# STATISTICAL ANALYSIS OF SECOND-ORDER RELATIONS OF 3D STRUCTURES

Sinan Kalkan, Florentin Wörgötter
*Bernstein Centre for Computational Neuroscience, Unv. of Göttingen, Germany*

Norbert Krüger
*Cognitive Vision Group, Unv. of Southern Denmark, Denmark*

Keywords: Range Data Statistics, Indirect Depth Estimation.

Abstract: Algorithmic 3D reconstruction methods like stereopsis or structure from motion fail to extract depth at homogeneous image structures where the human visual system succeeds and is able to estimate depth. In this paper, using chromatic 3D range data, we analyze in which way depth in homogeneous structures is related to the depth at the bounding edges. For this, we first extract the local 3D structure of regularly sampled points, and then, analyze the coplanarity relation between these local 3D structures. We can statistically show that the likelihood to find a certain depth at a homogeneous image patch depends on the distance between the image patch and its edges. Furthermore, we find that this prediction is higher when there is a second edge which is proximate to and coplanar with the first edge. These results allow deriving statistically based prediction models for depth extrapolation into homogeneous image structures. We present initial results of a model that predicts depth based on these statistics.

## 1 INTRODUCTION

Depth estimation relies on the extraction of 3D structure from 2D images which is realized by a set of inverse problems including structure from motion, stereo vision, shape from shading, linear perspective, texture gradients and occlusion (Bruce et al., 2003). In methods which make use of multiple views (*i.e.*, stereo and structure from motion), correspondences between different 2D views of the scene are required. In contrast, monocular or pictorial cues such as shape from shading, utilization of texture gradients or linear perspective use statistical and geometrical relations in one image to make statements about the underlying 3D structure.

Many surfaces have only weak texture or no texture at all, and as a consequence, the correspondence problem is very hard or not at all resolvable for these surfaces. Nevertheless, humans are able to reconstruct 3D information for these surfaces, too. This gives rise to the assumption that in the human visual system, an interpolation process is realized that starting with the local analysis of edges, corners and textures, computes depth also in areas where correspondences cannot easily be found.

In figure 1, the relation between the depth of homogeneous image structures and edges is shown. In figure 1(a), we see that the depth of homogeneous image structures is directly related to the depth of the bounding edges; however, this relation does not always exist as shown in figure 1(b,c) where the depth is cued in shading.

With the notion that the human visual system is adapted to the statistics of the environment (Brunswik and Kamiya, 1953; Knill and Richards, 1996; Krüger, 1998; Krüger and Wörgötter, 2004; Olshausen and Field, 1996; Rao et al., 2002; Purves and Lotto, 2002) and its successful applications to grouping, object recognition and stereo (Elder and Goldberg, 2002; Elder et al., 2003; Pugeault et al., 2004; Zhu, 1999), the analysis, and the usage of natural image statistics has become an important focus of vision research. Moreover, with the advances in technology, it has been also possible to analyze the underlying 3D world using 3D range scanners (Howe and Purves, 2004; Huang et al., 2000; Potetz and Lee, 2003; Yang and Purves, 2003).

In this paper, by making use of chromatic range data (see figure 3 for examples), we investigate

Kalkan S., Wörgötter F. and Krüger N. (2007).
STATISTICAL ANALYSIS OF SECOND-ORDER RELATIONS OF 3D STRUCTURES.
In *Proceedings of the Second International Conference on Computer Vision Theory and Applications - IU/MTSV*, pages 13-20