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A survey of photon mapping state-of-the-art research and future challenges

Key words: Global illumination, Photon mapping, Radiance estimation, Photon relaxation, Progressive photon mapping

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Motivation

- Photon mapping is an active research field in photo-realistic rendering, which has been developed over the past two decades. A survey along this direction is important and timely.

- The goals of our report are giving readers an overall introduction to photon mapping and motivating further research to address the limitations of existing methods.

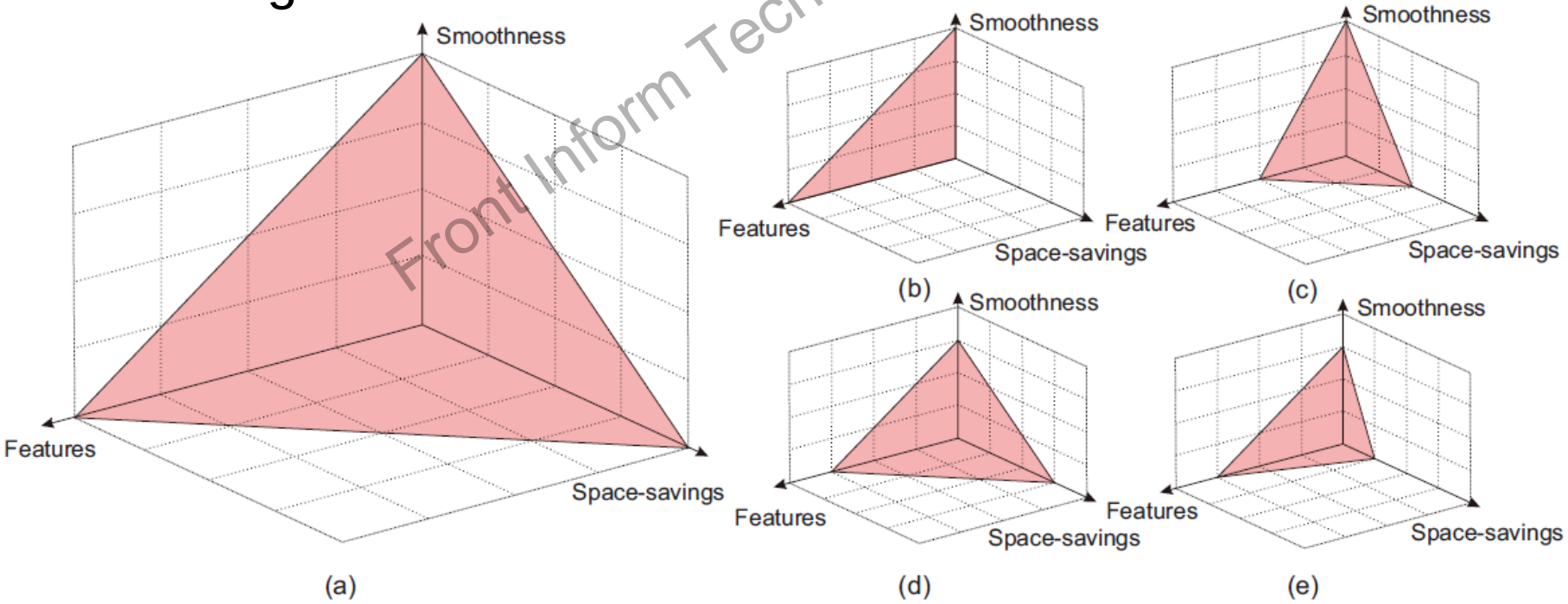
Overview

- We present a comprehensive overview of the photon mapping methods by classifying them into a set of categories including radiance estimation, photon relaxation, photon tracing, progressive photon mapping, and parallel methods.

- The analysis of the optimized methods is based on three main challenges, namely smoothness, features, and space-savings.

Overview

- Analysis of four kinds of methods based on three challenges: (a) ideal solution; (b) radiance estimation methods; (c) photon relaxation methods; (d) progressive photon mapping methods; (e) photon tracing methods.



Overview

- We introduce the optimization and analysis of photon mapping method one by one according to the categories.

- We also summarize the comparison of different methods in speed, quality, scalability, and parallelism in a table. The more solid points are painted, the higher score is obtained.

Comparison of different methods

Method	Speed	Quality	Scalability	Parallelism
Improved radiance estimation				
Jensen (1996)	●●○○○	●●○○○	●●●○○	●●●○○
Myszkowski (1997)	●●○○○	●●●○○	●●●○○	●●○○○
Roland (2003)	●●●○○	●●●○○	●●●○○	●●○○○
García *et al.* (2012)	●●○○○	●●●●○	●●●○○	●●○○○
García *et al.* (2014)	●●○○○	●●●●●	●●●○○	●●○○○
Schjøth *et al.* (2008)	●●○○○	●●●●○	●●●○○	●●○○○
Schjøth *et al.* (2007)	●●○○○	●●●●●	●●●●○	●●●○○
Havran *et al.* (2005)	●●○○○	●●●○○	●●○○○	●●○○○
Photon relaxation				
Spencer and Jones (2009)	●●●○○	●●●●○	●●○○○	●●○○○
Chen *et al.* (2013)	●●●○○	●●●●●	●●●○○	●●○○○
Spencer and Jones (2013b)	●●●○○	●●●●○	●●○○○	●●○○○
Spencer and Jones (2013a)	●●●○○	●●●●●	●●○○○	●●○○○
Spencer *et al.* (2015)	●●●○○	●●●●●	●●○○○	●●○○○

Comparison of different methods

Method	Speed	Quality	Scalability	Parallelism
Photon splatting				
Stürzlinger and Bastos (1997)	●●●○○	●●○○○	●●●○○	●●●●○
Lavignotte and Paulin (2003)	●●●○○	●●●○○	●●●○○	●●●●○
Herzog *et al.* (2007)	●●○○○	●●●●○	●●●○○	●●●○○
Frisvad *et al.* (2014)	●●○○○	●●●●●	●●●○○	●●○○○
Progressive photon mapping				
Hachisuka *et al.* (2008)	●●●○○	●●●●○	●●●○○	●●●○○
Hachisuka and Jensen (2009)	●●●○○	●●●●○	●●●●○	●●●○○
Knaus and Zwicker (2011)	●●●○○	●●●●●	●●●●○	●●○○○
Hachisuka *et al.* (2010)	●●●○○	●●●●●	●●●○○	●●○○○
Benthin *et al.* (2012)	●●●○○	●●●●●	●●●○○	●●○○○
Kaplanyan and Dachsbacher (2013)	●●●●○	●●●●●	●●●○○	●●●○○
Liu and Zheng (2014b)	●●●○○	●●●●●	●●●○○	●●○○○
Georgiev *et al.* (2013)	●●●○○	●●●●●	●●●●●	●●●○○
Davídovič *et al.* (2014)	●●●●○	●●●●●	●●●●●	●●●●○

Comparison of different methods

Method	Speed	Quality	Scalability	Parallelism
Progressive photon mapping				
Davídovič *et al.* (2014)	●●●●○	●●●●●	●●●●●	●●●●○
Hachisuka *et al.* (2012)	●●●○○	●●●●●	●●●●●	●●●○○
Photon tracing				
Suykens and Willems (2000)	●●○○○	●●●○○	●●●○○	●●●○○
Fan *et al.* (2005)	●●○○○	●●●○○	●●●○○	●●○○○
Hachisuka and Jensen (2011)	●●○○○	●●●●○	●●●●●	●●○○○
Liu and Zheng (2014a)	●●●○○	●●●●○	●●●○○	●●●○○

Conclusions

- Through the summary above, we find that progressive photon mapping is a hot-spot among existing studies.
- Photon relaxation, photon splatting, and photon tracing are local optimization methods. Future work on these kinds of methods can start from the parallel algorithm and new parameters.
- As for future work, photon mapping is expected to obtain more accurate results and play a more important role in industrial rendering.