Automotive Sensors Sharpen Up for Safer Driving

Opportunities for more and better automotive sensors continue to expand, as carmakers, legislators, and car buyers all seek further improvement in aspects such as reliability and safety. The number of sensors fitted to an average car is set to exceed 100 devices; as we move into the era of connected cars, the depth and diversity of information captured will continue to increase. By 2025 the number of sensors used in a car is supposed to double.

Sensor developers – including automotive tier-1 suppliers and specialist automotive-electronics businesses – need to continue to up their game as they develop sensors that are more highly integrated and offer higher performance with lower power consumption.

THE DRIVING FORCES BEHIND NEW SENSORS

Safety is a major driver for the development of new types of sensor. To reduce accidents on the roads, vehicles are taking on responsibility not only to manage their own safety-critical systems but also to help deal with driver fatigue, aid concentration, and alleviate stress. Indeed, driver fatigue is a factor in about 20% of road accidents today, and a high proportion of these tend to be serious or fatal because fatigue is often manifested as "micro sleeps" during which the driver has little or no ability to brake or steer to lessen the impact.

Driver monitoring systems tend to measure steering behaviour as an indicator of fatigue. Fortunately, steer-by-wire systems already capture angular position and rate information from high-resolution sensors made by companies such as Allegro Microsystems, Elmos, Infineon and NXP. A high-speed interface allows a host microcontroller to capture and process the sensor data, while some sensors feature built-in processing to reduce the load on the host.

Early signs of driver fatigue include long periods with barely any steering activity, punctuated by small but abrupt corrections. A driver-awareness algorithm may combine the steering-sensor data with other information, such as use of turn signals, the length of the journey, and time of day to calculate a level of fatigue and generate a warning if the level exceeds a pre-set threshold: some drivers may already be familiar with the coffee-cup symbol on the dashboard, as a common prompt to take a break.

Other means of detecting driver fatigue include monitoring the position and movements of the driver's head and eyes using 3D imaging techniques. With this technology in the cabin, combining cameras and other detectors such as time-of-flight proximity sensors marketed by suppliers like ON Semiconductor and STMicroelectronics, which measure the distance to objects more accurately than conventional contrast-based proximity sensors, other value-added features also become possible. In combination with geographical information and artificial intelligence, the vehicle can identify an object the driver may be seeing - such as an architectural site - and automatically provide information when the driver asks a question such as "What building is this?" 3D image sensors and time-of-flight proximity sensors are also important for the higher levels of autonomous driving (Level 4 and Level 5 as defined by the SAE).

At the opposite end of the driver-behaviour scale, stresses such as time pressure can translate into excessive speed and erratic driving. Techniques using infrared sensing to detect signs of over-stress can be linked with other vehicle systems to try to combat these effects. With the advent of tuneable LED-based interior lighting, the vehicle can adjust the light level and spectral content autonomously towards calming blue wavelengths to encourage safer driving.

Further innovations to improve comfort and aid concentration include so-called wellness seats. Sensors form the core of this type of innovation, using advanced techniques to achieve non-invasive monitoring of important vital signs such as the driver's heart rate or respiration. Pressure sensors are already widely used to assist lumbar support, and in fact are used in many places throughout the vehicle such as airbag controls and LPG (Liquid Petroleum Gas) fuel-pressure monitoring.

SENSING FOR TOUCHLESS HMI

Safety can be further improved by enabling drivers to interact naturally with in-cabin equipment such as infotainment or lighting. The arrival of touchscreens in the centre console has enabled new and more intuitive ways of tuning the radio, selecting music or adjusting climate settings, although there is clearly room for improvement. 2D and even 3D gesture sensing, leveraging controllers from suppliers such as Elmos, Microchip, or STMicroelectronics, can be applied to help drivers concentrate on the road instead of reaching to touch a chosen area on the screen. Additional controls such as window opening or roof position can also be brought into such a gesture-control system.

2D sensing technologies enable system makers to embed small touch sensors in the steering wheel, which are capable of detecting gestures such as single-finger tap or swipe, or more complex pinch and rotate using two fingers, to let drivers adjust a variety of settings without removing their hands from the wheel.

3D sensing, on the other hand, goes further still by enabling drivers to make their selections using larger mid-air gestures without diverting eyes from the road. Technical challenges include enabling these types of systems to differentiate between general hand movements and deliberate gestures that should be interpreted as commands. Some vendors have tackled this in software using Hidden Markov models.

IMPROVING THE BREED

While driver monitoring systems and better HMIs can contribute towards safer driving, further improvements to existing sensors have a role in increasing accuracy and minimizing the size of automated features such as wiper control and X-by-wire systems like braking and accelerator control.

To improve wiper control, for example, advanced measurement algorithms have successfully increased immunity to interference such as flickering light sources and effects such as ageing or surface contamination, and improved monitoring techniques have enhanced moisture detection and allowed smaller sensor form factors.

3D magnetic sensing is helping to shrink form factors throughout the vehicle, such as in position sensing for pedals, gear-stick and moving parts in the transmission. By replacing traditional position-sensing mechanisms using potentiometers or optical systems, non-contact 3D magnetic sensors eliminate the possibility for errors due to wear or contamination, ensure stable measurements up to high temperatures, and also save space.

Demand for automotive MEMS (Micro Electro-Mechanical Systems) sensors including accelerometers, gyroscopes, and pressure sensors, made by suppliers such as Elmos, Infineon, NXP Semiconductor, and STMicroelectronics, continues to grow strongly. About one-third of the roughly 100 sensor nodes in today's vehicles are now based on MEMS technology, and the Global Automotive MEMS Sensor Market Analysis & Forecast published via ResearchAndMarkets.com predicts continued growth at about 13% CAGR until 2022. The devices are key enablers for systems such as TPMS, wheel-speed sensing, or electronic parking brake systems, stability control, and crash detection and logging.

These are just a few of the opportunities for sensor makers and automotive tier-1 suppliers to create advanced, high-value sensing solutions that can enhance safety and reliability as well as the overall owner/driver experience delivered by the vehicle. Keeping pace with the latest developments in standards is vital, of course. Increasing electrification of modern cars focuses attention

on standards like ISO 11452-08 governing immunity of systems to magnetic fields either inside or outside the vehicle. Important new connectivity specifications are also emerging, such as the PSI5 sensor-interface. PSI5 simultaneously allows higher-performing sensor connections by operating up to 125kbit/s, which is faster than LIN, while also enabling cost and weight savings through its economical 2-wire protocol. Major component vendors are now supplying magnetic sensors with PSI5 interfaces, which meet ISO 11452-08 and, of course, the automotive safety standard ISO 26262.

FURTHER ALONG THE ROAD

Looking further into the future, exciting possibilities for smart sensors to further improve vehicle safety and reliability are emerging, leveraging wireless connectivity to introduce extra sensors to the vehicle without adding weight and cost in copper wires and connectors.

To present just one example, the Fraunhofer Institute is pursuing numerous automotive research projects, including embedded surface sensors for monitoring condition of tyres, or the vehicle skin, to detect anomalies long before the potential for failure arises. Working in addition to established wireless Tyre-Pressure Monitoring systems – which are themselves moving towards greater integration by combining the LF receiver, RF transmitter and microcontroller in a single package – Fraunhofer's embedded skin-surface sensing can make remote monitoring even more effective by detecting potentially dangerous damage to the tyre wall or tread before failure or deflation can occur.

Avnet Silica partners with leading sensor makers to help develop cutting-edge customer solutions using the latest sensor technologies. These span not only optical, magnetic and capacitive sensors, but also ultrasonic sensors that are widely used in parking-assistance and self-parking systems, MEMS sensors for movement and position sensing throughout the vehicle, and traditional Hall-effect and optical sensing, and pressure sensors. Covering the lifecycle, from engineering to supply chain, is important to select and design-in the most suitable parts bearing in mind long-term availability and access to manufacturer support.
Avnet Silica frequently demonstrates new and fresh concepts in automotive sensing, and will make several use-case presentations at Electronica in Munich this November, in hall B4 – Stand 514, and hall C5 – Stand 101.

CONCLUSION

Successive generations of vehicles have significantly increased safety for occupants and other road users by adding greater intelligence and convenience at affordable prices. Today's key demands are for driver-assistance features aimed at improving safety as well as comfort. Through advanced sensing techniques, as well as improvements to traditional sensors and sensing mechanisms, better performance, greater accuracy and reliability, and valuable space savings are all brought within reach.

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