Sensor Technology (TechVision)

Wearable Sensors

Wearable sensors poised to impact consumer electronics

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FROST & SULLIVAN

Contents

Sensor Technology Innovations in Wearable Sensing

Smart Contact Lens with In-built Pressure Sensor

Columbia University Medical Center–Wearable contact lens to monitor glaucoma

Tech. Profile

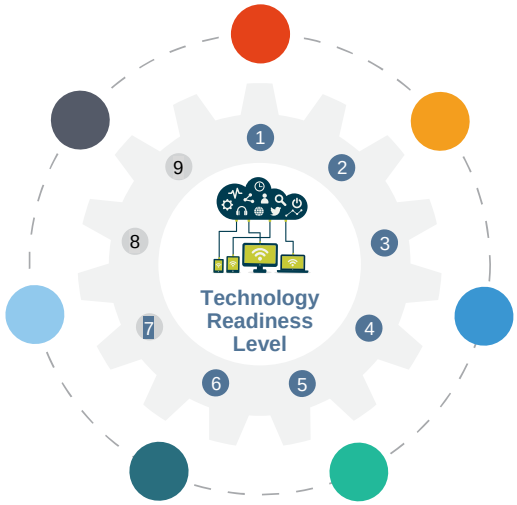
Researchers at Columbia University Medical Center have developed a wearable smart contact lens with an in-built low-power pressure sensor. This low-power pressure sensor is basically used to monitor glaucoma by changes in lens curvature due to eye pressure. The data collected is transferred to a wireless device such as a smartphone.

Year of Impact

The researchers are primarily focusing on monitoring glaucoma but the sensor is also expected to be used as a lens. It is expected to be commercialized in one to two years' time.

Market Opportunity

- ✓ Detect changes in temperature
- ✓ Keeping track of eye acidity levels
- ✓ Ophthalmologists performing surgery. It is expected that it will be widely adopted by ophthalmologists.



Competing Aspects

- ✓ Cost Efficient
- ✓ Reliable
- ✓ Easy to Use
- ✓ Highly Efficient Data Collection

Technology Convergence

With constant, real-time monitoring of patients' eye sight, opthalmologists are able to ensure continuous care and can act upon the actionable intelligence they access via the cloud, thereby improving the patients' quality of life.

Innovation Attributes

- ✓ The smart lens can be easily mounted in the eye and worn even during sleep.
- ✓ Monitoring glaucoma progression in real time
- ✓ Tracking the changes in eye acidity levels
- ✓ Researchers are currently working on powering the device. They are expected to use an antenna and RF chips.

Market Entry Strategies

The project was self funded by the university medical center, but it is expected that the university will bring its smart contact lens to the market by signing licensing agreements with medical companies.

Wireless Sleeves

University of Southampton–Wearable wireless sleeves to detect vibration of muscle

Tech. Profile

Researchers at the University of Southampton have developed a wireless sleeve which is comprised of mechanomyography microphone, tri-axial accelerometers, gyroscopes and magnetometers. Wireless sleeves will detect the vibrations in muscles and the data collected will be analyzed with the help of software which will be later sent to a tablet.

Year of Impact

The device will help the user and the government to save costs involved with constant monitoring of patients undergoing stroke rehabilitation. The wireless sleeve is expected to be commercialized in one to two years' time. In addition, it will help to improve the effectiveness of therapy.

Market Opportunity

- ✓ Patients take a long time to recover from a stroke. The wireless sleeves will help them to monitor their own performance in real time and at the same time motivate them to carry out their daily activities.

Competing Aspects

- ✓ User friendly computer interface
- ✓ Wireless connectivity, real-time monitoring, and accurate data
- ✓ Easy to use
- ✓ Cost efficient

Innovation Attributes

The user friendly interface of the device will help the user to accurately monitor muscle movement and how fast improvement is taking place.

Technology Convergence

Wearable electronics would establish contextual awareness and pervasive computing.

Market Entry Strategies

The university is expected to look out for collaborations with industry partners in the medical domain. At present, the university's main focus is on rehabilitation of patients who have experienced stroke.

Technology Readiness Level

1 2 3 4 5 6 **7** **8** 9

Wearable Fall Detector

SINTEF–Upper body wearable fall detector for safety purposes

SINTEF

Tech Profile

Researchers at SINTEF have developed a wearable fall detector device for elderly people which is comprised of pressure sensors and a Bluetooth device. The pressure sensors will be deployed around the room. Fall detectors will compare the change in pressure with respect to the human body and the sensors installed at the other points in the house. The researchers have developed a software to analyze the information.

Competing Aspects

- Cost efficient
- Highly accurate
- Easy to use
- Reduces government expenditure on old age homes

Innovation Attributes

- ✓ The device will be able to distinguish between falls and pressure changes.
- ✓ The software algorithm helps to distinguish between falls and pressure or outside noise.

Market Entry Strategies

- SINTEF is targeting the safety alarm system market. In addition SINTEF will commercialize its fall detector by collaborating with Tellu AS.

Technology Readiness Level

1 2 3 4 5 6 7 8 9

Impact & Opportunities

Wide-scale Adoption

✓Cost efficiency will help the company to get down to the mass market acceptable price levels

Market Opportunity

✓Safety Alarm System
✓Old Age Homes
✓Smart Homes

Technology Convergence

✓IOT is expected to be the gateway to the connected world.

Wearable Flexible Silicone Rubber Sticker

Carnegie Mellon University–iSkin for consumer electronics

Tech. Profile

○ Researchers at Saarland University, in collaboration with Carnegie Mellon University, have developed a flexible silicone rubber sticker called iSkin with pressure-sensitive sensors that can be fitted on the skin without any discomfort. iSkin senses two types of pressure, that is, light pressure with the help of capacitive sensing and firm pressure with the help of resistive sensing.

Innovation Attributes

✓ The iSkin device can be either wrapped around a body part or attached to the skin using biocompatible adhesives. An organic polymer called Polydimethylsiloxane (PDMS) is employed as a substrate in the iSkin manufacturing process. PDMS is the perfect material because of its biocompatible and elastic characteristic.

Technology Readiness Level

1 2 3
4 5 6
7 8 9

Competing Aspects

- Reliability
- Robustness
- Long Lifetime
- Easy to Integrate

Market Entry Strategies

- The main focus area for the university is the consumer electronics domain. The university is expected to get into a partnership agreement consumer electronics companies for commercializing the product.

Impact & Opportunities

Wide-scale Adoption

✓It is expected to be commercialized in one to two years' time

✓.The sensor has potential to be well received in the consumer electronics sector as it is easy to use, thin, flexible, and cost efficient.

Market Opportunity

The technology will be driven by applications in:

✓Consumer Electronics

✓Healthcare

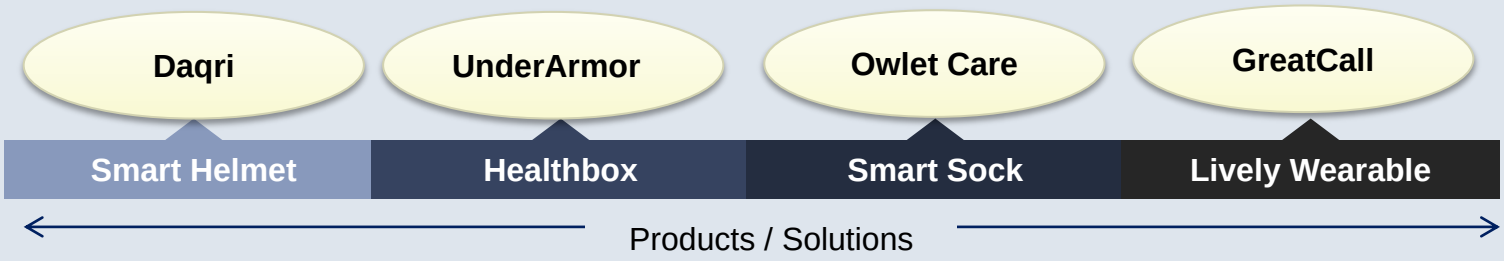
Technology Convergence

✓The technology has the potential to converge with associated technologies such as wireless communication, cloud computing, data analytics, and energy harvesting.

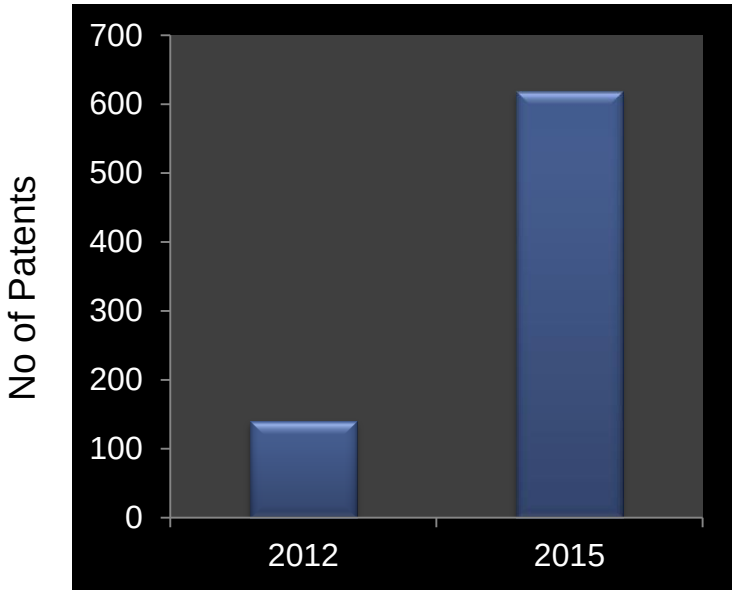
Strategic Insights

Strategic Insights

Companies to Watch in 2016



Intellectual Property (IP)



Source: WIPO/Frost & Sullivan

- Consumer inclination toward sophisticated gadgets and the rising trend toward a connected world are the significant factors driving the adoption of wearable sensing devices. Wearable electronics have several disruptive attributes, which have the potential to disrupt a number of industries, including banking, retail, healthcare, manufacturing, and security.
- Mobile devices, combined with wireless sensors and advanced communication technologies, have set the foundation for the wearable electronics market. Over the last few years, there has been tremendous growth in the wearable electronics market, particularly in the health and fitness sector.

Strategic Insights

Drivers

- ✓ Design Flexibility
- ✓ Low-power consumption
- ✓ New product development
- ✓ Strong R&D efforts
- ✓ Technology advancements
- ✓ Greater demand for enhanced user experience
- ✓ Entry of software and hardware giants
- ✓ Advanced sensor platforms, sensor fusion software, and algorithms

Restraints

- Ẋ Technological barriers such as battery, processing limitations
- Ẋ Security and privacy concerns
- Ẋ Lack of overall expertise in hardware and/or software

Focus Areas

- IOT
- Big Data
- System-on-Chip ICs
- Flexible and Stretchable Materials
- Energy Harvesting

Funding

- The University of Southampton has been funded by the National Institute for Health Research through its Invention for Innovation program with £1 million ($1.45 Million)
- The wearable fall detector is financed by the European Union's HEAD project and Oslo Regional Research Fund for the course of one year.

The 2020 Scenario

- ❑ The valuable insights generated by the advanced algorithms and the meaningful intelligence transferred via the cloud can be used for observation and research.
- ❑ Sensor fusion is common in already existing applications, such as compassing. The trend is now changing from sensor fusion to data fusion for situational and context awareness using wearable sensing.

Key Patents and Industry Interactions

Key Patents

No.	Patent No.	Publication Date	Title	Assignee
1	**US20160029778**	04.02.2016	WEARABLE MODULAR ELECTRONIC DEVICE, SUCH AS TO HOLD A SELECTABLE AND/OR REPLACEABLE BIOMETRIC SENSOR IN CLOSE PROXIMITY TO AND/OR IN PHYSICAL CONTACT WITH A WEARER AND/OR TO HOLD A BATTERY	Blingtec, Inc.
	A wearable modular electronic device to maintain an electronic module proximate to a wearer may be configured to attach to a wearable accessory such as, without limitation jewelry (e.g., necklace/pendant, finger ring, earring, body piercing, brooch, wrist bracelet, and/or wristwatch), a money clip, a belt buckle, a handbag, and/or an article of clothing. A wearable modular electronic device may be configured as a clasp assembly for a wristwatch, which may be configured to replace an existing clasp of a wristwatch, and which may be configurable for multiple types of wristbands (e.g., strap-type and/or metal). An electronic module may include a battery and/or sensor, such as a biometric sensor, and the wearable modular electronic device or a surface thereof may be contoured to coincide with a body part of a wearer and/or otherwise configured to maintain the biometric sensor proximate to the wearer.			
2	**US20160034764**	04.02.2016	Wearable Imaging Member and Spectroscopic Optical Sensor for Food Identification and Nutrition Modification	Robert A. Connor
	This invention is a wearable device or system for identification and quantification of food comprising an imaging member (such as a camera) that takes pictures of nearby food, an optical sensor (such as a spectroscopic optical sensor) which collects data concerning light that is reflected from this food, an attachment mechanism (such as a wrist band), and an image-analyzing member (such as a data control unit). This invention can further comprise a computer-to-human interface which modifies a person's nutritional intake based on identification of unhealthy vs. healthy food.			

Key Patents (continued)

No.	Patent No.	Publication Date	Title	Assignee
3	**US20160026240**	28.01.2016	WEARABLE APPARATUS WITH WIDE VIEWING ANGLE IMAGE SENSOR	ORCAM TECHNOLOGIES LTD.
	A wearable apparatus and method are provided for capturing image data. In one implementation, a wearable apparatus for capturing image data is provided. The wearable apparatus includes at least one image sensor for capturing image data of an environment of a user, wherein a field of view of the image sensor includes a chin of the user. The wearable apparatus includes two or more microphones, and an attachment mechanism configured to enable the image sensor and microphones to be worn by the user. The wearable apparatus includes a processing device programmed to capture at least one image, identify the chin of the user to obtain a location of the chin, select a microphone from the two or more microphones based on the location, process input from the selected microphone using a first processing scheme, and process input from a microphone that is not selected using a second processing scheme.			
4	**US20160022175**	28.01.2016	AUTOMATIC DETECTION OF A WEARABLE ELECTRONIC DEVICE NOT BEING WORN USING A MOTION SENSOR	Fitbit, Inc.
	Aspects of automatically determining a period of time when a wearable electronic device is not being worn are discussed herein. For example, in one aspect, an embodiment may automatically determine a period of time when the wearable electronic device is not being worn based on a comparison of the motion data and a not-worn profile that specifies a pattern of motion data that is indicative of when the wearable electronic device is not being worn by a user. The wearable electronic device also stores in the non-transitory machine readable storage medium, data associating the period of time with a not-worn state.			

Industry Interactions

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