# TECHNICAL INSIGHTS

## SENSOR

## TECHNOLOGY ALERT

**28th August 2015**

## 1. NON-INVASIVE BLOOD GLUCOSE MONITORING

People suffer from diabetes when insufficient insulin is produced in the body, resulting in high blood glucose levels. In type 1 diabetes, the body's immune system has destroyed insulin-producing cells so the body cannot make sufficient insulin. Type 1 diabetics take insulin injections.

In type II diabetes, the body needs more insulin to enable glucose to enter the cells due to insulin resistance, which occurs when fat, muscle, and liver cells do not use insulin to carry glucose into the body's cells for energy use. Over time, when blood sugar levels increase, such as after meals, the pancreas will not create sufficient insulin. Type II diabetes is the most common type of diabetes.

The typical electronic glucose monitoring method for diabetes involves piercing a finger to obtain a blood sample, which is generally collected on a test strip and then analyzed. The finger-stick method of monitoring glucose is uncomfortable, cumbersome, and time consuming. It can be unpleasant and inconvenient, particularly when frequent analysis of blood is required.

Electrochemical blood glucose sensing, a key type of blood glucose sensing technology presently used, could encounter difficulty detecting low glucose levels; if the glucose level gets too low, the amount of reactant is reduced and the electrical signal could become too low. Electrochemical sensors, moreover, can be vulnerable to interference caused by compounds that can be oxidized or reduced at the working potential. For instance, compounds commonly encountered in clinical samples, such as uric acid, acetaminophen, and ascorbic acid, can be oxidized, interfering with detection.

Researchers at the University of Leeds (UK) have developed an innovative non-invasive blood glucose sensing technology that uses low-power lasers to measure blood glucose without having to penetrate the skin. Such technology is capable of continuous monitoring for development for wearable applications. The technology has opportunities to provide a simpler, more cost-effective glucose monitor, compared to disposable strips and implantable, invasive glucose monitors. It also is conducive to enabling individuals to comfortably obtain continuous blood glucose readings.

The laser-based blood glucose sensing technology has been licensed to Glucosense Diagnostics, a spin-out company formed and funded by the University of Leeds and NetScientific PLC (London, UK). The non-invasive technology uses nano-engineered silica glass with ions that fluoresce in infrared light when struck by low power laser light. The extent of fluorescence signal varies based on the concentration of glucose in blood, when the glass contacts the user's skin. The device measures the length of time the fluorescence lasts and uses that time to calculate the glucose level in an individual's bloodstream without requiring a needle. This entire process spans less than 30 seconds.

The researchers are piloting a bench top version in their clinical investigations. The aim is to develop for the marketplace a finger-touch device similar to a computer mouse, and a wearable solution for continuous monitoring.

A pilot clinical study conducted at the Leeds Institute of Cardiovascular and Metabolic Medicine indicated that the new monitor has potential to perform as well as conventional technologies. Before the technology can gain regulatory approvals and be commercialized, it must undergo clinical trials and product optimization.

Details: Jin Jose, Professor and Chair in Functional Materials, Faculty of Engineering, University of Leeds, Engineering Building 134, Leeds LS2 9JT, UK. Phone: +44-113-343-2536. E-mail: g.jose@leeds.ac.uk. URL: www.engineering.leeds.ac.uk

## 2. CMOS CELLULAR SENSOR ARRAYS

A key need exists for cost-effective sensing solutions that are able to conduct very rapid, efficient, and larger-scale screening of *in vitro* (outside of the body) cells and tissues for applications such as pharmaceutical or chemical discovery and development. In the initial phases of drug development, *in vitro* cultured cells and tissues are employed to identify the effectiveness of drug candidates. Moreover, since different patients can react differently to the same type of drug even with the same dosage, the ability to test cell samples from a certain patient in order to determine patient-specific responses to a drug can enable more personalized medicine.

 

Addressing such needs, researchers from the Georgia Institute of Technology (USA) have developed an intriguing, multi-modality cellular sensing platform that is based a conventional CMOS (complementary metal oxide semiconductor) process. The technology, which combines semiconductor integrated circuits and living cells, allows each sensor pixel to concurrently monitor multiple different physiological parameters of identical cell and tissue samples for enhanced comprehensive and real-time physiological determination. Moreover, the hybrid electronics-biology technology platform can help enhance biotechnology and chemical and pharmaceutical development by providing an improved understanding of the physiological characteristics of living cells or tissues. Such technology has potential to help counteract the extremely high cost and risks of drug development.

The CMOS sensor array chip developed by the researchers offers key advantages, such as the ability to perform *in-situ* (situated in the original or existing place) signal processing or sensor fusion with respect to sensor information pertaining to multiple modalities. The technology, moreover, obviates the need for external electronic equipment.

High-throughput screening or scanning of chemicals or drugs, and monitoring of the efficiency or toxicity of such drugs or chemicals, can be obtained by configuring numerous (for example, thousands) of sensor array chips to operate together. This parallel scanning arrangement can purportedly attain significantly greater (more than 1,000 times) throughput compared to using fluorescent scanners for sequential scanning.

The research is under the domain of the Semiconductor Synthetic Biology (SSB) Program, which is sponsored and managed by the US-based Semiconductor Research Corporation (SRC), a major technology consortium to meet the needs of the semiconductor industry.

The researchers are looking at further increasing the density of the sensor array pixels and at packaging enhancements that are in sync with existing drug testing methods or techniques.

Details: Dr. Hua Wang, Assistant Professor, Bioengineering and Electronic Design and Applications, School of Electrical and Computer Engineering (ECE), Georgia Institute of Technology, 777 Atlantic Dr. NW, Atlanta, GA 30332. Phone: 404-385-6003. E-mail: hua.wang@ece.gatech.edu. URL: www.gatech.edu

## 3. MORE FLEXIBLE ULTRASONIC TRANSDUCER

Ultrasonic transducers convert ultrasonic waves into electrical signals or convert electrical signals into ultrasonic waves. Such transducers detect or evaluate a target based on its sound signals. Active ultrasonic transducers emit ultrasonic waves and evaluate the return echo received by the sensor. By measuring the time interval between sending the signal and receiving the echo, such transducers determine the distance to an object. Passive ultrasonic sensors (microphones) detect ultrasonic noise present under certain conditions and convert the noise to an electrical signal.

Piezoelectric ultrasonic transducers (the dominant type of ultrasonic transducer) tend to be fabricated using piezo composites, such as lead zirconate titanate (PZT) and epoxy filler. Such piezo composites have allowed for improved frequency bandwidth, enhanced sensitivity, and greater efficiency, compared to solid piezo ceramic materials.

One key application for ultrasonic transducers is flaw or crack detection. The propagation of sound waves through solid materials is used to detect hidden cracks, voids, porosity, or other internal discontinuities in metals, plastics, ceramics, or composites. Sound waves reflected form flaws generate distinct echo patterns that can be identified or recorded.

Researchers at the University of Strathclyde in Scotland have developed an ultrasonic sensor for detecting cracks in aero engines, oil and gas pipelines, nuclear facilities, or other structures that can feature a more flexible structure and can surmount the limits of conventional piezo composite ultrasonic transducers that are based on rigid structures and can have relatively narrow ranges. The ultrasonic transducer is based on fractals. Fractals are structures that have an irregular or fragmented shape at all scales of measurement such that certain mathematical or physical properties of the structure behave as if the dimensions of the structure are greater than the spatial dimensions. The Strathclyde researchers derived a mathematical model to predict the dynamics of a fractal ultrasonic transducer. The fractal used was a Sierpinski gasket.

Fractals are irregular shapes that occur repeatedly to form objects such as snowflakes, and make the structure appear more complex than it actually is. The fractal concept can underlay the hearing system of animals, such as bats, dolphins, and so on.

Anthony Mulholland, a reader in the department of mathematics and statistics at the University of Strathclyde and a co-researcher on the fractal ultrasonic transducer project, noted that fractal shapes and sound waves have geometrical features on a range of length scales. In contrast, man-made transducers tend to be characterized by a very regular geometry, which constrains their use in finding cracks and flaws in structures where safety is vital.

The ability to design fractal transducer is increasingly viable due to the ascendancy of innovative manufacturing technologies such as 3D printing, computer manufacturing, and laser technology.

The technology has opportunities to detect cracks in a range of sizes at an early stage, reducing the number of inspections required.

Details: Dr. Anthony Mulholland, Reader, Department of Mathematics and Statistics, University of Strathclyde, 16 Richmond Street, Glasgow G1 1XQ. Scotland, UK. Phone: +44-141-548-2971. E-mail: Anthony.mulholland@strath.ac.uk. URL: www.strath.ac.uk

## 4. ADVANCES IN INTEGRATION OF LIGHT SENSING AND COMMUNICATIONS

Visible light communications (VLC), which uses visible light between 780 and 375 nanometers to communicate data and encodes data into changes in light intensity at a frequency that the human eye cannot perceive, is attracting keen interest. Since light-generating devices are omnipresent, VLC can serve as a communications medium for ubiquitous computing. Furthermore, the use of light-emitting diodes (LEDs) for transmitting visible light and photodetectors to sense the light can enable integration of energy efficient, secure, safe data communication and human sensing.

Researchers at US-based Dartmouth College, under the direction of Xia Zhou, assistant professor of computer science and co-director of the DartNets (Dartmouth Networking and Ubiquitous Systems) Lab, have helped advance VLC-based sensing and transform light into a ubiquitous sensing medium by developing a VLC-based light sensing system that is able to continuously reconstruct human posture. Such capability can allow for using light to track human presence or location, facilitate human-machine interactions, and help sense how people behave in certain environments.

For example, using LED lighting on ceilings and photodiodes on the floor, individuals will be able to have gesture-based interaction with devices or objects in a room, such as computers, displays, appliances, and so on. No cameras or wearable sensors would be necessary for such capabilities. Furthermore, such light-based sensing is immune to electromagnetic interference and is not constrained to working with pre-defined gestures or activities.

The license technology developed by the Dartmouth researchers leveraged visible light communications to reconstruct the movements of a human skeleton in real-time. The light sensing test bed uses off-the-shelf LEDs, photodiodes, and microcontrollers. The postures of the 3D human skeleton are reconstructed using shadows created by a human body from blocked light.

To achieve the shadow-based human sensing, the researchers had to address the problem of having diminished and complex shadow patterns on the floor, caused by the multiple lights on the ceiling. VLC technology was used to create light beacons to separate the light rays from different light sources and retrieve the light pattern cast by each distinct light. Furthermore, the researchers create an algorithm in order to reconstruct the human postures utilizing two-dimensional (2D) shadow information containing the limited resolution from the floor-embedded photodiodes.

The researchers are engaged in further enhancement of smart, interactive lighting, and light-based sensing. Applications for such technology could include more intuitive interaction with objects in the environment such as drones, appliances, games, as well as facilitate passive behavioral monitoring and healthcare.

Details: Dr. Xia Zhou, Assistant Professor, Computer Science and Co-Director, DartNets (Dartmouth Networking and Ubiquitous Systems) Lab, Dartmouth College, Sudikoff 208, HB 6211, Hanover, NH 03755. Phone: 1-603-646-8871. E-mail: xia.zhou@dartmouth.edu. URL: www.dartmouth.edu.

## 5. RECENT PATENTS IN THE FIELD OF SMART SENSORS

A smart sensor is able to provide additional capabilities beyond simply detecting a parameter of interest (such as pressure, temperature, acceleration, gas concentration) and sending a raw, uncompensated signal. The smart sensor contains electronics or an on-board microprocessor that performs computations and conditions the raw signal before it is transmitted to its destination or to a control network. Smart sensors can provide such functionality as temperature compensation, signal amplification, self-diagnostics, and analog-to-digital conversion, and communications. Smart sensors with intelligent electronics and network communication capabilities can be more easily integrated into sensor networks and decrease the component cost for original equipment manufacturers (OEMs).

To enable the creation of more efficient and intelligent devices, systems, or networks, smart sensors are increasingly replacing conventional (“dumb”) sensors in varied industries or applications, such as

industrial monitoring and process control, energy management, building/home automation, smart infrastructure, structural health monitoring, consumer electronics, military/aerospace, transportation, healthcare. Smart sensors can be more easily arranged in a sensor network to drive applications related to the Internet of Things.

The patent filing activity for smart sensors is high in North America, Europe, and Asia-Pacific. A recent patent in this domain (EP2898485), assigned to Google Inc., pertains to devices for a sensor-based home. Such multi-sensing, intelligent and network-compatible devices provide smart home capabilities by communicating with each other or with a central server or cloudcomputing system.. Some of the companies with patents in this area are Omron, Freescale Semiconductor, STMicroelectronics, Bosch, ABB, InvenSense, Infineon, and Honeywell International.

| Title | Publication Date/Publication Number | Assignee | Inventor | Abstract |
|---|---|---|---|---|
| Devices, methods, and associated information processing for the smart-sensored home | 29.07.2015; EP2898485 | Google Inc. | Fadell Anthony M | This patent specification relates to apparatus, systems, methods, and related computer program products for providing smart home objectives. More particularly, this patent specification relates to a plurality of devices, including intelligent, multi-sensing, network-connected devices, that communicate with each other and/or with a central server or a cloud-computing system to provide any of a variety of useful smart home objectives. |
| Smart sensor devices for measuring and verifying solar array performance | 10.06.2015; EP2880423 | PowerOwners, LLC. | Leary, Daniel P. | A device comprises a platform constructed and arranged to be mounted to one or more solar array modules and one or more solar irradiance sensors on the platform configured to receive incident solar energy, the solar irradiance sensors oriented on the platform so that the received incident solar energy is comparable to that received by the solar array modules, the one or more solar irradiance sensors providing solar irradiance signals in response to the incident solar energy. A processor is on the platform, the processor configured to receive the solar irradiance signals and, in response, generating a performance reference metric based on the solar irradiance signals, the performance reference metric related to the expected performance of the one or more solar array modules to which the platform is mounted. A transmitter is on the platform, the transmitter configured to periodically transmit the performance reference metric to a receiver. |

| | | | | |
|---|---|---|---|---|
| Smart sensor unit with memory metal antenna | 07.05.2015; US20150127260 | Enlighted Inc. | Peter H. Mulller | Systems, method and apparatuses of a building control sensor unit are disclosed. One apparatus includes a building control sensor unit that includes one or more sensors operative to sense an environmental condition of a structure, and a transceiver, wherein the transceiver includes an extended antenna, wherein the extended antenna includes a strand of memory metal. The apparatus further includes a controller, wherein the controller is operative to receive information from other building control sensor units or a central controller, and transmit information to the other building control sensor units or the central controller, wherein the building control sensor unit is configured such that when placed on or within a ceiling of the structure, the extended antenna extends into the structure. |
| Building integrated photovoltaic devices as smart sensors for intelligent building energy management systems | 06.11.2014; US20140330538 | Conklin John Anthony | Conklin John Anthony | Building-integrated photovoltaic devices can be provided, which function as sensors, wherein the output parameters from the device are used to provide information about light intensity and ambient temperature, in addition to providing power, to an intelligent building energy management system. |
| Method of recognizing image and providing augmented reality using smart sensor, terminal device, and computer-readable recording medium | 03.12.2014; KR1020140137980 | Tekville.com Inc. | Park, Ki Hyun | The present invention can be implemented in a mobile terminal including a camera and a smart sensor, wherein the mobile terminal comprises: a smart sensor for acquiring three-dimensional azimuth angles of the camera and the mobile terminal; a sensor signal processing unit for controlling and processing the acquired signal; and a view angle adjusting unit which compares the sensor signal with an acquired reference image, analyzes a result, and adjusts a correlation between the three-dimensional azimuth angles and a view point of the camera toward a subject. Three-dimensional azimuth angle information of a terminal, which is obtained when taking an image of the subject by using the smart sensor, is analyzed such that images to be compared with the same azimuth angle can be quickly searched for in a database. By using the present invention, by adjusting the correlation between the three-dimensional azimuth angle of the terminal and the view point of the camera and performing a primary filtering process, an unnecessary comparing process related to images, which are irrelevant to the taken image, can be ignored in the data base including a plurality of images to be compared with. Also, by matching the image taken by the camera with a corresponding image to be compared, feature comparison time is reduced and augmented reality is quickly provided. COPYRIGHT KIPO 2015 |
| Coremicro reconfigurable embedded smart sensor node | 17.07.2014; US20140200855 | Oonk Stephen | Oonk Stephen | A Coremicro Reconfigurable Embedded Smart Sensor Node has the capability of hosting intelligent algorithms to support health monitoring applications and has optional standardized software communications stack. The purpose of this present invention is to provide a flexible low power distributed computational platform to deploy intelligent software elements (based on Artificial Intelligence techniques) among the system architecture to result in a reconfigurable scheme for distributed intelligence granularity. This invention is able to be applied to a wide variety of monitoring applications either as a Standalone Smart Sensor (SSS, i.e. single Smart Sensor Node) or as a modular and scalable Smart Sensor Network configuration. Therefore, the CRE-SSN is ultra-low in power consumption, has optional pattern recognition through Artificial Neural Network, physical communication layer reconfigurable capability, has scalable communications capability, and low in weight, |

| | | | | |
|---|---|---|---|---|
| | | | | and optimized in size. An optional IEEE 1451 software stack is provided to manage sensors via set of standardized commands. |
| Controlling use of parking spaces using cameras and smart sensors | 10.07.2014; US20140195313 | Cloudparc Inc. | Steven David Nerayoff | Tracking use of a destination location is disclosed. A first unique identifier of a first vehicle is received based on a sensor located within the first vehicle. A first location of the first vehicle is determined based on a first vehicle image taken at a second time. A second location of the first vehicle is determined based on a second vehicle image taken at a third time. Finally, it is indicated that the first vehicle began use of the destination location at the second time and that the first vehicle completed use of the destination location at the third time. |

**Exhibit 1 lists a few patents related to smart sensors.**

*Picture Credit: Frost & Sullivan, WIPO*

**Back to TOC**

**To find out more about TechVision, access http://www.frost.com/techvision Follow us on @TechVision_FS, http://www.frost.com/techvisionlinkedin**

**To comment on these articles, write to us at tiresearch@frost.com**

You can call us at: **North America**: +1-843.795.8059, **London**: +44 207 343 8352, **Chennai**: +91-44-42005820, **Singapore**: +65.6890.0275