TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

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1. ADVANCEMENTS IN WEARABLE TACTILE SENSORS

Tactile sensors and touch sensors measure parameters resulting from direct contact between the sensor and an object. Tactile sensing can be equated with touch sensing. However, in a more strict definition, touch sensing can be considered to pertain to the measurement of a contact force at a defined point, while tactile sensing refers to the detection and measurement of the spatial distribution of forces perpendicular to sensed area. A tactile sensing array is essentially a group of coordinated touch sensors. Tactile sensors consist of an array of touch-sensitive sites and can sense different parameters or stimuli such as the presence or absence of an object or a total tactile image. Tactile sensors can sense a variety of stimuli, including the presence or absence of a grasped object or an entire tactile image.

Key applications for tactile sensors can include robotics (for example, fingertips, arms, torso in humanoid robots, object orientation, soft robots that use soft materials), healthcare, automotive, military, consumer electronics (for example, wearable tactile keypads), and so on.

Various technologies are used for tactile or touch sensing, including resistive sensors, capacitive sensors, force sensing resistors (consisting of a conductive polymer with a sensing film of electrically conducting and non-conducting particles that change resistance with the application of force), strain gauge arrays (multiple strain gauges with each one sensing force in a certain direction), piezoelectric sensors, optical sensors, magnetic sensors.

To gain adoption and proliferation in promising applications other than traditional robotics, there is a need for tactile sensors with greater flexibility, agility, less weight , and less bulkiness than typical, conventional tactile sensors. Furthermore, tactile sensors for detecting minute changes should have very high sensitivity; and smaller, lighter types of tactile sensors can have a minimum effect on the measurement.

Responding to such needs, researchers from the National University of Singapore (NUS) Faculty of Engineering, under the guidance of professor Lim Chwee Teck of NUS' department of biomedical engineering, have developed a wearable liquid-based microfluidic tactile sensor. The device is small, thin, very flexible and durable and can be produced cost efficiently. Such capabilities render the device suitable and beneficial for applications such as soft robotics, wearable consumer electronics, healthcare (for example, smart medical prosthetic devices and real-time healthcare monitoring).

The liquid-based pressure sensing method used in the innovative tactile sensor design can overcome the limitations of conventional tactile sensors. The latter tend to be rigid and in solid-state form, which, when utilized, can constrain natural body movements. When pressure is exerted, such conventional tactile sensors may also be subject to plastic deformation, which can impair the sensor’s conformability, durability, and robustness.

The microfluidic tactile sensor, which is fabricated on a flexible substrate, such as silicone rubber, uses a non-corrosive, non-toxic two-dimensional (2D) nanomaterial suspension in liquid form, such as graphene oxide, as the pressure sensing element to observe or distinguish force-induced changes. In rigorous tests, including being run over by a car tire, the device has maintained its robustness, electrical output uniformity, and functionality.

Driven by its small and thin size, durability, flexibility, and ability to be easily produced, the liquid-based microfluidic tactile sensor has opportunities to further advance the prospects for tactile sensors in areas such as healthcare (for example, applications involving contact with human skin or monitoring very versatile human movements) and consumer electronics. For instance, the sensor can provide enhanced monitoring of natural body movements.

The researchers have filed a patent for the creation of the invention and desire to explore licensing partnerships for commercial development.

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2. PHOTONIC CRYSTAL FOR TOUCHLESS FINGER MOTION TRACKING

Humidity pertains to water vapor, or water in gaseous form. Relative Humidity (RH) is the ratio of the partial pressure of water vapor present in a gas to the saturation vapor pressure of the gas at a certain temperature.

Two widely used techniques to sense relative humidity include capacitive sensors and resistive sensors. The resistive humidity sensor measures a change in the electrical impedance of a hygroscopic medium, such as a conductive polymer. The capacitive humidity sensor can use a thin polymer film or metal oxide film deposited between electrodes. The change in dielectric constant is related to the relative humidity (RH) of the surrounding environment. The polymer-based resistive sensor responds to variation in moisture by changing its conductivity. The polymer-based capacitive sensor responds to water vapor by changing its dielectric constant.

Conventional humidity sensors are subject to limitations, such as susceptibility to contaminants (for instance, chemicals or dust), impaired accuracy due to condensation, and drift.

Humidity sensors are used in diverse applications, such as industrial processing (including food processing, wafer processing), heating, ventilation and air conditioning (HVAC), automotive, healthcare, and agriculture. Furthermore, humidity sensors offering compact size, low power, rapid response and compatibility with CMOS (complementary metal oxide semiconductor) electronics are used in consumer electronics for applications such as environmental control, and in home appliances for improved efficiency and performance.

There are ongoing opportunities to develop humidity sensors that are able to provide key enhancements in areas such as compactness, sensitivity, and long-term stability for expanded use in new or emerging high-volume applications.

Addressing such key needs, researchers at Ludwig-Maximilians-Univeristät (LMU) in Germany have fabricated an innovative photonic crystal from ultra-thin nanosheeets that change color in response to variations in humidity. The photonic nanostructures, which leverage the giant moisture dependent swelling capacity of 2D phosphatoantimonate nanosheets, are highly suited for humidity-sensitive contactless control of interactive screens in digital devices and for innovative user interfaces for touchless devices.

The ultra-sensitive photonic sensor is able to detect the humidity around a fingertip, which is slightly higher than the overall level of moisture in the surrounding air, and then exhibit a color change without contact with the fingertip. The sensor's ultra-sensitivity to local moisture renders it intriguing for contactless control and touchless screens. Potential applications could include advanced positioning interfaces and touchless navigation in ticket machines or cash dispensers.

Photonic crystals are periodically arranged nanostructures with the ability to reflect, guide, and confine light. The LMU team developed photonic crystals based on nanosheets of phosphatoantimonic acid. In addition to being extremely sensitive to moisture, this innovative nanomaterial is chemically stable, transparent and can be readily fabricated into nanosheets. In comparison with other vapor sensors based on nanosheets, the photonic material's architecture exhibits considerably increased response times, higher sensitivity, and long-term stability, compared to other nanosheet-based vapor sensors. Such attributes enable the photonic crystal to provide real-time tracking and color-coding of lateral finger motion under touchless conditions. Furthermore, the system is stable upon exposure to air and, therefore, can function in real-world environments that are subject to ongoing change.

The researchers have applied for a patent for the device. Moreover, in collaboration with Fraunhofer Research Institution for Microsystems and Solid State Technologies (Fraunhofer EMFT), the researchers are developing a prototype screen that will have electronic readout capability as well as color-coding capability.

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3. CROP MONITORING USING DRONES AND SENSORY SYSTEMS

According to a 2014 report from the United Nations, by 2050 the global population is expected to surpass 9 billion. With respect to today's population, the staggering figure represents a 25% increase in the population. In addition, considering the fact that food security is already a major problem, many countries are looking forward to practice modern agriculture to keep pace. According to the Association for Unmanned Vehicle Systems International (AUVSI), in the future, 80% of the drones in the market will involve agricultural deployment.

There has been significant interest in unmanned aerial vehicle (UAV) deployment in the agriculture sector over the past few years. Reduction in the prices of drones and an increase in availability will have a serious impact on the efficiency of farming operations. With the help of smart data analysis, optimal resources will be enabled. In addition, drones will remove the risks and problems associated with the traditional crop dusting methods such as inaccurate placement of chemicals. Employing drones for farming will address issues such as low flying planes and landing points.

Universidad Politécnica de Madrid (UPM), Spain, is a key participant in crop monitoring and spraying. Researchers at the university have developed a sensory platform for greenhouse monitoring. In addition, the researchers have deduced a method to map plant growth by analyzing the environmental conditions and identifying the leaks in humidity and temperature which can cause damage to crops. For monitoring crops, the researchers have employed a quadrotor drone and deployed the complete sensory platform on board to monitor conditions such as humidity, temperature, and carbon di oxide concentration and plotting maps with many other variables.

The sensors have been integrated to satisfy two needs—the collection and storage of measurements, including space and time references, and the communication between the mini-UAV sensory system and the greenhouse management system. The sensory system has a centralized architecture. The data from the sensory system is received by the central computer which is further compiled to make decisions and commands are sent to the actuator devices. The advantages related to centralized architecture are that all the information can be managed, collected and saved on a single computer with ease.

The sensory system on board with the quadrotor can be employed in diverse fields such as measurement of greenhouse gases in the atmosphere which include methane, carbon dioxide and many more. Moreover, drones with sensory systems can be used to identify the contaminant gases in the clouds and mapping the distribution of gases. With respect to agriculture or farming, the sensory systems in drones can be used for precision agriculture which includes the measurement of density of vegetation and determining the need for irrigation and crop monitoring in various types of fields.

Data-driven optimization is another major use of agricultural drones. It further draws advances in imaging and signaling technologies. With the help of drones, farmers also will be able to use low flying drones, which will be further used to capture images across a multiple spectrum of crops. With the help of the sensory systems and drones, farmers will be able to optimize a number of key resources such as reducing the pesticides and fertilizers used and increasing the yield of crops.

The sensory system developed for monitoring crops is the joint effort of two research groups and one university. The research groups that worked on the crop monitoring project are Spanish National Research Council and Robotics and Cybernetics Research Group.

The researchers have demonstrated their system prototype in the operational environment. The sensory system with drones is anticipated to be completed and qualified for use in the actual operational environment in one to two years' time, based on the technology readiness level. . There is an opportunity for venture capitalists and the other investors to move the technology to the market. It is expected that precision agricultural operation will have expanding market opportunities. With respect to the above technology, it can be expected that sensory systems can be integrated with unmanned ground vehicles because of cost efficiency. In addition, the market for crop monitoring and protection will be competitive because of development and adoption of UGVs (unmanned ground vehicles) and wireless sensor networks. There is still a need to identify the cost efficient technology enabled by energy harvesting which will further reduce the cost of batteries and fuel.

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4. COUNTER UAV SYSTEM WITH SENSOR FUSION

A top subject for government regulation is drones. Several countries have made some progress toward legislation and ongoing trial programs will set the pace for development. But it remains to be seen whether ideas will translate to implementation.

Specific drones require qualification to operate commercially in Europe. According to the European Commission (EC) guidelines, drones will be possible for limited use from 2018. The EC has set goals to integrate both private and public drones in the managed and unmanaged airspace by 2028, and the details of this can be found in the UAV steering committee's roadmap. The integration of public and private drones will ensure that regular and civilian drone flights will be legislated and regulated. In addition, air traffic systems are required to monitor drones alongside conventional aircraft.

North America is the geographic region with the highest military drone funding, which at $2.6 Billion which is more than five times higher than of the Asia Pacific region ($493 million). The United States Federal Aviation Administration (FAA)'s roadmap has set the end of 2015 as a target for covering standards for private and government drone use. Only 28 commercial entities have been awarded licenses for drones from the FAA as of February 2015. In February 2015, the FAA proposed rules for small commercial drones weighing 55 pounds or less. Such drone rules could be implemented around 2017.

Around the world, security gaps have been revealed because of small drones and its implementation in critical areas such as airports, military barracks, nuclear plant and many more. The security gaps in the operation of drones will further delay the government response in regulating drones. There is a need of a technology to respond quickly to the occurring threats and to keep the environment safe.

Airbus Defense and Space has developed a counter unmanned aerial vehicle (UAV) system. The system can identify UAV intrusion in critical areas even at long range and provide electronic countermeasures. This further helps to minimize the risk of any collateral damage in critical areas or in the public space.

The counter unmanned aerial vehicle system accepts data from multiple sensors and, and via sensor fusion, combines the data for high effectiveness. Sensor fusion combines sensor data from different and disparate sources, with the aim of providing a more meaningful, comprehensive, and relevant set of information, compared to that from individual sensors. The different types of sensors employed in the counter UAV system are radar, infrared, and a direction finder. The sensors help the system to identify other drones or any potential threat between 5 to 10 kilometers of range. In addition, the counter UAV system is integrated with jamming and signal analysis technologies. Once the threat is identified, the system collects data and sends it over to the ground station, where real-time analysis of the signal is performed, and compares it with the threat library to identify the exact level of threat. Once the threat is identified, the jammer is set to interrupt the communication link between the pilot and the drone or its navigation system. The smart responsive jamming technology developed by Airbus Defense and Space will block only the relevant frequencies which are used to operate the drone, while other frequencies will be unaffected. With the help of jamming technology and its transmitting and receiving capabilities, it is possible to take control of the UAV from the GPS. In addition, the direction finder helps to identify the exact position of the pilot. The counter UAV system will help to control space traffic and keep the environment safe.

Airbus Defense and Space has demonstrated the system prototype in the operational environment. It can be expected that by mid-2016, the system will be ready for use in the actual operational environment.

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5. PATENT ANALYSIS ON WHEEL SPEED SENSORS

A wheel speed sensor measures the wheel's rotational speed or the distance or angle covered per unit by the vehicle. Different systems, such as navigation and anti-braking systems (ABS) are dependent on wheel speed sensors. ABS uses wheel speed sensors to monitor each wheel's rotational speed to prevent the wheels from locking up. By comparing the data from the global positioning system (GPS) about the vehicle's position with the information from the ABS wheel speed sensors, the on-board computer can calculate the vehicle's route. In the navigation system, wheel speed sensors are used to calculate the distance the vehicle has covered.

The types of wheel speed sensing technologies used in vehicles include variable reluctance sensors (an older technology that can be a passive sensor since it does not require external power to operate), active Hall effect sensors, and magnetoresistive sensors (that use an effect similar to that of the Hall effect sensor), and anisotropic magnetoresistive (AMR) sensors, which use a thin permalloy (nickel-iron) film, and undergo a change in resistance when a magnetic field is applied and the magnetic domains swing around.

From the patent analysis for wheel speed sensors, it is evident that comparatively significant filers of wheel speed sensor patents include Hyundai Mobis (South Korea) and Bosch Automotive Products (Suzhou) Co. Ltd. (China).

Patent number WO 2015101219, filed by Bosch Automotive Products (Suzhou) Co. Ltd. (China), pertains to a wheel speed sensor unit installed on the wheel of the vehicle to measure the wheel speed in real-time. The patent also pertains to the components of the vehicle wheel hub and of the sensor unit. Patent KR 1020150003456, filed by Hyundai Mobis Co. Ltd. (South Korea) pertains to a new method for detecting the backward and forward motion of a vehicle using a wheel speed sensor without additional devices even in the event that the steering angle sensor malfunctions.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Wheel speed sensor and wheel speed sensor production method	Aug 06,2015/ WO 2015115288	Sumitomo Wiring Systems Ltd.	Yamamoto, Hironobu	The present invention pertains to a novel wheel speed sensor production method for advantageously and inexpensively producing a wheel speed sensor having a novel structure capable of reliably ensuring the water resistance of a drawn out portion of an output wire of the wheel speed sensor regardless of the material of the cover of the wire and pertains to a wheel speed sensor obtained through this novel production method. The method includes a primary molding step for forming a water-resistant-member cover portion (64) having a smooth peripheral surface on a primary molded article (104), a secondary molding step for integrally molding an engagement protrusion (72) and a cover (22) that embeds and covers a rotation detection element (28) and part of an output wire (30) in a state in which the rotation detection element (28) and output wire (30) are disposed so as to be inserted into the primary molded article (104), a water-resistant-member attachment step for tightly fixing a fixing part (86) formed on a water-resistant member (14) to the water-resistant-member cover portion (64), and an outer tubular member attachment step for fitting an outer tubular member (16) over the water-resistant member (14) and causing an engagement part (90) formed on the outer tubular member (16) to engage with the engagement protrusion (72).
Wheel speed sensor	July 23,2015/ WO 2015115288	Aisin Seiki Kabushiki Kaisha	Takanori Noda	A wheel speed sensor capable of stabilizing a projecting posture of a sensor unit when attached to a vehicle is provided. The wheel speed sensor includes a mounting base providing a first contacting part and a second contacting part when attached to the vehicle to come into contact with the vehicle at two positions of the first contacting part and the second contacting part, the sensor unit projecting from a position between the first contacting part and the second contacting part and inclining toward the first contacting part, the sensor unit being resin molded integrally with the mounting base and including a signal detection device provided in a distal end of the sensor unit, and a fixing member pressing and fixing the mounting base to the vehicle at a position between the first contacting part and the sensor unit.
Wheel speed sensor device, sensor unit thereof, and vehicle using the wheel speed sensor device	July 09,2015/ WO 2015101219	Bosch Automotive Products (Suzhou) Co. Ltd.	Yang, Xin	A sensor unit of a wheel speed sensor device installed on a vehicle wheel and for measuring vehicle wheel speed in real time. The vehicle wheel comprises a wheel hub (70) and a screw (73) that penetrates the wheel hub (70). The sensor unit of the wheel speed sensor device comprises: a fixing element fixed on the screw (73) of the vehicle wheel; a sensor circuit board (21) provided with a sensor element (22); the sensor circuit board (21) is fixed on the fixing element, and the sensor circuit board (21) extends in a direction approximately perpendicular to the central axis of the wheel hub (70). The wheel speed sensor device has more precise measurement results, is simple in structure and easy to install, and conserves installation time and installation material.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Wheel speed sensor and vehicle	July 09,2015/ WO 2015101222	Bosch Automotive Products (Suzhou) Co. Ltd.	Yang, Chao	A wheel speed sensor comprising: a casing (10), a main body part (11), and a fixing part (12), the inside of the main body part (11) being provided with an accommodation groove, the fixing part (12) being used for fixing the wheel speed sensor on a wheel of a vehicle; a sensor circuit board (21) being provided with a sensor element (22) and being inserted into and fixed in the accommodation groove of the main body part (11). The wheel speed sensor has a simple structure. The only requirement is the insertion of the sensor circuit board (21) into the pre-formed casing (10). Additionally, the sensor circuit board (21) and the casing (10) can be replaced in real time according to needs, thereby making the product flexible.
Wheel speed sensor interface, operation method thereof, and electronic control system including the same	April 30,2015/ US 20150120164	Electronics and Telecommunications Research Institute	Yi-Gyeong Kim	Provided is a wheel speed sensor interface. The wheel speed sensor interface includes: a speed pulse detection circuit configured to receive a plurality of sensor signals including wheel speed information of a vehicle, detect a plurality of speed pulses on the basis of the plurality of the received sensor signals, and transmit the plurality of the detected speed pulses to an external device; and a comparison speed detection circuit configured to generate a plurality of counting values by counting each of the detected speed pulses, generate comparison speed information by multiplexing the plurality of the generated counting values through a time division method, and transmit the generated comparison speed information to the external device.
Trailer heading angle using vehicle wheel speed sensors	Feb 26,2015/ US 20150057903	Ford Global Technologies	Douglas Scott Rhode	A system and method of calculating a heading angle for a trailer that is being backed by a vehicle. A trailer backup assist control module, in communication with a hitch angle detecting apparatus, receives a hitch angle and determines displacement of left and right vehicle wheels using information supplied by vehicle wheel speed sensors while the vehicle is backing the trailer. A vehicle heading angle is determined using left and right wheel displacement information and a known vehicle track width. A trailer heading angle is then calculated using the vehicle heading angle and the hitch angle.
Airplane wheel speed sensor capable of lastingly outputting high voltage and design method of airplane wheel speed sensor	Feb 18,2015/ CN 104354876	Xi'an Aviation Brake Technology Co. Ltd.	Liu Zhongping	The invention discloses an airplane wheel speed sensor capable of lastingly outputting high voltage and a design method of the airplane wheel speed sensor. According to the airplane wheel speed sensor capable of lastingly outputting high voltage, the diameter of a rotor shaft in fit with the inner diameters of bearings is selectively matched with the inner diameters of the bearings within the range that the tolerance is shown in the specification; the interference values of the bearings and the rotor shaft are 0.001-0.003mm; the inner diameters of the bearings are respectively shown in the specification; the gap delta between outer tooth crown of the rotor and the inner tooth crown of a ring gear is 0.1-0.25mm; the distance between the bearings is 10mm; the tooth width of the rotor is 7.2-7.3mm. Through reasonable control over the gap between the rotor and the ring gear and the distance between the bearings and reasonable control over the fit tolerance, the service life of the airplane wheel speed sensor is prolonged; the use reliability is improved.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Method and apparatus for detecting forward and backward movements of vehicle using wheel speed sensor	Jan 09,2015/ KR 1020150003456	Hyundai Mobis Co. Ltd.	Park, Young Ho	In the present invention, provided are a method for detecting forward and backward movements of a vehicle using a wheel speed sensor which can determine the condition of the forward and backward movements without additional devices even when a steering angle sensor malfunctions, and an apparatus therefor. The method for detecting forward and backward movements of a vehicle according to an embodiment of the present invention comprises the steps of: sensing wheel speed and real turning speed; calculating estimated turning speed based on the wheel speed; increasing a forward movement recognition counter or a backward movement recognition counter by comparing the estimated turning speed and the real turning speed to first minimum turning speed and second minimum turning speed; and determining that the vehicle moves forward or backward when the forward movement recognition counter or the backward movement recognition counter is over a forward movement recognition threshold value or a forward movement recognition threshold value. COPYRIGHT KIPO 2015
METHOD AND Apparatus for detecting forward and backward movements of vehicle using wheel speed sensor	Jan 09,2015/ KR 1020150003456	Hyundai Mobis Co. Ltd.	Park, Young Ho	In the present invention, provided are a method for detecting forward and backward movements of a vehicle using a wheel speed sensor which can determine the condition of the forward and backward movements without additional devices even when a steering angle sensor malfunctions, and an apparatus therefor. The method for detecting forward and backward movements of a vehicle according to an embodiment of the present invention comprises the steps of: sensing wheel speed and real turning speed; calculating estimated turning speed based on the wheel speed; increasing a forward movement recognition counter or a backward movement recognition counter by comparing the estimated turning speed and the real turning speed to first minimum turning speed and second minimum turning speed; and determining that the vehicle moves forward or backward when the forward movement recognition counter or the backward movement recognition counter is over a forward movement recognition threshold value or a forward movement recognition threshold value. COPYRIGHT KIPO 2015
Wheel speed sensor	Dec 31,2014/ CN 104251915	Dingjia (Tianjin) Automobile Electronics Co., Ltd.	Zhang Fenghong	Provided in the invention is a wheel speed sensor comprising a housing and a gear ring. The gear ring is arranged outside the housing. A cable, a permanent magnet, a polar shaft, and induction coils are arranged in the housing; the cable penetrates the whole middle portion of the housing; the permanent magnet and the polar shaft are sleeved at the cable; the lower end of the permanent magnet is connected with the upper end of the polar shaft; the induction coils are arranged at the two sides of the polar shaft. The wheel speed sensor is characterized in that a chisel type structure is formed at the head of the polar shaft; and reinforced rings are arranged at the head of the polar shaft. Because of the chisel type structure of the head of the polar shaft, the response to the electromagnetic conversion frequency is high, the generated signal is stable, and error prevention can be realized. Moreover, because the reinforced rings are arranged at the head of the polar shaft, signal transmission strength is enhanced and thus the velocity signal can be protected from electromagnetic wave interference during the transmission process, so that the signal is stable and the control unit of the automotive ABS can make a response rapidly.

Exhibit 1 lists some of the patents related to wheel speed sensors.

Picture Credit: Frost & Sullivan

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