MOBILITY INDUSTRY INSIDER

Q2 2019 | Pulse
Passenger Monitoring

FutureBridge

WHAT'S INSIDE!

In Q2 2019, we found that large number of OEMs are focusing on integration of biometric recognition feature in there newly launched models.

Emotion recognition is finding versatile use cases, such as in voice recognition and also for in-cabin setting configuration.

As part of our continuous product enhancement, with this version of the Pulse we introduce 2 new sections of analysis:

- A review of breakthrough academic research in this domain; and
- Insights on the development of our Startup Tracker in the quarter of scope

01

Pulse themes
a. Biometric recognition sees greater adoption in passenger monitoring systems
b. Emotion recognition system to be integral feature for monitoring

02

Quarterly review of early-stage research
a. Detection and prediction of driver drowsiness using artificial neural network models

NEW

03

Startup Tracker highlights
a. A snapshot of our Startup Tracker in Q2'19 with segmentation by technology, region and product commercialization
b. Insights on the 12 new startups we've started monitoring in Q2'19
c. Startup funding & distribution
d. Startup highlight – Vayyar's focus on sensors for health monitoring and In-car sensing

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01 | Emerging trends

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Passenger Monitoring | Q2 2019 Pulse

Biometric recognition sees greater adoption in passenger monitoring systems

CONTEXT

New technologies for biometric recognition are coming to the market, from fingerprint to facial recognition, driven by capabilities to efficiently authorize user access, but also monitor drivers' distraction, health and adjust cabin settings.

As technology progresses, we expect that biometrics for automotive applications will expand to new use cases, from security to in-car payments. A growing number of technology providers and auto makers are working on implementing biometrics for several different use cases but challenges over capturing and sharing data still persist.

Developments

- Jaguar Land Rover is developing a facial recognition system to allow motorists to adjust vehicle settings with facial expressions. Biometric sensors will monitor drivers to modify cabin settings, including heating, lighting, and media.

- Bentley has unveiled a new concept car EXP 100 which includes biometric seats. In addition to monitoring temperature, passenger position, and blood pressure, the biometric seats will sense when the driver is actually driving, and when she or he is being driven by the car

- Hyundai Mobis has announced the development of a Driver State Warning (DSW) system with biometric facial recognition and eye tracking to prevent traffic accidents caused by careless driving. The new DSW system from Hyundai Mobis features an infrared camera which detects the eyes, nose, mouth, and ears as well as pupils

DEVELOPMENTS

Intelligent edge computing software developer FogHorn collaborated with Porsche to provide vehicle access with real-time facial recognition with infrared video processing at the edge, along with multifactor authentication via a device such as a smartphone.

Suppliers like OmniVision - Fullhan and Ambarella – Baolong collaborated for integrated solutions with biometric facial analysis for driver monitoring

What should you investigate ?

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FutureBridge on Biometric recognition in passenger monitoring

Biometrics are being introduced to monitor the driver as well as modify cabin settings. From the 34 products we benchmarked in our H2'18 Deep Dive, 10 products, or 29%, offered facial recognition, of which 10 have already been commercialized, such SmartEye Blackbird AntiSleep and Denso's Driver Status Monitor.

We expect biometric recognition to be widely adopted in the automotive domain, however the speed at which this happens will depend on the biometric modality or combination of modalities that prove to be most secure, easier to integrate and accurate to use. With the advancements in technology, biometric functionalities expand from user identification and authentication to a variety of new applications and use cases, as displayed on the graph to the right.

However, a rising concern for companies is compliance with data collection & storage laws, as privacy regulations become stricter. One example is the General Data Protection Regulation in Europe, effective since May'18. In the U.S. the decade-old Biometric Information Privacy Act has gained renewed recent prominence which highlights the need for companies to provide transparency to users over consent and use cases for their data.

What should you investigate?

Who are the leading players working to integrate Biometric recognition in monitoring?

Which are the OEMs planning to incorporate biometric recognition in their vehicle?

Key functionalities for biometrics in connected cars

Vehicle Entry

Digital keys to unlock car by biometrics will become a new method to access the vehicle

Insurance

Supporting "Black Box" telematics by knowing exactly who is inside the vehicle

Engine Start

The engine of the vehicle can be started through the integration of biometric sensor

In-car payments

Biometrics can be used to support convenient payment authorisation in vehicle.

Car Personalisation

Biometric identity allows vehicle to be personalized for each driver

Health and wellbeing

Continuous monitoring for drivers for tiredness, illness and intoxication through face, ocular, ECG and EEG biometrics

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Emotion recognition system to be integral feature for monitoring

CONTEXT

AI-based emotion recognition is increasingly becoming a critical function of Passenger Monitoring Systems to mitigate distracted driving and driver drowsiness.

Today, most Driver Monitoring Systems provide warnings to take a break when tired or to keep your eyes on the road and your hands on the wheel. But they are increasingly becoming more intelligent, by using AI to understand driver emotions and take action.

Developments

- Kia's HabaNiro concept with READ system revealed at 2019 New York motor show. The system can personalize the cabin by reading a driver's emotion through AI based recognition technology

- Nuance and Affectiva to collaborate for the integrated solution that provides interactive automotive assistant that understands drivers' and passengers' complex cognitive and emotional states from face and voice and adapts behaviour accordingly.

- Aptiv and Affectiva partnered to enhance the perception capabilities in safety solutions. The suppliers are working together to provide platform to OEMs, on-demand mobility providers, and fleet management companies to build intelligent vehicles that understand every facet of the human experience within a vehicle

KIA KIA MOTORS

:) Affectiva

NUANCE

:) Affectiva

· A P T I V ·

DEVELOPMENTS

- Players like Affectiva and Nuance are working together to bring emotional intelligence to voice assistant that can change the voice tone of the assistant depending on the driver's emotional state

- Players like Daimler is investing in startup like Soul Machine that is developing emotional intelligence use cases based on Soul Machine's technology

What should you investigate ?

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FutureBridge on Emotion Recognition

Players are integrating emotional intelligence with cabin interior settings that can alter the cabin temperature, mood lighting, music and other functionalities. From the 34 products we benchmarked in our H2'18 Deep Dive, 10 of these products or 33% capture driver emotions, of which 4 systems are already available in the market.

Emotion AI can not only capture where is the driver looking - on-road or off-road but also body pose and the full visual aspect and behaviour of the driver. Thus, AI has the capability of determining the depth of human state and attention while driving. To be able to have that type of information is to provide and maintain safety.

This technology still faces challenges where human facial muscles can generate hundreds of expressions and emotions which involves analysing a lot of complex expressions and performing a lot of multi-attribute classifications. And it all needs to be done on a system fast enough to run on embedded systems and mobile devices.
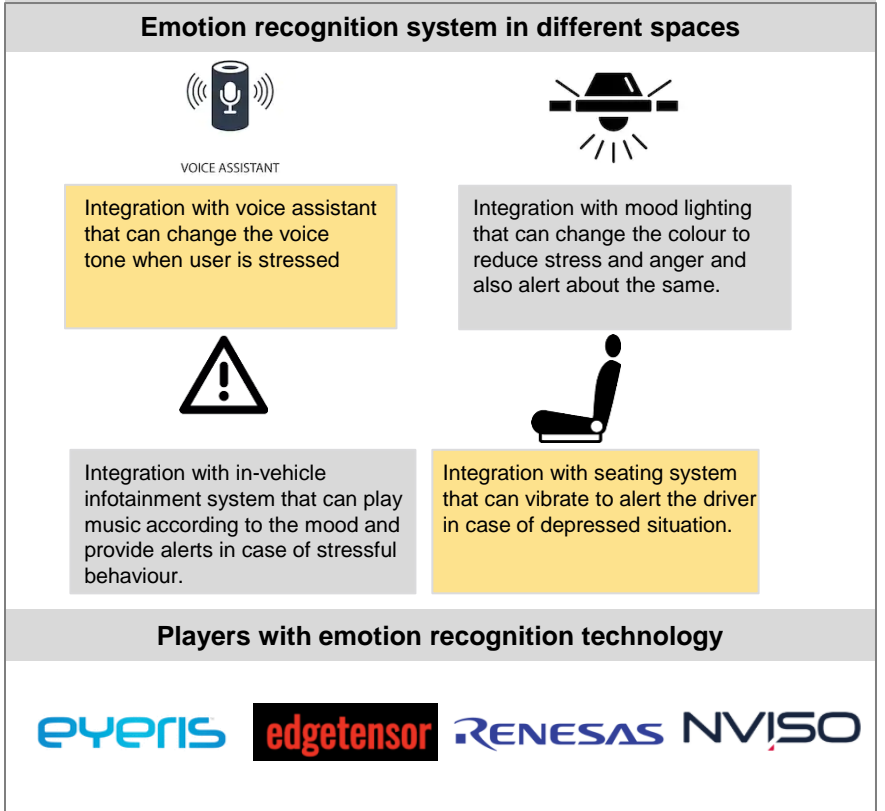
What should you investigate?

How can the emotion recognition technology be standardised for all the drivers?

What are the novel methods that automatically monitors and classifies the psychological condition of human subjects from a set of emotions?

Emotion recognition system in different spaces

VOICE ASSISTANT

Integration with voice assistant that can change the voice tone when user is stressed

Integration with mood lighting that can change the colour to reduce stress and anger and also alert about the same.

Integration with in-vehicle infotainment system that can play music according to the mood and provide alerts in case of stressful behaviour.

Integration with seating system that can vibrate to alert the driver in case of depressed situation.

Players with emotion recognition technology

eyeris   edgetensor   RENESAS   NVISO

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02 Quarterly review of early-stage research

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Detection and prediction of driver drowsiness using artificial neural network models

Background

The detecting as well as predicting impairment of a car driver's operational state is a challenge. A driver's operational state while driving a car involves a complex set of psychological, physiological and physical parameters. During driving activities, several factors can be critical: in particular, fatigue and monotony may cause a loss of attention, drowsiness and even sleepiness. The present study focuses on a specific type of impaired operational state: drowsiness. Drowsiness is an intermediate state between alertness and sleep.

Approach

- Twenty-one participants drove a car simulator for 110 min under conditions optimized to induce drowsiness.
- physiological and behavioral indicators such as heart rate and variability, respiration rate, head and eyelid movements (blink duration, frequency and PERCLOS) and recorded driving behavior such as time-to-lane crossing, speed, steering wheel angle, position on the lane were measured.
- Different combinations of this information were tested against the real state of the driver, namely the ground truth, as defined from video recordings via the Trained Observer Rating.
- Two models using ANN were developed, one to detect the degree of drowsiness every minute, and the other to predict every minute the time required to reach a particular drowsiness level (moderately drowsy).
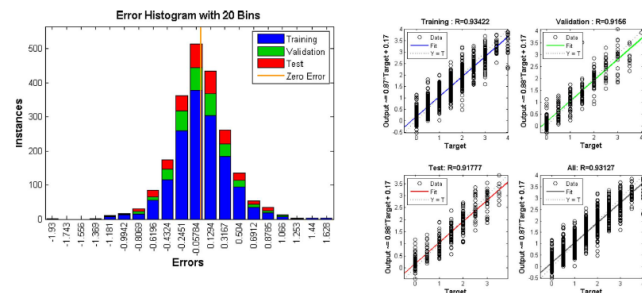

Fig. 1. frequency histogram of error distribution (left panel) and correlation (right panel) between real and estimated state, for a model trained with behavioral dataset, driving time and participant information.
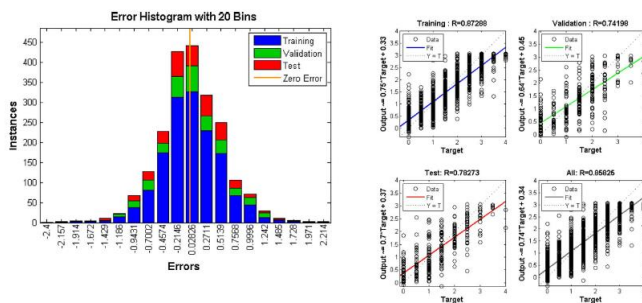

Fig. 2. frequency histogram of error distribution (left panel) and correlation (right panel) between real and estimated state, for a model trained with behavioral, car and physiological datasets.

Key insights

- Using an ANN (Artificial Neural Network) trained with the same information used to detect drowsiness, it is possible to predict when a driver's impairment will appear to an accuracy of approximately 5 min.
- There is not a simple linear relationship between driving time and the time before a given drowsiness level is reached.

Conclusions

- In this study, different ANNs were used either to detect a drowsiness level or to predict when a driver's state will become impaired. The best models used information about eyelid closure, gaze and head movements and driving time.
- Future performance improvements could be achieved by using recurrent neural networks or dynamic neural networks to add temporality to the model, or adding other features like context information (traffic, type of road, weather etc.).
- Modeling drowsiness as a continuum can lead to more precise detection systems offering refined results beyond simply detecting whether the driver is alert or drowsy.
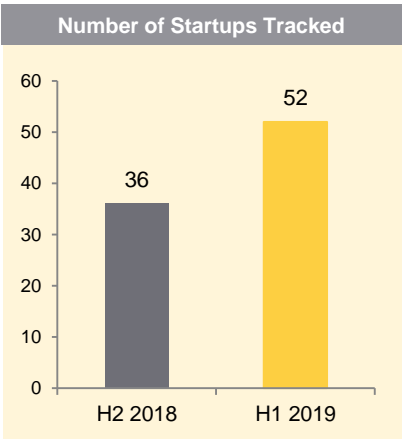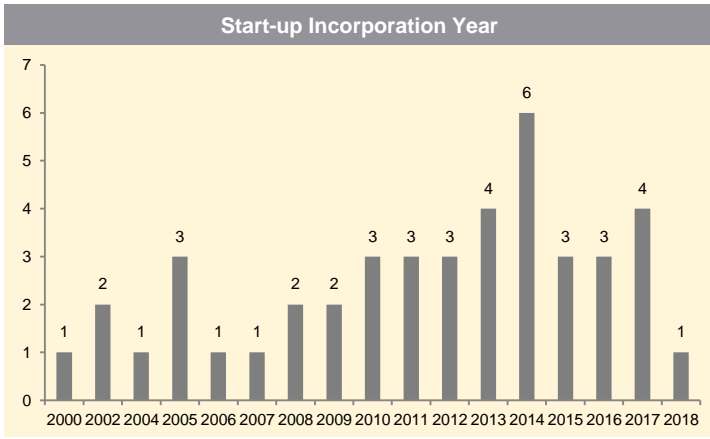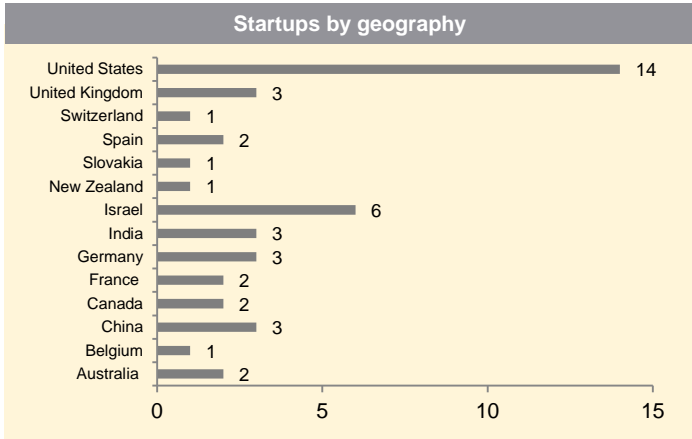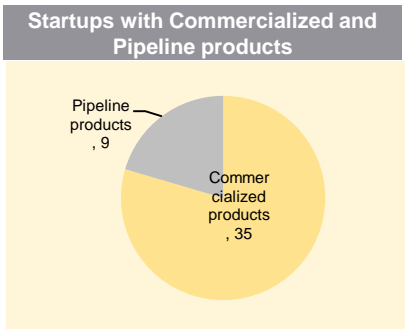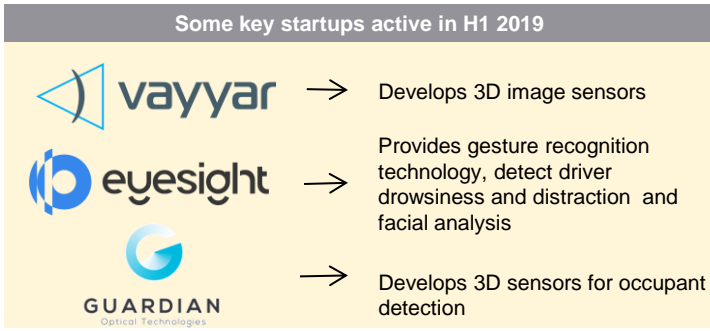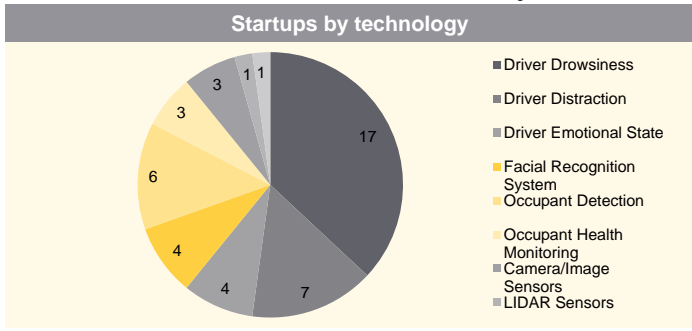
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03 | **Startups Tracker highlights in Q2'19**
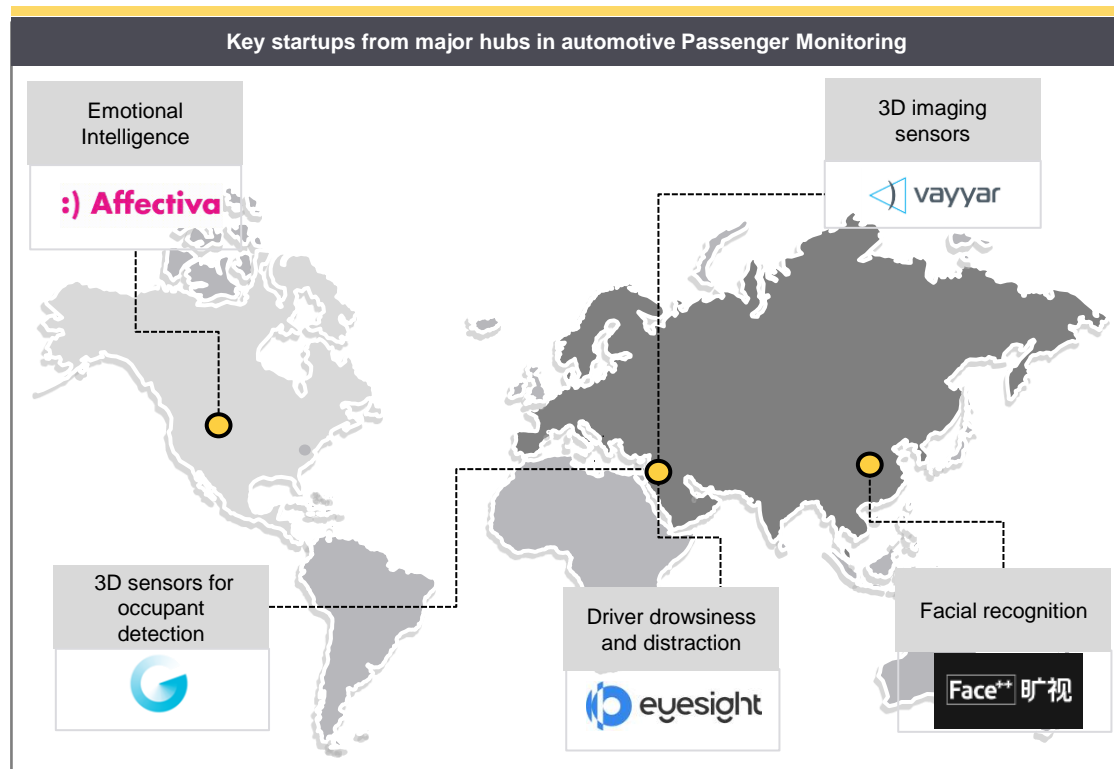
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Startup Activities – Q2'19 (1/2)

Segmentation of major startups in Passenger Monitoring active during Q2 2019. Q2 analysis shows that US leads the race and major area of focus is Driver distraction and drowsiness.

NEW

Startups by technology

Pie chart legend:
- Driver Drowsiness — 17
- Driver Distraction — 7
- Driver Emotional State — 4
- Facial Recognition System / Occupant Detection — 4
- Occupant Health Monitoring — 6
- Camera/Image Sensors — 3
- LIDAR Sensors — 3, 1, 1

Some key startups active in H1 2019

vayyar → Develops 3D image sensors

eyesight → Provides gesture recognition technology, detect driver drowsiness and distraction and facial analysis

GUARDIAN Optical Technologies → Develops 3D sensors for occupant detection

Startups with Commercialized and Pipeline products

- Pipeline products, 9
- Commercialized products, 35

Startups by geography

Country	Value
United States	14
United Kingdom	3
Switzerland	1
Spain	2
Slovakia	1
New Zealand	1
Israel	6
India	3
Germany	3
France	2
Canada	2
China	3
Belgium	1
Australia	2

Start-up Incorporation Year

Year	Value
2000	1
2002	2
2004	1
2005	3
2006	1
2007	1
2008	2
2009	2
2010	3
2011	3
2012	3
2013	4
2014	6
2015	3
2016	3
2017	4
2018	1

Number of Startups Tracked

Period	Value
H2 2018	36
H1 2019	52

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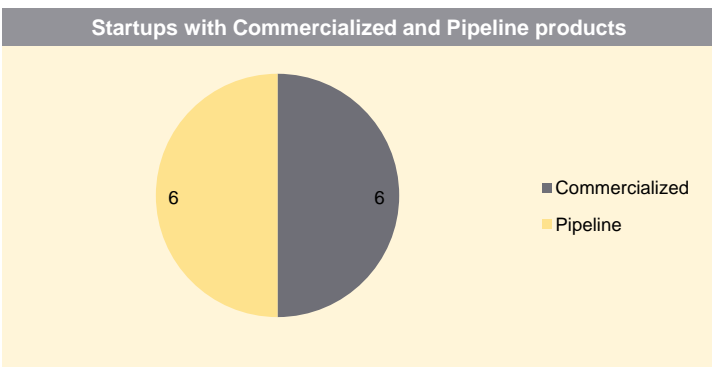# What are the hubs of startup innovation for Passenger Monitoring (2/2)
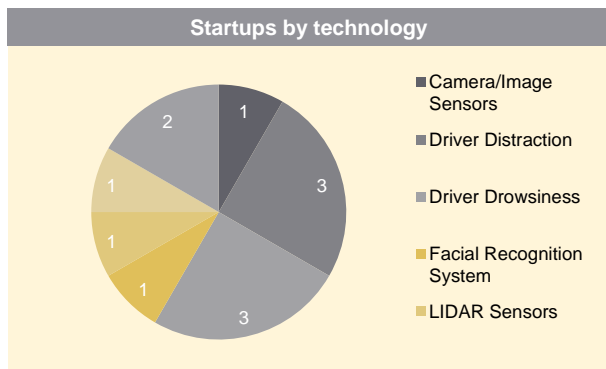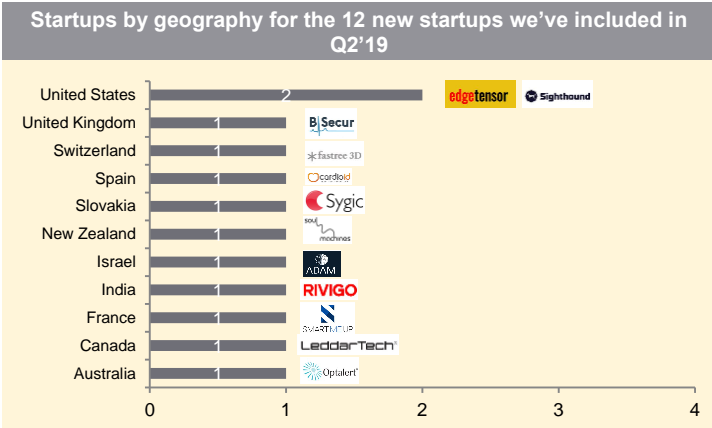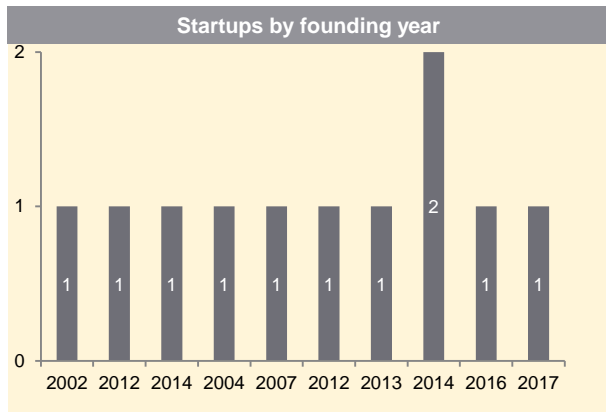
NEW

- Out of the **52** startups we have included in our Tracker, the majority of startups (**37%**) focus on reducing driver distraction followed by driver drowsiness (**15%**) because of the stringent regulations imposed by Governments (Europe, China etc.) in light of driver safety and reduction in number of accidents.

- **USA** leads in the startups (27%) followed by **Europe** (25%)**. Asia** is placed third in terms of startup hubs which is high compared to much developed US and Europe.

- There has been an increase from 36 startups to **52 startups** in our Tracker pointing that the startups are being encouraged by OEMs and suppliers through increased funding and in some cases collaborations.

- Novares unveiled its Nova Car #1 demo which features **FlexEnable's flexible OLCD** in the design of the cockpit.

Key startups from major hubs in automotive Passenger Monitoring

Emotional Intelligence — :) Affectiva

3D imaging sensors — vayyar

3D sensors for occupant detection

Driver drowsiness and distraction — eyesight

Facial recognition — Face++ 旷视

Startup Tracker summary for the 12 new startups we've started monitoring in Q2 2019

Q2 analysis shows that US leads the race and major area of focus is Driver distraction and drowsiness

NEW

Startups by founding year

Startups by geography for the 12 new startups we've included in Q2'19

Startups by technology

- Camera/Image Sensors
- Driver Distraction
- Driver Drowsiness
- Facial Recognition System
- LIDAR Sensors

Startups with Commercialized and Pipeline products
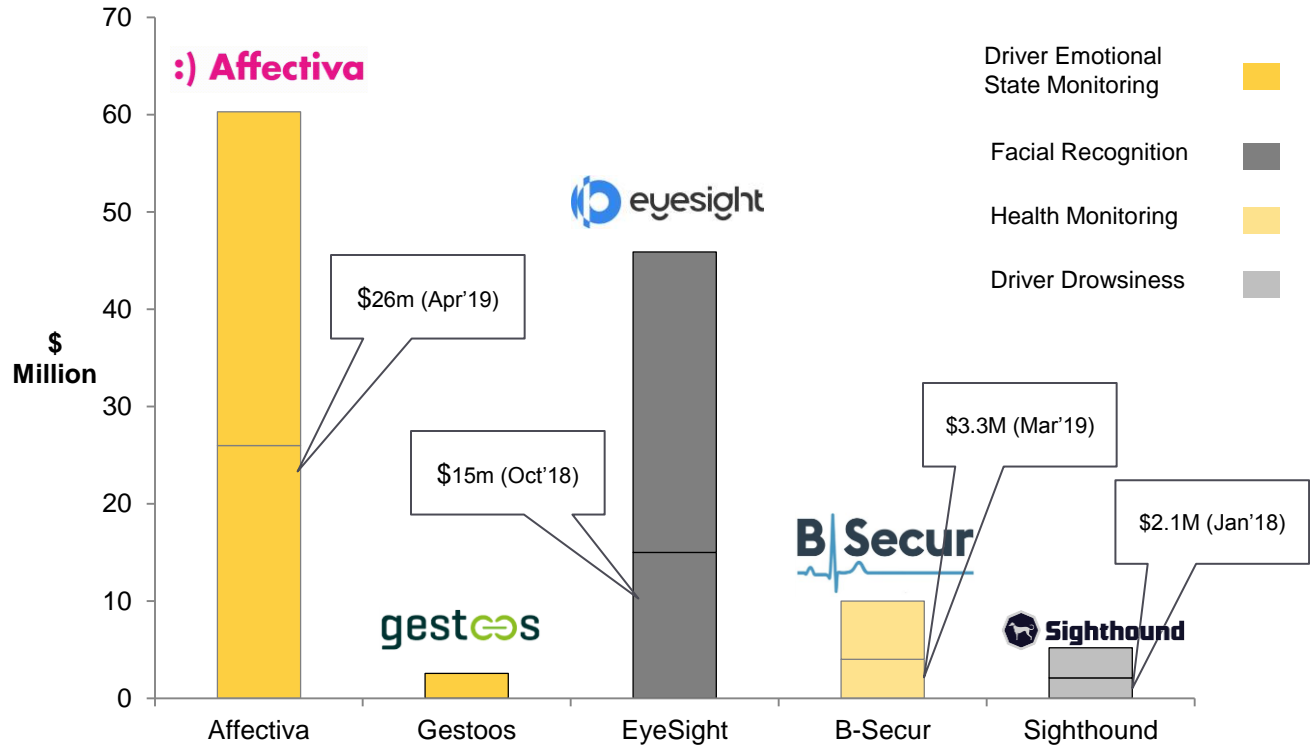

- Commercialized
- Pipeline

- These 12 startups are the ones which were captured during **Q2 2019** as they were highly active in relation to funding/ investments from OEMs.

- Out of the 12 startups covered, **25% each** are working on **driver drowsiness** and **distraction** as OEMs are under scrutiny from government bodies related to safety of drivers.

- **50%** of startups have commercialized product portfolio while **50%** have products in concept phase.

- Some startups like **Cardioid** are linking up with academic institutions to develop their products and push them towards commercialization.

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Startup funding & distribution
AI for emotion recognition, facial tracking, active health monitoring and driver drowsiness

Legend:
- Driver Emotional State Monitoring
- Facial Recognition
- Health Monitoring
- Driver Drowsiness

Chart data (approximate, $ Million):
- Affectiva: ~60 ($26m (Apr'19))
- Gestoos: ~2.5 ($15m (Oct'18))
- EyeSight: ~46 ($15m)
- B-Secur: ~10 ($3.3M (Mar'19))
- Sighthound: ~5 ($2.1M (Jan'18))

- Our Startup Tracker: Top 52 startups in this domain

- More than $45m in funding across the domain between 2018-19

- Emotion AI accounting for the biggest part

Startup highlight – Vayyar's focus on sensors for health monitoring and In-car sensing

NEW

COLLABORATION

"Cockpit of the Future" >   **faurecia**

Oct 02, 2018

Jan 15, 2019

brose Competence in Mechatronics   Sensor technology for new door and seat functions >

Advanced automotive sensors to enhance infant passenger safety >   **Valeo**

Oct 03, 2018

Vayyar's In-car sensing (360° sensor)

- Detect and monitor presence, location, posture, distances, vital signs and obstacles.
- Detect over 150K points of interest per second.
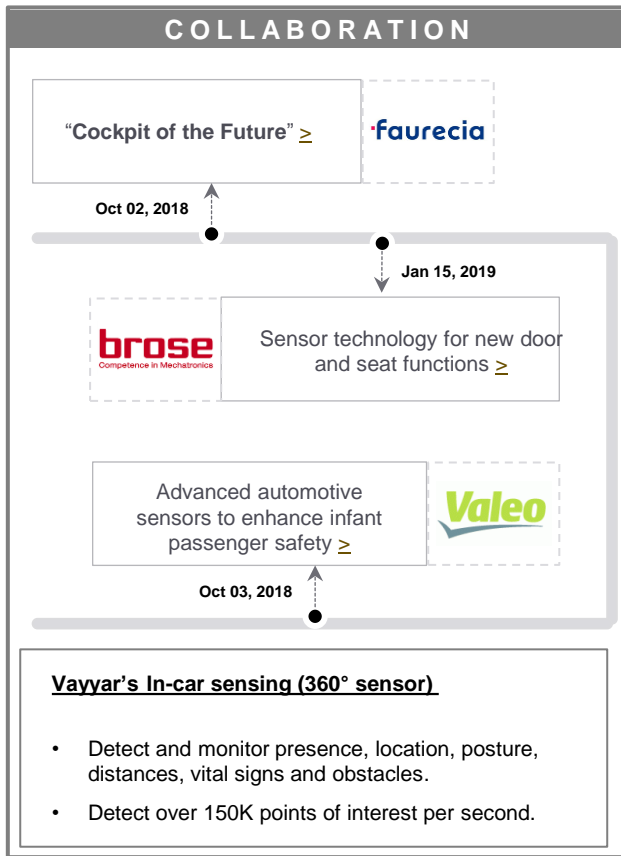
TECHNOLOGY

RF technology

- Vayyar uses advanced RF technology and creates high resolution images.
- The chip uses the imaging and RADAR bands of 3GHz-81GHz with 72 transmitters and 72 receivers

- The sensor is used for the following applications:
- Detect and monitor presence, location, posture, distances and obstacles.
- Track driver vital signs
- Identify head position and movement
- Recognize gestures for infotainment control
- Driver drowsiness alerts, and infant detection alarms

ACTIVITIES

Commentary

"The existing radar solutions do not deliver 4D point cloud capabilities. Vayyar is the first to close the gap between the robustness of radars and the resolution of LiDAR and optics. Our real-time, 4D point cloud solution can work in any environmental condition and doesn't compromise one's privacy. We believe our sensors will create a shift in the way the automotive industry will use radar in the future. We look forward to working with our partners to increase passenger safety worldwide" - *Ian Podkamien, Director of Automotive Business Development for Vayyar Imaging.*

Funding

Dec 13, 2017 | Series C | $45M

Dec 15, 2015 | Series B | $22M

Aug 1, 2012 | Venture Round

News

Aug 14, 2019 | Vayyar's launched universal sensor for safety and monitoring in the interior

Jun 07, 2019 | Vayyar launches single-chip imaging radar for driver drowsiness alert

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