Real-time Depth Map Processor for Offset Aperture based Single Camera System

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Background

- **Offset-Aperture camera**
  - Passive single lens camera
  - Both color image and depth map with single shot

- **Stereo vs. OA camera**
Structure of Depth Map Processor

- **Depth Map Processor (DMP)**
  - Real-time low-power ASIC for depth sensing of OA camera
  - Scanline processing without DRAM access
  - Efficient RGB-IR crosstalk elimination
Experimental Environment

- **<OA camera>**
  - Image (Parallel)
  - Control signals

- **DMP (ASIC)**
  - Image / depth (Parallel)

- **<FPGA>**
  - Memory
  - USB controller
  - AXI BUS
  - TRX handler
  - Control unit

- **<Display device>**
  - Image / depth (HDMI)

- **<Host PC>**
  - Control (USB 3.0)

- **<Demo Platform>**
  - Customized chip test board
  - FPGA board (Artix-7 xc7a200t)
  - OA camera
  - Chip socket
## Test Result

**Diagram:**
- SRAM for image processing
- ROM (61.4 KB)
- Serial I/F
- Pre-processing
- Interpolation, Gradient
- Cost Generation
- Cost Aggregation
- SRAM for CG and Box-filter (131.1 KB)

**Table:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>This work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera</td>
<td>OA* single camera</td>
</tr>
<tr>
<td>Technology</td>
<td>110nm 2P4M CIS</td>
</tr>
<tr>
<td>Core area [mm²]</td>
<td>52.63</td>
</tr>
<tr>
<td>On-chip memory [KB]</td>
<td>227</td>
</tr>
<tr>
<td>Gate counts [M]</td>
<td>1.156</td>
</tr>
<tr>
<td>Operating frequency [MHz]</td>
<td>76.8 (76.8°)</td>
</tr>
<tr>
<td>Image size &amp; throughput</td>
<td>1920x1080 @30fps</td>
</tr>
<tr>
<td>Depth level</td>
<td>32</td>
</tr>
<tr>
<td>Operating voltage [V]</td>
<td>1.5 core (1.8 I/O)</td>
</tr>
<tr>
<td>Board Power [mW]</td>
<td>280.53 @30fps</td>
</tr>
</tbody>
</table>

*Proposed offset-aperture camera [1]

*Worst-case post simulation results

**Graph:**
- Power consumption [mW] vs Operating Frequency [MHz]
- Operating Frequency (20 MHz to 100 MHz)
- Power consumption (100 mW to 300 mW)
- Key points:
  - 96.66 mW VGA 51 fps @ 20 MHz
  - 177.06 mW HD 35 fps @ 60 MHz
  - 234.68 mW HD 52 fps @ 80 MHz
  - 290.76 mW Full HD 31 fps @ 80 MHz

**Image:**
- Demonstration image with visible components and text:
  - <Demonstration>