Science Module: Human Machine Interface (HMI) Issues for Autonomous Vehicles

Summarizes key designs and challenges for autonomous vehicle human machine interfaces.

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WHAT IT DOES

The [human-machine interface (](HMI) is the collection of hardware and software responsible for communication between the autonomous driving system and system stakeholders (ie., the operator and other road users). The system presents information to individuals inside and outside the vehicle and accepts, interprets and fulfills commands.

The human-machine interface design of automated driving systems is crucial for road safety because it is the point of communication between the driving system, those internal to the vehicle, and those external to the vehicle. A good interface design will promote engagement between the driving system and those internal to the vehicle to keep them involved in the driving task and aware of driving conditions and events. This design will also promote engagement between the driving system and those external to the vehicle to ensure the safety of those around the vehicle. Human-machine interface designs that successfully open up an efficient and reliable means of communication between systems and stakeholders can increase trust in and acceptance of automated driving systems.

RELEVANT SCIENCE

Human to machine interface involves effective communication from those internal and external to the vehicle to the system to influence the system or provide the system with commands. Humans may need to communicate with the system to express destination goals, decision preferences, or dangers that the system cannot detect. Modalities of human to machine interface include:

- Audition – Voice control, natural language processing
- Tactile – Gesture control, touch input, manual controls
- Vision – Visual control, image detection, human recognition

Machine to human interface involves effective communicating from the machine to those internal and external to the vehicle. The system may need to communicate with humans to keep the driver updated on driving conditions, communicate any necessity for driver reengagement, prompt responses in situations where system action is subject to driver preference, and issue danger alerts to drivers and pedestrians. A machine to human interface is more generally called a display and can appear through multiple modalities, including:

- Visual – Gauges, meters and display screens combining text and graphics
- Auditory – Audible alerts and warnings, including alarms and digitized speech
- Force feedback – Haptic features communicated through the sense of touch, such as vibration

There are numerous barriers, both human-related and technology-related, that the industry must overcome to guarantee effective communication between the autonomous driving system and humans internal and external to the vehicle.

- Function allocation: Responsibility for driving tasks must be divided between the system and the driver to determine whether the driver or the system has the authority to make decisions in various circumstances. This division determines when the driver and system share joint authority of the driving tasks and when the driver and the system may influence and override each other to gain control of the driving tasks. HMI design will enable the driver and system to influence each other and request permission to take control of the driving task. However, this design must account for skillset differences that affect the qualifications of humans and driving systems to maintain control of the driving tasks. Driving systems are best at dealing with familiar situations because driving systems abide by programmed rules. Humans are best at dealing with unfamiliar situations because humans have the capacity to extrapolate new responses to unfamiliar situations. Until the abilities of driving systems advance past this barrier, it will be necessary to divide responsibilities of humans and driving systems according to these skill differences.
- Human factors issues include the physical and cognitive strengths and limitations inherent to people that are relevant complex systems, like driving. Numerous human factors concepts are relevant to the design of ADS; however there are a few key challenges.
  - Situational awareness: Level 3 autonomous driving systems introduce the handover transition, a point in which the driving task shifts from the responsibility of the system to the responsibility of the driver. Drivers must take over the driving tasks of the vehicle following a period in which they performed little to no driving tasks. This is a particularly difficult task given that level 3 autonomous driving systems only require the driver to assume control in the case of dangerous situations that the driving system cannot handle or system failure. Therefore, the system's ability to communicate the need for a transition is important for passenger safety. HMI design must ease the transition between these two modes to ensure that drivers are aware of all relevant information about their vehicle and driving conditions before assuming control of the vehicle.
  - Trust calibration: As autonomous driving systems become more advanced, drivers may begin to over-rely on performance of the system. If the driver's trust in the system exceeds the capabilities of the system, drivers may insufficiently monitor their environment and create a dangerous situation. On the flip side, if drivers mistrust the system, drivers may underuse the system and eliminate its advantages for safety. Furthermore, HMI design must clearly communicate the responsibilities of the driver to encourage driver trust.
  - Skills degradation: As autonomous driving systems require less engagement form the driver, the ability of the driver to perform driving tasks may worsen since they manual driving skills will go unused for long periods of time. The system's ability to give the driver advanced notice about the need for reengagement and clearly outline the required level of reengagement will help counter this effect.

BACKGROUND

Further reading:

https://link.springer.com/book/10.1007/978-3-662-48847-8

https://link.springer.com/book/10.1007/978-3-662-48847-8#page=125

http://acrs.org.au/files/papers/arsc/2015/CunninghamM%20033%20Autonomous... (

https://www.here.com/file/13726/download?token=njs4ZwfW

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