Contactless HMI

Human Machine Interface Q2 2020 Pulse

Contactless HMI innovation on the way to multi-modal input (voice and gesture control)

What's inside ?
1. Major developments in contactless HMI
2. Key patents by players in contactless HMI
3. Research highlights of key papers in Voice and Gesture control technology in 2020, Key findings and FutureBridge's take on the technology trends

FutureBridge

Image: Faurecia

THEMES AND KEY TAKEAWAYS IN Pulse

01	**Major developments in contactless HMI**

02	**Key patents by players in contactless HMI**

03	**Research highlights of top 13 papers in Voice control technology in 2020**

04	**Research highlights of top 9 papers in Gesture control technology in 2020**

05	**Startup tracker highlights in Q2 2020**

Contents covered in this Pulse

Major developments in contactless HMI
- Introduction to contactless HMI innovation on the way to multi-modal input
- Industry Development summary of Voice and Gesture Control in 2020
- Key activities in Voice control and Gesture Control during Q2 2020
- Challenges & Solutions provided by Industry Players
- FutureBridge on contactless HMI innovation on the way to multi-modal input

Key patents by players in contactless HMI
- Apple
- Tesla

Key Takeaways

- The voice and gesture control HMI technologies saw increased penetration in vehicles, as well as new product launch and enhancement of the existing products, paved the way for increased development in the segment of contactless HMI
- Collaboration for product deployment was the key theme that players were focused on in this quarter for voice control. Gesture control gained prominence as start-up received investment and compact product arrived gesture control market
- Contactless HMI technologies to experience higher penetration considering the COVID-19's impact demanding hygienic interfaces. Decrease in driver distraction also being a crucial reason

- Players are trying to incorporate other control functionalities in steering wheel. Tesla, in its patent was seen making an effective use of steering wheel to provide a set of controls in driver's hands via gesture control technology
- As the timeline for autonomous vehicles is approaching shrinking, there will be a growing prominence for technologies like voice and gesture to control the movement of the vehicle. Apple is combining these technologies and providing a multimodal input to guide the vehicle in its patent

THEMES AND KEY TAKEAWAYS IN Pulse

01	Major developments in contactless HMI
02	Key patents by players in contactless HMI
03	Research highlights of top 13 papers in Voice control technology in 2020
04	Research highlights of top 9 papers in Gesture control technology in 2020
05	Startup tracker highlights in Q2 2020

Contents covered in this Pulse

Research highlights of key papers in Voice and Gesture control technology in 2020
- Technology Trends in research publications in 2020
- Key Findings: Technical Challenges and solutions proposed by academia
- FutureBridge's take on the technology trends in research and their impact on the voice and gesture control technology

Startup tracker highlights in Q2 2020
- Start-ups added in our Startup Tracker in Q2 2020
- Startup Summary of total 63 start-ups after adding 5 entities in our Startup Tracker
- Startup Highlight: Kardome

Key Takeaways

- Noise mitigation in speech recognition, Empathetic and proactive assistants and driver distraction due to voice assistants are some of the key trends that we expect will have high impact on the technology in case of systems designs and increased reliability
- Considering the need to reduce driver distraction should be considered by players while designing the system as it can high impact on the acceptability of the gesture control technology

- Innovation in display technologies were the key focus of start-ups added in this quarter. Europe and North America were the key startup hubs
- Voice control and face/eye tracking are the major centre of focus of start-ups with USA and Germany showing significant efforts in terms of start-up activity
- Kardome focuses on voice control domain to reduce the noise during speech recognition and speech enhancement with the help of its patented technology

01

Contactless HMI innovation on the way to multi-modal input (voice and gesture control)

Upcoming Segment

- Introduction to contactless HMI innovation on the way to multi-modal input
- Industry Development summary of Voice and Gesture Control in 2020
- Key activities in Voice control and Gesture Control during Q2 2020
- Challenges & Solutions provided by Industry Players

Players in our coverage
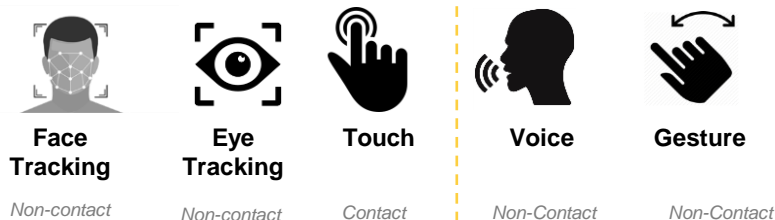

What do we see happening

- Technologies like voice and gesture received high traction in this quarter whereas COVID-19 situation and concerns arising due to driver distraction in vehicle seems to be the driver for the adoption of this technologies
- The voice and gesture control HMI technologies saw increased penetration in vehicles, as well as new product launch and enhancement of the existing products, paved the way for increased development in the segment of contactless HMI
- Collaboration for product deployment was the key theme that players were focused on in this quarter for voice control. Gesture control gained prominence as start-up received investment and compact product arrived gesture control market
- Cerence has developed a solution that allows multiple voice assistants to be used via a single interface. Speech recognition seems to be an area with more developments wherein players are trying different techniques to improve the rate for reliable communication

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Introduction to contactless HMI innovation on the way to multi-modal input

Technologies like voice and gesture received high traction in this quarter whereas COVID-19 situation and concerns arising due to driver distraction in vehicle seems to be the drivers for the adoption of this technologies

Some multimodal inputs in Human Machine Interface

Face Tracking
Non-contact

Eye Tracking
Non-contact

Touch
Contact

Voice
Non-Contact

Gesture
Non-Contact

Why Voice Control and Gesture Control?

- As players are striving to build automotive assistants for connected and autonomous cars, integration of additional modes of interaction will be essential to increase effectiveness and efficiency of the system
- Technologies consisting of non contact HMI which are Voice and Gesture control experienced increased developments in terms of technology development, collaboration, product launches and funding
- Not only there are advancements in these technologies, but players are seen deploying these technologies in their vehicles either independently or integrated together for reliable interaction in vehicle cabin
- Voice Control technology integrated with Gesture Control can enable a greater control to the user and in the autonomous future such system can be used to communicate with autonomous vehicles like the system recently patented by Apple

Drivers for contactless HMI solutions

Driver Distraction

- Driver Distraction is an area of concern for many of the players and also various region like EU are mandating the driver monitoring systems
- Players are developing solutions to monitor the distraction of the driver, on the other hand HMI technology developers are trying to mitigate the distraction by introducing non contact solutions like voice and gesture control to control the functionalities in cabin and also provide passenger convenience
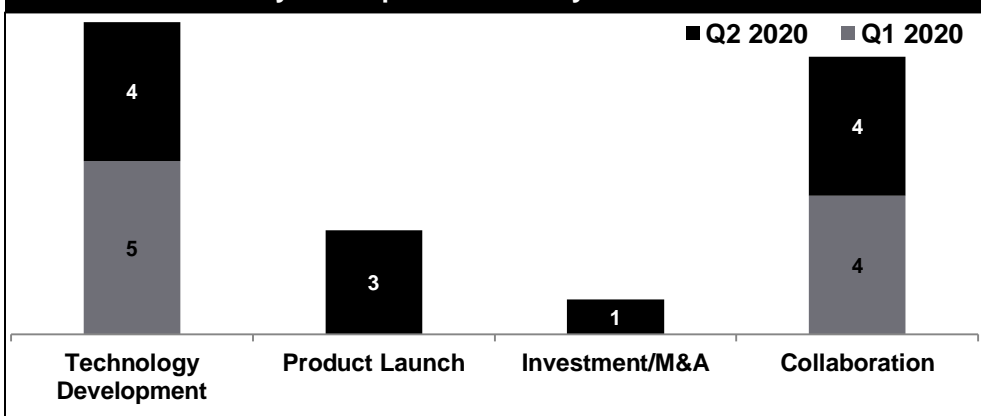
COVID-19

- The research undertaken by Ultraleap shows that touchscreens are losing consumer confidence as the world begins to re-open after lockdown
- Research undertaken by Ultraleap in late April and early May found that among 538 respondents split almost 50:50 between the United States (267) and the United Kingdom (271), just 12% (14% in the US vs 9% in the UK) believed that touchscreens in public spaces are hygienic, while more than 82% on average (79% in the US and 85% in the UK) were confident that touchless interfaces would be more hygienic and give them better protection. Covid-19 has dramatically changed consumers' perception of the hygiene risks of touchscreens in self-serve kiosk
- Recently Pratap Bose, Vice President, Global Design, Tata Motors also commented that a key feature which will gain importance in future vehicles are provisions like gesture control and voice command, which reduce the need to physically touch buttons. According to Pratap Bose, COVID-19 has brought personal hygiene to the forefront and people will now be more aware of their personal space. As a result, they will be more conscious of what they touch, including things inside the car. In line with this, there is a possibility that passengers will refrain from touching buttons and switches in a vehicle and instead use gesture control and voice command to operate infotainment systems. So, even though touchscreen systems are still a novelty and aspirational feature for customers, there seems a possibility that they could be soon surpassed by the advanced infotainment systems
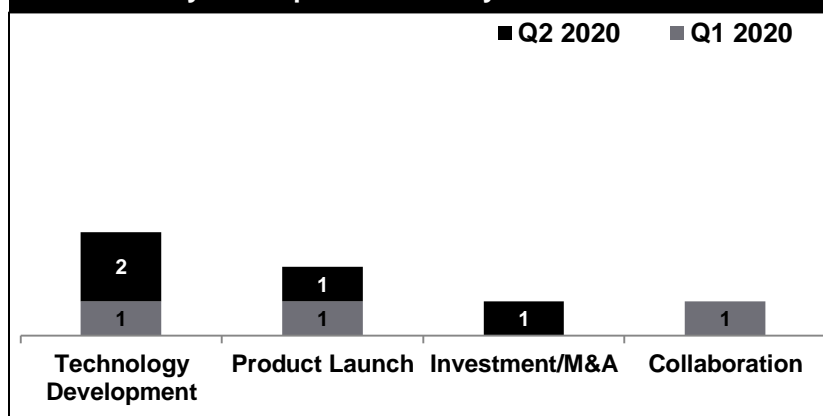
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Industry Development summary of Voice and Gesture Control in 2020

The voice and gesture control HMI technologies saw increased penetration in vehicles, as well as new product launch and enhancement of the existing products, paved the way for increased development in the segment of contactless HMI

Industry development summary for Voice Control

■ Q2 2020   ■ Q1 2020

Category	Q2 2020	Q1 2020
Technology Development	4	5
Product Launch	3	
Investment/M&A	1	
Collaboration	4	4

Industry development summary for Gesture Control

■ Q2 2020   ■ Q1 2020

Category	Q2 2020	Q1 2020
Technology Development	2	1
Product Launch	1	1
Investment/M&A	1	
Collaboration		1

- Voice and gesture control technologies experienced increased developments in Q2 2020. Players were seen deploying voice control technologies in their vehicles. Thus, we see increased collaboration in voice control domain
- Technology Developers are coming up with solutions that can mitigate the challenges like noise during speech recognition, evaluation of driver distraction because of voice assistants. Cerence holds a major part in collaboration and product launches in voice control domain
- Gesture control developments were o the rise with increased focus towards contactless HMI. Majority of the players used gesture control with voice and touch to reduce driver distraction and promote the use of multimodal HMI. Players such as Apple and Tesla have also filed a patent to use gesture with voice to increase user experience and reduce driver inconvenience vehicles

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Key activities in Voice control and Gesture Control during Q2 2020 (1/2)

Collaboration for product deployment was the key theme that players were focused on in this quarter for voice control. Gesture control gained prominence as startup received investment and compact product arrived gesture control market

Voice Control   **Gesture Control**   **Product Launch**   **Collaboration**   **Technology Development**   **Funding**

Carmen developed **personal AI vehicle assistant**. It is also fully integrated with CDK and DealerTrack, more DMS integrations >>

Research by the UK's **Transport Research Laboratory** suggests **safer** voice-controlled systems could cut **driver distraction** >>

Mercedes-Benz's MBUX artificial intelligence tech to become **proactive** >>

Osram launches ultra-compact **infrared LED** to enable gesture control in car interior >>

cerence **Great Wall**

TOPOSENS

cerence

| April 2020 | April 2020 | May 2020 | May 2020 | May 2020 | May 2020 | May 2020 |

CARMEN

Cerence announced that **Bean Tech** will deploy Cerence ARK (AI Reference Kit) to **build AI-powered automotive assistants** for the Chinese automotive group >>

TRL THE FUTURE OF TRANSPORT

Toposens raised **funding** in new financing round to **enhance sensor** technology and software, develop new partnerships, and launch new use cases >>

Mercedes-Benz

Cerence launched automotive voice assistant **Cerence ARK** Assistant in US **English** >>

OSRAM Group Website

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Not exhaustive list of players

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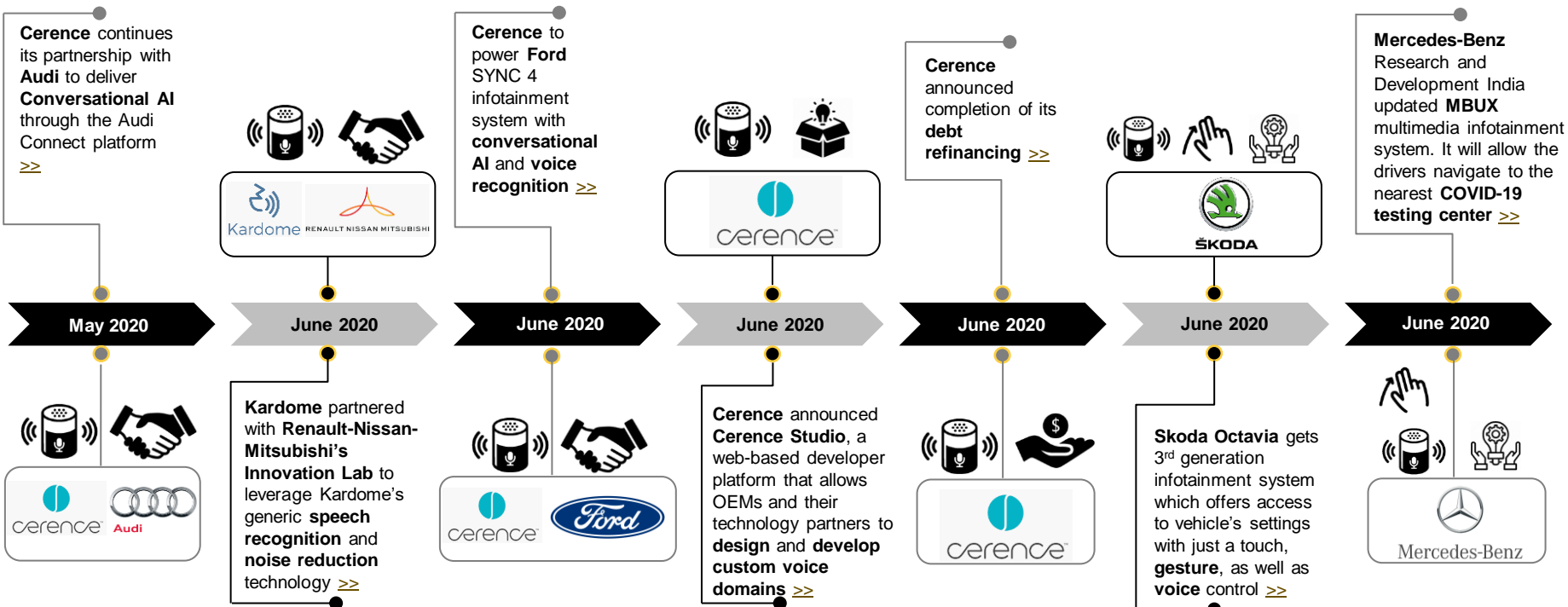## Key activities in Voice control and Gesture Control during Q2 2020 (2/2)
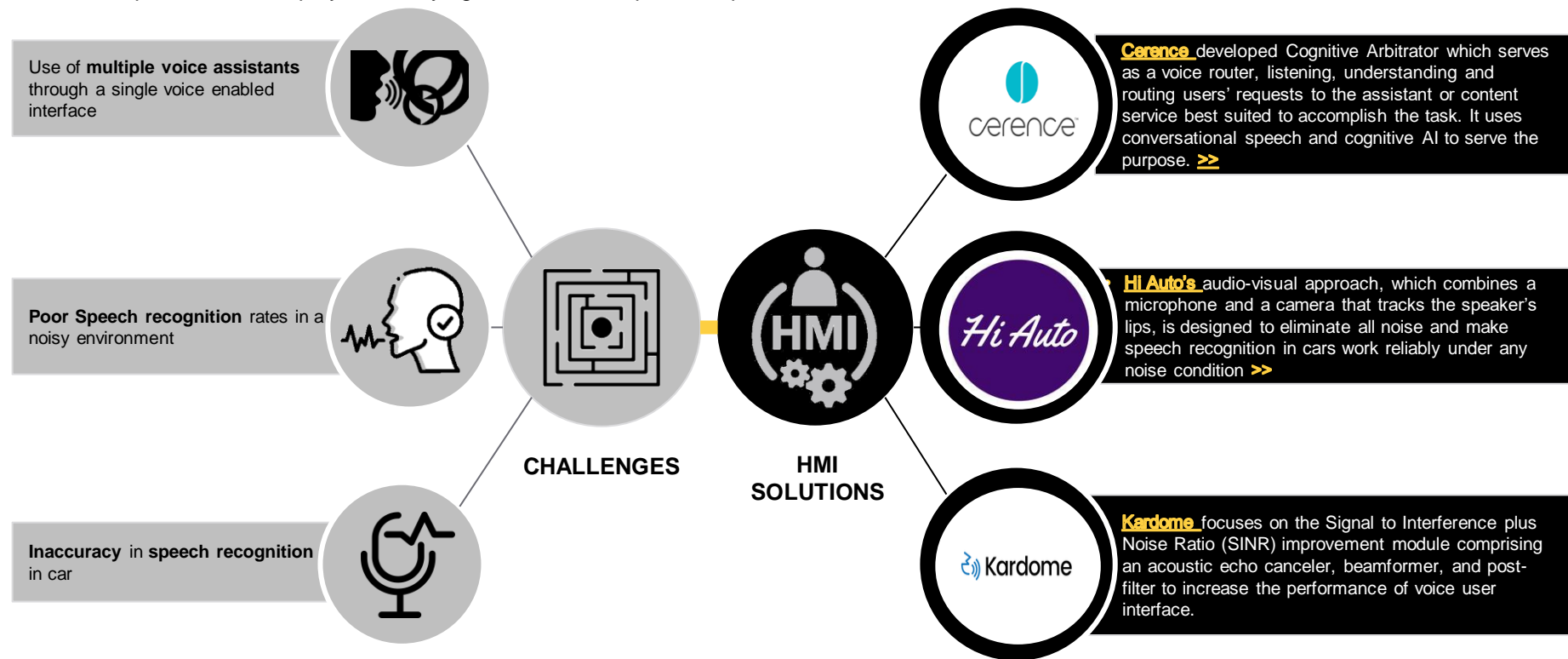
Collaboration for product deployment was the key theme that players were focused on in this quarter for voice control. Gesture control gained prominence as start-up received investment and compact product arrived gesture control market

Voice Control   **Gesture Control**   **Product Launch**   **Collaboration**   **Technology Development**   **Funding**

Cerence continues its partnership with **Audi** to deliver **Conversational AI** through the Audi Connect platform **>>**

Cerence to power **Ford** SYNC 4 infotainment system with **conversational AI** and **voice recognition >>**

Cerence announced completion of its **debt refinancing >>**

Mercedes-Benz Research and Development India updated **MBUX** multimedia infotainment system. It will allow the drivers navigate to the nearest **COVID-19 testing center >>**

Kardome RENAULT NISSAN MITSUBISHI

cerence

ŠKODA

| May 2020 | June 2020 | June 2020 | June 2020 | June 2020 | June 2020 | June 2020 |

Kardome partnered with **Renault-Nissan-Mitsubishi's Innovation Lab** to leverage Kardome's generic **speech recognition** and **noise reduction** technology **>>**

cerence Ford

Cerence announced **Cerence Studio**, a web-based developer platform that allows OEMs and their technology partners to **design** and **develop custom voice domains >>**

cerence

Skoda Octavia gets 3rd generation infotainment system which offers access to vehicle's settings with just a touch, **gesture**, as well as **voice** control **>>**

Mercedes-Benz

cerence Audi

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Not exhaustive list of players

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Challenges & Solutions provided by Industry Players

Cerence has developed a solution that allows multiple voice assistants to be used via a single interface. Speech recognition seems to be an area with more developments wherein players are trying different techniques to improve the rate for reliable communication
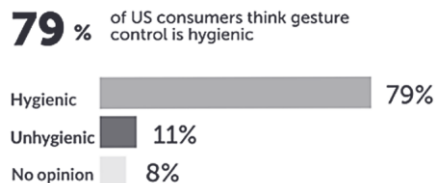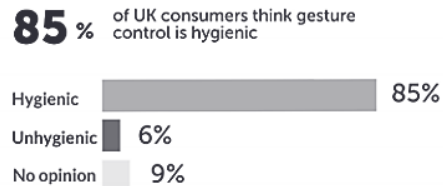
Use of **multiple voice assistants** through a single voice enabled interface

Poor Speech recognition rates in a noisy environment

Inaccuracy in **speech recognition** in car

CHALLENGES

HMI SOLUTIONS

Cerence developed Cognitive Arbitrator which serves as a voice router, listening, understanding and routing users' requests to the assistant or content service best suited to accomplish the task. It uses conversational speech and cognitive AI to serve the purpose. **>>**

Hi Auto's audio-visual approach, which combines a microphone and a camera that tracks the speaker's lips, is designed to eliminate all noise and make speech recognition in cars work reliably under any noise condition **>>**

Kardome focuses on the Signal to Interference plus Noise Ratio (SINR) improvement module comprising an acoustic echo canceler, beamformer, and post-filter to increase the performance of voice user interface.

# Human Machine Interface| Q2 2020 Pulse

FutureBridge on contactless HMI innovation on the way to multi-modal input

Contactless HMI technologies to experience higher penetration considering the COVID-19's impact demanding hygienic interfaces. Decrease in driver distraction also being a crucial reason

Key findings from the study

85 % of UK consumers think gesture control is hygienic

Hygienic	85%
Unhygienic	6%
No opinion	9%

79 % of US consumers think gesture control is hygienic

Hygienic	79%
Unhygienic	11%
No opinion	8%

% OF RESPONDENTS STATING THEY ARE "VERY LIKELY" TO INTERACT WITH THE TECHNOLOGY IN THE FUTURE

Touchless gesture	29%
Touchscreen	16%

1.8x

0%   10%   20%   30%
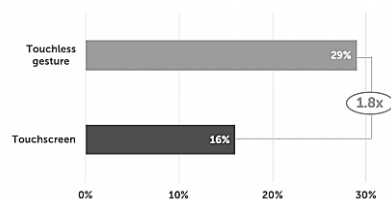
Source>>Ultraleap's study

- Contactless HMI technologies is gaining prominence with the increased concern among people for hygiene in vehicles post COVID 19. Study also shows that people are more comfortable with contactless interfaces in all the spaces and would prefer non contact interface in future. Some excepts of the study is shown in graph
- We believe that contactless HMI may pave the way for multimodal input wherein combination of such non contact technologies can provide more interactive interface with reduced distraction
- Though there are studies which suggests that such systems can increase the distraction among the drivers we expect these technologies to be critical if designed to be reliable and can adapt to the requirements for driver distraction. The study from Korean researchers is one such example which provides information in front of driver and the assistant interacts with driver only when it evaluated the communication to be safe

Future Outlook: What to expect?

- **Higher penetration of contactless HMI technologies**: Voice assistants are expected to have high penetration into vehicles with OEMs like Audi, GM etc. making it standard across its vehicles. Gesture control has also been used in vehicles like Skoda Octavia and DS Aero. Thus we see this technology to be adopted by players shortly
- **Compact solutions:** With increased functionalities integrated in vehicle cockpit we expect players to develop compact solutions like the developed by OSRAM for gesture control for the ease of integration and reduce bulky and complex vehicle cabins
- **Reliable products:** There is need for increased development and research to make the voice and gesture control technologies reliable with less noise interference in speech recognition algorithm and elimination of false detection of micro hand gestures in gesture recognition
- **Design considerations**: Product should be designed and provided with intelligence that can reduce the effect of distraction on driver due to these technologies. Integration with internal and external sensors that record the driver distraction and outside activities could be beneficial

02

Key patents by players in contactless HMI

Upcoming Segment

- Apple's new patent provides solution to communicate with autonomous vehicle using voice and gesture control
- Tesla's new patent for steering wheel to improve user interface for vehicle and reduce driver inconvenience

Players in our coverage

What do we see happening

- Traditionally steering wheels were used to control the movement of vehicle. With the advancements in technology, players are trying to incorporate other control functionalities in steering wheel. Tesla, in its patent was seen making an effective use of steering wheel to provide a set of controls in driver's hands via gesture control technology
- As the timeline for autonomous vehicles is approaching shrinking, there will be a growing prominence for technologies like voice and gesture to control the movement of the vehicle. Apple is combining these technologies and providing a multimodal input to guide the vehicle in its patent

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Key patents by players in contactless HMI (1/2)

Apple's new patent provides solution to communicate with autonomous vehicle using voice and gesture control technology

- A recent patent submitted by Apple showed a new technology in Apple's autonomous car. This new tech will allow the user to give voice commands to the self-driving car. The user can say where he/she want to go and the car will take the user to the destination and also park the vehicle
- Titled "Guidance of Autonomous Vehicles in Destination Vicinities Using Intent Signals", this patent application was filed by Apple back on August 2 of last year. It was recently made public, on January 23. The patent allows a self-driving car to get to a destination using voice commands, gestures and touchscreens

- Autonomous or self-driving vehicles are an increasing focus of research and development

- Given the multiplicity of choices that are typically available with respect to vehicle trajectories in real-world environments, occupant input or guidance with regard to selecting vehicle trajectories (without requiring traditional steering, braking, accelerating and the like) may be extremely valuable to the motion control components of such vehicles

- However, providing interfaces for such guidance which are intuitive and easy to use, especially within environments such as parking lots for which detailed and/or accurate mapping data may not be available, may present a non-trivial challenge
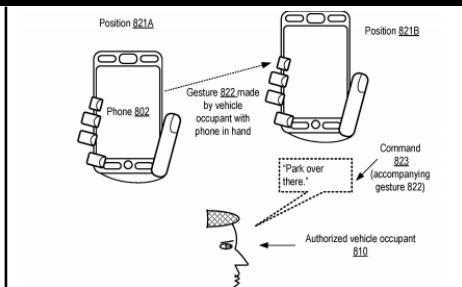
Different methods for interaction with autonomous vehicle
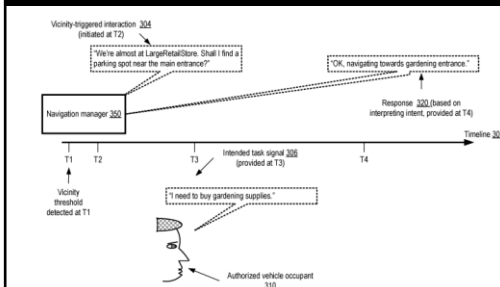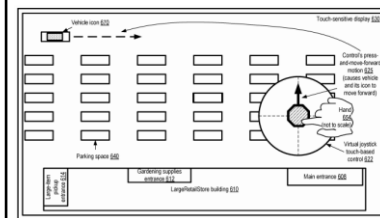

Voice commands

- The user would be able to tell the car that he/she want to buy flowers and the car will find the nearest florist and take the user there right away

Voice and Gesture commands

- The user can point the smartphone to a specific parking point and the car will recognize the gesture and voice commands and park on that specific point
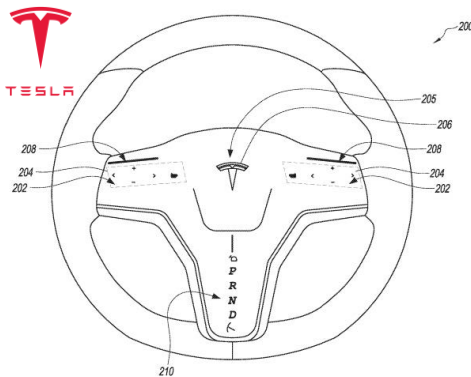
Touchscreen and Joystick

- The application describes a basic touch interface and a digital joystick to move the car manually
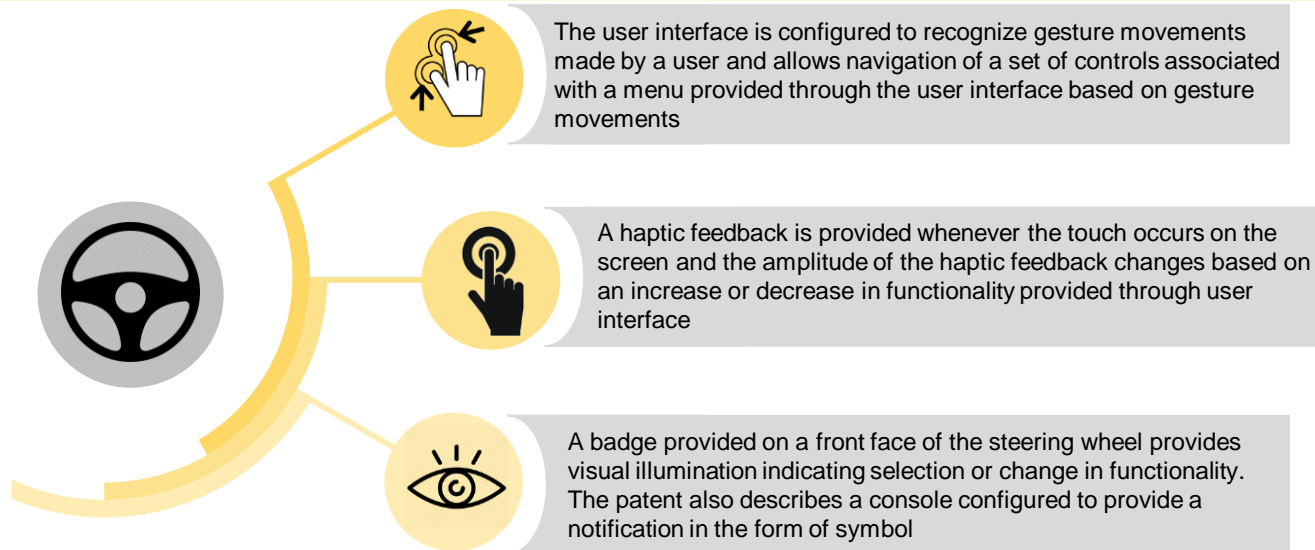
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Key patents by players in contactless HMI (2/2)

Tesla's new patent for steering wheel to improve user interface for vehicle and reduce driver inconvenience

- Traditionally steering wheels were used to control the movement of vehicle
- With the advancements in technology, players are trying to incorporate other control functionalities in steering wheel
- Tesla's recent patent is one of the example that describes about adding more control functionalities in the steering wheel

Tesla filed a patent titled "User Interface for Steering Wheel - WO 2020/028625 A1" which was filed last year. It describes integration of gesture, haptic and visual functionalities in a steering wheel in order to reduce inconvenience caused to driver while driving and keep driver's hand on steering wheel. The steering wheel is able to provide following HMI functionalities:

The user interface is configured to recognize gesture movements made by a user and allows navigation of a set of controls associated with a menu provided through the user interface based on gesture movements

A haptic feedback is provided whenever the touch occurs on the screen and the amplitude of the haptic feedback changes based on an increase or decrease in functionality provided through user interface

A badge provided on a front face of the steering wheel provides visual illumination indicating selection or change in functionality. The patent also describes a console configured to provide a notification in the form of symbol

Other players developing solutions for integrating various functionalities in steering wheel

TOYODA GOSEI	Mercedes-Benz	BMW	TOYOTA	JAGUAR LAND ROVER
Steering wheel with haptic feedback >>	Steering wheel with haptic feedback >>	Steering wheel with heart rate monitoring >>	Steering wheel with heart rate monitoring >>	Sensory Steering Wheel >>

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03

Research highlights of top 13 papers in Voice control technology in 2020
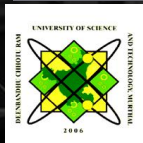
>> **Upcoming Segment**

- Technology Trends in Voice control research publications in 2020
- Key Findings: Technical Challenges and solutions proposed by academia
- FutureBridge's take on the technology trends in research and their impact on the voice control technology
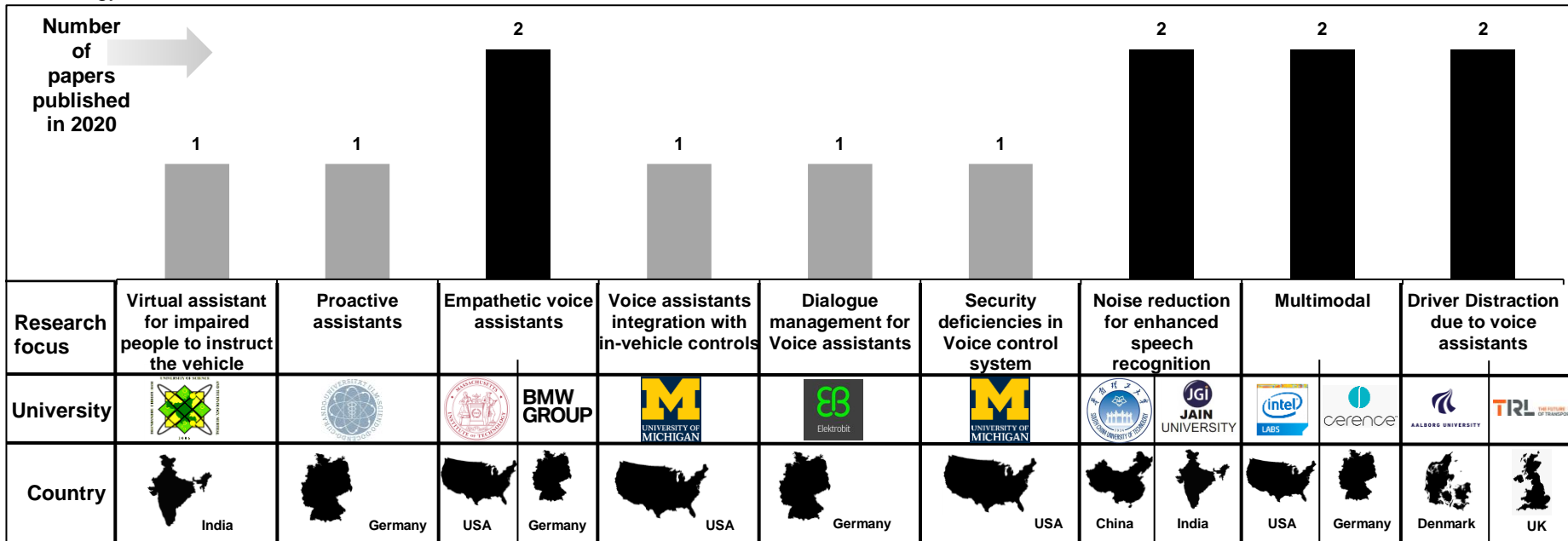
>> **Universities and players in our coverage**

>> **What do we see happening**

- Speech recognition in a noisy environment continue to be a major challenge for researchers as well which they tried to mitigate using noise reduction algorithms. Researchers also proposed a system that reduces driver distraction and communicates only under non hazardous situations
- Noise mitigation in speech recognition, Empathetic and proactive assistants and driver distraction due to voice assistants are some of the key trends that we expect will have high impact on the technology in case of systems designs and increased reliability

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Technology Trends in Voice control research publications in 2020 (1/2)

We analyzed 13 paper published in 2020 for voice control technology. Noise recognition being the primary challenge also received focus from researchers along with empathy in assistants and multimodal inputs like the non verbal ones. Europe arises as the hub for research innovation in 2020 for voice control technology

Number of papers published in 2020	1	1	2	1	1	1	2	2	2
Research focus	Virtual assistant for impaired people to instruct the vehicle	Proactive assistants	Empathetic voice assistants	Voice assistants integration with in-vehicle controls	Dialogue management for Voice assistants	Security deficiencies in Voice control system	Noise reduction for enhanced speech recognition	Multimodal	Driver Distraction due to voice assistants
University			MIT / BMW GROUP	UNIVERSITY OF MICHIGAN	Elektrobit	UNIVERSITY OF MICHIGAN	/ JAIN UNIVERSITY	intel LABS / cerence	AALBORG UNIVERSITY / TRL
Country	India	Germany	USA / Germany	USA	Germany	USA	China / India	USA / Germany	Denmark / UK

- **Europe** was the research hubs for voice control technology followed by North America and Asia
- **46%** of the research publications came from **Europe** region followed by **31%** from **North America** and **23%** from **Asia**

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Technology Trends in Voice control research publications in 2020 (2/2)

Majority of researchers were seen proposing solutions for the technology trends and challenges faced in voice control technology. Few researchers carried out experiment like Proactive assistants to know the response of the people and derive the results.

Virtual assistant for impaired people to instruct the vehicle
- Researchers used Google Assistant along with obstacle detection system to control the movement of the car for impaired people

Voice assistants integration with in-vehicle controls
- The research provides details about the system used for Ambient intelligence with the integration of Amazon Alexa with vehicle climate control, potentially augmented with brought-in devices

Improve speech recognition with noise reduction algorithms
- The research suggests that various noise reduction algorithms to enhance the speech recognition rates and improve the reliability of voice assistants

Proactive assistants
- Researchers were seen comparing proactive and non proactive assistants and it was observed that users wants to deactivate proactivity of the assistants at some points
- Though majority of the people took proactive assistants positively

Dialogue management for Voice assistants
- The research provides the concept of a virtual knowledge base to accommodate the diversity of dialog-relevant knowledge sources in a car to extend their built-in dialog management capabilities

Multimodal inputs integrated with voice control
- Researchers advice that multimodality can provide improved performance of a system with the help of text, audio, and visual inputs
- They aren't only taking speech, but also non verbal inputs are considered as efficient multimodal inputs

Empathetic voice assistants
- The researchers provided with the system that can detect the emotion of the driver and adapt the voice tone of assistants accordingly
  The results showed how empathetic voice assistants can have an influence on driving performance

Security deficiencies in Voice control system
- Researchers showed how an attacker can inject arbitrary audio signals to a target microphone by aiming an amplitude-modulated light at the microphone's aperture and proposed some possible software and hardware defences against the attacks
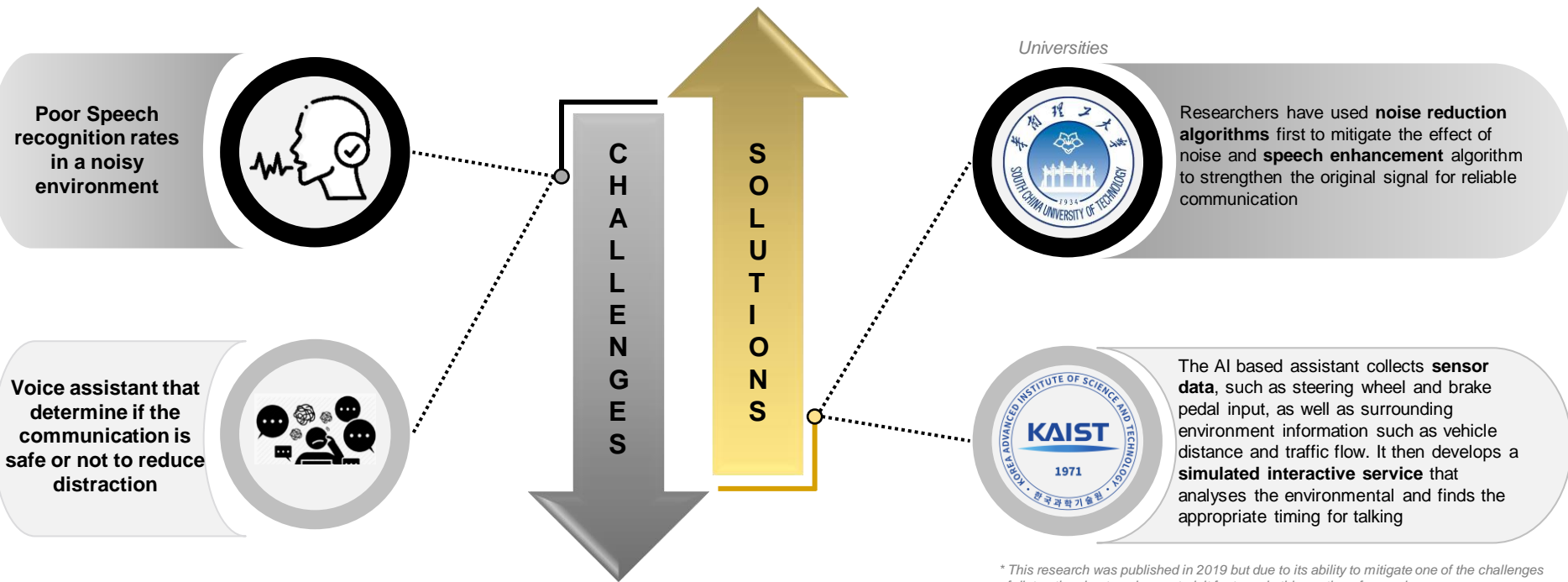
Distraction due to voice assistants
- The research suggests that voice assistants could potentially reduce visual and bio-mechanical distractions if they are usable enough to not increase a driver's cognitive load

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Key Findings: Technical Challenges and solutions proposed by academia

Speech recognition in a noisy environment continue to be a major challenge for researchers as well which they tried to mitigate using noise reduction algorithms. Researchers also proposed a system that reduces driver distraction and communicates only under non hazardous situations

Poor Speech recognition rates in a noisy environment

Voice assistant that determine if the communication is safe or not to reduce distraction

C H A L L E N G E S

S O L U T I O N S

Universities

Researchers have used **noise reduction algorithms** first to mitigate the effect of noise and **speech enhancement** algorithm to strengthen the original signal for reliable communication

The AI based assistant collects **sensor data**, such as steering wheel and brake pedal input, as well as surrounding environment information such as vehicle distance and traffic flow. It then develops a **simulated interactive service** that analyses the environmental and finds the appropriate timing for talking

* This research was published in 2019 but due to its ability to mitigate one of the challenges of distraction due to voice control, it features in this section of our pulse

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FutureBridge's take on the technology trends in research and their impact on the voice control technology

Noise mitigation in speech recognition, Empathetic and proactive assistants and driver distraction due to voice assistants are some of the key trends that we expect will have high impact on the technology in case of systems designs and increased reliability

High

I M P A C T

Low
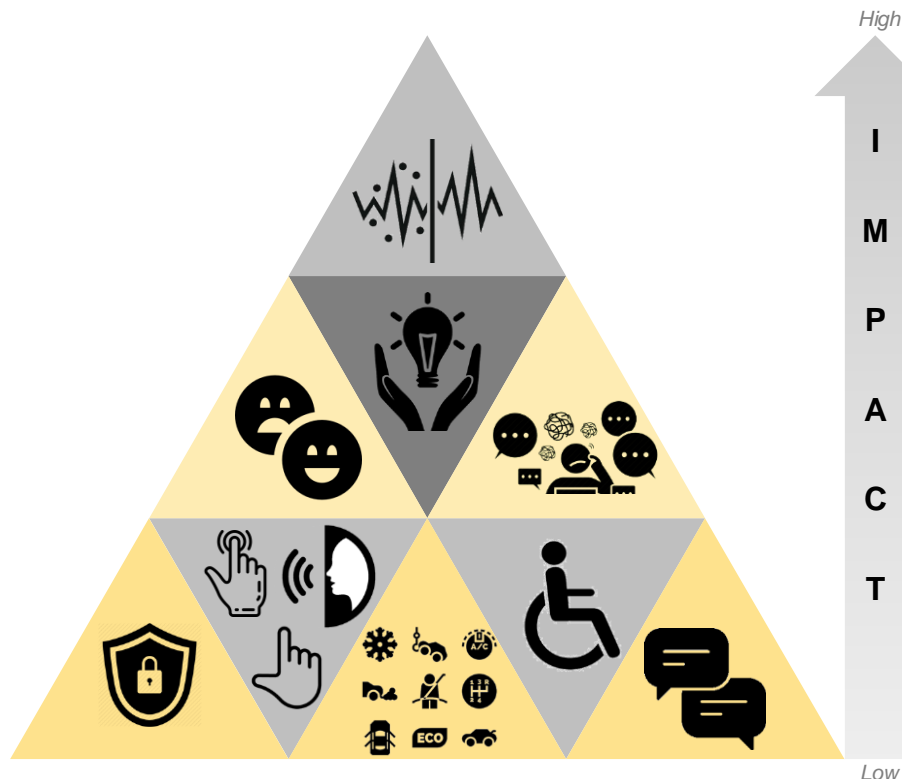
Key Takeaways on higher impact technologies in Voice Control Scientific Literature

- We expect that the development in **the speech recognition** system has the highest impact on the technology as the environmental and **background noise** is one of the **major concerns** during a conversation. Not only researchers are finding ways to mitigate the effect of noise and filter it but also players are developing solutions to enhance speech recognition in voice control systems in vehicles
- The **proactive assistants** are helpful as they seem to reduce the cognitive load from the driver's end. Proactive suggestions seem to make assistants appear intelligent, especially during high traffic scenarios, as it seems to be an efficient way of interaction. Thus, they can bring an impact on this technology only when there is an option to deactivate as suggested by studied because people would not prefer them in certain scenarios
- **Emotional Intelligence** can provide in-depth state of the driver and empathetic assistant can react to the recognized entity by the change of voice tone during the conversation. Bringing empathy to voice control will not only have an impact on voice control technology but it also serves as a purpose to **improve driving performance**. Thus, we can say that proactive assistants and empathetic ones go hand in hand
- **Driver distraction** is a point of interest concerning some researchers claiming that this voice control reduces it while others claiming to elevate it due to cognitive load. This trend will have a considerable impact on voice control technology as the system designers will have to consider that the technology doesn't overload the driver and stop when the driver is getting distracted

Improve speech recognition with noise reduction algorithm

Proactive assistants

Empathetic voice assistants

Distraction due to voice assistants

Voice assistants integration with in-vehicle controls

Dialogue management for Voice assistants

Security deficiencies in Voice control system

Multimodal inputs integrated with voice control

Virtual assistant for impaired people to instruct the vehicle

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04

Research highlights of top 9 papers in Gesture control technology in 2020

Upcoming Segment

- Technology Trends in Gesture control research publications in 2020
- Key Findings: Technical Challenges and solutions proposed by academia
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Universities and players in our coverage

東京大学 THE UNIVERSITY OF TOKYO
TUM
KU LEUVEN
ultraleap
KMU (KOOKMIN UNIVERSITY SINCE 1946)
ANNA UNIVERSITY PROGRESS THROUGH KNOWLEDGE
UAB Universitat Autònoma de Barcelona
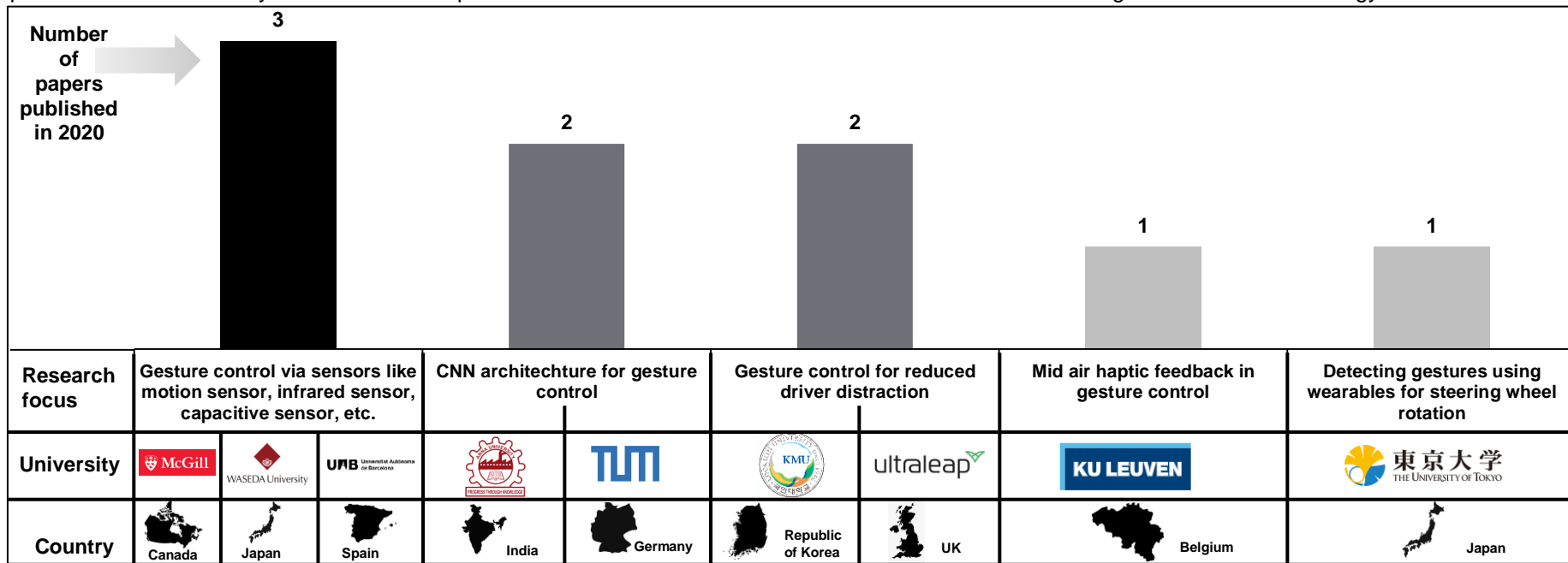WASEDA University
McGill

What do we see happening

- Noise, Errors in recognition, Car vibration, Micro hand gesture and illumination were some of the challenges faced by researchers in gesture recognition. They proposed the use of Infrared camera sensors and CNN architecture to mitigate these challenges
- We expect that the need to reduce driver distraction should be considered by players while designing the system as it can have a high impact on the acceptability of the technology with increased user experience

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Technology Trends in Gesture control research publications in 2020 (1/2)

We analyzed 9 paper published in 2020 for gesture control technology. Gesture recognition with the deployment of different sensors was the most preferred method used by researchers. Europe and Asia arises as the hub for research innovation in 2020 for gesture control technology

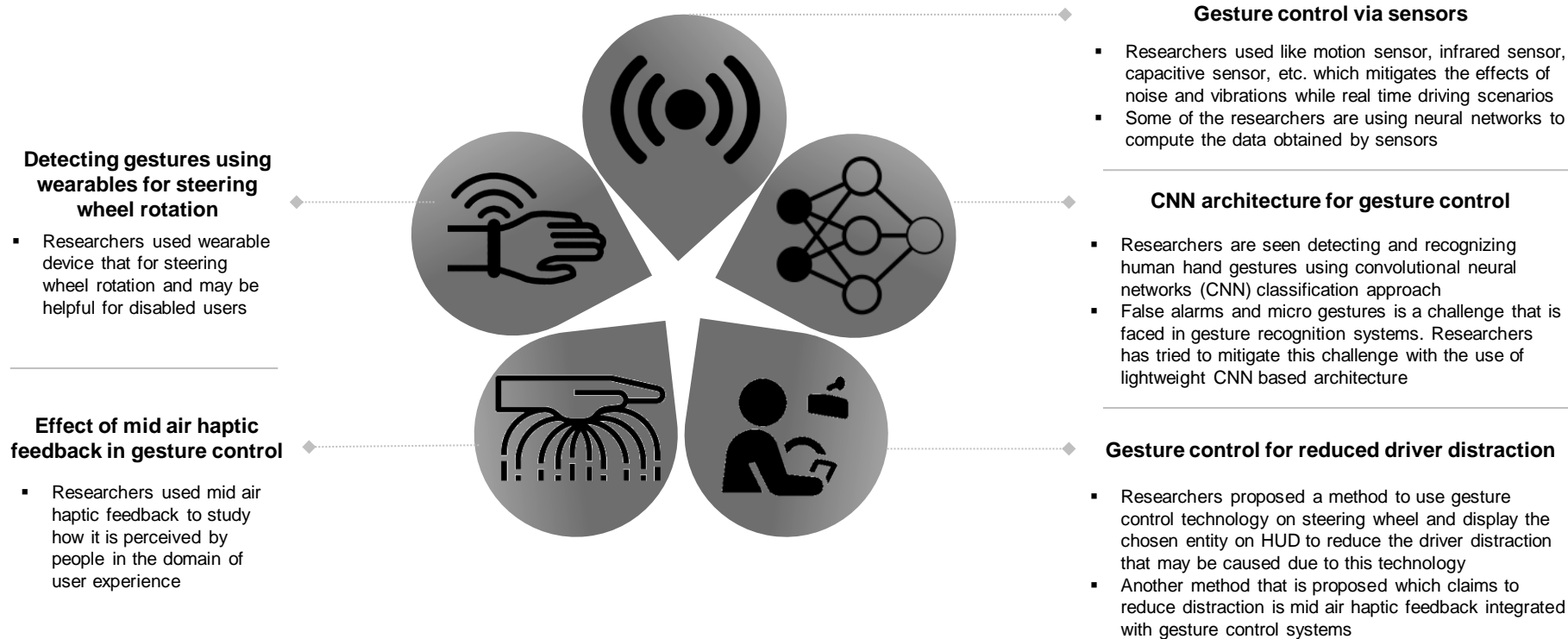| Research focus	Gesture control via sensors like motion sensor, infrared sensor, capacitive sensor, etc.			CNN architechture for gesture control		Gesture control for reduced driver distraction		Mid air haptic feedback in gesture control	Detecting gestures using wearables for steering wheel rotation
University	McGill	WASEDA University	UAB Universitat Autònoma de Barcelona		TUM	KMU	ultraleap	KU LEUVEN	東京大学 THE UNIVERSITY OF TOKYO
Country	Canada	Japan	Spain	India	Germany	Republic of Korea	UK	Belgium	Japan

- **Europe** and **Asia** was the research hubs for gesture control technology followed by **North America**
- **44%** of the research publications came from **Europe** and **Asia** region followed by **12%** from **North America**

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Technology Trends in Gesture control research publications in 2020 (2/2)

In vehicle vibration and noise remained the primary challenges for researchers while working on gesture control systems and thus tried to mitigate them.

Detecting gestures using wearables for steering wheel rotation

- Researchers used wearable device that for steering wheel rotation and may be helpful for disabled users

Effect of mid air haptic feedback in gesture control

- Researchers used mid air haptic feedback to study how it is perceived by people in the domain of user experience

Gesture control via sensors

- Researchers used like motion sensor, infrared sensor, capacitive sensor, etc. which mitigates the effects of noise and vibrations while real time driving scenarios
- Some of the researchers are using neural networks to compute the data obtained by sensors

CNN architecture for gesture control

- Researchers are seen detecting and recognizing human hand gestures using convolutional neural networks (CNN) classification approach
- False alarms and micro gestures is a challenge that is faced in gesture recognition systems. Researchers has tried to mitigate this challenge with the use of lightweight CNN based architecture

Gesture control for reduced driver distraction

- Researchers proposed a method to use gesture control technology on steering wheel and display the chosen entity on HUD to reduce the driver distraction that may be caused due to this technology
- Another method that is proposed which claims to reduce distraction is mid air haptic feedback integrated with gesture control systems

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Key Findings: Technical Challenges and solutions proposed by academia

Noise, Errors in recognition, Car vibration, Micro hand gesture and illumination were some of the challenges faced by researchers in gesture recognition. They proposed the use of Infrared camera sensors and CNN architecture to mitigate these challenges

Universities

Noise induced due to car vibration and uneven road resulting in challenges in gesture recognition, hardware latencies and sensing errors
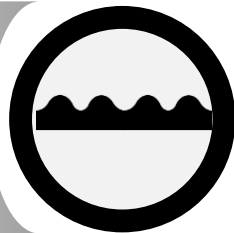
Micro hand gestures triggering false alarms

Environmental noise and illumination condition in gesture recognition for dark environment

C H A L L E N G E S

S O L U T I O N S

McGill

The researchers used **infrared camera** based **motion sensors** that could produce fine-grained hand model within a 3D space. Researchers used relative movement between different fingers to null out the impact of environmental noises and added a bump/pothole detector to make gesture control further safer and more adaptive

TUM
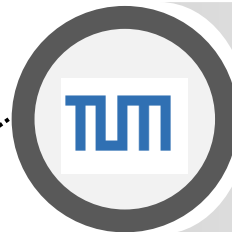
Researchers collected a multi-modal micro hand gesture dataset using a driver simulator and performed predefined micro gestures and consists of three data modalities, which are **RGB**, **infrared** and **depth**. They applied resource efficient 3-dimensional (3D) **CNN architectures**
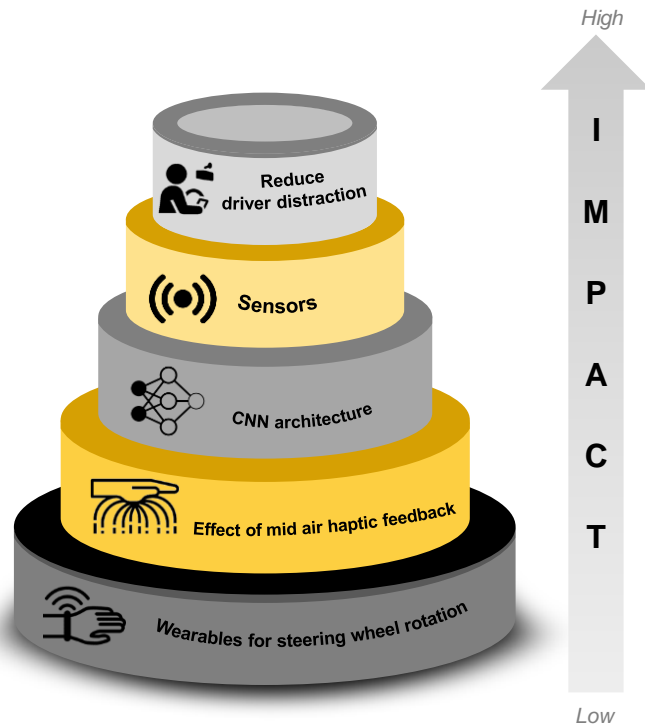
WASEDA University

A hand posture recognition system based on an **infrared sensor** is proposed. The input images are separated into images with objects and without objects. A **convolutional neural network** is applied as a classifier in order to realize the recognition of the target hand postures and non-target postures

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FutureBridge's take on the technology trends in research and their impact on the gesture control technology

We expect that the need to reduce driver distraction should be considered by players while designing the system as it can have a high impact on the acceptability of the technology with increased user experience

High

I
M
P
A
C
T

Low

Reduce driver distraction

Sensors

CNN architecture

Effect of mid air haptic feedback

Wearables for steering wheel rotation

Key Takeaways on impact of technology trends in research on Gesture Control

- **Reduction in driver distraction** is one of the main driving factors for innovations in gesture control technology. While there are studies that show that these technologies increase the driver distraction due to **inaccuracy** and **false triggers**, there are technology developers that are taking these considerations and are developing different technologies that reduce the load on the driver. Researchers used mid-air haptic technology to reduce distraction caused to the driver as the driver will be able to feel what he chooses via gesture technology through haptic feedback mid-air. Another approach was to use gesture control on the steering wheel and placing and HUD to keep the eyes of driver on road

- We expect that Driver distraction will have a high impact on this technology as the developers will have to consider this factor while designing and deploying their system

- Different **sensors** are being used by technology developers to get the input of gesture control systems. The **type of sensors** used for gesture recognition will have a significant impact on technology as sensors come with limitations and challenges while; the application in real-time driving scenarios as micro hand gestures can possess challenges and can give false alarms. Sensors that are compact and lightweight with reduced cost will have an upper hand as players want the systems that are integrated into the dashboard to be compact and that can be interfaced easily

- There is a concern for gesture recognition systems about the false triggers that happen and can distract the driver in case if it isn't needed. The use of **CNN architecture** claimed to remove the limitations and challenges of micro hand gestures. Also, the use of CNN classification approach claimed 98.1% of sensitivity, 93.4% of specificity, 96.2% of accuracy and 96.2% of recognition rate, which may prove to be beneficial

05

Startup tracker highlights in Q2 2020

Upcoming Segment

- Start-ups added in our Startup Tracker in Q2 2020
- Startup Summary of total 63 start-ups after adding 5 entities in our Startup Tracker
- Startup Highlight: Kardome

Universities and players in our coverage

IRYStec Perception Is Reality | SemsoTec | UVEYE VEHICLE INSPECTION SYSTEMS | RIGHTWARE | Kardome
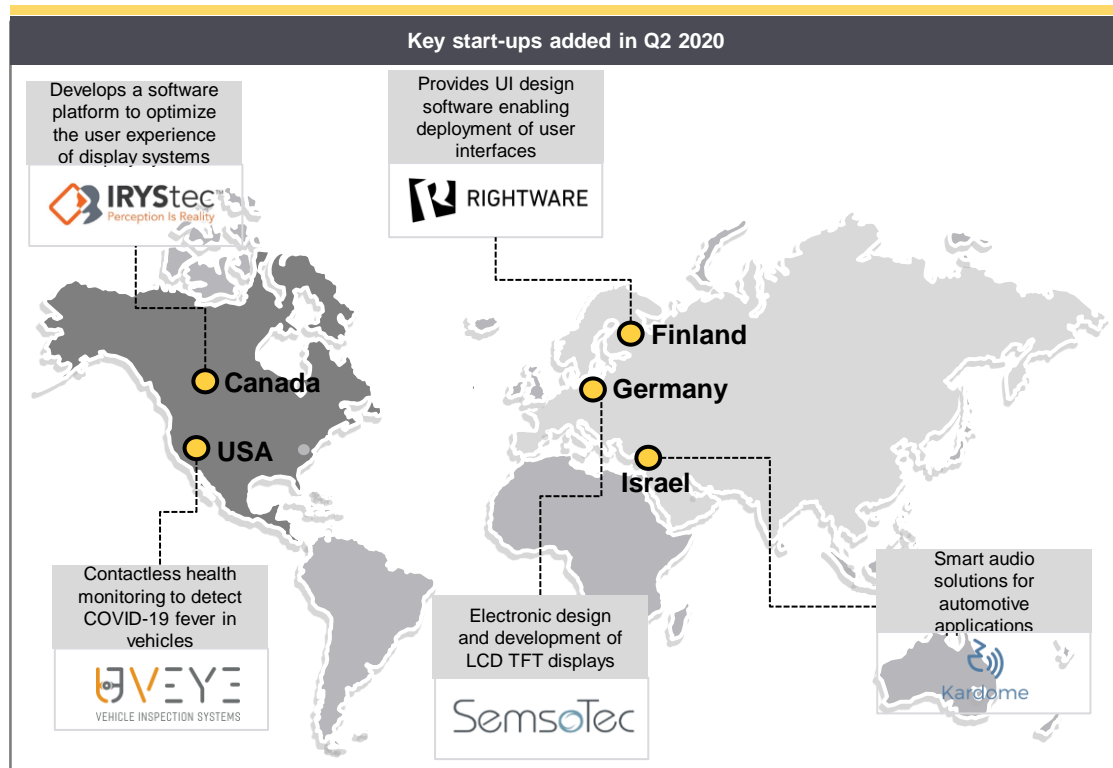
What do we see happening

- Innovation in display technologies were the key focus of start-ups added in this quarter. Europe and North America were the key startup hubs in Q2 2020
- Overall Voice control and face/eye tracking are the major centre of focus of start-ups with USA and Germany showing significant efforts in terms of start-up activity

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Start-ups added in our Startup Tracker in Q2 2020

Innovation in display technologies were the key focus of start-ups added in this quarter. Europe and North America were the key startup hubs

- Out of the 5 start-ups we have tracked in Q2 2020,
  - **60%** focuses on **displays**
  - **20%** focuses on **health monitoring**
  - **20%** focuses on **voice control**
- All of the start-ups that we captured this quarter were active during the course of 2020
- Start-ups were seen collaborating with other players to enhance and deploy their technology
- Rightware collaborated with LG Electronics to power graphics for curved OLED Display on 2021 Cadillac Escalade
- Kardome partnered with Renault-Nissan-Mitsubishi's Innovation Lab to test smart audio solution to reduce noise and enhance speech recognition in voice control
- Yanfeng and SemsoTec have announced the signing of a memorandum of understanding for collaboration in display and sensor technologies, components and products for automotive applications
- On the other hand UVeye has developed contact-free inspection systems equipped with infrared thermal sensors that can detect passengers and drivers with potential coronavirus fevers through the windshield. Infrared thermal sensors can read the body temperature of occupants, helping to flag possible COVID-19 carriers
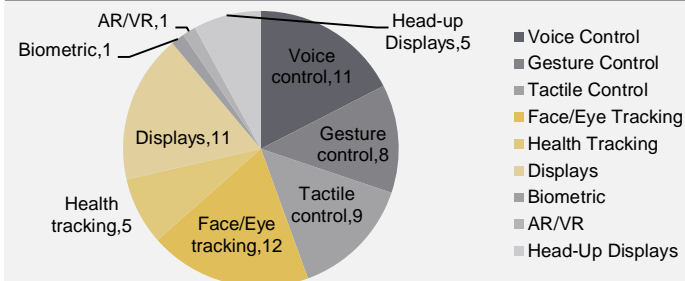
Key start-ups added in Q2 2020

Develops a software platform to optimize the user experience of display systems

IRYStec Perception Is Reality

Provides UI design software enabling deployment of user interfaces

RIGHTWARE

Finland

Germany

Canada

USA

Israel

Contactless health monitoring to detect COVID-19 fever in vehicles

UVEYE VEHICLE INSPECTION SYSTEMS

Electronic design and development of LCD TFT displays

SemsoTec

Smart audio solutions for automotive applications

Kardome

Human Machine Interface| Q2 2020 Pulse

Startup Summary of total 63 start-ups after adding 5 entities in our Startup Tracker

Voice control and face/eye tracking are the major centre of focus of start-ups with USA and Germany showing significant efforts in terms of start-up activity

Startups by technology

- Voice Control
- Gesture Control
- Tactile Control
- Face/Eye Tracking
- Health Tracking
- Displays
- Biometric
- AR/VR
- Head-Up Displays

Voice control, 11
Gesture control, 8
Tactile control, 9
Face/Eye tracking, 12
Health tracking, 5
Displays, 11
Biometric, 1
AR/VR, 1
Head-up Displays, 5

Funding received by start-ups in 2020

TOPOSENS — Raised additional undisclosed funding amount which will be used to enhance Toposens' sensor technology and software
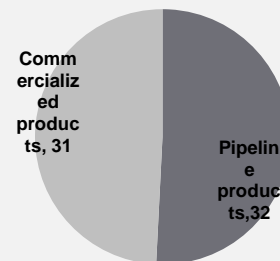
TACTOTEK — TactoTek announced that it has closed €23M in Series C equity financing co-led by Nordic Option Oy and Valeado AB. Bryan
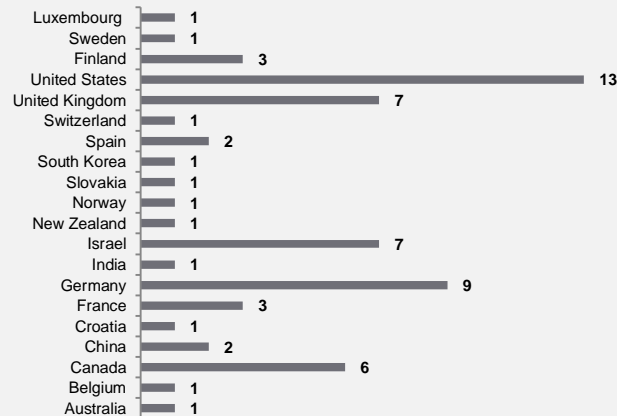
DIGILENS — DigiLens announced that Samsung Venture has increased its investment in DigiLens. Samsung Ventures first invested in DigiLens' Series C round and has again invested through a convertible debt instrument
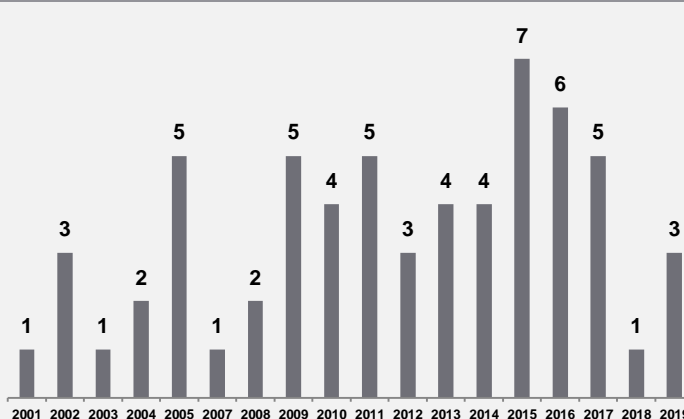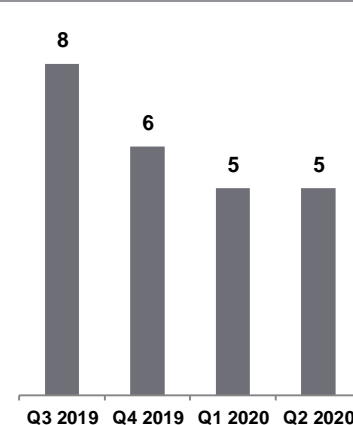
Startups with Commercialized and Pipeline products

Commercialized products, 31
Pipeline products, 32

Startups by geography

Country	Count
Luxembourg	1
Sweden	1
Finland	3
United States	13
United Kingdom	7
Switzerland	1
Spain	2
South Korea	1
Slovakia	1
Norway	1
New Zealand	1
Israel	7
India	1
Germany	9
France	3
Croatia	1
China	2
Canada	6
Belgium	1
Australia	1

Start-up Incorporation Year

Year	Count
2001	1
2002	3
2003	1
2004	2
2005	5
2007	1
2008	2
2009	5
2010	4
2011	5
2012	3
2013	4
2014	4
2015	7
2016	6
2017	5
2018	1
2019	3

Number of Startups Tracked

Period	Count
Q3 2019	8
Q4 2019	6
Q1 2020	5
Q2 2020	5

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Startup Highlight: Kardome

Kardome focuses on voice control domain to reduce the noise during speech recognition and speech enhancement with the help of its patented technology

Technology

- The company focuses on the Signal to Interference plus Noise Ratio (SINR) improvement module comprising an acoustic echo canceler, beamformer, and post-filter thus increasing the performance of voice user interface. Kardome provides a location-based speech enhancer, which focuses the microphone on the location of the desired source rather than toward the direction of the source

Patents

- The company has filed 1 patent till date titled Speech enhancement using clustering of cues with patent number US10535361B2

Team

- **CEO and Founder**: Dani Cherkassky
- **Director of Research Development**: Alon Slapak

Kardome

Israel 2019

Funding

- **Date**: 3rd Feb 2020
- **Transaction name**: Seed round
- **Lead investor**: Hyundai
- **Other investors**: ATOORO FUND, Nextgear Ventures
- **Money raised**: Undisclosed

Recent developments

- **June 2020:** Kardome has entered an agreement with Renault-Nissan-Mitsubishi's Innovation Lab to evaluate Kardome's smart audio solutions for automotive applications. The collaboration will leverage Kardome's speech recognition and noise reduction technology to solve the frequent issue of speech recognition in the car

Competitor

- Hi Auto uses audio-visual approach, which combines a microphone and a camera that tracks the speaker's lips, is designed to eliminate all noise and make speech recognition in cars work reliably under any noise condition

06

Appendix for supporting research

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SrNo	Date	Title	Domain	Sub-domain	URL
1	16-Apr-20	Intelligent Car with Voice Assistance and Obstacle Detector to Aid the Disabled	Voice Control	Virtual assistant for impaired people to instruct the vehicle	Link
2	16-May-20	How Users React to Proactive Voice Assistant Behavior While Driving	Voice Control	Proactive assistants	Link
3	01-Apr-20	EmpathicGPS: Exploring the Role of Voice Tonality in Navigation Systems during Simulated Driving	Voice Control	Empathetic voice assistants	Link
4	02-May-20	Integration of Voice Assistant and SmartDeviceLink to Control Vehicle Ambient Environment	Voice Control	Voice assistants integration with in-vehicle controls	Link
5	01-Jan-20	RULE-BASED DIALOG MANAGEMENT FOR VOICE ASSISTANTS IN AUTOMOTIVE ENVIRONMENTS	Voice Control	Dialogue management for Voice assistants	Link
6	22-Jun-20	Light Commands: Laser-Based Audio Injection Attacks on Voice-Controllable Systems	Voice Control	Security deficiencies in Voice control system	Link
7	14-Jun-20	Analysis of Noise Reduction Techniques in Speech Recognition	Voice Control	Noise reduction for enhanced speech recognition	Link
8	22-Jan-20	Enhancements in automatic Kannada speech recognition system by background noise elimination and alternate acoustic modelling	Voice Control	Noise reduction for enhanced speech recognition	Link
9	23-Jun-20	Audio-Visual Understanding of Passenger Intents for In-Cabin Conversational Agents	Voice Control	Multimodal	Link
10	01-Mar-20	Hands-free but not Eyes-free: A Usability Evaluation of Siri while Driving	Voice Control	Driver Distraction due to voice assistants	Link
11	06-Apr-20	What If Your Car Would Care? Exploring Use Cases For Affective Automotive User Interfaces	Voice Control	Empathetic voice assistants	Link
12	01-Apr-20	Non-Verbal Auditory Input for Controlling Binary, Discrete, and Continuous Input in Automotive User Interfaces	Voice Control	Multimodal	Link
13	31-Jan-20	Interacting with Android Auto and Apple CarPlay when driving: The effect on driver performance	Voice Control	Driver Distraction due to voice assistants	Link
14	05-Feb-20	Givs: Fine-Grained Gesture Control for Mobile Devices in Driving Environments	Gesture Control	Gesture control via sensors like motion sensor, infrared sensor, capacitive sensor, etc.	Link
15	23-Mar-20	An efficient method for human hand gesture detection and recognition using deep learning convolutional neural networks	Gesture Control	CNN architecture for gesture control	Link

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SrNo	Date	Title	Domain	Sub-domain	URL
16	19-Jun-20	User interface for in-vehicle systems with on-wheel finger spreading gestures and head-up displays	Gesture Control	Gesture control for reduced driver distraction	Link
17	02-Mar-20	DriverMHG: A Multi-Modal Dataset for Dynamic Recognition of Driver Micro Hand Gestures and a Real-Time Recognition Framework	Gesture Control	CNN architecture for gesture control	Link
18	18-May-20	Designing Mid-Air Haptic Gesture Controlled User Interfaces for Cars	Gesture Control	Gesture control for reduced driver distraction	Link
19	01-May-20	In-Vehicle Device Control System by Hand Posture Recognition with Movement Detection Using Infrared Array Sensor	Gesture Control	Gesture control via sensors like motion sensor, infrared sensor, capacitive sensor, etc.	Link
20	01-Apr-20	Better Because It's New: The Impact of Perceived Novelty on the Added Value of Mid-Air Haptic Feedback	Gesture Control	Mid air haptic feedback in gesture control	Link
21	02-Feb-20	Surface Electromyography-Controlled Automobile Steering Assistance	Gesture Control	Detecting gestures using wearables for steering wheel rotation	Link
22	24-Apr-20	Capacitive-sensing module with dynamic gesture recognition for automotive applications	Gesture Control	Gesture control via sensors like motion sensor, infrared sensor, capacitive sensor, etc.	Link

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