TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

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1. ENHANCEMENTS IN FORCE SENSING RESISTORS

Force sensing resistors consist of a conductive polymer material which undergoes a change in resistance and conductance when force or pressure is applied to the sensor’s surface. The sensing film can consist of conducting and non-conducting particles suspended in a matrix. Such sensors are very well suited for use in human-machine interface devices and applications, as they provide variable or dynamic resistance based on the amount of force or pressure applied to the device.

Force sensing resistors provide key benefits, such as very compact size, low thickness, low cost, and shock resistance. However, the precision and accuracy of conventional force sensing resistors can be further enhanced. Moreover, force sensing resistors need to perform optimally when integrated into a customer’s human-machine interface product. There are needs and opportunities for signal processing and algorithms that enable efficient gathering or processing data from rows and columns of sensing elements in order to provide more accurate, versatile, and advanced force sensing resistors for key emerging or expanding applications, such as multi-touch arrays.

Tangio Printed Electronics, the R&D Division of Sytek Enterprises, is helping to spearhead development of more advanced force sensors that are not simply single-zone sensors, but can enable true 3D multi-touch matrix arrays. Tangio is able to create force sensors comprised of materials of different thicknesses that are designed to provide performance benefits with respect to such attributes as size, resolution, and compatibility with a customer’s end-product.

Tangio's force sensing resistors can use different carbon-based inks with additives. Tangio perceives opportunities to exist in combining force sensing resistors with capacitive sensing to provide touchless proximity sensing, gesture recognition, or touch sensing along with force sensing. The company also sees opportunities to combine force sensing resistor technology with haptics to create intelligent surfaces that mimic the feel of, for example, mechanical buttons. In human-computer interaction, haptics provides tactile and force feedback.

Tangio views force sensing resistors as able to provide a richer scope of commands and gestures and to make surfaces interactive.

Tangio is working with partners to develop a clear, printable force sensing ink to be used in its clear force sensors. An early adopter customer segment for such clear force sensors entails electronic musical instrument manufacturers, who may use such sensors to make more sensitive, backlit, expressive user interfaces.

Tangio's force sensing resistors, furthermore, have opportunities in diverse applications, for instance, musical instruments (such as drum machines or keyboards), healthcare (for example, drug delivery systems), automotive (HVAC controls, audio controls, or seat sensors).

Tangio's market opportunities are boosted by the company's ability to design force sensing resistors for a plethora of specific customer applications and for diverse customer environments. The company focuses on being keenly aware of the functional and environmental attributes needed to build a viable and effective force sensing resistor application. For example, Tangio can design higher-resistance inks to sense heavier weight (such as a truck), or create a design that detects only a portion of the truck's force. Tangio can build force sensors to better sense different pressure ranges, from that of a light touch of a finger to a truck rolling over the sensor. The company focuses on continuously improving the consistency, repeatability and processabilityof its force sensing resistors.

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2. ENERGY HARVESTING CIRCUIT ADVANCES LOW-POWER SENSING

Energy harvesting technology leverages ambient energy sources to power devices. Such energy can be typically used for low-power applications. Battery-powered sensing devices can encounter key challenges, such as the need for regular maintenance or battery disposal issues, which can constrain the growth of wireless sensor networks, the embedding of sensors in a multitude of devices, vehicles or equipment in conjunction with the Internet-of-things phenomenon, ubiquitous monitoring, and so on.

Solar or photovoltaic energy harvesting has been used for large-scale applications and can also benefit low-power applications. However, solar energy harvesting has had certain limitations; for instance, silicon photovoltaic cells can have diminished effectiveness indoors, and solar energy harvesting has deficiencies during nighttime and limited conversion efficiency.

Researchers at the Massachusetts Institute of Technology have developed an ultra-low power converter chip that can very efficiently harvest energy from solar power and has opportunities to help spearhead the realization of larger-scale sensor networks and achieve key progress toward ubiquitous sensing. The power converter chip is able to harvest more than 80% of the energy flowing into it, even at the very low power levels representative of minute solar cells. This embodies a 30 to 40% increase in efficiency compared to prior experimental ultra-low power converters. The prototype chip was manufactured via Taiwan Semiconductor Manufacturing Company's University Shuttle Program.

The chip, moreover, is able to use a solar cell to charge a battery or directly power a device, and is able to power a device directly from the battery. The ultra-low-power circuit can interface with a solar cell and provide a regulated output voltage to power ultra-low-power sensors.

A single inductor, the primary electrical component of the chip, is used for the various operations. This scheme conserves circuit board space but increases circuit complexity although the chip is designed to have low-power consumption.

The chip integrates DC-DC converters and the required control circuits to regulate the input, output and battery protection during charging and discharging. A key attribute is the ability of the chip to operate very efficiently with very limited input power, ranging from 10 nanowatts to one microwatt.

The researchers were able to reduce the amount of power required by the chip without compromising the tasks it performs.

The main function of the circuit is to regulate the voltages between the solar cell, battery, and the device the cell is powering. In the event the battery operates for too long at a voltage that is too high or too low, its chemical reactants can break down, and the battery loses the ability to hold a charge.

An inductor in the form of a wire wound into a coil is used to control the current flow across the chip. When a current passes through it, the inductor generates a magnetic field, which resists any change in current.

The inductor will alternately charge and discharge when switches are thrown in its path. Therefore, the current flowing through the inductor continuously ramps up and then drops back to zero. The circuit's efficiency is improved by limiting the current, as the rate at which the current dissipates energy in the form of heat is proportional to the square of the current.

At zero current, the switches in the inductor's path must be thrown immediately to prevent current from flowing through the circuit in the wrong direction, which would drastically impair its efficiency. The timing of the throwing of the switch needs to vary, as the rate at which the current rises and falls depends on the voltage generated by the solar cell, which fluctuates.

The researchers used a capacitor, which is able to store an electrical charge, to control the timing of the switches. The capacitor fills more rapidly, the higher the current. The circuit stops charging the inductor when the capacitor is full.

The rate at which the current drops depends on the output voltage, which the chip is geared to regulate. As that voltage is fixed, the variation in timing must come from changes in capacitance. The chip is equipped with a bank of capacitors of different sizes. As the current drops, it charges a subset of the capacitors. The capacitor subset to be charged is determined based on the solar cell's voltage. The switches in the inductor's path are flipped when the capacitor fills.

The MIT researchers have created a complete, sophisticated system-on-chip for power management that is highly efficient for very low power levels.

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3. GREATER INSIGHTS INTO PROTEIN STRUCTURE VIA DNP-NMR

Nuclear magnetic resonance (NMR) spectroscopy is important for determining the structures in material science and structural biology. However, this technique has a limitation of relatively low sensitivity, due to the small magnetic moment of the nuclei under investigation. NMR signal intensities can be small, with signal averaging required to obtain a sufficiently high signal-to-noise ratio.

Dynamic nuclear polarization (DNP) leverages the spin polarization from electrons to nuclei to significantly boost the signal intensity, as well as the data acquisition rate, in NMR spectroscopy. DNP enables structure determination via high-resolution solid-state NMR spectroscopy.

DNP-NMR has opportunities to provide greater insight into the structure and function of proteins. It has been difficult to completely characterize the various structures that proteins can assume in their environments. Proteins can fold in various ways based on their environment. The different configurations can alter the protein’s function. Protein misfolding is often linked with diseases such as Alzheimer’s or Parkinson’s disease.

Using an enhanced sensitivity NMR technique, based on DNP, the researchers at Massachusetts Institute of Technology (MIT) demonstrated the ability to analyze the structure of a yeast protein as it interacts with other proteins in a cell. This technique allows for a greater understanding of the structure and function of proteins compared to more conventional NMR technology, which can require a large amount of purified proteins that are isolated from their environment.

In traditional NMR, the magnetic properties of atomic nuclei elucidate the structures of the molecules that contain the nuclei. Utilizing a strong magnetic field that interacts with the nuclear spins of carbon atoms in the proteins, the NMR technique measures the chemical shift for some of the individual atoms in the sample, which can indicate how the atoms are connected. However, the traditional NMR technique has limited sensitivity, as it only allows for obtaining information from carbon-13 nuclei in samples. Only about 1.1% of carbon nuclei occur naturally as the 13C form.

For two decades, the laboratory of Robert Griffin, MIT professor of chemistry and director of the Francis Bitter Magnet Laboratory, has been developing DNP, requiring transfer of polarization from unpaired electrons to protons and to carbon nuclei, using microwaves generated by a gyrotron (high-frequency microwave oscillator developed in cooperation with Richard Timkin of MIT's Department of Physics and Plasma Science and Fusion Center. Moreover, Timothy Swager and his group in MIT's department of chemistry have developed paramagnetic polarizing agents for such experiments. This development allows for enhancing the signal intensity in carbon-13 spectra by a factor of 100 to 400, representing a substantial gain in sensitivity.

In traditional solid-state NMR, around 30 milligrams of purified protein is required to obtain information in an adequate time frame. In contrast, the increase in sensitivity from the DNP technique eliminates the need for purified protein and enables it to be analyzed in amounts typically found in a cell. The researchers label only the target protein with carbon-13 to ensure that information is obtained solely from the protein of interest. Furthermore, there is no need to crystalline the proteins or put them onto a uniform solution. The proteins are able to be investigated in their natural environment.

As noted in "Sensitivity-Enhanced NMR Reveals Alterations in Protein Structure by Cellular Milieus," published in Cell, 2015 Oct.7, the researchers applied DNP NMR to investigate the structure of a protein containing an environmentally sensitive folding pathway and an intrinsically disordered region, the yeast prion-protein Sup35. They added an exogenously prepared isotopically labeled protein to deuterated lysates, making the biological environment "invisible" and enabling very efficient polarization transfer for DNP. The DNP renders structural studies of proteins at endogenous levels in biological contexts possible, and these contexts can influence protein structure.

Sup35 is a type of protein that may form amyloids, tangled clumps that can cause the Sup35 protein to stop terminating protein translation. Amyloids formed from human proteins are often associated with neurodegenerative diseases such as Alzheimer's, Parkinson's, or Huntington's, as well as rheumatoid arthritis.

In prior studies involving traditional NMR with purified Sup35 protein, researchers found that a large section of the protein that forms the amyloid has a beta-sheet structure resembling the folds of an accordion. Another large section is intrinsically disordered and does not form a consistent structure.

However, when the researchers investigated Sup35 surrounded by other cellular proteins in the new study, they discovered that the intrinsically disordered region assumes a regular structure, believed to be beta sheets, although more powerful resolution is required to substantiate this belief.

One of the key researchers, Kendra Frederick, assistant professor, University of Texas Southwestern, and formerly a post doc at Whitehead Institute, MIT, intends to continue using this NMR technique to investigate other yeast proteins and human amyloid proteins. Specifically, Kendrick seeks to understand why proteins can assume different conformations in different types of cells, or cells from individuals of different genetic backgrounds.

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4. HIGH-TEMPERATURE SQUID ARRAY

Superconducting quantum interference devices (SQUIDs) are extremely sensitive detectors of magnetic flux, which is the product of the average magnetic field times the perpendicular area that it penetrates. SQUIDs are able to measure extremely subtle, low magnetic fields. Applications for SQUIDs include magnetoencephalography (detecting the brain’s magnetic fields), magnetocardiography, magnetic resonance imaging (MRI), oil or mineral exploration, as well as biosensors.

There are basically two types of SQUIDs. The DC SQUID uses two Josephson junctions connected in parallel on a superconducting loop. The RF SQUID has a single Josephson junction inserted into a superconducting loop. The DC SQUID is more sensitive, but is more expensive to produce.

Most SQUIDs are comprised of niobium, a low transition temperature superconductor, and operated at or below 4.2 Kelvin, the boiling point of liquid helium.

High-transition temperature SQUIDs use thin films of high-transition temperature superconducting materials--YBa Cu O or yttrium barium copper oxide (YBCO)--which operate at or near the boiling point of liquid nitrogen (77 Kelvin). High-temperature SQUIDs are not as difficult or expensive to cool as the low-temperature SQUIDs. However, achieving high-transition temperature DC SQUIDs for operating at 77 K has been difficult, due to the relative immaturity of high-transition temperature Josephson junction technology and to noise issues.

Researchers from Loughborough University and Nottingham University in the UK have created a multi-SQUID device that can operate at 77 K and outperform most standard 4.2 K SQUID magnetometers.

The researchers achieved the enhancement in high-temperature SQUID performance by using an array of high-temperature SQUIDs which could theoretically attain the same performance as a single low-temperature SQUID. The array is fabricated via optical lithography after depositing a YBa2Cu3O7 thin film on a SrTiO3 bicrystal. Each SQUID consists of two Josephson junctions connected in parallel.

In an array of SQUIDs, the voltage output is proportional to the number of SQUIDs in the array, while the noise associated with the measurement only increases as a square root of the SQUID count. Therefore, the more SQUIDs utilized, the stronger the signal, and the more sensitive the measurement.

However, for a SQUID array to function so effectively, flux coherency (all the SQUIDs must experience the same magnetic flux) must be achieved and the interaction among each SQUID and its neighbors must be minimized. These conditions are difficult to achieve, due to the formation of parasitic fluxes during routine SQUID operation.

To address these issues, the researchers designed narrow yet long flux focusers, which are large areas of superconductors that improve magnetic field sensitivity and minimize parasitic fluxes. Previous SQUID arrays have typically either not used flux focusers or used flux focusers that were so large they constrained the number of SQUIDs that could be integrated onto a single chip. By keeping the width of the focusers identical to the SQUIDs' width, the researchers were able to create an array of an arbitrarily long series of SQUIDs, while also achieving a high degree of flux coherence and field sensitivity by increasing the length of the flux focusers.

In testing, the white flux nose (which is linked to sensitivity) of a 770 SQUID array and of a 484 SQUID array were superior to that of low-temperature single SQUIDs operating at 4.2 K.

The researchers are optimizing the shape and design of the SQUID arrays to increase their magnetic field sensitivity. The SQUID array has the potential for providing a more cost-effective solution than single SQUIDs operating at 4.2K, without compromising noise resolution.

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5. RECENT PATENTS IN THE FIELD OF MOBILE HEALTH SENSING

Wearable, smart, low-power sensors, and the successful integration of mobile phones and wireless technologies, are enabling the growth of the mobile health market. Wearable sensors collect health data, and the data can be further processed and analyzed in mobile devices for improved, real-time health monitoring and tracking. Mobile health encompasses medical, health, and wellness practices and activities supported by mobile devices, such as mobile phones, notebook, and tablet computers, or head bands or wrist bands, for gathering clinical, personal health or fitness data and delivering healthcare information to healthcare practitioners, patients, and researchers, or health-conscious individuals.

The different types of sensors employed in mobile health sensing include implantable sensors, smart shirts, fabrics, and patches, and body-worn vital sign monitors that track the different physiological parameters of the user/wearer, such as temperature, blood pressure, heart rate, blood oxygen. There are opportunities to track other physiological parameters in body worn devices, such a, for example, blood glucose. Sensors employed in mobile health monitoring are small, lightweight, unobtrusive, and robust.

Mobile health sensors allow for remote health data collecting and data mining that could be utilized for further analysis. This, in turn, reduces the cost and inconvenience of regular visits to medical practitioners. This ability to intervene earlier reduces medical risk in patients with chronic conditions, such as cardiovascular disease and diabetes. With wearable sensors and mobile apps, users can keep a tab on their own health, around the clock, and in case of any irregularities, they can contact the doctors.

With the help of patent filing trends, it is evident that advanced wireless sensors and the widespread use of mobile devices are creating new opportunities in the healthcare industry by offering advancements in real-time tracking of an individual's health and faster and easier access to health data. The market for mobile health devices is expected to expand rapidly in the coming years due to the ongoing advancements in wireless sensing technologies, signal processing, improved communication technologies, the expanding aging population, as well as availability of lower power, minuscule, highly sensitive sensors.

The US constitutes the largest geographic segment, and this region shows considerable growth opportunities. The mobile health market is gaining rapid attention in Europe, and is the second largest market for mobile health. The mobile health market in the Asia Pacific region is smaller than that of the US and Europe. It is an emerging market, and opportunities to provide remote monitoring services, to reduce the cost of healthcare, and to reach previously inaccessible patients are key drivers for the mobile health market in Asia.

Some of the companies investing in mobile health sensors include LifeWatch AG, Hidalgo Limited, Rest Devices, AliveCor, BodyMedia, and many more.

A recent patent in mobile health sensing (WO/2015/143723), assigned to SHENZHEN TATFOOK NETWORK TECHNOLOGY CO., Ltd., pertains to a cloud processing method for human health data, and a mobile terminal and communication system. The technology includes a pulse information detection device worn on a limb that receives external pressure; and a pressure sensor that continuously detects the pressure at an arterial location of the limb of the user.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Cloud processing method for human health data, and mobile terminal and communication system	01.10.2015; WO/2015/143723	Shenzhen Tatfook Network Technology Co., Ltd.	Sun, Shangchuan	A cloud processing method for human health data, and mobile terminal and communication system, the method comprising: S701: a pulse information detection device worn on a limb of a user receives external pressure; S702: a pressure sensor of the pulse information detection device continuously detects the pressure at an arterial location of the limb of the user via a resilient air bag sleeved on the periphery; S703: the pulse information detection device calculates and obtains human pulse information according to the pressure detected by the pressure sensor, and transmits the human pulse information to a cloud server; S704: the cloud server receives the human pulse information transmitted by the pulse information detection device; S705: the cloud server analyzes the physical condition of the user according to the human pulse information. The method can precisely acquire human pulse information, and conduct cloud processing of the physical condition of the user.
Multi-functional smart mobility aid devices and methods of use	01.10.2015; WO/2015/14857	Alghazi, Ahmad Alsayed, M.	Alghazi, Ahmad Alsayed, M.	Embodiments of a smart mobility aid device may have sensors to collect, monitor, analyze and represent data including but not limited to activity tracking, biometrics and safety and emergency features. The activity tracking include number of steps, miles, and activity speed, user pressure on a device, activity types and analysis. The user biometric data includes but is not limited to blood work, blood pressure, blood sugar, heart rate, oxygen level/rate, ECG, EMG, muscle strain, humidity, UV, body temperature. Additional features include an emergency button, fall detection, warnings, and user pattern analysis changes. The mobility aid device is connected to other smart electronic devices and/or the Internet using but not limited to Bluetooth, Wi-Fi, and or/and SIM card. The device gives the user or/and caregiver live feedback about user health metrics and status using a data representation method.
Mobile device casing for health monitoring	10.09.2015; US20150254414	Azoi Inc.	Hamish Patel	A casing adapted to use with a mobile device for monitoring health condition of a user is provided. The casing includes (a) a memory unit, (b) a sensor unit at a surface of the casing, (c) a plurality of health parameter measuring sensors embedded within the sensor unit for measuring raw health parameters data of the user, (d) a processor which is activated from a sleep mode based on a user input including contacting at least one predetermined sensor surface on the casing for a predetermined period, and (e) a power unit for controllably supplying power to the sensors and the processor upon detecting the user input. The processor (i) initializes and configures the sensors, and (ii) receives the raw health parameters data from the sensors. The casing further includes a communication unit for communicating the raw health parameters data to a mobile device for processing.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
System for integrated protocol and decision support	02.07.2015; US2015018703	General Electric Company	Christopher Donald Johnson	Embodiments of the system support hospital operations, delivery of health care, and improve patient satisfaction. The interactive hospital information system utilizes inputs from a mobile device, eliminating the cost of fixed cameras and sensor systems in the hospital facility. Aspects of the invention facilitate real-time patient care and patient room updates by care providers, validating that prescribed devices, services, and setups are in place per protocol. The system communicates with rounding persons as to specific care management. Network devices, such as an iPad® or smartphone, are utilized to monitor and record ongoing activities in the healthcare setting.
Pulse feeling mobile phone peripheral device	17.06.2015; CN104715135	Xi'an Dingzi Electronic Information Science & Technology Co. Ltd.	• Yang Furong • He Xingshi • Liu Yang • Shi Qiang	The invention belongs to the field of mobile phone peripherals and particularly provides a pulse feeling mobile phone peripheral device which comprises an outer shell (1), a USB connector (2), a processor (3), a power supply board (4), a USB driving circuit (5), a signal processing circuit (6), a pulse sensor (7), a connecting wire (8) and a bundling belt (9). Through the USB connector, the device is inserted into a USB port of a mobile phone, and communication of a peripheral and the mobile phone is achieved. Through measuring software on the mobile phone, the processor of the peripheral is controlled to measure the pulse information of a user, information collected by the processor is transmitted to the mobile phone, the mobile phone analyzes pulse information through a database of software of the mobile phone and a network database, the health information reflected by the pulse is displayed on a software terminal of the mobile phone, and automatic pulse feeling is achieved. Through a processor and a displayer of the mobile phone and a convenient network function, convenience of a medical device is achieved, operation is easy, and cost is greatly lowered.
Method for conducting medical treatment through internet of things	CN104715135; 17.06.2015	Hefei Caixiang Information Science & Technology Co., Ltd.	Noam Xue Shikai	The invention relates to the field of medical treatment conducted through the internet of things, in particular to a method for conducting medical treatment through the internet of things. A triangular interconnection structure is formed by intelligent wearing equipment containing a 3G network module, a medical server located in a medical center and a smart phone, the structure is connected through a 3G network and mainly used for old people or vulnerable groups with the poor health condition. The sensor network technology and the mobile internet technology which is mature gradually in the internet of things are adopted, the technology of the internet of things is introduced to the medical and health service industry actually, and an efficient and resource-sharing medical and health service system is formed.

Exhibits 1 list some of the patents related to mobile health sensing.

Picture Credit: Frost & Sullivan

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