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Chip closes distance to real-time 3-D images

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Portland, Ore. -- The problem with machine vision is that the cameras are two-dimensional recorders of three-dimensional scenes. Objects in an image may be obscured by lighting, occluded by obstacles or camouflaged by similar colors in the background. Sophisticated software can sometimes piece together ob- jects from subtle cues, such as when two camera positions are used to reveal parallax. But such algorithms take time to run, making them inappropriate for real-time applications, like automobile collision avoidance.

Now one company claims to have solved the problem with a real-time 3-D camera that uses pixel-level hardware to reveal the distance to any object in any scene, regardless of lighting, occlusion or blending. By integrating 3-D hardware into its SunShield CMOS 3-D time-of-flight imaging sensors, Canesta Inc. (Sunnyvale, Calif.) says it enables machine vision cameras that perceive objects, rather than just sense images, in a scene.

"We have been perfecting this technology since 1999, and we have finally cleared the last hurdle to commercialization," said Canesta CEO and president James Spare. "Our first application is slated for release in the fourth quarter of 2007."

Conventional image chips work by virtue of semiconductors that generate free electrons in response to light falling on them. Canesta's CMOS image sensor works the same way, but it is integrated with an infrared light-emitting diode that illuminates the scene with invisible light. Circuits built into each pixel time how long it takes the infrared light to reach an object. Those calculations yield a 3-D depth map for an entire scene in real-time.

"Our technology can perceive in 3-D using a true CMOS process. We do it by detecting phase delay to measure time of flight, which is proportional to the distance traveled, for each pixel in a scene," said Canesta CTO Cyrus Bamji.

The infrared light source in the Canesta approach sends out a 50-MHz pulse train. Each pixel is provided with a clock synchronized with the light source. It outputs two signals, which are integrated onto two capacitors. From the voltage difference between the capacitors, the phase can be determined to better than one part in 300, or less than 50 picoseconds, according to Canesta.

The SunShield technology enables the distance measurement to be made independently of how a scene is lit. It works even if lighting conditions are extremely bright--100k lux--and even if the shutter time is long and the lighting conditions quickly change from dark to light.

Ambient light affects the output voltages of the pixel capacitors equally, thus leaving the difference unchanged. However, sunlight may be 1,000 times brighter (50 times after optical filtering) than the LED light, thus causing the pixel to saturate quickly.

Unlike ordinary cameras, which in bright daylight can increase shutter speed or lens f/stop, time-of-flight systems like Canesta's must operate at full sensitivity to capture the maximum amount of infrared light. In the Canesta technology, however, the infrared illumination is stopped before the pixel can saturate. Then, by reversing the pixel capacitor leads and shorting them together, the common-mode signal caused by ambient light is discarded, and the useful differential signal is preserved. This operation is exactly the reverse of the differential-voltage cancellation that happens when two capacitors are shorted together without reversing the leads.

The SunShield operation is repeated about every 100 microseconds and thus never allows the pixel to saturate. By contrast, the small differential voltage is al-lowed to accumulate and build up over the entire frame time, of about 30 milliseconds, for about 1 million cycles of the light source.

At the end of each frame, a depth map is created from the accumulated differential charge at each pixel, the entire chip is reset and the process repeats.

Canesta is a fabless semiconductor house that outsources its manufacturing to Tower Semiconductor. Its 3-D CMOS image sensors are cast in a 180-nanometer process. Its business model calls for it to sell camera modules to OEMs and to license its technology to manufacturers that want to make their own cameras able to perceive in 3-D. So far it has sold about 100 development kits to OEMs and manufacturers for apps as varied as video games, industrial automation and automobiles.

Honda Motor Co. Ltd. has made investments in Canesta totaling more than $5 million over three years.

Canesta predicts that its first automobile design win will be for a "smart" automobile air bag that deploys with a force appropriate to the size of the passenger. Other pending automobile applications include adaptive cruise control, blind-spot detection, backup warning systems, pedestrian detection and parking assistance.