TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

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1. IMAGE SENSORS WITH AN ADVANCED SILICON RETINA

Image sensors continue to undergo advancements in smaller pixel size, increased pixel density, and enhanced resolution. However, the performance of conventional image sensors still considerably lags behind that of biological retinas. Conventional image sensors tend to produce redundant sequences of images at a limited frame rate.

Neuromorphic image sensors do not merely compute a linear function of image brightness at the location of each pixel (sensing element). Their processing generally involves a non-linear mapping function, local spatial-temporal filtering, and adaptation. Neuromorphic image sensors can provide low-power consumption, compactness, and a real-time response for applications such as autonomous mobile systems. However, neuromorphic silicon retina image sensors can have restricted applications due to their low-quantum efficiency and inability to combine high- quality spatial and temporal processing on a single chip.

The SeeBetter (Seeing Better with Hybrid BSI Spatio-Temporal Silicon Retina) project has been addressing such challenges by realizing an advanced silicon retina with superior quantum efficiency and spatio-temporal processing of biological retinas. The Seebetter consortium, comprised of Friedrich Miescher Institute for Biomedical Research, imec, Imperial College, and the University of Zurich, has been studying the functional roles of various retinal ganglion cells to better comprehend retinal vision, to design and build a high-performance silicon retina with a heterogeneous array of pixels specialized for both spatial and temporal visual processing; and to employ silicon back-side processing technology to increase the sensitivity of the sensor.

The silicon retina is essentially an image sensor manufactured in silicon, which works in a similar fashion to biological retinas. In contrast to conventional image sensors that generate data proportional to the amount of light landing on the sensor's pixels, the silicon retina is based on dynamic vision sensing. Instead of generating data proportional to the amount of light, each pixel is sensitive to timely changes impacting the amount of light. The data generated consists of asynchronous digital pulses, and the information lies in the amount of time between pulses. For instance, a slow change in the amount of light on a particular pixel will generate pulses at a relatively slow rate, whereas sudden changes will generate pulses at a high rate. When there are no changes in the scene captured by the sensor, no data is generated.

The additional functionality of the pixels achieved by the researchers has required larger pixels of between 10 and 20 micrometer pitches, depending on the technology node and the functionality included on the pixel.

The Friedrich Miescher Institute achieved an improved our understanding of how cone cells in the retina work. The University of Zurich demonstrated a unique silicon retina sensor with embedded standard pixels enabling more complex visual processing and extending the utility of such sensors. Imperial College developed a hardware emulator of a retina sensor utilizing standard off-the-shelf cameras. Imec developed and implemented silicon back-side processing for image sensors that is suitable for high-volume applications.

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2. FLEXIBLE SENSORS STREAMLINE DETECTION OF TOXIC GASES OR UV RADIATION

Sensors based on flexible electronics enable sensing devices with a very convenient footprint that can provide low power. Moreover, such devices, which are able to be bent, rolled, or folded without losing their basic functionality, have key advantages over silicon technologies, such as the use of inexpensive, flexible substrates, and low-cost manufacturing. Flexible electronics are attractive for use in wearable sensing applications to provide a more convenient, unobtrusive,

intuitive, yet durable means of gathering information about the wearer or one's environment.

A key area where gas sensors are used, entails monitoring toxic gases that can threaten worker safety in industries such as oil and gas, chemical and petrochemical, mining, electric or water utilities, and so on. Key types of toxic gases that are monitored for worker safety include chlorine, hydrogen sulfide, hydrogen, methane, nitrogen dioxide, and so on.

There is an ongoing need for lower cost, flexible gas sensors that can more easily be easily worn by a worker, or more readily be placed on safety gear, or used in space-constrained settings. Moreover, such sensors should provide advantages such as low power and rapid response.

With support from the Australian Research Council, researchers at RMIT University in Australia have developed sensors based on transparent, flexible electronics that can be worn as sensor patches, placed on work or safety gear, or incorporated in clothing, to detect hydrogen, nitrogen dioxide or other toxic gases. The technology could also be used detect ultraviolet (UV) radiation.

By monitoring key toxic gases (such as hydrogen) at production facilities, the sensors could safeguard against potential catastrophes and provide an early warning of a pending explosion.

Hydrogen, the lightest type of flammable gas, rapidly diffuses and is odorless, tasteless and undetectable using human senses. Hydrogen is flammable in concentrations above its lower flammable limit (LFL) (that is, 4% by volume or 40,000 parts-per-million [PPM]).

Furthermore, nitrogen dioxide, a highly reactive gas that forms when fuel is burned at high temperature, is a strong oxidizing agent that plays a role in atmospheric reactions that generate ground-level ozone (smog). The stretchable, unbreakable sensors could also be worn on the skin to detect UV radiation levels that could contribute to diseases such as melanoma. The researchers used extremely thin coatings of zinc oxide (which is utilized in sunscreen lotions) as the sensing material for UV sensors. The zinc oxide layer was configured in the form of a micro-tectonic plate-like structure in which the plates slide across each other. This phenomenon facilitates high sensitivity and allows for such sensing devices to bend or flex.

The researchers envision linking the sensors to electronic devices for continuous monitoring of UV radiation levels and warning of harmful UV concentrations.

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3. BRAIN-COMPUTER INTERFACE COMBINED WITH COMPUTER VISION IMPROVES DETECTION

Computer vision involves techniques for acquiring and analyzing images and data and electronically perceiving and understanding real-world images. Brain-computer interface (BCI) technology involves direct communication between the human brain and an implanted or external device. BCI allows bi-directional communication between the brain and the device; the brain can control or monitor the device, or the device can control or monitor the brain. BCI are used to monitor, control, or be controlled by the human cognitive or sensory-motor system. High-speed data processing and computing are required for real-time applications that utilize brain signals. One enabling technology used in BCI is electroencephalography (EEG), a non-invasive method that records electrical activity directly from the brain, typically via electrodes attached to the scalp.

Computer scientists at the University of California, San Diego, have used computer vision algorithms combined with a brain computer interface to accelerate the detection of mines in sonar images of the ocean floor. The project used an adapted a BCI C_3Vision^{TM} system and an EEG headset from Advanced Brain Monitoring.

The researchers collaborated with the US Navy's Space and Naval Warfare Systems Center Pacific (SSC Pacific) in San Diego, CA, to collect a dataset of 450 sonar images containing 150 inert, bright-orange mines that were placed in test fields in San Diego Bay. An image dataset was collected with an underwater vehicle equipped with sonar. The researchers trained their computer vision algorithms on a data set of 975 images of mine-like objects.

Initially, the researchers showed six subjects a complete dataset before it was screened by computer vision algorithms. Then, the image dataset was run through mine detection computer vision algorithms developed by the researchers. The algorithms flag images that most likely include mines. The results were

shown to subjects outfitted with an EEG system programmed to detect brain activity that showed subjects reacting to an image that contained a key feature (likely a mine). The subjects detected mines considerably faster when the images had already been processed by the algorithms.

The algorithms serve as a series of classifiers, designed to capture changes in pixel intensity between neighboring regions of an image, and to enhance speed and accuracy. The goal of the system is to detect 99.5% of true positives and only generate 50% of false positives during each pass through a classifier. While true positives will remain high, false positives will decline with each pass.

Several versions of the dataset generated by the classifier were shown to six subjects outfitted with the EEG gear, which had been calibrated for each subject. Subjects performed best on the data set containing the most conservative results generated by the computer vision algorithms. The subjects sifted through a total of 3,400 image chips containing about 100 x 50 pixels. Each chip was shown to a subject for only one-fifth of a second; just enough time for the EEG-related algorithms to determine whether the subject's brain signals indicated they saw something of interest. All of the subjects performed better when they were shown the full set of images without pre-screening by computer vision algorithms. Certain subjects also performed better compared to the computer vision algorithms on their own.

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4. RECENT PATENTS IN THE FIELD OF PERIMETER INTRUSION DETECTION SYSTEM

For airport operators, as well as such applications as border and pipeline security, perimeter security is of top priority. The standard installation throughout the world for perimeter security is the fence. Fence installation for perimeter security differs from site to site. The capability of the perimeter fencing has increased so that the security officer can now protect large sites with less manpower.

Three functions are provided by perimeter intrusion detection systems--detect, delay, and deter. Perimeter security technology allows the system to assess and monitor any breach and communicate the appropriate response.

The most inexpensive and common solution for perimeter security is the chain link fence. Apart from fencing, different types of sensor technologies, such as taut wire, fiber optic, vibration, pressure, seismic, magnetic, microphonic, passive and active infrared sensors, radar, are used in perimeter intrusion detection.

Some of the companies providing or developing perimeter security intrusion detection technology include Senstar Inc., RBTec, ST Electronics, Southwest Microwave, Sing Corp., Future Fiber Technologies, Magal S3, AGT International, and Fiber SenSys.

A recent patent (US20150009031), assigned to Honeywell International Inc., pertains to a multilayer perimeter intrusion detection system that includes sensors and a computer processor. Data received from the perimeter intrusion detection sensors are fused together, and an alarm is triggered when unusual behavior (a breach of an area) is detected.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Multilayer perimeter instrusion detection system for multi-processor sensing	08.01.2015; US20150009031	Honeywell International Inc.	Bedros Saad J.	A system includes perimeter intrusion detection sensors and a computer processor communicatively coupled to the perimeter intrusion detection sensors. The system receives data from the perimeter intrusion detection sensors, fuses the data from the perimeter intrusion detection sensors, and generates a single alarm from the fused data when the fused data indicates a breach of an area associated with the perimeter intrusion detection sensors. A sensor fusion framework for accomplishing these tasks is described.
Security barriers with automated reconnaissance	07.04.2015; US09000918	James O. McLaughlin	James O. McLaughlin	An intrusion delaying barrier includes primary and secondary physical structures and can be instrumented with multiple sensors incorporated into an electronic monitoring and alarm system. Such an instrumented intrusion delaying barrier may be used as a perimeter intrusion defense and assessment system (PIDAS). Problems with not providing effective delay to breaches by intentional intruders and/or terrorists who would otherwise evade detection are solved by attaching the secondary structures to the primary structure, and attaching at least some of the sensors to the secondary structures. By having multiple sensors of various types physically interconnected serves to enable sensors on different parts of the overall structure to respond to common disturbances and thereby provide effective corroboration that a disturbance is not merely a nuisance or false alarm. Use of a machine learning network such as a neural network exploits such corroboration.

System for detecting an intrusion attempt inside a perimeter defined by a fence	25.12.2014; US20140375453	Inoxys S.A.	Chamoux Thierry	The present invention relates to a system for detecting an intrusion attempt inside a perimeter defined by a fence including panels attached onto posts, comprising a means for detecting shocks and/or vibrations (**4**), which is connected to a remote station (**7**). Said system is characterized in that it comprises at least one housing (**1**) including at least one central processing unit or CPU (**2**), which is connected to at least one memory unit (**3**), to at least one shock and/or vibration detector (**4**), and to at least one field bus (**5, 6**) and/or at least one video bus (**27, 28**), each housing (**1**) being self-contained and connected to another housing (**1**) and/or to at least one remote station (**102**) for transmitting at least one computer file generated by the central processing unit (**2**) when a shock and/or vibrations are detected by one of the housings (**1**). DRAWING: FIG. **1: 3***a* RAM Memory **3***b* Flash Memory **3***c* ROM Memory **3***d* EPROM Memory **4** Gravitometer/accelerometer sensor **5** Field bus **6** Calendar clock **7** Clock synchronization **8** Temperature sensor **9** Cable tension sensor **10** Cable strength sensor **11** Internal or external physical measurement sensors: Radioactivity Flow rate Pressure Temperature Hygrometry **12** Added functional bus
Cooperative intrusion detection	17.12.2014; EP2814012	Honeywell Int Inc.	Katuri Srinivasarao	Systems, methods, and devices for cooperative intrusion detection are described herein. For example, one or more embodiments include completing a radar scan with a network of outer perimeter radar nodes, detecting an intrusion event with the network of outer perimeter radar nodes, notifying at least one inner perimeter radar node in a network of inner perimeter radar nodes of the intrusion event, activating the at least one inner perimeter radar node from an idle mode in response to the notification of the intrusion event, and completing a radar scan with the at least one inner perimeter radar node upon activation.
Underground pipeline perimeter intrusion early warning system	16.07.2014; CN103927834	Li Suzhen	Li Suzhen	An underground pipeline perimeter intrusion early warning system is used for monitoring and alarm for underground pipeline perimeter intrusion accidents. The system comprises an optical cable, an on-site alarm and an alarm management center host, wherein the optical cable is arranged along an underground pipeline, the on-site alarm is arranged along the underground pipeline and comprises an optical fiber loss test module, a data acquisition and storage module, a data remote transmission module, a second alarm module and a power supply, and the alarm management center host comprises a database, a first early warning module and a first alarm module. The system is used for detecting, analyzing and processing loss data of points along the optical cable, judging whether intrusion accidents occur or not and space positions and occurrence time corresponding to the intrusion accidents and giving an alarm according to analysis and judgment results. The system can carry out early warning and positioning as long as the optical cable is directly damaged or cut off, has the advantages of being simple in structure, small in false alarm probability and the like, and is especially suitable for application places of underground pipelines.

Leaky cable perimeter intrusion detection system	25.06.2014; CN103886703	Wang Bin	Wang Bin	The invention relates to the field of radio detection and especially relates to a leaky cable perimeter intrusion detection system. The system is mainly formed by three portions: a detection system main machine, a leaky cable module and a terminal module. The detection system main machine comprises a carrier wave signal generation module, a pseudo random coding generation module, an emission signal synthesis module, a signal emission module, a signal reception module, a signal processing module, an information processing module, an alarm module, a display module, a power supply module and a lightning-protection module. The leaky cable module is provided with an emission cable and a reception cable. The terminal module is provided with two matched resistors. One end of the emission cable and one end of the reception cable are connected with the detection system main machine, and the other ends are connected with the terminal module. The leaky cable perimeter intrusion detection system is relatively-high in anti-interference capability, strong in imperceptibility, high in positioning accuracy and low in alarm missing rate and mis-alarming rate; and no interference is generated between adjacent equipment.
Perimeter safety protection system	14.05.2014; CN103794010	China Changfeng Science Technology Industry Group Corp.	Luo Kegang	The invention provides a perimeter safety protection system. The system comprises a monitoring management subsystem, a sensing detection subsystem and a transmission and power supply subsystem, the monitoring management subsystem receives and records a confirmed intrusion alarm signal from a district management unit through an operation command center, automatically switches an image of a section where alarm conditions occur as a main picture according to alarm information, and displays an alarm position through an electronic map; the front end sensing detection subsystem uses a front end sensor array to sense various intrusion behaviors and gives out alarms, locates the position of an intrusion target, guides video monitoring for tracking, commands large screen display of a monitoring center, and recombines the intrusion target through security personnel; and the transmission and power supply subsystem is used for providing a power supply to perimeter sensing detection equipment, command control center equipment and district management unit system equipment.

Exhibit 1 lists some of the patents related to perimeter intrusion detection system.

Picture Credit: Frost & Sullivan

5. TECHVISION 2015

The TechVision program is the premier offering of Technical Insights, the global technology innovation-, disruption-, and convergence-focused practice of Frost & Sullivan. TechVision embodies a very selective collection of emerging and disruptive technologies that will shape our world in the near future. This body of

work is a culmination of thousands of hours of focused effort put in by over 60 global technology analysts based in six continents.

A unique feature of the TechVision program is an annual selection of 50 technologies that are driving visionary innovation and stimulating global growth. The selected technologies are spread across nine Technology Clusters that represent the bulk of R&D and innovation activity today. Each Cluster represents a unique group of game-changing and disruptive technologies that attract huge investments, demonstrate cutting-edge developments, and drive the creation of new products and services through convergence.

Our technology analysts regularly collect deep-dive intelligence on several emerging and disruptive technologies and innovations from around the globe. Interviews are conducted every day with innovators, technology developers, funders, and others who are a part of various technology ecosystems. The respondents are spread across public and private sectors, universities, research institutions, and government R&D agencies. Each technology is rated and compared across several parameters, such as global R&D footprint, year of impact, global IP patenting activity, private and public funding, current and emerging applications, potential adoption rate, market potential, and so on. This organic and continuous research effort spread across several technologies, regions, organizations, applications, and industries is used to generate an annual list of Top 50 technologies that have the maximum potential to spawn innovative products, services, and business models.

Furthermore, we analyse several possible convergence scenarios where two or more of the Top 50 technologies can potentially come together to disrupt, collapse, and transform the status quo. Driven by IP interactivity emanating from each of the top technologies, a whole range of innovative business models, products, and services will be launched at unprecedented speed in the future. We have come up with over 25 such unique convergence scenarios.

The Top 50 technologies we have selected for TechVision 2015 have the power to drive unique convergence and catalyse wide-scale industry disruptions. Frost and Sullivan’s TechVision program empowers you with ideas and strategies to leverage the innovations and disruptive technologies that can drive the transformational growth of your organization.

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