

# Exact Blur Measure Outperforms Conventional Learned Features for Depth Finding



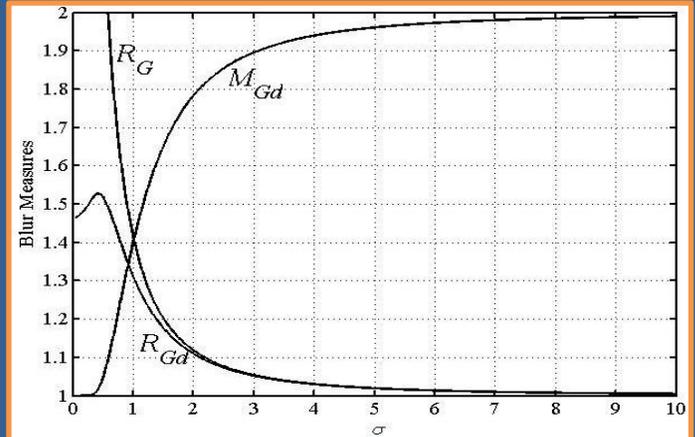
Akbar Saadat  
 Passive Defense R&D Dept.  
 Tech. Deputy of Iranian Railways  
 saadat\_a@rai.ir  
<https://www.linkedin.com/in/akbar-saadat-profile>



SSPD 2017  
 Sensor Signal Processing  
 For Defence Conference.  
 6-7 December 2017  
 London

**Abstract**—Image analysis methods that are based on exact blur values are faced with the computational complexities due to blur measurement error. This atmosphere encourages scholars to look for handcrafted and learned features for finding depth from a single image. This paper introduces a novel exact realization for blur measures on digital images and implements it on a new measure of defocus Gaussian blur at edge points in Depth From Defocus (DFD) methods with the potential to change this atmosphere. The experiments on real images indicate superiority of the proposed measure in error performance over conventional learned features in the state-of-the-art single image based depth estimation methods.

**Keywords**—DFD; exact blur measure; learned features



Defocused Image at edge locations:

$$i(y) = i_{min} + \frac{i_{max} - i_{min}}{2} \left( 1 + \operatorname{erf} \left( \frac{y}{\sqrt{2}\sigma} \right) \right)$$

Re-blurred Image:

$$i_1(y) = i_{min} + \frac{i_{max} - i_{min}}{2} \left( 1 + \operatorname{erf} \left( \frac{y}{\sqrt{2\pi(\sigma^2 + \sigma_1^2)}} \right) \right)$$

**Conventional Blur Measure:**

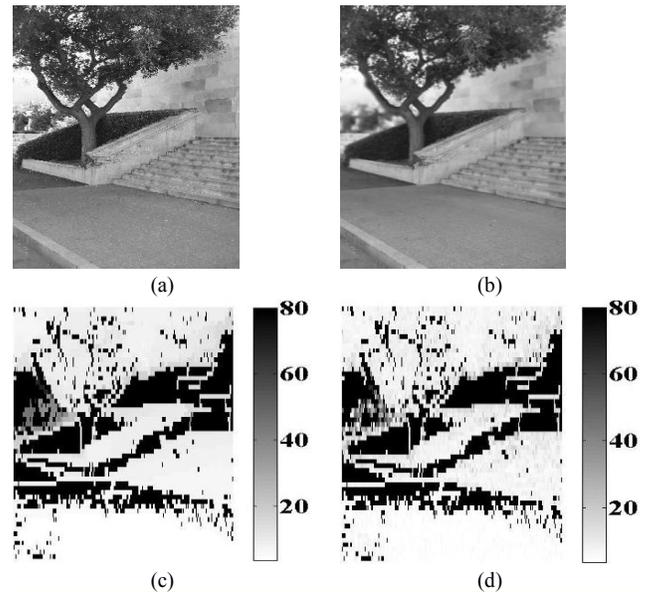
$$R_G(\sigma) = \frac{|\nabla i(0)|}{|\nabla i_1(0)|} = \sqrt{\frac{\sigma^2 + \sigma_1^2}{\sigma^2}}$$

**Exact Discrete Value of Blur Measure:**

$$R_{Gd}(\sigma) = \frac{i(1) - i(0)}{i_1(1) - i_1(0)} = \frac{\operatorname{erf} \left( \frac{1}{\sqrt{2}\sigma} \right)}{\operatorname{erf} \left( \frac{1}{\sqrt{2(\sigma^2 + \sigma_1^2)}} \right)}$$

**Proposed Blur Measure:**

$$M_{Gd}(\sigma) = \frac{i(2) - i(-2)}{i(1) - i(-1)} = \frac{\operatorname{erf} \left( \frac{\sqrt{2}}{\sigma} \right)}{\operatorname{erf} \left( \frac{1}{\sqrt{2}\sigma} \right)}$$



**Experiment results on a sample of the test image of the Make3D range image dataset.** (a) Original image in size of 2272 by 1704 pixels. (b) The defocused image by depth dependent blur. (c) Original depth map in size of 55 by 305 pixels. (d) Estimated depth map by the proposed measure in the size of original depth map. Depth values are expressed in meters.

## ERROR PERFORMANCE ON THE MAKE3D DTATA SET

Year	2005	2009	2010	2014	2014	2015	2016	2016	Now
Reference	A.Saxena, etal	A.Saxena, etal	B.Lin, etal	K.Karsch, etal	M.Lin, etal	F.Liu, etal	F.Liu, etal	A. Grigorev, etal	$M_{Gd}$
Depth Resolution	55x35	55x35	55x35	55x35	55x35	38x28	38x28	38x28	55x35
Relative Error	0.530	0.370	0.375	0.361	0.338	0.307	0.287	0.275	0.275