A Novel Fast Shuttered Pixel

Principles of operation and characterization





Indirect Pulsed Time of Flight



1. Pulse of light is sent by the Camera

2. Pulse of light is returned from the target





3. Returning light is truncated by the shutter

4. Pixel response corresponds to imaged depth



IToF Workshop - 2014

A Novel Fast Shutter Mechanism

PPD with a VOD shutter





Standard CCD pixel exposure



Fast shutter exposure



Low

High





Reset

Waveforms and controlled parameters



Shutter Delay Shutter Width

 Fast shutter exposure has more parameters...

Fast Shutter Characterization

Experimental setup

Fast Shutter Exposure



Typical shutter response function



Quantum Efficiency

1. Measure the imager QE in standard operation - QE_{CW} , in standard setup.

TG	
RST	
Illum.	

2. Measure the sensor response with a pulsed source and shutter turned off – R_{ref}



3. Measure the sensor response with a pulsed source and fast shutter $-R_{pulsed}$





Shutter Signal Propagation



Pixel to Pixel Timing

Certain sensors exhibit timing variations between adjacent pixels in the shutter falling edge \Box



electron velocity plots

Falling edge uniformity can be fixed by better photodiode design or higher voltage



Electron arrival times may differ due
to process / voltage variations



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Contrast Ratio



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Contrast Ratio Map



Dark Current Buildup



* Lado Filipovic (2012) Topography Simulation of Novel Processing Techniques (Doctoral dissertation)

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Summary

- A very mature mechanism that can be utilized for ToF imaging
- There are many potential image sensors with various traits
- Several new parameters that have to be characterized
- New sensor-level characterization techniques are required
- Deep understanding of the pixel design and low-level characterization is crucial and can lead to better ToF imagers



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Thank you for listening!