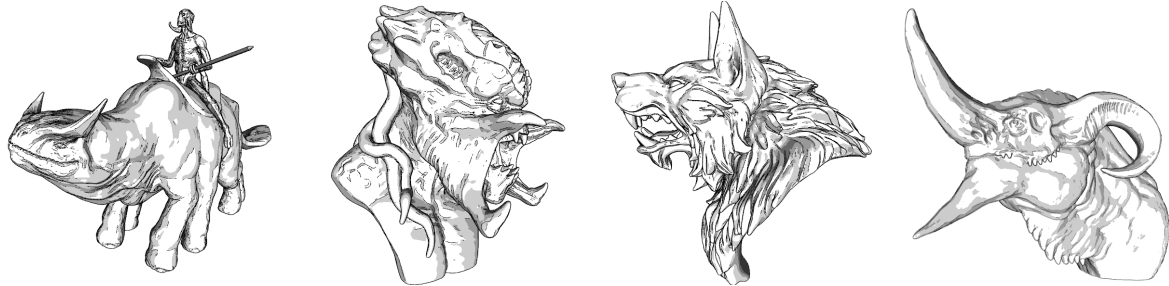


# Photic Extremum Lines

Markus Pawellek  
markus.pawellek@mailbox.org



---

## Abstract

*Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.*

**Keywords:** Non-Photorealistic Rendering, Feature Lines, View-Dependent Object-Space Algorithm, Contours, Silhouettes, Suggestive Contours, Photic Extremum Lines, Illumination, Interactive

---

## 1 Introduction

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

## 2 Related Work

## 3 Mathematical Preliminaries

## 4 Photic Extremum Lines

## 5 Algorithm

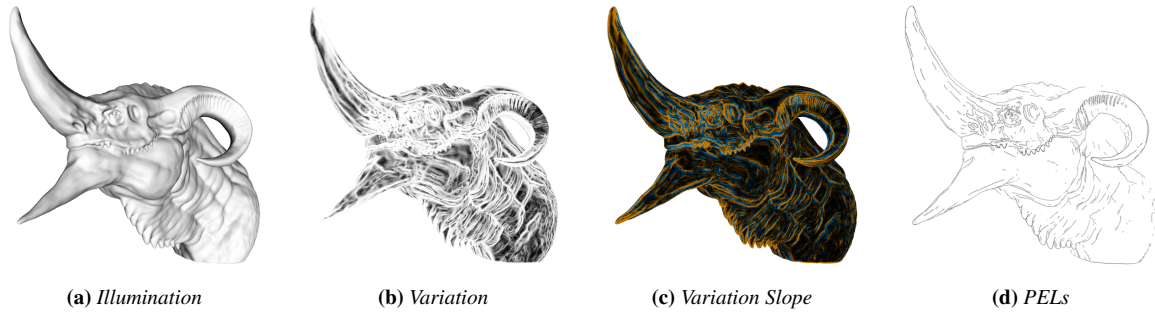
## 6 Implementation

## 7 Results and Comparison

## 8 Conclusions

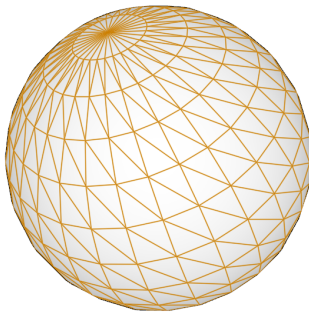
## References

- DeCarlo, Douglas et al. (July 2003). "Suggestive Contours for Conveying Shape". In: *ACM Trans. Graph.* 22, pp. 848–855. DOI: [10.1145/1201775.882354](https://doi.org/10.1145/1201775.882354).
- Hertzmann, Aaron and Denis Zorin (2000). "Illustrating Smooth Surfaces". In: *Proceedings of the 27th Annual Conference on Computer Graphics and Interactive Techniques. SIGGRAPH '00*. ACM Press/Addison-Wesley Publishing Co., 517–526. ISBN: 1581132085. DOI: [10.1145/344779.345074](https://doi.org/10.1145/344779.345074).

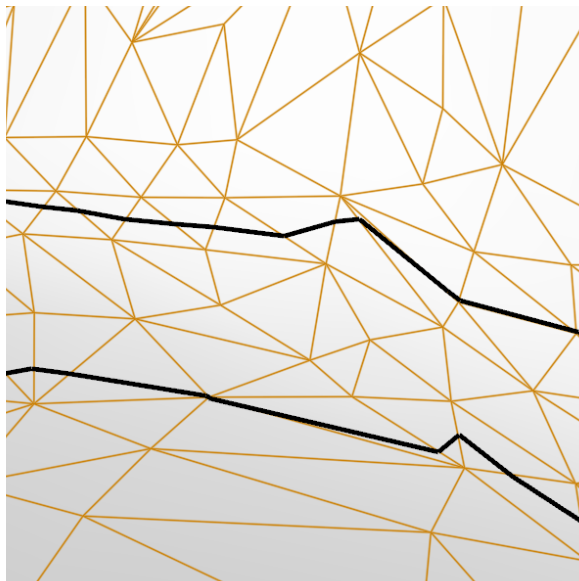


**Figure 1: Short Summary Part**

*Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.*

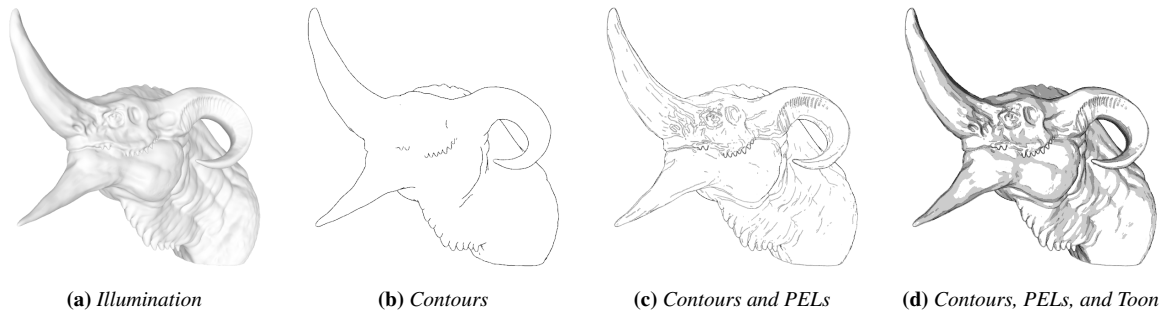


**Figure 2: Triangulated Meshes**



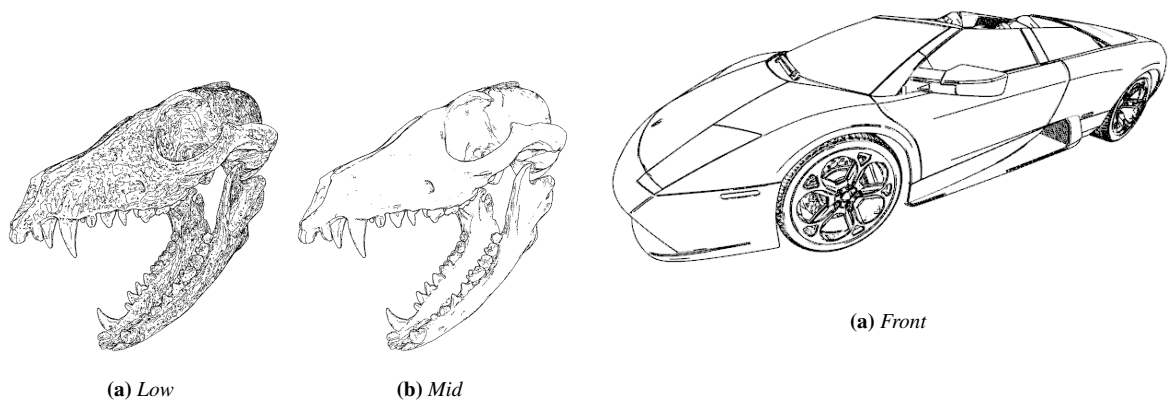
**Figure 3: Sub-Polygon Feature Lines**

- Isenberg, Tobias et al. (August 2003). "A Developer's Guide to Silhouette Algorithms for Polygonal Models". In: *Computer Graphics and Applications, IEEE* 23, pp. 28–37. DOI: [10.1109/MCG.2003.1210862](https://doi.org/10.1109/MCG.2003.1210862).
- Jin, Shuangshuang, Robert Lewis, and David West (February 2005). "A Comparison of Algorithms for Vertex Normal Computation". In: *The Visual Computer* 21, pp. 71–82. DOI: [10.1007/s00371-004-0271-1](https://doi.org/10.1007/s00371-004-0271-1).
- Kindlmann, Gordon et al. (November 2003). "Curvature-Based Transfer Functions for Direct Volume Rendering: Methods and Applications". In: vol. 2003, pp. 513–520. ISBN: 0-7803-8120-3. DOI: [10.1109/VISUAL.2003.1250414](https://doi.org/10.1109/VISUAL.2003.1250414).
- Kolomenkin, Michael, Ilan Shimshoni, and Ayellet Tal (December 2008). "Demarcating Curves for Shape Illustration". In: *ACM Trans. Graph.* 27, p. 157. DOI: [10.1145/1457515.1409110](https://doi.org/10.1145/1457515.1409110).
- Max, Nelson (January 1999). "Weights for Computing Vertex Normals from Facet Normals". In: *Journal of Graphics Tools* 4. DOI: [10.1080/10867651.1999.10487501](https://doi.org/10.1080/10867651.1999.10487501).
- Meyer, Mark et al. (November 2001). "Discrete Differential-Geometry Operators for Triangulated 2-Manifolds". In: *Proceedings of Visualization and Mathematics* 3. DOI: [10.1007/978-3-662-05105-4\\_2](https://doi.org/10.1007/978-3-662-05105-4_2).
- Rusinkiewicz, Szymon (October 2004). "Estimating Curvatures and Their Derivatives on Triangle Meshes". In: pp. 486–493. ISBN: 0-7695-2223-8. DOI: [10.1109/TDPVT.2004.1335277](https://doi.org/10.1109/TDPVT.2004.1335277).
- Rusinkiewicz, Szymon, Michael Burns, and Douglas DeCarlo (July 2006). "Exaggerated Shading for Depicting Shape and Detail". In: *ACM Trans. Graph.* 25, pp. 1199–1205. DOI: [10.1145/1179352.1142015](https://doi.org/10.1145/1179352.1142015).
- Xie, Xuexiang et al. (November 2007). "An Effective Illustrative Visualization Framework Based on Photic Extremum Lines (PELs)". In: *IEEE transactions on visualization and computer graphics* 13, pp. 1328–1335. DOI: [10.1109/TVCG.2007.70538](https://doi.org/10.1109/TVCG.2007.70538).
- Zhang, Long, Ying He, and Hock Seah (June 2010). "Real-Time Computation of Photic Extremum Lines (PELs)". In: *The Visual Computer* 26, pp. 399–407. DOI: [10.1007/s00371-010-0454-x](https://doi.org/10.1007/s00371-010-0454-x).
- Zhang, Long et al. (July 2011). "Real-Time Shape Illustration Using Laplacian Lines". In: *IEEE transactions on Visualization and Computer Graphics* 17. DOI: [10.1109/TVCG.2010.118](https://doi.org/10.1109/TVCG.2010.118).

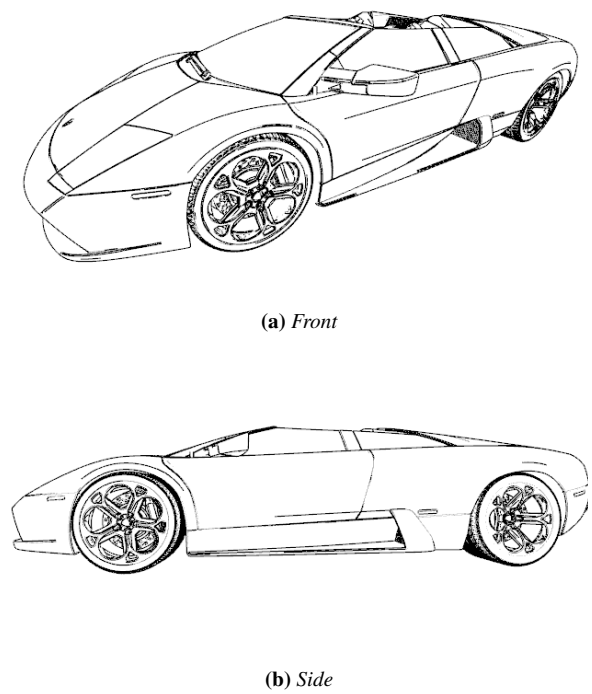


**Figure 4: Short Summary Part**

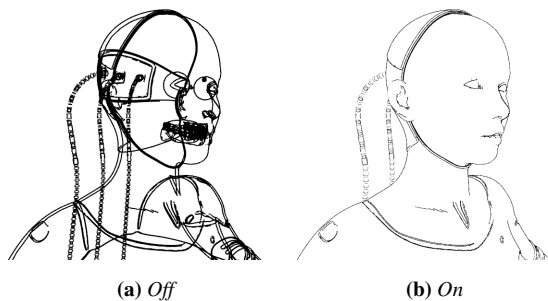
*Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.*



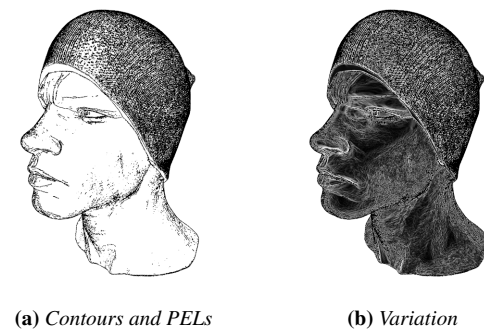
**Figure 5: Effect of thresholding**



**Figure 7: Nearly Perfect Line Extraction for Smooth Objects**



**Figure 6: Two-Pass Rendering for Hidden Line Removal**



**Figure 8: Erroneous Line Extraction for Noisy Objects**