Addressing Passenger-Vehicle Conflicts: Challenges and Research Directions

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Abstract

As the complexity and capability of vehicles increase, they adopt higher degrees of responsibility and execute greater levels of autonomous decision-making. On the way to full automation, they act with the user as a team. This can lead to conflicts that are detrimental to automation engagement. We explore factors influencing conflict development with automated vehicles and discuss challenges and possible future research directions.

Keywords

passenger-vehicle interaction, automation engagement, conflicts

1. Introduction

Automated systems are becoming increasingly prevalent in huge parts of our lives. Not excluding mobility. Here, the future vision of self-driving vehicles is currently at the center. Expected benefits are safer and more efficient traffic as well as an increased comfort level and user experience for passengers [1]. The accompanying shift of the driving task from the driver to the vehicle not only results in an allocation of vehicle control but also power, authority, and responsibility [2]. However, until full automation is reached, the driver and the vehicle stay in a cooperative and collaborative relationship with mutual dependencies [3]. A driver's behavior and expectations within this relationship depend on their abilities, knowledge, experience, trust, and interests, such as needs, values, or goals [4]. This can lead to conflicts when the interests of the vehicle and the driver contradict each other, where conflict is seen as the state in which interests cannot be achieved by one or more agents [5]. This can be negatively supported by a lack of a shared situation representation [6]. If conflicts concern the driving task, i.e., if the desired behavior of the driver contradicts the expected behavior of the vehicle, the driver will wish to override the driving behavior of the automation, if allowed to [2]. This in turn can lead to safety-critical situations. One reason is the "out-of-the-loop" effect, meaning the driver is no longer engaged in the driving task, resulting in decreased situation awareness and skill loss in the long term [7, 8]. Consequently, taking over control and performing all parts of the driving task can lead to safety-critical driving behavior [9, 10, 11]. With or without the opportunity to take over control, conflicts can lead to decreased trust, negative emotions such as frustration, and non-acceptance [2].

With this, conflicts are a huge factor that can negatively impact automation engagement.

Nowadays it is already possible to detect different driver states and intentions by in-vehicle monitoring (for an overview see [12]). Among them, there are various works that also deal with the detection, and resolution of conflictual driver states in vehicles (e.g., [6, 13, 14]). However, so far there is no work that considers the development of conflicts between drivers and vehicles as a whole. As a first step, we, therefore, use this position paper to address this gap by identifying factors that play a role in the emergence of conflicts specifically for Human-Vehicle Interaction (HVI) and derive challenges and possible research directions and questions. We contribute to future conflict research in HVI by highlighting the importance of considering identified conflict development factors.

2. Factors of Conflict Development in Human-Vehicle Interaction

Conflicts between passengers and vehicles can occur in a broad range of situations and have a wide variety of causes. In order to explore these further, the first step is to identify factors that influence conflict development.

2.1. Human-Vehicle Relationship

The type of transportation (e.g., individual, or public) has an influence on the relationship between the user and the vehicle. Among other things, ownership, legal frame-

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work, privacy, and mutual knowledge vary, which may have a direct impact on performance expectancy [15], trust [16], communication, power dynamics, and, thus, conflict development.

In individual transport, where the driver is the owner of the vehicle, the driver is familiar with the technology and its capabilities, which can increase confidence and comfort level when using the vehicle [16]. However, expectations for the satisfaction of personal needs might be high. In contrast, when an HAV is used as part of a car-sharing or rental service, the driver may have limited knowledge of the technology and its capabilities [16]. Conflicts may more probably arise due to a lack of experience and mutual understanding, which can lead to distrust. In public transport, having no control might influence conflict development.

Thus, the relationship and dynamics between the user and the vehicle need to be considered in order to understand conflict development.

2.2. Human-Vehicle Interaction and Communication Strategies

Full vehicle automation is approached via the intermediate steps of conditionally and highly automated vehicles that gradually assume more and more of the driving task but still are in need of support or possible takeovers by a driver. Different interaction strategies, such as cooperative and collaborative approaches, shared control strategies, or takeovers and handovers (see [17] for an overview) affect the level of control and responsibility that drivers have over the vehicle. How control and responsibility are distributed are factors influencing for instance the driver's sense of agency [18]. If the driver loses the sense of agency or develops an overreliance in the vehicle, a dismissal of intervention responses gets possible [18]. Interaction strategies may also influence a driver's behavior in case of a conflict. Thus, if they are allowed to, drivers may take over control, if not, they may reject the use of the system.

Further, for example, poor communication between the driver and the HAV, such as a lack of clear and concise instructions or feedback, can lead to confusion and frustration on the part of the driver, which may also lead to conflicts.

Thus, HVI and communication strategy are key factors that can impact the development of conflicts between drivers and HAVs. Therefore, it is necessary both to consider possible interaction strategies during conflict research and when designing future interaction strategies not to neglect their conflict potentials.

2.3. Vehicle and Passenger Goals

Automated vehicles are developed aiming for a safe, efficient way of traveling. However, a vehicle follows objectives such as providing convenience, reliability, and accessibility.

Those goals are aimed at the passengers on the one hand, but also at the environment and the community. For example, safety should be ensured for the passengers but obviously also for other road users and the general public. Thus, there are potential conflicts between the driver and the public good predominance in vehicle design. For example, if passenger comfort is maximized, the overall traffic speeds may be decreased, and if the highest value is the protection of passengers the crash risk of other road users may increase [19].

Passenger goals are highly dependent on individual factors such as personality traits. Thus, sensation-seeking passengers probably aim for a high user experience and driving fun, perhaps demanding a faster and riskier driving style. Compared to environmentally conscious people, who may have a sustainable and economical ride as their goal, whereby tend to demand a conscious, fuel-efficient driving style.

If a vehicle does not know these goals and the derived interests of the driver, they may conflict with the standard behavior of the vehicle.

In addition, the goals of each agent can contradict each other and as a result, must be prioritized depending on the situation. In certain cases, different priorities set by the driver and the vehicle can therefore also lead to a conflict.

2.4. Vehicle Capabilities and Passenger's Expectations

Even if higher-level goals are inherently the same, conflicts can still arise because both parties simply perceive and project situations differently.

This can lead to differences between the driver's desired behavior and the actual behavior of the vehicle, but also between the behavior expected by the driver and the actual behavior of the vehicle. These differences are directly related to a vehicle's capabilities, but more importantly, the capabilities expected by the driver. For example, a driver who misunderstands the capabilities of the HAV may become frustrated when the vehicle does not perform as they expect. What plays a major role here is a driver's previous experience, trust, and acceptance of the vehicle.

A vehicle's sensing and reasoning capabilities could potentially generate interpretations of situations and plans of action that will be more effective than that of a driver. However, this could also lead to conflicts if the driver cannot understand exactly why the vehicle is acting in this way. For example, if the vehicle overtakes another car despite poor visibility due to weather conditions [2].

2.5. Context

Situational context and environment can play a significant role in the development of conflicts by affecting human and vehicle factors.

The behavior in driver-vehicle cooperation is, for instance, influenced by the perceived environmental context, such as weather conditions [2], road conditions, or the behavior of other road users in mixed traffic. But also drivers' situational context, such as time pressure, stress, or a negative emotional state affects a driver's behavior and the expectations of the vehicle's behavior, and thus, needs to be considered in conflict research.

3. Challenges and Research Directions

As seen multiple factors can play a role in conflict development. In the next step, we will derive challenges and possible future research directions.

3.1. Conflict Prevention

To prevent conflicts from emerging, we see it as essential to agree on common goals beforehand, to establish an equal understanding of the situation, and to transparently communicate the vehicle's capabilities and its behavior/next steps in an appropriate manner. A large number of studies are currently dealing with how to achieve a shared situation representation (e.g., [6, 20, 21, 22]). We, thus, rather see a gap in research particularly in shared goal setting and especially in how community goals can be negotiated efficiently without losing trust and acceptance towards the system.

In order to actually be able to prevent conflicts successfully, we also see it as indispensable to gain knowledge about the driver's individual factors that influence their situation awareness, decision, and performance of actions, such as personal goals, automation experience, or driving abilities. However, since this is extremely complex, we do not expect that conflicts can be completely avoided, so research on how to deal with them is highly important.

3.2. Authority Allocation

Autonomous vehicles are required to be programmed based on ethical and community goals to ensure safe and efficient traffic [19]. It needs to be determined to what extent the common good can be elevated in automobile design, without generating undue friction with the objectives of the driver. Further, the correlation between the common good and the relationship and roles between the driver and the vehicle needs to be examined. This requires Human-Computer Interaction (HCI) based, legal, and ethical considerations. Questions that arise and need to be clarified are: How unethical requests from a driver should be handled [23]? Should these be rejected? What might a rejection look like that the driver accepts? Unethical requests include, for instance, those that ask the vehicle to act unlawfully or that willfully disadvantage other road users. Another question is if the driver can be overridden in certain situations, what should such a situation look like and how should such a process be handled?

The theory on the sense of agency has to be considered here as well. It refers to the subjective experience of control and influence over actions and their outcomes [24]. In a restrictive and rejecting vehicle driver's sense of agency may be impacted, which also may lead to conflicts when the driver perceives a loss of control over the vehicle.

3.3. Psychological Conflict Resolution Strategies

In order to resolve or even prevent conflicts successfully, the vehicle needs to be seen as reliable, trustworthy, and acceptable. One way to achieve this is to make use of psychological conflict resolution strategies that are derived from human strategies of social influence. This is already a large field in Human-Robot Interaction (HRI), based on the assumption that HCI is fundamentally social [25], which allows transferring social psychology strategies. Therefore, HRI research explores if it might be acceptable and effective if robots mimic human conflict resolution behavior and act like human interaction partners, considering, for instance, persuasive strategies, assertiveness, and negotiation (e.g., [26, 27, 28, 29]).

HCI research has also addressed conflicts by incorporating social psychological strategies into the vehicle (e.g., [13, 6]). To date, however, strategies have been studied only isolated and primarily in situations where the vehicle is perceived by the driver to be unreliable. Thus, the strategies should aim to avoid unsafe takeover maneuvers from the driver. There remains a research gap for other strategies and types of conflicts, e.g., goal conflicts, and how strategies can be utilized to enforce community goals when they are not aligned with the driver's personal goals.

In HRI, it is further confirmed that the success of psychological resolution strategies depends on the relationship between humans and robots [27]. So it further stands to reason that this also applies to HVI. A possible research question here could be how, for instance, vehicle assertiveness affects the acceptance of the vehicle in different ownership models.

3.4. Post Conflict

The resolution of conflicts can have significant implications for both the driver and the vehicle. How conflicts are handled by HAVs and if they were resolved successfully can have long-term impacts on driver behavior and the perceived reliability and trust in the automation system.

The impact of resolved and unresolved conflicts on driver behavior and how the vehicle should adapt its behavior accordingly needs to be explored. By addressing questions such as, how the behavior of drivers does adopt after resolved and unresolved conflicts, or how should the vehicle adjust its behavior in response to conflicts without being perceived as inconsistent?

3.5. The Good Conflict?

In human-human interaction, conflicts can also yield positive effects, such as increased productivity, positive interpersonal outcomes (e.g., development of better communication strategies), or constructive organizational changes [30]. We wonder if the same is applicable to HVI. For example, can actively communicating the recognition of a conflict before it is resolved demonstrate a vehicle's situation awareness and ability to compromise and cooperate in order to enhance trust, perceived reliability, and acceptance? Or can a conflict lead to a better understanding of the driver's goals and interests and help avoid similar conflicts in the future?

4. Conclusion

Conflicts are an inevitable part of human automation interaction, including those between drivers and HAVs. They are a critical issue that can lead to safety-critical situations, decreased trust, negative emotions, and non-acceptance and thus stand in strong opposition to successful automation engagement. Through this position paper, we have identified factors that contribute to conflict emergence in HVI and derived challenges and research directions. By emphasizing the importance of considering identified conflict development factors, our work can contribute to future conflict research in HVI and ultimately help to ensure conflictless automation engagement.

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