Research casts new light on bike safety in the age of self-driving cars

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Credit: University of Glasgow

Equipping self-driving cars with external displays that use colored lights to communicate their next maneuver could help keep cyclists safe on the roads of the future, researchers say.

With autonomous vehicles becoming more common, reducing active human involvement in driving in the process, researchers from the University of Glasgow have been working to investigate new ways to help self-driving cars speak the language of cyclists.

Their suggestion is that external human-machine interfaces, or eHMIs, could be the key to quickly and reliably signaling self-driving cars' intentions to bike riders. eHMIs are devices which use screens or lights to display information and can be added to surfaces like car doors or roofs to communicate with anyone nearby.

The team's latest study suggests that a ring of pulsing colored lights displayed on all sides of self-driving cars could be the most effective way for cyclists to quickly determine how nearby vehicles will move next—key for ensuring the safety of vulnerable road users. It will be presented as a paper at the Association of Computing Machinery CHI conference on Human Factors in Computing Systems (CHI 2024) next week.

The finding builds on several years of research by the team, which brings together human-computer interaction specialists and psychologists. They initially conducted a study to better understand the complex verbal and non-verbal communication between cyclists and human drivers, which helps determine who has the right of way in traffic and at junctions to prevent accidents.

Then, they worked with bike riders to design several prototype eHMIs which could be added to the exteriors of autonomous vehicles to replace the complex language of human road users.

In the new study, the team took three of those prototype designs and tested their effectiveness by asking cyclists to interact with cars equipped with eHMIs, first in a virtual reality environment and then in the real world.

In the virtual environment, 20 volunteers cycled on stationary bikes while wearing VR headsets which showed them interactive videogame-like digital versions of city streets. While riding around the city in a

series of different traffic situations, they encountered a simulation of a self-driving Citroen C3 hatchback equipped with one of the three prototype eHMIs.

One design used a digital screen on top of the car to flash emojis to bike riders, with a happy face to communicate yielding and a grumpy face to communicate the opposite. A second design projected colors onto the road around the car, with green to show the car would yield and red to confirm it would not. Finally, a ring of LEDs around the car's exterior showed lights that bunched up to signal braking and spread apart to show acceleration.

The volunteers reported that they strongly preferred the simple red and green signals over the more complex emojis or light animations, which they felt took more time and effort to understand.

Ammar Al-Taie, of the University of Glasgow's School of Computing Science, is the paper's corresponding author. He said, "The VR portion of the study helped us to effectively test cyclists' reactions to the three prototypes in an entirely safe and controlled environment.

"The results clearly showed that cyclists prefer visual signals which can be understood at a glance—they felt that the emojis were too complicated to 'read' without taking their eyes off the road for longer than was comfortable."

"Once we had that feedback, we incorporated the recommendations into improved versions of the three interfaces and set out to test them in the real world."

In the study's second phase, the improved designs for LED strips, rooftop displays and projectors were added to the exterior of a real Citroen hatchback.

On a disused piece of road on the University's Garscube campus, a hidden human driver piloted the car through simulated traffic situations while 20 volunteers biked alongside, watching the eHMIs for signals about the car's intentions. The car's driver wore a costume designed to look like a car seat to heighten the cyclists' impression that they were interacting with a real self-driving car.

After each session of cycling, the cyclists gave their feedback on how effective they felt the eHMI was before moving on to another simulated traffic situation.

In this portion of the study, LED lights ringing the car edged out simple red/green signals as being most helpful for awkward lane merges and intersections. Adding pulses to the lights helped reinforce the meaning of the car's intentions too.

In both stages of the study, having any interface was far better than no display for cyclist confidence and safety. When left to guess vehicle intent from driving behavior alone, bikers slowed down, checked more over their shoulders, and reported feeling stressed.

Professor Stephen Brewster leads the Multimodal Interaction Group at the University of Glasgow and is a co-author of the paper. He said, "Taking this study into the real world for the first time gave us really valuable insights into what works for cyclists. It's clear that keeping it simple is the key to effective communication.

"Bike riders want to be able to stay focused on the road, so lights placed all around the car help them to make immediate decisions about their next move.

"This feedback will help us refine future designs, which we hope will be of use to manufacturers to consider integrating into the next generations

of self-driving cars. We're also keen to look more at how we can tap into the devices that cyclists often have with them to help keep them safe—most bike riders carry phones, for example, so perhaps there's the option to use vibration to communicate with autonomous cars.

"This is still an evolving area of research but it's important that we do everything we can to ensure the roads of the future are safe for all users."

Al-Taie added, "We're continuing to refine our designs and to expand our understanding of what works best for cyclists. We also want to conduct more research outside the UK to see how the language of the roads varies in different countries, and how eHMIs might adapt to those differences."

More information: Light it Up: Evaluating Versatile Autonomous Vehicle-Cyclist External Human-Machine Interfaces. eprints.gla.ac.uk/324528/

Provided by University of Glasgow

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