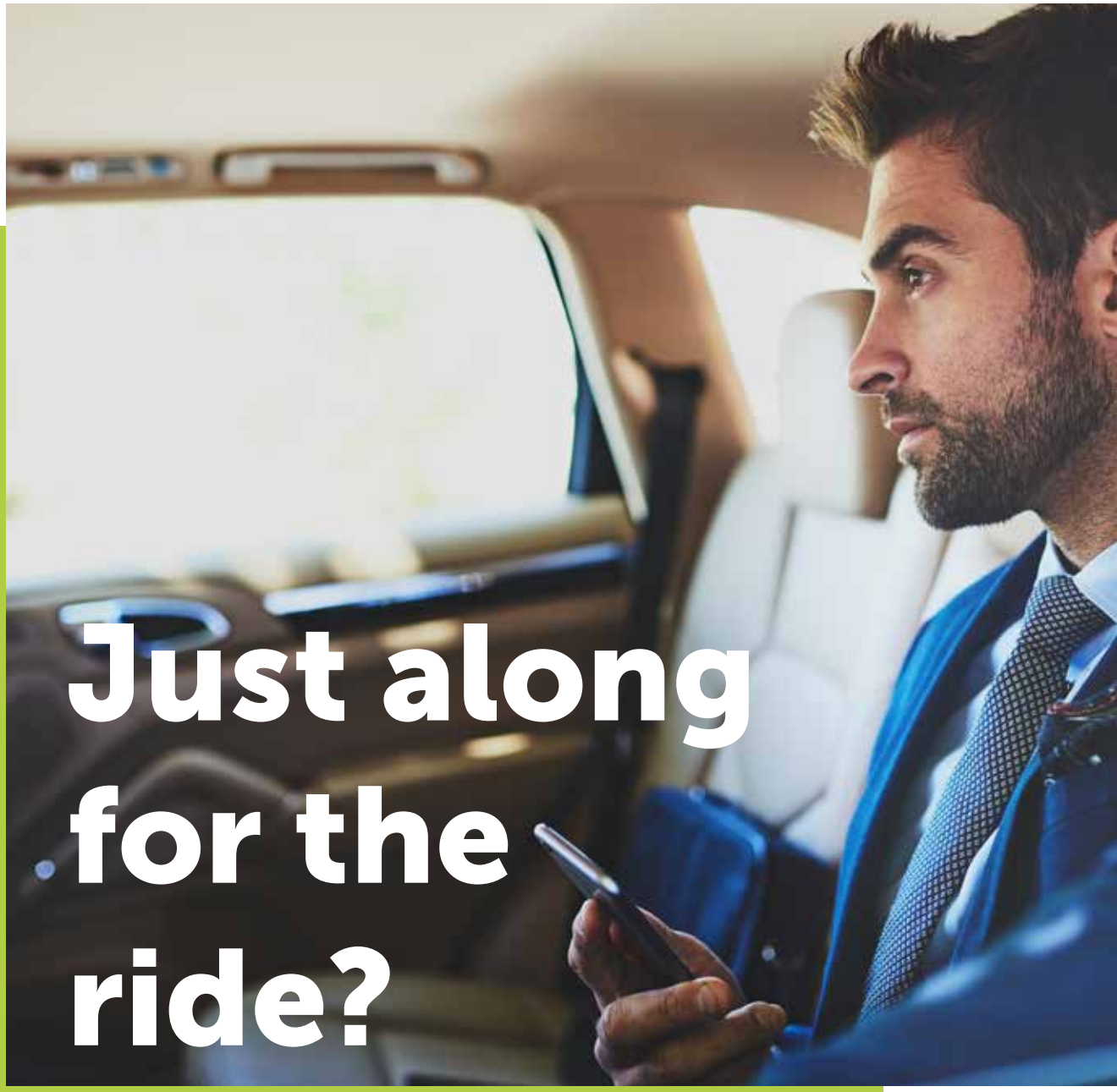


Just along for the ride?

How automotive UI will differentiate brands and monetize the passenger economy in autonomous and MaaS vehicles

ultraleap

Executive Summary

The automotive industry has always been a home of innovation. However, even by these standards we are currently seeing an unprecedented level of disruption, mostly driven by advances in technology.

Driverless cars are already a reality in some cities. Shared journeys are increasing via taxis, car sharing, and mobility-as-a-service platforms – and these two trends are also self-perpetuating.

The way we get from A to B will fundamentally change over the next 20 years, and the passenger experience rather than the driver experience will be key to success.

Some passengers will want a "budget" model where the cost of transit is all that matters. Others will be looking for high-performance, ultra-connected computing and entertainment centres. The opportunities for additional services, monetization of the passenger economy, and brand differentiation are huge.

In passenger-centred vehicles, the user interface will be pivotal in connecting passengers to car brands, content, services, and advertisers. However, the challenge is that vehicles, and particularly shared vehicles, present unique practical obstacles that need to be overcome to create effective passenger-centred UI.

The passenger of the future might be wearing AR glasses or a VR headset, but they also need to be able to interact meaningfully with that virtual content. And solutions – such as hand-held controllers – that work well at home or work are much less optimal when people are in transit.

This whitepaper examines the opportunities and risks created by the shift from driver-centred to passenger-centred vehicles, the key challenges in developing automotive UI for passengers in the cars of the future, and the pros and cons of different HCI (human-computer interaction) technologies for this unique use-case.

The challenge of managing interaction will only increase for manufacturers, as cars are increasingly judged on journey quality rather than driving performance. Choosing and effectively integrating the right HCI technologies will be key to success.

Charlie Alexander
Director, Automotive

The future is autonomous

- **Waymo has racked up more than 10 million miles of running driverless cars on US public roads.[1]**
- **Trials of other autonomous vehicles are happening all over the world, from San Francisco to Singapore to London.**
- **The UK Government has claimed driverless cars could be in full use on the road by 2021.[2]**
- **McKinsey predicts 15 per cent of new cars sold by 2030 could be fully autonomous.[3]**
- **A 2019 Accenture survey[4] found that owners of premium brand cars were more likely than owners of non-premium brands to say they would give up car ownership for autonomous mobility solutions.**

[1]https://techcrunch.com/2018/10/10/waymos-self-driving-cars-hit-10-million-miles/ | [2]https://edition.cnn.com/2019/02/06/uk/driverless-cars-scli-gbr-intl/index.html | [3]https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/disruptive-trends-that-will-transform-the-auto-industry | [4]https://newsroom.accenture.com/news/nearly-half-of-drivers-in-multi-country-survey-indicate-willingness-to-give-up-car-ownership-in-the-future-in-favor-of-autonomous-mobility-solutions-accenture-report-finds.htm

The shift from driver-centred to passenger-centred cabins

The experience of the driver has always been behind innovation in the car market, and the full force of most automotive marketing campaigns has been aimed squarely at the person behind the wheel. However, future cars will be designed with the passenger in mind.

As shared rides become the norm and car ownership goes down, the passenger experience will be an important differentiator for taxi and mobility-as-a-service operators. In the longer term, as vehicles become autonomous, the driver's experience will disappear completely, and we'll all become passengers.

Welcome to the journey of the future: A virtual desktop in the cabin of the autonomous mobility solutions of tomorrow. Image from Ultraleap demo.

There are five levels of automation in car design. As cars progress through the levels, the experience of the driver fades.

LEVEL 0: No automation

LEVEL 1: Automation of driver assist functions (e.g. adaptive cruise control and lane assist)

LEVEL 2: Partial automation of central driving functions (e.g. traffic jam assist or driver assist functions to increase safety)

LEVEL 3: Fully automated, but a human may be required to take over (hands are off the wheel but a driver is still required behind the wheel)

LEVEL 4: Fully automated, but the vehicle is constrained to specific use-cases (i.e. specific areas under carefully controlled conditions)

LEVEL 5: Fully automated in all driving scenarios (no human intervention required)

Welcome to the journey of the future: A 3D, tactile shopping experience in the cabin of the autonomous mobility solutions of tomorrow. Image from Ultraleap demo.

"...brands will have to focus on what passengers can do on the journey, and premium brands have the opportunity to deliver a premium experience. "

For luxury and sports car brands in particular, the experience in the cabin will be a critical part of the brand experience. Driverless cars will be heavily regulated to ensure safety. Car manufacturers may find that previously vital statistics such as acceleration, braking, torque, and top speed become standardized requirements and therefore entirely redundant as a selling point.

Instead, brands will have to focus on what passengers can do on the journey, and premium brands have the opportunity to deliver a premium experience.

For example, the potential for virtual personal assistants (VPAs) in cars is already well understood, but could these be an extension of the car brand itself? Would passengers looking for a premium experience perhaps want their VPA to be a butler – to do secretarial work, arrange their schedule, or secure exclusive access to events or restaurants?[5]

In all of this, the user interface will be a key point of connection between passengers and car brands. And the quality of that interface will become all-important in delivering stand-out passenger experiences.

[5]https://www.engadget.com/2019/07/10/bentley-exp-100-gt-concept-car/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAAaQ-fbBQ7zFxqcobE2606eJ7oPTZkBn69KY_xbYHXv-lJtwfSuJGg64YwEb5JLcU4Wt2_WlSryUTE033hn-EOEY33KaemDmi8IoKijmOWw5TQLNBlk7fhSIJV32gSFkUwH7Hd57u7prJgl7b5eaXXpA8tRfAtC3nJrlfZYTTde

New mobility solutions, new opportunities

The opportunities for additional services in the car of the future are huge. According to Accenture, 89 per cent of people would be interested in "add-on services" (anything from video streaming to massage chairs) during autonomous car journeys. This rose to 97 per cent of those aged between 18 and 37.

Advertising and marketing

A passenger in a self-driving car is surely an advertiser's dream – a captive audience, looking for something to do. Driverless cars represent a big commercial opportunity, and we can expect the passenger economy to quickly become monetized.

Some taxis already have back-seat touchscreens and advertising, and the opportunities are only going to get bigger. Could an autonomous taxi be 10 per cent cheaper if you don't mind watching some ads during the journey? Or would you be happy to pay a little more for a ride with an AR headset that turns the passing view into a gaming experience?

Immersive entertainment

"Just like being at home" will no longer be the aim for in-car entertainment. The centre stack will become a powerful, connected entertainment centre. Personalized experiences using virtual, augmented, and mixed reality will become compelling out-of-home entertainment experiences in their own right.

Productivity

The cabin of an autonomous car could easily become an extension of the office. Passengers could host virtual meetings, or explore 3D models and prototypes using audio, visual, hand tracking, and haptic technology.

"Driverless cars represent a big commercial opportunity, and we can expect the passenger economy to quickly become monetized."

[6] https://newsroom.accenture.com/news/nearly-half-of-drivers-in-multi-country-survey-indicate-willingness-to-give-up-car-ownership-in-the-future-in-favor-of-autonomous-mobility-solutions-accenture-report-finds.htm

The need for control

One common factor in all these scenarios is control. The passenger will be in control of whatever service or experience they choose. They'll also want to control the climate, lighting, and stay comfortable in their seats. There won't be anyone on hand to explain how things work, and passengers won't want to read instructions. The interaction between physical and digital worlds must be seamless.

Data and personalization

Another common factor is data. As consumers, we already expect a personalized experience when we interact with technology. Connected, autonomous cars will generate a huge amount of data about their occupants, from TV preferences to regular journey patterns. Used wisely, this data can personalize and improve the passenger experience – suggesting music en-route perhaps, or a good stop for coffee.

However, this can be a challenging area. Car makers will increasingly need to be mindful of privacy concerns, and ensure they have a clear understanding of who owns that data and what constitutes acceptable usage.

"There is clearly great interest — and therefore significant revenue potential — for add-on services in the future of autonomous mobility. To get a jump on the competition, car companies should start piloting and refining these services to be ready once autonomous vehicles hit the market."

Juergen Reers | Managing Director at Accenture and leader of the Mobility X.0 practice[7]

[7] https://newsroom.accenture.com/news/nearly-half-of-drivers-in-multi-country-survey-indicate-willingness-to-give-up-car-ownership-in-the-future-in-favor-of-autonomous-mobility-solutions-accenture-report-finds.htm

The challenges of interaction in the vehicles of the future

From hearing a car stereo above a roaring engine to telling a taxi driver where to drop you off, interaction in vehicles has presented challenges for almost as long as cars have been around.

It's important to understand that these challenges are unique to the automotive industry and need bespoke solutions. Interaction with technology when in a car (and particularly a shared car) is very different to what happens at home or in an office. The challenge of managing it will only increase for manufacturers, as cars are judged on journey quality, rather than driving performance.

Key challenges of interaction in autonomous vehicles

Ease of use

There's little point in immersive entertainment systems and VPAs if they are difficult to operate. There is simply no time to learn, and passengers will expect their surroundings to "just work."

Hygiene

Any suppliers of shared equipment, from bowling shoes to 3D glasses in cinemas, have faced the sometimes sticky issue of hygiene. As shared vehicles become the norm, this will become increasingly important in automotive.

Passengers will expect to control everything around them, but shared buttons, VR headsets or touchscreens also mean shared germs. This is particularly unappealing when a passenger doesn't know who has been in a car before them or what they were doing.

Passengers will be travelling light

Hand-held controllers work well for home gaming, but it seems unlikely that consumers will be prepared to carry their own controllers or haptic gloves with them on everyday journeys.

Robustness, security, and maintenance

Any device installed in a shared vehicle will need to be robust and hard to remove.

Privacy and security

Interacting and connecting with systems in shared vehicles will naturally raise concerns around privacy and security, which manufacturers will need to address.

"Interaction with technology when in a car (and particularly a shared car) is very different to what happens at home or in an office. "

HCI technologies and their pros and cons

What options are available for human-computer interaction (HCI) in passenger-centred cabins?

Hand-held controllers

When it comes to XR technology, hand-held controllers could integrate with the centre stack to provide easy, natural control. However, hygiene and maintenance present big challenges for shared controllers, and passengers won't bring their own devices.

Buttons and touchscreens

A simple way to control your surroundings that we're all familiar with. Car designers should consider access, as all physical controls need to be within easy reach. Again, hygiene could be an issue. Buttons are also likely to get very heavy use and would be a point of possible mechanical failure.

Voice control

Voice control removes hygiene concerns and is intuitive, but it has limitations. In shared cars the challenge is obvious – who would want to use voice control in front of strangers? Even in private autonomous vehicles, voice control can hinder natural conversation, destroy concentration and interrupt entertainment. And while voice control is extremely well-suited to some sorts of commands, it is less useful for others.

Eye tracking

Another intuitive, natural approach to HMI. However, the technology itself can be erratic – most "eye tracking" solutions available today actually track head movement with very little precision. To perform a secondary interaction using eye tracking, you also have to look away from the primary task in hand. It adds an extra load to visual communication, rather than complementing it.

Portable devices

Passengers may be unwilling to bring a VR controllers on a journey, but they'll certainly have their phone, smart watch, or possibly even AR glasses with them. If interaction can be channelled via a personal device, users will feel immediately comfortable. However, security and privacy need to be considered when passengers are linking their own devices to networked systems on board. Interaction via a small, 2D screen will also not be suitable for all experiences (such as interactive games or 3D object manipulation).

Hand tracking

Our hands are sophisticated, powerful tools that don't need a user manual. Tracking devices can be built into the structure of the vehicle, even using the sensors that are already there. Passengers can interact intuitively with virtual and digital content using hand movements and gestures. Interaction is also contactless, removing concerns about hygiene in shared vehicles.

Contact haptics

Haptic feedback is the use of touch to communicate with users. There is a large body of evidence that adding haptic feedback to interfaces improves performance, increases users' sense of control and connection and deepens emotional engagement. However, haptics in touchscreens and/or controllers or portable devices will have the same limitations around hygiene, robustness, and convenience.

Mid-air haptics

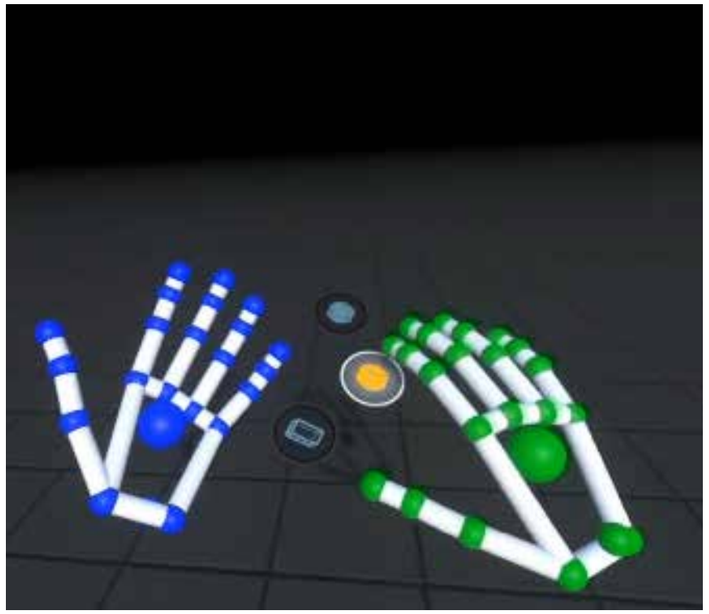
Mid-air haptics is built into the structure of the vehicle and creates tactile sensations in mid-air, with no need to touch any surface. It has all the benefits of contact haptics without the accompanying concerns around hygiene, robustness, and convenience.

Ultraleap hand tracking: There is no second best

Hand tracking enables users to interact naturally with digital and virtual content using only their hands – just as they interact in the real world.

Your hands are an incredible work of natural engineering: powerful, intricate, flexible, and nuanced. Our world-leading software is all of those things too. It captures all the subtlety and complexity of natural hand movements with near-zero latency.

- Accurate skeletal tracking based on a decade of development and iteration, three generations of research in artificial intelligence and the feedback of hundreds of thousands of developers
- High accuracy and reliable hand/gesture detection
- Near-zero latency
- Hand size/geometry automatically accounted for
- Low compute requirements
- Easy to integrate as a software layer on vehicle systems

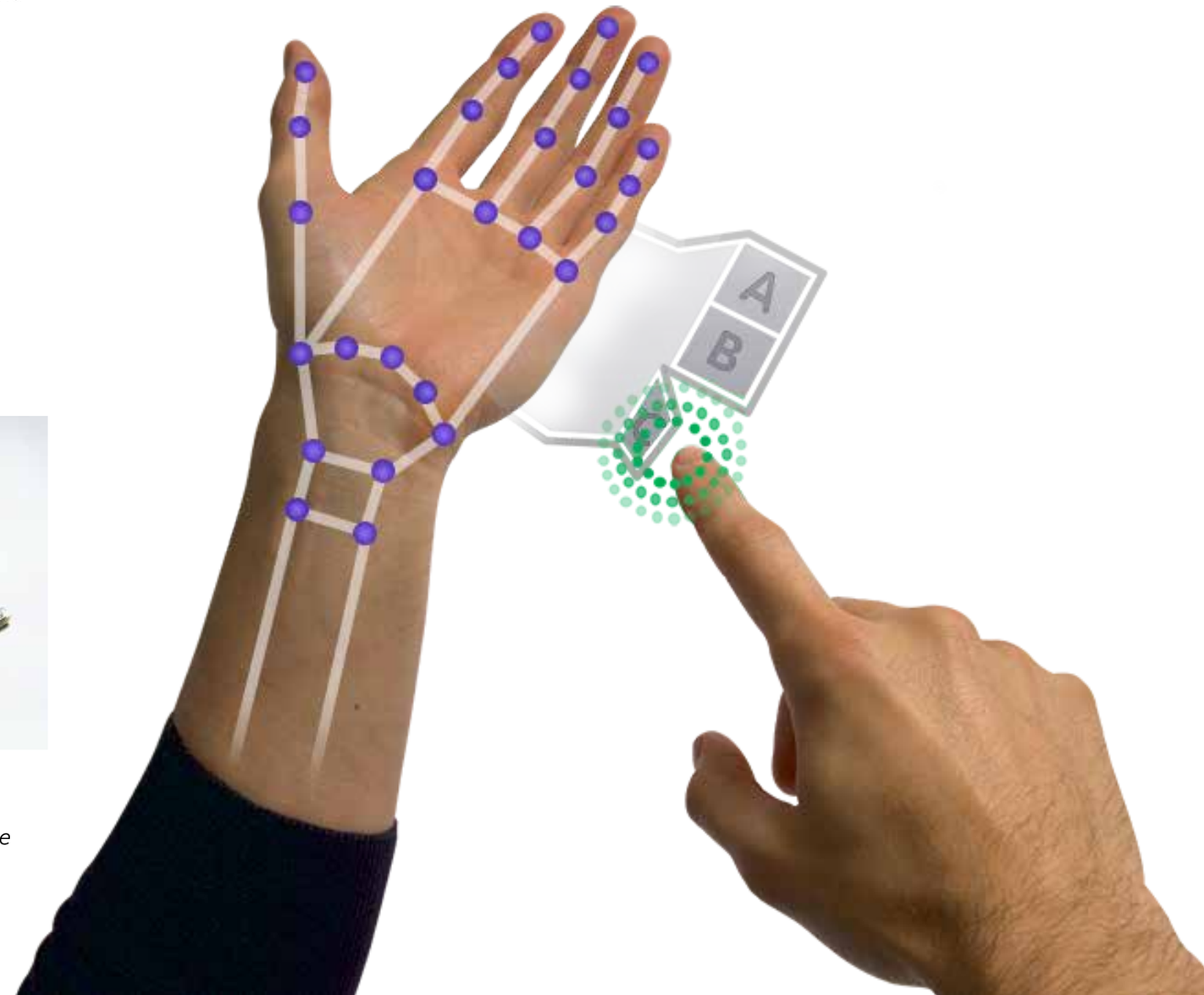


Ultraleap's stereo infrared hardware unlocks the "gold standard" of tracking: accurate real-time depth data, highly robust to occulsion, in total darkness or direct sunlight.

Why does great hand tracking matter for in-vehicle interactions?

When it comes to hand tracking, second best is not good enough. Humans are used to using and communicating with our hands in extraordinarily subtle, fluid, and personal ways. Even slightly crude or sluggish hand tracking causes frustration – whereas responsive, sophisticated systems build trust.

- Reliable hand detection ensures first-time gesture and hand pose recognition, improving user preference. Hand size, geometry, and pose are automatically accounted for.
- More commands / functions can be supported to build out a simple interactive language (e.g. pinch and slide to change volume).
- Commands can be easily customized to suit user preference without extensive learning processes.



Ultraleap haptics: How mid-air haptics works

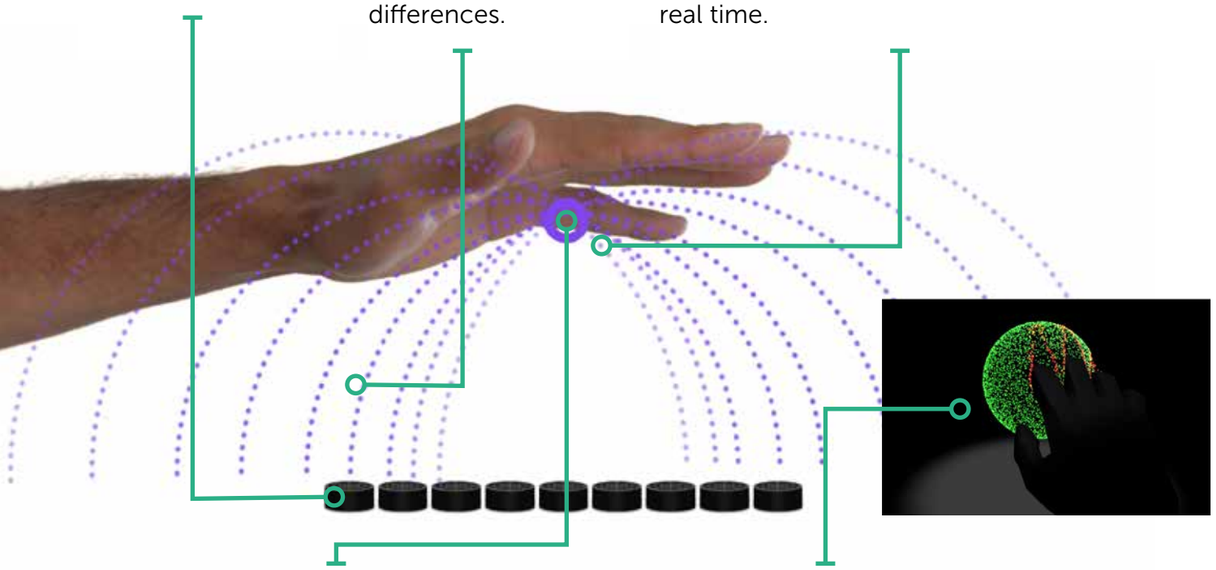
No wearables are needed for mid-air haptics. Instead, Ultraleap's patented algorithms modulate ultrasound waves to project shapes and textures directly onto a user's hands.

In-car installations typically include ultrasonic speakers mounted under the fascia or in a control panel, combined with a hand tracking system. They can provide the sensation of touch up to 1 metre (3 feet) away from the surface. The accuracy of the sensation is less than a finger-width apart.

1. An array of ultrasound speakers transmits ultrasound waves.

2. The speakers are triggered one after the other with very specific time differences.

3. Because of the time differences, the ultrasound waves end up arriving at the same point at the same time. Where this point is positioned in 3D space is programmable in real time.



4. The combined force of the ultrasound waves generates enough force to create a pressure point on the surface of your skin.

5. Pressure points can be moved around very quickly to create animated effects, or to sculpt lines or shapes.

Happy haptics: The emotional benefits of touch technology

The emotional component of the passenger experience will become more and more important in brand differentiation and in-car advertising and marketing.

Touch has an important role to play in that. From birth, our sense of touch is intimately woven into our emotional experience. Adding haptic feedback to user interfaces is proven to increase user preference and engagement.

- Users consistently rate interfaces including haptics as more enjoyable to use. For car manufacturers, especially luxury and sports car brands, it's difficult to overstate the importance of the fun factor to the user experience.
- Touch provides a sense of presence for XR experiences in a way that no other sense does. It's an instinctive reaction to reach out and touch an object to see if it's real.
- An Ultraleap study showed that when haptic feedback was added to interactive digital out-of-home advertising, there was a 27 per cent increase in focussed attention, a 50 per cent increase in interaction time, and users' sense of excitement increased (78 per cent with haptics versus 66 per cent without).[7]

At CES 2020, Ultraleap collaborated with Luxsoft to create an Advanced Augmented Reality Digital Cockpit Concept for future in-vehicle interaction, featuring mid-air haptic feedback. Image courtesy of Luxoft.

7 https://www.ultraleap.com/company/news/blog/boost-customer-engagement-study/

In control like never before

Uses of hand tracking and mid-air haptics in passenger experiences:

- Integrate hand tracking and/or haptic feedback into holographic displays, so passengers can reach out and interact directly with digital objects without the need for controllers.
- Create dynamic virtual controls anywhere in the cabin. Controls can come to passengers' hands when needed, and climate, lighting, seats, and windows can be operated without touching surfaces.
- Integrate hand tracking and haptics into AR and VR experiences for more intuitive interaction and deeper presence.
- Transform the centre stack: use hand tracking to turn 2D touchscreens into 3D interactive experiences by creating tactile interaction zones in mid-air.
- Software-controlled haptic sensations can be changed from journey to journey, keeping passengers coming back for more.
- Create individualised three-dimensional interaction zones, personal to each passenger.
- Develop tactile haptic alerts to let passengers know they are near their destination, to guide users' interactions, or to point out places of interest en-route.

Welcome to the journey of the future: Destination selection in the cabin of the autonomous mobility solutions of tomorrow. Image from Ultraleap demo.

About Ultraleap

No wearables. No controllers. Just natural interaction.

Ultraleap brings together the world's most powerful hand tracking with the only haptic technology able to create the sensation of touch in mid-air. Together, these technologies are a powerful combination.

We have a team of more than 150 spread across the world, with locations in Silicon Valley, US and Bristol, UK. Our team includes world-leading experts in interface design, acoustics, machine learning, and computer vision.

Automotive Design Acceleration Program (ADAP)

We have a specialist five-stage R&D program for automotive customers:

0 | Technology evaluation	Delivers: • Technology demonstrator for internal evaluation. • Easy access to technology
1 | Requirements and use-case	Delivers: • Documented use-case analysis and example builds • Bespoke concept specification
2 | Concept development	Delivers: • Proof of principle demonstrator / BUC • Refined system specification
3 | Finalise and prove concept	Delivers: • Vehicle integration concept • Proof-of-concept demonstrator
4 | Technology transfer and support	Delivers: • In-house system design competence

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