- Provision of comfort to humans by reducing uncertainty and stress.

After discussing these requirements, a simplified model of the impact of these items is presented, together with implications for HMI design.

The main considered parameters in the presented mathematical model are:

- Response time (T_{human}): The needed time for a driver to notice that an action is required is when a message is relayed to the driver and made clear to the time the driver realizes that an action must be taken. The driver response time is a function of the mental status of the driver, age, experience, physical health, road conditions, weather, and Human Machine Interface (HMI) design.

- Processing time for the vehicle (sensors and hardware) ($T_{machine}$), which is the time taken to process a message inside a vehicle received through the onboard unit (OBU).

Based on the previous assumptions, a mathematical model is constructed. Such a model will show the human element's contribution to affecting the AVCS system's performance in the vehicular environment.

The presented effectiveness model is important to assist in designing and characterizing the different vehicular systems and establishing confidence levels in their mechatronic systems as well as the driver-vehicle interface design, as this determination is a key to driver safety, mobility, vehicle reliability, and comfort. Also, many accidents can be avoided if a reliable vehicular management system is used to overcome human driver limitations.

The effect of human time on actions taken by the AVCS system can be represented in equation (1).

$$T_{human} = \left(T_{perception} + T_{reaction}\right) = \left(2 * T_{response}\right) * \left(\frac{1}{1 + exp - \left(T_{response\ threshold} - T_{response}\right)}\right) \quad (1)$$

The effect of machine time on actions taken by the AVCS system can be represented in equation (2).

$$T_{machine} = \left(T_{(sender)} + T_{(receiver)}\right) = \left(2T_{processing}\right) * \left(\frac{1}{1 + exp - \left(T_{processing\ threshold} - T_{processing}\right)}\right) \quad (2)$$

Equations (1) to (2) include the squashing sigmoid function, an intelligent control function. It also acts as a comparator enabling critical decision-making. In addition, it is used to enhance HMI design by substituting different values for the T_{human} interface and $T_{machine}$ using experimental and simulated values to achieve optimum response times that contribute to higher reliability, safety, and better usability.

Also, as vehicular design and technology advance with different materials, sensors, electronics, and higher communication bandwidths with faster transfer rates, different values for the T_{human} threshold and $T_{processing}$ threshold can be tested using sigmoid functions. Such testing can be tied with HMI designs and driver responses, leading to different usability values correlated to advances in vehicular communication technologies. In addition, the control dynamics were achieved using the sigmoid function under different scenarios and conditions. The previous is critical, especially when considering other parameters, such as driver age, driving experience, and driving conditions under which drivers must interact with the vehicle interface.

The relative effect of human interaction over machines is represented in equation (3).

$$R = \left(\frac{T_{machine}}{T_{human} + T_{machine}}\right) \quad (3)$$

Substituting equations (1) and (2) into equation (3) results in equation (4).

$$R = \left(\frac{\left(2T_{processing}\right)\left(\frac{1}{1 + exp - \left(\Delta T_{processing}\right)}\right)}{\left(2T_{response}\right)\left(\frac{1}{1 + exp - \left(\Delta T_{response}\right)}\right) + \left(2T_{processing}\right)\left(\frac{1}{1 + exp - \left(\Delta T_{processing}\right)}\right)}\right) \quad (4)$$

Where:

$T_{response}$ and $T_{processing}$ threshold: Maximum safety human response and electronic machine interface times.

Equation (4) can be represented as in equation (5).

$$R = \left(\frac{\left(2T_{processing}\Phi\right)}{\left(2T_{response}\Theta\right) + \left(2T_{processing}\Phi\right)}\right) \quad (5)$$

Equation (5) can be rewritten as in equation (6).

$$R = \left(\frac{\alpha}{\alpha + \beta}\right) \quad (6) \quad (6)$$

Dividing by α results in equation (7).

$$R = \left(\frac{1}{1 + \kappa}\right) \quad (7)$$

κ is given by equation (8)

$$\kappa = \left(\frac{\Theta}{\Phi}\right)\left(\frac{T_{response}}{T_{processing}}\right) \quad (8)$$

From equations (1) and (2), equation (8) becomes equation (9).

$$\kappa = \left(\frac{\left(1 + exp - \left(T_{processing\ threshold} - T_{processing}\right)\right)}{\left(1 + exp - \left(T_{response\ threshold} - T_{response}\right)\right)}\right)\left(\frac{T_{response}}{T_{processing}}\right) \quad (9)$$

Equation (9) can be rewritten as in equation (10).

$$\kappa = \left(\frac{\left(1 + exp - \left(\Delta T_{processing}\right)\right)}{\left(1 + exp - \left(\Delta T_{response}\right)\right)}\right)\left(\frac{T_{response}}{T_{processing}}\right) \quad (10)$$

Three distinct cases can be realized in equation (10):

1. $\Delta T_{processing} = 0$ ➔ Equation (10) becomes equation (11).

$$\kappa = \left(\frac{2}{\left(1 + exp - \left(\Delta T_{response}\right)\right)}\right)\left(\frac{T_{response}}{T_{processing}}\right) \quad (11)$$

2. $\Delta T_{response} = 0$ ➔ Equation (10) becomes equation (12).

$$\kappa = \left(\frac{\left(1 + exp - \left(\Delta T_{processing}\right)\right)}{2}\right) * \left(\frac{T_{response}}{T_{processing}}\right) \quad (12)$$

3. $\Delta T_{processing} = 0$ and $\Delta T_{response} = 0$ ➔ Equation (10) becomes equation (13).

$$\kappa = \left(\frac{T_{response}}{T_{processing}}\right) \quad (13)$$

The assumption that the difference in response and processing times and threshold times could reach large values is rare. It will mean that there is a major human problem and a technical issue, which statistically has a very small probability of occurring using the AVCS system.

When $\kappa<1$, there is a major technical problem with the vehicle sensors, as the processing time is too large (driver response time cannot be less than processing time). When $\kappa>1$, a human response issue needs handling. Also, κ‡1, as driver time, cannot equal processing time.

Predicting usability values as part of an intelligent algorithm involves using probability parameters. This will enable decision-making based on expected values to take action and allow technical issues to be considered, thus avoiding traffic problems. So, equation (7) becomes equation (14).

$$R = \left(\frac{\left(1 - P_{failure}\right)}{1 + \kappa}\right) \quad (14)$$

Substituting equation (10) into equation (14) results in equation (15).

$$R = \left(\frac{\left(1 - P_{failure}\right)}{1 + \left(\left(\frac{\left(1 + exp - \left(\Delta T_{processing}\right)\right)}{\left(1 + exp - \left(\Delta T_{response}\right)\right)}\right)\left(\frac{T_{response}}{T_{processing}}\right)\right)}\right) \quad (15)$$

At $\Delta T_{processing} = 0$ and $\Delta T_{response} = 0$, and $P_{processing failure} = 0$ ➔ Equation (15) becomes equation (16).

$$R = \left(\frac{1}{1 + \left(\frac{T_{response}}{T_{processing}}\right)}\right) \quad (16)$$

Equation (15) can be represented as in equation (17).

$$R = \left(\frac{\left(1 - P_{failure}\right)}{1 + \left(\left(\frac{(1 + \lambda)}{(1 + \omega)}\right)\left(\frac{T_{response}}{T_{processing}}\right)\right)}\right) \quad (17)$$

At the limit of 0, for both λ and ω, equation (17) will reduce to equation (16). This is due to the zero probability of failure. On the other hand, if both λ and ω approach 1, then usability in equation (17) approaches zero, as the probability of failure becomes very high. If either λ or ω is zero, then usability will be at half its maximum value. Equations (16) and (17) show that usability decreases as the probability of processing failure or response failure increases.

Equation (17) can be simplified as in equation (18).

$$R = \left(\frac{\left(1 - P_{failure}\right)}{1 + \left(\varphi\left(\frac{T_{response}}{T_{processing}}\right)\right)}\right) \quad (18)$$

Equation (18) can be represented as in equation (19).

$$R = \left(\frac{\left(1 - P_{failure}\right)}{1 + \left(\varphi(Time_{Ratio})\right)}\right) \quad (19)$$

Equation (19) analyses effective driver interaction with driven vehicles through HMI.

III. RESULTS AND DISCUSSION

Figures 1 to 6 Show the effect of both probability of failure as the independent variable and the effect of variation of driver response time and machine processing time on effective interaction between the driver and the vehicle. From the figures, it is evident that the response time ratio $\left(\frac{T_{response}}{T_{processsing}}\right)$ Increases, the effectiveness of the HMI and driver interaction will decrease as a function of how far each time is from the threshold, specified as the maximum allowed time beyond which a human (driver) or machine (vehicle) problem will be assumed. The plots also show that as φ increases, the interaction effectiveness (R) decreases. In addition, as expected, the probability of failure increases, and the effective interaction between the driver and the vehicle decreases.

The previous indicative of two issues:

1. The human factor that affects effective interaction due to human distraction and the mental and physical status of the driver.
2. The electronic design and the design of the HMI also can affect interaction as a result of either wrong message display order, electronic and sensor failure, or processing time delay.

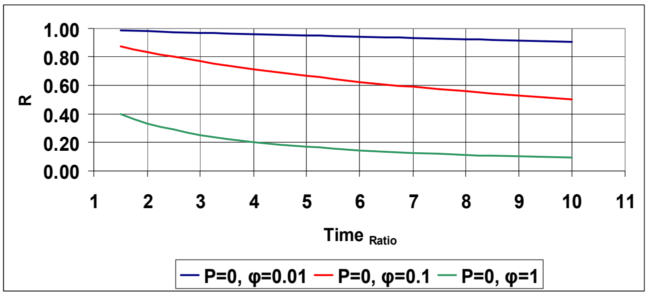

Fig. 1 Effective driver interaction as a function of time ratio-discrete probability.

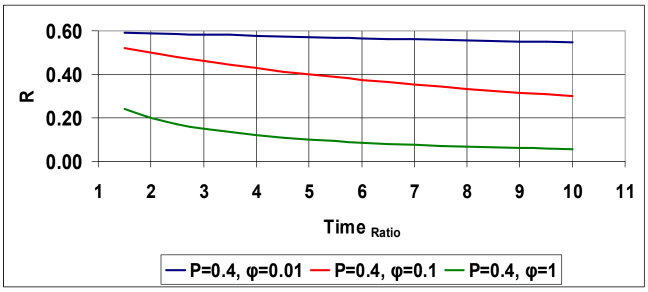

Fig. 2 Effective driver interaction as a function of time ratio-discrete probability.

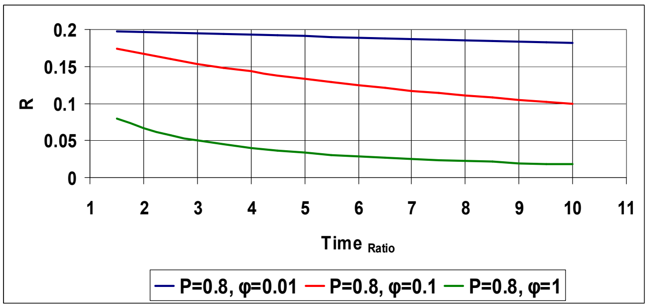

Fig. 3 Effective driver interaction as a function of time ratio-discrete probability.

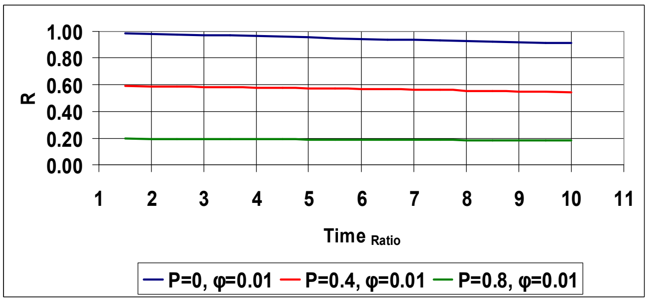

Fig. 4 Effective driver interaction as a function of time ratio-discrete probability.

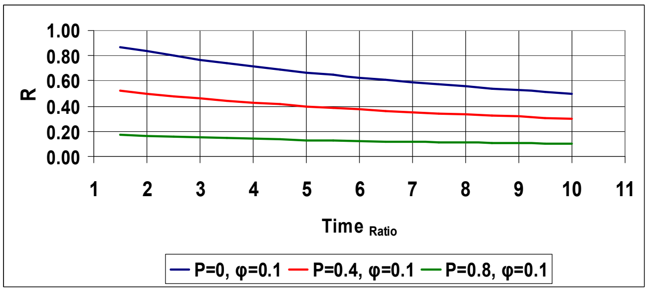

Fig. 5 Effective driver interaction as a function of time ratio-discrete probability.

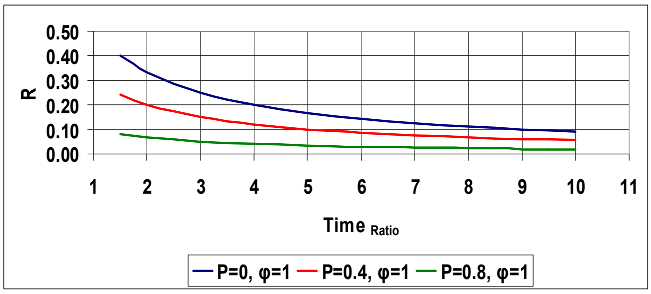

Fig. 6 Effective driver interaction as a function of time ratio-discrete probability.

Equation (20) presents the simulation fitting for equation (19).

$$R = \omega\left({Time_{Ratio}}^{-\eta} \right) \quad \text{For } \varphi = \{0.01, 0.1, 1\}, P = \{0, 0.4, 0.8\} \quad 0.1 \le \omega \le 1 \quad -0.04 \le \eta \le -0.8 \tag{20}$$

The probability of failure can be correlated to the driver response time and machine processing time, as in equation (21).

$$R = \left(\frac{\left(1 - \left(exp(-Time_{Ratio})\right)\right)}{1 + \left(\varphi(Time_{Ratio})\right)} \right) \tag{21}$$

Figure 7 shows a plot for equation (21) represents correlated probability to $\left(\frac{T_{response}}{T_{processsing}}\right)$.This enables adaptive HMI design that considers human and machine responses and computes the probability based on such critical parameters. From the plot and equations (21) to (23), it is evident that the highest interactive effectiveness is for φ "1. This is a criterion for design; the driver response time should always be much less than the specified threshold. The processing should be kept lower than the threshold, with their ratio always less than 1; otherwise, action needs to be taken by the vehicle control system through AVCS.

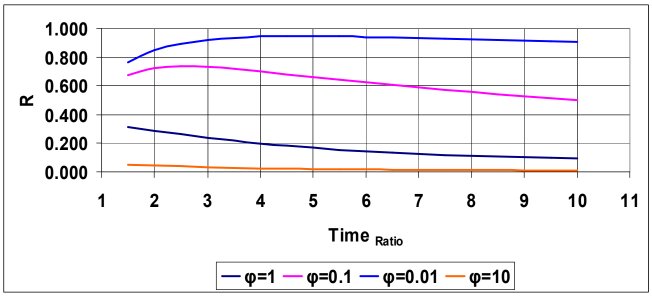

Fig. 7 Effective driver interaction as a function of time ratio.

$$R = \omega\left({Time_{Ratio}}^{\eta} \right) \quad \text{For } \varphi = \{0.01, 0.1\} \quad 0.8 \le \omega \le 1 \quad -0.06 \le \eta \le -0.2 \tag{22}$$

$$R = \omega\left({Time_{Ratio}}^{-\eta} \right) \quad \text{For } \varphi = \{1, 10\} \quad 0.1 \le \omega \le 0.5 \quad -0.07 \le \eta \le -0.9 \tag{23}$$

IV. CONCLUSION

In this work, an investigation through mathematical modeling of the parameters affecting safety in driving is carried out. The work presented a parameter (R) that computes effective driver interaction with the vehicle through HMI. The presented mathematical model includes both human and machine times in the computation, with discrete and correlated probability functions to enable better vehicular HMI design that considers both distracting human factors and electronics and sensors detection and processing problems. The work can be further developed by including detailed time components and using higher probability functions.

REFERENCES

[1] P. Drivers, M. Poliak, L. Svabova, and J. Benus, "Driver Response Time and Age Impact on the Reaction Time of Drivers : A Driving Simulator Study among," 2022.

[2] W. Kim, J. Kim, H. Kim, S. Lee, and D. Yoon, "A Study on the Driver's Response Performance according to Modality of Planned TOR in Automated Driving," *2019 Int. Conf. Inf. Commun. Technol. Converg.*, pp. 1471–1473, 2019.

[3] O. Lindov, "New Technologies for Improving Driver Response Efficiency in Risk Prevention from Traffic Environment," pp. 1–9, 2020, doi: 10.1007/978-3-030-46817-0.

[4] L. Pipkorn, T. W. Victor, M. Dozza, and E. Tivesten, "Driver conflict response during supervised automation : Do hands on wheel matter ?," *Transp. Res. Part F Psychol. Behav.*, vol. 76, pp. 14–25, 2021, doi: 10.1016/j.trf.2020.10.001.

[5] Z. Yan and Z. Jun, "Simulation Research on Driver Response Time and Steering Stability Based on EPS System," 2019.

[6] P. M. Greenwood, J. K. Lenneman, and C. L. Baldwin, "Transportation Research Part F : Traffic Psychology and Advanced driver assistance systems (ADAS): Demographics , preferred sources of information , and accuracy of ADAS knowledge," vol. 86, no. April, pp. 18–20, 2022.

[7] W. H. Hsu, "arXiv : 2110 . 11608v1 [cs . CV] 22 Oct 2021 Multi-Stream Attention Learning for Monocular Vehicle Velocity and Inter-Vehicle Distance Estimation," pp. 1–13.

[8] I. S. In and I. S. In, "Driver-in-the-Loop for computer-vision based ADAS testing," pp. 2–4, doi: 10.1109/NILES53778.2021.9600491.

[9] I. S. In and I. S. In, "A Progressive Review : Emerging Technologies for ADAS Driven Solutions," pp. 2–4, doi: 10.1109/TIV.2021.3122898.

[10] I. S. In and I. S. In, "Driver-in-the-Loop for computer-vision based ADAS testing," pp. 20–22, doi: 10.1109/NILES53778.2021.9600491.

[11] M. Murtaza, C. Tsun, C. Mohammad, and F. John, "The importance of transparency in naming conventions , designs , and operations of safety features : from modern ADAS to fully autonomous driving functions," *AI Soc.*, no. 0123456789, 2022, doi: 10.1007/s00146-022-01442-x.

[12] D. Palac, I. D. Scully, R. K. Jonas, J. L. Campbell, D. Young, and D. M. Cades, "Advanced Driver Assistance Systems (ADAS): Who' s Driving What and What' s driving use ?," no. 2018, pp. 1220–1224, 2021, doi: 10.1177/1071181321651234.

[13] K. Bengler, M. Rettenmaier, and N. Fritz, "From HMI to HMIs : Towards an HMI Framework for Automated Driving," 2020.

[14] O. Carsten and M. H. Martens, "How can humans understand their automated cars ? HMI principles , problems and solutions," *Cogn. Technol. Work*, vol. 21, no. 1, pp. 3–20, 2019, doi: 10.1007/s10111-018-0484-0.

[15] V. Charissis *et al.*, "applied sciences Employing Emerging Technologies to Develop and Evaluate In-Vehicle Intelligent Systems for Driver Support : Infotainment AR HUD Case Study," 2021.

[16] K. Dargahi, N. Franz, A. Katharina, B. Jan, and B. Torsten, "Modeling driver-vehicle interaction in automated driving," pp. 65–79, 2022, doi: 10.1007/s10010-021-00576-6.

[17] J. Dou, S. Chen, Z. Tang, and C. Xu, "SS symmetry Evaluation of Multimodal External Human – Machine Interface for Driverless Vehicles in Virtual Reality," 2021.

[18] C. Guo, C. Sentouh, J. Popieul, and J. Haué, "Cooperation between driver and automated driving system : Implementation and evaluation," *Transp. Res. Part F Psychol. Behav.*, pp. 1–12, 2017, doi: 10.1016/j.trf.2017.04.006.

[19] S. Li *et al.*, "Evaluation of the effects of age-friendly human-machine interfaces on the driver' s takeover performance in highly automated vehicles," *Transp. Res. Part F Psychol. Behav.*, vol. 67, pp. 78–100, 2019, doi: 10.1016/j.trf.2019.10.009.

[20] H. Muslim, M. Itoh, C. K. Liang, and J. A. Makoshi, "Effects of gender , age , experience , and practice on driver reaction and acceptance of traffic jam chauffeur systems," *Sci. Rep.*, pp. 1–9, 2021, doi: 10.1038/s41598-021-97374-5.

[21] D. Hu, X. Yang, and X. Zhao, "Method of HMI Optimization Design Based on Fixation Transition Characteristics and Visual Attention Trajectory : A Driver Simulator Study," no. August, pp. 1–12, 2022.

[22] Z. Hu and H. Tang, "Design and Implementation of Intelligent Vehicle Control System," vol. 2022, 2022.

[23] A. L. I. Mahmood, M. Almaged, and M. N. Noaman, "Adaptive Cruise Control of A Simscape Driveline Vehicle Model Using Pid Controller," vol. 16, no. 1, pp. 681–695, 2021.

[24] G. De-las-heras and S. Javier, "sensors Advanced Driver Assistance Systems (ADAS) Based on Machine Learning Techniques for the Detection and Transcription of Variable Message Signs on Roads," pp. 1–18, 2021.

[25] C. Lv, Y. Li, Y. Xing, C. Huang, D. Cao, and Y. Zhao, "Human – Machine Collaboration for Automated Driving Using an Intelligent Two-Phase Haptic Interface," vol. 2000229, 2021, doi: 10.1002/aisy.202000229.

[26] C. Paper, D. Grzechca, and L. Chruszczyk, "Review of advanced driver assistance systems (ADAS)," no. April 2019, 2017, doi: 10.1063/1.5012394.

[27] R. Risser, "Advanced Driver Assistant Systems Focused on Pedestrians' Safety : A User Experience Approach," 2021.

[28] E. Technology, "Trends and Future Prospects of the Drowsiness Detection and Estimation Technology," 2021.

[29] P. Zontone *et al.*, "Car Driver' s Sympathetic Reaction Detection through Electrodermal Activity and Electrocardiogram Measurements," vol. 9294, no. c, pp. 1–12, 2020, doi: 10.1109/TBME.2020.2987168.

[30] P. Anani, "Impact of Driver Distraction and Its Effect," no. January, 2019, doi: 10.28933/irjph-2019-10-0607.

[31] M. L. Cunningham and M. A. Regan, "Driver distraction and inattention in the realm of automated driving," vol. 12, pp. 407–413, 2018, doi: 10.1049/iet-its.2017.0232.

[32] B. Kateřina, M. Eva, Z. Robert, M. Pavlína, K. Martina, and M. Roman, "Factors contributing on mobile phone use while driving: In-depth accident analysis," *Trans. Transp. Sci.*, vol. 10, no. 1, pp. 41–49, 2019, doi: 10.5507/tots.2019.008.

[33] K. Kim and D. Park, "Driver Reaction Acceptance and Evaluation to Abnormal Driving Situations," *2018 Int. Conf. Inf. Commun. Technol. Converg.*, pp. 1377–1379, 2018.

[34] T. Y. Kim and S. H. Lee, "Combustion and Emission Characteristics of Wood Pyrolysis Oil-Butanol Blended Fuels in A Di Diesel Engine," vol. 16, no. 6, pp. 903–912, 2015, doi: 10.1007/s12239.

[35] R. Romano *et al.*, "Impact of lane keeping assist system camera misalignment on driver behavior," *J. Intell. Transp. Syst.*, vol. 25, no. 2, pp. 157–169, 2021, doi: 10.1080/15472450.2020.1822174.

[36] N. S. Trindade, A. H. Kronbauer, H. G. Aragão, and ..., "Driver Rating: a mobile application to evaluate driver behaviour.," *Geoinfo*, pp. 1147–1160, 2019, doi: 10.46932/sfjdv2n2-001.

[37] J. Wang, Z. C. Wu, F. Li, and J. Zhang, "A data augmentation approach to distracted driving detection," *Futur. Internet*, vol. 13, no. 1, pp. 1–11, 2021, doi: 10.3390/fi13010001.

[38] P. Zontone *et al.*, "Car Driver's Sympathetic Reaction Detection through Electrodermal Activity and Electrocardiogram Measurements," *IEEE Trans. Biomed. Eng.*, vol. 67, no. 12, pp. 3413–3424, 2020, doi: 10.1109/TBME.2020.2987168.

[39] G. Bathla *et al.*, "Autonomous Vehicles and Intelligent Automation : Applications , Challenges , and Opportunities," vol. 2022, 2022.

[40] H. Si, G. Tan, Y. Peng, and J. Li, "Dynamic Coordination-Based Reinforcement Learning for Driving Policy," vol. 2022, 2022.