Supplemental Material of Submission 598
A Minimum Error Vanishing Point Detection Approach for Uncalibrated Monocular Images of Man-made Environments

November 21, 2012

Outline

1 Jacobian Matrix for function $g(\cdot)$

The input of the function $g(\cdot)$ is four endpoints of two line segments $\mathbf{l}_j$ and $\mathbf{l}_k$ in the image:

$$[\mathbf{e}_{j1}, \mathbf{e}_{j2}, \mathbf{e}_{k1}, \mathbf{e}_{k2}] = [u_{j1}, v_{j1}, u_{j2}, v_{j2}, u_{k1}, v_{k1}, u_{k2}, v_{k2}].$$

The output is the intersection of the extension lines of $\mathbf{l}_j$ and $\mathbf{l}_k$ in the image: $[u_{(j,k)}, v_{(j,k)}]$. The Jacobian matrix of $g(\cdot)$ is

$$\mathbf{G}_{(j,k)} = \begin{bmatrix} g_{11} & g_{12} & g_{13} & g_{14} & g_{15} & g_{16} & g_{17} & g_{18} \\ g_{21} & g_{22} & g_{23} & g_{24} & g_{25} & g_{26} & g_{27} & g_{28} \end{bmatrix},$$

where

$$g_{11} = \frac{(u_{k1}-u_{k2})(v_{j1}-v_{j2})(u_{j2}v_{k1}-u_{k1}v_{j2}-u_{j2}v_{k2}+u_{k2}v_{j2}+u_{k1}v_{k2}-u_{k2}v_{k1})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{12} = -\frac{(u_{j1}-u_{j2})(u_{k1}-u_{k2})(u_{j2}v_{k1}-u_{k1}v_{j2}-u_{j2}v_{k2}+u_{k2}v_{j2}+u_{k1}v_{k2}-u_{k2}v_{k1})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{13} = -\frac{(u_{k1}-u_{k2})(v_{j1}-v_{j2})(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}+u_{k2}v_{j1}+u_{k1}v_{k2}-u_{k2}v_{k1})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{14} = \frac{(u_{j1}-u_{j2})(u_{k1}-u_{k2})(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}+u_{k2}v_{j1}+u_{k1}v_{k2}-u_{k2}v_{k1})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{15} = \frac{(u_{j1}-u_{j2})(v_{k1}-v_{k2})(u_{j1}v_{j2}-u_{j2}v_{j1}-u_{j1}v_{k2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{16} = -\frac{(u_{j1}-u_{j2})(u_{k1}-u_{k2})(u_{j1}v_{j2}-u_{j2}v_{j1}-u_{j1}v_{k2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{17} = -\frac{(u_{j1}-u_{j2})(v_{k1}-v_{k2})(u_{j1}v_{j2}-u_{j2}v_{j1}-u_{j1}v_{k1}+u_{k1}v_{j1}+u_{j2}v_{k1}-u_{k1}v_{j2})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{18} = \frac{(u_{j1}-u_{j2})(u_{k1}-u_{k2})(u_{j1}v_{j2}-u_{j2}v_{j1}-u_{j1}v_{k1}+u_{k1}v_{j1}+u_{j2}v_{k1}-u_{k1}v_{j2})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{21} = \frac{(v_{j1}-v_{j2})(v_{k1}-v_{k2})(u_{j2}v_{k1}-u_{k1}v_{j2}-u_{j2}v_{k2}+u_{k2}v_{j2}+u_{k1}v_{k2}-u_{k2}v_{k1})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{22} = -\frac{(u_{j1}-u_{j2})(v_{k1}-v_{k2})(u_{j2}v_{k1}-u_{k1}v_{j2}-u_{j2}v_{k2}+u_{k2}v_{j2}+u_{k1}v_{k2}-u_{k2}v_{k1})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{23} = -\frac{(v_{j1}-v_{j2})(v_{k1}-v_{k2})(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}+u_{k2}v_{j1}+u_{k1}v_{k2}-u_{k2}v_{k1})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{24} = \frac{(u_{j1}-u_{j2})(v_{k1}-v_{k2})(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}+u_{k2}v_{j1}+u_{k1}v_{k2}-u_{k2}v_{k1})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{25} = \frac{(v_{j1}-v_{j2})(v_{k1}-v_{k2})(u_{j1}v_{j2}-u_{j2}v_{j1}-u_{j1}v_{k2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{26} = -\frac{(u_{k1}-u_{k2})(v_{j1}-v_{j2})(u_{j1}v_{j2}-u_{j2}v_{j1}-u_{j1}v_{k2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{27} = -\frac{(v_{j1}-v_{j2})(v_{k1}-v_{k2})(u_{j1}v_{j2}-u_{j2}v_{j1}-u_{j1}v_{k1}+u_{k1}v_{j1}+u_{j2}v_{k1}-u_{k1}v_{j2})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2},$$

$$g_{28} = \frac{(u_{k1}-u_{k2})(v_{j1}-v_{j2})(u_{j1}v_{j2}-u_{j2}v_{j1}-u_{j1}v_{k1}+u_{k1}v_{j1}+u_{j2}v_{k1}-u_{k1}v_{j2})}{(u_{j1}v_{k1}-u_{k1}v_{j1}-u_{j1}v_{k2}-u_{j2}v_{k1}+u_{k1}v_{j2}+u_{k2}v_{j1}+u_{j2}v_{k2}-u_{k2}v_{j2})^2}.$$

2 Representative results compared to existing works

Here we present our representative line segment clustering and horizon detection results compared to existing works. Fig. 1 shows several images on which our algorithm produces significantly improved horizon estimation.

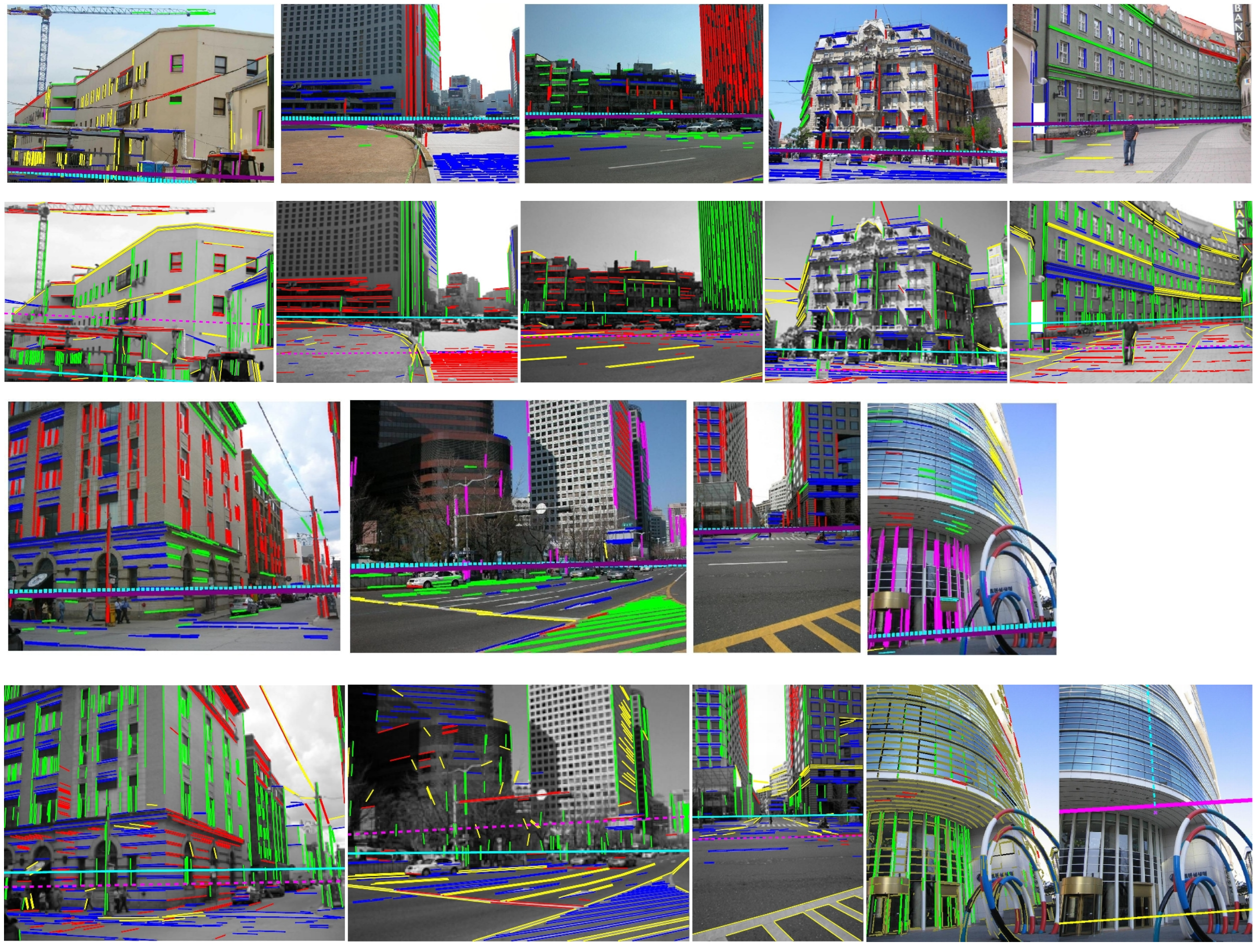

Figure 1: Several images on which our algorithm produces significantly improved horizon estimation compared to existing works. Rows 1 and 3 show the results produced by our minimum error algorithm; each parallel line segment cluster is highlighted with different color; the dashed cyan line is the horizon ground truth and the solid purple line is the computed horizon. Except for the last image in row 4, which is produced by the "Geometric Parsing" algorithm [1], all rest images in row 2 and 4 show results produced by the 4-line RANSAC algorithm [2], where red, green, and blue colors indicate three mutually orthogonal vanishing directions, respectively. The solid cyan line is the horizon ground truth and the dashed magenta line is the computed horizon.

3 All results on YUD and ECD datasets

We have visualized and included the results on all images in YUD and ECD datasets. Please find the results in respective folders. Note, each parallel line segment cluster is highlighted with different color. The dashed cyan line is the horizon ground truth and the solid purple line is the computed horizon.

References

[1] E. Tretyak, O. Barinova, P. Kohli, and V. Lempitsky. Geometric image parsing in man-made environments. *IJCV*, 97:305–321, 2012.

[2] H. Wildenauer and A. Hanbury. Robust camera self-calibration from monocular images of manhattan worlds. In *CVPR*, 2012.