TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

15th August 2014

1. ECONOMICAL HANDHELD NEAR INFRARED SPECTROMETER

A near infrared spectrometer essentially measures the pattern (wavelength and intensity) of absorption of near infrared light from a given sample. Near infrared light pertains to the region of the electromagnetic spectrum ranging from 800 nanometers to 2500 nanometers. Applications for near IR spectrometers include pharmaceutical, medical diagnostics, neuroimaging, food quality control, remote monitoring and hyperspectral imaging, astronomy, agriculture, and so on.

Although near infrared spectroscopy can be relatively inexpensive compared to other spectroscopic techniques, spectrometers used for near-IR spectroscopy have tended to be used in laboratories or in offline factory applications.

Consumer Physics Inc., founded in 2011 and based in Israel, has created a highly innovative SCiO device, which leverages low-cost optics and advanced signal processing algorithms, to provide a miniature, consumer friendly near infrared spectrometer, designed to be mass-produced at low cost. The company uses technologies developed for cell phone cameras and optical communications devices to significantly reduce the cost and size of near infrared spectrometry systems.

The basis for the near infrared spectroscopic material analysis method used in SciO is that each type of molecule vibrates in a unique way, and such vibrations interact with light to create a unique optical signature.

SCiO contains a light source that illuminates the sample and an optical sensor, or spectrometer that collects the light reflected from the sample. The spectrometer breaks down the light into its spectrum, which includes the information required to detect the result of the interaction between the illuminated light and the molecules in the sample. To provide real-time information to the consumer, SCiO can communicate the spectrum of the sample

To deliver relevant information in real time, SCiO can wirelessly communicate the spectrum of the sample to a smart phone, which can send such information to a cloud-based service for review. Advanced algorithms can use an updatable database to analyze the spectrum within milliseconds and to swiftly deliver information about the analyzed sample back to the user’s smart phone.

The handheld SCiO molecular analyzer will be able to identify the composition of materials. For instance, it can be used to measure the properties of food, cosmetics, clothes, medication, flora, soil, jewels and precious stones, leather, rubber, oils, plastics, and so on. SCiO could be used to analyze the ingredients of a material, for instance, to isolate the concentration of macronutrients (for example, fat in salad dressing or sugar in fruits), measure hydration levels in plants, and find out your car’s fuel grade. If the user encounters materials not supported by the existing database, he or she can use SCiO to enrich and expand it. SCiO should be placed from about 5 mm (0.2) up to about 20 mm (~0.8”) from the sample.

SCiO has been aimed at applications, such as food, pharmaceuticals, and horticulture. For example, users could see the number of calories in a piece of cheese or determine when fruit will reach peak ripeness. SCiO also has opportunities for identifying contaminated foods or counterfeit drugs.

Last year, Consumer Physics created the first working prototype of the SCiO spectrometer, and it took another year to perfect it. The company is fine tuning the design for mass production.

Consumer Physics, which is backed by Khosla Ventures, launched a Kickstarter crowd funding campaign on April 29, 2014, which was successfully funded.

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2. COMBINATION CMOS CCD TDI IMAGE SENSOR

Complementary metal oxide (CMOS) image sensors record light intensity as variable charges similar to that of a charge coupled device (CCD) image sensor. However, unlike CCD image sensors, CMOS image sensors do not use charge coupling, which transfers charges to a second bank of photosites before performing analog-to-digital conversion. As standard CMOS chips, CMOS image sensors have amplifiers and output circuitry connected to each photosite. Since CMOS image sensor chips can be made on standard CMOS fabrication lines, their development can be less costly, and auxiliary circuitry, such as analog-to-digital conversion, can be combined on the same chip. CMOS chips can use less power than CCDs.

A CCD image sensor has pixels that are represented by p-doped metal oxide semiconductor capacitors, which during image acquisition can allow for conversion of incoming photons into electrical charges at the semiconductor oxide surface. The CCD then reads out the charges. CCD image sensors have traditionally been used in applications demanding high-quality images, although the quality disparity between CCD image sensors and CMOS image sensors has been narrowing and the quality of CMOS image sensors has been steadily improving.

Line scan cameras can only capture one image line in fast succession and are well-suited to, for example, checking longer objects and continuous materials. TDI is based on accumulating multiple exposures of the same (moving) object, thereby increasing the integration time available for collecting the incident light. TDI cameras are typically used in applications such as machine vision and remote sensing. Such devices operate much like a line scan imager, except that the TDI process combines line after line of images to deliver more detail from many, often hundreds, of lines.

Although the read noise in a single CMOS sensor is much lower than in a comparable CCD solution, the architectural differences between such types of image sensors can significantly increase, as the number of scan lines increase. Since CCD sensors add pixel data together without added noise, they can achieve an increase in signal-to-noise ratio in accordance with the number of lines. On the other hand, a conventional CMOS sensor cannot sum pixel data without increasing the noise level.

TDI sensors are beneficial in conditions where light levels are low, requiring long exposures. By timing the transfers to occur at the same rate that the image moves across the arrays, each array can capture the same image segment. Adding the data together can transform the TDI array into a line array with an effective exposure time equal to the sum of the exposure times for each line. Such a TDI array can allow for line scan imaging when high-speed motion creates too short an exposure for a single line sensor. TDI imaging is useful in high-performance applications where there are very weak signals, such as scientific research, medical, aerial reconnaissance, earth imaging, and so on.

CMOS image sensors have been eclipsing CCD image sensors in many area and line scan imaging applications; although CCD image sensors have continued to excel against CMOS imagers in high-end, demanding imaging applications under low-light conditions.

However, the combination of CMOS imagers with CCD technology, in the form of a light-sensitive CCD-based time delay integration (TDI) pixel array with CMOS readout electronics could be a game-changer, combining CCD's low-noise performance that is ideal for TDI imaging with the low power and fast readouts of CMOS imaging technology.

Belgium-based Imec has developed and fabricated a high-performance TDI image sensor based on its proprietary embedded CCD in image sensor technology. This image sensor was developed and fabricated for CNES, the French Space Agency, for space-based earth observation. This hybrid sensor approach could enable CMOS image sensors to capture high-performance TDI imaging applications.

The CCD pixel structure provides low-noise TDI performance in the charge domain, while CMOS technology allows low-power, on-chip integration of fast and complex circuitry readouts.

By combining the TDI pixels array with CMOS readout circuitry on the same die, Imec produced a camera-on-a-chip or system-on-a-chip (SOC) imager, which can reduce overall system complexity and cost. The CMOS technology enables on-chip readout electronics, such as clock drivers and analog-to-digital convertors (ADCs), operating at higher speeds and lower power consumption, which cannot be attained with traditional CCD technology.

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3. MEMS VCSEL LIDAR SYSTEM AMPLIFIES SIGNAL WITHOUT LOSS OF POWER

Light detection and ranging (Lidar), a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light, has found use in such applications as topographical surveying and mapping, meteorology, robotics, law enforcement, and automotive (for example, adaptive cruise control and prototype autonomous vehicles), and so on. Although Lidar provides very high accuracy, in order to capture higher volume, mass production applications, the cost of Lidar systems needs to decrease. Moreover, lasers used in high-resolution Lidar imaging systems can be relatively bulky and power hungry.

The vertical-cavity surface-emitting laser (VCSEL) is a type of semiconductor laser diode that emits laser beams perpendicular from the top surface, In contrast, conventional edge-emitting semiconductor lasers emit from surfaces that are formed by cleaving a chip from a wafer. Advantages of VCSELS compared to edge-emitting laser include: unlike the latter, VCSELS can be tested throughout the process to check for any issues in material quality or processing; since VCSELS emit a beam perpendicular to the active region of the laser, numerous (e.g., tens of thousands) of VCSELS are able to be processed simultaneously on a three inch gallium arsenide wafer. Moreover, while VCSEL production is more labor and material intensive than production of edge-emitting lasers, yields can be more predictable.

Micro-electromechanical systems (MEMS)-controlled VCSELs, which can have their top mirror suspended on a flexible membrane to allow the cavity length and, therefore, wavelength to be altered, can enable low-cost, portable, low power laser systems for new or expanding applications; for example, wavelength division multiplexed systems, gas spectroscopy applications, and so on.

Leveraging the capabilities of MEMS VCSELs, researchers at the University of California at Berkeley have developed technology based on a VCSEL that is wavelength-tunable using a moveable MEMS device. The solution has the potential to reduce the size, power consumption, as well as cost of Lidar systems without compromising the distance-sensing capability of the system.

The system has used frequency-modulated continuous-wave (FMCW) Lidar to provide the imager with good resolution along with lower power consumption. This type of system emits "frequency-chirped" laser light (whose frequency is either increasing or decreasing) on an object and then measures changes in the light frequency reflected back.

The MEMS elements help to change the frequency of the laser light for the chirping, while the VCSELs are inexpensive integrable semiconductor lasers with low power consumption. Using the MEMS device at its resonance (the natural frequency at which the material vibrates), the researchers were able to amplify the system's signal without a great expense of power. Typically, increasing the signal amplitude results in increased power dissipation. The solution avoids this tradeoff, retaining the low-power advantage of VCSELs.

The system can remotely sense objects across distances as long as 30 feet, purportedly ten times farther than comparable current low-power laser systems. The Berkeley researchers have noted that the sweet spot for emerging consumer and robotics applications is around 10 meters or slightly more than 30 feet.

By 2016, the team plans to integrate the VCSEL, photonics and electronics into a chip-scale package, which could enable smaller, less expensive 3D imaging systems with an exceptional range for potential use in varied applications, such as autonomous vehicles, smart phones and interactive video games, without the need for large, bulky boxes of electronics or optics. The integration would be achieved via wafer bonding.

Bernhard Boser, Department of Electrical Engineering and Computer Sciences, University of California at Berkeley and co-Director, Berkeley Sensor & Actuator Center and UC Berkeley Swarm Lab, indicated to *Technical Insights* that there are many challenges in accomplishing the integration and that this is a high-risk, high-payoff DARPA (US Defense Advanced Research Projects Agency) endeavor. He also noted that enhancements or modifications, such as higher optical output and beam steering, would need to be made in order for the Lidar system to be used in driverless cars.

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4. RECENT PATENTS IN THE FIELD OF FORCE SENSORS

Force sensors essentially are transducers that convert an input mechanical force into an electrical output signal. A force sensor is basically a resistor whose resistance decreases with increased applied pressure. The force transducer can convert measured forces representing force, weight or load, or pressure into output signals. Key sensing technologies used to measure force or load have included piezoresistive (strain gauges), piezoelectric, capacitive, as well as sensors that use conductive or semiconductive inks for sensing.

Applications for force sensors have included test and measurement, weighing, automation and robotics, health care (e.g., infusion pumps, kidney dialysis machines), traffic sensing, computer pointing/input devices, automotive (e.g., vehicle seat occupant monitoring and classification, driver presence detection), switches for handheld devices, and so on. Moreover, opportunities have been opening up for force sensors in activity (for example, foot-force) monitoring.

The total time taken by athletes to complete their sporting activity is getting shorter day by day. With an increase in competition, athletes are struggling for perfection and it is very crucial for athlete to monitor and analyze their activities.

A recent patent in force sensing (WO/2014/121011), assigned to Nike Inc., analyzes an athlete's athletic activity using force sensors to sense force exerted by the user's foot. The system also has an electronic module that collects data based on force input form the sensors and transmits the data.

From 1982, Nike Inc. has approximately 3,270 patents registered in the field of athletics. Of these, 94 patents are sensor-based and 8 patents purely focus on force sensing, which is incorporated in footwear.

From January 2014 to August 2014, 25 patents have been registered to measure force in sporting activities. In 2014, the trend of measuring force exerted on the cycling shoe was emerging. Force sensors are also getting incorporated in various other sporting activities, such as in rowing for measuring the force applied to the oars. Force sensors are also used in racing activities such as MotoGP and F1. In racing activities, force sensors are being incorporated in the driver's helmet for safety. In case of the impact on the head, this helmet will distribute the force to more than one location.

Recent trends suggest that inventors and investors are focusing on integrating force sensors in footwear for sports activities such as running and cycling. In the future, force sensors have opportunities to be deployed in footwear used in other sports, such as football and cricket. Force sensors integrated in footwear have opportunities to receive a positive response from the athletes to track their activities.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
SYSTEM AND METHOD FOR ANALYZING ATHLETIC ACTIVITY	07.08.2014; WO/2014/121011	NIKE, INC	GIEDWOYN, Anna, A.	A system for analyzing athletic activity is usable with an article of footwear including a sensor system with a plurality of force sensors configured to sense force exerted by a user's foot, an electronic module contained within the article of footwear, and a plurality of sensor leads connecting the sensors to the electronic module, wherein the electronic module collects data based on force input from the sensors and transmits the data. The system also includes an electronic device in communication with the electronic module. The electronic device includes a processor that receives the data from the electronic module, compares the data to a footstrike template corresponding to a desired footstrike pattern to determine whether a deviation from the footstrike template exists, and generates an indication to the user when the deviation from the desired footstrike pattern is determined to exist, which may also include a degree of such deviation.
FOOT-MOUNTED SENSOR SYSTEMS FOR TRACKING BODY MOVEMENT	26.06.2014; WO/2014/100045	Qi2 ELEMENTS II, LLC	BLUMENTHAL, Tyler	A method is disclosed for foot sensors to be used to determine at least two characteristics of a subject's activity by using a combination of sensors for force and foot orientation/motion/position. A wearable footwear ecosystem is comprised of the subject's footwear, sensor-enabled insoles or insertable devices, in- or on-footwear electronics that is hard wired to the sensors and may contain additional sensors such as accelerometers, a master device and means to communicate (typically wirelessly) among the various sensor platforms, and the master device including clock synchronization. Correlating the time stamps for data among various sensors, and the master device communicating wirelessly is critical to accurate determination of the desired characteristics. Multiple force-sensitive resistors on a common substrate are individually optimized for dynamic range. Pulse sensors using arrays of such force-sensitive resistors are implemented. The resultant system can profitably be used for gaming, biometric monitoring, and activity tracking.
STARTING DEVICE FOR PARTICIPANTS OF SPORTING EVENTS	10.06.2014; RU0002519497		ZANETTA Andre (CH) GRIMM Sedrik (CH) GALLI Reto (CH)	FIELD: sports. SUBSTANCE: starting device (1) for participants of sporting events is preferably made in the form of a starting block. The starting device comprises at least one rear base (2) for fixing this device on the surface of the competition, at least one sensor element such as a force transducer (3, 3') connected to an electronic data processing device, and one or two stops (5, 5') for feet of the participant. Each stop is mounted on the longitudinal rail (10) and its position can be adjusted; the longitudinal rail (10) is connected to the base and actuates the sensor/sensors to determine the reaction time of a participant at the start. The longitudinal rail (10) is attached to the H-shaped structure (4) comprising two planks (14, 24) located at a distance from each other. The ends of the two planks are rigidly connected to the fixed part (7) of the rear base (2), and the central rail (6) connecting two planks is attached to the rear end of the longitudinal rail. When a force is applied to the stop/stops the central rail (6) can be shifted in a given direction, bending two planks and activating the sensor, thereby providing the measurement of reaction time of the participant of the sporting event at the start. EFFECT: providing accurate indication of the moment of the start of the athlete, regardless of the force applied at the start. 19 cl, 4 dwg

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
SYSTEM AND METHOD OF EXERCISING AND STRETCHING THE TORSO MUSCLE GROUPS OF THE BODY, USING AS ITS MAIN FORCE RESISTANCE, THE WEIGHT OF THE USER	05.06.2014; WO/2014/083365	PAPPAS, Andreas	PAPPAS, Andreas	A system and method for exercising and stretching of the body and in particular, the muscle groups of the torso, which use as force resistance the weight of the user, in which the fore and aft longitudinal levers, through the concurrent exercise of force from the legs and torso of the user on respective platforms that are mounted on said levers rotate on pivots and through rods apply leverage that diverges said levers, in such a manner that the central platform is displaced vertically upwards, guided by concave axes with slide vertically in respective concave guides, overcoming the weight of the user which is exercised on the central horizontal longitudinal axis, raising the mid area of the user's body respectively. With the decrease of force from the legs and torso on the platforms, and the concurrent contraction of the user, folding of the fore and aft longitudinal levers and their respective platforms takes place, returning the central horizontal longitudinal axis and respective platform, and the user up to the initial position of the exercise.
ACCESSORY WITH INTEGRATED IMPACT DETECTION DEVICE	29.05.2014; US20140143940	Iuliano Gerardo	Iuliano Gerardo	An integrated protective accessory for a helmet comprising: a protective element for rigidly attaching to an external shell of the helmet via one or more fasteners; The protective element includes an impact detection device integrated with the protective element via one or more device fasteners such that a portion of the protective element has a compatible fastening element to that of the one or more device fasteners so that the impact detection device is rigidly attached to the protective element, the impact detection device having: a housing; one or more sensors within the housing for sensing an impact event of a wearer when wearing the helmet and for producing sensor data; an alarm element coupled to the housing such that an alarm condition produced by the alarm element is detectable by one or more persons near the wearer; and a processor within the housing for processing the sensor data against an impact threshold and for producing an alarm condition signal for expression by the alarm element as the alarm condition. One or the sensors can be a gyroscope for measuring rotational aspects of G forces from the impacts forces.
INTELLIGENT PROTECTIVE GEAR BRACING MECHANISM	24.04.2014; US20140109304	Kwan Avery Audrey		IProtective gear such as a helmet includes an intelligent bracing mechanism such as an intelligent neck bracing mechanism. The intelligent bracing mechanism detects imminent mechanical forces such as impact, shear, and rotational forces and stiffens the bracing mechanism so that forces imparted onto the protective gear can be distributed to one or more other locations. In one example, a sensor detects an imminent mechanical force impact on an outer shell of a helmet and stiffens a neck brace connected to the helmet to distribute some of the energy from the impact onto the shoulders.
SIMULATOR FOR TRAINING ROWERS	10.04.2014; RU0002512792		Lugovoj Sergej Igorevich (RU)	FIELD: sports. SUBSTANCE: invention "Simulator for training rowers" is intended for training athletes performing in rowing. Computer-training complex consists of a frame on which a carriage with a movable seat for an athlete is mounted, foot rests, handles of conventional oars, loading module comprising aerodynamic turbine, as well as comprising sensors of forces and displacements. The loading simulator module additionally comprises an electromagnetic braking device, at that the sensors are mounted on the carriage with the foot rests, on the handles of conventional oars, the movable seat and the loading device, and are connected to the computer that reads the information coming at them and, depending on the accuracy of technique of the paddle implementation, generates a control signal coming to the electromagnetic braking device, creating an additional braking of the aerodynamic turbine. EFFECT: approximation of conditions of the training process on the simulator to the conditions of the training process in a boat on the water. 4 cl, 1 dwg

Exhibit 1 lists some of the patents related to force sensors in sports.

Picture Credit: Frost & Sullivan

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