Doors of perception

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3-D sensors are enabling a new mode of imaging.

Euclid and Archimedes didn't notice it, Newton missed it, and even Leonardo da Vinci didn't fully appreciate it-although he did notice that our two eyes have different views of the same sphere. It wasn't until 1838 that Charles Wheatstone discovered stereovision. A physicist and inventor, he noted that an artist could not faithfully represent a close object because each eye would see a slightly different view of the object.

Wheatstone went on to design the first fully 3-D picture, the stereogram, which created a 3-D effect by superimposing images taken by two cameras. The stereoscope used to view these pictures became the "television" of the 19th century, with friends and family gathered round to view stereo photos of the Egyptian pyramids or Niagara Falls.

In machine vision and other imaging applications, the 3-D challenge has been met by using two cameras to compute an object's position in space. For a number of years, researchers have been developing single-sensor solutions that can perform this same task. Today, products such as CMOS sensor systems and cameras are emerging from two companies in Europe and one in the U.S. Their target markets are in automotive, safety, and security applications, and potentially many other areas including industrial machine vision.

All three of these companies have based their technology on the time-of-flight (TOF) principle-long established in radar and lidar. The time of flight is measured by detecting the phase difference between a modulated light source, such as an LED or laser, located near the sensor and the returning light at every pixel in every frame. By detecting the phase difference at each pixel in the sensor, a map of the distance of objects from the sensor can be computed.

At CSEM (Centre Suisse d'Electronique et de Microtechnique) in Zurich, Switzerland, the Swiss Ranger SR-2, a 3-D miniature camera with 870-nm LED illumination, has been released. Its 124 ×160-pixel sensor is based on custom CMOS/CCD technology, provides a depth resolution down to 5 mm, and images at up to 100&#x2011frames/s. CSEM is a privately held company that carries out applied research, product development, and engineering for Swiss universities, industries, and government. The team developing the 3-D camera won the 2004 European Grand Prize for Information Science Technology.

At the University of Siegen's Interdisciplinary Center for Sensor Systems (Siegen, Germany), Rudolf Schwarte holds some of the first patents on the TOF principle and developed the photonic mixer device (PMD), a CMOS-based sensor that forms the heart of products from a spinoff company, PMDTechnologies (Siegen, Germany). The company was formed by Schwarte and the Audi subsidiary Audi Electronics Venture to strength Audi's electronics capabilities, including driver-assistance systems that could monitor the driver's blind spot, detect potential collisions, or observe the passenger seat to ensure proper airbag inflation. A 16 ×16-pixel sensor from PMDTechnologies should be available in some Audi cars in 2005. The company has also developed the Observer 19k 3-D camera, with a 160 ×120-pixel sensor, depth resolution to 6 mm, and a speed of up to 100 frames/s.

In the United States, Canesta (San Jose, CA) recently revealed its 64 ×64-pixel Equinox sensor, built by standard CMOS processes. Initially, Canesta had used its technology to create projection keyboards that track finger movements on a flat surface and interprets them as keystrokes for a PDA. Its new Electronic Perception Development Kit includes a single sensor, a software-development kit, and a graphical user interface for control and visualization. The idea is to give potential users of the sensor a tool to help them design new products and to help Canesta build demand for its sensors.

To illustrate how valuable the market may be-Canesta has raised $36 million in venture backing from investors such as Carlyle Venture Partners, JPMorgan Partners, Thales Corporate Ventures, and Venrock Associates. And several large international electronics companies are said to have their own 3-D sensor projects under way. Canesta says its advantage is a strong patent position and the low cost of its standard CMOS manufacturing process. But patent conflicts, if there are any, lie in the future. At the moment, the fact that several very smart companies are developing single-sensor 3-D products seems like a good sign that a

new dimension is being added to the imaging marketplace.

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Laser Focus World October, 2004

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