Horizon Lines in the Wild

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Single image horizon line estimation is one of the most fundamental geometric problems in computer vision. Knowledge of the horizon line enables a wide variety of applications, including: image metrology, geometry-aware object detection, and automatic perspective correction. Despite this demonstrated importance, progress on this task has stagnated. We believe the lack of a suitably large and diverse evaluation dataset is the primary cause. Existing datasets [2, 3] are often small and were created to focus on evaluating methods that use a particular geometric cue (*e.g.*, orthogonal vanishing points). Methods that perform well on such datasets often perform poorly in real-world conditions.

We introduce *Horizon Lines in the Wild* (HLW), a new dataset for single image horizon line estimation. HLW is several orders of magnitude larger than any existing dataset for horizon line detection (containing 100553 images), has a much wider variety of scenes and camera perspectives, and wasn't constructed to highlight the value of any particular geometric cue. The dataset (including models and sample code) is available for download at our project website [1].

Using HLW, we investigate methods for directly estimating the horizon line using convolutional neural networks (CNNs), including both classification and regression formulations. We focus on the GoogleNet architecture and explore the impact of design and implementation choices on the accuracy of the resulting model. Additionally, we propose two post-processing strategies for aggregating horizon line estimates across subwindows.

Our approach is fast, works in natural and man-made environments, does not fail catastrophically when vanishing point detection is difficult, and outperforms all existing methods on the challenging real-world imagery contained in HLW. Further, when combined with the recent method by Zhai et al. [4], which uses a CNN to provide global context for vanishing point estiDepartment of Computer Science University of Kentucky Lexington, KY, USA



Figure 1: Example results showing the estimated distribution over horizon lines (ground truth dash green and predicted horizon magenta).

Table 1: Quantitative evaluation.

	HLW	ECD	YUD
Ours	69.97%	83.96%	85.33%
Ours (average)	71.16%	83.60%	86.41%
Ours (optimize)	70.66%	86.05%	86.11%
[4] (CNN = Orig.)	58.24%	90.80%	94.78%
[4] (CNN = Ours)	65.50%	91.29%	95.46%

mation, we obtain state-of-the-art results on two existing benchmark datasets [2, 3].

Our main contributions are: 1) a novel approach for using structure from motion to automatically label images with a horizon line, 2) a large evaluation dataset of images with labeled horizon lines, 3) a CNN-based approach for directly estimating the horizon line in a single image, and 4) an extensive evaluation of a variety of CNN design choices.

- Horizon Lines in The Wild project website. http://hlw.csr.uky.edu/.
- [2] Olga Barinova, Victor Lempitsky, Elena Tretiak, and Pushmeet Kohli. Geometric image parsing in man-made environments. In ECCV, 2010.
- [3] Patrick Denis, James Elder, and Francisco Estrada. Efficient edge-based methods for estimating manhattan frames in urban imagery. In ECCV, 2008.
- [4] Menghua Zhai, Scott Workman, and Nathan Jacobs. Detecting vanishing points using global image context in a non-manhattan world. In *CVPR*, 2016.