2025 July

Haptic Feedback

Tactile Evolution’s Impact on Automotive UX

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USER DRIVEN STRATEGIES

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1. Introduction

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Introduction

As automotive interfaces evolve, the importance of haptics increases as they enable safer and more intuitive interactions with in-vehicle controls. While current production models offer limited and often inconsistent haptic capabilities, the reliance on touchscreens and emphasis on minimalist interior design makes the integration of purposeful haptic feedback a strategic design decision for future vehicles.

While touchscreens and capacitive surfaces offer flexibility and visual minimalism, they also create new UX challenges. With hard buttons and controls, users can feel their way to the correct control with visual glances. However, with touch screens and capacitive surfaces, that tactile feedback is either entirely missing or much less beneficial, increasing the time the driver is not attending to the driving task.

This report looks at the key factors optimizing haptic HMI, key providers of haptic interfaces, and a look at what we expect from the next generation of haptics.

2. Use Cases & Key UX Factors

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Automotive Use Cases

There are two key use cases for haptics that would be applicable for infotainment and ADAS applications which leverage touchscreens, trackpads or touch-sensitive controls, steering wheels, other interior surfaces, and seats:

- Replacing physical controls
  - This is default example for many haptics, with the simplest use case being providing the feel of a button click on a flat touchscreen. More advanced haptics can mimic sliders or turning a dial.
- ADAS Alerts
  - Haptics are used for high priority alerts such as lane departure or collision warning systems. Vibrating steering wheels or seats are common examples of these.

Source: Immersion

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Key Factors for Haptics

- Any physical interface needs to let the user know each of the following:
  - What actionable area they are pressing
  - When an actionable area is pressed
  - That an action occurred because of the press
- Typically, the third key information piece (confirmation of action) is delivered through visual and/or audio modalities.
- Haptics does a fair job of informing the user that something has been pressed, but it has historically failed at the first key information piece (identifying the actionable area being pressed).
- If advancements in haptics can provide confirmation or identification of the actionable area they are pressing, that would better enable software-defined interfaces and reduce the arguments against the reliance on touchscreens over physical controls.

Source: Immersion

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3. Key Players

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Key Players: Immersion

- Immersion is a key haptics leader, with an exceptionally strong portfolio of over 3200 patents.
- They provide haptic solutions for the automotive, gaming, and mobile markets.
- Their Active Sense Technology can provide haptic feedback to replicate button presses, moving sliders, and turning a dial.
- They can also provide some feedback to help a user locate controls by providing feedback at a button edge or by altering the surface texture.

Immersion Active Sense Technology Source: Immersion

Analysis: Immersion claims their solutions reduce secondary glance rates and improve task completion time, which is likely true when compared to a touchscreen without haptic feedback.

While they can adequately replicate the manipulation of controls, the haptics provided for locating controls are not as effective. While better than nothing, we would expect longer glance times during initial control location than when using physical controls.

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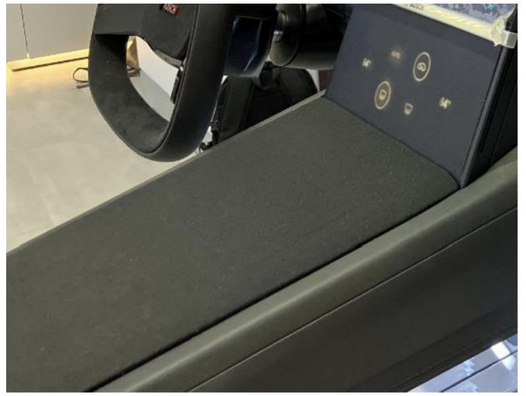
Key Players: Bosch

- Bosch promotes their Adaptive Haptics solution.
- This system detects the driver's hand as it approaches from the left (for right-hand-drive vehicles) and then activate controls relevant to the current context. When not in use, keys remain invisible.
- Driver personalisation is possible, with different colours/themes, or favourite controls displayed.

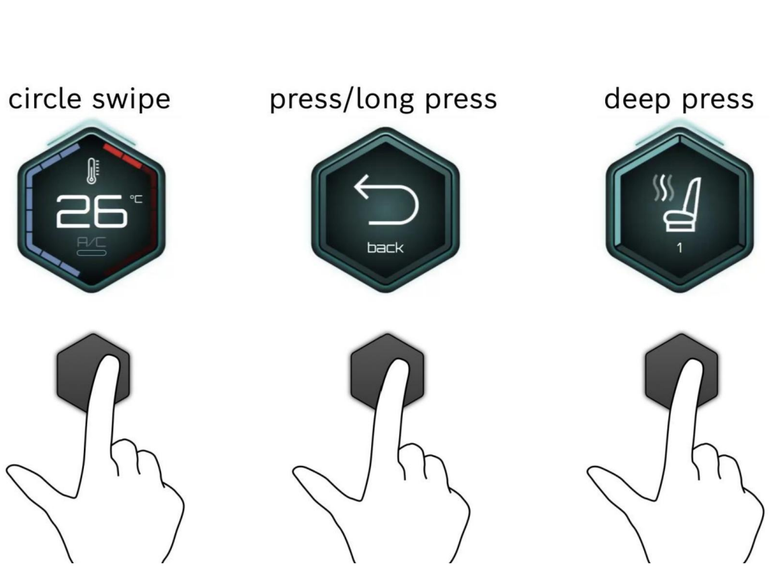
Analysis: The adaptive nature of the controls is an advantage, but this system has two distinct issues:

- A minor issue is relying on indirect control (visual feedback is not at the point of action).
- The major issue is that since the system does not activate until a reach has been initiated, the driver needs to know what they are reaching for. With the controls invisible, it is not even apparent that controls are even available, much less what they would do. This increases workload has the driver would almost always have to engage in an additional glance and reach correction every time.



Inactive state:
Flat, seamless surface

Active state:
Push-button controls and multi-touch area



Indirect touch gesture actions

Situation-dependent activation

Source for all images: Bosch

Key Players: Continental

- Continental has had its 3D touch surface display for several years now.
- This system is a 3D touchscreen surface, with curves and haptic feedback providing information to users as to where they are on the display.
- Haptic feedback tells drivers when they have reached the edge of an actionable area as they pass their finger over the screen. Haptic feedback is provided in the form of a short mechanical pulse.

Analysis: The 3D touch surface display enables the potential for glance-free touch operation. However, even though the system was showcased at CES in 2018, it has yet to be adopted, likely due to the high price tag.

Continental 3D Touch Surface Display

Source: Continental

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Key Players: Vibra Nova

- Vibra Nova was formed in 2024 out of the assets of Hap2U and focuses on automotive, home appliance, medical, and industrial applications.
- They partnered with Continental recently to announce an advancement in surface haptics in which actuators are placed on the side of the display, eliminating the need for large bezel areas, which had been initially required to position the actuators at the back of the cover glass.

Vibra Nova and Continental Announcement

Source: Vibra Nova

Analysis: Given the current direction of in-vehicle displays, eliminating a need for large bezels is a must-have. The edges of touch displays play an important role while driving, providing an anchor and reference point to interact with actionable areas. Removing the bezel can bring actionable areas closer to the edges which can facilitate more efficient touch gestures.

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Key Players: Boréas

- Boréas produces integrated circuits for haptic applications for automotive, consumer electronics, and industrial applications.
- Their automotive haptic module relies on piezoelectric actuators, Piezoelectric actuators offer fast, precise, and localized haptic feedback in an ultra-thin form factor.
- Their piezo haptic technology has recently been implemented in the Nio ET9's TUI bar, which is a touch sensitive bar located in the centre console which controls the vehicle's three front displays.

Analysis: Piezoelectric actuators are much more expensive and thus are currently gaining traction in the luxury and luxury EV markets, especially in China.

Nio ET9 TUI bar

Source: Boréas

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Other Key Players

- Synaptics – Their key advantage is providing haptic solutions integrated into their broad automotive offerings, including displays, touchpads, and display driver ICs.
- Cirrus Logic – LRA haptic providers with their Sensor-less Velocity Control system specifically designed to provide high-definition haptics within the rigors of the automotive environment
- Texas Instruments – Provides a broad portfolio of haptic driver ICs which are widely adopted by Tier 1 suppliers due to their configurability, automotive-grade reliability, and integration support.
- TDK – Their strength is its in-house manufacturing of piezo actuators and thin haptic modules, offering scalable solutions for behind-display tactile feedback in centre stacks and touch panels.
- Johnson Electric – They differentiate with their robust production of automotive-grade vibration actuators (including LRAs and voice coils), which power tactile feedback in steering wheels, seats, and driver alert systems across high-volume platforms.
- AAC Technologies – Promoting their RichTap product across multiple applications, including automotive. Though they have a long history in the Chinese market, they have been shifting away from automotive toward gaming and mobile.
- GREWUS – An acoustic and haptics supplier, GREWUS developed Exciter, combines haptic feedback and acoustic output in a single device.

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4. In-Air Haptics

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In-Air Haptics

- UltraLeap has been at the forefront of in-air haptics, which uses ultrasound to create the sensation of touch in mid-air.
- In-air haptics requires cameras to detect hand position and software algorithms to identify gestures.
- In-air haptics provides the feedback that some action was recognized, but is limited in the ways feedback can be communicated.
- UltraLeap has created a best-practices document for developers in an attempt to define a common gesture and feedback library.

Analysis: As an HMI, User Driven Strategies does not see in-air haptics to be a viable solution.

In-air haptics provides feedback for in-air gesture control, which is a flawed in-vehicle HMI due to the potential for inadvertent actuation and the limited number of intuitive gestures.

This renders in-air haptics of limited UX value and not worth the development and implementation costs.

UltraLeap In-Air Haptics

Source: UltraLeap

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5. Conclusions

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Conclusions

- The past 15 years has been marked by a power struggle between touchscreens and physical controls. Designers and many consumers prefer the minimalist cockpit, but older drivers and safety regulators require manual manipulation.
- Touchscreens are more usable when there is appropriate haptic feedback. The best implementations of haptic feedback are almost indistinguishable from and actual button press. However, haptics have traditionally struggled to fulfil all feedback needs, specifically consumers' need to know which control is being activated, enabling true eyes-free interaction.
- Haptic technology has advanced from simple vibration motors to precise, localized feedback delivered via piezoelectric actuators, enabling crisper and configurable tactile sensations on increasingly flatter touchscreens and capacitive surfaces.
- However, the biggest challenge remains eyes-free discoverability: while haptics can confirm actions, helping users locate virtual controls on smooth surfaces without visual guidance still requires more sophisticated feedback systems or emerging surface-haptic technologies not yet scaled for mainstream production.

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MORE INFORMATION

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For more details about the data described herein, or for User Driven Strategies clients with inquiry privilege who would like additional analyses for this data set, please contact the author of this report.

Chris Schreiner is a renowned expert in automotive HMI and UX, with over 25 years of specialized expertise improving the usability and efficacy of UI for human transport. Chris has worked for automotive OEMs, suppliers, academic research institutions, and consultancies, providing objective and actionable guidance impacting design.

Beyond cars, Chris's work spans many other segments including digital health, mobile devices, smart home, and other consumer electronics. He has conducted research across the globe, chaired and presented at international conferences, and authored numerous technical reports and peer-reviewed publications.

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