



# Time-Of-Flight 3D Coming To A Device Near You

Microsoft's Kinect introduced Xbox 360 gamers to 3D sensors and body gesture recognition. It utilized technology from PrimeSense that projects an infrared (IR) pattern and uses a conventional IR sensor array to detect that pattern. A custom system-on-chip (SoC) does the heavy-duty number crunching so the host gets a depth map instead of information overload. The Xbox One comes with the second generation of the Kinect. However, it switches to a new technology for 3D imaging, time-of-flight (ToF).

## TIME-OF-FLIGHT SENSOR

ToF measures the time a light pulse takes to travel from an emitter, reflect off an object, and return to the sensor. The distance to the object is half the time of travel. Simple. All you need is a sensor that works fast enough and performs the calculations quickly. Hard.

ToF sensors have been around for a very long time. They can be very accurate even at distances of miles. The Apollo 11, 14, and 15 missions placed retroreflectors on the moon so 1D ToF lasers could help accurately measure the distance to the Earth.

Cost is a major factor in adopting ToF 3D technology. Light detection and ranging (LIDAR) using a rotating mirror and a single laser source often is used in 2D ToF scenarios. The mirror causes the 1D ToF range finder to scan along a line. 3D LIDAR is possible but more challenging mechanically.

LIDAR units have been big, bulky, and expensive. Compact sensors like Hokuyo's URG-04LX have reduced the cost, but they are still too expensive for consumer applications. LIDAR can use visible light laser sources, but normally IR is used so its operation is invisible. A laser light show can be rather annoying and possibly distracting when a driverless car rolls by.

ToF cameras bring range finding to 3D. Instead of a single sensor, they use an array similar to those used for digital cameras. The challenge is handling the timing and then crunching lots of numbers. It's a great application for an FPGA.

SoftKinetic has done a lot of work with IR-based 3D ToF cameras. The intensity of the illumination source affects the range. If it's too bright, the light will overpower the sensor. On the other hand, more light is important for items more than a meter away. This is the difference between detecting fingers in front of a laptop and a body gyrating in front of a large HDTV.




1. SoftKinetic's DS311 can handle hand and finger recognition at a range of 0.15 to 1 m. It can also manage body recognition from 1.5 to 4.5 m using a brighter IR emitter setting.

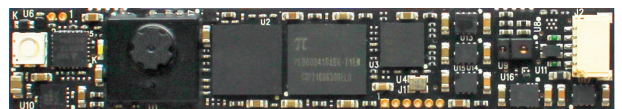
## NEAR FINGERS AND LIMBS AFAR

SoftKinetic's DS311 could be considered old technology since it was announced at the end of 2011 (Fig. 1). But getting the DepthSense CMOS in front of everyone's hands takes a while. It handles near-field hand and finger recognition from 15 cm up to 1 meter or a person or two at a distance of 1.5 to 4.5 meters, all at 60 frames/s with a resolution of 160 by 120 pixels. The DS325 provides 320 by 240 pixels but for near-field only.

For many embedded applications, range information is sufficient. For many applications like gaming, pairing the range sensor with a visible light camera makes sense. This is what DepthSense and Microsoft's Kinect does. Alignment helps so the color image can be combined with matching distance information.

Texas Instruments licensed the sensor technology from SoftKinetic. Creative Labs is turning it into a product, but crafting custom 3D sensor cameras isn't as hard as it might appear. Of course, checking out SoftKinetic's modules, reference design, driver, and gesture recognition software helps as well (Fig. 2).

So with all this hand waving, I close with Arthur C. Clarke's third law from "Hazards of Prophecy: The Failure of Imagination": Any sufficiently advanced technology is indistinguishable from magic. 



2. SoftKinetic modules can be used in embedded applications.

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