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MOTHERS AGAINST DRUNK DRIVING

Report on Advanced Drunk Driving Prevention Technologies

NO MORE VICTIMS:
Technologies to eliminate drunk driving, and other forms of driver impairment, are ready for the road

January 11, 2021

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85 Federal Register 71987

Letter from MADD National President

In 2019, 10,142 people were killed in alcohol-related traffic crashes, and hundreds of thousands more were seriously injured. For forty years Mothers Against Drunk Driving (MADD) has given a voice to millions of crash victims and their families. We have taken our collective pain and turned it into action, with the goal of no more victims. From passage of the 21 Minimum Drinking Age Law, to the national .08 BAC standard, high-visibility enforcement campaigns, all-offender ignition interlocks laws, and now advanced drunk driving prevention technology, MADD will not rest until drunk driving is a thing of the past.

We at MADD believe that advanced drunk driving prevention technology will eliminate drunk driving, and other forms of impaired driving, by passively and unobtrusively detecting if a driver is unable to safely operate a vehicle.

The automotive and technology industries are in the midst of a traffic safety revolution. These industries have invested billions of dollars in autonomous vehicle (AV) technology, electric vehicles, driver monitoring systems (DMS), and advanced driver assistance systems (ADAS) such as automatic braking and lane departure warning systems. The investment in AV technology also relies on technology that can monitor the state of the driver to determine when AV technology must be deployed.

Government entities are mandating DMS on vehicles. A regulation enacted by the European Union in 2019 requires all new vehicles by 2026 to deploy technology for "warning of driver drowsiness and distraction." The rules under development are set up to be completely technology-neutral, and will be based on performance requirements. In Shenzhen, China in 2019 (a city with more than 12.5 million people), the government passed a law requiring commercial vehicles to be equipped with driver monitoring systems.

In February 2019 the European New Car Assessment Program (Euro NCAP) released a paper on "Assessment Protocol - Safety Assist" stating "Euro NCAP envisages an incentive for driver monitoring systems that effectively detect impaired and distracted driving and give appropriate warning and take effective action, e.g. initiating a safe evasive maneuver, limp home mode, increasing sensitivity of Electronic Stability Control, lane support, speed, etc. Implementation in the overall rating is planned in

phases, starting with systems that have already entered the market. The assessment will evolve around how reliably and accurately the status of the driver is detected and what action the vehicle takes based on the information. Other aspects, such as driver position monitoring, could be added in future iterations of the protocol."

MADD has collected information gathered from patents, automakers, news articles, and Tier 1 and Tier 2 suppliers. More than 180 forms of technologies are currently deployed, in development, or soon to be on the market. These technologies, or a system of these technologies, hold great promise for eliminating drunk driving. Advanced drunk driving prevention technology must be a standard feature on all new vehicles.

Here is just one example of advanced drunk driving prevention technology already developed:
- In March 2019, Volvo announced technology that monitors for alcohol or distracted driving impairment would be a feature on new vehicles in the early 2020s.
  - The Volvo system uses "in-car cameras and other sensors that monitor the driver and allow the car to intervene if a clearly intoxicated or distracted driver does not respond to warning signals and is risking an accident involving serious injury or death."
- The Volvo systems detect impaired driving using the very same technology that more than 100 other driver monitoring systems use.
  - These systems determine a driver's state using one or a combination of the following monitoring features: 1) optical or infrared camera to look at the face or eyes of the driver; 2) seat to monitor body movement, breathing, heart rate or brain waves; and 3) steering wheel sensors.
- This video describes the technology, and various actions taken by the vehicle when impairment is detected: https://www.media.volvocars.com/global/en-gb/media/videos/250162/in-car-cameras-and-intervention-against-intoxication-distraction-animation1

Additionally, Nissan and Toyota had drunk driving prevention concept cars a decade ago:
- Nissan Drunk Driving Prevention Concept Car: https://www.nissan-global.com/EN/TECHNOLOGY/OVERVIEW/dpcc.html
- Toyota Announced a Drunk Driving Prevention System in 2007 with Hopes of Having it in Cars by the End of 2009: https://www.nbcnews.com/id/wbna16449687

This report provides detail about three types of advanced drunk driving prevention technologies: DMS that are not alcohol-specific but could be programmed to determine impairment by alcohol or other drugs, DMS that are alcohol-specific, and touch or breath systems that monitor for alcohol impairment.

According to the Insurance Institute for Highway Safety, if all cars were equipped with technology that could stop a drunk driver from operating a vehicle, more than 9,400 lives could be saved annually. Advanced drunk driving prevention technologies will eliminate drunk driving, the leading killer on America's roads. On behalf of drunk driving victims, I urge the National Highway Traffic Safety Administration to mandate drunk driving prevention technology as soon as possible. Time lost equals lives lost.

Sincerely,

Alex Otte

Alex Otte
MADD National President

Overview of Advanced Drunk Driving Prevention Technologies

Background
Technology is here that can passively detect drunk driving, and eliminate this violent crime. Driver monitoring systems can work in-tandem with other products to passively and unobtrusively detect and stop impaired driving.

Driver Monitoring Systems utilize cameras, seats, driving behaviors, artificial intelligence, and other technologies to monitor a driver. All of the systems use technology to track the driving performance of the vehicle. Nearly all of the systems also use cameras, which look at the eyes and face of the vehicle user. These systems are integrated with other technologies that are widely available right now, including lane assist and emergency braking technologies.

This document will explore 187 advanced technology systems divided into three areas:
- **Driving monitoring systems that measure a driver's physical characteristics.** Pages 5 to 77 explore these technologies. Manufacturers do not advertise their products as addressing the issue of drunk driving. These products typically address fatigue and drowsy driving. These technologies monitor one or a combination of the following: eyes, face, heart, body, or voice. These technologies use cameras, seats, and other in-vehicle sensors. These technologies these human characteristics detect can be indicators of substance impairment as well.
- **Driving monitoring systems that can measure a driver's physiological characteristics for substance impaired driving.** Pages 78 to 111 explore technologies that advertise as being able to determine if a person is substance impaired.   Most of these are links to those patents, which have links to the Patent, which in many cases includes artwork on how the technology might work.
- **Technologies that directly monitor for alcohol impairment.** Page 111 to 124 looks at these technologies, which typically measure a person's breath or skin. Most of these products are links to Patents.

Indicators for alcohol impairment are very telling through the eyes and face
When exploring technology that focuses for visual signs of impairment in the face, it is important to remember how often law enforcement look for these signs following a suspected incidence of impaired driving. Standard Field Sobriety Test (SFST), Advanced Roadside Impaired Driving Enforcement (ARIDE), Drug Recognition Expert (DRE) and other tests law enforcement use look specifically at the movement and characteristics of a person's eyes for alcohol and other drug-impairment. This matrix, from the Minnesota Department of Public Safety, shows how drugs and alcohol (depressants) affect a person's eye movement and other body characteristics. The driving monitoring systems that currently exist can determine drowsy and distracted driving could also, in many instances, detect substance impairment.

How Does the Current State of Technology Compare to Previously Tested Technologies?
Over the past decade, automotive technology advancements have been described as revolutionary. Investments in electric and autonomous vehicles have resulted in cars being compared to smartphones and even supercomputers on wheels. Some cars are even being built without steering wheels. Current DMS are passive and unobtrusive to attentive and sober drivers. Additionally, Artificial Intelligence and the multiple sensors that go along with DMS create a system of redundancy that would make for this technology as a standard feature more seamless and completely unobtrusive to sober drivers.

How MADD will describe technologies in this RFI submission for each of the nearly 200 products:
1) Methods and Systems. Impairment measurement metrics, impairment classification approaches and capabilities, availability of test results and data that support system capabilities and limitations, advanced sensors;
2) Other technologies that could be used in a vehicle to detect impaired drivers;
3) Whether and how systems have been validated to date, and user acceptance;
4) More Information such as links to videos and company website.

Driving monitoring systems that measure a driver's physical characteristics. These technologies are not advertised specifically as addressing the issue of drunk driving.

These products are typically described as addressing fatigue and drowsy driving. These technologies monitor one or a combination of the following: eyes, face, heart, body, or voice. These technologies use cameras, seats, and other cabin sensors.

These Driver Monitoring System technologies are divided up into the following areas:
1) Auto Companies - or Original Equipment Manufacturer (OEM) - technology deployed or in development
2) Tier one auto suppliers who are developing or deployed this technology. This also includes large tier two companies that have put resources together to form a company.
3) Tier Two auto suppliers who are developing or deployed this technology.
4) After-market products: Technology the general public can install in their vehicles or commercially operated vehicles can install on their fleets.
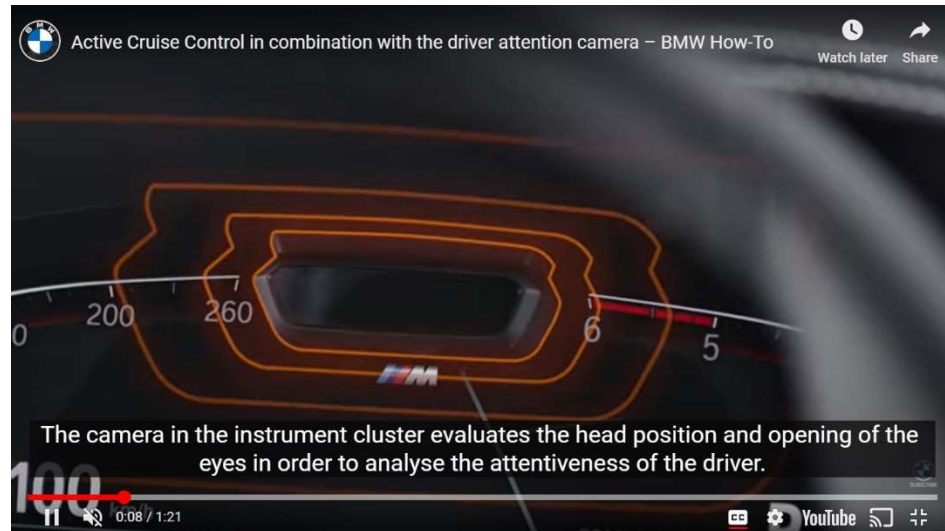
Auto Company (OEM) technology deployed or in development
There are over 28 driver monitoring systems by an OEM or have been announced as a concept by an OEM.

1. BMW

Methods and systems

The BMW driver attention monitor captures head and eye movement of driver. The technology looks at a person's eye and analyzes a person head movement.

According to a 2019 Cars.com

Image of BMW Driver Monitoring System (YouTube)

review, the system is "driver-facing camera monitors your nose and eyes to make sure you're facing forward with eyes open." The YouTube video by BMW demonstrates how "the system evaluates the heads positions and opening of the eyes in order to analyze the attentiveness of the driver." The camera is mounted in the instrument panel above the steering wheel.

The technology acts immediately for driver inattention but may be limited to use while a vehicle is stopped. Another limitation is the driver can also turn of this technology

Other technologies that could be used in a vehicle to detect impaired drivers

As this technology measures body and eye and movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

The technology has been around since at least 2019 on certain BMW vehicles and is advertised by BMW dealers and is also showcased on BMW's YouTube page.

There must be a good level of acceptance as it is an option on BMW vehicles. This technology seems tied in with the use of the vehicle while using cruise control.

More information
- Company Website: https://www.bmwofminnetonka.com/bmw-active-cruise-control-with-driver-attention-camera/
- "Active Cruise Control in combination with the driver attention camera – BMW How-To" BMW on YouTube. https://www.youtube.com/watch?v=LkxgOXuhBUg
- "Our Hands-on Experience With the 2019 BMW X7's Hands-Free Driving Mode" Cars.com, August 12, 2019. https://www.cars.com/articles/our-hands-on-experience-with-the-2019-bmw-x7s-hands-free-driving-mode-407421/

- "Learn How To Use The Driver Attention Camera with Active Cruise Control," Fields BMW Lakeland. https://www.youtube.com/watch?v=fNZ6NBZlTWA

2. DS Automobiles

Methods and systems

DS Automobiles, owned by Groupe PSA, features the DS Driver Attention Monitoring, which is an eye-based monitoring system. The system features a driver-facing camera that monitor three key physical signs of distraction or drowsiness; movement of the eyes, eyelids or neck. If any signs of distraction are detected, an audible alert is set off and a warning notice appears on the digital instrumentation display. At the same time, vehicle position monitoring constantly tracks the car in relation to road markings and warns the driver with an audible alert if there are any sudden or unexpected steering movements.

Images of DS Driver Attention Monitoring System (YouTube)
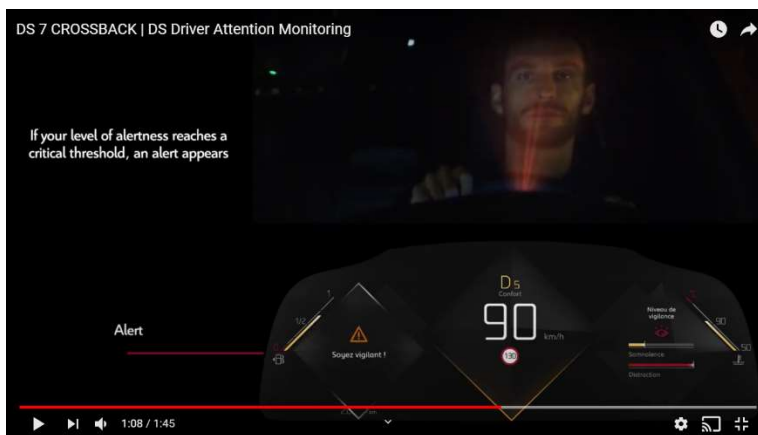
Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures body and eye and movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

The system is an option on certain new vehicles. It is unclear if the driver can physically disable this feature if they get it installed on their vehicle.

More Information

- DS Automobiles: https://www.dsautomobiles.co.uk/inside-ds/ds-news/ds-automobiles-anti-fatigue-technology
- YouTube Video "DS 7 CROSSBACK | DS Driver Attention Monitoring," April 26, 2018. https://www.youtube.com/watch?v=UAVbZI0A3WA
- "DS Anti-Fatigue Monitoring to Boost Safety," InformaTech, November 8, 2019. https://www.tu-auto.com/ds-anti-fatigue-monitoring-to-boost-safety/#
- "This Is How the DS-7 Crossback Driver Attention Monitoring System Works," AutoEvolution, November 8, 2019. https://www.autoevolution.com/news/this-is-how-the-ds-7-crossback-driver-attention-monitoring-system-works-138884.html

3. Daimler

Methods and systems

The Mercedes Attention Assistant system monitors the driver for their attention level first introduced in 2009. The Active Steering Assist system monitors the drivers and works with the Mercedes Active Emergency Stop Assist to stop the vehicle and call for help if the driver is incapable of driving.

Mercedes-Benz S-Class 2017: Active Emergency Stop Assist (YouTube)

The Mercedes Attention Assistant system works the following way (it does not use a camera):

> The system monitors the driver's behavior in the first 15 minutes and uses this as a benchmark in its continuous monitoring and analyzing as long as the system is enabled and the vehicle is traveling at highway speeds. While the system does not monitor eye movement/eye scans, it does analyze more than 70 parameters in total, including time of day, steering movements, vehicle speed, vehicles acceleration, driver's operating actions (such as use of control buttons for radio, steering column adjustment actions, instrument cluster or steering wheel actions such as turning windshield wipers or lights on or off), etc.

The Mercedes Active Steering Assist works in the following way:

> Active Steering Assist (as part of the E/S-Class Driver Assistance Package) does indeed monitor how much input the driver is providing the system and will alert the driver to put their hands on the wheel if it detects an absence of input. A feature called Active Emergency Stop Assist will be activated if the system determines there is no driver input at all for a continued period of time (like in the case of a debilitating health event) and if the driver does not respond to various alerts and notifications from the system. In this case, the vehicle will then bring itself to a stop, unlock the doors, and can even activate an SOS call to emergency responders.

Other technologies that could be used in a vehicle to detect impaired drivers

The Active Steering Assist and Attention Assist System seems like it could be programmed or adjusted to detect for substance impaired driving.

Whether and how systems have been validated to date and user acceptance

Both of these systems are available as an option on certain Mercedes. The ability for a car to slow down and pull over to call for help if the driver is deemed incapacitated is available or being developed by other auto companies.

More Information

- Mercedes Driver Assistance Tech FAQ 2018 S-Class Sedan: https://media.mbusa.com/releases/driver-assistance-tech-faq?firstResultIndex=0&sortOrder=PublishedDescending
- Video of Mercedes-Benz S-Class 2017: Active Emergency Stop Assist: https://www.youtube.com/watch?v=J5urCuA6BQE&feature=emb_title

4. Daimler

Methods and systems

The Patent filed by Daimler, the auto company that makes Mercedes, is for an eye-based monitoring system. It measures the eye for changes in pupil. The results are immediate, and the eye monitoring measures a previous image of the eye of the user for comparison.

FIG 1A

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures eye movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

The specific system has not been validated, but similar systems are in development or deployed. Once this technology is available by this OEM, it is unclear whether or not users will be able to turn of this function.

FIG 1B

More Information

- Patent filed in 2018 in Germany: DE102018009100A1.
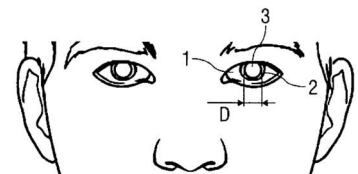 https://patents.google.com/patent/DE102018009100A1/en
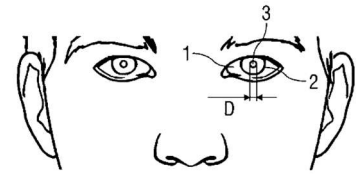
Drawings from Patent DE102018009100A1

5. Ford

Methods and systems

The Ford Co-Pilot 360 Infrared driver-facing camera will track eye gaze and head position. The system looks at eyes and head position while the car is in hands free mode semi-autonomous driving. Drivers will be notified by visual prompts on their instrument cluster when they need to return their attention to the road or resume control

Image of Ford Driver Monitoring System (YouTube)

of the vehicle. This technology appears to only work when the vehicle is in hands free mode.

Other technologies that could be used in a vehicle to detect impaired drivers

As this technology measures body and eye and movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

As the system will be available in Ford vehicles in 2021 and has already been tested on over 100,000 miles of road in the United States, this technology is ready to go. The driver monitoring is only active during certain times of operation.

More information
- Ford Website: https://media.ford.com/content/fordmedia/fna/us/en/news/2020/06/18/ford-co-pilot360-technology-adds-hands-free-driving.html
- "Hands-Free Driving Coming To 2021 Ford Mustang Mach-E," June 18, 2020. Forbes.com. https://www.forbes.com/sites/samabuelsamid/2020/06/18/hands-free-driving-coming-to-2021-ford-mustang-mach-e/?sh=7b5076e54113
- Video of technology from Ford: https ://www.youtube.com/watch ?v=x-Ig-98jutA

6. Ford

Methods and systems.

This is a Heart rate-based monitoring system through a seat. Other Driver Monitoring Systems that are being developed or are developed are also able to monitor the heart rate of operators.

According to the Mayo Clinic, consuming three alcohol drinks in one sitting can temporarily increase your blood pressure. An elevated heart rate is associated with higher blood pressure. (NIH, 2013).

Image of Ford Heart Monitoring System (YouTube)

The limitations are that changes in a person's heart rate could be for multiple reasons. However, the test results are immediate.

Other technologies that could be used in a vehicle to detect impaired drivers

The heart rate monitoring systems would work well with a camera monitoring system of the eyes or face to monitor an operator for impairment.

Whether and how systems have been validated to date and user acceptance

News Articles on this Ford heart rate-based monitor dates back to 2011. Tier 1 suppliers have also explored this technology for vehicles. Seat based heart monitors do not appear to be widely available.

Humans have various reasons for changes in their heart rate. A Heart rate monitor alone cannot be the sole indicator to determine impairment but might be helpful with other driver monitoring systems to ensure redundancy when determining impairment.

More Information

- "Ford develops heart-monitoring seat" CNET, May 24, 2011. https://www.cnet.com/news/ford-develops-heart-monitoring-seat/
- Video: "IFA 2011: Ford Heart Rate Monitoring Seat" YouTube, September 1, 2011. https://www.youtube.com/watch?v=zIR9kFwngjc
- "Alcohol: does it affect blood pressure?" Mayo Clinic. https://www.mayoclinic.org/diseases-conditions/high-blood-pressure/expert-answers/blood-pressure/faq-20058254
- "Heart Rate and Blood Pressure: Any Possible Implications for Management of Hypertension?" Ruele, Curr. December 2013. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3491126/#:~:text=Elevated%20heart%20rate%20is%20associated,consideration%20in%20choosing%20antihypertensive%20medications.
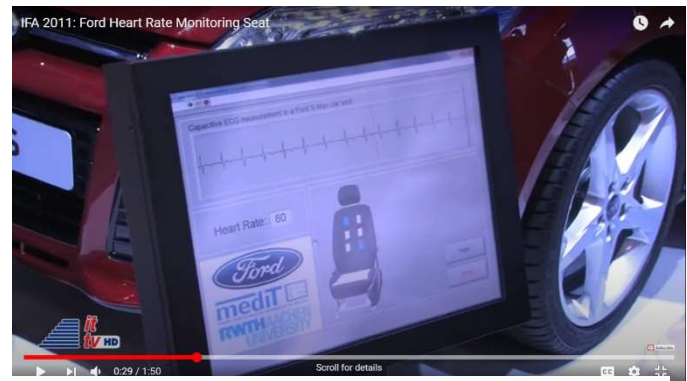
7. Fuso

Methods and systems

Fuso is 89% Owned by Daimler Truck AG. The Fuso "Active Attention Assist" on commercial trucks tracks head and eye movement to determine driver attention in addition to other features such as tracking for lane departure. The test results are immediate, but a person can turn off the feature and it only operates above certain speeds. The advanced optical sensors utilize facial recognition technology

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures a person's face, eye and head for signs of distraction or fatigue, it could also be programmed to determine substance impairment.

Images of Fuso Active Attention Assist (YouTube)

Whether and how systems have been validated to date and user acceptance

Currently, it is a feature only on Fuso commercial vehicles. The user can turn off the feature.

More Information
- Fuso New Zealand website: https://www.fuso.co.nz/news/shogun-first-safety
- Fuso Active Attention Assist ad: https://www.youtube.com/watch?v=qcRADEWxTgM
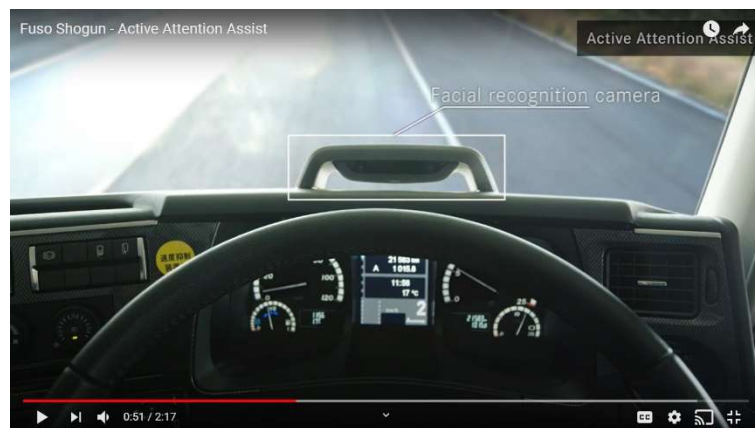
8. Genesis (Owned by Hyundai)

Methods and systems

The Genesis "Forward Attention Warning" checks driver face with IR optical camera installed on the instrument cluster. According to their website, "Forward Attention Warning helps limit the dangers of driver fatigue and tiredness by reading the face of the driver through an IR camera built right into the dashboard"

Images of Genesis Forward Attention Warning (YouTube)

The test is immediate and fatigue is noted: "When the system detects closed eyes or lack of attention, it warns the driver with pop-up notifications and an acoustic warning sound designed to effectively secure the driver's attention."

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures body and eye and movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

It is advertised as a new option on vehicles. The technology is dependent on a person opting for this technology to be installed in the vehicle that they purchase. The person could also turn off the system if it is installed in their vehicle.

More Information

- Genesis website: https://www.genesis.com/ca/en/luxury-suv-genesis-gv80-safety.html
- Video of GV80 | Driver Attention Warning: https://www.youtube.com/watch?app=desktop&v=1gktZsO9kFo.
- Video of G80 and GV80 Forward Attention Warning https://www.youtube.com/watch?v=wEj03gpM4rc&list=PLW77CkZQxeR3Ia_pcxVnDiB7ziv04ZE3a

9. Hyundai

Methods and systems

The DDREM (Departed Driver Rescue and Exit Maneuver) system monitors the driver via a camera. The system is developed by a Tier 1 company Hyundai Mobis. The system "uses camera sensors installed in the cabin to monitor the position of the driver's head, line of sight, blinking speeds, and other identifiable physiological behavior."

Image of Hyundai Mobis DDREM (YouTube)

It can measure a person's head, blinking eyes. The test results are immediate. DDREM "system also continuously learns the baseline patterns of a normal driving condition for the driver, so it can distinguish between different driving states, and minimize false alarm." It uses cameras and other advanced software and Autonomous Vehicle technology to take over control if the operator is incapacitated as shown from the images below.
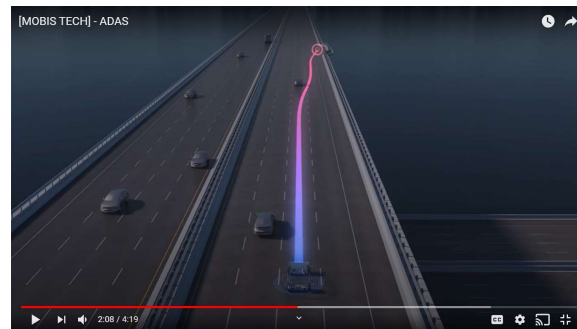
Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures body and eye and movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

The system was announced in 2018 by Hyundai's Tier One supplier Hyundai Mobis. The technology is promoted in at least two places on the Hyundai's OEM website.

The technology is meant for drivers who are fatigued or having other medical conditions. The technology could take over for a driver unable to operate their vehicle.

More Information

- Hyundai website: https://tech.hyundaimotorgroup.com/article/farewell-to-drowsiness-behind-the-wheel/

- October 16, 2019 video from Hyundai Mobis shows how the technology works: https://www.youtube.com/watch?v=a7VU9e2TtVs&t=113s&fbclid=IwAR3b8wmBAjCkyFYlWcQBNQlwQTFhLxBsfkmFxSIyb20srMhX0KdwpWbV7X4.
- "Hyundai Mobis develops 'in-cabin systems' utilizing the state-of-the-art autonomous driving sensors one after another!" March 24, 2020. https://news.hyundaimotorgroup.com/MediaCenter/News/Press-Releases/Hyundai-Mobis-develops-in-cabin-systems-utilizing-the-state-of-the-art-autonomous-driving-sensors-one-after-another
- "What if your car becomes a clinic?" March 26, 2020. Hyundai https://news.hyundaimotorgroup.com/Article/What-If-Your-Car-Becomes-a-Clinic.

10.   Cadillac Super Cruise (General Motors)

Methods and systems

Eye and head-based monitoring system that is available as on certain Cadillac vehicles. Camera measures a person's attention while in hands free driving mode. The camera can sense if a person is paying attention. The results are immediate, and driver's seat will vibrate. The technology cannot be used when the vehicle is not in the hands-free mode.
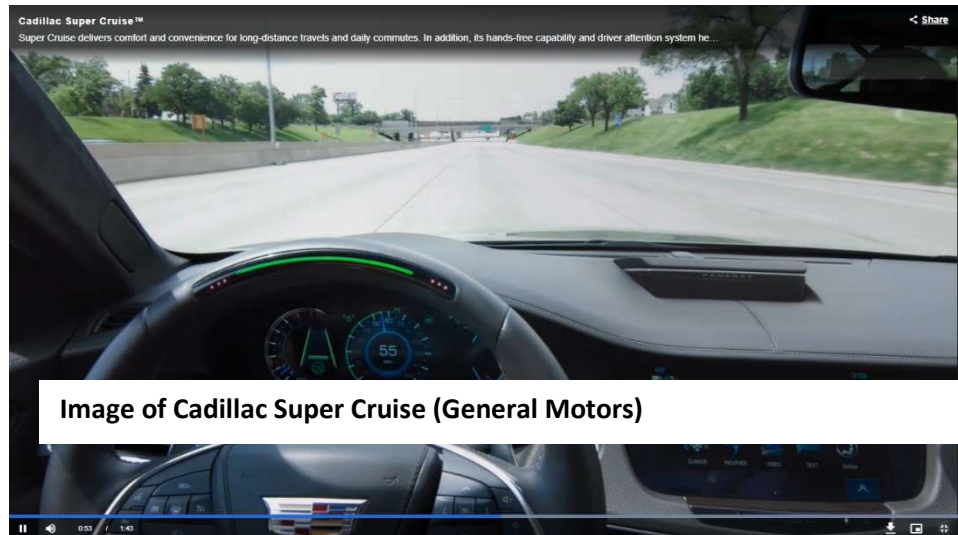
Image of Cadillac Super Cruise (General Motors)

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures eye and head movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

This is a feature on certain GM vehicles and is deployment currently. Users are not required to use the hands-free driving mode. This technology would work to determine substance impairment if it was required to be in operation during the beginning and operation of the vehicle.

More Information

- GM website: https://media.gm.com/media/us/en/cadillac/news.detail.html/content/Pages/news/us/en/2017/apr/0410-supercruise.html

11. Jaguar Land Rover

Methods and systems

Jaguar Land Rover eye and head-based monitoring system is called simply a "Driver Monitor System." The technology looks at a person's eyes and analyzes a person head movement. It utilizes advanced software. The results seem to act immediately for driver inattention. Jaguar Land Rover's website says "DMS is unique because it is the only driver monitoring system that can achieve this even if the driver is wearing shades, or in full sunshine." The Driver Monitor system also uses advanced computer software.

Other technologies that could be used in a vehicle to detect impaired drivers

The website says "The algorithm we have developed for DMS has the potential to seamlessly enable a host of safety and autonomous driving features and reduce the potential for accidents caused by the driver not paying attention." As this tech measures eye and head movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

It is along in the process, but not fully available on every vehicle. On the website, "DMS was developed at Jaguar Land Rover's new R&D facility in Portland, Oregon, and while it was demonstrated in a Jaguar F-Type prototype, Nick Langdale-Smith, Vice President of Seeing Machines, believes the technology holds huge potential for other Land Rover vehicles."

As the technology is still not fully available, the question will be whether users will have the option to turn off this feature if they get in on their vehicle.

More Information

- Jaguar Land Rover: https://www.landrover.com/experiences/news/jlr-new-driver-monitor-system.html

12. Jaguar Land Rover

Methods and systems

Jaguar Land Rover's "Sixth Sense Project" monitors brain waves and heart rate of driver by using sensors on the seat and steering wheel. Additionally, uses seat-based sensors for heart and breathing ability. The test results could be immediate.

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures body, heart, and brain movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

The system was announced as in development since 2015, it does not appear this technology has been incorporated into the vehicles. In the Driving Monitoring System space, other companies are looking into brain waves and also into using seats for monitoring the driver.

On Driving Monitoring, only a handful of companies look into monitoring brain waves. The steering wheel measurement of heart rate seems like it has potential.

More Information
- Jaguar Land Rover: https://www.jaguarlandrover.com/news/2015/06/jaguar-land-rover-road-safety-research-includes-brain-wave-monitoring-improve-driver
- "jaguar land rover reveals new road safety systems," Top Speed. June 18, 2015. https://www.topspeed.com/cars/car-news/jaguar-land-rover-reveals-new-road-safety-systems-ar170001.amp.html

13. Nissan

Methods and systems

The Nissan ProPilot 2.0 measures for driver attention using a camera and also measures outside conditions. The system is a driver-facing camera that tracks eyes and head. The results are immediate.

Image Nissan ProPilot 2.01 driver monitoring system (Nissan)

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures head and eye and movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

The technology appears to be an option on certain Nissan vehicles for sale in the World. It is not clear if the driver can disable the system.

More Information
- Nissan: https://www.nissan-global.com/EN/TECHNOLOGY/OVERVIEW/ad2.html
- Nissan ProPILOT 2.0 driver monitoring system confirms the driver is attentive: https://global.nissannews.com/en/photos/photo-bafd61da591f6a12b9336e84540019ad-propilot-20-driver-monitoring-system-confirms-the-driver-is-attentive
- Nissan Reveals Revolutionary Hands-Off Self-Driving Tech, Forbes. July 23, 2019. https://www.forbes.com/sites/peterlyon/2019/07/23/autonomous-driving-war-heats-up-as-nissan-launches-revolutionary-self-driving-tech/?sh=2e4f41407fc3

14. Subaru

Methods and systems

The Subaru "Driver Focus" or "Driver Monitoring System" monitors head and eye movement for fatigue and distraction. The driver-facing camera will track eye gaze and head position. It gives an immediate alert for fatigue or distraction. The car will not slow down or stop if the alert goes off. The advanced optical sensors look at head movement and the opening of the eyes.

Image of Subaru Driver Monitoring System (YouTube)

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures body and eye and movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

The systems appear ready to be rolled out in all new vehicles and appear to be well tested. The beeping to the driver may be an annoyance.

More Information

- Subaru Driver Focus: https://www.subaru.com/guides/forester/my19/content/driver_focus.html
- "What is Subaru DriverFocus Technology?" JD Power. June 25, 2020. https://www.jdpower.com/cars/shopping-guides/what-is-subaru-driverfocus-technology
- "Subaru DriverFocus: Most Innovative New Safety or Driving Aid" Edmunds. February 26, 2019. https://www.youtube.com/watch?v=vwJQ2HeXq7M
- "Subaru DriverFocus Technology" October 5, 2018. https://www.youtube.com/watch?v=T2fZCSZK710
- "Subaru Driver Monitoring System" August 27, 2019. https://www.youtube.com/watch?v=BDAILNxqB6M

15. Lexus

Methods and systems
Lexus, owned by Toyota, has an eye and face camera-based Driver Monitoring System.

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech measures head/eye movement, it could also be programmed to determine substance impairment.
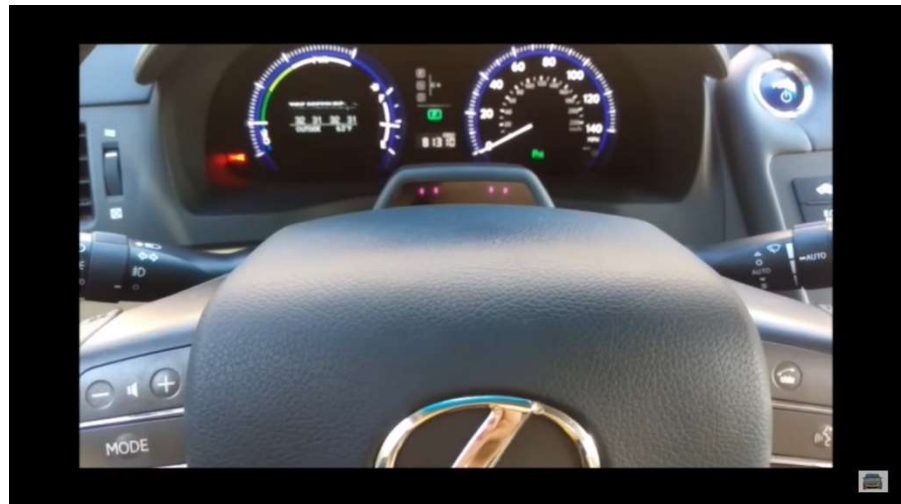

Image of Lexus Driver Monitoring System (YouTube)

Whether and how systems have been validated to date and user acceptance
This is currently an option on Lexus vehicles sold in Japan.

More Information
- Video of the technology from YouTube:
  https://www.youtube.com/watch?v=7MommnELwwM

16. Lexus

Methods and systems
Lexus, owned by Toyota, has a system called the "Preventative Safety Package." If driver is unable to operate the vehicle, vehicle stops moving. The system appears to measure for sudden changes of driver behavior and can stop the vehicle and call for help. The system can sense if the driver is unable to operate the vehicle and pull over the vehicle safely. The type

Lexus Safety System +A (YouTube)

of sensors it uses are unclear, but they must monitor the driver in order to take control of the vehicle.

Other technologies that could be used in a vehicle to detect impaired drivers
As this can tell if a driver is physically unable to operate a vehicle, it would be appear that it could stop a substance impaired driver from operating a vehicle.

19

Whether and how systems have been validated to date and user acceptance
Lexus must think highly of this technology as it is on their website. The technology takes over the vehicle and it is unclear if the feature can be disabled.

More Information
- Lexus: https://lexus.jp/technology/safety/
- This Lexus Video shows how the system operates around minute 2:30: https://youtu.be/7oAR7hV2JPA

17. Toyota

Methods and systems
This driver monitoring system monitors the eyes and head. The system detects the eyes and lower eyelids, calculating how open are the eyes. The system also looks if driver is facing forward and can detect distracted or drowsy drivers. The results of the tests are immediate. The systems uses a system of cameras and other sensors.

Toyota driver monitoring configuration (Toyota, 2005)

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech measures eye movement, it could also be programmed to determine substance impairment
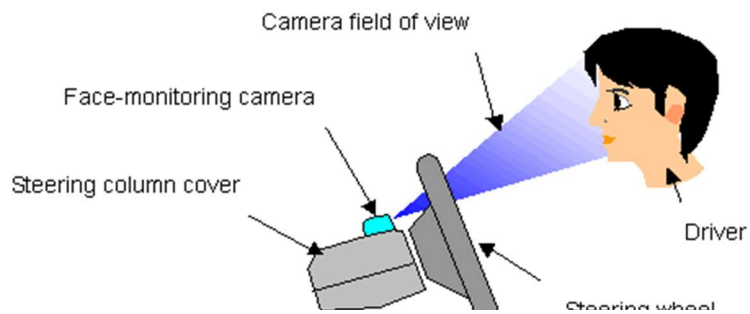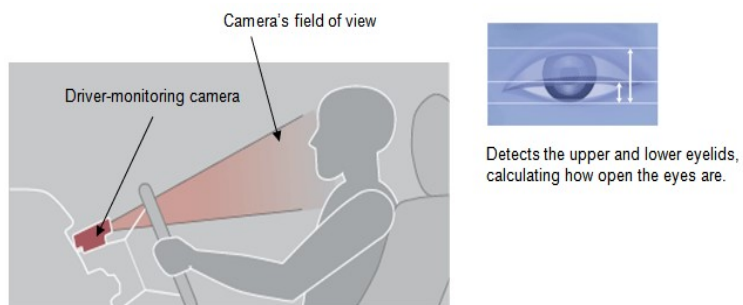
Toyota driver monitoring configuration (Toyota, 2008)

Whether and how systems have been validated to date and user acceptance
The technology was announced in 2006 and was announced again in 2008. It is unclear if the cameras are an option on Toyota vehicles.

More Information
- Toyota Enhances Pre-crash Safety System With Driver-monitoring Function," September 6, 2005. Toyota. https://global.toyota/en/detail/248128.
- "Toyota Enhances Pre-crash Safety System with Eye Monitor," January 22, 2008. Toyota. https://global.toyota/en/detail/281564

18. Toyota

Methods and systems

If driver is unable to operate vehicle, vehicle stops moving. The system measure uses heart rate using sensors. A researcher on the project says "Our goal is to help inform the development and adoption of in-vehicle cardiac monitoring systems, which we believe can help reduce the number of traffic accidents and save lives." The technology would interact

Image from Toyota press release (September 29, 2020)

with the driver. According to a researcher on the project, the goal is to "install cardiac sensors directly into vehicles so that the car itself would have the capacity to detect a heart anomaly. If detected, the vehicle could attempt to warn the driver or, if the driver was unresponsive, in conjunction with other technology under development, it could pull over, stop the car and summon help."

Other technologies that could be used in a vehicle to detect impaired drivers

Heart related changes can be indictive of impairment. The sensor might be able to pick up on other health problems and impaired driving.

Whether and how systems have been validated to date and user acceptance

As noted in 15, Lexus is rolling out similar technology and other companies are looking into technology that monitors a person's heart and a driver's physical state.

The Lexus models of Toyota seem to be incorporating this technology as an option on their vehicles.

More Information
- "Making Roads Safer by Detecting Driver Heart Anomalies," Toyota.
  https://pressroom.toyota.com/making-roads-safer-by-detecting-driver-heart-anomalies/
- "Toyota Driver Monitoring Sensors Could Detect Heart Trouble." DesignNews, October 28, 2020.
  https://www.designnews.com/automotive-engineering/toyota-driver-monitoring-sensors-could-detect-heart-trouble

19. Toyota

Methods and systems

The Patent is for technology that measures drivers' condition while driving and stops the vehicle. The patent says the technology "is described to detect a driver's consciousness lowering (a symptom of napping) by measuring a driver's heart rate, a time period without steering, a time period without blinking, etc. (through monitoring a driver's face with a camera) and to execute an automatic vehicle stop when the driver's consciousness lowering repeatedly occurs even if the driver is prompted to awake."

The patent says the technology can measure consciousness, heart rate, face, eyes, which could all show signs of substance impairment. The results of the driver monitoring system appear to be immediate. The system uses camera and other sensors.

Other technologies that could be used in a vehicle to detect impaired drivers
All of the technologies outlined in the Patent could help detect impaired driving.

Whether and how systems have been validated to date and user acceptance
This feature appears to be an option on Lexus vehicles and Toyota is researching this technology as of 2020. Toyota has researched it since at least 2011. There appears to be a market for technology that monitors heart rate as major auto companies are researching this technology (Toyota, Jaguar Land Rover, Hyundai).

More Information
- Patent (Filed in 2011 and currently assigned to Toyota) : US8954238B2
  https://patents.google.com/patent/US8954238B2

20.   Toyota
Methods and systems
The patent filed in Japan in 2016 and in the United States in 2017 says "The driver monitor camera is provided on a cover of a steering column of a vehicle and in front of the driver, and images a head of the driver. Since the driver monitor camera images the driver from plural directions, plural number of cameras may be provided. The driver monitor camera it transmits a driver image in which the driver is imaged to the ECU 20."

The technology also measures a driver's "readiness" stating "The driving readiness estimation unit 25 estimates a driving readiness relating to the driving consciousness of the driver." The technology can also measure the brainwaves and heart rate of the user.

The tests would be immediate through the camera. The technology also seems to work with autonomous vehicle technology.

Other technologies that could be used in a vehicle to detect impaired drivers
The technology that monitors the driver's state and consciousness could apply to impaired driving monitoring.

Whether and how systems have been validated to date and user acceptance
The driver state monitoring technology put forward in this Patent are similar to the Patent from Toyota in 2011 (US8954238B2) in the sense that it can determine a driver's state. Lexus is incorporating driver state monitoring.

The technology appears to put the vehicle in Autonomous driving mode if a driver is determined unfit to operate a vehicle.

More Information
- Patent (Filed in 2017 and assigned to National Institute of Advanced Industrial Science and Technology AIST Toyota Motor Corp): US10640122B2
  https://patents.google.com/patent/US10640122B2

21. Seat

Methods and systems

Seat, owned by Volkswagen, is working with Cipia (formerly EyeSight) in deploying driver monitoring in vehicles.

The Cipia system uses artificial intelligence and driver monitoring for a person's head and eye movement. The Seat website says, The website says "Eye 23penness, angle

Image from Seat video "This is How we explore the future" (YouTube)

of vision, head position… An algorithm analyses the actions of the driver and warns them in the event of distraction or drowsiness. It also detects mobile phone use and whether the seatbelt is fastened."

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech measures body and eye and movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance
Cipia is paired up with many Tier 1 suppliers and other companies and this technology is moving along quickly. It is unclear how the technology will be implemented in vehicles.

More Information
- "This is how you explore the future." Seat. https://www.seat-mediacenter.com/storiespage/newstories/Connectivity/This-is-how-you-explore-the-future.html
- YouTube video from Seat. https://youtu.be/_-pXiI4LeGk

22. Volkswagen

Methods and systems
The Patent filed by Volkswagen in 2018 in Germany appears to be part of a larger driver monitoring system as this Patent is for computer software relating to driver attention

monitoring. The computer software program that can work with other sensors to determine a driver's attention.

Other technologies that could be used in a vehicle to detect impaired drivers
This could work with all other technology and is specific to driver monitoring such as optical, heart, seat, or other sensors.

Whether and how systems have been validated to date and user acceptance
As this is a patent, it has not been validated. However, software is being developed and been deployed to aid driver monitoring systems (Cameras, etic) to determine a driver's attention level.

More Information
- Patent filed in 2018 in Germany and assigned to Volkswagen: DE DE102018216511A1
  https://patents.google.com/patent/DE102018216511A1/en

23.   Volkswagen

Methods and systems
The patent filed in 2019 in Germany for this driver monitoring systems says "According to one variant, the selection is made as a function of the driver's status and the driver's status is determined using at least one of the following variables:
- a tiredness size; - a pupil size; - an eye movement quantity; - a pitch; - a pulse size"

The patent says: "driver state determining device determines 24 a current level of awareness and / or drowsiness of the driver. For this purpose, it determines at least some of the parameters explained above using suitable sensor devices (for example a camera device, a microphone device and, for example, the microphone device 18th of the driver information system 10 or a biometric sensor). The driver condition determining device 24 then sends a determined driver status to the driver information system 10 out. If this reaches a predetermined critical reference state, the driver information system chooses 10 select the voice input mode as the active input mode from the available input modes."

The patent seems that it would give the results of the driver's state immediately. It appears the tech would use a camera, microphone and other sensors to determine a person's pulse.

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech appears to measure multiple driver characteristics and perhaps upon entry into the vehicle, it could also be programmed to determine if a person is substance-impaired. It also appears this technology could be used in the Autonomous vehicle space to determine if a driver is unfit to operate the vehicle that the vehicle would drive itself with no driver interaction.

Whether and how systems have been validated to date and user acceptance
This patent is extensive, but it has not been rolled out by Volkswagen. Additionally, the patent was translated from German to English on Google, which may have resulted in some missed translations. However, the driver monitoring tech described in the patent is currently in development but multiple other companies.

The technology could be adapted to determine substance impaired driving or in the Autonomous vehicle space.

- Patent filed in 2019 in Germany: DE102019206307A1
  https://patents.google.com/patent/DE102019206307A1/en

24.   Honda

Methods and systems

The driver monitoring Patent from Honda is for technology that can measure body and face to determine impairment. The Patent says "additionally, the optical sensors 202 can noninvasively monitor a condition of the driver 118 through the determination of biological signals, such as body-trunk plethysmograph and respiration that are detected from the driver's back from one or more optical sensors 202 included within sensor assemblies 120 disposed at the seat back 134 of the vehicle seat 122. In particular, one or more filtered signals can be evaluated to determine the driver's PPG signals that fall between normal and intoxicated states in order to determine driver intoxication."

Drawings from Patent US10153796B2 (Honda)

The results seems immediate under this patent. The technology appears to use: seat sensors, Skin sensors, and optical sensors.

Other technologies that could be used in a vehicle to detect impaired drivers

As this measure a person via seat sensors, touch sensors, optical sensors, it could be adapted to determine substance-impairment.

FIG. 2A

Whether and how systems have been validated to date and user acceptance

No, but similar auto companies and other auto supplies are developing similar technology.

More Information

- Patent filed in 2015 in the United States: US10153796B2.
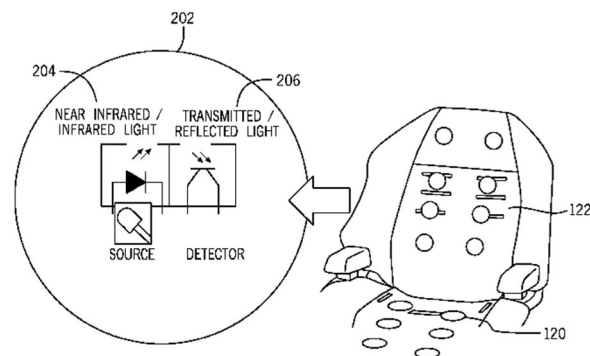 https://patents.google.com/patent/US10153796B2

25.   Honda

Methods and systems

The Honda Patent for is for technology that monitors: heart, eyes, face, brain waves and entire driver body state. The Patent states "In particular, the level of drowsiness may be detected by sensing different degrees of driver behavior. For example, as discussed below, drowsiness in a driver may be detected by sensing eyelid movement and/or head movement. In some cases, the degree of eyelid movement (the degree to which the eyes are open or closed) or the degree of head movement (how tilted the head is) could be used to determine the body state index. In other cases, the autonomic monitoring systems could be used to determine the body state index. In still other cases, the vehicle systems could be used to determine the body state index. For example, the degree of unusual steering behavior or the degree of lane departures may indicate a certain body state index."

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures the body, it could be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

No. Portions of this driver monitoring system described in this patent have been advertised or are development by other OEM, Tier 1 and Tier 2 suppliers.

FIG. 11

Drawings from Patent US20180072310A1 (Honda)

FIG. 33   **FIG. 34**

FIG. 35

in

More Information

- Patent filed in 2018 in the United States: US20180072310A1. https://patents.google.com/patent/US20180072310A1

26.   Honda

Methods and systems

The technology filed in this Patent monitors for cardiac changes and other body changes by using sensors in the headrest, steering wheel and a camera. According to the patent, the driver
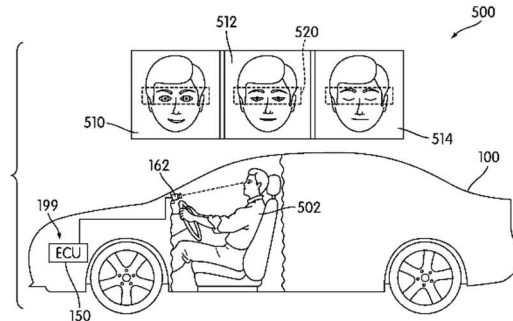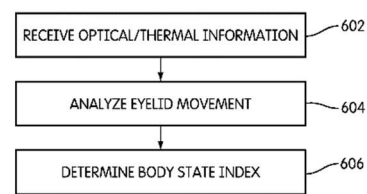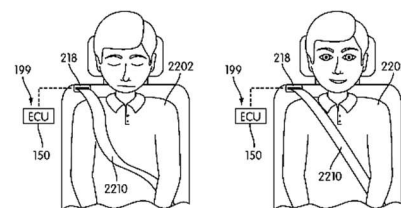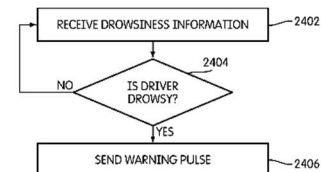
monitoring could include " The monitoring system 212 can be the same or similar to the monitoring system 110. For example, the monitoring system 212 can include and/or communicate with various sensors. Specifically, in FIG. 2, the sensors include a first sensor 216 in a headrest 214, a second sensor 218 in a seat 220 and a camera 222. A steering wheel 224 may also include sensors (not shown) for identifying body state changes"

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech monitoring body for changes, it could also be programmed to determine substance impairment

Whether and how systems have been validated to date and user acceptance
This system has not been validated, but this OEM has other patents that incorporate aspects of this technology into their product. Additionally, other OEM and Tier 1 and Tier 2 suppliers have developed similar technology. Explaining how this technology would work is the biggest barrier.

More Information
- Patent filed in 2016 in the United States: US10238304B2.
  https://patents.google.com/patent/US10238304B2

27. Honda
Methods and systems
The Patent filed is for this driver monitoring system relating to sleep states of driver and occupants. The Patent says:

> The method includes determining a target sleep state of the vehicle occupant based on at least one of the state of the vehicle occupant, the physiological data and vehicle system data and controlling a vehicle system of the vehicle based on the state of the vehicle occupant in relation to the target sleep state. The method includes monitoring the state of the vehicle occupant including monitoring the physiological data of the vehicle occupant in response to controlling the vehicle system and controlling the vehicle system according to the monitoring in relation to the target sleep state.

> The monitoring system 202 of FIG. 2 can sense and determine physiological data of one or more vehicle occupants. For example, the monitoring system 202 can include one or more bio-monitoring sensors, heart rate sensors, blood pressure sensors, oxygen content sensors, respiratory sensors, perspiration sensors, imaging sensors to sense eye movement, pupil dilation, gestures, as well as any other kinds of sensors for monitoring one or more vehicle occupants (e.g., vehicle sensors 124). It is understood that said sensors of the monitoring system 202 could be disposed in any location of a vehicle (e.g., the vehicle 300, FIG. 3). For example, sensors could be disposed in a steering wheel, seat, armrest or other component to detect physiological data associated with the one or more vehicle occupants.

Other technologies that could be used in a vehicle to detect impaired drivers
Depending on how this technology is deployed, it could be programed to monitoring for substance impairment.

Whether and how systems have been validated to date and user acceptance
This system has not been validated to date. It does show an overall patten of how Honda is developing driving monitoring systems to determine a driver's state.   As this Patent seems more in-line with the OEM researching a driver's state, it seems this tech would not be acceptable. However, it shows the OEM is looking into driver monitoring especially when

looking at other patents filed by this OEM which are more specific to passively monitoring a driver's state.

More Information
- Patent filed in 2014 in the United States: US9463805B2.
https://patents.google.com/patent/US9463805B2

Tier one auto suppliers who developed or deployed this technology.

This also includes large tier two companies that have put resources together to develop technology. There are at least 40 technologies that being put together by Tier 1 auto suppliers.

28.   Cipia (formerly EyeSight)

Methods and systems
This DMS measures eye and head movement using a camera to determine distraction and drowsiness. The results of the tests are immediate.

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech measures body and eye and movement, it could also be programmed to determine substance impairment.
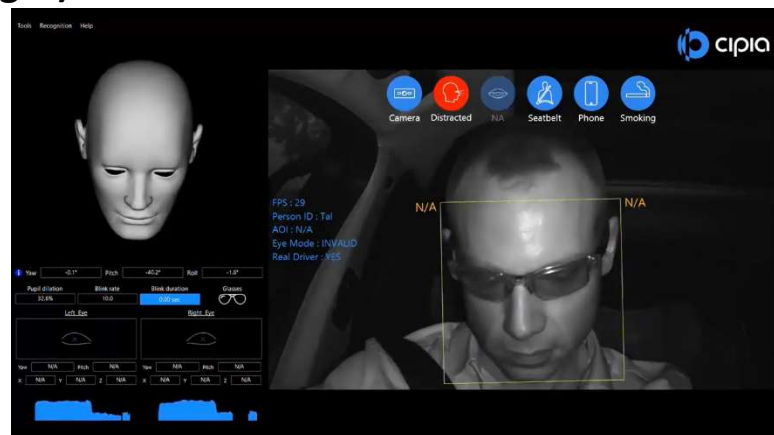
Images of Cipia driver monitoring system by (YouTube)

Whether and how systems have been validated to date and user acceptance
Cipia has multiple partners of Tier 1 suppliers and an OEM (Seat). The technology is available to be part in new vehicles, aftermarket for fleets.

More Information
- Cipia: https://cipia.com/
- For information on the technology, visit: https://cipia.com/driver-sense/
- Video: https://youtu.be/Qp5mAKQ7KtQ

29.   Grupo Antolin

Methods and systems

Grupo Antolin, a Tier 1 automotive supplier, is a partner with Cipia (formal EyeSight)in cabin integration of driving monitoring. Their website says:

> Grupo Antolin's technological knowhow, the ability to integrate 3rd party solutions into its components and development of their control electronics, will be paired with Eyesight Technologies' advanced in-cabin sensing solutions to deliver smart-integrated systems with great added value. The collaboration will provide car manufacturers with in-cabin solutions tailored to the needs of future electric, connected, and semi-autonomous to fully autonomous vehicles, leveraging the technological capabilities of driver and occupancy/interior monitoring.

This is part of Cipia and integrates with the camera system.

Other technologies that could be used in a vehicle to detect impaired drivers

As this Cipia technology monitors head and eye and movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

Grupo Antolin is one of multiple partners with Cipia in integrating driving monitoring technology. Grupo Antolin has a far reach as it is a Tier 1 automotive supplier.

More Information

- Grupo Antolin: http://www.grupoantolin.com/en/grupo-antolin-and-eyesight-technologies-team-provide-intelligent-cabin-monitoring-solutions

30.   Joyson Safety

Methods and systems

Joyson Safety, a Tier 1 automotive supplier, is a partner with Cipia. Joyson Safety helps with the camera hardware for the Cipia system. The camera looks at a person's eye and analyzes a person head movement and detects drowsy or distracted driving.

Images of Joyson Safety driver monitoring system (Joyson Safety)

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures body and eye and movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

Joyson Safety is a Tier 1 automotive

supplier. This technology is part of the Cipia driver monitoring system or it could be a separate type of technology.

More Information
- Joyson Safety: https://www.joysonsafety.com/en/technology/integrated-safety-solutions/vision-radar-systems/
- Video: https://www.joysonsafety.com/media/jss_v_r_dms.mp4

31. Ambarella

Methods and systems

Driver Monitoring system integration and partner with Cipia. Ambarella integrates driving monitoring systems. Ambarella's website says "Ambarella's automotive solutions are designed for both human and computer vision, combining high-resolution imaging and neural network processing into a single, low-power embedded platform. We specialize in edge devices with low latency, high efficiency and exceptional performance, including front ADAS cameras, smart electronic mirrors, drive recorders, fleet management solutions, DMS/OMS, and more."

More Information
- Ambarella: https://www.ambarella.com/applications/automotive/
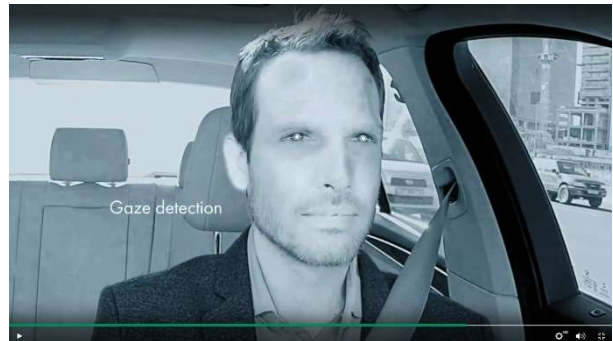
32. Jabil

Methods and systems

Camera platform to support driving monitoring system software, partner with Cipia. The company website says:

> Camera-based Driver Monitoring Systems (DMS) are an integral element of next-generation ADAS solutions. DMS are increasingly being used by the automotive & transportation industries to reduce distraction and drowsiness related crashes. And they must be present in all vehicles capable of SAE levels 3-4 autonomous driving – to ensure the driver is awake and alert and capable of taking back control of the vehicle after "hands-off and feet off' modes."
>
> Jabil offers a Camera Platform optimized to support Driver Monitoring System software. Jabil's expertise in optics industrialization and manufacturing has delivered a highly accurate and dependable DMS camera. The Camera Platform is application ready and can be tailored to customers' requirements. Evaluation hardware systems are available now for lab and vehicle test and development.

Images of Jabil driver monitoring system (Jabil)

More Information

- Jabil: https://www.jabil.com/industries/automotive-electronics-components/advanced-driver-assistance-monitoring-systems.html
- There is a video demonstration on the upper right corner of the company's website of its driver monitoring system: https://www.jabil.com/industries/automotive-electronics-components/advanced-driver-assistance-monitoring-systems.html
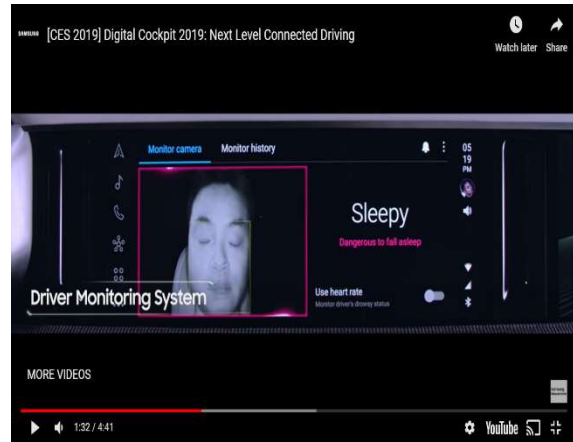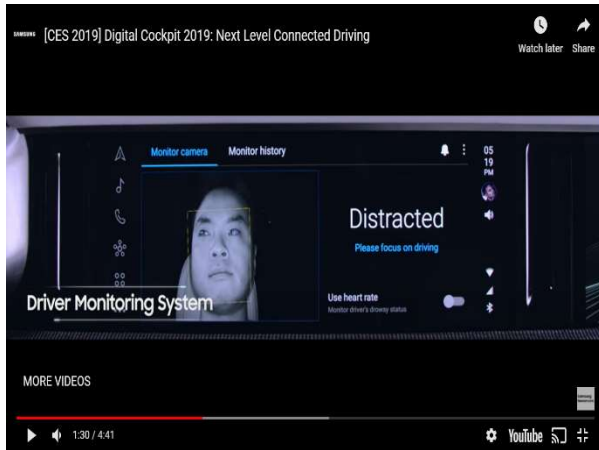
33. Samsung

Methods and systems

Samsung is listed a partner with Cipia. It appears to be developing facial and body monitoring technology including that of measuring a person's heart-rate. It is unclear if that technology is also part of Cipia.

On their website, it says "The Driver Monitoring System will also transmit a warning sound if it detects dangerous behavior, such as driving while drowsy or sending text messages behind the wheel."

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures body and eye and movement, it could also be programmed to determine substance impairment.

**Images of Samsung driver monitoring system**
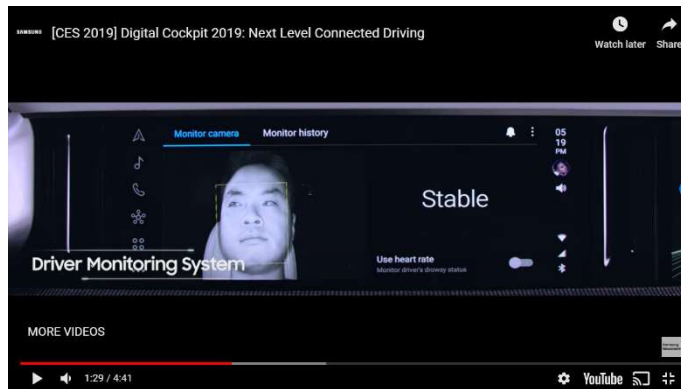
More Information
- Samsung: https://news.samsung.com/global/video-digital-cockpit-2019-next-level-connected-driving
- Video: https://youtu.be/nAa6_IaobAI

34. Sony

Methods and systems

Listed a partner with Cipia. The technology listed on Sony's website may be entirely different to Cipia's technology. On Sony's website it says "Inside the cabin, sensors will monitor the condition of drivers and passengers. The facial

Sony driver monitoring system (Sony)

expression and body movement of drivers will be used to gauge their concentration and fatigue levels, sending out alerts as necessary."
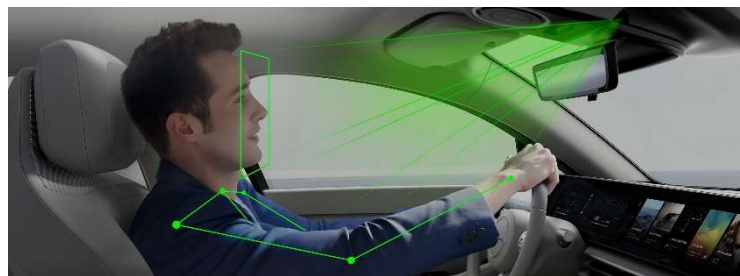
Other technologies that could be used in a vehicle to detect impaired drivers

The technology appears to use cameras and other sensors to monitor a driver. These sensors could be programmed to determine substance impairment of a driver.

Whether and how systems have been validated to date and user acceptance

The Cipia platform has a range of partners. The technology outlined by Sony may be part of the Cipia system or may be something different.

More Information
- Sony: https://www.sony.net/SonyInfo/vision-s/safety.html. The portion on driver monitoring is at the bottom.
- Possible Patent filed in 2016 by Sony: US10768617B2. https://patents.google.com/patent/US10768617B2/en?oq=10471969

35.   Adient

Methods and systems

Adient is a seat based monitor that can measure heart rates and breathing. According to the website in 2017 "Additionally, integrated health monitoring features can measure breathing and heart rate, providing valuable feedback to enable smart management of passenger health while sitting comfortably on the seat."

Whether and how systems have been validated to date and user acceptance

This technology is not widespread in the driver monitoring system space compared to eye and face based monitoring. Seat based systems are under development by other OEM's and automotive suppliers.

More Information
- Adient: https://www.adient.com/media/press-releases/2017/09/12/adient-ai18-demonstrator-shows-future-of-automotive-seating

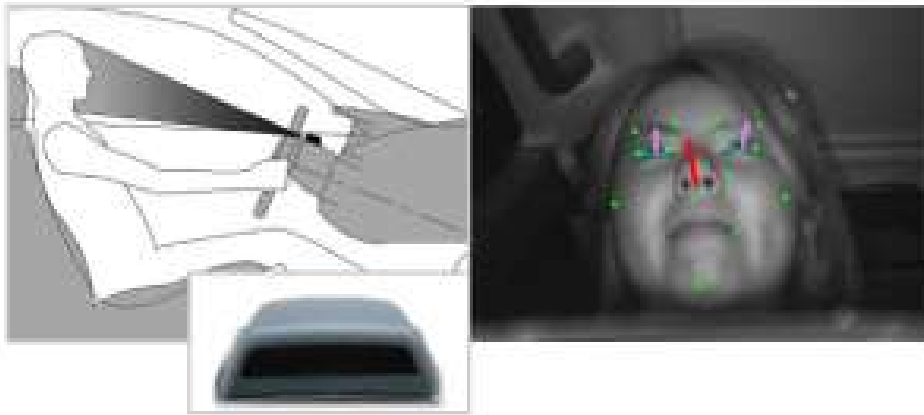# 36.   Aisin Seiki Co.

Methods and systems

The system is a face based driver monitoring system. According to their website "The camera captures the driver's face and detects the driver's face orientation and eye open / closed state. It is used in a system to prevent accidents caused by looking aside or falling asleep."

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures face movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

Aisin Seiki is a Tier 1 auto supplier and it is unclear if this technology is developed already or in development. According to their website, they say "We provide system products that highly control "running," "turning," and "stopping" in order to achieve zero traffic accidents. We are also developing products that enhance the enjoyment of driving and comfort such as riding comfort."

Aisen driver monitoring system (Aisen)

More Information
- Aisin Seiki: https://www.aisin.co.jp/product/automotive/brake_chassis/#productTtl.

37. Aptiv

Methods and systems
The Aptiv Driver State Sensing system monitor the cognitive state of driver by measuring body positioning, gestures, and eye movement.

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech measures body and face movement, it could also be programmed to determine substance impairment.

Images Aptiv driver monitoring system. The warning for inattentive drive is near the windshield. Green for paying attention and red for inattentive driving. (Vimeo)

Whether and how systems have been validated to date and user acceptance
The system is shown in a video on a vehicle. It is unclear if this system is deployed and widely available for consumer use.

More Information
- "Safety and Convenience Innovations Powered by Interior Sensing," Aptiv. January 21, 2020. https://www.aptiv.com/insights/article/safety-and-convenience-innovations-powered-by-interior-sensing.
- Aptiv Video demonstration of the DMS system: https://vimeo.com/385547091.
- "Aptiv 2019 Investor Conference presentation" https://s22.q4cdn.com/336558720/files/doc_presentations/2019/07/Aptiv-2019-Investor-Conference.pdf

38. Autoliv

Methods and systems
Eye and head-based monitoring system that uses a camera. The company website notes their tech:

> Autoliv's state-of-the-art driver monitoring system (DMS) can detect distracted and drowsy drivers by accurately measuring eye and head position, driver attention and fatigue. The DMS will invoke action when a dangerous situation is detected or imminent. A reliable analysis of the driver's state will also enable Autoliv to develop technologies that are critical for supporting highly autonomous driving functions, with safe hands-off-wheel operation. Autoliv's DMS understands driver behavior, allowing tomorrow's vehicles to make better decisions to improve comfort and safety.

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech measures face and head movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance
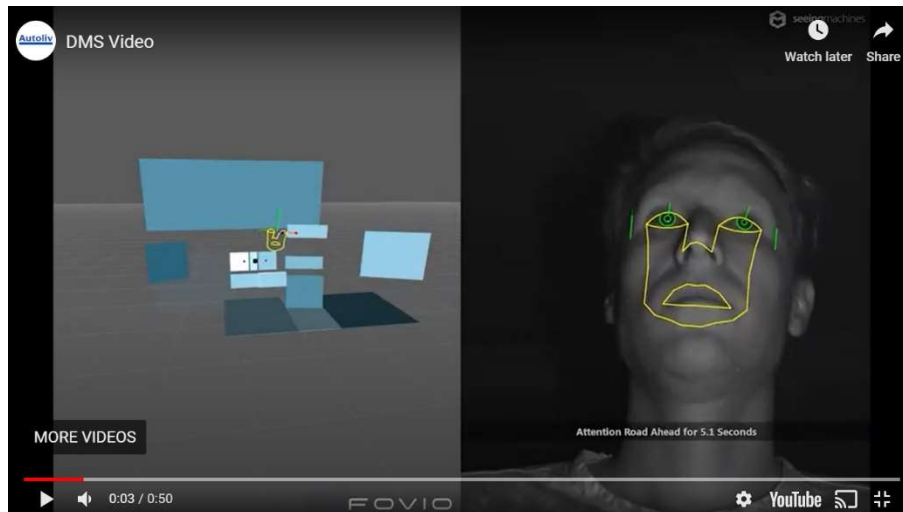It is unclear if the system has been validated, but it is similar to many other DMS on the market.

Image of Autoliv driver monitoring (YouTube)

More Information
- Autoliv: https://www.autoliv.com/index.php/products/electronics/driver-monitoring-systems
- Video: https://www.youtube.com/watch?v=GB-x01_LL3s&feature=youtu.be

39.   Bosch

Methods and systems

The system is a camera based monitor for face movement and other movement of occupants in the vehicle. It can also be used in conjunction with autonomous vehicle driving as according to Bosch it can determine if the "driver is capable of taking back control of the vehicle in a critical situation."

Bosch Driver Monitoring system (Bosch)

The Bosch website says "Based on a driver's eyelid movements, the interior monitoring system detects if the person is drowsy or distracted by his or her smartphone and triggers an alert if this is the case."

The system also "The driver monitoring camera monitors the alertness and condition of the driver. It can detect distraction, drowsiness, and microsleeps and can alert the driver in time."

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures face and head movement, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance
It is unclear where this technology is currently deployed, but it seems that Bosch is developing this technology in conjunction with Autonomous vehicle technology.

More Information
- Bosch interior monitoring systems: https://www.bosch-mobility-solutions.com/en/products-and-services/passenger-cars-and-light-commercial-vehicles/interior-and-body-systems/interior-monitoring-systems/
- Bosch Artificial intelligence in everyday life: https://www.bosch.com/stories/ces-2020-artificial-intelligence-in-everyday-life/
- "Bosch develops new Interior Monitoring System," New Mobility. December 16, 2019. https ://newmobility.global/future-transportation/bosch-develops-new-interior-monitoring-system/

40.   Continental

Methods and systems
Face based camera monitoring system that also incorporates Artificial Intelligence. According to Continental, "The Interior Camera can even help with the wellbeing of the driver. Health states and emotions can be recognized and used as input parameters for artificial intelligence solutions like virtual assistants."

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech measures the wellbeing of the driver, it could also be programmed to determine substance impairment.

More Information
- Continental: Face based driver monitoring: https://www.continental-automotive.com/en-gl/Passenger-Cars/Information-Management/ICAM-Campaign.

41.   Continental

Methods and systems
This 2018 Patent describes a driver monitoring system that may include camera system to capture if a driver is attentive or fatigued. It may also include measuring the heart rate of the driver. The patent describes how it would capture if a driver is paying attention in the following:

> The degree of attention can be detected, for example, by means of an optical detection system, for example using an interior camera. This can capture the current line of sight. The frequency at which the driver turns his eyes away from the road can be determined from the detection of the current line of sight. The driver's current level of attention can be determined from this frequency. Further methods according to the prior art for determining the driver's level of attention can also be used, such as, for example, the detection and evaluation of driver's

biometric parameters, as will be explained in more detail below, the first parameter / the driver's level of attention being directly or indirectly the driver's level of fatigue can be derived from the second parameter.

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech measures face and head movement, it could also be programmed to determine substance impairment.

More Information
- Patent filed in 2018 in Germany: DE102018210367A1.
  https://patents.google.com/patent/DE102018210367A1/en.

42.   Delphi/Borgwarner

Methods and systems
The system tracks eye movement for distraction. According to the description of the 2016 YouTube video by Delphi the system "an enabler for automated driving, intelligently monitors the driver's fatigue and distraction level and then reacts. The driver can be warned via seat and steering wheel vibrations or the system can offset driver workload or take specific action to help ensure safety."

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech measures face and head movement, it could also be programmed to determine substance impairment.

More Information
- Delphi Auto YouTube video of technology:
  https://www.youtube.com/watch?v=p2z8AFFSITk.

43.   DENSO

Methods and systems
The face-based monitoring DENSO's Driver Status Monitor "uses a camera to capture an image of the driver's face and establishes the driver's condition based on visual analysis. It detects carelessness, distraction and drowsiness, and then alerts the driver of any potential danger."

Concept of DENSO Driver Monitoring system (DENSO)

Other technologies that could be used in a vehicle to detect impaired drivers
As this tech measures face and head movement, it could also be programmed to determine substance impairment.

More Information

- DENSO Driver Status Monitor: https://www.denso.com/global/en/business/products-and-services/mobility/pick-up/dsm/

44. DENSO

Methods and systems

The Patent filed by DENSO in Japan originally in 2007 is a: face, steering wheel, body sensor and voice based monitoring system technology.

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures a driver's movement and body condition, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

It is unclear if Bosch has incorporated portions of this Patent into the technology described in 43. However, the original Patent dates back to 2007 in Japan, so it is unclear if the systems have been validated.

Sketch of Patent US7821382B2.

More Information

- Patent filed in 2008 in the United States: US7821382B2: https://patents.google.com/patent/US7821382B2.

45. DENSO

Methods and systems

This Patent filed originally in 2014 is for technology that monitors the driver for inattentive driving using camera and other sensors in the vehicle.

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures a driver's movement and body condition, it could also be programmed to determine substance impairment.

More Information

- Patent filed in 2015 in the United States: US9855956B2.
  https://patents.google.com/patent/US9855956B2.

46. DENSO

Methods and systems

The Patent filed originally in 2014 looks at sensors including face images and also for brainwaves and relates to when to transfer control of a vehicle between a driver and in self-driving autonomous vehicle mode.

Other technologies that could be used in a vehicle to detect impaired drivers

The monitoring of brainwaves might be able to detect other cognitive impairment signs.

More Information

- Patent filed in 2015 in the United States: US10398368B2.
  https://patents.google.com/patent/US10398368B2.

47. DENSO

Methods and systems

The Patent filed originally in 2017 for a face and eye based monitoring system to determine drowsy driving.

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures face and head movement, it could also be programmed to determine substance impairment.

More Information

- Patent filed in 2020 in the United States: US20200286358A1.
  https://patents.google.com/patent/US20200286358A1

48. Faurecia Clarion

Methods and systems

Provides software and hardware components for Driver Monitoring Systems. Faurecia Clarion says:

> Our solutions are built on a scalable architecture that can integrate a range of different onboard cameras (near infrared, thermal), radars or biometric sensors that address multiple use cases. This allows automakers to maximize their technology investment through solutions that meet evolving safety requirements as well as providing data to enhance users' onboard comfort."

> We support automakers from full camera and sensor systems to standalone software managing multiple situations: multi-person detection, driver identification, distraction and drowsiness monitoring, gesture analysis, emotional assessment and health monitoring.

Whether and how systems have been validated to date and user acceptance

The company notes they "support automakers" with their technology which seems to paint a picture that their technology is currently being deployed.

Driver Monitoring system (Faurecia Clarion)

More Information
- Faurecia Clarion: https://www.faurecia-clarion.com/technology/immersive-experiences.

49. Gentex

Methods and systems

Monitors a driver's eye for security reasons. As this technology monitors the iris, it could have other driver monitoring functions.

Other technologies that could be used in a vehicle to detect impaired drivers

As this tech measures eyes, it could also be programmed to determine substance impairment.

Whether and how systems have been validated to date and user acceptance

It is unclear if this biometric system only monitors once a driver enters a vehicle and immediately stops or if it is constant monitoring of the driver.

More Information
- Gentex Press release from January 2, 2018: https://ir.gentex.com/news-releases/news-release-details/gentex-demonstrate-new-connected-car-biometrics-and-digital-rear.

50. Hitachi

Methods and systems

The 2017 presentation from Hitachi shows a system that monitors the: face, eyes, breathing and heart.

More Information

- "Driving with AI:The Future of Mobility and Transportation," Harsha Badarinaraya. Hitachi. 2017. https://www.hitachivantara.com/en-us/pdfd/presentation/future-of-mobility-and-transportation.pdf.

51. Hyundai Mobis

Methods and systems

The Patent for this technology originally filed in 2014 is for driver state monitoring. The patent summary states "method for detecting a driver status, which grasp a driver's mental and physical condition to determine whether or not a driver drives a vehicle with safety and induce the driver to drive the vehicle with safety in various ways when the driver is determined not to be in a safe driving state so as to protect the driver."

FIG.2

CAMERA
CLUTCH PEDAL SENSOR
MICROPHONE
MULTIFUNCTIONAL SWITCH SENSOR
AVN SENSOR
STEERING WHEEL SENSOR
BRAKE PEDAL SENSOR
ACCELERATOR PEDAL SENSOR
TRANSMISSION SENSOR
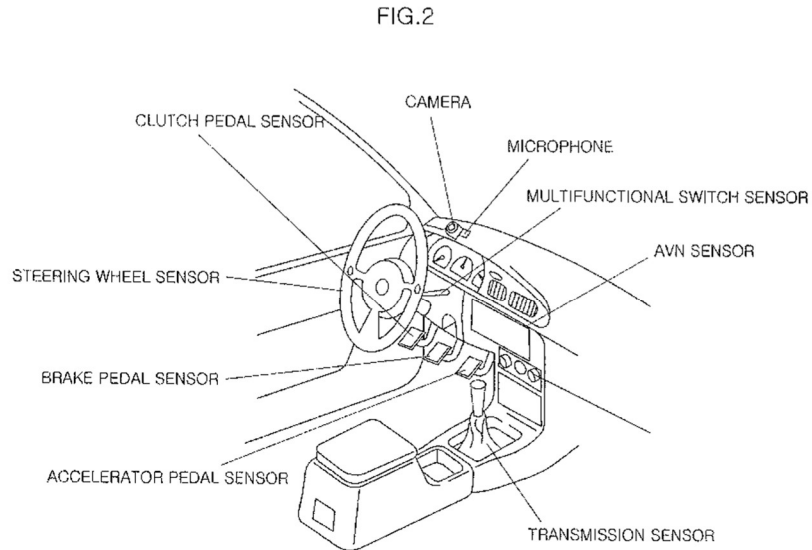
Sketch from Patent US9682711B2

The patent says ""The driver status information acquisition portion may include one or more of a microphone, a driver observation camera, an ECG (electrocardiogram) sensor, an EEG (electroencephalogram) sensor, and a PPG (photoplethysmography) sensor, in order to acquire information according to a driver status during driving of a vehicle.

Each of the EEG sensor, the ECG sensor, and the PPG sensor may be a wearable sensor."

Other technologies that could be used in a vehicle to detect impaired drivers
The camera and microphone could be used to detect substance impairment.

Whether and how systems have been validated to date and user acceptance
The Patent was originally filed in 2014. It is unclear if portions of this technology have been adapted to current products in development.

More Information
- Patent filed in 2015 in the United States: US9682711B2. https://patents.google.com/patent/US9682711B2.

52. Hyundai Mobis

Methods and systems

This Patent filed in 2017 is for driver state monitoring, vehicle control, and autonomous vehicle technology. It monitors movement of the body, including the face and eyes. If a person is determined unable to operate the vehicle, the tech appears to allow for the vehicle to take over and include autonomous vehicle technology. The patent states:

> The driver monitoring unit 110 may monitor the physical features, physical characteristics, posture and control intention of a driver. The driver monitoring unit 110 may include various sensors and devices for performing the above-described function. For example, the driver monitoring unit 110 may include a camera or radar for monitoring the physical features, physical characteristics and posture of the driver, and a steering wheel angle sensor, acceleration pedal sensor and brake pedal sensor for monitoring the vehicle control intention of the driver. [0086]

The test results seem immediate. The only limitations is how if the technology also would rely to external sensors not built into the vehicle.

FIG. 16
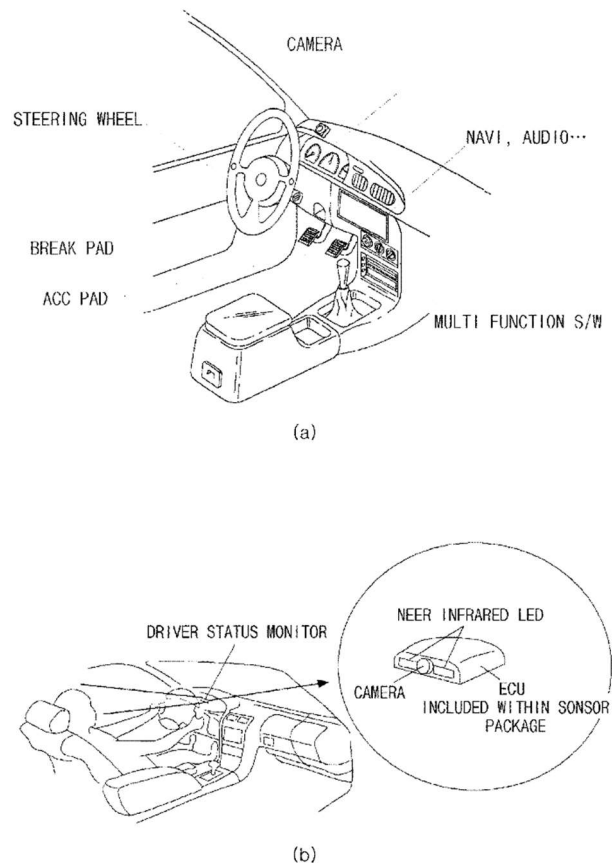
Sketch from Patent US20200098265A1

Other technologies that could be used in a vehicle to detect impaired drivers

The camera and other technology to determine the operator condition, may be used to determined substance impaired driving.

Whether and how systems have been validated to date and user acceptance

The Patent is very exhaustive and expansive. It is unclear if this technology has been incorporated into the Hyundai Mobis technology called "DDREM(Departed Driver Rescue and Exit Maneuver)" system. Additionally, as this technology involved Autonomous Vehicle technology, AV technology has received billions of dollars of investment and is the process of being tested.

More Information

- Patent filed in 2017 in the United States: US20200098265A1.
  https://patents.google.com/patent/US20200098265A1.

53. Infineon Technologies

Methods and systems

A "3D" camera based monitoring system of the driver that interacts with advanced driver assistant systems and autonomous vehicle technology.

Infineon says "Today's advanced driver assistant systems (ADAS) and, perhaps in the future, autonomous cars require precise information about the driver's focal point and what's happening inside the vehicle. This is where 3D camera-based, in-cabin sensing applications come in. They recognize driver behavior and deliver this information to the ADAS system so it can react accordingly."

More Information
- Infineon In-Cabin Sensing: https://www.infineon.com/cms/en/applications/automotive/chassis-safety-and-adas/in-cabin-sensing/
- Infineon TOF 3D Image Sensors : https ://www.infineon.com/cms/en/product/sensor/tof-3d-image-sensors/ ?redirId=121614

54. Lear

Methods and systems

Seat monitoring system that can determine a heart rate or a driver's breathing. Lear says "Our non-intrusive sensor technology utilizes biometrics to detect stress, drowsiness and heart rate variability, and could activate seat treatments including heat and massage function, as well as transmit critical data via secure wireless communication to a health care professional or family member."

More Information
- Lear Bio Bridge: https://www.lear.com/Site/Technology/Biobridge.aspx
- Lear Video: https://www.lear.com/Site/Technology/Intu.aspx

55. Leopold Kostal

Methods and systems

A 2017 presentation details possible Leopold Kostal Driver Monitoring system that is camera and voice based. The camera measures the face and eye movement of the driver.

Kostal's website describes the company's 7th generation driver assistance technology as "It also includes the driver-monitoring camera. This camera operates in the interior of the vehicle and checks the driver's head and eyelid positions, thus detecting his or her attention level. In future, where piloted steering is installed, this will allow the driver to take his hands from the steering wheel."

More Information
- "Driver Monitoring: A Deep Learning Approach for Gaze Estimation" GPU Technology Conference 2017. https://on-demand.gputechconf.com/gtc/2017/presentation/s7624-cornelius-wefelscheid-driver-monitoring-a-deep-learning-approach-for-gaze.pdf
- Kostal: https://www.kostal-automobil-elektrik.com/en-gb/produkte/mechatronik-module/fahrerassistenz

56.   Magna

Methods and systems
Monitors driver's gaze and level of alertness. Magna says "The technology can not only tell when a driver is not paying attention, but makes allowances for normal actions, such as looking in the side-view mirrors."

More Information
- Magna Takes Aim at Distracted Driving: https://www.magna.com/innovation/driven-people-driving-change/article/magna-technology-takes-aim-at-distracted-driving.

57.   Magna Electronics

Methods and systems
The patent filed in 2020 looks for driver drowsiness or distraction by looking specifically at the driver's breathing.

Other technologies that could be used in a vehicle to detect impaired drivers
If the technology monitors for breathing, it is unclear if it can also be programmed to detect alcohol-impairment.

Whether and how systems have been validated to date and user acceptance
The Patent discusses wearable sensors as well, which would make this technology unacceptable to the general public.

More Information
- Patent filed in 2020 in the United States: US20200283001A1.
  https://patents.google.com/patent/US20200283001A1/en?oq=+20200283001

58.   Mitsubishi Electric

Methods and systems
Camera and other system to monitor the face and body of the driver. Mitsubishi Electric says the technology:
1) Monitoring both driver and front passenger for enhanced safety and convenience.
    -Monitor both the driver and the front passenger to provide automated assistance, such as adjusting the air conditioning or audio entertainment system.
    -Recognition of hand gestures of both the driver and the front passenger to control various in-vehicle devices.
    -To-be-developed detection of not only heads but also upper bodies to detect potentially dangerous behavior, such as abnormal postures including slumping over or collapsing backwards.

Whether and how systems have been validated to date and user acceptance
The company says portions of this technology would be ready by 2018.

Driver Monitoring System (Mitsubishi Electric)

More Information

- "Mitsubishi Electric Develops Driver Monitoring System with Wide-angle Camera," October 5, 2017. https://www.mitsubishielectric.com/news/2017/1005.html.
- "Mitsubishi Electric Unveils EMIRAI S concept car fitted with novel HMI / biotech sensors," October 10, 2019. https://optics.org/press/4475.
- "How DMS is Creating the Future of Mobility — Giving Drivers a Taste of 'Omotenashi,'" January 10, 2020. https://www.mitsubishielectric.com/en/our-stories/article/xx_ww_f_in2001_02.html?fbclid=IwAR1cS4iqxCN_SYB6kYTOdhMSeAHdgVgXw6ImDfP6u_ZABwnYnERKurUWcpY
- Video: https://www.facebook.com/watch/?v=853865211709762

59. Sumitomo Riko

Methods and systems

The "Smart Rubber" sensor is seat monitoring of: heart rate, drowsiness and breathing.
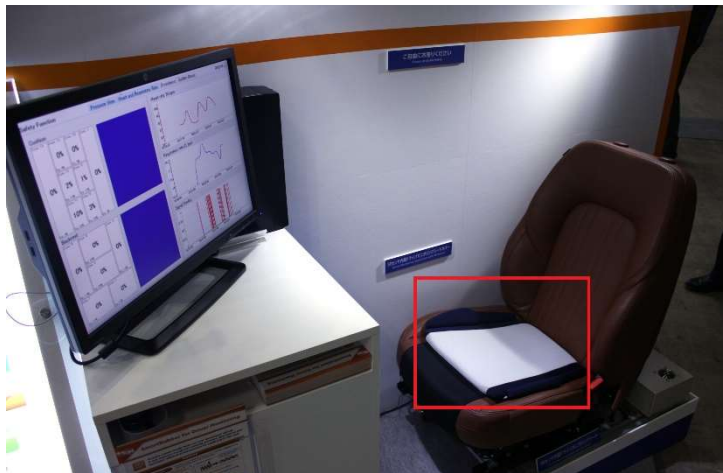
Cushion with built in SR Sensor (Sumitomo Riko)

More Information

- Sumitomo Riko DMS Presentation from 2018: https://www.sumitomoriko.co.jp/wordpress/wp-content/uploads/sites/4/2018/05/sumitomoriko_DMS_E.pdf.

- Press release: https://www.sumitomoriko.co.jp/english/sumitomo-riko-exhibiting-at-automotive-engineering-exposition-2019-yokohama-2/

60. Toyoda Gosei

Methods and systems

Steering wheel camera based monitoring. A 2018 press release from the company said "A camera in the steering wheel monitors the driver's face and alerts the driver when inattention or drowsiness are detected"

Whether and how systems have been validated to date and user acceptance

Toyoda Gosei notes the technology could be put on commercial vehicles "These steering wheels can be retrofitted and are expected to contribute to the prevention of accidents involving trucks*, which are more likely to cause severe damage."

More Information
- "Toyoda Gosei Accelerates Development of Steering Wheels with HMI Functions," November 28, 2018. https://www.toyoda-gosei.com/news/detail/?id=199.
- "Toyoda Gosei to Launch Truck Steering Wheels that Warn Drivers of Inattention or Drowsiness," January 30, 2018. https://www.toyoda-gosei.com/news/detail/?id=174

61. Toyota Boshoku

Methods and systems

The concept by Toyota Boshoku and four other companies within the Toyota group is a seat based and cabin based monitoring of the driver and other occupants. The Active Driver Engagement System "Naturally eliminating drowsiness utilizing air, temperature, music and vibration."

Concept of Monitoring system (Toyota Boshoku)

More Information
- MX 191: https://www.toyota-boshoku.com/global/special/ces2020/mx191.html
- Aces: https://www.toyota-boshoku.com/global/special/ces2019/aces.html

62. TS Tech

Methods and systems

A seat-based monitoring system. TS Tech says "The seat uses a sensor to monitor changes in respiration, including deep breathing or yawns, to detect a state of low arousal such as drowsiness. A vibration motor in the seat will alert the driver when drowsiness is detected."

Whether and how systems have been validated to date and user acceptance

The company says "The seat was exhibited at the 43rd Tokyo Motor Show 2013. The Company is continuing development of this technology as it works towards mass production."

More Information

- TS Tech Safety Technology:
  https://www.tstech.co.jp/english/development/technology/safety.html

63.   Valeo

Methods and systems

Face and eye based camera monitoring system. Valeo says the system "The purpose of the Driver Monitoring system is to alert the driver when signs of drowsiness or distraction are detected. Other applications for the system are also possible, such as driver identification and control functions using the eyes. These developments will contribute to heightened safety and more intuitive use of the new generation of driver assistance functions."
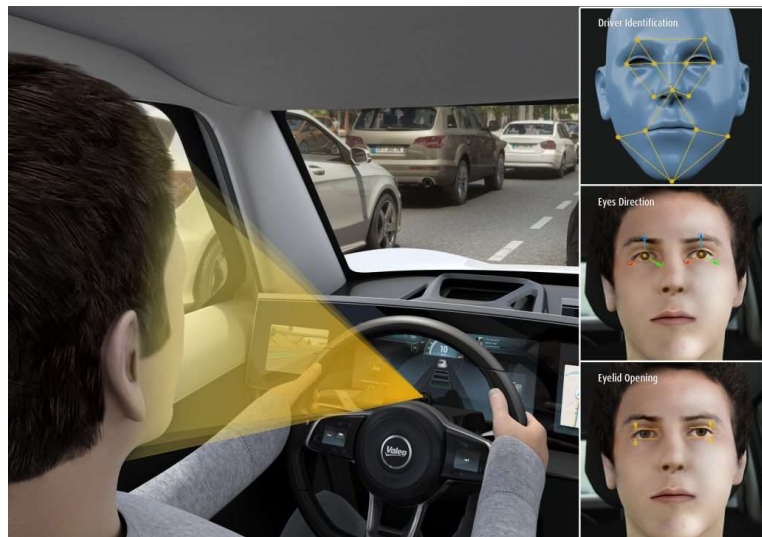
Driver Monitoring system (Valeo)

More Information

- Valeo Driver Monitoring: https://www.valeo.com/en/driver-monitoring/
- Video: https://www.trendhunter.com/trends/safran-and-valeo

64.   Visteon Corp

Methods and systems

Camera based monitoring system that uses Artificial Intelligence focusing on face, head and eyes.

Driver Monitoring system (Visteon)

Visteon describes their technology as:

> How do we ensure the person behind the wheel is prepared to drive? A driver monitoring system (DMS) identifies the drowsiness and distraction level of the driver. Visteon's infrared camera-based solution is capable of facial recognition and incorporates artificial intelligence to monitor driver distraction, drowsiness, emotion, and head and eye gaze. Our range of solutions can increase vehicle safety today,

while allowing for a scalable approach as new autonomous features are deployed to comply with safety regulations.

More Information
- Visteon Interior Sensing: https://www.visteon.com/technology/interior-sensing/
- Visteon White Paper: Camera-based driver monitoring system using deep learning. https://www.visteon.com/wp-content/uploads/2019/04/camera-based-driver-monitoring-system-using-deep-learning.pdf
- Video: https://www.visteon.com/newsroom/white-paper-camera-based-driver-monitoring-deep-learning/

65. Yanfeng

Methods and systems

Facial recognition system monitoring. Yanfeng says "Using facial recognition technology, the system can read facial fatigue and emotional cues, alerting or accommodating the driver with ambient lighting changes. Detectable sentiments or expressions include joy, smiling, sadness, anger, yawning, or sleepiness."

More Information
- "touchIN provides an Interactive and Responsive User Experience," Yanfeng. September 4, 2019. https://www.yfai.com/en/touchin-provides-interactive-and-responsive-user-experience.

66. ZF Friedrichshafen AG

Methods and systems

The ZF coPilot monitors the driver for unsafe driving and interacts with autonomous vehicle driving. ZF Friedrichsafen says were the driver to become distracted, their focus too far removed from traffic on the road or show signs of drowsiness. In addition to intelligent route guidance including "MyRoute" – a map function that recognizes repeat routes – the ZF coPILOT is also equipped with voice recognition so that the driver can conveniently enable, operate and disable driver assistance functions via voice commands, if they wish to drive manually."

More Information
- "ZF coPILOT Enables Enhanced Safety and Driving Comfort," ZF Friedrichshafen. April 19, 2019. https://press.zf.com/press/en/releases/release_6848.html
- "ZF Sensor Power: Autonomous Driving With All the Senses," ZF Friedrichshafen AG. January 7, 2019. https ://news.cision.com/zf/r/zf-sensor-power—autonomous-driving-with-all-the-senses,c2713081

67. Yazaki

Methods and systems

The Patent filed in 1996 originally in Japan relates to driving monitoring by using a camera. It appears the Patent in the United States expired in 2017.

Whether and how systems have been validated to date and user acceptance

As it appears the patent expired, it seems this technology was not necessarily workable. However, it shows that driver monitoring systems are not a new idea in promoting safety.
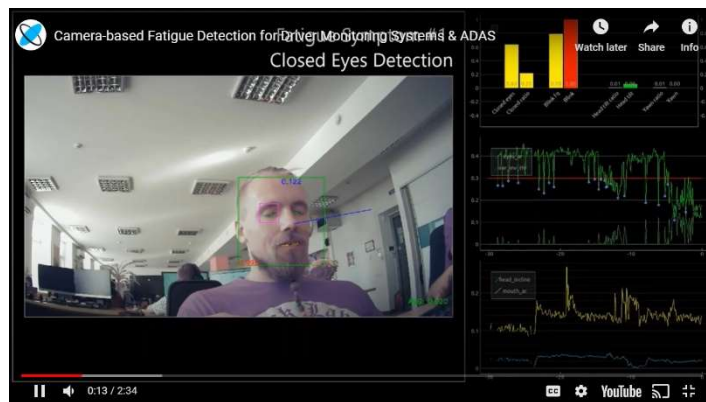
More Information
- Patent filed in 1997 in the United States: US6049747A. https://patents.google.com/patent/US6049747A/en.

Tier Two auto suppliers who are developing or deployed Driving Monitoring System technology. There are at least 29 systems that are in development.

68. Abto

Methods and systems
An eye and head-based monitoring system for fatigue.

Driver Monitoring system (Abto)

More Information
- Abto Software: https://www.abtosoftware.com/blog/fatigue-detection-for-driver-monitoring-systems

69. Affectiva

Methods and systems
Face and voice based monitoring system that also uses Artificial Intelligence. Affectiva says their technology "takes driver state monitoring to the next level, analyzing both face and voice for levels of driver impairment caused by physical distraction, mental distraction, drowsiness and more."

More Information
- Affectiva: https://www.affectiva.com/product/affectiva-automotive-ai-for-driver-monitoring-solutions/

Driver Monitoring system (Affectiva)

70. AMS

Methods and systems

Measures eye and steering movement. According to AMS:

> In all but fully autonomous vehicles (classified as 'Level 5' autonomy), the driver's ability to take back control of the vehicle must be monitored continuously. For this function, 3D optical sensing is already in use in vehicles to create depth maps which reveal the driver's posture, and show where the driver is looking – data which can be used to determine their state of readiness to assume control of the vehicle. 3D sensing can also be used for driver identification and access control.
>
> 3D sensing solutions in use today and under development make use of ams technologies such as time-to-digital converters for time-of-flight measurement, and illumination solutions for structured light and adapted stereo vision systems.

Driver Monitoring system (AMS)

More Information
- AMS Driver monitoring and identification systems: https://ams.com/automotive#drivermonitoring
- Video: https://www.youtube.com/embed/5zknGuXNXwQ?rel=0&fs=1

71. Autocruis Technology Co

Methods and systems

Driver monitoring that helps to monitor a driver using sensors intersects with Artificial Intelligence.

Whether and how systems have been validated to date and user acceptance

The company website says "First driver monitoring system based on deep learning technology in China! The software partner for Driver Monitoring System (DMS) of Bosch China."

More Information
- Autocruis Driver Monitoring System: http://www.autocruis.com/en/Drivermonitoringsystem/

72.   Baidu Apollo

Methods and systems

Face based driving monitoring that looks for fatigue.

More Information
- Apollo:https://apollo.auto/platform/dueros/competencies.html#fatigue
- Video of Baidu Apollo Driver Fatigue Detection: https://www.youtube.com/watch?v=HocfBmg4qgo
- Video: https://twitter.com/baidu_inc/status/1146739566486757376?lang=en

73.   CardioID

Methods and systems

The system uses a steering wheel to monitor for drowsiness and heart related problems. CardioID says "It's an Advanced Driver Assistance System that acquires the electrocardiogram (ECG) from the driver's hands to continuously detect drowsiness, cardiac health problems and biometric identity recognition."

Whether and how systems have been validated to date and user acceptance

This appears to be available for fleet use.

More Information
- What is Cardiowheel? https://www.cardio-id.com/cardiowheel

74.   D.T.S. AutoSense

Methods and systems

Artificial Intelligence that helps with driver and occupant monitoring systems for distracted and drowsy driving.   The product discusses Autonomous vehicle technology: "As autonomous cars pave the way to smarter cockpits, in-cabin cognition technologies become increasingly crucial for enhancing the in-car user experience. At all times, a smart car should understand all objects and living beings that are inside the cabin and should be capable of taking actions to improve their safety and driving experience."

Whether and how systems have been validated to date and user acceptance

DTS Autosense has an area where people can contact their sales team about this technology. It is unclear if it is deployed.

More Information
- DTS AutoSense: https://dts.com/autosense/

75.   Eyegaze

Methods and systems

The system measures eye movement.

Whether and how systems have been validated to date and user acceptance
Eyegaze is currently not utilized in vehicles but is widely used elsewhere. The company informed MADD device could be adapted to be put in vehicles.

More Information
- Eyegaze website: https://eyegaze.com/eye-tracking-technology-is-making-new-cars-safer/

76.   Harman

Methods and systems
The system monitors the driver head and eyes and could intersect with autonomous vehicle technology. Harman describes their tech as "HARMAN's advanced driver monitoring solution uses camera sensors to capture the driver's most important first-order biometric features, such as gaze, head position and pupil diameter, among many other key facial features. It detects minute fluctuations in pupil diameter and calculates brain activity level, especially high cognitive load."

More Information
- Harmen: https://car.harman.com/solutions/adas/driver-and-occupant-monitoring-system

77.   Joynext

Methods and systems
The system uses biosensors and other sensors to determine the state of the driver. If the driver is incapacitated, the technology could call for help. Joynext says "JOYNEXT is working on a Driver Monitoring System (DMS), which uses biosensors and an Empathic Assistant to detect the emotional and physical state of the driver and respond accordingly. In extreme emergencies, such as serious health problems, this system could even stop the vehicle and send out an emergency call for assistance.

More Information
- Joynext: https://www.joynext.com/en/portfolio/driver-adas-and-personalization/

78.   Melexis

Methods and systems
The system uses Time of Flight technology to assist with driver monitoring systems.   The system can help track "fatigue, eye gaze, hands-on wheel," as well "body, head, face pose and people identification."

Whether and how systems have been validated to date and user acceptance
Melexis appears to sell these systems. On their website, it says "Based on Sony DepthSense™ Time-of-Flight pixel technology, these sensors combine high sensitivity with high sunlight robustness."

79. NVIDIA Corporation
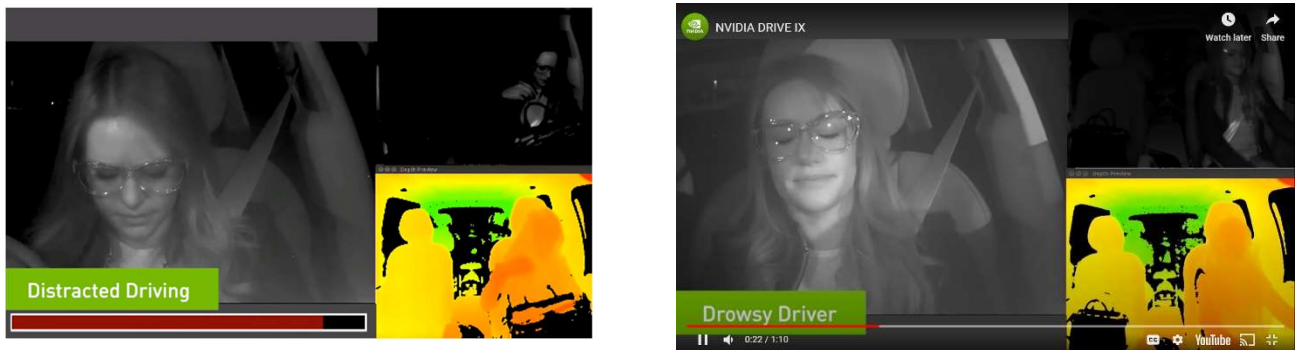
Methods and systems

Driving monitoring system that uses Artificial Intelligence and other sensors. NVIDIA says of the system:

> AI CoPilot provides driver monitoring system using a driver-facing camera, IR LED, and sophisticated deep learning software running on the NVIDIA DRIVE AGX system in the car. This module enables development of applications to ensure drivers stay alert, or take action if a driver is distracted or drowsy. For example, by tracking head and eyes to understand where driver is paying attention, and monitoring blink frequency to assess fatigue and drowsiness. Some of the key capabilities of AI Co-Pilot include: 3 dimensional gaze detection, drowsiness detection, distraction detection and head pose detection.

Images of Driver Monitoring System (NVIDIA, YouTube)

More Information

- NVIDIA Drive IX: https://developer.nvidia.com/drive/drive-ix
- NVIDIA: https://nvidianews.nvidia.com/news/nvidia-introduces-drive-autopilot-worlds-first-commercially-available-level-2+-automated-driving-system
- Video: https://youtu.be/OKQfTP7D1bM

80. NXP

Methods and systems

Monitors the face of a driver and other vehicle occupants. NXP says their system "includes a camera-based driver monitoring systems (DMS) pointed at the driver's face which provides a real-time evaluation of the presence and the state of the driver."
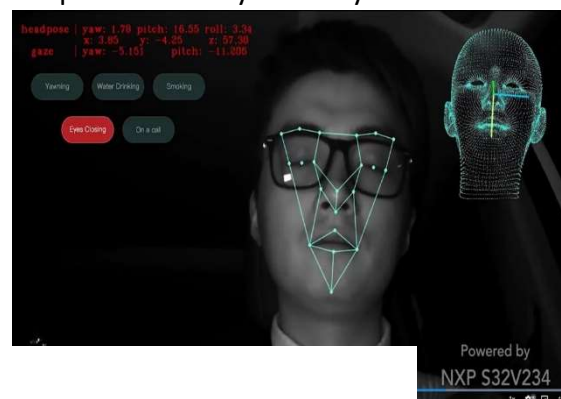
Images of Driver Monitoring System (NXP)
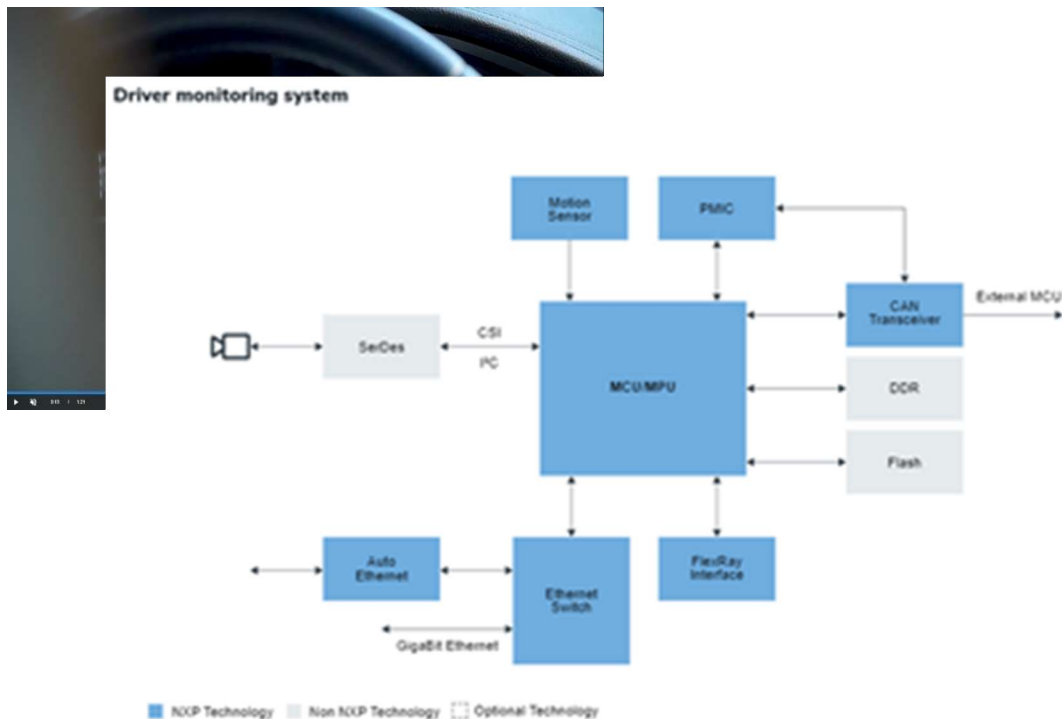
Schematic of Driver Monitoring System (NXP)

More Information
- NXP: https://www.nxp.com/applications/automotive/adas-and-highly-automated-driving/driver-monitoring-systems-dms-and-occupant-monitoring-systems-:DRIVER-MONITORING-SYSTEMS

81. Optalert

Methods and systems

The Optalert system focuses on detecting drowsy or distracted driving. Optalert says their technology "is the only objective measure, capable of quantifying eye and eyelid movements. Rich data sources enable biomarkers of drowsiness to be captured, and a driver's eyes to be tracked to accurately determine when their eyes are not on the road in front of them."

More Information
- Optalert: https://www.optalert.com/industries/human-centric-automotive/

82. Panasonic

Methods and systems

Drowsy driver face monitoring systems that also uses Artificial Intelligence. The company notes that the technology does the following:

> Panasonic's drowsiness-detection technology identifies and predicts a person's level of drowsiness by accurately measuring the driver's states without physical contact, including blinking features and facial expressions, etc. captured by an in-vehicle camera, and processing these signals using artificial intelligence. Further, using measurement data from the in-vehicle environment, such as heat loss from

the driver, Panasonic's new technology also predicts transitions in the driver's drowsiness level. The technology also combines a thermal sensation monitoring function, allowing the driver to stay comfortably awake while driving.

An emotion detection system is embedded within this driver monitoring demonstration. Using near-infrared camera technology, the system collects facial feature points from the driver to determine his/her state of emotions, such as irritation, happiness or fear, and current drowsiness level.

Panasonic's newly developed technology, with 22 patents on file, is suitable for applications in human and environment monitoring systems for use in such places as private and commercial vehicles, offices and educational institutions; drowsiness-prediction systems; and drowsiness-control systems for keeping people awake.

More Information
- Panasonic: https://na.panasonic.com/us/automotive-solutions/vision-sensing-0
- "Panasonic Develops Drowsiness-Control Technology by Detecting and Predicting Driver's Level of Drowsiness," Panasonic. July 27, 2017. https://news.panasonic.com/global/press/data/2017/07/en170727-3/en170727-3.html
- Video: https://www.youtube.com/watch?v=CT4qnpMnrxg

83. Pioneer
Methods and systems
Driver monitoring system that works with Autonomous Vehicles depending on the state of the driver. In 2017, at CES, Pioneer described their Driver Monitoring System in the following:
- Driver Monitoring System
  - The driver's status must be monitored in order to determine if he or she is alert and capable of re-engaging with the vehicle and taking control of driving. Pioneer's Driver Monitoring System is designed to detect driver conditions with image status and recognition technology used to estimate attentiveness, drowsiness, tension and fatigue.
  - Facial Recognition Camera for condition and status of the driver
  - Heart Rate Monitor for condition and status of the driver
  - Steering Wheel Sensor
  - Seat Sensor
  - Seat Vibration to improve level of alertness

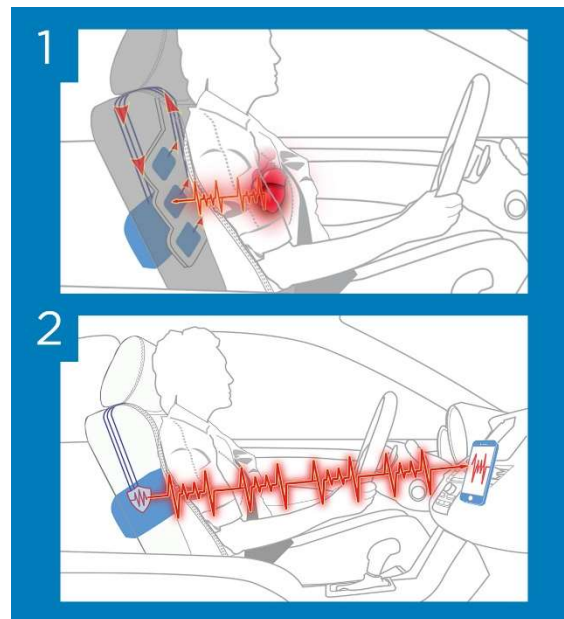**Image of Driver Monitoring System Pioneer)**

More Information

- "Pioneer Showcases Automotive Technologies for Cars of Yesterday," Pioneer. 2017. https://www.pioneerelectronics.com/PUSA/Press-Room/Car-Audio-Video/Pioneer+Showcases+Automotive+Technologies+for+Cars+of+Yesterday,+Today+and+Tomorrow
- "Pioneer Develops a Driver Monitoring System that Detects Driver Drowsiness Early and Improves the Level of Alertness," Pioneer. December 15, 2016. https://global.pioneer/en/corp/news/press/2016/pdf/1215-1.pdf
- "Pioneer introduces camera for AI-based ADAS solutions," Auto Car Pro. March 29, 2019. https://www.autocarpro.in/news-international/pioneer-introduces-camera-for-aibased-adas-solutions-42532

84. Plessey Semiconductors Ltd.,

Methods and systems

The Plessey Warden driver alertness system uses a car seat to monitor a driver. Plessey says of the system:

The WARDEN™ system uses an array of sensors to detect changes in electric potential in the human body. WARDEN™ senses the electrical impulses of the heart without direct skin contact and returns an accurate R peak signal from the users ECG, this in turn can be used to calculate heart rate variance (HRV). In the end application the EPIC™ sensor electrodes can be easily and discretely incorporated inside vehicle seatbacks to access the necessary biometric signals and provide earlier warning of drowsiness or health issues than systems based on eye or head movement. WARDEN™ can be used to provide an indication of the driver's alertness, signaling to them when they need to stop and take a break. Plessey's award winning EPIC™ sensor technology has been creating considerable interest with car manufacturers as it can be used to provide low cost, reliable detection systems for several automotive applications. Using EPIC™ (Electric Potential Integrated Circuit) sensing technology, Plessey has developed WARDEN™, a new heart-rate based driver alertness monitoring system.

Schematic of Driver Monitoring System (Plessey)

More Information

- Plessey WARDEN™ driver alertness monitor: https://www.astute.global/products/plessey-warden-driver-alertness-monitor/

85. Primax

Methods and systems

Working with ST in implementing Driver Monitoring systems. According to October 18, 2019 YouTube video by ST, Primax is developing the cameras for this system.
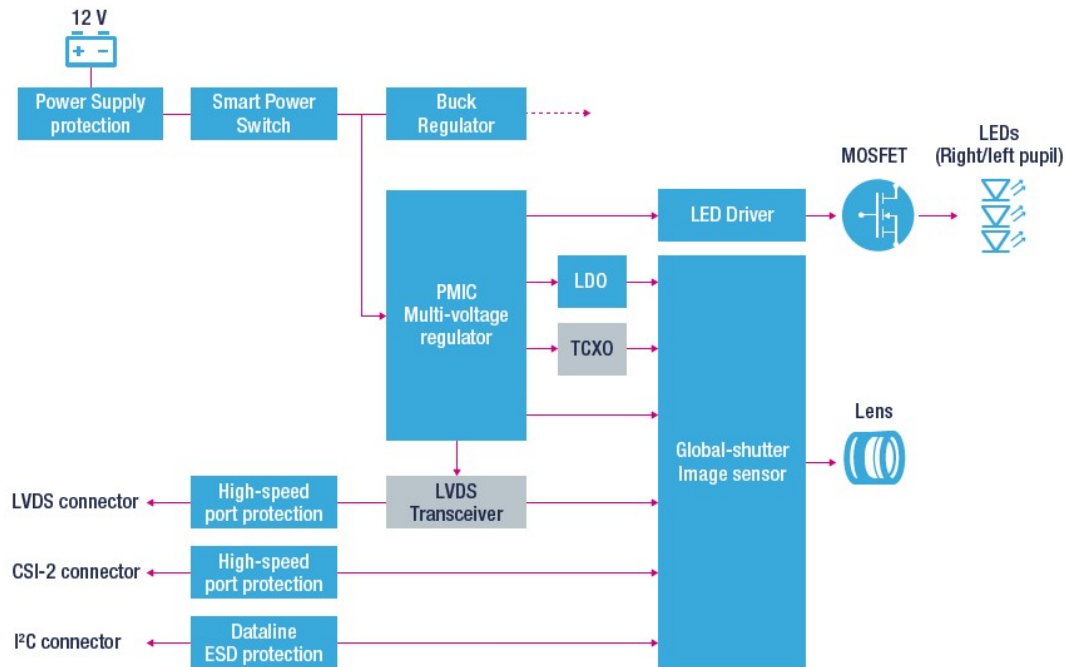
More Information
- Primax: https://www.primax.com.tw/en/product_mobile.htm#14
- Video: https://www.youtube.com/watch?v=kV2kKLbSVyo

86. ST Microelectronics

Methods and systems

The technology is a camera based solution to driving monitoring. ST Microelectronics states:

> ST comes with a scalable solution for Driver Monitoring System (DMS) applications, thanks to its HDR Global Shutter sensor (1.6 Mpixel & 2.3 Mpixel), together with a Multichannel Voltage regulator ASIL-D compliant and Automotive led drivers, MEMS Sensors, assuring the best flexibility for high-end computer vision applications in very critical environments.

Schematic of Driver Monitoring System (ST Microelectronics)

More Information
- ST Microelectronics: https://www.st.com/en/applications/adas/driver-monitoring-system-dms.html.
- Video: https://www.youtube.com/watch?v=kV2kKLbSVyo

87.   Seeing Machines

Methods and systems

The company calls itself the "World leading driver monitoring technology" and it's technology is in the Cadillac SuperCruse. Seeing Machines also has aftermarket technology called "Guardian" which will be described later in the document. Seeing Machines describes how DMS are critical to AV technology.

Seeing Machines discusses below how their system operates:

> The DMS consists of a small infrared camera and near infrared lighting pods mounted on the driver's side vehicle cockpit and is focused toward the driver's face. The raw video from the camera is passed to main processing element with Seeing Machines' FOVIO Driver Monitoring Engine (DME) where it is processed real-time and measures attention by continuously searching for and tracking the features of the driver's face and eyes. Simultaneously tracking the multiple points on the face, eyelids and pupils in a large head box over large and sudden head rotations and eye gaze angles, operating robustly in all foreseeable driving conditions including direct sunshine and total darkness, regardless of race or ethnicity, and even when the driver is wearing sunglasses is key to securing a highly reliable real-time core signal set for our classifiers for driver attention and driver state to work from.

> Based on thresholds set by the OEM or Tier One electronics integrator, if the driver looks away from the road or closes their eyes for more than a certain period (for example, can be dependent on the speed of the vehicle), the system will begin to escalate a series of warnings to encourage the driver to re-engage their attention to the road. Notably, in most circumstances, as soon as the driver looks back to the road, the warnings to the driver may be switched off. If the driver does not or cannot re-engage their attention to the driving task after the full series of escalating warnings, the DMS will output this information to the vehicle systems to take action (for example, automatically slowing and stopping the vehicle). Integrated with the various vehicle ADAS and Human Machines Interface (HMI) systems, the DMS acts as a friendly co-pilot, reminding the driver to pay attention, but with absolute minimum effort and reducing the number of unnecessary warnings.

Left: Seeing Machines Fovio Chip (Seeing Machines)

**Right: Cadillac SuperCruise driver monitoring system (General Motors)**

More Information
*   Seeing Machines:
    https://www.seeingmachines.com/industry-applications/automotive/

88.   Sight hound

Methods and systems

Camera based driver monitoring system that can detect drowsy and distracted driving. The company says "Sighthound's software uses a complex combination of monitoring functions to determine whether a driver might be distracted or tired. Alerts can be set to create a safer driving experience."
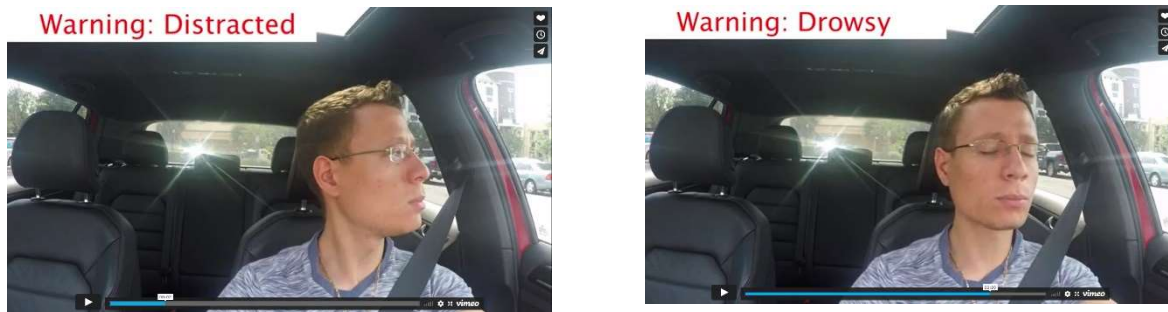
Images of Driver Monitoring System (Sighthound, Vimeo)

More Information
- Sighthound: https://www.sighthound.com/solutions/automotive

89. Smart Eye
Methods and systems
Uses sensors and software to monitor a driver via the face and voice. Smart Eye says:

> Smart Eye's DMS solution offers eye tracking software for integration in passenger cars and other vehicles to facilitate better safety and other functions that improve the user experience. By studying a person's eye, face and head movements, Smart Eye's interior vehicle algorithms can draw conclusions about a person's alertness, attention and focus. Today, car manufacturers (OEM:s) that has included the technology include German premium car manufacturers as well as one of China's largest OEM:s, Geely. Smart Eye is the market leader within the Automotive industry, paving the way for high performance reliability, precision, optimized costs and availability.

More Information
- Smart Eye: https://smarteye.se/automotive-solutions/
- Schematic of how the technology works: https://smarteye.se/wp-content/uploads/2018/11/AutomotiveSolutions_liggande-01.svg

90. Tata Elxsi
Methods and systems
The product provides software for driver monitoring systems. The company notes their technology helps provide detection of "eye gaze, head pose, alertness status, drowsiness, shades/eyeglasses, eye closure graph."

More Information
- Tata Elxsi Driver Monitoring System: https://www.tataelxsi.com/whats-new/Events/CES-2019/Flyers/Driver-Monitoring-System-flyer-Jan19.pdf

91. Veoneer

Methods and systems

Eye and head based monitoring system that measures driver's attention and fatigue. The company says:

> Veoneer's state-of-the-art driver monitoring system (DMS) can detect distracted and drowsy drivers by accurately measuring eye and head position, driver attention and fatigue. The DMS will invoke action when a dangerous situation is detected or imminent. A reliable analysis of the driver's state will also enable Veoneer to develop technologies that are critical for supporting highly autonomous driving functions, with safe hands-off-wheel operation. Veoneer's DMS understands driver behavior, allowing tomorrow's vehicles to make better decisions to improve comfort and safety.

> Driver monitoring is rapidly spreading across vehicle manufacturers who are launching level 3 and level 4 autonomous driving systems. Veoneer's solution builds on traditional systems and adds face identification, expression recognition for human-machine interactive systems, which enhances driver/vehicle trust and allows tomorrow's vehicles to make better decisions to improve comfort and safety.

More Information:
- Veoneer: https://www.veoneer.com/en/driver-monitoring-systems

92. Xperi

Methods and systems

Helps with the development of algorithms for driver monitoring systems.

> Our driver monitoring solution is currently in production and shipping in five light commercial vehicles from three different OEM brands, while 15 new vehicle design-ins, awarded by global OEMs for occupancy monitoring and driver monitoring technologies, are estimated to go into mass production starting in 2021, and expected to continue over a multi-year production life.

> Our in-cabin monitoring technologies support a safer driving experience and may ultimately help prevent traffic accidents, by providing driver and occupant state analytics through edge computing and sophisticated neural networks. In addition to detecting all human occupants of a vehicle, our solution detects pets and relevant objects, such as child seats. For each human occupant, the technology provides advanced analytics such as passenger authentication, age group, emotional state, and body pose.

> Xperi enables OEMs to deliver high-performing, camera-based in-cabin monitoring algorithms in their vehicles. Significantly, our solutions are able to monitor drivers with multiple occlusion types, including: glasses, helmets, hats, scarves, and face masks. Occlusion handling has become a particularly valuable feature today as so many people around the world are wearing face masks as a preventative measure against COVID-19.
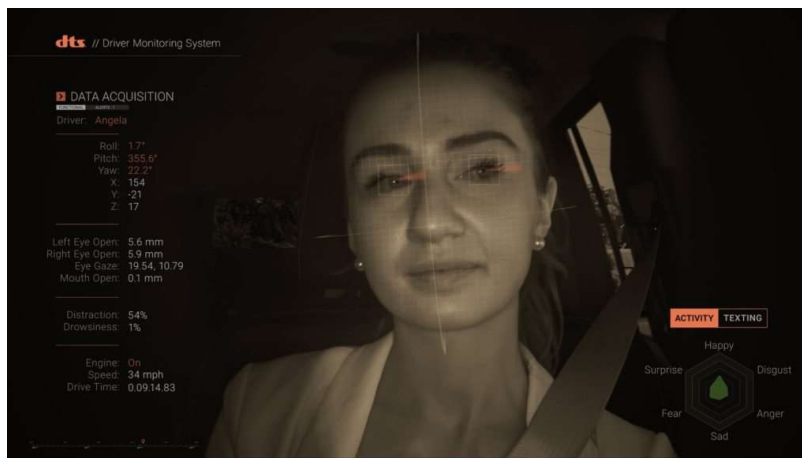
Driver Monitoring System (Xperi)

More Information

- Xperi: https://www.xperi.com/news/xperi-wins-key-oem-vehicle-design-ins-for-in-cabin-monitoring-systems/

93. NEC Group

Methods and systems

A patent filed in 2007 of a driver monitoring system that broadly discuss a system that monitors for driver's behavior and also uses computer algorithims. The Patent expired in 2011.

More Information

- Patent filed in 2007 in the United States: US7839292B2. https://patents.google.com/patent/US7839292B2.

94. 陈敏

Methods and systems

The Patent filed in 2020 is for technology that monitors a driver using a camera and other systems.

More Information

- Patent filed in 2020 in China: CN111547063A. https://patents.google.com/patent/CN111547063A

95. State Farm Insurance

Methods and systems

The 2014 Patent is for monitoring a driver during the operation of a vehicle. The system may be incorporated into a device that is installed on a vehicle after market.   The Patent says:

> The method, system, and computer-readable medium cause the monitoring of a vehicle operator during the course of vehicle operation to determine whether the vehicle operator is impaired and causes a mitigating response when an impairment is determined to exist. The vehicle operator, the environment surrounding the vehicle, or forces acting on the vehicle may be monitored using a variety of sensors, including optical sensors, accelerometers, or biometric sensors (e.g., skin conductivity, heart rate, or voice modulation). When the vehicle operator is determined to be impaired, an alert or other mitigating response is implemented, based on the sensor data. In some embodiments, mitigating actions may be taken to avoid vehicle operator impairment. In further embodiments, a training period may be used to generate a profile for the vehicle operator.

Sketch from Patent US9440657B1

FIG. 1
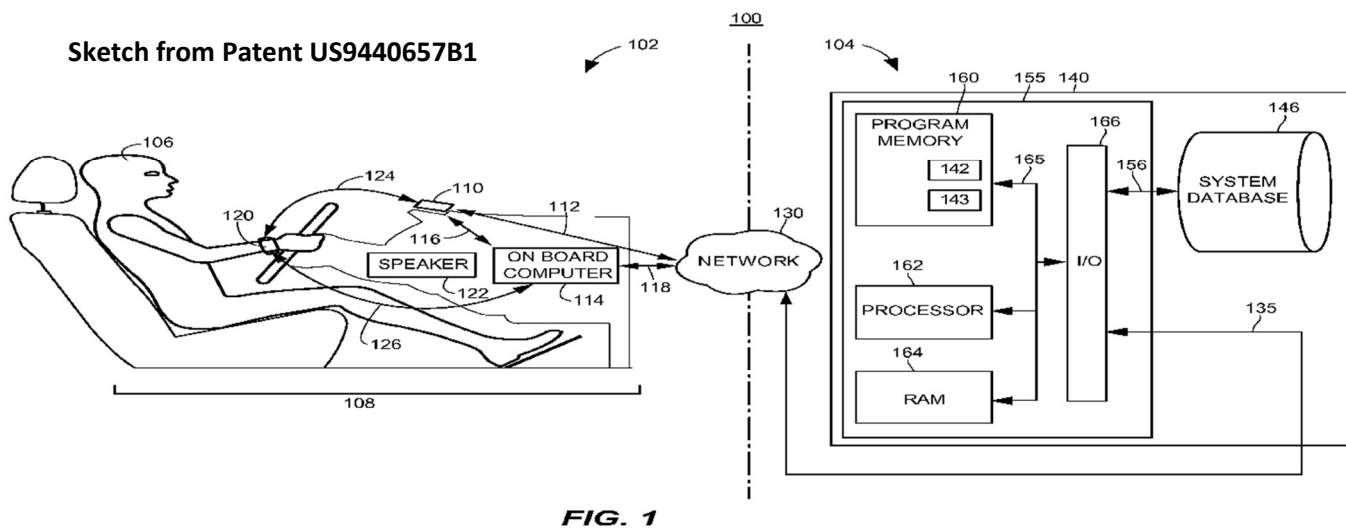
The front-end components 102 are disposed within one or more mobile devices 110 or on-board computers 114, which may be permanently or removably installed in the vehicle 108. The mobile device 110 or the on-board computer 114 may interface with one or more physiological sensors 120 or various other sensors (not shown) within the vehicle 108 (e.g., a braking sensor, a speedometer, a tachometer, an accelerometer, an optical sensor, a microphone, etc.), which sensors may also be incorporated within or connected to the mobile device 110 or the on-board computer 114. In some embodiments, the various other sensors (not shown) may perform part or all of the functions of the physiological sensor 120, in which case the physiological sensor 120 may not be present. Any of the sensors within the vehicle 108 may be installed by the manufacturer of the vehicle 108 or as an aftermarket modification to the vehicle 108. The mobile device 110 or the on-board computer 114 may further interface with various output devices in the vehicle 108, such as one or more speakers 122 or displays (not shown**). The physiological sensor 120 may include a thermometer, microphone, thermal image capture device, electroencephalograph (EEG), galvanic skin response (GSR) sensor, heart rate sensors, respiratory rate sensor, or other biometric sensors. The sensors may also include other sensors currently existing or later developed.**

More Information

- Patent filed in 2014 in the United States: US9440657B1.
  https://patents.google.com/patent/US9440657B1/en.

After-market Driver Monitoring System Products: Technology the general public can install in their vehicles or commercially operated vehicles can install on their fleets. There are at least 13 forms of technology available.

96. Belesh

Methods and systems

For around $76 on Amazon, a person could buy a driver monitoring system and try it out. The Belish system advertises the product on Amazon:

> Monitor the status of the driver through the facial recognition system. Safe driving Anti Sleep Drowsy Alarm Sleepy Reminder surveillance, Driver to Keep Awake. When the vehicle speed is lower than 30KM/H, the DMS function is turned off by default. or that DMS function is automatically turned on. eyes close, bow your head, yawn, smoking, make a call, look right and left, occlusion lens . Safe driving to protect yourself and other's life. Car Anti-Sleep Anti-Sleep Reminder.

Infrared fill lens, inner lens four infrared fill lamps are dark

It can be opened automatically in case of insufficient light during night driving,

Make night warning more accurate.

Belish Fatigue Monitoring System (Amazon)

More Information

    a. Belish Driver Monitoring System on Amazon:
https://www.amazon.com/dp/B08GSMN9TJ

97.   Car and Driver

Methods and systems

The Car and Driver Co-Pilot Fatigue Monitor system can be found at Best Buy and Home Depot for around $200. Car and Driver describes the technology:

> Car & Driver's Copilot Fatigue Monitor™ helps you avoid the effects of fatigued and distracted driving. The Copilot uses cutting edge facial recognition technology to monitor eye, eyelid and head positioning. If you get distracted, text and drive or begin falling asleep, the Copilot gets your attention with a loud, beeping alarm and optional vibrating seat pad. This device has all the qualities of a great copilot, without being a backseat driver.

Car and Driver Fatigue Monitoring System (Home Depot, Car and Driver)

More Information

- Car and Driver: https://caranddriverdashcams.com/fatigue-monitor/
- Home Depot: https://www.homedepot.com/p/Driver-Fatigue-Monitor-CAD-CP1001/314783217
- Best Buy: https://www.bestbuy.com/site/car-and-driver-driver-fatigue-monitor-with-face-and-eye-tracking-and-safety-alerts-gray/6416048.p?skuId=6416048

98.   Mascot

Methods and systems

The fatigue warning system is for sale on Amazon for $67. The Mascot system is described as:

> Fatigue driving warning device is with a unique designed product with pupil identification and detection technology to determine whether the driver is tired or inattentive state by analyzing the changing of characteristics of the pupil.
>
> Once the driver is detected fatigue or distracted driving, F16 will immediately send an alarm signal to remind the driver. F16 uses an image sensor to capture infrared images of a human face, analyzes and verifies whether a driver is tired or unmotivated by a high-speed digital signal processor.
>
> With the advance of non-contact mode and cutting-edge algorithm, F16 can accurately detect the driver's fatigue state, no matter under what circumstances (day, night, wearing glasses, recommended not to wear sunglasses), and issued a reminder and alarm to driver in real-time to ensure the life and property safety of the driver.

Mascot Fatigue Monitoring System (Amazon)

More Information

- Mascot: https://www.amazon.com/Fatigue-Driving-Warning-Blinking-detection/dp/B07MHVMV59.

99.   Camera Matics

Methods and systems

Driver facing camera that can detect fatigue that appears for fleets. Camera Matics describes their technology:

> The main element of the fatigue detection system is the driver-facing infra-red camera. This special camera is mounted in a specific point on the dash that gives it a full view of the driver's face and head but does not impede their view of the road.
>
> The Infra-red camera creates a high-contrast image that is sent to main ADAS unit to process in real-time. The camera has a very narrow view that focuses solely on the driver's face, with a little margin that allows for their head movement. This minimizes intrusion into their work space.

Driver Fatigue Warning System camera (Camera Matics)

More Information

- Camera Matics: https://www.cameramatics.com/driver-fatigue-warning-system-and-how-it-works/

100. Dot Netix

Methods and systems

The Nexus system uses camera that monitors the face and uses algorithms. The system is described by Dot Netix as "The Operator fatigue monitoring system monitors the operator using advanced sensors to determine if the operator is distracted or tired. Using advanced algorithms the unit is able to detect the operators face and monitor his facial features. Audible alerts are created for the driver while real-time remote alerts can be analyzed for fatigued or distracted operators."

Dot Netix Nexus (Dot Netix)

More Information
- Dot Netix: https://www.dotnetix.ai/fatigue-monitoring

101. Exsun

Methods and systems

Implementing Cipia (formerly Eye Sight Technologies) in fleets in China.   A 2018 press release from Exsun and Cipia states:

> Chinese authorities are demanding that trucking companies combat this danger. Shenzhen, one of China's largest and fastest-growing cities, recently passed a law requiring all heavy trucks to have Driver Monitoring Systems (DMS) installed by this coming June.
>
> To meet these new safety requirements, Eyesight and Exsun have signed a multi-million-dollar deal to produce an aftermarket Driver Monitoring System. Eyesight's camera and Computer Vision AI will be part of Exsun fleet management and telematics solutions, which are installed in hundreds of thousands of trucks. Eyesight's technology tracks the driver's gaze direction, pupil dilation, eye openness, blink rate and head position to determine in real-time if the driver is drowsy, inattentive or unfocused on the road.

More Information
- "Eyesight and Exsun Partner to Bring Life-saving AI Vision to China's Trucking Industry," Press release. November 28, 2018. https://www.prnewswire.com/news-releases/eyesight-and-exsun-partner-to-bring-life-saving-ai-vision-to-chinas-trucking-industry-300756737.html

102. Edge3

Methods and systems

Driver monitoring system for fleets. It appears that the system does not immediately notify the driver of distraction/fatigue. Instead, the video is reviewed by the specific company at a point in the future.

More Information
- Edge3: https://edge3technologies.com/drive/
- Edge 3 Product Home: https://www.edge3technologies.com/product-home/
- Edge 3 Patents: https://edge3technologies.com/home-2/patents/
- Edge 3 Cloud Detect: https://www.edge3technologies.com/clouddetect/

103. Hikvision

Methods and systems

According to a 2020 report, Hikvison has "Driver Behavior Analysis Camera" that can detect fatigue and other driver actions. It has been deployed in taxis and rideshares. It is unclear if the driver is alerted of fatigue or if this camera is for review by a monitoring agency.

More Information
- Hikvison: https://www.hikvision.com/content/dam/hikvision/ph/htc-training-slides/2020/hikapril24/HIKAPRIL24%20-%20Hikvision%20Mobile%20Surveillance%20Solution%20V1.2.5.pdf

104. Meitrack

Methods and Systems

The Meitrack system can monitor for distraction and fatigue. It is unclear if this system alerts the driver of fatigue or distraction immediately or if the video is reviewed later.

More Information
- Meitrack: https://meitrackusa.com/driver-fatigue-monitor-system

105. Nauto, Inc.

Methods and systems

Distracted and drowsy driver monitor system that utilizes Artificial Intelligence. Nauto says their system "Continuously process images from the interior sensor to analyze facial movements and detect unsafe driver behavior in real-time."

Whether and how systems have been validated to date and user acceptance

The system appears to be ready to be sold for fleet use and may already be in use.

More Information
- Nauto: https://www.nauto.com/product/driver-behavior-alerts#how-it-works

106. Netradyne Inc

Methods and Systems

Fleet based driving monitoring system that gives real-time alerts of driver behavior to company and the user. Netradyne states "Distracted Driving events are captured and analyzed as they occur so violations can quickly be addressed. Drivers are reminded with in-cab audio alerts and managers are notified of the alert via mobile app or the Driveri portal."
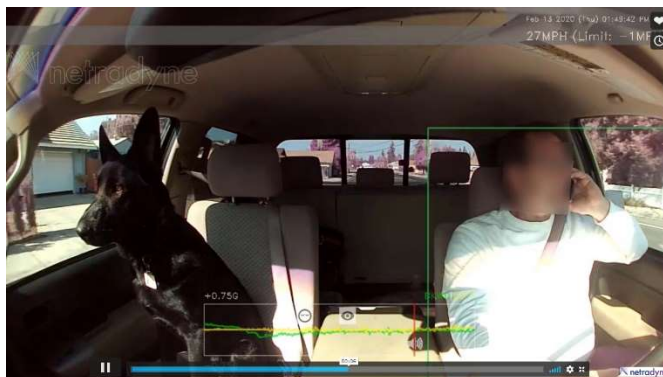
Driveri driver monitoring system (Netradyne)

More Information

- Netradyne: https://www.netradyne.com/driveri/
- Comparing Vision-based Safety Systems: Trigger-Based vs Edge Computing: https://www.netradyne.com/comparing-vision-based-safety-systems-trigger-based-vs-edge-computing/
- Possible Patent related to technology filed in 2017 in the United States: US10460600B2. https://patents.google.com/patent/US10460600B2/

107. Seeing Machines

Methods and systems

Seeing Machines' Guardian system is for fleet use in driver monitoring. The system is a:

Face- and eye-tracking algorithms measure the driver's head position and eye closure and, when safety parameters are exceeded, audio alarms and powerful seat vibration are immediately activated. Data and footage are immediately relayed to the 24/7 Guardian Centre through a secure connection for review. If needed, fleet management are notified and can respond in real time.

Seeing Machines Guardian monitoring system (Seeing Machines)

Whether and how systems have been validated to date and user acceptance

The system is operational 400 companies and according to the Guardian website, the system has tracked over 5.7 billion kilometers, detected over 8.1 million events of distractions. Additionally, in the last 12 months, the system detected nearly 155,000 fatigue events.

More Information

- Seeing Machines Guardian: https://www.seeingmachines.com/guardian/
- Video: https://www.youtube.com/watch?v=6gVek5XpVKQ
- Brochure: https://www.seeingmachines.com/guardian/wp-content/uploads/sites/2/2018/06/SM-Guardian-Brochure2019-web.pdf

108. Sensetime

Methods and systems

Driver monitoring for fleets. It is unclear by the description if there are alerts to the driver for distraction or fatigue. The description by Sensetime of their technology:

> Leveraging SenseTime's leading image recognition algorithms and outstanding deep learning capabilities, this solution eradicates security risks caused by driver error. Key features include driver identification, drowsiness detection, distraction detection, and dangerous driving behavior analysis. It also adapts extreme weather conditions and supports 4G and Wi-Fi networks and OTA updates, realizing equipment self-diagnosis and low-power operations in addition to meeting the requirements for long equipment running time.

More Information

- Sensetime: https://www.sensetime.com/me-en/product-detail?categoryId=21433

109. Stonkam

Methods and systems

Driver monitoring for fleets with real-time alerts. The system "Detect and alarm driver unsafe behaviors: fatigue detection, distraction detection, phone call detection."

Driving Monitoring system (Stonkam)

More Information:

- Stonkham: https://stonkam.com/products/Driver-Fatigue-Monitoring-System-AD-A11.html
- Video: https://youtu.be/G-4I_WqDm4w

Driving monitoring systems that can measure a driver's physiological characteristics for substance impaired driving. These technologies advertise as being able to determine if a person is substance impaired.

110. Volvo

Methods and systems

The monitoring system of the driver uses camera and other sensors to determine if the driver is intoxicated, distracted, drowsy or driving erratically. Volvo says the system would also have an intervention "That intervention could involve limiting the car's speed, alerting the Volvo on Call assistance service and, as a final course of action, actively slowing down and safely parking the car.

What is described in this Monitoring system is like other auto companies are developing.

Whether and how systems have been validated to date and user acceptance

Volvo plans to have the "introduction of the cameras on all Volvo models will start on the next generation of Volvo's scalable SPA2 vehicle platform in the early 2020s. Details on the exact amount of cameras and their positioning in the interior will follow at a later stage."
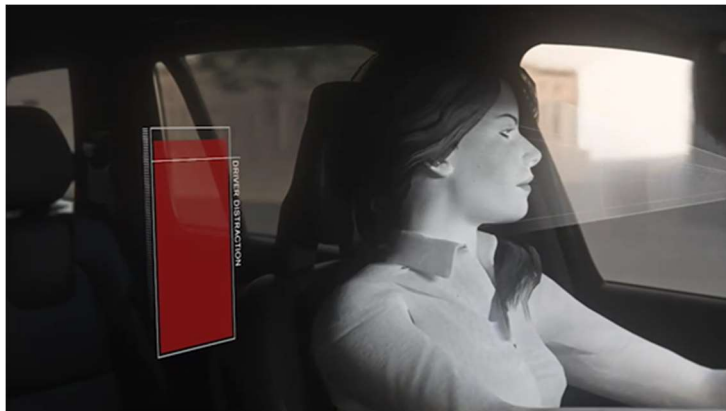
In-car cameras and intervention against intoxication, distraction: Animation (Volvo)

More Information

- Volvo press release: https://www.media.volvocars.com/global/en-gb/media/pressreleases/250015/volvo-cars-to-deploy-in-car-cameras-and-intervention-against-intoxication-distraction
- Video: https://www.media.volvocars.com/global/en-gb/media/videos/250162/in-car-cameras-and-intervention-against-intoxication-distraction-animation1
- "Volvo to put cameras and sensors in its cars to tackle drunk driving," CNBC. March 21, 2019. https://www.cnbc.com/2019/03/21/volvo-to-put-cameras-and-sensors-in-its-cars-to-tackle-drunk-driving.html
- "Safety first: Volvo to add in-car sensors to prevent drunk driving," Reuters. March 20, 2019. https://www.reuters.com/article/volvocars-safety/safety-first-volvo-to-add-in-car-sensors-to-prevent-drunk-driving-idUSL3N2172D8
- "Volvo Using Technology to Cut Down on Distracted Driving — Due to Technology," The Detroit Bureau. October 19, 2020. https://www.thedetroitbureau.com/2020/10/volvo-taking-more-steps-on-car-safety/

111. Volvo

Methods and systems

The Patent from Volvo was filed in 2004 and aims to detect for perpetual errors of drivers or other heavy machine operators.

The technology aims to detect impaired driving and other driving conditions. The Patent says the object of the invention to provide a method and system for automatically:

- **Executing a drug recognition expert (DRE) on a driver.**
- **Testing for the influence of drugs and/or alcohol.**
- Conducting perceptual suitability tests on a driver of a vehicle or a person operating equipment or a device while driving a vehicle or operating the equipment or device.
- Executing such suitability tests on the basis of eye and/or head movements or reactions of the related vehicle driver or any other person who operates equipment and/or devices as mentioned above.
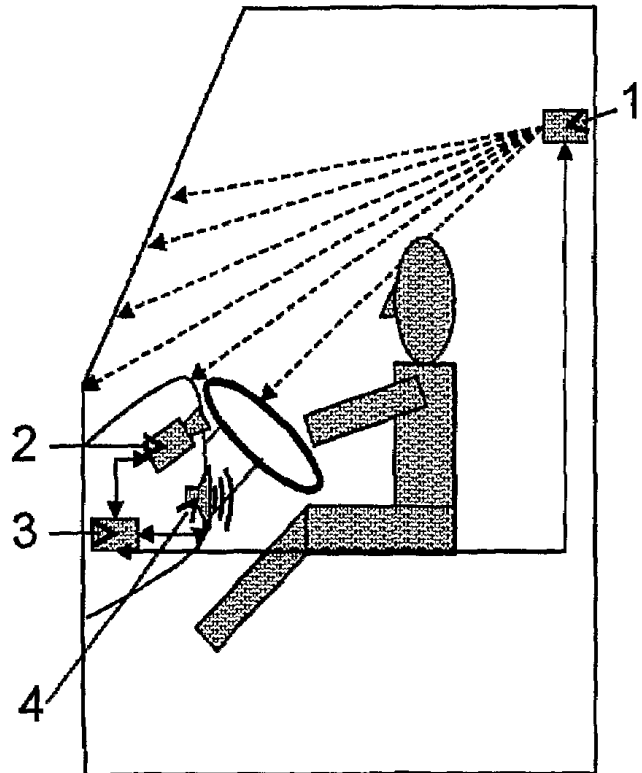
Sketch from United States Patent: US7455405B2

According to the description of the sketch above, it shows a side view into the cabin of a system comprised of a stimulus generation device 1; an eye movement and/or head movement and/or pupil reaction registration device 2; a computation, control, and output device 3; and a sound generation unit 4.

Whether and how systems have been validated to date and user acceptance

The Patent was filed in 2004. It is unclear if portions of this concept are incorporated into other Volvo technologies.

More Information

- Patent filed in the United States in 2004: US7455405B2.
  https://patents.google.com/patent/WO2005098777A1/en

112. Nissan

Methods and systems

In 2007, Nissan announced a concept vehicle that could detect alcohol-impaired driving by using sensors such as odor detectors as well as facial recognition of the driver via a camera all while monitoring any erratic driving of the vehicle operator.

When an alcohol odor would be detected via the gear shift knob or breath sensor on the seat, the driver would be notified. The camera system worked in the following way:

> A camera is mounted on the instrument cluster facing the driver to monitor the driver's face. The system is calibrated to monitor the driver's state of consciousness through the blinking of the eyes. When the system detects signs of drowsiness, a voice and message alert is triggered via the navigation system. Additionally, a seat-belt mechanism is activated which tightens around the driver to gain his or her immediate attention.

Images of Camera and Facial Recognition (Nissan, 2007)

Whether and how systems have been validated to date and user acceptance

According to the 2007 press release, Nissan was looking into reducing drunk driving

> Nissan has already launched and is developing several initiatives to help prevent drunk driving. In June, the company introduced the "drunk driving" message alert on its navigation system. In July, Nissan also began testing of a new on-board breathalyzer system in cooperation with several local government authorities, where an interlock mechanism will immobilize the vehicle if the driver's breath indicates the presence of alcohol above a specified level.

It is unclear what happened with the Nissan project or if the company has incorporated driving monitoring using a camera into other technologies.

More Information

- "Concept car to showcase anti-drunk-driving technology," Nissan. August 2, 2007. https://global.nissannews.com/en/releases/release-95e86dba49c0e8277e3c7b662e6aac68-070803-02-e
- Video: "A Car that combats drunk driving." August 5, 2007. https://www.youtube.com/watch?v=dV9LfD1CYhI

113. Toyota

Methods and systems

Announced in 2007 and mentioned in news reports, this system monitors a driver's alcohol level through a steering wheel sensor and also uses a camera to see if a driver's pupils are dilated.

Whether and how systems have been validated to date and user acceptance

The system was mentioned in 2007 and forms of the technology have been developed by other auto companies and technology companies.

More Information

- "Toyota creating alcohol detection system," Associated Press. January 3, 2007. http://www.nbcnews.com/id/16449687/ns/technology_and_science-innovation/t/toyota-creating-alcohol-detection-system/#.XZ52cVVKjIU

114. Toyota

Methods and systems

This Patent is for an eye-based monitoring system that also senses for lane departure. The Patent notes that its pupil detection technology can detect for alcohol use:

> Continuing to analyze the driver's pupil may guard against the scenario where the driver consumes a large amount of alcohol shortly prior to operation of the vehicle 100 such that his or her pupils have not yet fully dilated or otherwise changed in size at the moment the vehicle 100 initially processes the size of the pupil. By repeating the collection and analysis processes, the system 200 is able to take into account any further change in the size of the pupil due to the absorption of alcohol or drugs thereby achieving a more accurate assessment of whether the driver is intoxicated.

On the sketch of the Patent to the right, 110 represents where a camera could be to detect a driver's pupil.

Whether and how systems have been validated to date and user acceptance

The pupil and camera-based monitoring is in development or deployed in other DMS, however nearly all are not marketed to detect for alcohol or drug impairment like this Patent.
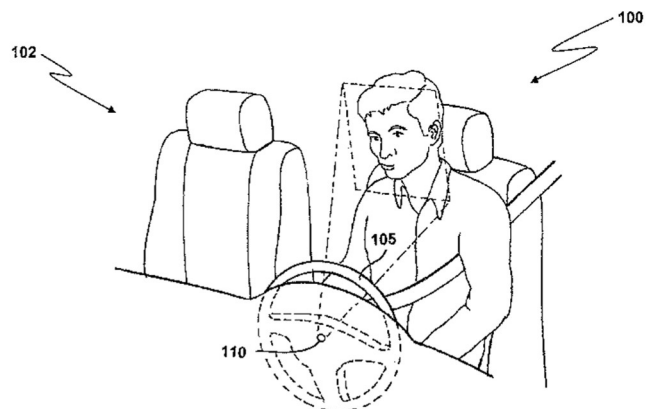
FIG. 1A

Sketch of Patent US9542847B2

More Information

- Patent filed in 2013 in the United States: US9542847B2. https://patents.google.com/patent/US9542847B2/en?oq=9542847

115. Toyota

Methods and systems

The Patent filed in 2015 is for speech and camera-based sensors for alcohol or other types impairment. Specially, the Patent notes the:

Sketch of Patent US10166992B2

> The system further includes an impairment event unit. The impairment event unit compares the operation of the vehicle with the sober driver profile after the motor vehicle stop. The impairment event unit identifies the motor vehicle stop as an impairment event when the operation of the vehicle deviates a predetermined amount from the sober driver profile. Accordingly, an impairment event, as used herein, relates to an event which impairs the driver's ability to operate the vehicle. Factors which the impairment event unit may consider include the braking profile, turning profile, traffic speed, acceleration, and lane departure. **The impairment may be a result of alcohol or drug consumption.**

The Patent shows technology that attempts to determine the impairment level of a driver as noted by using eye gaze:

> The challenge 14 is configured to determine if the driver is impaired. For example, the challenge 14 may be a verbal response, one challenge 14 selected from the group consisting of a mathematical problem, a repetition of a phrase, a physical act, a horizontal gaze nystagmus test, or a blood alcohol breathalyzer test. The challenge unit 28 may be configured to issue one or more challenges 14. The challenge unit 28 renders the motor vehicle 12 inoperable until the challenge 14 is passed. The challenge unit 28 may be further configured to wait a predetermined period before issuing a challenge 14 in the event the driver fails a challenge 14.

The Patent goes on to state that it attempts to use voice recognition to determine if the driver is slurring speech.

Whether and how systems have been validated to date and user acceptance

It is unclear if portions of this technology have been incorporated into other technologies. It appears the horizontal gaze test and speech recognition may somewhat obtrusive as it requires a driver to take an additional step. However, other technologies that are being developed or are developed have been able to determine a person's distraction or drowsiness via horizontal gaze without any additional steps by the vehicle operator.

More Information

- Patent filed in 2015 in the United States: US10166992B2.
  https://patents.google.com/patent/US10166992B2/en?oq=10166992

116. Toyota

Methods and systems

The Patent filed originally in Japan in 2015 shows camera and other sensors that also include alcohol sensors. This DMS also intersects with the operation of an Autonomous Vehicle. Sensors in addition for that of alcohol also include sensors for heart rate.
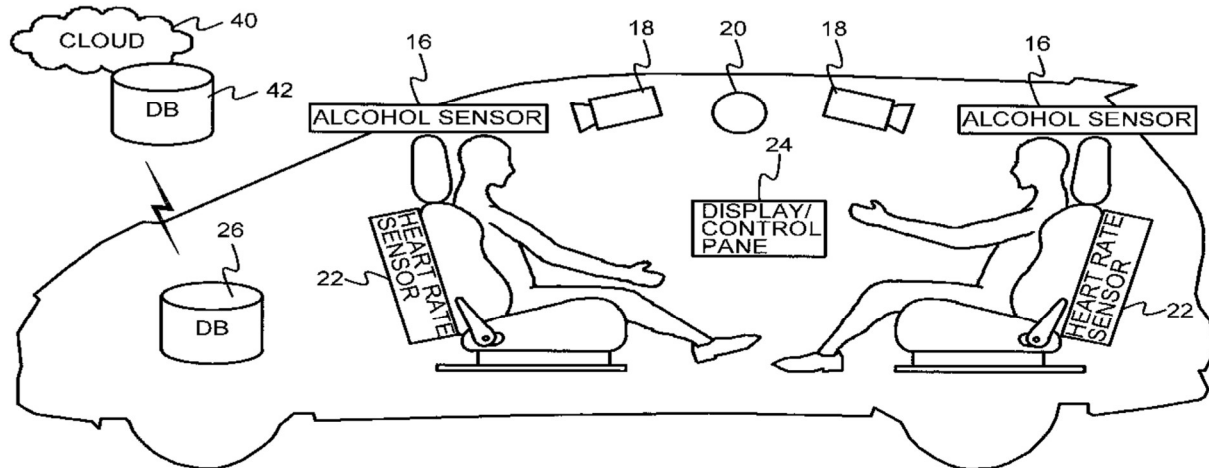
Sketch of Patent US9783202B2

The Patent describes the alcohol sensors in this system:

> An acquisition unit is provided in the vehicle in order to acquire various kinds of information about vehicle occupants from the occupants. The information serves as conditions for determining whether or not each occupant is suitable for being the driver. Alcohol sensors 16, cameras 18, a microphone 20, heart rate sensors 22, a display/control panel 24 and a database (DB) 26 serve as the acquisition unit. The database 26 encompasses smartphones, smart watches and the like belonging to individuals.

> **Each alcohol sensor 16 is disposed at a position at which the breath of an occupant can be easily detected such as, for example, a headrest or the like.** By detecting alcohol, the alcohol sensor 16 determines whether or not an occupant sitting on a seat is under the influence of alcohol.

Whether and how systems have been validated to date and user acceptance

The system has not been validated to date but shows Toyota is looking into breath sensors in addition to other driving monitoring systems and how these play a role in determining the driver's state in the operation of an autonomous vehicle.

More Information

- Patent filed in 2016 in the United States: US9783202B2.
  https://patents.google.com/patent/US9783202B2/en

117. Toyota

Methods and systems

This Patent is for technology that monitors speech and utilizes other sensors that can determine if the driver is under the influence of alcohol.

The Patent says about the speech recognition:

> According to the vehicle control device of the first aspect, in a case in which it is determined that the driver is in the intoxicated state based on the speech data, the start operation of the vehicle is limited. Here, the start operation is an operation performed by the driver with respect to the vehicle to start driving the vehicle. **Therefore, according to the vehicle control device of the first aspect, in a case in which the driver is in the intoxicated state, the start operation of the vehicle is limited, and thus, intoxicated driving may be prevented.**
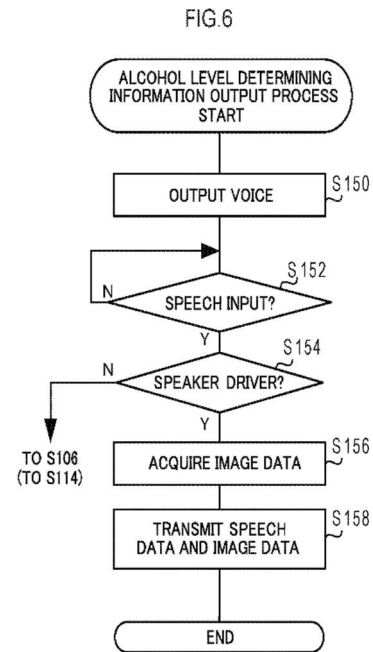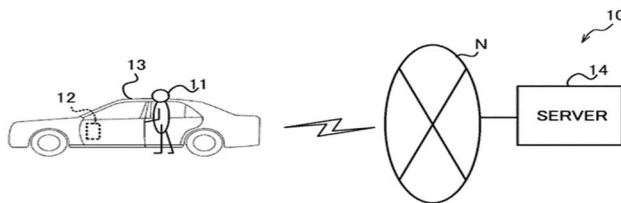
Sketches of Patent US20190210607A1

Whether and how systems have been validated to date and user acceptance

Driver monitoring systems that utilize speech to determine a driver's state are not as widespread as those that utilizes a camera. The Patent also has an image capturing portion to it that may help validate if a driver is intoxicated coupled with the speech recognition.

More Information

- Patent filed in 2018 in the United States: US20190210607A1.
  https://patents.google.com/patent/US20190210607A1

77

118. Lime Scooters

Methods and systems

Lime Scooters is developing technology that can determine drunk driving or other dangerous behavior based off how the scooter movement of the operator.   If such behavior is detected, the scooter can be automatically slowed down.

Whether and how systems have been validated to date and user acceptance

Scooters are available in many areas. It is unclear if this technology has been made available.

More Information

- "Lime working on drunk driving detection feature," Consumer Affairs. April 18, 2019. https://www.consumeraffairs.com/amp/news/lime-working-on-drunk-driving-detection-feature-041819.html

119. ADAM

Methods and systems

Eye based and Artificial Intelligence monitoring of a driver. Their company says of the technology:

> ADAM monitors driver's perception and attention in Real time , while analyzing the required cognitive resources toward prioritized content, redirect the driver's attention to the new destination, keeping him during or before transfer of control as relaxed he could be for optimal response, during or before transfer of control.
>
> ADAM CogTech is focused on providing software solutions for the measurement and enhancement of human cognitive performance for safety critical operations such a driving, human machine cooperation and many more.

A video demonstration of the technology from ADAM doses a driver with alcohol and shows how the system detects that the driver is impaired by alcohol below:

Whether and how systems have been validated to date and user acceptance

It is unclear if the system has been tested in a vehicle or not.

More Information

- ADAM: http://adam-cogtec.com/why-adam/
- Video of ADAM: https://drive.google.com/file/d/1PRii2qpwVHcwfciDAAtc_IWdDH0UWVYe/view

120. Wipro

Methods and systems

The camera-based monitoring system measures a person's head and eye as well as check their level of attentiveness. Wipro says:

> Wipro's Driver Monitoring System is a smart dash camera-based solution to recognize drivers and monitor their behavior to check for the level of attentiveness. The state-of-the-art solution leverages computer vision to continuously monitor drivers and passengers, by measuring eye and head position, presence of distractions within the cabin etc. The system makes smart situational decisions to avert disaster in case of drowsiness, distraction, fatigue, or even drunk driving.

Whether and how systems have been validated to date and user acceptance

It is unclear if the system is available as an option in vehicles.

More Information

- Wipro: https://www.wipro.com/en-US/engineeringNXT/driver-monitoring-system/
- Wipro's Driver Monitoring System Brochure: https://www.wipro.com/content/dam/nexus/en/service-lines/product-engineering/latest-thinking/wipros-driver-monitoring-system.pdf

121. Ford

Methods and systems

The Patent filed in 2007 is for a system that can monitor for signs of impairment and appears to be able to take over operation of the vehicle.

The Patent describes how the system works:

> The present invention is directed to an active safety system for recognizing that the vehicle's driver is impaired and not responding to alert warnings and initials countermeasures to safeguard the vehicle occupants and others that may be on or nears the road. This is accomplished by first determining what other vehicle system capabilities are present on the vehicle (i.e., adaptive cruise control with stop and go;
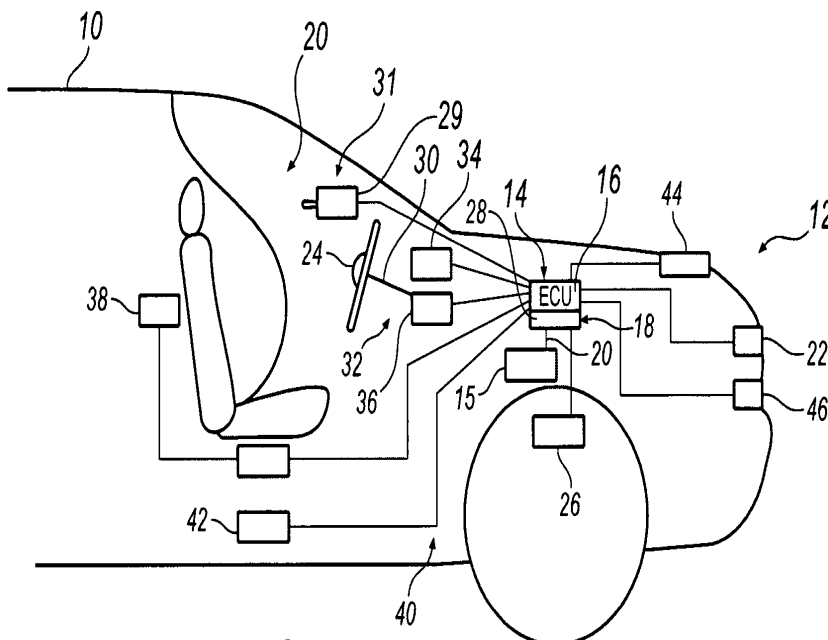
FIG. 1

Sketch of Patent US7777619B2

The vehicle is also equipped with devices 40 for sensing driving state variables, such as motion detectors 42, cameras 44 and radar sensors 46. The cameras, motion detectors and radar sensors are used in vehicle equipped with external sensing to gather data and information about the surrounding area of the vehicle, and use the data to determine whether there are any other vehicles or objects in proximity to the vehicle that may pose a hazard or obstacle to the operation of the vehicle, and to implement steering control or to chart a path to the safe side of a road.

blind spot detection; traction control; steer by wire; external sensing-lane detection; path prediction; obstacle detection, etc.), and adapting the active safety feature accordingly. The system monitors the driver to determine whether the driver is not responding to the alert warning. If it is determined that the diver is not responsive to the alert warning, the method includes initialing counter measures such as adjusting safety restraints, in the case of pretension restraints, reducing vehicle speed via a message to the engine controller and/or the vehicle brakes, to a full stop. The system and method further contemplates activating the vehicle emergency warning lights and horn. These additional measures are initiated and tracked to bring the vehicle to a safe stop and warn others outside and inside the vehicle that the driver is no longer in control of the vehicle.

Whether and how systems have been validated to date and user acceptance
It is unclear if portions of this technology in other Ford products. Other Auto Companies have incorporated driver control if the driver is unresponsive too.

More Information
- Patent filed in 2007 in the United States: US7777619B2.
  https://patents.google.com/patent/US7777619B2/

122. Ford
Methods and systems
This Patent was filed in 2011 and is voice-based alcohol impairment monitor. The Patent describes the technology:

> A system is disclosed herein that utilizes an acoustic phonetic impairment test (APIDT) that uses properties of speech performance to detect driver impairment. For example, the system may compare recorded phrases or words (or random combination of words) to established or initially stored phrases or words, respectively, to assess driver impairment. **Such impairment may be attributed to factors such as driver alcohol consumption, driver glucose levels, illegal drugs, etc.** These factors may change the speech of the driver and such a change may be indicative of the driver being impaired.

More Information
- Patent filed in 2011 in the United States: US9963033B2.
  https://patents.google.com/patent/US9963033B2/en?oq=10471969

123. Ford
Methods and systems
The Patent filed in 2017 describes a system uses a patch and watch to determine impairment in addition to other sensor to detect impairment. The system also intersects with Autonomous Vehicle technology. The system is described as:

A computer is programmed to receive biometric data, from a transdermal patch in a vehicle during operation of a vehicle, wherein the biometric data include a measurement of a chemical. The computer is programmed to actuate a vehicle component, upon determining from a combination of the measurement of the chemical and vehicle operating data that a risk threshold is exceeded.

FIG. 1
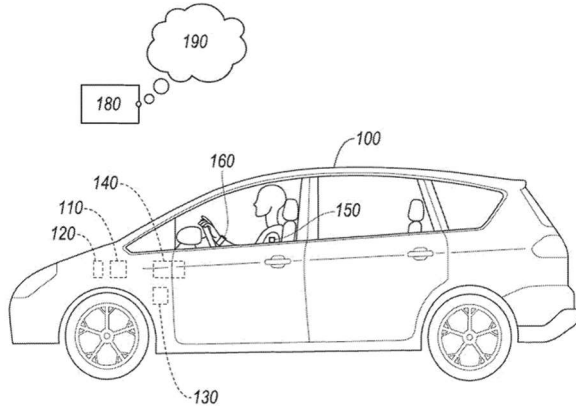
Sketch of Patent of US20200148231A1.

The sketch to the right shows a "Human Machine Interface (HMI) 140 is typically located in a passenger cabin of the vehicle 100. For example, the HMI 140 may provide information to the occupant including an indication of vehicle 100 occupant impairment, an activation of vehicle 100 autonomous mode based on vehicle 100 occupant impairment, etc."

Whether and how systems have been validated to date and user acceptance

Any technology that requires an additional step by a driver is not workable. It unclear if this technology has other passive sensors made into the vehicle to determine impairment. This Patent seems to intersect with a vehicle operation in Autonomous Vehicle modes, which is like other technologies by other companies.

More Information

- Patent filed in 2017 in the United States: US20200148231A1.
  https://patents.google.com/patent/US20200148231A1/en

124. GM

Methods and systems

The Patent filed in 2009 is driving monitoring technology for impairment. The Patent is described:

Impairment sensor system 108 includes an analyzer adapted to estimate an impairment-related metric ("IRM") (e.g., blood alcohol content) from a non-invasive interaction with a vehicle operator (e.g., from a breath sample). **The analyzer may include, for example, an ethanol-specific fuel cell sensor, which generates an electric current having a magnitude that is related to a concentration of alcohol within a breath sample. Alternatively, the analyzer may utilize infrared spectroscopy or other technologies for detecting a concentration of alcohol from transdermal images.** From the detected alcohol concentration, the impairment sensor system 108 may determine a detected blood alcohol concentration

Whether and how systems have been validated to date and user acceptance

It is unclear where this system is in the process.

Sketch of Patent US8196694B2

More Information

- Patent filed in 2009 in the United States: US8196694B2. https://patents.google.com/patent/US8196694B2

125. GM

Methods and systems

The 2014 Patent is for driving monitoring system for impairment, and measures for intoxications, while also intersecting with autonomous vehicle technology.
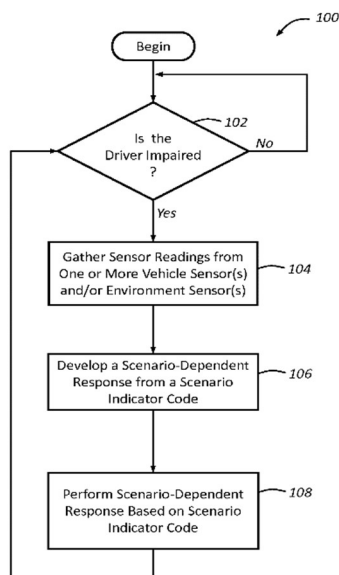
The Sketches are from Patent US9290174B1 shows the intersection of determining a driver state and engaging autonomous vehicle driving mode.
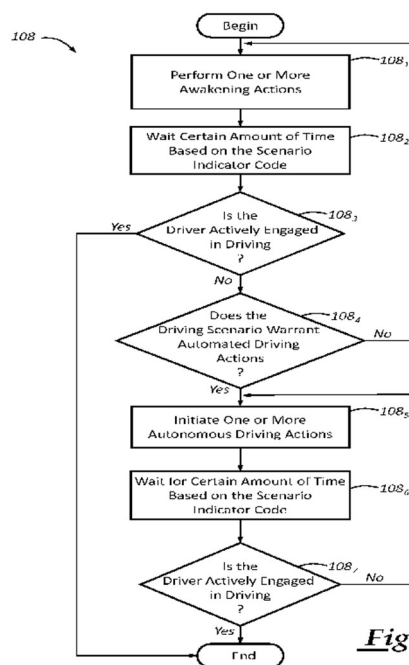
Figure 2

Figure 5

Figure 2 above shows a basic overview on how the system determines impairment, including that for intoxication as also described below from the Patent

> Beginning with step 102, the method determines whether the driver of the host vehicle is impaired, and may do so in any number of different ways. **An impaired driver may be a sleepy or drowsy driver, an injured or debilitated driver, or an intoxicated driver**, for example. Step 102 may employ any known method or technique for detecting an impaired driver, including techniques that rely on driver readings from driver sensors 18 to capture and evaluate images of the driver's face in order to look for slackening facial muscles, to evaluate the frequency, duration and/or pattern of eye closure, to examine the orientation or movement of the driver's head or body, or to monitor the direction or pattern of the driver's gaze, to cite a few possibilities. Movement of the driver may also be monitored by sensors located in the driver's seat to detect driver position, as well as sensors in the steering wheel to monitor the driver's hand position. In other examples, driver impairment is determined not by directly monitoring the face or body of the driver, but by evaluating the behavior or performance of the driver and looking for signs of impairment such as lane departure, inconsistent vehicle speed, erratic driving, etc.

Whether and how systems have been validated to date and user acceptance

Other auto companies have developed similar systems monitoring a driver and determining when Autonomous Vehicle will be engaged. It is unclear where GM is at with rolling out this technology.

More Information

- Patent filed in 2014 in the United States: US9290174B1.
  https://patents.google.com/patent/US9290174B1/en?oq=9290174

126. GM

Methods and systems

The Patent filed in 2016 is for a system monitors for impairment including for that of alcohol or other drugs. The Patent seems to have application with autonomous vehicle technology or finding a different mode of transportation if the driver is determined impaired. The Patent Abstract describes a comprehensive system that:

> The method includes detecting a first impairment level at a first time; detecting a second impairment level at a second time after the first time; based on the detected first impairment level and the detected second impairment level, determining a third impairment level at a third time after the second time; and inhibiting vehicle operation in response to determining that the third impairment level is greater than an impairment threshold. The apparatus and method may be used in a vehicle or other apparatus to prevent vehicle operator from operating the vehicle while impaired or prior to becoming impaired.
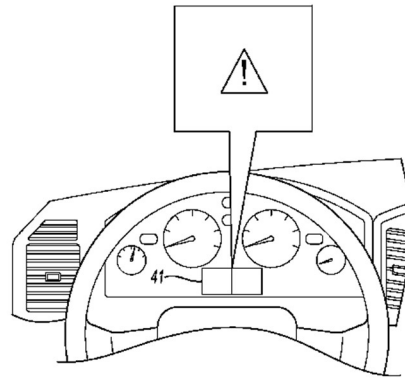
Fig-4A

Fig-4B

The Sketches to the right are from US20180037228A1 shows notification to warn of impairment

The Patent appears to allow for the user to call or request a ride if the driver is determined impaired by the system.
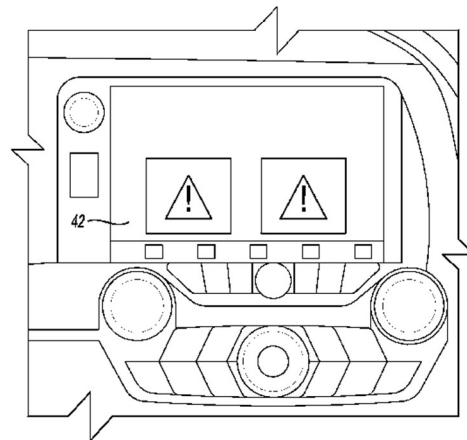
Whether and how systems have been validated to date and user acceptance

It is unclear if this technology has been developed or not.

More Information

Patent filed in 2016 in the United States: US20180037228A1.
https://patents.google.com/patent/US20180037228A1

127. GM

Methods and systems

The Patent filed in 2007 shows a system that monitors for forms of impairment including for those impaired by a substance. The system also seems to allow for the vehicle to take control if the driver is too impaired to operate a vehicle either by a substance or other form of impairment.

As it relates to measure for alcohol-impairment, this is the description from the Patent:

> The impairment measurement device 198 may measure a BAC each time a driver requests the starting of the engine 102 (e.g., each time and ignition key, button, or switch is operated). Alternatively, the impairment measurement device 198 may measure a BAC each time the ignition state 178 transitions to one or more of the "on" power modes (e.g., accessory, run, and/or crank). In addition, the impairment measurement device 198 may periodically measure a BAC during operation of the vehicle. This enables appropriate responses even if the impairment value changes during operation, as could be the case if the driver drinks alcohol while driving or shortly prior to driving the vehicle. The time between measurements, or a sample frequency, may be determined by the impairment control module 196.
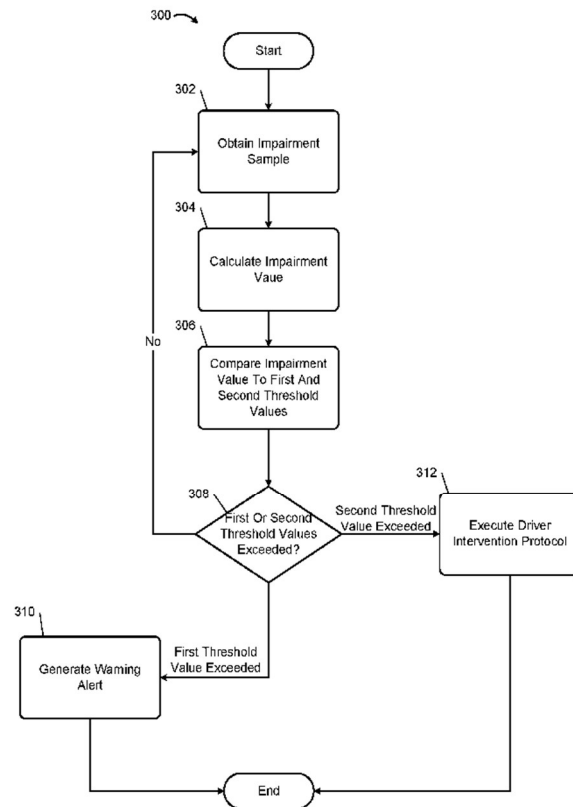
FIG. 3

The Sketch is from Patent US10507844B2, which describes how substance impairment is determined.

Whether and how systems have been validated to date and user acceptance

There appears to be a method in this Patent for the vehicle to take control if the driver too impaired. This is similar to other technologies developed by other companies.

More Information

Patent filed in 2017 in the United States: US10507844B2.
https://patents.google.com/patent/US10507844B2/en?oq=10507844

128. GM

Methods and systems

The 2019 Patent monitors for driver impairment and intersects with autonomous vehicle technology if a driver's state is too impaired by substance or unable to operate a vehicle.

The Patent notes the importance of detecting intoxication when it comes to autonomous vehicle technology "It is therefore desirable to restrict vehicle occupants from shifting their autonomous vehicle to a manual driving mode while they are intoxicated. It is further desirable to automatically transfer the autonomous vehicle out of its manual driving mode when its occupant(s) are detected as being impaired"

Whether and how systems have been validated to date and user acceptance

The technology outlined in the Patent is very similar to other technologies that aim to determine when the driver should go into autonomous vehicle driving mode depending on the state on the driver.

More Information

- Patent filed in 2019 in the United States: US10471969B1.
  https://patents.google.com/patent/US10471969B1/en?oq=10471969

129. Honda

Methods and systems

The Patent originally filed in 2015 and updated in 2017, 2019, and 2020 relates to driving monitoring to detect impaired drivers and the intersection with autonomous vehicle technology. The Patent is very extensive and includes over 144 sketches of the technology.
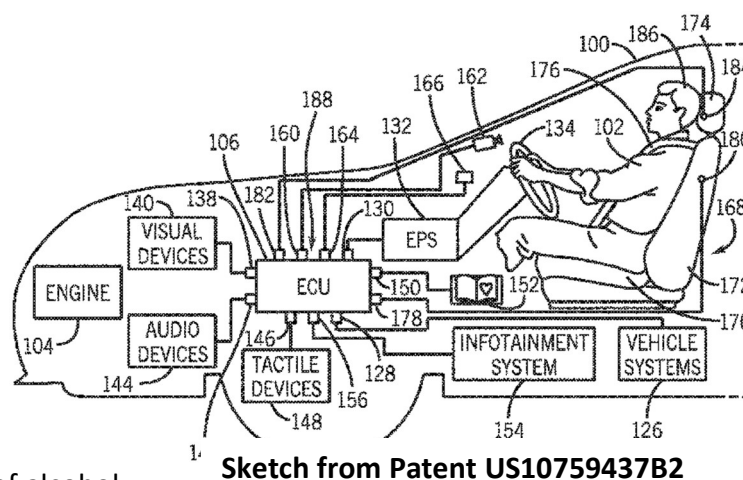
Sketch from Patent US10759437B2

Under the Patent, the determination of alcohol impairment is as follows:

> In another embodiment, **the ECU 106 can determine blood alcohol content (BAC) (e.g., blood alcohol levels) of the driver from information received by the blood alcohol content sensors 310**. For example, an optical sensor can emit light towards the driver's skin and measure a tissue alcohol concentration based on the amount of light that is reflected back by the skin. The BAC can be analyzed to determine if the BAC coincides with a particular physiological driver state. For example, high BAC can coincide with an impaired/distracted driver state (e.g., an intoxicated driver).

> The optical and thermal sensing devices can be used to monitor physiological information, for example, heart rate, pulse, blood flow, skin color, pupil dilation, respiratory rate, oxygen content, **blood alcohol**

The sketch on the right is from patent US10759437B2. 310 on the right shows that blood alcohol content sensors are part of the monitoring system. The Sketch also shows the many other sensors built into the technology to monitor the driver.

Whether and how systems have been validated to date and user acceptance

The Honda monitoring system also intersects with autonomous vehicle technology and seems to allow for the vehicle to take control if the drive is impaired is some fashion. The Patent has a lot of sensors associated with the DMS that monitor everything from the eyes, BAC, heart to the Brain.

This technology seems similar in concept to other technologies developed or in development by other auto companies.

More Information

Patent filed in 2019 in the United States: US10759437B2.
https://patents.google.com/patent/US10759437B2/en
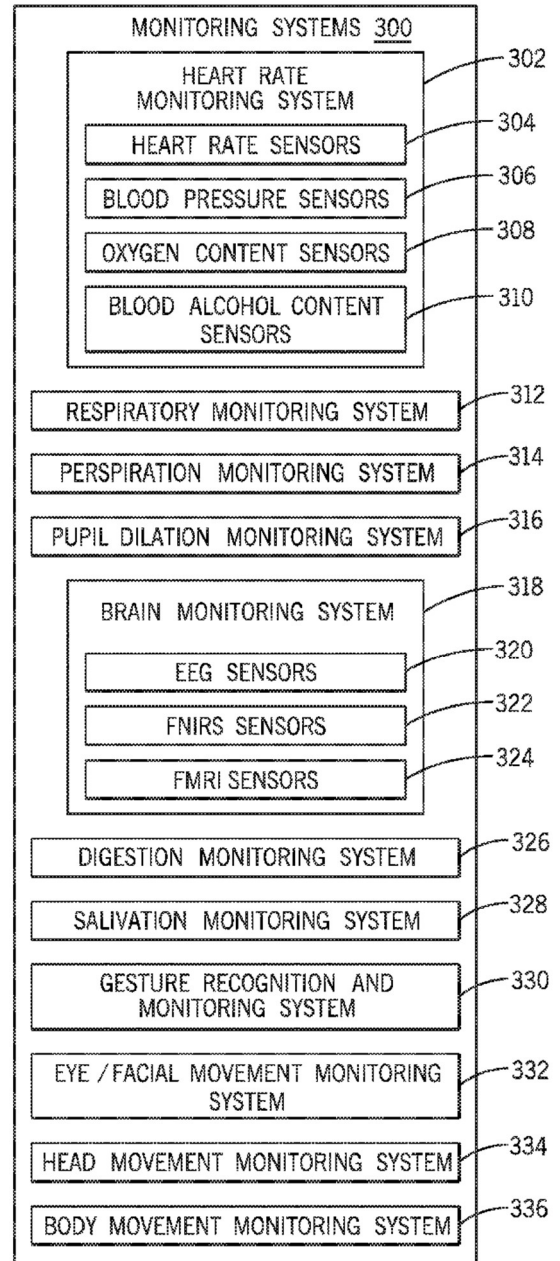
FIG. 3

130. Honda

Methods and systems

The Patent filed in 2014 is for alcohol detector level for the driver of the vehicle. From the abstract:

> A vehicle control system includes an alcohol detector which detects an alcohol intake level of a driver of a vehicle; and a controller which determines whether the driver is a drunk person based on a detection result obtained from the alcohol detector, and which stops the vehicle when a determination result that the driver is the drunk person is obtained. After a door of the vehicle is switched from a closed state to an open state, and before an operation of a start-up of the vehicle is performed, the controller controls the alcohol detector so that a detection of the alcohol intake level is started, and allows a travelling of the vehicle before the detection result is output from the alcohol detector.

FIG. 1

FIG. 2

Sketch is for Patent US9073431B2

The sketch above the Patent shows the working of the alcohol sensors. The patent describes this sketch:

> The alcohol detector 11 is disposed in the vicinity of a driver seat 1 a of a vehicle 1. For example, the alcohol detector 11 includes a breathalyzer type alcohol sensor 11A that is provided on an upper surface of a steering column cover 31, a breathalyzer type alcohol sensor 11B that is disposed on an instrument panel 33 farther outside than a steering wheel 32 in a width direction of the vehicle 1, and two touch type alcohol sensors 11C that are provided on the steering wheel 32.

> Each of the breathalyzer type alcohol sensors 11A and 11B detects an alcohol density in an exhalation of a driver of the vehicle 1 as an alcohol intake level of the driver, and outputs a signal indicating a detection result of the alcohol density to the controller 14.

> Each of the touch type alcohol sensors 11C detects the alcohol density in the sweat secreted from surfaces of the palm or the fingers of the driver, or in the subcutaneous tissues of the driver as the alcohol intake level, and outputs the signal indicating the detection result of the alcohol density to the controller 14.

Whether and how systems have been validated to date and user acceptance

It is unclear if this technology has been incorporated into another Honda Patent or other technology, but this technology has yet to be announced.

More Information

- Patent filed in 2014 in the United States:
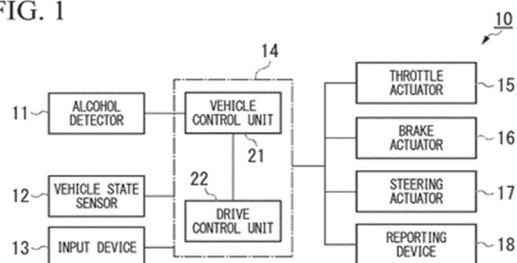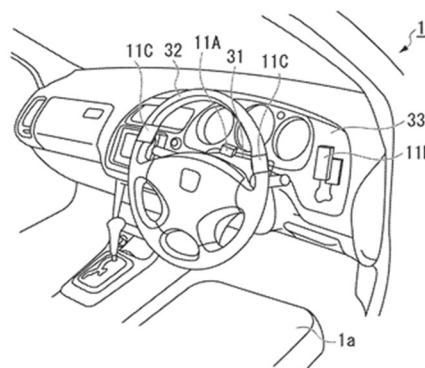 https://patents.google.com/patent/US9073431B2/en?oq=9073431

131. Honda

Methods and systems

The Patent filed in 2018 could determine if a driver is intoxicated based off speech recognition. The technology also intersects and could enable autonomous vehicle driving technology. The Patent states:
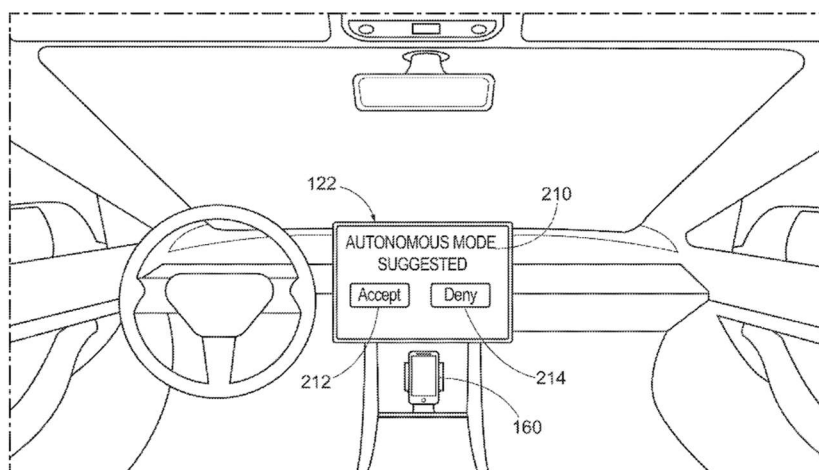

FIG. 2   **Sketch is for Patent US10789973B2**

> The controller may automatically enable autonomous driving based on the estimated state of the driver being intoxicated. The system may include a transmitter transmitting a warning signal to a mobile device based on the estimated state of the driver. The system may include a transmitter transmitting a rideshare signal to a mobile device associated with launching a rideshare application based on the estimated state of the driver. The system may include a display displaying a warning notification based on the estimated state of the driver.

The sketch on the right shows the system determines a driver state is below. The Patent describes it as:

> FIG. 3 is a flow diagram of a method 300 for driver management, according to one aspect. The method 300 may include receiving 302 a first speech segment of a driver of an autonomous vehicle at a first time and a second speech segment of the driver of the autonomous vehicle at a second time or merely receiving a speech segment of the driver. The method 300 may include tracking 304 a prior destination, a future destination, a route, a set of waypoints, etc., associated with the driver of the autonomous vehicle. The method 300 may include determining 306 an estimated state of the driver based on the one or more speech segments, the destination(s) or locations associated with the driver of the autonomous vehicle, and a calendar event associated with the driver of the autonomous vehicle, and controlling 308 operation of a vehicle system of the autonomous vehicle or a mobile device 160 based on the estimated state of the driver.
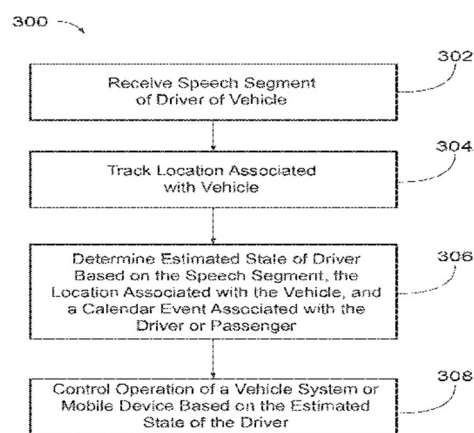

FIG. 3

Whether and how systems have been validated to date and user acceptance

The technology in this Patent which allows for Autonomous vehicle control based off of the driver's state is in development or developed by other Auto companies.

More Information

- Patent filed in 2018 in the United States: US10789973B2.
  https://patents.google.com/patent/US10789973B2/en?oq=10471969

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132. Hyundai

Methods and systems

The Patent filed in 2017 includes a monitoring system that monitors for brainwaves using a seat headrest. The system seems to intersect with autonomous vehicle technology depending on the state of the driver.

The Patent describes the sketches on the right of how a drunken state might look like based off of brainwaves:

> As illustrated in FIG. 9, the brainwave signal based on the driver state may be determined by using the maximum amplitudes of the brainwave signals**. As described with reference to FIG. 8, the P300 potential component of the ERP has a feature of representing that the brainwave signal rises or increases after about 300 ms (a dotted rectangular part)** if the normal reaction is made with respect to the auditory stimulation signal. Referring to FIG. 9 based on the above feature, it may be recognized that a dotted curve and a solid curve have the maximum amplitudes after about 300 ms from that the stimulation starts.
> **The dotted curve represents the brainwave signal of a driver in a normal state and the solid curve represents the brainwave signal of the driver in a drunken state**. As described above, the brainwave signals of the driver in the normal state and the drunken state have the maximum amplitudes after about 300 ms from that the abnormal stimulation starts.
>
> **However, the brainwave signal of the driver in the drunken state is lower than the brainwave signal of the driver in the normal state in the maximum amplitude value.** Accordingly, it may be understood that the driver is more insensitive to the stimulation from the outside in the abnormal state rather than the normal state
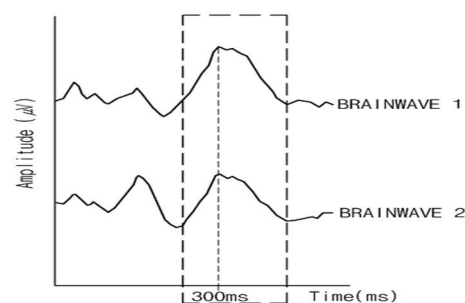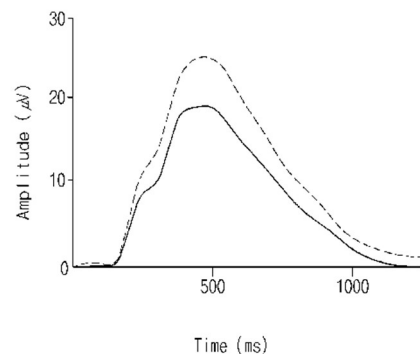
FIG. 8

FIG. 9

Whether and how systems have been validated to date and user acceptance

It is unclear if the technology from this Patent is incorporated to other driver monitoring systems by Hyundai or if this will be incorporated with determining when a vehicle will go into autonomous driving mode based off the driver's state.

More Information

Patent filed in 2017 I the United States: US20190161091A1.
https://patents.google.com/patent/US20190161091A1.

133. Hyundai

Methods and systems

A Patent filed for technology that monitors a driver's state using cameras and other sensors. The Patent states it can determine "a state of a driver to determine his or her impaired state by determining his or her state based on his or her reflex response time according to behavior of a vehicle."

As shown in the sketch to below from the Patent and described throughout the technology, the Patent also involves Autonomous Vehicle driving technology depending on the driver's state:

If the present disclosure is applied to a fully autonomous vehicle or a partially autonomous vehicle and if it is determined that the driver is in the impaired state, the determination device 30 may adjust a time when control of the vehicle is transferred to the driver, may adjust a type of control transferred to the driver, or may make an emergency stop of the vehicle on a safety zone.
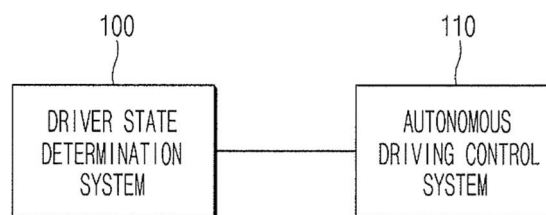
In other words, as shown in FIG. 4, **if it is determined that the driver is in the impaired state by the driver state determination system 100, an autonomous driving control system 110 may adjust a time when control of the vehicle is transferred to the driver**, may adjust a type of control transferred to the driver, or may make an emergency stop of the vehicle on a safety zone.

FIG.4

Whether and how systems have been validated to date and user acceptance

The Patent is similar to other technologies in developed or development that can determine a driver's state and take over control of the vehicle if the driver is incapacitated.

More Information

Patent filed in 2017 in the United States: US10558875B2.
https://patents.google.com/patent/US10558875B2/en

134. Bosch

Methods and systems

The Patent is for a camera-based system to determine if a person is under the influence of alcohol or fatigued. The Patent is for gauging the reaction time of a driver. The Patent describes the technology:

In order to determine a condition of a driver, for example under the influence of fatigue or alcohol, the reaction time and also the size of the range of vision can be included as important bases for measurement. Reaction time becomes slower when the driver is tired or under the influence of alcohol. In addition, the size of the visual field in which movements are still perceived becomes smaller. This is referred to for example as tunnel vision.

Fig. 1

Sketch is from Patent US20160046295A1.

The Patent describes the sketch to the right:

In FIG. 1, a so-called tunnel vision situation is shown, which is distinguished by a small angle and which permits the inference that driver 2 is under the influence of alcohol or is tired.
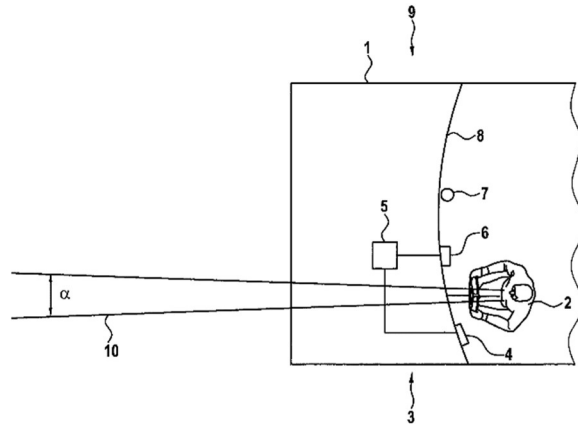
View recognition device 3 is part of a device 9 for determining a reaction time of vehicle driver 2. The described elements of view recognition device 3, namely camera 4, computing device 5, and display device 6, can also be part of device 9 for determining the reaction time. For the recognition of the reaction time, computing device 5 is configured to determine or to measure the time between the displaying of visual stimulus 7 and the recognition of the acquisition of visual stimulus 7 by vehicle driver 2. This time duration corresponds to the reaction time of driver 2.

Whether and how systems have been validated to date and user acceptance
It is unclear if Bosch has incorporated aspects of this Patent into other technology.

More Information
- Patent filed in 2014 in the United States: US20160046295A1. https://patents.google.com/patent/US20160046295A1

135. DENSO Corp, Soken Inc

Methods and systems
The Patent originally filed in 2008 in Japan uses a camera and other direct sensors to determine alcohol-impairment. The camera detection aspect seems intended to verify the identity of the user of the vehicle. However, the alcohol sensor technology is described as:

The alcohol concentration determiner calculates an index value of a blood alcohol concentration of the driver based on the pulse detected at the detection part by the sensor, and determines whether the index value exceeds a criterial value of a drinking assessment or not. The permission means permits the driver to start an engine of the vehicle when it is determined by the individual certification means that the driver of the vehicle is the authorized person and it is determined by the alcohol concentration determiner that the index value does not exceed the criterial value of the drinking assessment. The sensor is configured to detect the pulse of the driver at the detection part and to take the image of the detection part when the driver brings the detection part close to the case.
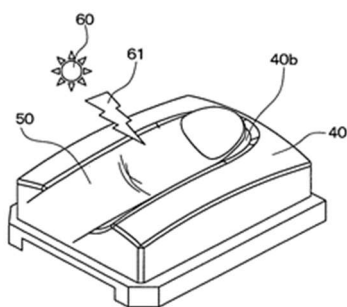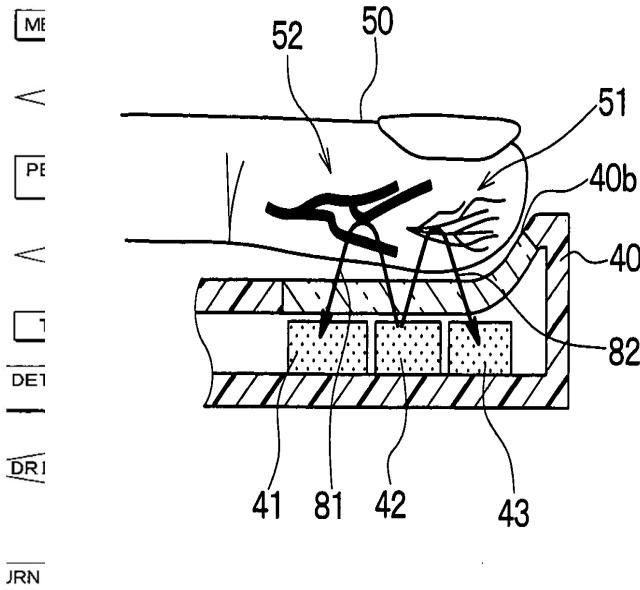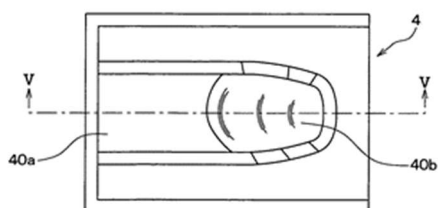
FIG. 7

FIG. 3

FIG. 4

The sketches above from the Patent show a touch based system to dertimine alcohol impairment.

The sketch to the right of the Patent shows how the system would operate or not operate depending if the user is alcohol impaired.

Whether and how systems have been validated to date and user acceptance
This Patent has been around in Japan since 2008 and in the United States since 2009. It is unclear if this technology has been fully developed or not.

More Information
- Patent filed in the United States in 2009: US8469134B2.
  https://patents.google.com/patent/US8469134B2/en?oq=8469134

136. Faurecia Automotive Seating LLC

Methods and systems

The Patent is for seat sensors that can help in determining a driver or occupant's state. The Patent describes how the technology could work with other car systems to substance impairment:

> A driver-capability assessment mode may use sensor data collected by electronics system 16 to determine if the driver's capability to operate the vehicle is impaired due to overload, fatigue, drowsiness, stress, and alcohol or drug impairment. As a result, computer 54 may command via output 56 various equipment in the vehicle to communicate to the driver that their capability is impaired. Computer 54 may also take command of the vehicle to slow the vehicles speed or call for assistance.

The Sketches of the Patent shows how the sensors (16) in the seat may help detect possible impairment by the driver.
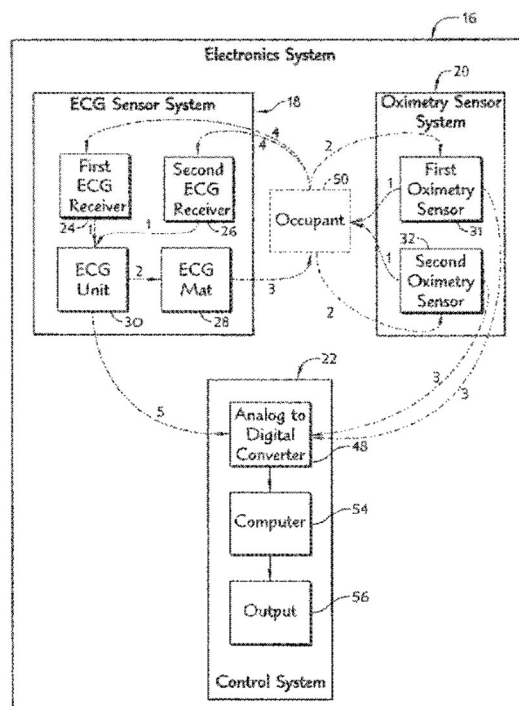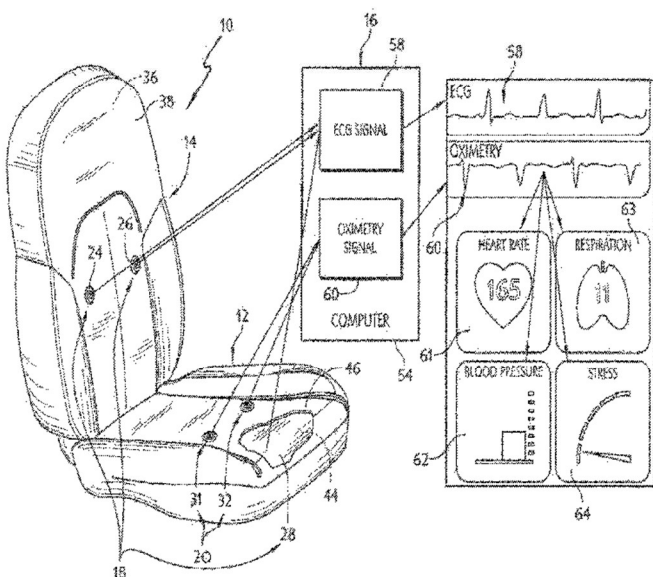
FIG. 8

Whether and how systems have been validated to date and user acceptance

It is unclear if this technology has advanced since the original Patent. Other companies are also looking into seat-based monitoring technology.

More Information

- Patent filed in 2015 in the United States: US9848814B2.
  https://patents.google.com/patent/US9848814B2

137. Valeo Comfort and Driving Assistance SAS

Methods and systems

The Patent is for technology that monitors a driver through a camera and other sensors and can determine an alcohol impairment level based off touch sensors.

Although this technology does have a component to verify the identity of a driver. It is mainly focused on determining the alcohol level through a touch-based method, where a driver puts his hand on the hand rest to determine the alcohol level. IT is unclear if there are alcohol sensors elsewhere.

The sketch to the right is from the Patent on how the system operates. The sketch below is of the touch-based sensor from the Patent.
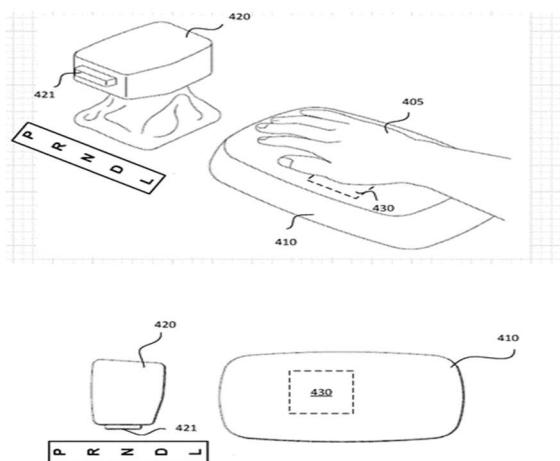
FIG. 4
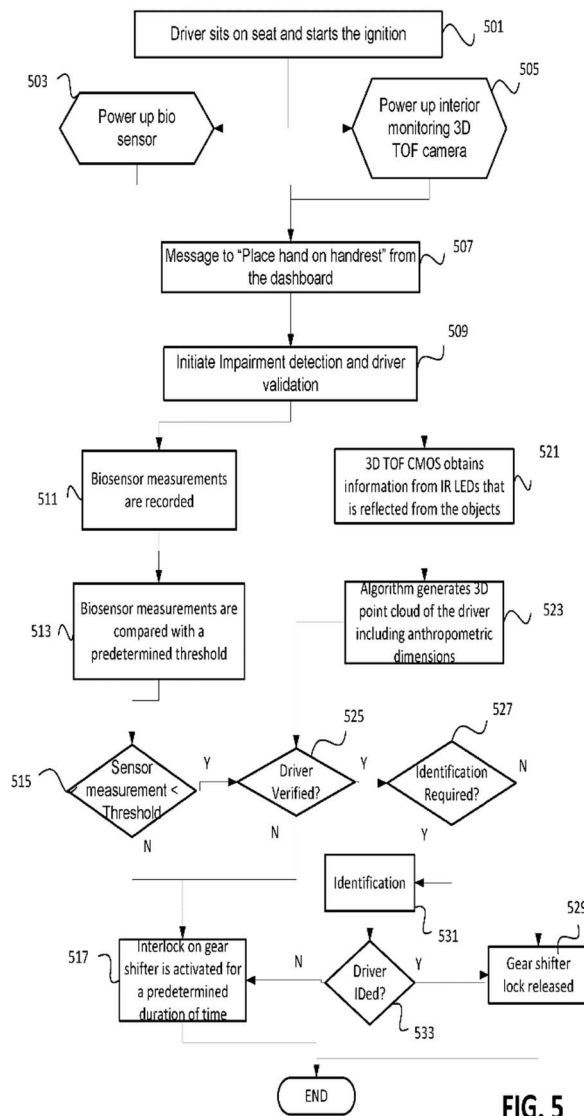
FIG. 5

Whether and how systems have been validated to date and user acceptance

It is unclear where this technology system at in the stage of development. It seems placing a person's hand on a hand rest may be an additional step to operating a vehicle, which would make this technology undesirable.

More Information

- Patent filed in 2018 in the United States: US20200122731A1.
  https://patents.google.com/patent/US20200122731A1/en?oq=20200122731

138. State Farm Insurance

Methods and systems

The driving monitoring technology in the Patent relates to "system and a method for determining the gaze location of a vehicle operator and, more particularly, to a device that can be installed in a vehicle to observe the gaze location of the vehicle operator and provide recommendations to the vehicle operator to improve performance."

The technology can be paired with other sensors, including that for alcohol to determine impairment either through a mobile phone or onboard computer. The Patent states "an alcohol sensor may detect whether there is alcohol in the vehicle operator's 106 breath and/or in the air inside the vehicle 108, which may indicate that the vehicle operator 106 is intoxicated."
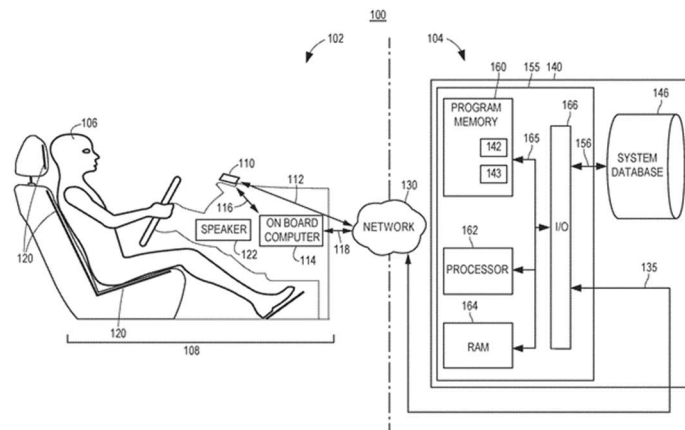

FIG. 1

Sketch is for Patent US10343693B1

Whether and how systems have been validated to date and user acceptance

This technology seems like it is more for testing affects of impairments and possibly as a measure to help improve driving of those who might drive impaired. There are three other similar Patents from State Farm relating to monitoring of driving behavior.

More Information

- Patent originally filed in 2012 in the United States: US10343693B1.
  https://patents.google.com/patent/US10343693B1.

139. State Farm Insurance

Methods and systems

The Patent is aimed at improving autonomous vehicles and specifically for "operating autonomous vehicles based on a state of an individual with the vehicle." The Patent discuss the integration of sensors for alcohol impairment in addition to capturing images of the driver.

Fig. 1A (pictured right) from the Patent is described below with the sensors:

According to some embodiments, the set of **sensors may also include a breathalyzer or similar type of device that may be configured to measure a BAC reading of the individual** 102. It should be appreciated that additional sensors configured to detect a reading associated with a current state of the individual 102 are appreciated, including the image sensors 105, 106, 107. Further, in implementations, it **should be appreciated that additional sensor devices that may be able to detect the same or alternate states of impairment (e.g., those caused by alcohol, marijuana, prescription drugs, controlled substances, energy products, etc.)** are envisioned.
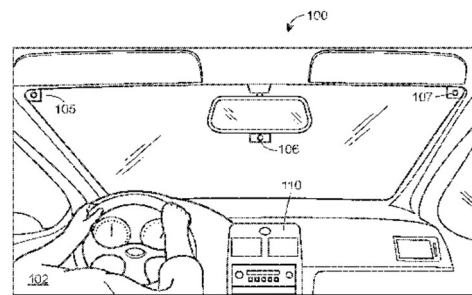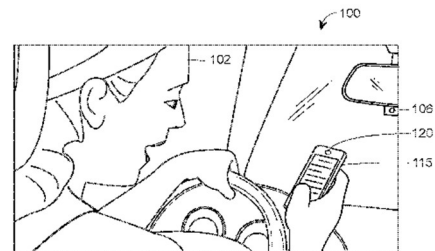

FIG. 1A

FIG. 1B

Whether and how systems have been validated to date and user acceptance
It is unclear if this technology is for testing purposes of differing levels of Autonomous Vehicle technology or if is for something different.

More Information
- Patent filed in 2018 in the United States: US10549759B1. https://patents.google.com/patent/US10549759B1.

140. State Farm Insurance
Methods and systems
This Patent filed in 2016 and updated in 2019 is very similar to the Patent mentioned in 139. (US10549759B1). However, this Patent is specific to monitoring the driver as opposed to the intersection of Autonomous Vehicles. The Patent abstract notes:

> The electronic device may also access certain data related to a condition of the individual, and may accordingly determine whether the individual is fit to operate the vehicle. If the individual is unfit to operate the vehicle, the electronic device may generate and display a notification that warns of the dangers of operating the vehicle and encourages the individual to not operate the vehicle.

This Patent also works sensors for alcohol and other drugs in determining the driver's state.

Whether and how systems have been validated to date and user acceptance
It is unclear the goal of this device, but any driving monitoring device that requires extra action by a user seems not workable for mass production.

More Information
- Patent Filed in 2019: US10828985B1. https://patents.google.com/patent/US10828985B1

141. Nauto, Inc.
Methods and systems
Patent for a method for analysis of driver behavior including monitoring for distracted driving based off the movement of the steering wheel and other sensors. The Patent states:

> In an embodiment, the measure of driver distraction can include a driver distraction score, with a range between 1 and 10, wherein 1 corresponds to a non-distracted state and 10 corresponds to a maximally

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distracted state. **For example, the score can be based on determined distraction analysis such as a driver distraction categorization (e.g., categorization from a set of categories including highly or overly vigilant, drunk or cognitively impaired,** struggling or labored driving, distracted and/or fatigued, and any other suitable category),

The technology provides information on driver distraction and could also take control of the vehicle to avoid unsafe driving.

Whether and how systems have been validated to date and user acceptance
It is unclear if this is on the market.

More Information
- Patent filed in 2019 in the United States: US20200198645A1.
  https://patents.google.com/patent/US20200198645A1/en

142. FutureWei Technologies Inc
Methods and systems
Uses "Machine Learning" to evaluate driver condition and the cabin conditions. The Patent states it uses a "machine learning method, the images are processed to classify a condition of the driver and of the interior environment of the vehicle."

The system intersects with the operation of an autonomous vehicle and also could detect alcohol and drugs in the interior environment of the vehicle. The system can be used to determine a person's facial expressions if the driver is drunk. Below is a sketch from the Patent.
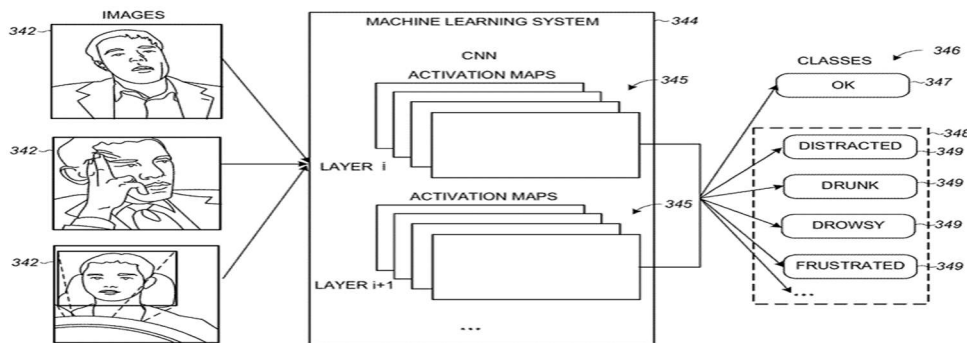

FIG. 3B

Whether and how systems have been validated to date and user acceptance
It is unclear where this technology is at in development, but there are other technologies that use cameras and Artificial Intelligence in determining the state of a driver.
More Information
- Patent filed in 2017 in the United States: US10592785B2.
  https://patents.google.com/patent/US10592785B2

143. BOE Technology Group Co Ltd
Methods and systems
The Patent is for a system that uses a license and alcohol monitoring of some kind to determine state of driver. The Patent states it could capture alcohol impairment:

An alcometer may be used to detect the alcohol content of the driver. The alcometer may be an infrared sensor, which may output a laser beam at a stable frequency through a semiconductor laser and then capture an absorption peak of alcohol (with the interference from any other gases being removed) so as to detect the alcohol content of the driver. A detection error may be reduced through adjusting a wavelength of the laser beam. The optical detection method has rapid response and high stability. The alcometer may be mounted on a steering wheel of the vehicle, so as to detect the alcohol content in a contacted manner, thereby to reduce, during the detection in a contactless manner, the detection error caused in the case that a passenger in the vehicle has drunk or the alcohol exists in the air.

Whether and how systems have been validated to date and user acceptance

Any monitoring system that requires an additional step by the driver (figuring out the driver's license of the user) is difficult to build public acceptance.

More Information

Patent Filed in 2015 in the United States: US20170144628A1.
https://patents.google.com/patent/US20170144628A1

144. American Vehicular Sciences LLC

Methods and systems

The Patent is for technology that monitors a driver for drowsiness or "otherwise unable to operate the vehicle." The technology also utilizes other sensors to determine a driver's state.

The technology could also determine if the driver is drunk through "The vehicle interior monitoring system could also determine that the object is an adult, that he is drunk and that he is out of position relative to the airbag."

The sketches to the right are from the Patent. Figure 6 shows where various sensors for could be placed including that for a heart sensor.

FIG. 5

FIG. 6
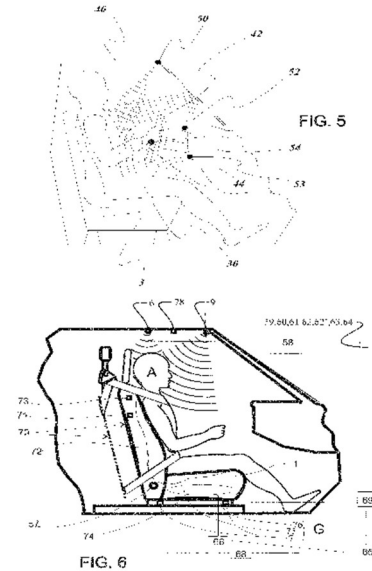
Whether and how systems have been validated to date and user acceptance

It is unclear if any of this technology has been tested and developed.

More Information

- Patent filed in 2013: https://patents.google.com/patent/US9129505B2/en

145. Ha Q Tran

Methods and systems
Whether and how systems have been validated to date and user acceptance
More Information

    a. Camera that can monitor driver behavior for level 3 autonomous driving including alcohol/drug impairment (Patent filed in 2019): https://patents.google.com/patent/US10768620B1

146. 장종욱이재웅

Methods and systems

The Patent is for technology that can directly detect the alcohol content of a driver and switch the vehicle to autonomous vehicle if the driver is determined impaired.

The Patent says:

> The drinking state determining unit includes a driver recognizing unit for recognizing a driver who sees whether the vehicle is seated and to detect respiration, an exhale amount measuring unit for measuring the amount of exhaled breath of the driver, an alcohol concentration And an alcohol concentration value measuring unit for measuring the alcohol concentration value.

> The driving mode setting unit may set an autonomous driving mode when the measured alcohol concentration value is equal to or greater than a predetermined concentration value.

Whether and how systems have been validated to date and user acceptance

It is unclear if the technology has been verified and some information is lost in the translation from Korean to English in the Patent.

More Information

- Patent filed in 2017 in Korea: KR20190079568A.
  https://patents.google.com/patent/KR20190079568A

147. 张晨成

Methods and systems

The Patent is for an alcohol sensing device that also uses a camera to determine the state of the driver. The technology appears to capture images of the driver before entering the vehicle as noted in the Patent:

> The sensing device comprises a smell detection device for detecting smell in the vehicle, and when alcohol is detected in the vehicle, the control processor judges that the operation of the user is abnormal; the image shooting device is used for shooting images outside the vehicle; the control processor also comprises a storage module, wherein the storage module is internally pre-stored with the user image and the normal walking gait of the user

Whether and how systems have been validated to date and user acceptance

The Patent is from China and some of the information on the technology may be lost in translation. It is unclear how far this technology has progressed what type of additional steps might need to be taken by a driver.

More Information

- Patent filed in 2017 in China: CN107618369B.
  https://patents.google.com/patent/CN107618369B/en?oq=10471969

148. 方昌銮孙继业周清华杨云林

Methods and systems

The system monitors using software, cameras, and other sensors to determine alcohol impairment.

Whether and how systems have been validated to date and user acceptance

The Patent is automatically translated from Chinese, so some of the exact details may be lost. Some aspects described in the Patent as described above are used in other DMS in development or deployed elsewhere.

More Information

- Patent filed in China in 2019: CN109606106A.
  https://patents.google.com/patent/CN109606106A/en

149. 李东林

Methods and systems

Eye based and alcohol sensor-based driver monitoring system.

Whether and how systems have been validated to date and user acceptance

The Patent is automatically translated to English from Chinese so all of the information and details of the Patent may have been lost in translation. In addition, the Patent was filed in 2020.

More Information

- Patent filed in 2020 in China: CN111572457A.
  https://patents.google.com/patent/CN111572457A/en

150. 苏彦明

Methods and systems

The Patent uses sensors and facial recognition to determine if the driver is impaired by alcohol. The Patent translates to "If the face recognition and the alcohol detection are both passed, controlling to allow the vehicle to start, and if the face recognition or the alcohol detection is not passed, controlling to forbid the vehicle from starting"

Whether and how systems have been validated to date and user acceptance

The Patent is automatically translated to English from Chinese so all of the information and details of the Patent may have been lost in translation. In addition, the Patent was filed in 2019.

More Information

- Patent filed in 2019 in China: CN111086519A.
  https://patents.google.com/patent/CN111086519A

151. 허치영신용수

Methods and systems

The Patent is for a camera and headrest sensor to determine drunk driving impairment.

Whether and how systems have been validated to date and user acceptance

The original Patent was filed in Korea in 2009 it appears that Patent may have lapsed. There is another Patent filed in 2010 in the International Patent System.

More Information

- Patent filed in 2010: WO2011037368A2.
  https://patents.google.com/patent/WO2011037368A2/en

Technologies that directly monitor for alcohol impairment, which typically measure a person's breath or skin.

152. Driver Alcohol Detection System for Safety

Methods and systems

The Driver Alcohol Detection System for Safety began with federal government funding in 2008, which led to a cooperative agreement between the National Highway Traffic Safety Administration (NHTSA) and the auto industry. The research project focused on the creation of a proof-of-concept prototype to determine which type of alcohol detection technology was most promising for vehicle integration. In 2013 the cooperative agreement was extended to further develop a touch based and breath-based alcohol detection technology. In June 2015, the Department of Transportation unveiled the DADSS vehicle, and auto industry representatives stated at the event the technology could be deployed in less than five years.

Whether and how systems have been validated to date and user acceptance

There is still not a vehicle ready for commercial or consumer use.

More Information

- Driver Alcohol Detection System for Safety: https://www.dadss.org/.
- "Drunk-Driver Proof Cars Could Be Sold by 2020," Newsweek. June 8, 2015. https://www.newsweek.com/drunk-driver-proof-cars-could-be-sold-2020-340706

153. Automotive Coalition for Traffic Safety

Methods and systems

Touch based sensor that uses optical sensors that can determine alcohol concentration.

Whether and how systems have been validated to date and user acceptance

The original Patent dates to 2011 and the most recent Patent is in 2019. The technology is currently not available on any commercial or consumer vehicles.

More Information

- Patent Filed in 2019 in the United States: US20190275886A1. https://patents.google.com/patent/US20190275886A1/en

154. Automotive Coalition for Traffic Safety

Methods and systems

Passive alcohol breath-based alcohol sensors

Whether and how systems have been validated to date and user acceptance

The Patent was filed in 2016 and the technology is not available for commercial or consumer use.

More Information

- Patent filed in 2016 in the United States: US20170274768A1
  https://patents.google.com/patent/US20170274768A1/en?oq=20170274768

155. Automotive Coalition for Traffic Safety

Methods and systems

A Patent for a breath based alcohol sensor that can also detect a person's voice. The Patent says:

> The technology utilizes a speech recognition system that can understand a driver's voice command such as "start car". The alcohol measurement is taken in real-time and synchronized to the driver giving the voice command. If the system detects a BAC measurement above a predetermined threshold, the vehicle is disabled or prevented from moving. The system may give warnings if the measurement is above a predetermined threshold.

Whether and how systems have been validated to date and user acceptance

The Patent was filed in 2019 and is still in development as part of the DADSS system.

More Information

- Patent filed in 2019 in the United States: US20200101982A1.
  https://patents.google.com/patent/US20200101982A1/en?oq=20200101982

156. Ford

Methods and systems

Touch based sensor to determine alcohol or drug impairment on a start/stop ignition button.

A sketch of the Patent is on the right.

Whether and how systems have been validated to date and user acceptance

The Patent was filed in 2006 with the European Patent office. It does not appear anything has happened with this technology.
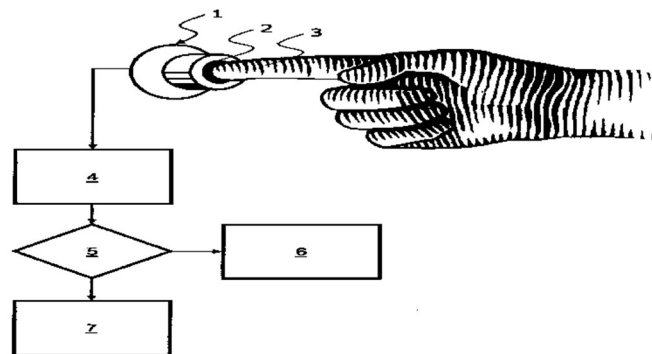
FIG. 1

More Information

- Patent filed in 2006 by the European Patent Office: EP1849644B1.
  https://patents.google.com/patent/EP1849644B1

157. Toyota

Methods and systems

The Patent is for a breath/air and touch based system for alcohol. The Patent Abstract says:

> A drunk driving prevention system is equipped with an external server and an on-vehicle component. The on-vehicle component is equipped with a detection unit that detects an alcohol concentration of a driver, an acquisition unit that acquires information on a current position of a vehicle, and a communication unit that transmits to the external server the alcohol concentration as well as the current position information. The external server is equipped with a storage unit that stores a plurality of criteria that relate to an alcohol concentration falling under drunk driving and are different from one another as a result of geographical differences, a communication unit that receives the alcohol concentration and the current position information, and a determination unit that determines, based on that one of the criteria, whether the alcohol concentration received is an alcohol concentration falling under drunk driving.

FIG.6

Sketch is from Patent US20120245763A1

Whether and how systems have been validated to date and user acceptance

The 2012 Patent was abandoned in the United States but the Patent from 2011 in Japan is still pending.

More Information

- Patent filed in 2012 in the United States: US20120245763A1.
  https://patents.google.com/patent/US20120245763A1/en?oq=20120245763

158. DENSO

Methods and systems

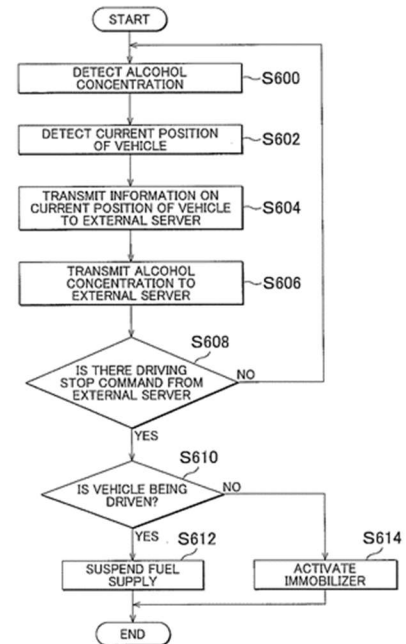A Patent for a touch and sensor based for alcohol impairment

Whether and how systems have been validated to date and user acceptance

The Patent was filed in 2008 and it is unclear of the status of this technology.

More Information

Patent filed in 2008 in the United States: US8469135B2.
https://patents.google.com/patent/US8469135B2

159. DENSO

Methods and systems

The Patent is for technology that includes breath and air-based alcohol sensors. The Patent states:

> An alcohol detection system detects alcohol concentration in breath air of a driver seating in a vehicle, permits normal travel of the vehicle when alcohol concentration measured under the predetermined stable operation state is below a threshold level, and prohibits travel of the vehicle over a predetermined travel speed when the alcohol concentration is over the threshold level. The alcohol detection system detects a pre-driving output signal outputted necessarily before an engine switch is manipulated, and instruct start of an alcohol measurement preparation operation when the pre-driving output signal is detected. Thus, measurement of alcohol concentration can be started without necessitating long wait time.

Whether and how systems have been validated to date and user acceptance

The Patent is from 2009 and it is unclear if this technology has been developed further or adapted into other technology.

FIG. 6

Sketch from Patent US8201437B2

More Information

- Patent filed in 2009 in the United States: US8201437B2.
  https://patents.google.com/patent/US8201437B2/en?oq=8201437

160. DENSO

Methods and systems

The Patent is for a passive breathe based alcohol sensors. The Patent states the technology is:

> An alcohol concentration detecting device for a vehicle includes an alcohol sensor to detect alcohol component contained in an expiration of an occupant of the vehicle, a gas sensor to detect gas components other than the alcohol component contained in the expiration, and an alcohol-detecting controller to calculate alcohol concentration based on detection value of the alcohol sensor. The alcohol-detecting controller corrects the calculated alcohol concentration based on detection value of the gas sensor. The alcohol sensor and the gas sensor are configured to further detect a state of air in a passenger compartment of the vehicle.

Whether and how systems have been validated to date and user acceptance

The Patent was filed in 2010 and it is unclear if this technology has been further developed.

More Information
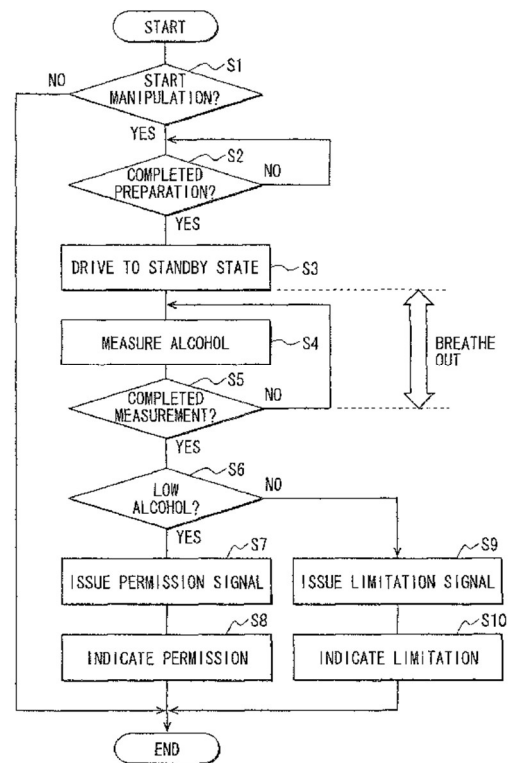
- Patent filed in 2010 in the United States: US8441357B2
  https://patents.google.com/patent/US8441357B2/en?oq=8441357

161. Continental

Methods and systems

The Patent is for a touch-based sensor to determine alcohol impairment. The Patent says the technology would "equip the driver of an accessory on which is mounted an electronic module comprising a microprocessor, means for measuring the BAC by near infrared spectrometry arranged to extend in contact with the skin of the conductor equipped with the said accessory, and means for transmitting and receiving signals."

Whether and how systems have been validated to date and user acceptance

There are other Patents for similar technology, and it is unclear of the status of this Patent.

More Information

- Patent filed in 2009: WO2011038803A1.
  https://patents.google.com/patent/WO2011038803A1

162. Joyson Safety Systems Acquisition LLC

Methods and systems

The Patent is for a seat based and touch based alcohol sensors

The Sketch on the right is of the Patent. Figure 2 is described as:

FIG. 1

FIG. 2

> A blood alcohol detection system is provided. The blood alcohol detecting system includes a finger sensor 50 for sensing the finger of the vehicle driver. The results of the interaction between the finger sensor and the driver's finger are analyzed by a controller to determine the blood alcohol concentration of the driver. The sensor and alcohol detecting system may employ any of a number of known technologies. For example, the alcohol detection systems disclosed in U.S. Patent Documents Nos. 6,229,908, 7,413,047 and 2010/0036592 may be employed. Also, the scope of the present invention is not limited to the use of a finger sensor. For example, as disclosed in U.S. Pat. No. 7,413,047 the sensor may rely on the interaction between the driver's hand and the steering wheel of the vehicle.
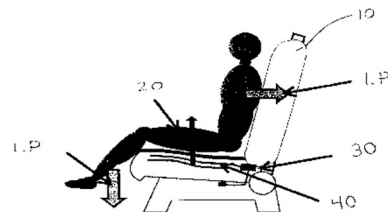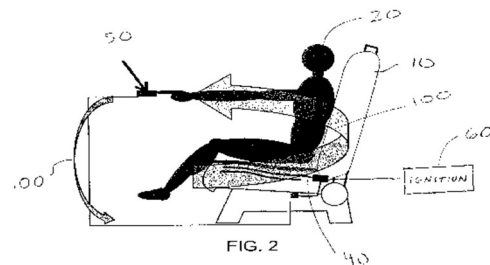
More Information

- Patent filed in 2011 in United States: US20120228047A1.
  https://patents.google.com/patent/US20120228047A1/en?oq=20120228047

163. LG Electronics Inc

Methods and systems

A Patent for air and touch sensor for alcohol and could switch the vehicle to self-driving mode depending on the state of the driver.
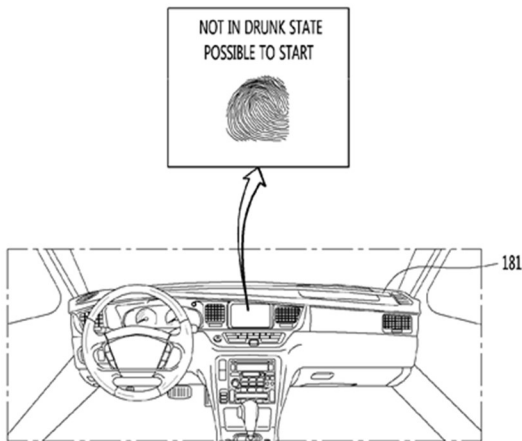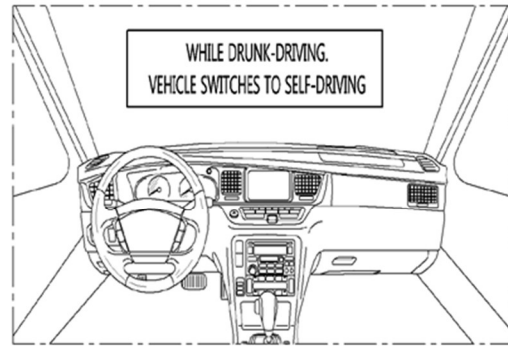
FIG.7

FIG.9

FIG.8

FIG.10

**Sketches from Patent US10435027B2**

More Information

- Patent filed in 2015 in the United States: US10435027B2.
  https://patents.google.com/patent/US10435027B2/en?oq=10471969

164. LG Innotek Co Ltd

Methods and systems

The Patent is for a touch-based alcohol sensor system. The Patent states "a touch part physically contacting skin of a man; an optical sensor part projecting an electromagnetic wave of a predetermined frequency region to the skin of a man contacted by the touch part and receiving a reflective signal of the projected electromagnetic wave; and an analysis part analyzing the reflective signal and outputting a start control signal as a result of the analysis."

The sketch on the right is from the Patent and shows how the system is designed to work.
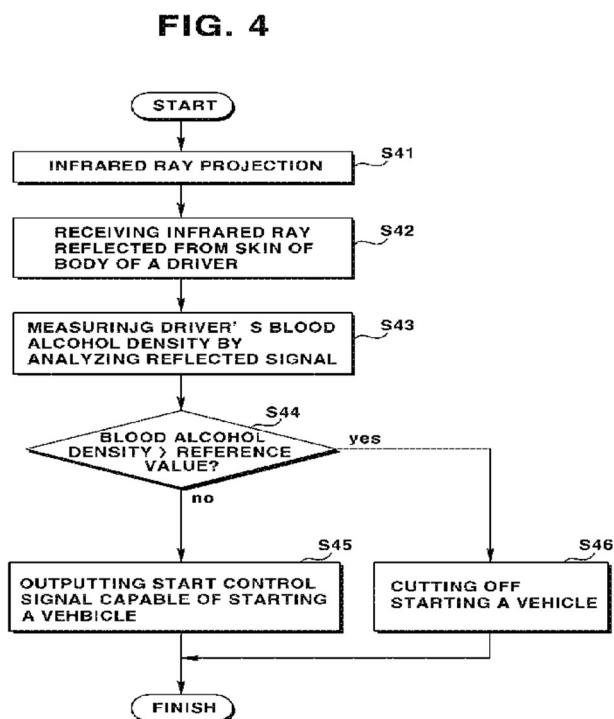
FIG. 4

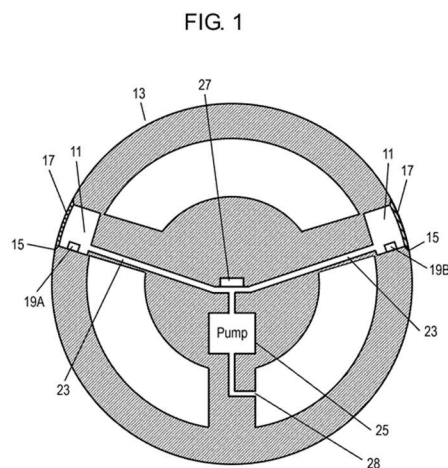**More Information**

- Patent filed in 2016 in the United States: US20180037113A1.
  https://patents.google.com/patent/US20180037113A1/en?oq=20180037113

165. Panasonic Corp

Methods and systems

A Patent for a steering wheel-based touch alcohol sensor.

The sketch on the right is from the Patent and represents the alcohol sensors on the steering wheel. The Patent goes into greater details on sketch.

FIG. 1

More Information

- Patent filed in 2008 in the United States: US7911350B2. https://patents.google.com/patent/US7911350B2/en?oq=20080316037

166. Apple

Methods and systems

A Patent for a seat belt-based system that can monitor for alcohol impairment and other driver state conditions.

The Patent describes the sketch:

Shows a monitoring feature for an augmented safety restraint 720 that is attached to a seat 718 for use by a passenger 726. The augmented safety restraint 720 can include sensors 734 that are able to measure properties of the passenger 726 and/or the environment. In some embodiments, the sensors 734 are operable to measure the vital signs of the secured passenger 726 such as the passenger's heart rate, breathing rate, temperature, CO level, blood alcohol content, etc. This information can be used to document the passenger's health status, stress level, and emotional well-being for various purposes (e.g., diagnostic, research, investigations, etc.) and falls into the category of activities meant to monitor driver/passenger physical status.
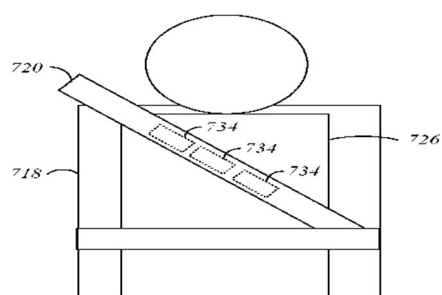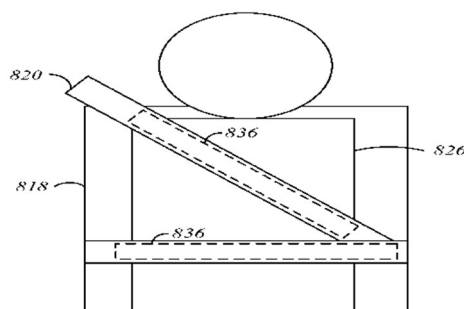

FIG. 7

FIG. 8

More Information
Patent filed in 2015 in the United States: US10189434B1.
https://patents.google.com/patent/US10189434B1/en?oq=10471969

167. HID Global Corp

Methods and systems
A Patent filed originally in 2006 for a touch-based system to determine a diver's alcohol level.

More Information
- Patent filed in the United States in 2010: US8184873B2.
  https://patents.google.com/patent/US8184873B2/en.

168. HID Global Corp

Methods and systems
A Patent originally filed in 2003 for a touch-based system to determine a driver's alcohol level.

More Information
- Patent filed in the United States in 2010: US7819311B2.
  https://patents.google.com/patent/US7819311B2

169. Hitachi Ltd

Methods and systems

A patent for an air and breath-based alcohol sensor for a driver.

More Information
- Patent filed in 2012 in the United States: US8921776B2.
  https://patents.google.com/patent/US8921776B2

170. Sober Steering Sensors Canada Inc.

Methods and systems

A patent for steering wheel touch-based alcohol sensor.

The sketch to the right is from the Patent of the steering wheel sensors for alcohol.

FIG. 4
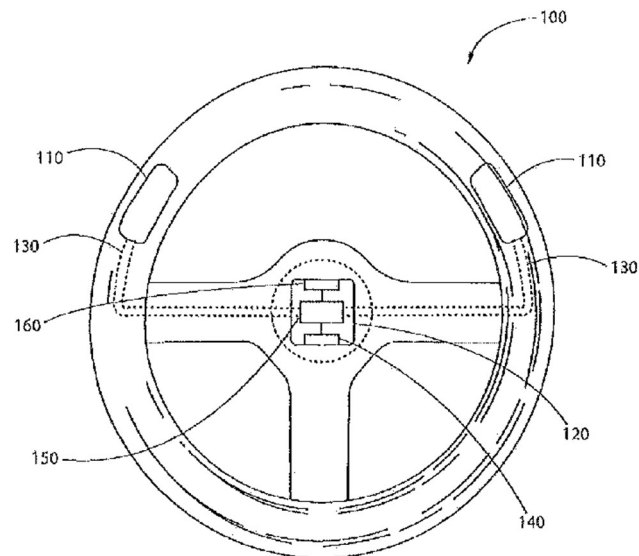
More Information
- Patent filed in 2009 in the United States: US9326713B2.
  https://patents.google.com/patent/US9326713B2/en?oq=9326713

171. Transbiotec, Inc.

Methods and systems

The Patent is for a touch-based alcohol sensor in a vehicle that also works with what is described as an ignition interlock. It is unclear if the term "ignition interlock" described in the Patent is in reference to ignition interlocks currently in use or not.

More Information

Touch based alcohol sensor (Patent filed in 2012):
https://patents.google.com/patent/US9296298B2/en?oq=+9296298

172. Driving Management Systems Inc.

Methods and systems

A Patent for a breath-based alcohol sensor.

- Patent filed in 2011 in the United States: US20160185217A1
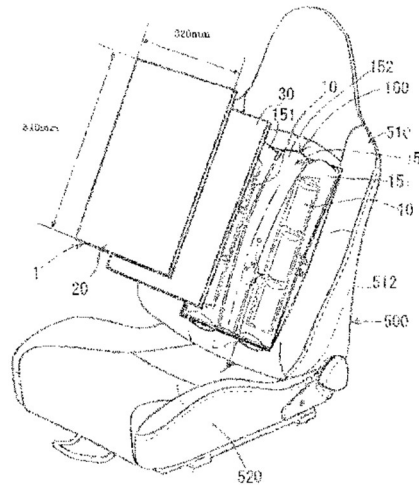 https://patents.google.com/patent/US20160185217A1

173. Delta Tooling Co.

Methods and systems

A Patent for alcohol detection that appears located in a seat.

The sketch to the right is from the Patent which shows biosensors in the Seat.

More Information

- Patent filed in 2009 in the United States: US9149231B2. https://patents.google.com/patent/US9149231B2

174. Sadeq Albakri

Methods and systems

A patent for a steering wheel alcohol sensor-based system.

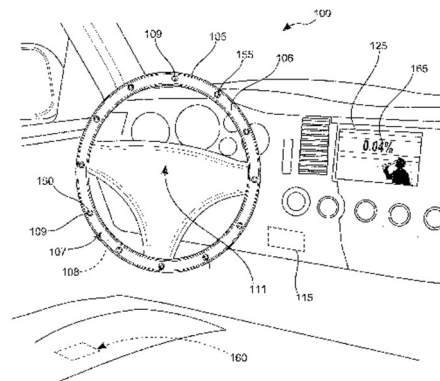The sketch to the right is from the Patent and shows the steering wheel sensors and other displays.

FIG. 1

More Information

- Patent filed in 2019 in the United States: US20190248237A1. https://patents.google.com/patent/US20190248237A1

175. Tammy Berg-Neuman, James L Gowan

Methods and systems

Patent for a steering wheel alcohol sensor.

More Information

- Patent filed in 2015 in the United States: US9775565B1.
  https://patents.google.com/patent/US9775565B1

176. Wellen Sham

Methods and systems

A Patent for a touch-alcohol sensor on a steering wheel, other sensors, that includes other technology to determine the identity of the driver.

More Information

- Patent filed in 2016 in the United States: US10173687B2.
  https://patents.google.com/patent/US10173687B2

177. 염정국양희창유동민정효선우창용옥태화

Methods and systems

A Patent filed for a Touch and breath-based alcohol sensor system.

More Information

- Patent filed in 2020 in South Korea: KR20200019912A.
  https://patents.google.com/patent/KR20200019912A/en

178. 유도준정종진김용이준노

Methods and systems

A Patent filed for a touch or breath-based alcohol detection system.

More Information

- Patent filed in 2018 in South Korea: KR101998612B1
  https://patents.google.com/patent/KR101998612B1/en?oq=10471969

179. 이정훈이홍균

Methods and systems

Touch based steering wheel to determine alcohol impairment.

More Information

- Patent filed in 2019 in South Korea: KR102069859B1.
  https://patents.google.com/patent/KR102069859B1/en?oq=10471969

180. 김연재

Methods and systems

A patent for a steering wheel with a breathalyzer.

More Information

- Patent filed in 2018 in South Korea: KR20200073916A.
  https://patents.google.com/patent/KR20200073916A

181. 袁帆

Methods and systems

A Patent for a breath alcohol detection sensor.

More Information

- Patent filed in 2020 in China: KR20200073916A.
  https://patents.google.com/patent/CN111469661A

182. 장종기장인철

Methods and systems

A Patent for an alcohol sensor.

More Information

- Patent filed in 2003 in South Korea: KR200330745Y1.
  https://patents.google.com/patent/KR200330745Y1/en?oq=10471969

183. Stephanie Sofer

Methods and systems

A Patent for an alcohol steering wheel sensor and other sensors. The system seems to also communicate with a call center which would make this technology difficult for consumer use.

More Information

- Patent filed in 2005 in the United States: US8089364B2.
  https://patents.google.com/patent/US8089364B2/en?oq=8089364

184. Betty Brown, Annie Minter

Methods and systems

A Patent for a touch based steering wheel sensor for alcohol impairment.

More Information

Patent filed in 2004 in the United States: US20050230175A1.
https://patents.google.com/patent/US20050230175.

185. Future Technologies Partners LLC

Methods and systems

A Patent for wearable technology connected with car operation to determine alcohol impairment.

Whether and how systems have been validated to date and user acceptance

The wearable technology aspect of this technology makes it difficult for large scale use.

More Information
- Patent filed in 2014 in the United States: US10493996B2.
  https://patents.google.com/patent/US10493996B2/en?oq=10493996

186. Magna Mirrors of America Inc

Methods and systems

A Patent for a rearview camera that measures for alcohol through breath.

More Information
- Patent filed in 2012, abandoned: US20120236136A1.
  https://patents.google.com/patent/US20120236136A1/en?oq=20120236136

187. Pathfins Okezie

Methods and systems

A Patent for a touch-based alcohol wheel sensor.

More Information
- Patent filed in 2002 in the United States, abandoned: US20040083031A1
  https://patents.google.com/patent/US20040083031A1/en?oq=10471969.