ADVANCED MATERIAL HANDLING WITH

New Sony DepthSense™ ToF Technology

Jenson Chang
Product Marketing
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3D SENSING APPLICATIONS

- Pick and Place
- Drones
- Collision Detection
- People Counting
- Palletizing/de-palletizing
- Warehouse Robot
- Metrology
- Senior/Patient Monitoring
3D SENSING TECHNIQUES

STEREO VISION

- Extracts depth information by matching the same point in two images
- Can use a pattern projector to add texture
- Suffers from occlusion - object seen by one camera but not the other
STRUCTURED LIGHT

- Projects a light pattern on the object. Uses the pattern distortion on the object to reconstruct the object shape
- Light source can be laser, IR or visible light
- Higher accuracy but requires calibration and resolution limited by light source
TIME OF FLIGHT

- Measures time it takes for the emitted light to be reflected back. Two techniques, one measure time directly, one measures phase difference of the emitted and received signal.
- Light source can be laser, IR or visible light
- Multipath - emitted light is reflected back from more than one path
- Less expensive and no calibration required
MARKET SEGMENT BY TECHNOLOGY

- **STRUCTURED LIGHT**
  - Inspection / Metrology
  - Automated Material Handling

- **TIME-OF-FLIGHT**
  - People Monitoring / Obstacle Avoidance
  - Navigation / Mobile Robot

**Accuracy**
- 1μm
- 1mm
- 1cm+

**Distance**
- 50cm
- 1m
- 5m
- 7m
- 10m
Challenges with structured light solutions in automated materials handling

• Sensitive to ambient light
• Challenges with certain packaging
• High precision systems are expensive
• In-field calibration required
• High CPU resources needed for depth processing

Challenges with capturing depth data for packaging that are shiny, reflective or clear

Sensitivity to sunlight from window or factory doors open/closing
# CURRENT SOLUTIONS FOR MATERIAL HANDLING

<table>
<thead>
<tr>
<th></th>
<th>STEREO VISION</th>
<th>STRUCTURED LIGHT</th>
<th>TIME-OF-FLIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Distance</td>
<td>Limited</td>
<td>Scalable</td>
<td>Scalable</td>
</tr>
<tr>
<td>Depth Accuracy</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Resolution</td>
<td>Full resolution</td>
<td>Limited by light pattern</td>
<td>Full resolution</td>
</tr>
<tr>
<td>In-field Calibration Needed</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Size</td>
<td>Increase with working distance</td>
<td>Increase with working distance</td>
<td>Compact</td>
</tr>
<tr>
<td>Cost</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Sony has combined SoftKinetic’s ToF technology with its own backside-illuminated technology to create the IMX556.

Sony’s backside-illuminated technology has better light collection efficiency in NIR compared to front-illuminated sensors.

Phase detection speed is improved, enabling higher modulation frequency.

### Sony DepthSense IMX556PLR CMOS

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Size</td>
<td>8mm diagonal (1/2 type)</td>
</tr>
<tr>
<td>Resolution</td>
<td>640 (H) x 480 (V), VGA</td>
</tr>
<tr>
<td>Pixel Size</td>
<td>10 μm (h) x 10 μm (V)</td>
</tr>
<tr>
<td>Framerate</td>
<td>60fps @ full resolution</td>
</tr>
</tbody>
</table>
VALUE PROPOSITION

HIGH RESOLUTION & HIGH SPEED
640 x 480 @ 60 fps, higher resolution than most ToF cameras

INCREASED PRECISION
Standard deviation $\sigma < 2.5$mm at 1m distance

BETTER PERFORMANCE WITHOUT PAYING MORE
Lower cost compared to 3D cameras with similar performance

Helios ToF 3D Camera Prototype
55mm x 55mm x 76mm
# LUCID HELIOS TOF 3D CAMERA

## Features

<table>
<thead>
<tr>
<th>Features</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Working Range</strong></td>
<td>Three operating modes</td>
</tr>
<tr>
<td>1.</td>
<td>Less than 1.5m with 100MHz modulation frequency</td>
</tr>
<tr>
<td>2.</td>
<td>Less than 3m with 50MHz modulation frequency</td>
</tr>
<tr>
<td>3.</td>
<td>Less than 6m with 25MHz modulation frequency</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td>&lt; 5mm from 0.3m to 1.5m in Mode 1 (preliminary)</td>
</tr>
<tr>
<td><strong>Precision</strong></td>
<td>Sigma &lt; 2.5mm at 1m in Mode 1 (preliminary)</td>
</tr>
<tr>
<td><strong>Lens Field of View</strong></td>
<td>$65 \times 46^\circ$ (nominal)</td>
</tr>
<tr>
<td><strong>Illumination</strong></td>
<td>4 x VCSEL laser diodes @ 850nm</td>
</tr>
<tr>
<td><strong>Digital Interface</strong></td>
<td>1 Gigabit Ethernet with M12 connector IEC 61076-2-109</td>
</tr>
<tr>
<td><strong>GPIO Interface</strong></td>
<td>8-pin M8 connector IEC 61076-2-104</td>
</tr>
<tr>
<td><strong>I/O ports</strong></td>
<td>1 input, 1 output, 2 bidirectional</td>
</tr>
<tr>
<td><strong>Dimension</strong></td>
<td>55 x 55 x 76mm</td>
</tr>
<tr>
<td><strong>Lens Mount</strong></td>
<td>Integrated S-mount lens</td>
</tr>
<tr>
<td><strong>Operating Temperature</strong></td>
<td>-10° to 50° C</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>280g</td>
</tr>
<tr>
<td><strong>Power Consumption</strong></td>
<td>TBD</td>
</tr>
<tr>
<td><strong>Conformity</strong></td>
<td>CE, RoHS, FCC, WEEE, Eye safety IEC 60825-1:2014</td>
</tr>
</tbody>
</table>

## Compliance

- GigE Vision 2.0, GenICam 3D
- Manual, Auto, External Trigger Signal via PTP
- 1 Default, 2 Custom
- 3D Point Cloud, Intensity and Confidence
- Windows and Linux
- Arena SDK, C++, C and C#

## PRELIMINARY DATA
GIGE VISION AND GENICAM 3D SUPPORT

<table>
<thead>
<tr>
<th>Pixel Format</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coord3D_ABC</td>
<td>Coordinate of the 3D image data with C being the depth data</td>
</tr>
<tr>
<td>Coord3D_A</td>
<td>Coordinate of the 3D image data with coordinate A only</td>
</tr>
<tr>
<td>Coord3D_B</td>
<td>Coordinate of the 3D image data with coordinate B only</td>
</tr>
<tr>
<td>Coord3D_C</td>
<td>Coordinate of the 3D image data with coordinate C only</td>
</tr>
<tr>
<td>Confidence</td>
<td>Confidence of the pixel value</td>
</tr>
<tr>
<td>RGB8</td>
<td>False color for depth visualization (red=closest, blue=furthest)</td>
</tr>
</tbody>
</table>

**Arena SDK**

- Camera control and image acquisition
- Data visualization such as point cloud, depth map, confidence map
### IMX556 Spectral Response Curve

![Graph showing the spectral response curve of IMX556 sensor.](image)

### EMVA Preliminary Data

<table>
<thead>
<tr>
<th>Mode</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+B</td>
<td>271508 e-</td>
<td>134718 e-</td>
</tr>
<tr>
<td>Saturation Capacity</td>
<td>271508 e-</td>
<td>134718 e-</td>
</tr>
<tr>
<td>Temporal Dark Noise (Read Noise)</td>
<td>117.3 e-</td>
<td>81.5 e-</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>67.05 dB</td>
<td>63.9 dB</td>
</tr>
</tbody>
</table>
Model Results

Simulated conditions:
- Constant 100k e- signal
- 80% modulation contrast
- 82 e- read noise
- 10 bit quantization

Sensor Model Data vs. Helios Measured Data
Test Conditions
- 4 lasers, at 1W optical power each
- Room light off
- Exposure time = 1000 us for all tested distances except for 30 cm
- 11x11 pixels in image center
- Standard deviation over 100 images

Results
- $\sigma = 2.25$ mm at 1 meter
- $\sigma = 4.56$ mm at 2 meter
Test Conditions
• Same conditions as previous

Results
• $\sigma = 2.34$ mm at 1 meter
• $\sigma = 4.36$ mm at 2 meter
Test Conditions

• Same conditions as previous
• Differences between measured and ground-truth distance
• Offset adjusted for 1 meter
COMPARED TO KINECT2

PRELIMINARY DATA

Helios ToF

Kinect2
SAMPLE IMAGES

Sample object: Muffins

Depth map, top view

Point clouds, angled view
SAMPLE IMAGES

Sample object: Boxes

PRELIMINARY DATA

Depth map, top view

Point clouds, angled view
WHO IS LUCID

• LUCID Vision Labs is a new company that designs and manufactures innovative machine vision products that creatively leverage new technology to deliver exceptional value to our customers.

• Founded in January 2017 in Canada, first product shipped in March 2018

• Headquartered in Canada, with regional sales and support offices in Germany, Japan and China
THANK YOU

COME TO BOOTH 1C62 FOR LIVE DEMONSTRATION

Be Inspired. Think Lucid.