Human-Computer Interaction in IoT-driven Autonomous Vehicle Environments

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1. Introduction

The environment has been designed to receive various signals and information conducted with different technologies such as Long-term evolution (LTE), ZigBee, Vehicular Ad-hoc Network (VANET), WLAN (IEEE 802.11a/g), Google Glass, Android-based tablet, and Car Multimedia. The information received by AVN is processed by a novel application of Avatar–Environment Interaction (AEI) protocol [1]. The experimental results revealed that jointly utilizing connected autonomous vehicles (CAVs) and non-authonomous vehicles (NAVs) signals would enhance road safety by improving navigation in a traffic scenario through applications download-based security threats, telephony and networking threats, three-dimensional printing threats, cloud-to-vehicle (C2V) communication threats, denial of service (DoS) and distributed Denial of Service (DDoS).

Various modern technologies have been incorporated in IoT-driven autonomous vehicle environments, leading to their operation becoming almost effortless [2]. These technologies yield efficient human-computer interaction (HCI) systems capable of making navigation through IoT-driven autonomous vehicle environments user friendly. The design of HCI systems calls for technologies requiring low computational resources for their implementation, for real-time response in signal communication between autonomous vehicles (AVs) and non-autonomous vehicles (NAVS), and last but not least for cost-effectiveness to be affordable for civilians. The design of the IoT-driven autonomous vehicle environments is accomplished by applying many technologies required to perform sensing, communication, decision-making, and actuation tasks.

1.1. Background and Significance

This development gains additional importance as the global human population is aging, and as the modern mobility sector exhibits an augmented dependency on IoT-based multimodality. However, seamless integration of AI-wrangling human psycho-physiological, emotional, and cognitive states can be attributed as being one of the foremost research challenges in the contemporary scenario. The way a vehicle responds to a transition from a beginner automobile driver to a seasoned commuter, or the manner in which an overwhelmed parent corporates with a child left at rest inside a car are examples of scenarios for which a traditionally drafted AI-responder onboard an AV demands an evolution. Human physiological wellness, emotional-touch, and cognitive comfort are pivotal to the meaningful design of succeeding mobility as a global norm [refs: 87cc7bb2-5043-446b-9a69-28ec240abb97, 70cdc9b6-7120-4fb6-970d-5d0f9bda0f55].

This transformation is primarily driven by advancements in AI, and the developments in multi-service interaction between a growing variety of dynamic actors—on board, on ground, on air, and in space. The Internet of Things (IoT)-driven contemporary AV ecosystem modifies itself based on operator/occupant status, and adapts its on-board environment based on the specific requirements and preferences of the users [3].

The automotive ecosystem is experiencing a major transformation—an evolution fuelled by the application of Artificial Intelligence (AI) in the context of the Internet of Things (IoT). The contemporary scenario witnesses both traditional powertrains and electric vehicles (EVs) embarking on a transformative journey towards the realization of autonomous vehicles (AVs), with a major focus on enhancing people-mobility experiences while keeping in mind the concerns of energy efficiency.

1.2. Research Objectives

'article_id: 7d25b312-7b8b-4be5-97c6-88ae8b101a55' - Interaction with Autonomous Vehicles (AVs) is a crucial part of human-vehicle interaction in the study of autonomous driving experience. Interaction occurs automatically in AVs in both in-car and external environments. In autonomous vehicles, critically minor vehicle reaction deficits in human instruction, combined driver-transfer behaviours and the delicate space and time capturing of crossing manoeuvres between vehicular sub-behaviours substantially affect road traffic safety especially in mixed traffic environments. Realistic road traffic driving investigations are not frequently applicable in VR-based simulations, they are difficult to achieve. The chosen strategy introduces a general design of an experimental study on a performed publicly accessible routing that requires various human-vehicle interactions across different automatic driving support thresholds, which necessitate the variation of shared (external or internal) network habits in concrete road traffic merging circumstances. By clarified relevance of telecongressions in manual/autonomic run, V2X-enabled crosswalk of automated processes are uniform and to the predictions spotted in the literature.

'article_id: aaa0c067-2afc-4abd-b9d2-fd110d8a1ac4' - The development of embedded systems and improvements in wireless communications have led the automotive industry to witness a massive inflow of technological advancements in autonomous vehicle technology. Experts have identified a requirement to determine seamless communication channels between the vehicle and a human to allow for socio-technological challenges of mixed environments within the connected vehicle-driven autonomous vehicle technology. Foots receive information about vehicle motion, location, condition, and performance observable from the vehicle. For the driver, inside the vehicle, smartphones will be linked with spatial and virtual reality (AR-VR) tools and haptic input and output schemes, including human emotion recognition, human-machine dialogue, driving behaviour and context awareness (D-behav), and sensory input– output detection techniques. AI communication treatments adapt themselves to continuously enhance learning strategies, user behaviour, abilities, expertise and nominal assessments, or to improve acceptance, trust, individual driving skill levels, temporary commandeering control levels, and transportation. The chief aim to be achieved is to create a layered communication network for both traditional and autonomous vehicles in transport.

2. Fundamentals of Human-Computer Interaction

[4]
H-CI is an interdisciplinary discipline among various sub-disciplines of HCI-related to both (i) natural interactions such as speech, gesture, and cognitive science, and (ii) scientific disciplines such as psychology, sociology, and ergonomics. HCI has always been a complex collaborator among psychology, cognitive ergonomics, and participatory design. In models of intelligent cognitive automotive interaction, science and engineering cognition, psychology, learning, and machine learning closely interact both in in-car smart devices and in advanced driver-assistance systems. The diverse methods and models of human factors and ergonomics

in previous studies are applied to the design of safety-critical systems. The integration of cognitive science with hypotheses in cognitive models and help automate human-system design. H-CI researchers in the cognitive domain have widened their research horizons to different driving tasks and in-car setup, with different age groups of drivers and external environments, regarding i-Interaction within the vehicle, gesture recognition outside the vehicle to operate different trunk/services (e.g., online shopping), and personalized customer care. They have proposed models with the lowest cognitive load for different user groups. [5]

In fact, driver support systems such as adaptive cruise control (ACC) and autonomous emergency braking (AEB) are used in new cars as standard safety modules. In addition to these features, the industry is moving towards long screening times towards, just like no steering system or automatic steering as endgame systems. The immediate objective was to advance customer requirements for autonomous systems. In research traditionally emphasized real driving and simple driving simulators, drivers and peddle functions are developed and verified according to the metrics of adjacent vehicles. The cognitive representation of the vehicle, specifically the drivers' understanding of how an assisted system behaves in different conflict situations, is a fast changing issues. In safety critical, every day traffic in VI (vehicle infrastructure) %VV (other vehicles) count is in the non-dominant area. Moreover improved behavior in dominated scenario can result in better acceptance in non-dominated traffic situations as well. This is the main part of our presented short paper.

2.1. Definition and Concepts

In all of these contexts, drivers should remain capable of resuming manual control of the vehicle safely and effectively by maintaining proper situation awareness. To achieve successful HCAIM, these aspects require an adroit combination of sensory perception, multisensory fusion, and visual search and recognition strategies. These features play an important role in human error during interaction with automated systems. Although automation is a benefit for the operator to some extent, it may also lead to attention undervaluation, complacency, haptic, visual, or auditory thresholding, or effects caused by the de-skilling of an operator. Moreover, the automation policy and strategy that underlies the automated system can also lead to a loss of effectiveness, situation awareness, and handling confusion in the actual context. Given this, the operator may lose vigilance, attention deviations, workload amplification or Khurana mobility, behavioral adaptation, automation bias, mode confusions, social loafing, and misunderstood automation as the automated features of vehicles increase [5].

The first meaning of HCAIM is found in takeover timing, which refers to the information and transfer of control from a vehicle or system back to the human operator in a timely manner [6]. To this end, vehicle automation and the authority of the autonomous system could be designated by taking into account the human expertise based on human behavior models, also known as human-centered automation. The second meaning is rooted in takeover performance, which refers to the degree of ease of information access, transparency in communication, and understanding of the system operation by the operator in the autonomous or shared control driving mode. This includes direct communication and the intuitiveness of communication with the system and the ease of user interface operation.

2.2. Theories and Models

[7] 3.1. External motive theories are concerned with a person's readiness to act based on his expectations and perceptions toward the ends or effects of actions. As the potential of vehicle automation, in general, and of AVs, in particular, grows, more data pertaining to human readiness for different interaction scenarios should be acquired. This is especially warranted in light of widespread skepticism about automated driving systems among the public. Extant research in this regard has addressed a range of topics, including trust in automation, trust calibration, and reactions to imminent failures. Such data will be crucial in the pre-implementation phase to help developers identify use cases for vehicle automation toward environmentally responsible practices. There is a legitimate, ethical and societal concern that automation should not allow more traffic and highways too. [1] Specific interactive scenarios between drivers, V2X technology, and different car automation levels are complex topics of research in terms of human factors. In the propagation phase of NAVs among road users, driver state should be continuously monitored to maximize driving safety. This includes monitoring drivers' behaviors, including their self-concentration level, and using various auto-driver control strategies to safely come to a controlled stop. Unrealistic workload expectations should be discouraged, and drivers should be encouraged to continuously monitor the road environment and to regain control of their vehicles when the current automation level is not enough to provide full traffic adaptability. [8] Human–computer interaction (HCI) is the cornerstone for smooth driver–AD interaction. While integrating

technological tools in this area, such as virtual reality (VR) and advanced sensors, complex interaction requirements should be satisfied. Presents a VR environment, together with a virtual traffic micro-simulator, calibrated and validated against a classical traffic micro-simulator. The VR environment is successfully used to evaluate drivers' behaviors in varying traffic conditions—longitudinal-regulated but also emergency-braking interventions. Although we are experiencing a rapid transition to vehicle automation, since the former does not still completely replace human drivers, the interaction between drivers and automation is an interesting and important topic.

3. Autonomous Vehicles and IoT

In a similar sense we should quote the work generated by Ning et al. in [9], that proposes Differentially-Private Non-negative Matrix Factorization (DPNMF). It is analyzed in terms of providing privacy in a real automotive scenario. Vehicular Ad-hoc Networks (VANETs) are networks formed by vehicles, to either communicate among themselves using Vehicle-to-Vehicle (V2V) communication mode, or to communicate with RoadSide Units (RSUs) using Vehicle-to-Infrastructure (V2I) communication mode. In these different communication modes, privacy of the participating vehicles or RSUs can be compromised. Vehicular communication systems such as Dedicated Short Range Communication (DSRC) and Cellular-V2X (C-V2X) facilitate the communication between vehicles and infrastructure. Data generated from VANETs and the vehicles is relayed to Data Access Points (DAPs) from where the data is relayed to central nodes also known as datascapes.

Next, we consider the concept of Internet of Autonomous Vehicles (IoAV) of level 5 of vehicle automation in [10]. Although the denomination includes the term autonomous, it is necessary to consider that manually driving road users will continue to coexist for a long period of time, and gradually decrease their presence. Therefore, the communication of IoAV in road traffic should be designed not only to share information among them but also with manually driven vehicles, pedestrians, traffic signals, and the whole infrastructure on the road. These vehicles will exchange safety essential information such as their future positions and provisional speeds. According to UK Department of Transport, single vehicle accidents account for around half of all road accidents and contributing factors in these single car incidents include animal incursions, broken down vehicles and environmental hazards. These accidents can also prevent an adjacent manually driven road user from passing causing accidents. To prevent any possible accident by sharing real-time road incidents information to human drivers, it is intended to develop a "Road user communication service" (RUCS) by fusing V2X technology with existing navigation system of driver's cellular phones.

3.1. Overview of Autonomous Vehicles

The awareness and vision toward the autonomous vehicles are at such a level globally, that most countries are making strict laws and supportive regulatory laws to make their way open for the development of autonomous vehicles. Out of all the autonomous vehicles, the most talked-about and developed vehicles at present are related to the area of ground transport. Automated vehicles are also referred to as self-driving cars or driverless vehicles—that are controlled and regulated by the IoT, which combine the action of automated mechanical instruments. Thus, the ultimate vision of self-driving autonomous vehicles is to utilize the IoT to steer, observe, absorb, contemplate, evaluate, and recognize traffic circumstances, and take protective actions on behalf of the driver. This progression is dominantly reliant and encouraged by upcoming technologies such as IoT, vehicle clouds, networked IoV technology, etc..

Transportation is a necessity in everyone's life in the current era of increased wealth and mobility [11]. Due to the latest advancements in the IoT and AI technologies, a major demand for autonomous vehicles has emerged this past decade [12]. The development of these autonomous and driverless vehicles has become quite significant in solving several issues linked with the conventional driver-based cars: such as human errors (which leads to most of the accidents), environmental pollution, ever-increasing fuel prices, increasing travel distance, and low compliance with the traffic laws and speed limits. "Automation and computer-based decision-making can bring a significant reduction in the fabrication of cars as well as their depreciation. AI in a car can be considered as a mind, as it is able to analyze and reach to the correct decision at the correct time but with the help of the technology installed in the car." [13].

3.2. IoT in Autonomous Vehicles

Vehicular Ad-hoc Networks (VANETs) are a cost-effective solution for the establishment of a road safety communication infrastructure in the short term, but they are not designed for fully autonomous vehicles. Wired communications are a stable alternative, but they have a relatively high cost; in the long term, wireless communications will be the key technology. Proper navigation of hills and built-up concentrations must be ensured by autonomous vehicles, which is not possible by the Internet or other accurate networks [14]. Only IoT algorithms based on big data can solve these navigations effectively. Automats can enjoy dynamic road-guidance by automating communications. Automats could transmit their dynamics, velocity, and tensor data to the next road-gated control center or next automatically designed vehicle movement units, and so on. When automats stop at red lights or accident sites, the central office will handle accident bots and automatic allowing/directing of road traffic can be automated.

The Internet of Things (IoT) is expected to spring up as an emerging technology creating ample possibilities for application in smart cities, and in particular in autonomous vehicle systems [11]. Properly designed, AI algorithms built on the big data in the IoT system can become a road-guide for the driverless vehicles, automatically tracking where road-trucks have to go, determining their scheduled arrival time, offering a rising alarm of failing to reach their goals, and so forth. Vehicles could be continuously charged at the right time and place on account of the IoT equipment. Additionally, the IoT data processing could provide better visualization tools for the transportation of containers and could support overall logistic solutions. Big data and AI could be applied not only in human tracking, vehicle counting, vehicle detection, vehicle classification, vehicle tracking, vehicle speed estimation, etc., but also in understanding flows, detecting anomalies, identifying the route log and determining transport mode shares [15].

4. Challenges in HCI for Autonomous Vehicles

Moreover, HCI future scenarios will also foster an integration between the housing culture and the car one, between the car concept and nomadism—futuristic needs in the context of the environment crisis and the changes caused by the pandemic on urban planning. It will be a matter of enrolling shared technologies like wireless network, Bluetooth, Li-Fi, and the high-speed 5G band, new materials, natural forms, technologies and architecture able to build, build installing sustainable and shared systems in vehicles, able to offer a unique, interactive, comfortable, solidary, futuristic and intelligent travel experience. This turn would promote a prêt-à-porter approach to living, encouraging automobile makers to create socioeconomic systems that incorporate into the vehicles services and experiences that are ecological, experienced, always similar, and always different at the same time, and that reinforce, repair, and renew the urban and new urban ecosystems [16]. The attention paid to the international community's policy aimed at sharing transport/attention on climate/environment would become a part of a refined aesthetic-cum-technological strategy of adoption, domestication, expansion, and artistic naturalization of the process by which cultural and design concepts manage to integrate "digital" and "electronic" cultures, illustrated in the context of the n. c. times and in the design of AI.

The HCI in complex environments of today is a step-stone toward collaborative exploration in the interactive, pervasive, and semiautonomous environments of tomorrow [17]. The augmentation of perspectives will be the keystone of HCI in human–autonomous vehicle interaction. The presentation of alternative viewpoints will instigate new a priori collaborative insights and will foster new cultures that enrich human–driver dialogue. The framework could instigate new aesthetic patterns and new forms of emotional pathways, identifying relevant and consistent catalogued solutions in the hyper-variety of dorsa-automobilistics. The willingness to endorse collaboration—especially in the context of the ontological shift between human and devices— depends on the degree unobtrusiveness in the interaction. As for the short-term deployment scenarios, future human–driver interaction should take place through cutting-edge technologies in content-delivery technology. This approach will profit from large investments in domains such as game design, live tracking, virtual tourism, docufiction, and cosmetic computer graphics [18]. Marketing strategies such as product placement and guerilla marketing should be pursued to create reasoning trends in the present pandemic context and stimulate social acceptance of the trend of cars as living environments, fait accompli not only in scientific circles but also in ordinary people's awareness. Also, ready-to- use cloud services should be developed, capable of delivering and recomposing new interactive environments strictly related to the car projects they refer to. The aim is to facilitate users in transforming— in a few clicks—inhospitable vehicles into similar but radically different representations of themselves, in which the different acts of comfort are respected both in the internal landscapes made with Augmented Reality and in the creative customization of the interiors, and in their different environments.

4.1. Safety and Trust Issues

In particular, the explosion of autonomous vehicles (AVs) in research and industry is exacerbated by creating a global need to address safety issues and validate drivers' reliance upon command controls. With the widespread deployment of AVs, safety doubts have emerged among the public, and these should be addressed if larger implementation can be taken. On comparing the current status of proposed methodologies and appraising which of them provide improved values to consumers, we have concluded it through many current biannual reviews that no sufficient common understanding had yet been found or a methodological placing on trust and security had failed to do so. [19]

Pairing of controllability levels and relevant confirmatory warnings by considering the specific context of the AV interactions to be designed should be an attempt to increase public confidence and trust in autonomous vehicles (CAVs). In this area, it is important to communicate the vehicle's readiness in advance with driving behavior, danger, and safety regulations. It could also promote the trust of pedestrians and empower them to decide better if the CAV displays the driving status and intention information clearly. It will attract considerable interest and open up new areas of research to investigate the characteristics of being a social object with probabilistic-dependent events [20].

The transition process to an autonomous vehicle (AV)-driven environment can pose an immediate threat to safety and user trust due to the variety of control mechanisms, experience levels, and autonomous driving policy models being developed. This expectation further demonstrates the need for the development of safe, succinct, and informative communication channels to be deployed within the AV that can reduce the cognitive overload of monitoring tasks performed by human must be ensured in this transition process [21].

4.2. User Experience Challenges

Most drivers would agree that the available time during a non-interactive long-haul highway stretch can comfortably be dedicated to avoiding social isolation in comparison with the tamer. Inheritance of this innovative form of user experience pleasurably corresponds with the communication and interaction component of Maslow’s pyramid. Primarily, large quantities of technical deficits in the surrounding of tasks from usability and learnability, or from the human factors subset, were mentioned in the subject group of the user mobility model and above all focussed on the demands in infrastructure support. Transparency, the distribution of cognitive load and the leader-follower philosophy all represent requirements that cannot be resolved with the current automation strategies leading to this mapping into the needs of the "efficiency" component of shared autonomous driving requirements [18].

The maneuvering of an autonomous car currently obeys primary driving tasks or, at best, single tasks involving the design of automotive user interfaces [22]. However, it is known that a person's focus in the driving task naturally varies from i) controlling the vehicle, ii) analysing the road, to physical interactions in the cabin that are carried out either in resting time or in cooperative/extensive "man to machine" discussions. The intelligent automation of these numerous social media-utilising liaison partners initiates the challenges of collaborative driving. From a driver's interaction demands perspective, current automotive user interfaces in the context of autonomous driving very often force their users to work in cooperation with inflexible virtual butlers. In addition, the potential of social automotive user interfaces dedicated to the needs of collaborative passengers has not been researched in depth based upon consumer evaluations [6].

5. Design Principles for HCI in Autonomous Vehicles

While one set of design principles may work well for a specific design project in a specific technological environment, it is becoming increasingly clear that principles ensure success within a limited domain and only temporarily, in any case. It is expected that interaction designers will develop new design principles that consider the full scope of the problems presented by disruptive technologies such as autonomous vehicles.

Managerial Navigation: Spatial problems should be handled in a unified fashion. Coordination decisions made autonomously on behalf of the passengers should be easily understood by them and by their delegates. Decision rationale should be adaptable according to the passenger's current state. Guidance should explain contextualized decisions rather than providing the rationale as a set of predetermined steps, taking into account user privacy concerns. Techniques should encourage the passenger to value the Managerial Navigation system's point of view. Roles allowing some sorts of guidance assistance should be adaptable on an individual and/or group basis.

5.1. User-Centered Design

The lack of standardized design methodology in creating the user interface for IoT-driven autonomous vehicle environments, which will be within the interaction scope of multiple levels of users (i.e. passengers, automobile drivers that start driving when needed, users who aim to use devices they have with them during the journey). Standard methodologies are also used in different stages of the integration process in the value chain of the autonomous vehicle with the vehicle components to be defined. Consequently, in this study, a user interface is proposed to support the interaction flow of vehicle users through a multi-stage methodology based on the Golden Circle Principle, V-Model, ADKAR, and Kutmosis Model. As a result of the analyses conducted, an intelligent vehicle architecture that will enable vehicle users to use or command vehicle components in accordance with the context by creating a flexible, simple, and understandable status interface control using IoT based on the cause-and-effect relationships of vehicle components was created.

User-Centered Design considered the User Experience (CX), Scalability and Complexity in Autonomous Vehicle Environment. Today's system and software-based products that vehicles are at the center of are finding importance in terms of increased customer satisfaction and added value for the users with the increasing mobility. In order to ensure the user-centric design of such products, conducting research in line with industry-wide standards and frame infrastructures are of great importance for their recognition and competitiveness as well as their compliance with input-output in the design process.

5.2. Adaptive Interfaces

Adaptive interfaces are built on top of situation-aware systems and are created to deal with dynamically varying situations and to adapt if certain events occur. In the driving context, adaptive interfaces can perceive the appearance of dangerous driving conditions and adapt to them. They can reduce task complexity according to the driver's workload and the task priority by analyzing the driver's vital signals. In particular, the interface can proactively show some important information when driving in a tricky situation.

An adaptive system can, in general, evolve to four major levels of capability to adapt, i.e. none, passive, active, and proactive adaptation. None-adaptable systems have no capability to increase system adaptability. Passive adaptation permits system properties to remain constant; however, this should not prevent transients from occurring. If a system is capable of monitoring the state of operation and then adjusting the system property accordingly, the system is defined as an active adaptable system. The proactive capability, in contrast, would predict the future operating conditions or construct an expectation of future states and modify the system properties accordingly.

6. Case Studies and Best Practices

[17] With the emergence of autonomous driving, many services, which were previously provided as stationary, will be shifted to moving vehicles. This shift opens new research and development questions at the interface of transportation and smart home technologies. This is because the previously stationary user can now be assumed to be a moving user. Furthermore, the boundaries between in-car and at-home situations will increasingly blur, especially when considering a future with autonomous driving.
In our ongoing research, we develop and experiment with new ideas around the transformation of today's home into a moving one. In this paper, we follow a human-computer interaction approach and focus on the design of corresponding interactions. To validate our approach, we conduct a user study in which we implemented our concept in a real prototype – a home IoT connected vehicle based on a Volkswagen Transporter T5. This prototype comprises a variety of smart home sensors and actuators, a powerful mobile edge computing device, and an infotainment system, which connects the car and most of the embedded sensors and devices using Raspberry Pi.
[23] Human-robot interaction (HRI) deals with the full sweep of scenarios in which a robot interacts with people or other autonomous robots as well as with the underlying models of behavior and social functions. The goal is to endow a robot with varying capabilities, such as natural language understanding and generation, speech recognition, dialog management, emotional states, complex behaviors that encompass the movement of various parts of the robotic body, and the like. Among the methods generally adopted to implement systems for human-robot interaction, there is an increasing interest devoted to the design of situations in which the robot proactively promotes and supports the ongoing interaction, autonomously deciding what actions can enhance the interaction quality, what information can make the user aware of the most relevant elements that should be taken into account, what messages can trigger the user's attention and, so on. Proactive interaction has been formalized in HRI with the expression proactive behaviors (or routines). In human–computer interaction, the term proactive refers to the capacity of a system, an agent or a device to anticipate the user's future requests or to react in advance by offering, for instance, additional features to make the interaction evolve in the right direction.

6.1. Existing HCI Solutions in Autonomous Vehicles

The analysis presented in this article presents a framework from which to build future research. This paper is structured well with contextual information and sets the scene for the research proposal and literature synthesis. The focus, relevance, and use of a variety of accessible data sources, in the synthesis of literature, are commendable and representative of a high level of research and evidence-based practice within the transport management discipline. Also, the critical analysis of the literature and the importance of each of the topics covered, relate strongly to the identified research problem and seek to inform best practice for the contribution of current and future research and policy development [24]. The tables contained within are representative of a comprehensive and systematic methodology, in that they provide a strong level of understanding for the reader in the hierarchy of the importance and the contrasting discussion of the use of the Human-Centred Design approach within smart transportation system design in autonomous vehicles.

Recent advances in sensor technology, artificial intelligence, and communication protocols have transformed road transportation from human-driven to intelligent, connected, and automated transportation systems [16]. Full automation of physical tasks in complex and dynamic environments, however, requires intelligent human–machine interaction. This is especially challenging in highly automated driving modes, as it is difficult to anticipate and prepare for dynamic and likely-sensitive human interventions. This literature review is well-timed and comprehensive; it contributes a structured analysis, categorization, and discussion of HCI techniques for automated vehicles from various aspects, which is clearly described describing methods used and data sources and analysis approach [25]. The article is valuable to the academic community and provides a solid foundation for further research in this field.

7. Future Directions and Research Opportunities

The introduction of autonomous vehicles will increase road safety by eliminating human error. At present, different advanced driving assistance systems (ADAS) and driver support systems (e.g., adaptive cruise control, automatic lane keeping systems) already exist, but these are primarily focused on the driver. In the light of the ultimate aim of the introduction of autonomous vehicles, though, it is desirable to pay attention to all road users and to allow them to operate in a more comfortable and conflict-free environment. The acceptance of autonomous vehicles would be enhanced when it can cooperate with other road users [5].

Passenger and pedestrian incorporation into vehicle systems is a relatively new topic of study due to the traditional assumption that only a human driver is present in a vehicle and crossing the vehicle's path at anytime. Future autonomous vehicles might not only allow such users to take control of the vehicle, but could also be able to navigate in a cooperative way with these users [7].

7.1. Emerging Technologies in HCI for Autonomous Vehicles

In this vision the car is a transportation system that happens to be automated but human–machine interaction remains in the emergency case and temporary as long as the fault is fixed. The second view is the human–machine communication: if one imagines a vehicle without any driver, one sees a room on four wheels, a vehicle that should then be designed following, as far as possible, the principles of the architecture of interiors. In that case a car can roll without any mechanical contact with the human being and interactions between cars could take the form of calls, mostly vocal calls, as it is today the case for smart phones. It has appeared recently that the midpoint of the two previous views gives rise to more satisfactory solutions [26]. With clever design cars can "talk" with their surrounding environments, with many pedestrian and traffic signs by a mix of visual and auditory signals, and with other drivers all verbalizations made by local system and displayed on an external screen, called Turn Signal Information System, through an internally generated avatar. Clearly so-called surround cars can exchange information about their location, their speed and their trajectory. At the same time drivers are still sitting there, and it means that all we have been used to dealing with (those joined in the previous A and B spaces) are still and should remain available. In one word, the simple idea that the concept "car" does not change with the coming of "smart" is fundamentally respected. In short, it is always the same vehicle which can still be driven in an old-fashioned way. It is the way you put the emphasis on that concept that changes.

The range of modalities that are becoming widely available — such as smartwatches, connected cards, smart home devices, interactive TVs, and more sophisticated educational, assistive, and health devices — is overwhelming [17]. The landscape is significantly enriched by the forthcoming advent of the fully autonomous vehicle, resulting in a plethora of Human–Computer Interaction (HCI) challenges [16]. Two typical views are provided in Fig. 1 as an illustration. The first one is a very traditional one: the driver conveys his/her inputs via a mechanical steering system, gas and brake pedals, and related communication areas (e.g., turn signals) with additional elements taken for granted such as the dashboard and the lights and wipers control bar. Over time, that setup was enriched by a control board. The upcoming fully autonomous car adds a lot in terms of sensors (6 LiDARs, at least 4 cameras, 26 ultrasonics, and redundant radars) but this addition can hardly be considered as a game changer in terms of car interior: that clearly remains a mechanical one. This led to the hypothesis of many studies that Interior design can be preserved in its present state adding, at the most, an equivalent electronic system which serves both as a support of the classical mechanical path and as an alternate one in case of faults on the mechanical path. Consistently, most studies about future vehicles do not even mention the control board and the dashboard (in the future: the A and B spaces in Fig.

8. Conclusion

The demand will continue to shift from navigation assistance to advanced assistance features and finally to fully automated driving in addition to navigations and non-navigational applications [19]. Need for HMI services provided in the IoT-driven personal vehicle to receive a proper guide on driving routine based on traffic hazards prediction. A survey was conducted with the aim of accurately assessing the behavior of the drivers and thus identifying the relevant variables that influence the drivers' approach and commitment with connected car technologies to determine their acceptance.

Given the growing interest in IoT-driven autonomous vehicles (NAV) communication and control, it is possible to collect significant data that can be virtually processed by drivers and transmitted to the CAVs to establish a new evening ITE process based on simulation system construction and testing [1]. As a result, the developed simulation system can be used to test different practical combinations of traffic conditions and information arrangements, reproducing realistic situations. In this research scenario, it is also possible to validate specific vehicle data transmission targets with unique characteristics, replicating the work with different CAV features and different complexities of traffic. Nevertheless, according to [17], to ensure good interfacing performance and support meaningful interaction, the number of communicational channels can be made available to drivers with the right set of information and at the right time respecting individual differences and landscapes.

8.1. Key Findings and Contributions

The concept of automatic delegation as proposed in this paper is naturally inspired by the development in technology of the automotive industry. Various types of driver assistance systems and autonomous driving functions are gradually becoming more widespread. Although the perspective of this paper is aimed at automated driving, in general, the concept of automatic delegation has applications beyond the automotive domain. The autonomous vehicle as an environment or microenvironment exerts an influence on the driver and the human driver with his or her movements generates an influence over this automotive ecosystem. This reciprocation could be described using the HRET and with the context of autonomous driving, we could introduce the concept of 'driver state' related steering behaviour and automated vehicle state related system reactivity/delegatability. The adaptive HRET correlates to the upcoming future technology of automated vehicles and realizing a new system approach in the automobile by treating the upcoming cars and their human user as a joint system, HRET for adaptive driver-adaptive vehicle automation, is a promising research topic. Especially in perspective of the numerical driving simulators, the HRET should provide conceptual findings in the future in order to optimize prototypical and serial vehicles for various individual performance levels which are adjusting to the initial driver capabilities and later behavioral forms of the individuals related to vehicle design, car configuration and automotive function utilization. The theory sees an enormous potential and by now areas for further research, e.g., Intelligent driver adaptability to be experimented and to be modeled in the brain (J. Jang and H. Park 959 123 kar, or future technology adaptation and this integration of human thoughts versus vehicle tasks via the technical subsystem of the co-active driveradaptive vehicle control. How the upcoming people and future automotive technology combine and agree on safe and comfortable traffic soon will be the central point of development in transportation. The HRET provides a controlled approach to understand and investigate according natural user actions in artificial environments like trainee driving simulators which are comparably related to real traffic denseness and multi-modal user demands [27].

Considering the insights obtained from the literature review, five main contributions can be inferred from this empirical research work. "Automated adaptable cycling human–automation collaboration with a distributed vehicle platform (DFKM)" has been developed on the theoretical basis of combining feedback feedforward control optimal human–automation collaboration for automated driving. A goal was incomprehensible and promptly worse controllers endowment coursework on automatic driving safety and driver's task burdens the exclusive advantage of estimated host machines. A decentralized MSM has been proposed and implemented in the DFKM means that the human sits on the same hierarchical level as the driver vehicles. This ensures that the driver vehicles are agents who can determine the vehicle motion without violating their own goals and objectives. An evaluation of the extended conceptual model for delegations and takeback, introduced in our previous publication, is provided based on objective and subjective criteria [5].

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