Human-aware automation: The future of vehicle intelligence depends on understanding people

Driving automation is advancing rapidly, yet the biggest challenges ahead have less to do with sensing the road and more to do with understanding the human behind the wheel. Human-aware automation will become one of the defining features for an elevated driving experience and safe mobility.

By Dr. Pnina Gershon

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Autonomous vehicles are an ambitious technological undertaking that have evolved dramatically over the past decade and are reshaping the transportation landscape. The momentum is palpable. But this progress has highlighted an important truth apparent across every level of deployment: the technical side of driving automation is advancing faster than our understanding of how humans are interacting with these systems. To reach their full potential, driving automation systems require more than advanced environmental sensing; rather, they depend on a deeper understanding of the human beings sharing control, riding inside, and moving around these vehicles. Eventually, the real differentiator between driving automation systems will not be better sensors or faster computing, it will be technologies that can interpret and respond to the human state, human behavior, and human variability. Simply put, driving automation systems need to understand people.

For years, conversations around driving automation systems centered on environmental perception: lidar, radar, computer vision, and neural networks. But as these systems have been deployed in the real world, the biggest challenges that have emerged are not just about detecting lane lines or classifying objects, they are about people: their attention, habits, trust, fatigue, reactions, and expectations. Most automated systems still operate on the implicit assumption that humans will adapt to the machine. And humans do adapt, but not always in ways designers and engineers intend or expect. Our research across multiple studies makes this clear.

What real-world driving reveals about people and automation

For more than a decade, the MIT AgeLab's naturalistic driving research program has been building one of the richest datasets available to study driver interaction with technology and driving safety. As the director of research at the MIT Advanced Vehicle Technology Consortium, and through close collaboration with industry partners and stakeholders, I work to understand how drivers use, adapt to, and behave with the most advanced automation systems currently available on the market. At the AgeLab, we study how people engage with advanced vehicle systems in both their everyday lives and across their lifespans. This work provides a rare window into directly observing and objectively quantifying the dynamics of driver behavior, vehicle kinematics, and environmental context. It offers a triad of information essential for designing intelligent driving systems.

In our studies, we look at the different ways people actually engage with automation, interact with other road users, and make decisions about whether they trust these systems. Understanding these behavioral patterns is essential for mitigating misuse and disuse, and for advancing support that future driving automation systems can offer. We see that drivers use automation fluidly, moving in and out of different levels of assistance based on moment-to-moment road conditions, traffic cues, and shifts in personal preferences. Drivers often want to do something that is beyond the automation's capabilities, or they simply prefer a different speed, lane position, or driving strategy. The result is a wide range of human–automation interactions that unfold in ways current systems cannot fully anticipate or adapt to.

Over time, drivers also seem to learn system boundaries and safeguard sequences, becoming faster at responding to automation alerts and more adept at identifying brief "windows" where they can shift attention away from driving to engage in non-driving tasks, often accompanied by more off-road glances and more frequent hands-free driving. These findings underscore that driving automation does not remove the driver from driving, but it does change how drivers manage control and direct attention, and they do not always stay within the system's intended boundaries.

Further, our studies of driver-pedestrian interactions show that this is not just a detection-and-yield problem. These interactions are fundamentally social and far more nuanced than right-of-way rules suggest. Pedestrians rely on subtle cues—for example, how quickly a vehicle decelerates, whether it maintains speed, how long it pauses at the curb, and whether the driver acknowledges them—and these cues differ across environments and locations. These findings reinforce the dynamic nature of driver-pedestrian interactions with bidirectional communication processes that future driving automation systems should learn to interpret and replicate.

Consumer acceptance is another aspect to consider. Our longitudinal survey work demonstrates that acceptance of automation tends to be conditional, and it depends on the use case, the perceived benefit, and whether automation solves a problem that people actually face. We found that baseline willingness to use an autonomous vehicle remained cautious over the years, yet acceptance increased dramatically when framed around specific situations or cases, such as being unable to drive due to age or injury, or being assured that the vehicle is "as safe as" the human driver is. These conditional scenarios suggest that people evaluate autonomous vehicles in relative terms: *Will this be safer than me? Will it help when I can no longer drive?* Further, acceptance is not universal and varies by characteristics like age. Younger adults express higher enthusiasm for full autonomy, whereas older adults overwhelmingly prefer driver-assist features but become nearly as willing as younger adults once safety and mobility-loss scenarios are introduced.

The lesson from naturalistic driving research is simple: people are complex and variable. They adapt in unexpected ways. They bring their beliefs, context, emotions, distractions, and experiences with them into the vehicle. As such, over the next decade of vehicle automation development, the technology needs to understand people better and be able to detect, interpret, and respond to human needs, especially in the dynamic, real-world conditions of driving. Recent advances in AI, particularly in multimodal sensing, foundation models, and real-time behavioral inference, now make it possible for systems to interpret attention, workload, fatigue, stress, and intent with far greater fidelity than before. These capabilities open the door to transformative intelligent systems that apply behavioral engineering to guide drivers toward safer behaviors and mark a shift from observing and reacting to risk toward shaping the decisions and contexts that give rise to it. Driving automation designed to recognize this variability and adapt in a corrective, supportive way, guiding drivers toward the right action when it matters most, will be one of the defining features of an elevated driving experience and safe mobility.

Toward human-aware vehicle intelligence

Recognizing this need to understand human behavior better, the AgeLab developed AWARE (AI with Awareness in Real-world Environments). AWARE is built around this principle: advancing human-aware AI that senses, interprets, and adapts to human variability with the goal of supporting positive behavioral change in dynamic, real-world conditions. We envision that the vehicle of tomorrow will be more than just a mode of transportation; rather, it will serve as a platform for mobility, services, and human support.

Using multimodal sensing, behavioral modeling, and AI, AWARE develops the foundations for building systems that are not only technically capable but also human-attuned. AWARE brings together interdisciplinary research in sensing, behavior, health, and design, addressing safety issues like driver distraction, impairment, changes in mental and physical states as well as enhancing well-being and the overall driving experience.

As we look ahead, an important challenge is to develop frameworks that help us anticipate how people will actually interact with emerging intelligent systems. Different design philosophies and levels of AI embedding can lead to very different patterns of use, misuse, and disuse of these systems. To build technologies that truly support the driver, we need predictive methods that can estimate how humans will adapt to new automation features and how they will respond to behavioral-engineering interventions before these systems reach the market.

The path forward calls for a coordinated effort. Industries would benefit from shared standards for measuring and communicating the human state, along with frameworks for evaluating interactions with adaptive automation. The AWARE initiative invites partners interested in advancing human-aware intelligent systems to join us in shaping technologies that understand human engagement. By shifting toward systems that proactively support the human, AWARE positions human-centered intelligence as a foundational element of future-ready vehicles and mobility ecosystems. •

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