NeurVPS: Neural Vanishing Point Scanning via Conic Convolution

Yichao Zhou* Haozhi Qi* Jingwei Huang‡ Yi Ma*

*University of California, Berkeley ‡Stanford University

https://github.com/zhou13/neurvps

NeurIPS 2019
33rd Conference on Neural Information Processing Systems

Vanishing Point Detection

- After perspective projection, parallel lines intersect at the same point, i.e., the vanishing point;
- Vanishing points bridge 2D and 3D by giving the 3D **line direction** in camera space from a single 2D image.

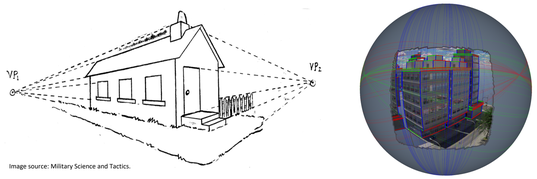


Image source: Military Science and Tactics.

Applications

(a) 3D Wireframe Lifting

(b) Camera Calibration

(c) Photo Forensics

Related Work

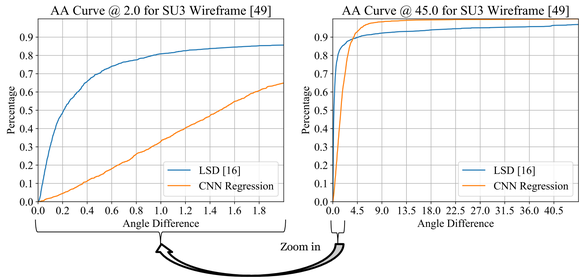
Traditional Methods

- Two-stage algorithms
- First, extract line segments from images
- Next, cluster lines based on their intersections
- Not end-to-end trainable
- **Accurate**, but outliers may result in total failure

CNN-Based Methods

- [1]: Divide images into patches and classify them
- [2]: Use neural networks to filter outlies
- Hard to utilize geometric properties of VPs
- **Robust**, but CNN only gives a coarse estimation

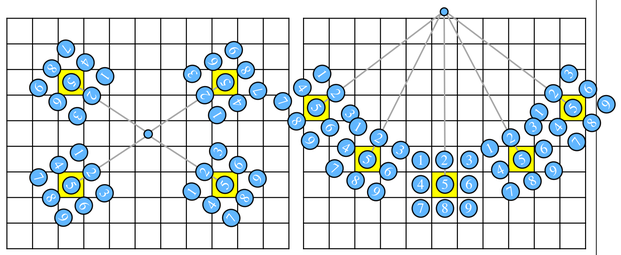
Accuracy of VPs with Naive CNNs



Motivation

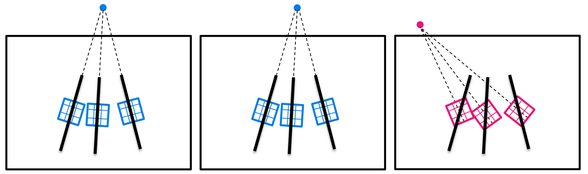
- **Accurate** as traditional line clustering algorithms;
- **Robust** as (convolutional) neural network-based algorithms;
- End-to-end trainable without using existing line detectors;
- Able to capture geometric cues of vanishing points.

Conic Convolution



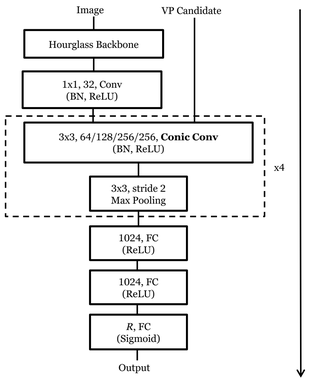
(a) VP candidate inside the image (b) VP candidate outside the image

Geometric Intuition of Conic Convolution

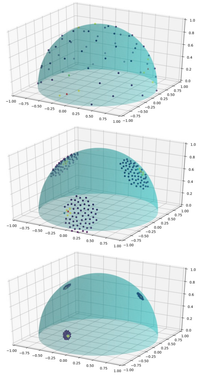


(a) Ground Truth (b) True Proposal (c) False Proposal

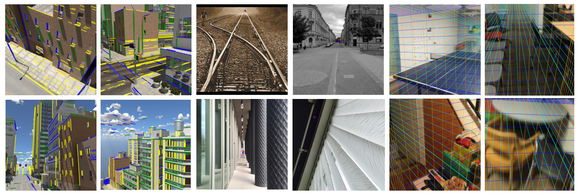
Network Structure



Hierarchical Inference

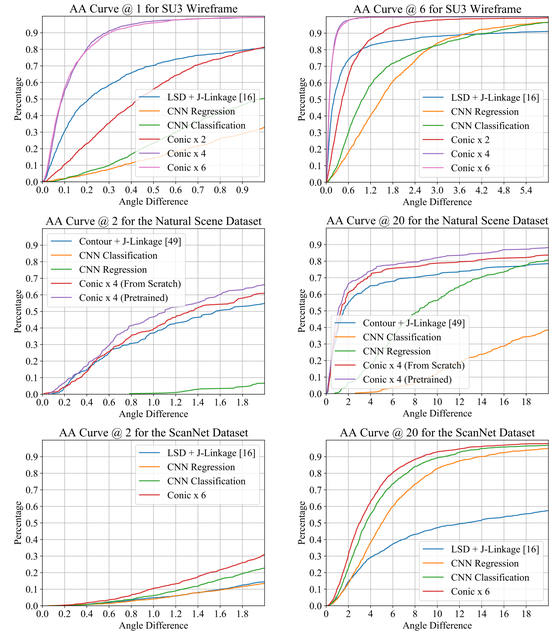


Datasets and Visualization



(a) LSD/J-Linkage on SU3 [3] (b) NeurVPS on [4] with GT (c) Ground Truth of ScanNet

Results



Acknowledgement

This work is partially supported by Sony US Research Center, FHL Vive Center for Enhanced Reality, Berkeley BAIR, and Bytedance Research Lab.

Reference

- [1] "DeepVP: Deep learning for vanishing point detection on 1 million street view images", Chin-Kai Chang, Jiaping Zhao, and Laurent Itti. ICRA 2018.
- [2] "Detecting Vanishing Points using Global Image Context in a Non-Manhattan World" Menghua Zhai, Scott Workman, Nathan Jacobs. CVPR 2016.
- [3] "Learning to Reconstruct 3D Manhattan Wireframes from a Single Image." Zhou, Yichao, Haozhi Qi, Yuexiang Zhai, Qi Sun, Zhili Chen, Li-Yi Wei, and Yi Ma. ICCV 2019.
- [4] "Detecting Dominant Vanishing Points in Natural Scenes with Application to Composition-Sensitive Image Retrieval" Zihan Zhou, Farshid Farhat, and James Z. Wang. TMM 2017.

Berkeley UNIVERSITY OF CALIFORNIA