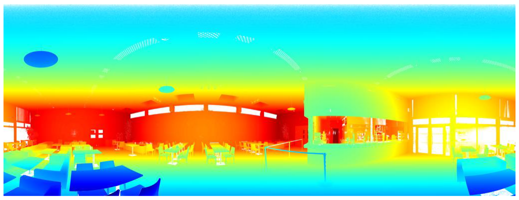
Learning to identify depth edges in real-world images with 3D ground truth

Visual edges can be produced by multiple causes: occlusion, change in surface normal, change in surface reflectance or illumination. Identifying edge types is an important visual processing step which supports object recognition and segmentation. Previous studies of edge classification have generally relied on small and potentially biased hand-labelled datasets. We take a more physics-based approach to edge classification by identifying and classifying edges in spherical images with ground-truth depth information.

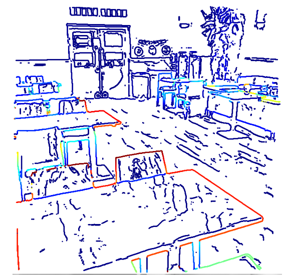
Spherical HDR image



LiDAR range data: log(distance) in meters

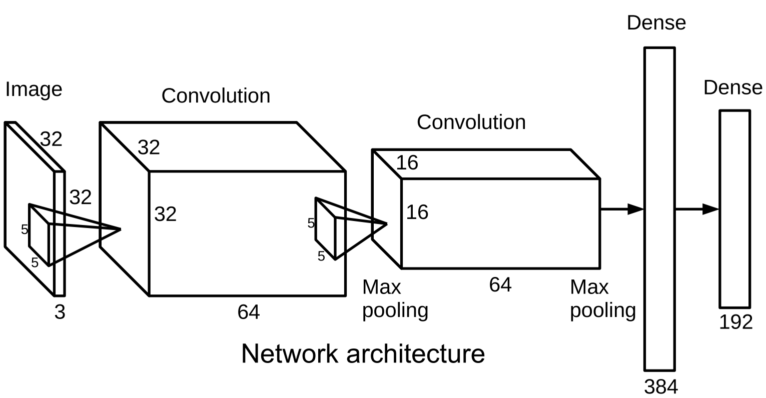
Projected view

Edge map from Elder & Zucker (1998)

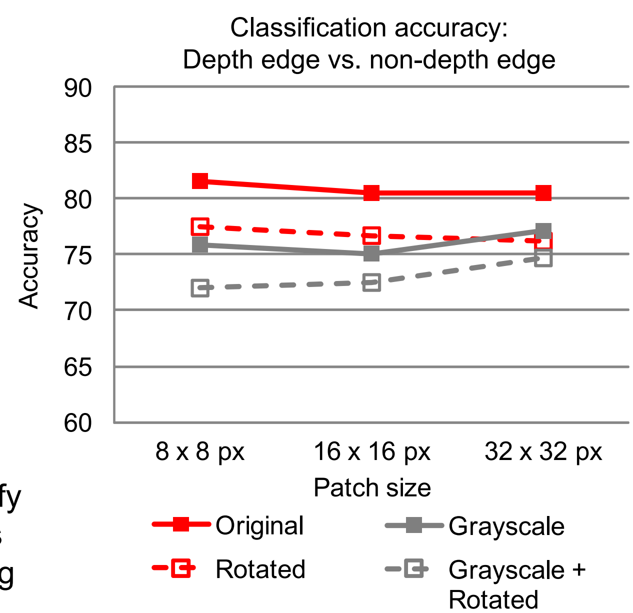


Depth contrast
blue = non-depth edges,
red = highdepth edges

We use the Southampton-York Natural Scenes (SYNS) dataset (Adams, et al., 2016), which includes spherical HDR imagery and LiDAR range data for 73 randomly-selected indoor and outdoor locations. We sample view directions uniformly over each spherical image and identify visible edges in the HDR images using the Elder & Zucker (1998) edge detection algorithm. We measure the depth contrast at each edge by averaging the depth values in a small region on either side of the edge.



Network architecture



We trained convolutional neural networks to discriminate depth from non-depth edges in image patches ranging from 8x8 to 32x32 pixels. The models were able to classify contrast-normalized edges with about 81% accuracy; this performance was similar across all patch sizes. Removing information about color and edge orientation reduced performance, which shows that these low-level features provide useful priors about the presence of a depth edge. However performance remained well above chance, implicating additional spatial (e.g., blur, textural, configural) cues.

Adams, W.J., Elder, J.H., Graf, E.W., Leyland, J., Lugtigheid, A.J., & Muryy, A. (2016). The Southampton-York Natural Scenes (SYNS) dataset: Statistics of surface attitude. *Scientific Reports, 6*, 35805.

Elder, J. H., & Zucker, S. W. (1998). Local scale control for edge detection and blur estimation. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 20*, 699–716.