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Autonomous Vehicles: Where Automation Ends and the Communication Begins

Thilo von Pape

Etymologically speaking, the idea of automated transportation is as old as the word "automated" itself. It first occurred in the Iliad, to describe how the gate of heaven opened "by itself" ("αὐτόματος") for Hera in her golden chariot (Vasileiadou, Kalligeropoulos, & Karcanias, 2003, p. 77), and later how Phoenician ships piloted themselves. It takes only a few steps from there to the Society of Automotive Engineers' (SAE) standard definition of driving automation systems as "systems that perform part or all of the dynamic driving task (DDT) on a sustained basis" (SAE International, 2018, p. 2), with its categorization from levels zero to five. Yet despite this conceptual history and authoritative endorsement, laymen and experts increasingly abandon the notion of "automated vehicles." They speak of "autonomous" vehicles (AV) instead, borrowing another Greek word, which initially designated cities that made their law (νόμος) themselves (αὐτο) (Dworkin, 1988). This change from a technological term to one derived from the social sciences parallels the conceptual shift from *Human–Machine Interaction* (HMI) to *Human–Machine Communication* (HMC) that is the broader subject of this handbook. Both shifts attempt to come to terms with progress in artificial intelligence (AI) and robotics. Both also operate questionably across the boundaries between the human and the technological, the agent and the instrument.

It is in this sense that this chapter discusses applications of HMC to AVs: not to hold AVs up as some clear prism to unravel the complexity of HMC. But as a chimeric apparition that complicates our understanding of communication in and with vehicles to a level from which we can better appreciate the general complexity of HMC. Therefore, we will first investigate the communicative challenges posed by the autonomization of vehicles. The second section discusses how these challenges resonate in different strands of research on HMC and which responses this new field may bring to them.

CHALLENGES EMERGING FROM THE AUTONOMIZATION OF VEHICLES

Many works discussing AVs and future technologies, in general, caution us of conceiving them as mere "driverless cars." This conception would amount to the *ceteris paribus* fallacy of deriving expectations from a single change while holding *all else equal* (cf. SAE International, 2008;

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Townsend, 2020). The resulting visions of AVs generally amount to a version of today's luxury cars with incremental adjustments that reflect the transformation of drivers into passengers, such as turning front seats backward. However, avoiding this fallacy through the inclusion of additional variables will increase the whole consideration's complexity exponentially. Therefore, we must carefully consider which types of technologies and practices it is worth pondering their future developments under conditions of vehicle autonomy and what kind of conditions vehicle autonomy constitutes in the first place.

Status Quo of Vehicles, Infrastructures, and Practices

Given the widespread fixation on personal cars, we should first recognize the actual diversity of vehicles worldwide and of the infrastructures and practices in which they are involved. Well over one billion automobiles are in use today (Sperling & Gordon, 2010), defined as vehicles that are powered internally and move freely on roads with diverse surfaces to transport small amounts of people and cargo (Oxford English Dictionary, 2012, p. 100). The next larger category of automotive ground vehicles consists of buses and trucks. A third category includes even larger ground vehicles (tramways and trains) with constant dependence on physical infrastructure for guidance (rails) and energy supply. Below the car come motorized vehicles for the transportation of one to three persons and minimal cargo – motorbikes, rickshaws – and (increasingly electrified) bicycles, the one vehicle that rivals cars numerically. Finally, there are human-powered or motorized micro vehicles such as electric scooters, skateboards, or self-balancing pods. Vehicles of all sizes also exist for transportation in the air (airplanes, rotorcrafts, airships), in water (personal and cargo boats of all sizes, submarines), and in space – the latter ones requiring the most autonomous control systems.

We must further broaden our view beyond the vehicles, just as scholars of media change look beyond the devices themselves to infrastructures, institutions, and practices. Technologically, the vehicles profoundly depend on infrastructure, which provides the mechanically necessary conditions for them to move (roads, rails, networks of energy provisions with service stations), and signage systems. These information systems include road signs and markings, traffic lights, and schedule displays. They may take the form of paper supports (maps, travel guides, tickets, stamps) and digital interfaces (navigation software in smartphones or vehicle dashboards) (Oswald, 2016; Wilken & Thomas, 2019). Traditional vehicles also depend on human operators. The human drivers have been so profoundly integrated in certain vehicles such as cars that Dant (2004) considered these vehicles as assemblages combining the human sensory and control system with the machine's motor power. While the internal interactions between drivers and cars through pedals, levers and various indicators are primarily mute, it is conceivable that "interactions with 'mute' technologies constitute communication," as Guzman (2016, p. 1) argued for manufacturing technologies. And to the outside world, the vehicles operate as avatars of their human drivers.

The practices involved in even the most basic tasks of getting cargo from A to B reach far beyond what the SAE defines as the "dynamic driving task" (DDT). Consider the kinds of "cargo" involved in everyday transportation: persons in emergency conditions, business travelers, garbage, schoolchildren, livestock, pizza, amazon packages, deep-frozen vaccines… all come with specific expectations regarding stowage, temperature, hygiene, but also care, entertainment, wifi, etc. to make sure the travel time is not only safe but also enjoyable and productive (Lyons & Urry, 2005). These practices are not contained to the vehicles as cocoons but often involve the environment as well, if only as a stream of impressions perceived through the windscreen (Packer & Oswald, 2010) and deliberately soundtracked (Pink, Fors, & Glöss, 2019). The travel time is productive in the pragmatic sense of passengers finishing their homework and symbolically, as the means and destinations of transportation also constitute meaning (von Pape, Goggin, & Forlano, 2019). One illustration of the range at which vehicles allocate identity and social status – also to those they are passing by, is Towns' (2015) study "Riding while White." Towns argued how tourist bus-tours through troubled districts of Los Angeles actualize hegemonic meanings of whiteness and blackness by emanating a moving ceasefire around the primarily white tourists, hovering above the suspended violence just as white visitors could traverse troubled areas unperturbed in past decades.

Vehicle Autonomy

To discuss what the autonomization of these vehicles may signify for the communication involved in the associated practices, we must establish what autonomy means for machines. A technical definition is proposed by Antsaklis' (2020). He first established the locus of machine autonomy by stating that “every autonomous system is a control system” (Antsaklis, 2020, p. 16). While we commonly attribute the autonomy and conscience of humans and animals to their bodily individuality, a rolling vehicle is not the beholder of its autonomy. The control systems are both more limited to specific parts and wirelessly extended beyond their physical bodies. As Waymo’s co-founder Anthony Levandowski stated, autonomous cars move “like a train on software rails’’ (Townsend, 2020, p. 68). Wilken and Thomas (2019, p. 2719) thus emphasized that mapping technologies serve “not as subordinate or ancillary systems, but as essential elements for the control of the vehicle, integrated into their design at a fundamental level.” Other more or less externalized informational systems are also highly integrated into the vehicles’ control system to constantly optimize the security, legality, and profitability of their operations. According to Townsend (2020, p. 42), “the only independence that’s left for AVs is from us – not from other machines, networks, the law, or markets.”

Antsaklis (2020, p. 16) further postulated two sets of conditions that determine the degree of system autonomy: “if a system has the capacity to achieve a set of goals under a set of uncertainties in the system and its environment, by itself, without external intervention, then it will be called autonomous with respect to the set of goals under the set of uncertainties.”

Autonomy to the Extent of Pursuing Larger Sets of Goals

For vehicles moving through public space – as opposed to AI moving pawns on chess boards – even seemingly small goals include vast sets of secondary objectives. Otherwise, the simple request to “get to the airport as fast as possible” would lead to accidents and arrest on arrival. How autonomous machines understand and accommodate their users’ requests, their underlying interests, and the interests and rights of third parties – is, therefore, a key concern to AI scholars in general: the “goal-alignment problem” (Tegmark, 2017, p. 259).

Its purely epistemic intricacies have been emphasized through apocalyptic scenarios, such as that of a benevolent AI tasked with maximizing the production of paperclips, which inadvertently eliminates humanity in the process (Russell, 2019). Knowing what users truly want is no less complicated in the intricate domain of transportation, even for a single user himself: do I want to go to the supermarket to get my groceries, to meet people, or just for the ride in my prestigious car? How, then, to convey a goal to the AI in one unequivocal request? Computer scientists lead this epistemological side of the goal-alignment problem to an issue of communication: “Inevitably, these machines will be uncertain about our objectives – after all, we are uncertain about them ourselves – but it turns out that this is a feature, not a bug […] Uncertainty about objectives implies that machines will necessarily defer to humans: they will ask permission, they will accept correction.” (Russell 2019, p. 12)

The goal alignment problem has a second, more conflictual side, prominently discussed through the so-called “trolley problem.” How should a vehicle faced with an unfolding heads-on accident weigh different possible outcomes of human suffering against each other? Should it be “loyal” to its passengers, spare uninvolved third parties on the sidewalks, or apply purely utilitarian standards? Here, too, the AI scholars’ life and death scenario overshadows far more common and complex questions: whom to allow riding through the congested city center, whom to route via a bypass or a secondary mode of transportation? How to account for the users’ financial, social, cognitive, physical resources and needs? These questions are the object of continuous negotiations in and between diverse organisms such as urban transportation boards, the vehicles’ operators, and users’ associations. While technology can support these processes, the often democratic human representation and deliberation at their heart cannot be cast into code.

Autonomy to the Extent of Mastering Uncertainty

Antsaklis (2020, p. 16) further advanced that “for the same set of goals, the larger the set of uncertainties the system can handle, the higher is its degree of autonomy.” Autonomous buses shuttling children to school through the predictable dryness of Arizona suburbs are less autonomous than those serving the same goal in rainy Mumbai. On an epistemological level, this demands the vehicles to model the physical conditions of their environment and make sense of the social interactions between the involved road users. Given the complex interdependencies of traffic, uncertainty reduction also requires the vehicles to actively express their intentions to other road users. The breadth of different practices in which vehicles are involved beyond basic traffic interactions leads to further uncertainty: how long can the passenger “hold” his need for a toilet break? Which music best fits the trip? Which detour for dropping off one passenger is tolerable for the others? Again, the questions are not just epistemological but also involve conflicts of interest. Again they call for communication, the proven means for uncertainty reduction and conflict resolution.

Judging by the two criteria of machine autonomy – the size of goal sets and the degree of internal and external uncertainty – vehicle autonomy appears categorically different from both the SAE's benchmark of "full automation" and the kind of autonomy proper to humans. The type of autonomy proper to vehicles perhaps comes closest to that of so-called "autonomous" government agencies that can reach very high competencies but remain ultimately accountable to human elected officials. Again in Russell's (2019, p. 176) terms: "the machine […] remains coupled to the human, who is a potential source of information that will allow it to avoid mistakes and do a better job."

RESPONSES BY HUMAN–MACHINE COMMUNICATION

Whereas computer scientists can refer to this communicative coupling of machines to humans as a durable response to their problems of goal alignment and uncertainty reduction, this is where the issues for communication researchers only begin. How to conceptualize exchanges between humans on the one side and their vehicles' control systems on the other, each side being endowed with a distinct kind of autonomy? How to grasp the rise of these exchanges above the level of passing and receiving of commands to a level where meaning is constituted in collaboration and negotiation? In their research agenda for Human–Machine–Communication, Guzman and Lewis (2020, p. 70) emphasized three aspects of communicative AI technologies:

"(1) the *functional* dimensions through which people make sense of these devices and applications as communicators, (2) the *relational* dynamics through which people associate with these technologies and, in turn, relate to themselves and others, and (3) the *metaphysical* implications called up by blurring ontological boundaries surrounding what constitutes human, machine, and communication."

Functional Aspects

Burleson (2010, p. 151) defined interpersonal communication as "a complex, situated social process in which humans and machines who have established a communicative relationship exchange messages in an effort to generate shared meanings and accomplish social goals." How can communication involving AVs operate towards these goals and meanings?

Humans and their vehicular interlocutors often pursue common goals, as when a driver and her navigation system confer about the destination of a trip and the desired route – the fastest, cheapest, most scenic, or most ecological? Such dialogues for goal-alignment might even lead to abandoning the trip, at least for the human. This would be the case if the dialog ascertained that the ultimate goal was to get certain products home, and that this goal was better achieved by delivery or digital transmission. In this case, human spatial mobility would be replaced by the mobility of the machine or a form of mediated mobility (Keightley & Reading, 2014). The secondary goal of avoiding collisions is already the object of many exchanges between vehicular and human road users and generally functions very reliably (Stanciu et al., 2018).

Significant questions remain when the goals of humans and machinal road users diverge. How to handle the epistemic dominance (Zuboff, 2020) enjoyed by autonomous systems – particularly those owned by corporations that also provide web searches and mobile operating systems – over their human counterparts in confrontational situations such as price negotiations? In other conditions, the AVs' strength can play to their disadvantage. This is the case for the game-theoretical problem of "crosswalk-chicken": two traffic participants moving towards a point of collision, which both want to avoid, while neither wants to step out of his way first. We can expect AVs to perceive and avoid any risk, whereas humans could always be distracted or reckless. Generalized confidence in AVs systematically breaking for others could paralyze AVs and traffic in general (Millard-Ball, 2017). Communicative approaches to this problem – such as designing aggressive car "faces" to intimidate other participants (Landwehr et al., 2011) – run counter efforts to raise the acceptance of AVs through external car displays (ECD) that express attention and care (Holländer et al., 2019). It may require non communicative solutions, in the form of traffic regulations and urban road design, to resolve these conflicts sustainably (Millard-Ball, 2017).

Generating shared meaning also proves problematic when conflicting interests come into play. The mildest form of such conflicts can arise when systems nudge users toward certain navigational choices (cf. Hebblewhite & Gillett, 2020), which the users approve generally, but not in the given moment. Thus, a hurried driver may be frustrated by the slow country roads onto which her navigation system sends her, until she remembers that she had programmed the system's default to avoid highways. The interference becomes more problematic when the systems accommodate the interests of third actors to whom they are also accountable, such as stockholders, legislation, or even broader societal interests in health and environmental interests. The confusion and malaise which AI can cause when mingling in individual and collective meaning-making processes has already been discussed at the examples of photo hosting and social networking services curating personal snapshots into soundtracked storylines (von Pape, 2017). We can expect similar complications when a car attempts to underscore the hypothesized social meaning of a journey (professional? familial? romantic?) through its route choices, interior lighting, and background music.

Relational Aspects

As the above example suggests, transportation as a meaning-making process also affects the relationships and identities of the involved persons. This phenomenon can play out on a fundamental symbolic level – tourist buses actualizing specific meanings of whiteness and blackness (Towns, 2015) – and in very concrete interactions. Thus, Laurier and Dant (2012) showed how AVs eliminate the traditionally patriarchal role of a car's driver and, in consequence, also the supporting role of the co-driver, whose contribution through navigating, leading the conversation, etc. they referred to as "passengering." The disappearance of this mutual obligation and support in AVs liberates all passengers for more productive and individualistic work – perhaps to their regret, as pilot studies suggests (Fraedrich & Lenz, 2016).

The users' relation with the vehicle is also expected to evolve. Ratan (2020) conceptualized possible forms of this evolution through the Self-Other-Utility (SOU) framework from the study of player-avatar relations in video games. With increasing autonomy, the car's role for the user broadly tends to evolve from directly embodying her in a utilitarian sense (as in first-person shooters where the avatar's body is barely visible), to representing her self symbolically (as avatars in Second Life), to assisting her as an independent social other (as do virtual assistants) – but it can also constitute any combination of these for different persons and contexts. The vehicles' independence may go as far as to reason with users about inappropriate requests (by pointing out that they exceed speed limitations), proactively suggesting certain user behaviors (to take a break, fasten the seatbelt), or imperatively requesting them (to take over control of the vehicle, see Sandry, 2018). Given the vehicles' assumed superior driving competencies and knowledge of the environment, and given their obligations to third actors such as their corporations, the risk appears high that the vehicles' control systems may themselves assume a paternalistic role. They could end up infantilizing their users as flight attendants sometimes do to a point where they challenge the underlying ethical principle of human sovereignty over machines. In sum, a principal and mostly unresolved challenge to HMC lies in accommodating these heavy shifts that can produce rapidly within the relation of users and their vehicles.

Metaphysical Aspects

These relational questions lead to the ultimate metaphysical questions on the meaning of being human, being a machine, and being mobile or immobile (Smets, 2019). As Ess (2018) pointed out at the example of sex, advancements of machine autonomy in new realms can raise our awareness of human characteristics and virtues (namely, the preciousness of experiencing genuine emotions, empathy, and embodied desire). To consider what a reflection of AVs can teach us about humanity – and vice versa – we can build on an essay by Goggin (2019) on disability and the future of cars. Goggin argued how commercial discourses insisting on the merits of AVs to make mobility accessible for disabled persons could have an inverse effect, at least on a symbolical level. By emphasizing the need for the blind to drive a car as any "normal" person does, these discourses further elevate the relevance of specific modes of mobility that are generally difficult for many disabled persons to acquire. They thus echo past decades' talk in praise of prostheses and walking sticks as means to "liberate" people from their wheelchairs, which has also had the effect of diminishing the status of wheelchairs as means of locomotion. This attachment of humanity to specific transportation skills is also enforced in conceptualizations of full vehicle automation as "systems that do not rely on a human to take over" (Autonomous Vehicle Industry Association, 2022), as though it ultimately required humanity and not specific, trained, skills, to steer a car. In analogy to Ess' (2018) interrogation on sex, we should therefore ask which experiences in mobility require and manifest our humanity?

These experiences include the perception of changes in a transversed environment, the desire to expose oneself to these changes and to overcome distances, and the virtues of conceiving oneself in other places and in the places of others. These can be tightly associated with the tasks that are bound to be executed by machines, as shown in an investigation into the pleasure of driving: drivers draw a significant part of this pleasure from the satisfaction of executing their acquired driving skills (Zoller, 2017). Articulating and affording these genuinely human experiences and contributions to transportation is also a function of HMC.

CONCLUSION

This investigation into AVs as an application of HMC builds on a deliberately broad understanding of transportation, vehicles, and autonomy. It assumes that, just as communication, transportation is not only about getting things "across" a given divide. Transportation serves a broad range of goals. It constitutes meaning, positions people to each other socially, and provides unique ways to experience and express our humanity. Therefore, the operations conducted by vehicles reach far beyond the "dynamic driving task" specified in the SAE's "vehicle automation" concept. They touch the full range of logistical, cultural, and social domains involved in mobility itself. This open-ended scope of the vehicles' operations is better accommodated by the bottom-up logic of Antlakis' (2020) technical concept of "autonomy," as the degree to which machines take on increasingly complex goals in ever less predictable environments. For all its breadth and potential, this machinal kind of autonomy cannot be confused with the original meaning of autonomy that had been reserved for humans since Greek city-states first gave themselves constitutions. The machines can write their own code, but not their own laws. They remain "coupled" (Russell, 2019, p. 176) to humans to assert their goals and reduce uncertainty. However, that "coupling" is much richer than the receiving of orders and returning of feedback which had long constituted the interactions of humans and their vehicles: the vehicles grasp much more of the meaning attributed to various journeys, and they have a say in it in their own particular way.

This HMC-based understanding of vehicle autonomy can guide us in examining the communicative processes in which humans and their algorithmic interlocutors establish how things, beings, and symbols are moved and what this movement signifies. To illustrate its potential contributions to ongoing interrogations on mobile communication and transportation, I have declined it along the three aspects of HMC highlighted by Guzman and Lewis (2020). First, HMC provides the analytical distinctions to tell apart the cooperative and antagonistic dynamics which these communicative and transportation processes may assume: from the micro-level of communicative protocols through which the transfer of control occurs within a vehicle, to the negotiations of "crosswalk-chicken" between human and robotic participants to the politics of transportation planning. Second, it guides our attention to the positions into which the emergence of AVs can put humans – individually as passengers or delivery customers, or collectively as boards of transportation – with respect to each other and their machinal counterparts. Thirdly, HMC encourages us to ask not just what remains to be done for humans in increasingly autonomous mobility systems but how to transform these systems so that they can enhance our humanity.

The future directions for robotics and communication which we can draw from this broad approach to autonomous vehicles do not come in specific predictions on the trajectory of AVs. Despite the bottom-up approach to vehicle autonomy advocated here, the medium-term future might very well follow the incremental path of five levels of automation which is foreseen by the SAE's top-down taxonomy. This is at least the direction in which the current system of automobility is pulling with all its inertia. In that case, social scientists may find little innovation for either robotics or communication. What we can still derive from this chapter in any case are indications where to look for innovations for robotics and communication that go beyond the automatic, the vehicular, and indeed the mobile. Concerning personal travel, we may seek innovation for AVs in new methods to emphasize the traveler's experience of the traversed environment and to replace the mutual obligation which people had appreciated in the collaboration of "driving" and "passengering." Rather than automating the human out of the transportation process, we may even seek innovation in new and secure ways to give drivers the satisfaction of moving skillfully through the landscape. The machines to move us in these ways may be vehicles, but may also be other devices that provide forms of "mediated mobility" (Keightley & Reading, 2014), in which the humans' condition is a state of spatial immobility. This could be achieved in multiple ways, from the simple transmission of digital content to the affordance of a bike ride with friends, on a stationary workout device through an environment in virtual reality.

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