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Image meshing via hierarchical optimization

Key words: Image meshing, Hierarchical optimization, Convexification

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Introduction

Convert a raster image into a vector graphics:

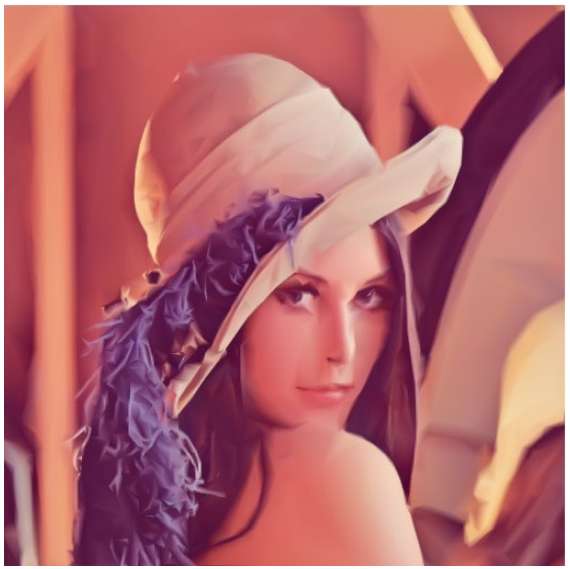
- Input: a raster image, the number of vertices
- Output: a triangular mesh with colors



Input image



Output mesh



Rendered image

Innovations

- A hierarchical process is proposed which provides an initial input for a finer level with the result of a coarser level to make the original problem smoother.

- By combining the color space and image space, a conversion from a non-convex problem to a convex one is also proposed to further reduce the complexity of problem at the stage of geometry optimization.

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Pipeline

The pipeline of our algorithm

1: HierarchyEstablishment
2: MeshInitialization
3: $i \Leftarrow N - 1$
4: **while** Level $i \geq 0$ **do**
5: ObjectiveConvexification(i)
6: AlternatingOptimization(i)
7: $i \Leftarrow i - 1$
8: **end while**

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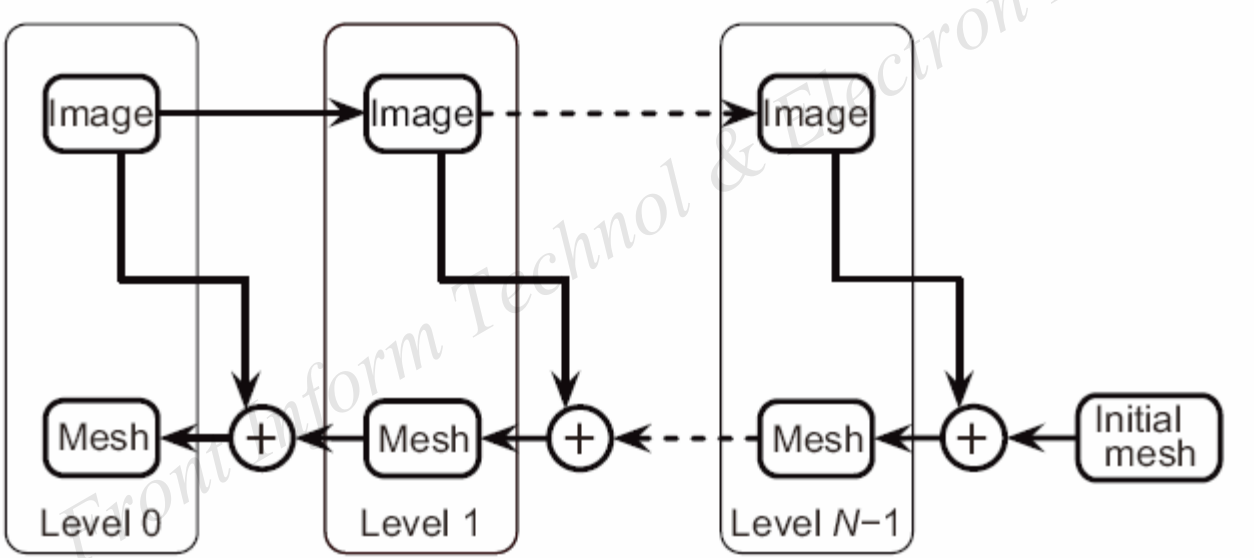
Hierarchy establishment



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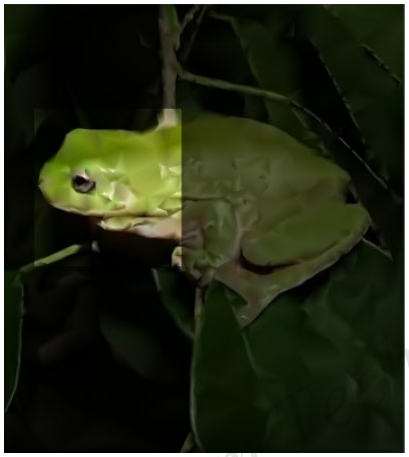
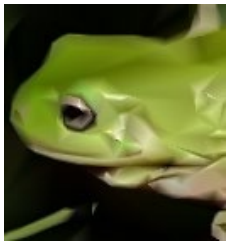
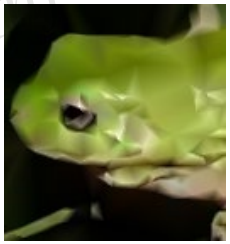
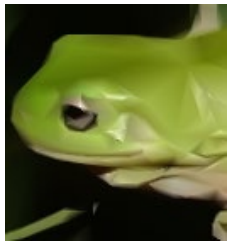
Experimental results (*frog*)




Adams (2011)

Xie *et al.* (2014)

Ours

Original image

Experimental results (*leaf*)



Adams (2011) Xie *et al.* (2014) Ours Original image

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Measurement results

Table 1 Peak signal-to-noise ratio (PSNR) comparison among our algorithm and the algorithm proposed by Adams (2011) and Xie *et al.* (2014)

Image	SR (%)	PSNR (dB)		
		Adams (2011)	Xie *et al.* (2014)	Ours
Lena	1	27.3759	28.8600	**29.7244**
	2	29.8263	30.9544	**31.3691**
	3	30.9801	31.9918	**32.1422**
Fruits	1	25.9269	26.9589	**27.7363**
	2	28.5327	29.4424	**29.7518**
	3	29.9629	**30.8024**	30.5960
Flower	1	25.8028	26.9718	**27.7477**
	2	27.9217	29.6071	**29.9863**
	3	28.6615	30.8009	**30.9495**
Falcon	1	27.3196	29.9666	**30.4886**
	2	28.5323	31.9729	**32.1160**
	3	28.8675	**32.7877**	32.7106
Car	1	23.1645	24.6478	**25.0299**
	2	25.6941	26.8857	**27.2032**
	3	26.8163	27.9490	**28.0324**
Fish	1	23.9873	25.2301	**25.9045**
	2	26.6296	27.7636	**28.1316**
	3	28.1074	29.2166	**29.2648**
Leaf	1	26.8061	27.8816	**28.6272**
	2	28.8395	29.9846	**30.3554**
	3	29.5924	31.0008	**31.1287**
Swan	1	24.4826	25.9614	**26.7547**
	2	26.9890	28.3783	**28.9821**
	3	28.3651	29.7019	**30.0601**
Frog	1	27.4404	28.9776	**29.8903**
	2	29.8848	31.0584	**31.5725**
	3	30.8791	31.9689	**32.2853**

SR: sampling rate

Table 2 Runtime of our algorithm

Image	Resolution	SR (%)	Time (s)	Image	Resolution	SR (%)	Time (s)
Lena	512×512	1	2.03	Fish	320×400	1	0.66
		2	3.66			2	1.05
		3	6.23			3	1.66
Fruits	512×480	1	1.75	Leaf	373×400	1	0.83
		2	3.10			2	1.36
		3	5.19			3	2.20
Flower	400×300	1	0.66	Swan	286×400	1	0.60
		2	1.02			2	0.95
		3	1.61			3	1.48
Falcon	400×280	1	0.59	Frog	357×400	1	0.90
		2	0.86			2	1.44
		3	1.33			3	2.27
Car	400×300	1	0.64				
		2	1.04				
		3	1.61				

SR: sampling rate

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Conclusions

- We present a novel algorithm to convert a raster image into a vector graphic represented by a triangular mesh.
- Compared with other algorithms, the results are improved by establishing a hierarchy of several levels for the input image.
- A convexification of the problem in the stage of geometry optimization is also performed to further simplify the non-linear problem into a linear least squares one.

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