TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

07th November 2014

1. RECONFIGURABLE IMAGE SENSING TECHNOLOGY

The Internet of things (IoT) represents a global network of billions of sensors, appliances, equipment or other objects communicating in real time. These connections would move beyond computing devices to billions of everyday devices in cars, homes, factories, hospitals, city infrastructure, agricultural activities, and more. In this area, the ability to perform image processing in the image sensor is critical for timely and correct decision making. Compressing data degrades data quality and impacts decision making time and quality. Hence, there is a need for a device that can provide unique image capture and processing capabilities for different applications. The device should also enable critical and smart decisions.

To address the above-mentioned challenge, researchers from Forza Silicon Corporation and Lattice Semiconductor have developed a new architecture for the image sensor. It is integrated with a low power compact image sensor and MachXO2-7000 field programmable gate array (FPGA) from Lattice Semiconductor.

Forza Silicon's new reconfigurable image sensor enables smart applications in the increasingly interconnected world. The reconfiguring capability of the sensor provides a flexible platform that can be used to connect smart sensors to the Internet and enable vaious IoT product applications. The image sensor developed by the synergistic efforts of Forza Silicon and Lattice Semiconductor is a single device merging and imaging array with a configurable analog and digital processor. To enable the functions of camera, programmable logic can be configured to enable different systems, such as, network connections, including, Bluetooth, Wi-Fi, Ethernet, memory processors, and USB. It also enables image processing, which includes color processing, motion detection, high dynamic range, and facial recognition. For improved performance, such as, different frame rates, power conservation, and noise limits, the onboard analog-to-digital converter is adjusted.

The reconfigurable image sensor can be used with smoke detectors inside houses. The sensor will monitor and detect smoke and stream video confirmation of the fire event inside the house and send an alert to house owner over mobile phone. The same sensor device can be used in multiple product applications and can be configured for the specific task and requirements of the products. It can be programmed for decision making tasks.

The project was partly funded by both Forza Silicon and Lattice Semiconductor. The research team is currently working on finding the additional features and capabilities that can be programmed into the existing device. The reconfigurable image sensor technology is expected to be commercialized in one to two years' time. The technology, once commercialized, is expected to get a good response from manufacturers as it will allow them to upgrade their products' firmware.

Details: Shawn Maloney, Executive Vice President of Business & Product Strategy, Forza Silicon Corporation, 2947 Bradley Street, Suite 130 Pasadena, California 91107. Phone: +1-626-796-1182. E-mail: info@forzasilicon.com. URL: www.forzasilicon.com

2. ENERGY HARVESTING USING PIEZOELECTRIC STACK

To avoid catastrophic failures, hydraulic hose and piping systems can deploy sensors or sensor nodes for monitoring structural health. These sensors or nodes are connected through wires to the main system or are battery operated. This increases the risk of device failure because of the power loss and also increases the maintenance cost of the device. There is a need for a device that can eliminate the risk of device failure. In addition, it should be cost efficient.

To address the above-mentioned challenge, researchers from the Georgia Institute of Technology (Georgia Tech) have developed a device that can help to generate electricity from pressure ripples. The device is integrated with a piezoelectric stack and pressure sensor.

The piezoelectric stack, used in the construction of energy harvesters, is made of many thin piezoceramic layers. The layers are constructed with the help of ceramics. The piezoelectric stack is employed in the construction of energy harvesters because of its principal characteristics, such as low voltage operation, fast response, and high energy conversion efficiency. The piezoelectric stack developed by the researchers from Georgia Tech is designed from multiple piezoceramic layers and is enforced by pressure ripples travelling through hydraulic lines. The pressure ripples deflect the piezoelectric material and produce a relevant voltage across the electrode, leading to piezoelectric effect. The terminals of the electrode are connected to the external resistive load. Pressure ripple from 15 psi to 45 psi can generate a power of 3.2 milliwatt to 150 microwatt. This power output can provide power to a broad range of sensing and communication applications.

Once the project is completed, this energy harvesting technology in hydraulic systems might get integrated with health monitoring and temperature sensors. This technology will provide power to individual sensors and eliminate the need for wires and batteries. This will further eliminate the risk of power loss and device failure. The researchers are currently working on extending the pressure range--both dynamic and static--with the help of hydraulic pressure energy harvester. This development demands appropriate design of the power conditioning circuit and of the device, which will further help to achieve maximum energy production using the pressure ripple input. The researchers are working toward identifying an advanced material for the piezoelectric stack, which would have a higher energy density potential. Researchers are also working toward identifying applications that are relevant to the hydraulics industry.

The project was funded by the Center for Compact and Efficient Fluid Power (CCEFP)—a National Science Foundation Engineering Research Center (NSFERC). The industrial sponsors for NSFERC are Danfoss and Parker-Hannefin. To scale up the production of the device from the laboratory to the industry, the university is interested in partnering with other companies.. The device will power the sensors wirelessly and has potentail to get a good response from different industries.

Details: Kenneth A. Cunefare, Professor, Mechanical Engineering, Georgia Institute of Technology, 177 North Ave NW, Atlanta, Georgia 30332-0181. Phone: +1-404-894-4726. E-mail: ken.cunefare@me.gatech.edu. URL: www.gatech.edu

3. OPTICAL SENSORS TO PREDICT LANDSLIDES

Landslides are a regular phenomenon in certain geographical locations. They occur because of soil movement, which can be caused by floods, rockfalls, debris, shear strains, among several other causes. Good tools are required to predict critical information about landslides, such as, when and where they are expected to occur, as they can be greatly damaging to life and property. Currently, in many places, rain gauges are used to detect the potential for occurrence of landslides. The recorded level of current rainfall is compared with historical data about landslides to predict when a landslide may be triggered. To detect landslides, point-based sensors are also being used. However, these sensors are powered with the help of a ground-plugged device. It further restricts the coverage of the sensor to a small area. Hence, there is a need for a device that can monitor the landslides remotely and continuously. The device should be accurate, easy to use, and cost efficient.

To address the above-mentioned challenge, researchers at The Second University of Naples in Italy have developed an optical sensor to predict landslides. When the sensor is implanted in the soil or ground, it can constantly monitor the changes in the land.

To predict landslides, the researchers have used optical fiber as the sensor. They have pooled several optical fiber sensors in a tube made from plastic. The sensor uses the interaction of light with acoustic waves, known as stimulated Brillouin scattering. These sensors stretch and twist when the force is exerted at the time of pre-failure strain, such as, when the soil undergoes sliding or collapse. Thus, the bending and the movement of the optical fiber indicate whether landslide is imminent. The optical fiber is embedded in the ground and monitors the slow slope movements and landslides through the elongation induced in the fiber. The sensors have the ability to detect the soil movement of a centimeter over a distance of kilometer, and can withstand larger soil deformation.

Once the sensor is fully developed, it will be embedded in the shallow trenches of the ground. It will be deployed before constructing buildings, malls, hotels and many more. The optical sensors will be able to monitor large areas continuously with high accuracy. The sensors can also be used in places such as near dams, walls of tunnels, underneath bridges and in remote rural areas along pipelines and railways. Regular inspection is not required for such sensors as the data is transmitted wirelessly and can be operated from a remote point.

The project was funded by The Second University of Naples in Italy and the National Research Council of Italy. The researchers are currently working on expanding the applications of the sensor; and toward implanting the sensors in shallow trenches of hills to detect and monitor slow movements of slope and large landslides. Once the project is commercialized, it has potential to get a good response from construction industry to integrate the sensor in the construction site/land before commencing the construction of buildings.

Details: Luigi Zeni, Professor, Department of Industrial & Information Engineering, The Second University of Naples Italy, Via Antonio Vivaldi, 43, 81100 Caserta CE, Italy. Phone: +390817620659. E-mail: luigi.zeni@unina2.it. URL: www.unina2.it/

4. RECENT PATENTS IN THE FIELD OF ENERGY HARVESTING USING PRESSURE SENSOR

Conversion of ambient energy into electrical energy is accomplished by energy harvesting. Energy harvesting reduces the associated cost of batteries, and can increase the lifetime of sensors or sensor networks . In addition to sensor networks for diverse applications, energy harvesting devices are suitable for use in sensitive or remote areas that require maintenance-free power at low voltages.

A recent patent in energy harvesters is an energy harvesting device with a self-powered touch sensor that can sense pressure from an external touch, (US20140210313) assigned to Samsung Electronics Co. Ltd. From 1957 to October 2014, approximately 15,387 patents have been registered with the title pressure sensing. From 1970 to October 2014, approximately 129,162 patents have been registered under energy harvesting. Approximately, 72 patents have been registered under energy harvesting using pressure sensing.

There are several different energy sources from which energy can be harvested. The different types of sources include solar, vibration, thermal, radio frequency (RF) waves, human power. Energy harvesting using pressure sensing can be used in industrial monitoring, for powering remote infrastructure, in wireless sensor networks, wireless tire pressure sensors, pipeline actuators, and many other applications.

Energy harvesting has growth opportunities in various application segments, such as military/defense, automotive, consumer electronics, and environmental monitoring.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
ENERGY HARVESTING DEVICE HAVING SELF-POWERED TOUCH SENSOR	31.07.2014; US20140210313	SAMSUNG ELECTRONICS CO., LTD.	KIM Hyun-jin	Provided is an energy harvesting device having a self-powered touch sensor so that the energy harvesting device is capable of sensing pressure due to an external touch without using external power and harvesting and storing energy generated in response to the touch pressure. The energy harvesting device includes first and second electrodes facing each other, an energy generation layer disposed on the first electrode, and an elastic layer disposed on the second electrode layer, the elastic layer facing the energy generation layer and being configured to be elastically deformed according to pressure applied to the elastic layer. The energy generation layer is configured to generate energy according to the pressure applied to the energy generation layer.
REAL-TIME WIRELESS DYNAMIC TIRE PRESSURE SENSOR AND ENERGY HARVESTING SYSTEM	13.03.2014; US20140070935	NORTHEASTERN UNIVERSITY	WANG Ming	An instantaneous/real-time wireless dynamic tire pressure sensor (DTPS) for characterizing pavement qualities and for detecting surface and subsurface pavement defects under normal driving conditions. Signal processing provides quantitative assessment of surface conditions. DTPS includes a vehicle tire valve stem-mounted pressure sensor and wheel hub-mounted signal conditioning, amplification, and transmitting circuitry. A signal processing computer within the vehicle is wirelessly coupled to the hub-mounted circuitry. Tire pressure changes caused by ground vibration excitation from the interaction between the tire and pavement at normal driving speeds are detected. When acoustic radiation from a surface wave is significantly stronger than acoustic noise, subsurface information can be extracted. An energy harvester based on strong magnetostatic coupling between a high permeability core solenoid, fixed proximate a vehicle wheel, and a bias magnet array, fixedly mounted in conjunction with a dust shield, can provide power the DIPS.
HYBRID NANOGENERATOR FOR HARVESTING CHEMICAL AND MECHANICAL ENERGY	06.06.2013; WO/2013/082571	GEORGIA TECH RESEARCH CORPORATION	WANG, Zhong	A fiber pressure sensor includes a carbon fiber. A generating unit includes a first insulator layer disposed about the carbon fiber adjacent a first end, a cathode disposed about a portion of the first insulator unit. The cathode includes a first conductor coupled to a glucose catalyzing enzyme, a second insulator layer disposed about the carbon fiber, and an anode disposed about a portion of the second insulator unit, the anode including a second conductor to which is coupled a an oxidase enzyme. A third electrode is disposed adjacent to the second end carbon fiber. A dense plurality of piezoelectric nanowires extends radially outwardly from the carbon fiber. A fourth electrode is in electrical communication with distal ends of the piezoelectric nanowires and is electrically coupled to the anode. A current sensor senses a current indicative of pressure applied to the dense plurality of piezoelectric nanowires.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
SYSTEMS AND METHODS FOR ENERGY HARVESTING IN A CONTAINED FLUID CIRCUIT	16.02.2012; WO/2012/021551	UNIVERSITY OF WASHINGTON THROUGH ITS CENTER FOR COMMERCIALIZATION	CAMPBELL, Tim	Systems and methods for harvesting energy from a closed fluid circuit, such as a water pipe system in a building. An energy harvester can be installed at a point in a water circuit and can generate energy from pressure differentials caused when a valve is opened or closed at any other point in the water circuit that is in fluid communication with the energy harvester. The energy can be used to power, for example, a sensor and/or a transmitter.
IMPLANTABLE MEDICAL DEVICE HOUSING MODIFIED FOR PIEZOELECTRIC ENERGY HARVESTING	16.12.2010; US20100317978	MAILE KEITH R	MAILE KEITH R	Methods, systems, and apparatus for powering and/or recharging medical devices implanted within the body are described. An illustrative implantable sensor for sensing one or more physiologic parameters within a body lumen includes a housing having an exterior wall that has an inner surface and an outer surface and that defines an internal cavity. A portion of the housing includes an electrically conductive material that functions as a first electrical conductor. A flexible piezoelectric layer is disposed adjacent to a portion of the exterior wall and a second electrical conductor is disposed adjacent to the piezoelectric layer. The piezoelectric layer is configured to displace in response to periodic pressure pulses within the body lumen and generate a voltage differential between the first and second electrical conductors.
In Situ Energy Harvesting Systems for Implanted Medical Devices	25.11.2010; US20100298720	POTKAY JOSEPH ALLEN	POTKAY JOSEPH ALLEN	This invention concerns miniature implantable power sources that harvest or scavenge energy from the expansion and contraction of biological tissues, for example, an artery or a bundle of muscle fiber. Such power sources employ an energy harvesting element that converts mechanical or thermal energy existing or generated in or from a pulsatile tissue into a form of electrical energy that can be used or stored by an implanted medical device, such as a blood pressure sensor, a flow meter, or the like. Preferred energy harvesting element embodiments utilize a piezoelectric thin film embedded within a flexible, self-curling medical-grade polymer or coating. Such power sources can be used to produce self-powered implanted microsystems with continuous or near-continuous operation, increased lifetimes, reduced need for surgical replacement, and minimized or eliminated external interface requirements.
Drilling system powered by energy-harvesting sensor	07.02.2008; US20080033653	Schlumberger Technology Corporation	Pabon Jahir	A method and system is provided for determining the value of an attribute of ambient energy at a drilling assembly at the bottom of a borehole. Ambient energy includes kinetic energy, hydraulic energy and thermal energy. Attributes include vibration frequency spectrum, pressure difference, and temperature difference. The method uses energy harvested by at least one energy-harvesting sensor to power the system. The system generates data signals from at least one energy-harvesting sensor at one or more locations along a downhole drilling assembly, and transmits data up the borehole.

Exhibit 1 lists some of the patents related to energy harvesting using pressure sensor.

Picture Credit: Frost &Sullivan

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