TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

31st January 2014

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1. OPPORTUNITIES IN TRAFFIC MANAGEMENT SENSORS

Sensors have opportunities to be increasingly used in traffic monitoring, management, vehicle classification, and in crash avoidance systems to enable more intelligent transportation management, provide improved real-time information for drivers and transportation system operators, and enhance traffic manangement. Improvements in the ability of sensors that are used as part of the road infrastructure, or in the vehicle, such as the capability to detect or classify such elements as lane markings, road signs, or roadside obstacles, would enhance driver safety.

Moreover, traffic congestion and air pollution could be significantly improved through installing a plethora of accurate, robust yet inexpensive sensors in a wide area of highways and other roads that were wirelessly linked in a comprehensive data network. Furthermore, there are opportunities for using sensors capable of detecting different types of marketing, signs, or obstacles at greater distances for use in more advanced driver assistance systems. Such driver assistance systems would achieve a higher level of driver automation, leading to more autonomous driving.

The types of sensors that can be used in traffic monitoring, management, or in crash avoidance include inductive loop sensors, camera-based systems, pneumatic tubes, global positioning systems (GPS) and mobile phones equipped with positioning navigation functionality, ultrasonic/acoustic sensors, RFID (radio frequency identification) transponders, radar, Lidar (light detection and ranging). Moreover, there are various sensor technologies used in vehicle classification or weigh-in-motion applications, such as piezoelectric load sensors, load cells, and magnetic field sensors.

The inductive loop sensors, an older technology used at intersections with traffic actuated signals, can be intrusive, tend to have high set-up and maintenance costs, and are vulnerable to weather conditions such as snow and ice. The video camera and image processing system can be expensive and susceptible to visual obstruction (such as poor lighting conditions, shadows, strong winds, and bad weather). Pneumatic tubes have limited lane coverage, are prone to damage by vehicles , may be intrusive and are not geared for year-round use. GPS signals can be obstructed by tall buildings (urban canyons) and trees and provide only vehicle-specific data. Ultrasonic/acoustic sensors cover a short range (detect objects about 2 to 4 meters away) and are subject to accuracy errors due to the particular surface of the detected object. RFID technology can only detect vehicles equipped with such tags at a point of the roadway.

Radar has the advantages of robustness, cost-effectiveness, and non-intrusiveness in traffic monitoring or in driver assistance systems, and is able to infer speed, bearing, altitude, and range (distance). However, radar can have limitation with respect to detecting or classifying such elements as lanes or lane lane markings, road signage, or roadside obstacles.

Three-dimensional Lidar scanning systems are able to provide comprehensive detection, tracking, and classification to facilitate crash avoidance and eventually automated driving. However, Lidar is currently very expensive for such applications as in-vehicle crash avoidance.

In crash avoidance systems, sensor fusion (such as using a camera-based sensor along with radar or Lidar) could reduce the potential for error. In addition, the implementation of vehicle safety communications in vehicles could enhance the robustness of the crash avoidance or driving automation system. Such communications may eventually somewhat reduce dependence on expensive sensor suites (for example, active sensor suites). Active sensors use their own energy , which is reflected from a target object and measured by the sensing element to obtain such characteristics as relative position, speed, and so on. However, until driver assist technologies and vehicle communications advance and are implemented in a greater number of vehicles, a plausible path is to more widely deploy radar or other active sensing technologies in the infrastructure to achieve active traffic management by monitoring such parameters as traffic speed, flow, and density.

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2. SENSOR HUBS FOR MOBILE DEVICES

Mobile devices greatly rely on programmable capabilities that can supplement and increase capabilities of these products especially with regard to context awareness functionalities. The design engineers of the mobile devices usually rely on functions such as I2C control, GIPO (General Purpose Input/Output) expansion, and interface bridging. However, with these applications the need to integrate the devices with sensor hubs has also increased. Many of the mobile phone manufacturers have started employing sensor hubs in their products, but when these sensor hubs are placed for a long time in the devices it results in significantly large amount of power loss. Wearable electronics and tablets are other market areas where these sensor hubs are employed on a large scale. Companies are now trying to come up with novel software products that are built using new architectural designs, which can be integrated into their products thereby reducing power consumption of the devices.

QuickLogic Corporation, USA, has developed a platform solution named PolarPro 3, which provides a fully programmable solution for the mobile handheld market. This platform solution addresses the power consumption issue and uses only 1% of the battery's consumption even when the sensor hubs are on all the time in the mobile device. This new product increases efficiency and uses a very less amount of power in the devices where they are employed. Since this product is programmable, it also enables OEMs (original equipment manufactures) to alter the software based on the specific needs of the customer’s product.

QuickLogic has implemented its proprietary technology in this product. The company has completely redone the processing architecture that is required for carrying out the various functionalities of PolarPro 3 Software Solutions. While most companies employ the conventional ARM-based microcontrollers (based on reduced instruction set computing architecture developed by ARM Holdings) in their products, QuickLogic has changed this conventional practice by adopting an innovative architectural architecture using its programmable logic controllers. The company has also provided PolarPro 3 with a software tool that enables it to target the hardware of the appliances that they are used with the user's algorithm.

Mobile devices have become context aware these days, with more number of sensors being added to them, and adding more processing power that is required to convert the data obtained by the sensors into information. Usually, context awareness is calculated based on the context in which the mobile device is being used. For instance, by employing Quicklogic's solution it is possible to reduce the power consumption to less than 1% of the system's battery power or 300 microwatts for current devices that are used for sensor computing.

The fastest growing applications that company is targeting now are mobile phones, tablets, and wearable electronic appliances. Quicklogic believes that these markets have enough volume and growth rate in the next 3 to 5 years; therefore, they are targeting these three market areas with this latest product. Sensor hubs are becoming standardized in the industry these days and a lot of flagship mobile phones have been employing sensor hubs in their products. With the new architecture and software used in the Polar Pro 3 Solutions, which increases efficiency of mobile devices, this product has the potential to have a significant market impact.

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3. HIGHLY SENSITIVE ELECTRONIC WHISKERS FOR ROBOTIC APPLICATIONS

Sensors enable robots to better understand the environment, more deftly handle objects or items, and undertake informed decisions. By enabling robots to see, touch, or feel the environment similarly to human beings, safer human-machine interaction can be achieved. The key sensor technologies that are used in robots for this purpose include vision sensors, and magnetic compasses for robot navigation and positioning, or inertial measurement units consisting of an accelerometer, gyro and magnetometer to measure orientation; and tactile sensors, which can be sensitive to touch, force, or pressure and can measure, for example, the amount of grip required to hold an object. In recent times, there has been interest in using nanotechnology to develop highly sensitive sensors that can be used in various applications, including artificial skins for robots.

In line with this trend, researchers at the University of California at Berkeley, USA, have developed highly sensitive tactile sensors that imitate the functionality of whiskers. The electronic whiskers can be used to help machines, such as robots, to accurately gauge its environment and move accordingly. Whiskers are known to be used by various animals for monitoring wind and navigating around obstacles. Based on this concept, the researchers have developed similar electronic whiskers using nanosensors.

The electronic whiskers were developed using composite films made of carbon nanotubes and silver nanoparticles. This film was then coated on elastic fibers having a high aspect ratio. The carbon nanotubes essentially form a highly bendable conductive network matrix. The use of silver nanoparticles further enhances the conductivity of the film while infusing high strain sensitivity. The nanosensors have pressure sensitivity of up to 8%/Pa, which is considerably higher than conventional capacitive and resistive pressure sensors. By altering the composition ratio of the nanoparticles, the sensitivity of the sensors can be modulated by few orders of magnitude.

The researchers fabricated whisker arrays using the sensors and used them to produce two-dimensional and three-dimensional mapping of wind flow. Currently, only pressure can be sensed by the electronic whiskers, but the technology can be potentially developed to have other sensing properties. This would require advanced signal processing circuits. The sensors can be used particularly in robots to help them navigate through spaces. They can also be used in other applications, such as wearable electronics and other flexible devices. In future research, the team wants to demonstrate printing fabrication of the sensor that will enable low cost of manufacturing. High sensitivity and low production costs will enable electronic whiskers to facilitate advanced robots, as well as more efficient human-machine user interfaces.

The work of the researchers was supported by the Defence Advanced Research Projects Agency (DARPA) of USA. The researchers have provided their findings in a paper titled, 'Highly sensitive electronic whiskers based on patterned carbon nanotube and silver nanoparticle composite films.' The paper was published online in the Proceedings of the National Academy of Sciences on January 21, 2014.

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4. RECENT PATENTS IN THE FIELD OF HUMIDITY SENSING

Humidity sensors monitor the amount of water vapor present in the environment (for example, air or other gases). Humidity sensing can be broadly divided into two types, depending on the measurement units--absolute humidity sensing and relative humidity sensors. Absolute humidity measures the amount of water content in air, while relative humidity refers to the ratio of the partial pressure of water vapor in an air/vapor mixture to the saturated vapor pressure of water at a certain temperature. The most common relative humidity sensing technologies are capacitive sensing and resistive sensing. Resistive type humidity sensors can be less sensitive than capacitive sensors and can be temperature dependent, although such sensors can be interchangeable (field replaceable), low cost, and robust. Capacitive humidity sensors can have a broad humidity range and temperature range, good stability and repeatability, can have a more linear response than resistive sensors, but can be subject to calibration drift due to condensation and contamination and may not work well in corrosive atmospheres.

Humidity sensors are being increasingly used in diverse application areas such as environmental monitoring, industrial processing, clean rooms and semiconductor wafer processing, heating, ventilation and air conditioning (HVAC) systems (in buildings as well as vehicles), and so on. In the automotive arena, humidity sensors could also be implemented for improved engine control.

Recent patents in this field indicate a focus on increasing the reliability of the sensors and having simpler circuit designs. A number of patents have been filed by automotive companies, which show the increased usage of, or interest in, humidity sensors in this area. Patent No 8,603,310 granted to NGK Spark Plug Co. (Japan) indicates the use of a gas (for example, oxygen-type) sensor to detect humidity. Patent no 8,631,786, granted to Ford Global Technologies pertains to systems and a sensor to detect humidity in air through using ammonia sensor in the exhaust of an engine, such as a diesel engine

PATENT TITLE	PUBLICATION DATE / NUMBER	ASSIGNEE	INVENTORS	ABSTRACT
Method, systems and sensor for detecting humidity	January 21, 2014; US 8,631,786	Ford Global Technologies, LLC (Dearborn, MI)	Van Nieuwstadt; Michiel J. (Ann Arbor, MI), Weber; Dave Charles (Toledo, OH)	Methods systems and device for detecting humidity in air through use of an ammonia sensor included in the exhaust of an engine, such as a diesel engine are provided. In one example, a method for an engine having an exhaust with an ammonia sensor includes adjusting an operating parameter in response to ambient humidity, the ambient humidity based on a first ammonia sensor reading at a first exhaust air-fuel-ratio and a second ammonia sensor reading at a second exhaust air-fuel-ratio.
Humidity sensing circuit with temperature compensation	January 7, 2014; US 8,621,924	Delta Electronics, Inc. (Taoyuan Hsien, TW)	Liu; Te-Chung (Taoyuan Hsien, TW), Lee; Yi-Hua (Taoyuan Hsien, TW)	A humidity sensing circuit with temperature compensation includes a wave producing module, a phase processing module, a sensing module and a detecting module. The wave producing module outputs a wave signal. The phase processing module outputs an oscillatory wave and an invert oscillatory wave according to the wave signal. The sensing module has a temperature sensor and a humidity sensor which are connected in series. The temperature sensor and the humidity sensor respectively receive the oscillatory wave and the invert oscillatory wave. The sensing module outputs a parameter signal according to the oscillatory wave and the invert oscillatory wave. The detecting module outputs a detection signal according to the parameter signal. Hence, the humidity sensing circuit with temperature compensation senses the temperature and humidity by the simple circuit design. Moreover, it is feasible for circuit design and application.
Humidity sensor	January 7, 2014; US 8,621,923	Micronas GmbH (Freiburg i. Br., DE)	Frerichs; Heinz-Peter (St. Peter, DE)	A humidity sensor has, on a substrate, at least one voltage sensor with a sensor region and at least one control electrode. The control electrode is connected to a signal source which is designed such that a variable control voltage can be applied to the control electrode. A moisture-permeable sensor layer whose dielectric constant depends on humidity

				is located on the sensor region. The control electrode is adjacent to the sensor layer in such a manner that the measured voltage signal of the voltage sensor depends on the control voltage and the humidity. The voltage sensor is connected to an analysis unit for ascertaining the humidity on the basis of the measured voltage signal. In the vertical projection onto the plane in which the substrate extends, the control electrode is located laterally next to the sensor region.
Implant sensor and control	December 31, 2013; US 8,620,444	Med-El Elektromedizinische Geraete GmbH (Innsbruck, AT)	Zimmerling; Martin (Patsch, AT), Hochmair; Ingeborg (Axams, AT), Hochmair; Erwin (Axams, AT), Kerber; Martin (Innsbruck, AT), Lindenthaler; Werner (Oberperfuss, AT), Nopp; Peter (Birgitz, AT), Schmidt; Marcus (Innsbruck, AT), Schoesser; Hansjorg (Reith im Alpbachtal, AT), Zierhofer; Clemens (Kundl, AT)	An implant includes a humidity sensor for generating a signal indicative of humidity within the implant. A controller within the implant receives the signal indicative of humidity, and controls the implant based on the signal indicative of humidity.
Gas-concentration/humidity detection apparatus	December 10, 2013; US 8,603,310	NGK Spark Plug Co., Ltd. (Aichi, JP)	Ishida; Noboru (Kakamigahara, JP), Mori; Kentaro (Nagoya, JP), Tajima; Tomohiro (Kasugai, JP)	A sensor control apparatus (3) includes a full-range gas sensor composed of an oxygen concentration detection cell having a pair of electrodes (21, 22) and an oxygen pump cell having a pair of electrodes (19, 20). In an electric circuit section (30), an Ip current flowing between the electrodes (19, 20) is controlled such that an electromotive force Vs produced between the electrodes (21, 22) becomes equal to a reference voltage. The reference voltage is usually set to a first reference voltage. However,

				when the subject gas is air, the reference voltage is set to a second reference voltage. Humidity of the subject gas is detected on the basis of an error .DELTA.Ip between an Ip current detected when the reference voltage is set to the first reference voltage, and an Ip current detected when the reference voltage is set to the second reference voltage.
Capacitive humidity sensor and manufacturing method	November 5, 2013; US 8,573,052	Korea Electronics Technology Institute (Seongnam-si, Gyeonggi-do, KR)	Hong; Sung Min (Yongin-si, KR), Kim; Kun Nyun (Yongin-si, KR), Jo; Young Chang (Suwon-si, KR), Kim; Won Hyo (Yongin-si, KR)	A capacitive humidity sensor, and more particularly, to a capacitive humidity sensor and a manufacturing method thereof capable of increasing reliability of the sensor by forming a dehumidification layer of a polymer material having a large surface area between a lower electrode layer and an upper electrode layer while miniaturizing the humidity sensor by forming a sensor unit on an ROIC substrate.

Exhibit 1 lists some of the recent granted patents in the field of humidity sensing.

Picture Credit: USPTO/Frost & Sullivan

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