TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

10th October 2014

1. HOME AUTOMATION DEVICE INTEGRATING ARRAY OF SENSORS

Development of innovative products in home automation is gaining increased attention. In home automation, sensors are playing a vital role. Sensors that are available in the market are designed to perform relatively simple tasks such as temperature monitoring inside the house, detecting leakage of water, and monitoring energy usage. There is a need for a device that is capable of performing multiple sensing tasks while providing accurate results. The device should be cost efficient, easy to use, and provide updates in real time.

To address the above-mentioned challenge, researchers from Colorado-based Loop Labs Inc. have developed a device with an array of sensors named Notion. Notion is circular in shape, compact in size, and can be placed anywhere easily. Notion is Wi-Fi-enabled and integrated with seven different sensors for variety of applications.

Notion employs an accelerometer, ambient light sensor, gyroscope, temperature sensor, piezoelectric transducer, proximity sensor, and water leak probes. The ambient light sensor is used to detect whether the lights have been left on when no one is inside the house. The gyro is used to detect whether a door or window has been opened. The temperature sensor is used to identify whether the temperature inside the house is too cold or hot. Water leak probes are used to identify leaks in the pipeline. Developers of Notion have also developed an application for smart phones. With the help of Wi-Fi, Notion is connected with the user through the smart phone and provides real-time update. Thus, with the help of Notion’s smart system, users can be connected with their houses at all times.

Notion sensors will be used to make offices and home intelligent. The device will be used in the house for security purposes. Once the sensor is implemented on the doors and windows of a house, the device will help to identify whether the door has been opened by an uninvited guest and alert the owner of the house through messages or alarms. It can also be implemented on the safety box inside the house. The system identifies the temperature inside the house and guides the user to maintain the desired temperature either by turning on the air conditioners or the heaters. Notion sensors have various different applications such as managing home and office environment and making these spaces automated and intelligent.

The project was initially supported by the start-up accelerator company Techstars. For pilot production and commercialization, Loop Labs has approached Kickstarters for crowd funding. The Notion device has generated $200,000 through crowd funding. The researchers are currently working on identifying different applications for the Notion sensors. The project is expected to be commercialized in early 2015. The Notion device is easy to use, cost-efficient, and has numerous applications. Once the project is fully commercialized, it is has opportunities to get a good response from end uers.

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2. TACTILE DEVICE WITH THREE MODALITIES--FORCE, TEMPERATURE, AND VIBRATION

In the robotics industry, there is ongoing interest in developing innovative tactile sensing. Tactile sensing has opportunities to play a vital role in this industry. Robots with tactile sensors are used in industrial applications, such as more dextrous handling of objects.. A variety of tactile sensors are available in the market, including those that use conductive inks as sensor films. However, such equipment can face certain challenges, such as, inaccuracy, not being able to conform according to the shape of the object, difficulty in integration. There is a need for accurate, cost efficient, easy-to-use devices with capabilities such as sensing temperature change.

To address the above-mentioned challenge, researchers from California-based SynTouch LLC have developed a tactile sensor named BioTac. BioTac is integrated with three different types of sensors that help the device to collect information in a manner similar to human fingertips.

BioTac is embedded with impedance sensing electrodes. When shear or normal forces are applied to the skin of BioTac, these electrodes help to measure the deformation. A sensitive pressure transducer is integrated into BioTac. When the device slides over the textured surface, it can experience vibration and fluid pressure; the pressure transducer helps to sense vibrations. A set of thermistor and heater is deployed in the device. When the device is used to touch object with different thermal properties, a thermistor is used to sense the thermal gradients. BioTac has a line of tactile sensing products. It is also engaged in development of custom sensors for specific applications.

BioTac's main application is tactile sensing. It registers three different modalities such as temperature, vibration, and force. It allows robots to be more agile and perform wide range of tasks. Prosthetic hand is the main application of BioTac. Due to its advanced tactile sensing abilities, BioTac is also being used in industrial applications. The sensor is used to measure the force and vibration on the fingers of the robot, which use tactile sensing to deform according to the shape of the object. The sensor is used to measure the force and uses algorithms to calculate the total load and tighten the grip depending on the load. BioTac sensors have high dynamic range, are light in weight and robust to withstand high impact. Thus, the BioTac sensor is well suited for robotic applications.

The project was self-funded by SynTouch LLC. It was supported by the University of South California. Researchers at SynTouch are identifying different robots to custom integrate the BioTac sensor. They are also working on enhancing machine touch algorithms that will help to identify robots' movements. The BioTac device is available in the market and can be integrated into different types of robotic applications. The company is able to provide a wide array of products, thus gaining a competitive edge over other companies in the industry. The device is getting good response because of its superior capabilities in sensing temperature, force, and vibration.

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3. NOVEL MICROCAVITY LASER SENSOR USING STIMULATED RAMAN SCATTERING

Raman scattering can be defined as an inelastic light scattering process in which energy of the photon is altered due to the inelastic interaction with the cavity material. As the energy state of the cavity material changes, an equivalent amount of energy is lost by the photon. The scattered light has lower frequency and is called Stokes emission. Molecular vibration in the cavity material is equivalent to the difference in energy between the incoming photon and the scattered Stokes photon.

Researchers from Peking University have developed a novel microcavity Raman-laser sensor and have achieved single nanoparticle detection in both air and in water environment. They were able to detect a nanoparticle of size 20 nanometers in radius in water.

The whispering gallery mode (WGM) optical microcavities are used for this research. The microcavities are similar to the acoustic whispering gallery in St. Paul Cathedral in London and the echo wall in Temple of Heaven in Beijing. The small size of microcavities and the low propagation loss enables the photons to move around the cavities hundreds and thousands of times, which increases the interactions between light and matter. Thus, the ultra-sensitive detection of nano objects can be achieved by using WGM microcavities.

In this work, stimulated Raman scattering is used to detect the nanoparticles. When a nano scale object is encountered by a Raman laser, it will induce a coupling between the two counter propagating modes through back scattering. This in turn will split the Raman laser into two Raman lines. When the two split modes lase simultaneously, a beat note with the frequency corresponding to the Raman mode splitting is produced. Thus the nanoparticles can be detected by observing the beat frequency of the split-mode Raman lasers.

The advantage of this mechanism is that it is robust to noise sources such as thermal noise and the laser frequency noise as the same noise is shared by both the modes. Another advantage is that there is no need to dope the cavity with an additional gain medium as the Raman gain is an inherent property of any material. Also, the sensing method removes the requirement of specific wavelength bands for the pump laser as the Raman scattering occurs under any pump wavelength. Because of all these advantages, the Raman laser sensor is considered as a major step toward practical micro laser sensors.

The ultra-high sensitive optical sensor can have applications in various fields such as in environmental monitoring, diagnosis of human diseases, and also homeland security.

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4. RECENT PATENTS IN THE FIELD OF ENERGY HARVESTING

Regular maintenance is required for devices powered by batteries. Technologies such as wireless sensor networks fully depend on battery power. Issues related to batteries such as battery life and disposal have hindered the growth of ubiquitous sensing. Existing ambient energy sources are used to harvest energy and power the devices. Different sources to generate energy include vibrations, thermal energy source, and solar power. Energy harvesting devices available in the market are thermoelectric, piezoelectric, magnetic induction, and so on.

A recent patent in an energy harvester powered accelerometer (US20140182378) is assigned to KCF Technologies Inc., which has been classified under harvesting energy through vibratory motion with the help of piezoelectric elements.

From 1970 to 2014, approximately 120108 patents have been registered under piezoelectric sensing. From 1956 to 2014, approximately 129162 patents have been registered under energy harvesting. From 2002 to 2014, approximately 29 patents have been registered under energy harvesting using piezoelectric sensing.

Devices or sensors powered by energy harvesters allow application flexibility and are cost-effective. Energy harvesting brings down the associated cost of batteries, and powers device for long periods of time. Energy harvesting devices have advantages in, for example, sensitive or remote areas that require maintenance-free power at low voltages. Wireless sensor networks have opportunities in areas such as building automation to improve occupant comfort by enabling optimum energy consumption and cost-effective building operations.

Energy harvesting has growth opportunities in various application segments, such as military/defense, automotive, consumer electronics, environmental monitoring, monitoring utility substation equipment or transmission lines, and so on.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Energy harvester powered accelerometer	03.07.2014; US20140182378	KCF Technologies Inc.	Loverich Jacob J.	A sensor may include a base, a resonator centered over the base, and an accelerometer disposed in a base of the resonator. The resonator may be configured to harvest energy from vibratory motion of a host device and includes a slot disposed on a center rectangular plane of the sensor. The sensor may include a circuit arrangement disposed on the accelerometer and in the slot on the center rectangular plane of the sensor. A piezoelectric element may be mounted on the resonator and electrically coupled with the circuit arrangement. The piezoelectric element may be configured to convert vibratory energy of the resonator to electrical energy. An optional antenna may be coupled with the circuit arrangement and configured to wirelessly transmit data from the sensor to a receiving station.
Power managing energy-harvesting for selectively controlling a state of individual computer based on a harvesting energy stored available	01.07.2014; US08769315	Ortiz Albert	Ortiz Albert	According to typical inventive practice, each inventive sensor node performs computer processing that is tri-chotomized in a progressive, power-regulating scheme of three processors, namely, a low-performance processor, a middle-performance processor (which remains in sleep mode until activated upon demand for a middle-computation function), and a high-performance processor (which remains in sleep mode until activated upon demand for a high-computation function). The low-performance processor performs low computation functions such as routine sensing functions. The middle-performance processor performs middle-computation functions such as validative sensing functions. The high-performance processor performs high computation functions such as remedial communicative functions. Each sensor node has one or more transceivers for wirelessly transmitting and receiving radio signals (e.g. remedial communication) to and from transceivers of other sensor nodes. Some transceivers may be specifically dedicated to wirelessly communicating "wake-up" signals among nodes. Inventive practice is notably efficacious in furtherance of situational awareness of damage events onboard naval ships.
Methods and apparatus for harvesting biomechanical energy	05.06.2014; US20140152008	Bionic Power Inc.	Donelan James Maxwell	Methods and apparatus are disclosed for harvesting energy from motion of one or more joints. Energy harvesters comprise: a generator for converting mechanical energy into corresponding electrical energy; one or more sensors for sensing one or more corresponding characteristics associated with motion of the one or more joints; and control circuitry connected to receive the one or more sensed characteristics and configured to assess, based at least in part on the one or more sensed characteristics, whether motion of the one or more joints is associated with mutualistic conditions or non-mutualistic conditions. If conditions are determined to be mutualistic, energy harvesting is engaged. If conditions are determined to be non-mutualistic, energy harvesting is disengaged.
System for harvesting energy including a counterweight and a system for controlling the angular position of the counterweight	05.06.2014; US20140152025	Aktiebolaget SKF	Renga Flavio	A system for harvesting energy including: an electrical machine including a first and a second structure, movable with respect to each other; a counterweight coupled to the second structure; a power transfer structure, electrically connected between the first structure and the load; an angular position sensor which provides a position signal ({right arrow over (ε)}(t)) indicating the angular position of the counterweight; and an accelerometer which provides an acceleration signal ({right arrow over (a)}(t)) indicating an acceleration which affects the first structure. The system for harvesting energy further comprising a control unit, which includes: a first stage which generates a limit position signal ($\{\text{right arrow over } (\varepsilon)\}_{lim}(t)$) indicating an angular instability region (R-I); and a second stage which controls the power transfer structure based on the position signal and on the limit position signal, so as to modulate the transfer of electrical power to the load so as to prevent the counterweight from entering into the angular instability region.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Magnification loupe with energy-harvesting system	22.05.2014; WO/2014/076048	orangedental GmbH & Co. KG	Laxhuber, Ludwig	The present invention relates to optical instruments, in particular to magnification loupes, such as those worn by dentists and surgeons. The invention features magnification loupes that are equipped with a light source, an energy harvesting component and an energy storage component. The invention further relates to magnification loupes comprising a light source and a polymer battery as energy storage component. In addition, the invention is directed to magnification loupes comprising a first light source emitting a light beam and a sensor structured and configured to detect a refiection of this light beam. If such a reflection is detected, a second light source mounted on the magnification loupe is turned on or off. The invention further concerns a ring made from or coated with a light-reflecting material. The invention also relates to a battery charging station on which the batteries present in the magnification loupes can be recharged.
Motion control system and method with energy harvesting	08.05.2014; WO/2014/068594	Jain Irrigation Systems Limited	Defrank, Michael, Patrick	A motion control apparatus and method is disclosed. The motion control apparatus comprises a movable mechanism coupled to an external energy source, the energy source providing kinetic energy to the mechanism. An energy conversion module is mechanically coupled to the mechanism for converting kinetic into electrical energy. An electronic circuit is coupled to the energy conversion module and a storage module and a mechanism controller is coupled to the electronic circuit. A sensor module is coupled to both the electronic circuit and the movable mechanism to sense the movement of the movable mechanism to determine speed of the movable mechanism and transmit speed information to the electronic circuit. The method comprises applying energy to a movable mechanism, converting kinetic to electrical energy, storing the electrical energy converted, controlling the motion of the mechanism and sensing the movement of the mechanism.
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.

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

Picture Credit: Frost & Sullivan

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