# TECHNICAL INSIGHTS

## SENSOR

## TECHNOLOGY ALERT

**09th May 2014**

## 1. SMART FABRICS FOR REAL-TIME MONITORING

'Quantified self' is a concept where people can monitor various physiological parameters to draw conclusions about health. The quantified self requires body worn electronics and sensors to collect and transmit data to a remote device such as a smart phone for analysis and representation. Among the various wearable technologies, such as bands, rigid sensors, flexible body patches, and others, smart fabrics provide a platform that promises the maximum benefits. This is because smart fabrics have a large surface area, which enables integration of multiple sensors at different locations to retrieve optimum information about the different parameters.

In line with this trend, the Smart Sensing Program--a French Industrial project headed by Cityzen Sciences, France-- has led to the development of a smart fabric, which can monitor body heat, heart rate, respiration rate, and motion using GPS (global positioning system) sensors. The fabric can be used to manufacture different types of clothing such as gloves, trousers, and body suits, depending on the application requirement. The fabric consists of miniaturized sensors, which collect and transmit physiological data using a battery powered transmitter to a central unit. This unit links data with a smart phone where apps analyze the data. Deductions can be then made about the physical state of the individual to indicate, for example, fatigue, stress level, and predict the possibility of a heart attack. The data collected by the smart fabrics will be utilized by Cityzen Data to partner with organizations such as sporting clubs for developing applications intended for coaches and training.

The key challenges identified and solved in the development of the fabric were miniaturization, integration of the sensors with the textile, data management, transmission, and processing. Moreover the data collected by the sensors need to be properly analyzed to provide relevant information to the users.

The smart fabric has potential applications mainly in the field of sports and healthcare. The targeted application area of the smart fabric is sports where athletes' performance and health can be monitored. This can lead to better coaching, improved techniques, and avoidance of injury or fatality. In the field of healthcare, the smart fabric is a key enabling technology for mobile health (m-health). Doctors can use smart fabrics to remotely monitor patients as well as for real-time monitoring in a hospital. The fabric can also be used to monitor sleep patterns, daily activities, exhaustion, and so on. The smart sensing platform can be used to develop customized products including customized algorithms and apps. This will allow clients to develop application specific solutions for various industries including industrial safety, child monitoring, and so on.

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## 2. COLOR CHANGING PRESSURE SENSING FILM USING NANOPARTICLES

Pressure sensors have various uses in a wide array of industries such as automotive, consumer electronics, industrial, healthcare, and so on. The different applications can have different requirements in terms of sensitivity, range, and so on. In certain applications, such as curved surfaces, where pressure at a point or on flat surfaces is not required, or in determining the pressure distribution of two conducting surfaces, pressure sensing films can have better applicability than conventional rigid pressure sensors. Currently available pressure sensor films tend to indicate pressure by change in intensity of a single colour (for example, mild red to dark red). This change may not be very easy to interpret and could be subject to a lower resolution.

Researchers at the University of California, Riverside, have developed an innovative pressure sensor that is able to change its color in accordance to different levels of applied pressure. The sensor originally has a blue color and slowly turns into red as the applied pressure increases.

The sensor was created using a self-assembly method by which gold nanoparticles were strung together and then integrated into a polymer film.

When pressure is applied to this film it deforms, thereby stretching the nanoparticle strings. It leads to an increased distance between the gold nanoparticles. The separation leads to an alteration in the way the nanoparticles interact with light. When the nanoparticles are linked together, the film appears blue. As the disassembling happens, the color gradually changes to red. Due to this phenomenon, it can be easily deduced the level of pressure applied on the surface of the film. The change in color does not revert when the pressure is removed.

The Office of Technology Commercialization of the University of California Riverside has already filed for a patent on this technology. There are various potential applications of this pressure sensing film in the fields of consumer electronics, automotive testing, healthcare, and so on. For instance, crash testing involving dummies can use this technology to get a holistic map of pressure impacts in a visual way. The pressure intensity can also be used by athletes and sports persons to better understand the amount of pressure they are applying and thereby improve their techniques. The technology is expected to enable easy to deduce pressure distribution over complex surfaces.

The findings of the research (paper title: Colorimetric Stress Memory Sensor Based on Disassembly of Gold Nanoparticle Chains) have been published in the journal Nano Letters on April 8, 2014. The research was supported financially by the National Science Foundation, USA. Even though gold nanoparticles were used for this process, silver and copper can also be potentially used. This would enable less expensive sensors.

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### 3. REAL-TIME BRAIN INJURY MONITORING FOR SPORTSPERSONS

Head injuries are very common in contact sports such as rugby, American football, boxing, and so on. Most of the times the injury remains undetected as signs are not prominent initially. It is important to detect head injuries at an early stage so that required medical attention can be provided to the athlete. However , the challenge is in developing a system, which consists of sensors integrated with the helmet so that it can detect the injury at the onset.

Researchers at the University of Arkansas, USA, have developed an innovative sensor system that can detect these head injuries in real time. The sensors can also wirelessly transmit the information to concerned medical authorities or team staff so that necessary measures can be taken. The system developed by the researchers consists of textile-based nanosensors that continuously monitor brain and neural functions to detect early signs of brain injury. The data collected from the sensors are used to quantify the impact on the brain. The neural activity is monitored to detect symptoms, such as dizziness, sudden fatigue, drowsiness, anxiety, and sensitivity to light, which indicate possible concussion or traumatic brain injury.

The sensors used are flexible and can be printed or woven into a skullcap. This skullcap is thin enough to be worn under the helmet. The sensors are built on the nanotechnology platform, leveraging carbon nanotubes and textile nanostructures developed at the University of Arkansas. Using wireless connectivity, such as Bluetooth, data from the sensors is transmitted to a central receiver, from where the information can be sent to a remote computer or a smart phone. However, to enable data from multiple users to be collected and transmitted wirelessly, a powerful wide area network is required. The sensor chips have been made to withstand moisture and high temperature, which is normally present inside the helmet of an athlete.

The different sensors integrated into the skullcap include pressure sensors, a gyro, accelerometer, and electrical activity monitoring sensors. The flexible sensors can be manufactured using printing techniques, which will also make them low cost sensors. The pressure sensors are used to detect the level of impact. The gyro and accelerometer are used to determine the position of the head and the body. The electrical activity sensors are used to determine the onset of brain injuries. Apart from these, pulse rates and blood oxygen levels are also detected by the system.

The system has been tested for real-time application on a small scale. The researchers now plan to test it during actual games to monitor the performance. Once commercialized, the system can prove beneficial for physicians accompanying sports teams so that they can prevent athletes from suffering from the consequences of late or no treatment of brain injuries.

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## 4. RECENT PATENTS IN THE FIELD OF LIGHT DETECTION AND RANGING (LIDAR)

Light detection and ranging (LIDAR) technology involves the use of a laser to measure the distance and other properties of objects from a source. In a LIDAR system, light is emitted from a laser source and the backscattered light is analyzed to determine the distance and, in some cases, the properties of objects. The principle used for determining the distance is based on speed of light times time of flight. LIDAR is used for obstacle detection in various industries including robotics. It is a key enabling technology for navigation and obstacle detection in emerging autonomous vehicles. LIDAR has applications in mapping, surveying, agriculture, as well as in law enforcement, biological threat detection, electric power transmission line monitoring, wind shear forecasting, and so on.

The cost of LIDAR systems has traditionally been a constraint for adoption. But, increased applications for LIDAR are expected to drive down the cost. Among recent patents in this field, patent no. US20140036252 indicates the use of LIDAR for navigation of airborne vehicles. Patent no. US20140035285 indicates the usage of LIDAR data to determine sudden changes in wind direction, which can cause damage to wind turbines. Patent no. WO/2014/062522 indicates the usage of LIDAR for remote sensing of vegetation such as trees. This can be used for detecting, for instance, obstructions to electric power transmission lines.

| PATENT TITLE | PUBLICATION DATE / NUMBER | ASSIGNEE | INVENTORS | ABSTRACT |
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| SYSTEM FOR DETECTING PLANTED ITEMS OF VEGETATION WITH REMOTE SENSING DATA | 24.04.2014; WO/2014/062522 | WEYERHAEUSER NR COMPANY | ROJAS, Julio, C. | Disclosed is a system and method for processing remote sensing data such as LiDAR return data prior to analyzing the data to detect planted items of vegetation such as trees. In one embodiment, LiDAR return data for an area in question is filtered to remove data that are not within a predetermined area of where trees have been planted. Planting data such as GPS data that is collected by tractors or other |

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| | | | | equipment records the location of where trees are planted. The planting data is used to filter the LiDAR return data by eliminating or ignoring LiDAR return data that are not within a buffer zone around the location where the trees have been planted. Once filtered, the LiDAR return data can be analyzed to detect trees or other items of interest in the remote sensing data. |
| HIGH-ENERGY, BROADBAND, RAPID TUNING FREQUENCY CONVERTER | 03.04.2014; WO/2014/051573 | UTAH STATE UNIVERSITY RESEARCH FOUNDATION | FOLTYNOWICZ, Robert | An Optical Parametric Oscillator capable of rapid or broadband frequency tuning by non-mechanical or mechanical means includes a resonant cavity with one or more non-linear crystals in an optical path thereof. The non-linear crystals may be driven by actuators. A pump laser pulse is transmitted into the resonant cavity with one or more seed beams having a desired wavelength. The output beam from the resonant cavity may have the same center wavelength as the one or more seed beams which may be modulated at a frequency larger than that of the pump laser, or the inverse of the pulse duration. The OPO may be used in Light Detection And Ranging or Differential Absorption LIDAR analysis by intra-pulse modulation of output to measure absorption at multiple frequencies for each pulse of a pump beam. Sum Frequency Generator configurations may be suitable for narrow and broadband UV generation. |
| OFF ANGLE THREE DIMENSIONAL FACE STANDARDIZATION | 20.03.2014; WO/2014/042853 | DIGITAL SIGNAL CORPORATION | RUSS, Trina, D. | A system uses range and Doppler velocity measurements from a lidar system and images from a video system to estimate a six degree-of-freedom trajectory of a target. The system utilizes a two-stage solution to obtain 3D standardized face representations from non-frontal face views for a statistical learning algorithm. The first stage standardizes the pose (non-frontal 3D face representation) to a frontal view and the second stage uses facial symmetry to fill in missing facial regions due to yaw face pose variations (i.e. rotation about the y-axis). |
| METHOD AND APPARATUS FOR | 13.03.2014; US 20140070538 | Bowyer Robert | Bowyer Robert | A wind turbine has a scanning Lidar arranged on the nacelle. The Lidar has a single scanning beam which |

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| PROTECTING WIND TURBINES FROM EXTREME EVENTS | | | | scans about a substantially vertical axis to sense wind related data in a measurement volume a predetermined distance from the Lidar. Fast Fourier transforms of data from a plurality of points in the measurement volume are analysed to derive a peak velocity and a measure of variance. A controller receives the peak velocity and measure of variance as inputs and generates an output if the controller determines that the input data shows that the wind conditions are such that damage to the wind turbine is likely. |
| METHOD AND APPARATUS FOR PROTECTING WIND TURBINES FROM EXTREME EVENTS | 06.02.2014; US 20140035285 | Creaby Justin | Creaby Justin | A wind turbine has a Lidar (20) device to sense wind conditions upstream of the wind turbine. Signals from the wind turbine are processed to detect an extreme change in wind direction. The detection is performed by differentiating the rate of change of wind direction and filtering for a period of time. On detection of extreme change the system controller takes the necessary evasive action which may include shutting down the turbine, commencing an immediate yawing action, and de-rating the turbine until the yawing action is complete. |
| Coherent Doppler Lidar for Measuring Altitude, Ground Velocity, and Air Velocity of Aircraft and Spaceborne Vehicles | 06.02.2014; US 20140036252 | Amzajerdian Farzin | Amzajerdian Farzin | A Doppler lidar sensor system includes a laser generator that produces a highly pure single frequency laser beam, and a frequency modulator that modulates the laser beam with a highly linear frequency waveform. A first portion of the frequency modulated laser beam is amplified, and parts thereof are transmitted through at least three separate transmit/receive lenses. A second portion of the laser beam is used as a local oscillator beam for optical heterodyne detection. Radiation from the parts of the laser beam transmitted via the transmit/receive lenses is received by the respective transmit/receive lenses that transmitted the respective part of the laser beam. The received reflected radiation is compared with the local oscillator beam to calculate the frequency difference therebetween to determine various navigational data. |

 

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| Lidar Measurement Device for Vehicular Traffic Surveillance and Method for Use of Same | 02.01.2014; US 20140002808 | Applied Concepts, Inc. | Gammenthaler Robert S. | A Lidar measurement device for vehicular traffic surveillance and method for use of same are disclosed. In one embodiment, video circuitry acquires video of a field of view having a target therein. A steerable laser progressively transmits laser range-finding signals to the field of view in a horizontal and vertical step-wise manner and receives reflected laser range-finding signals from the target. A processing circuit portion determines target data of the target based upon range and time measurements associated with the reflected laser range-finding signals. The processing circuit then integrates the target data into the video such that the video may displayed with an image of the target and speed measurement associated therewith. |

Exhibit 1 lists some of the recent published patents on LIDAR.

Picture Credit: USPTO/Frost & Sullivan

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