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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

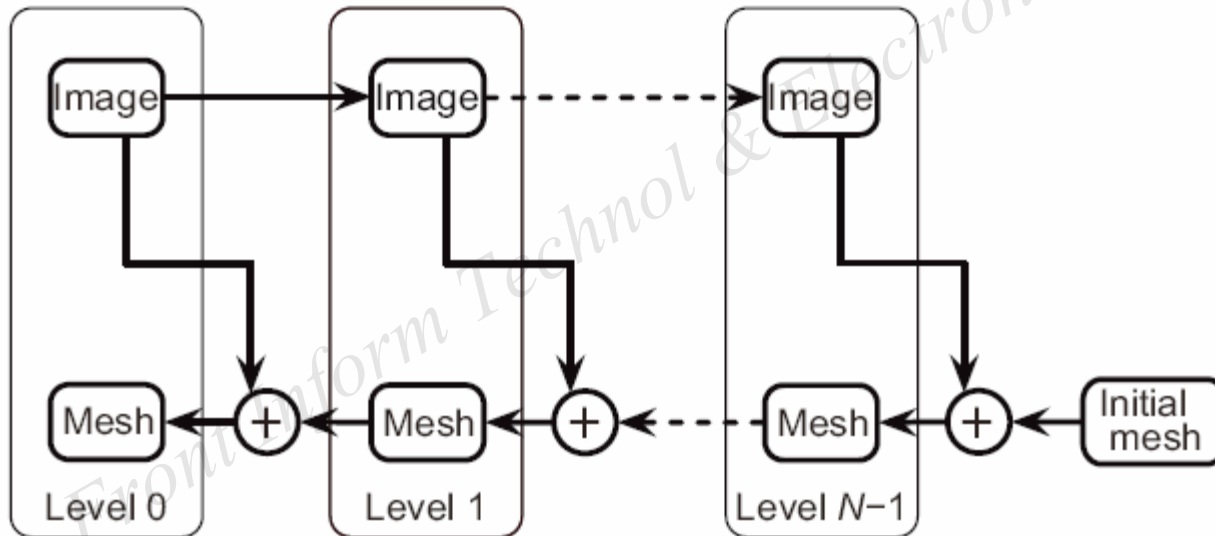
- A hierarchical process is proposed which provides an initial input for a finer level with the result of a coarser level to make the original problem smoother.
- By combining the color space and image space, a conversion from a non-convex problem to a convex one is also proposed to further reduce the complexity of problem at the stage of geometry optimization.

# Pipeline

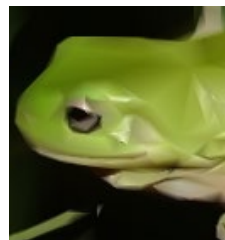
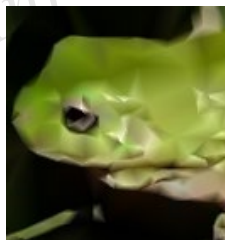
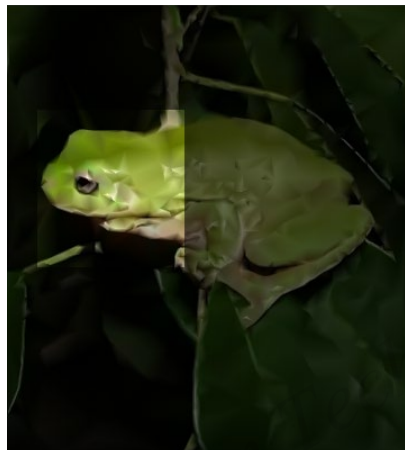
## The pipeline of our algorithm

- 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**

# Hierarchy establishment



# Experimental results (*frog*)



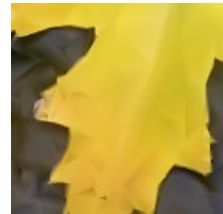
Adams (2011)

Xie *et al.* (2014)

Ours

Original image

# Experimental results (*leaf*)



Adams (2011)

Xie *et al.* (2014)

Ours

Original image

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

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

# 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.