Parameterization-Aware MIP-Mapping

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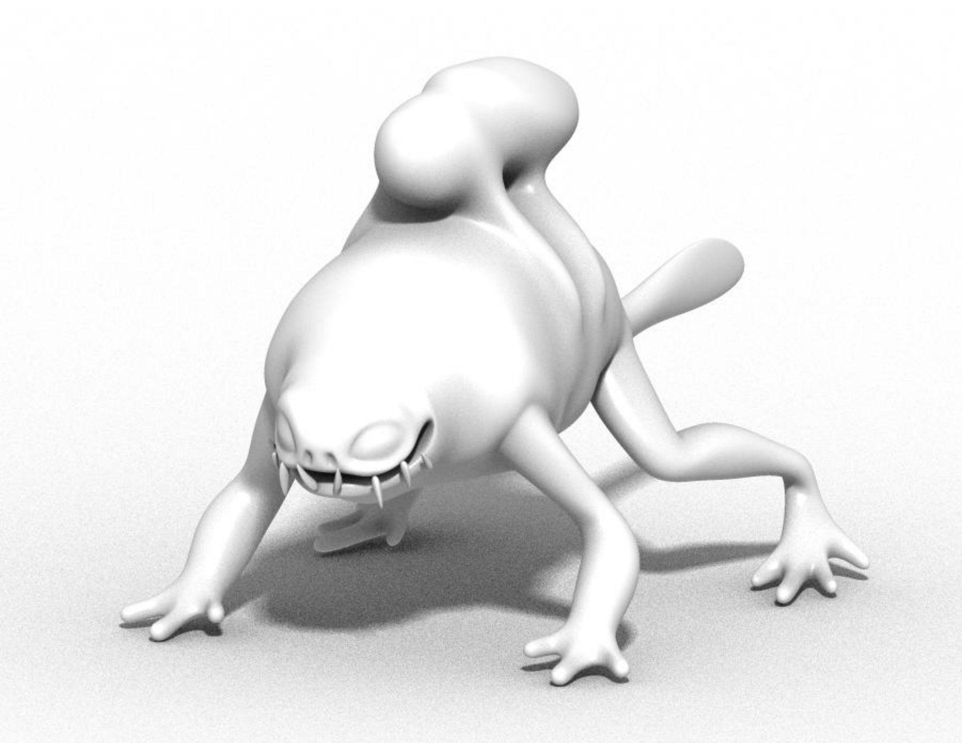
Texas A&M University

Texture Parameterization



Texture Parameterization

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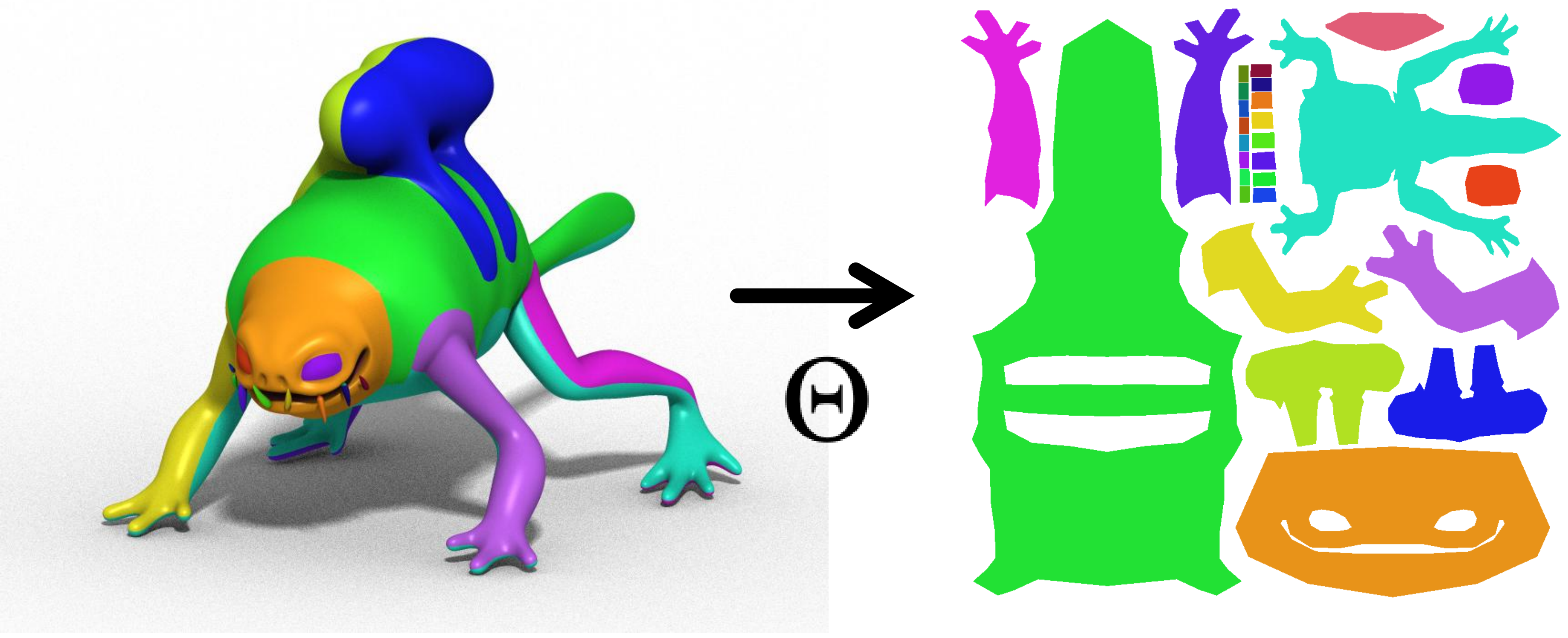
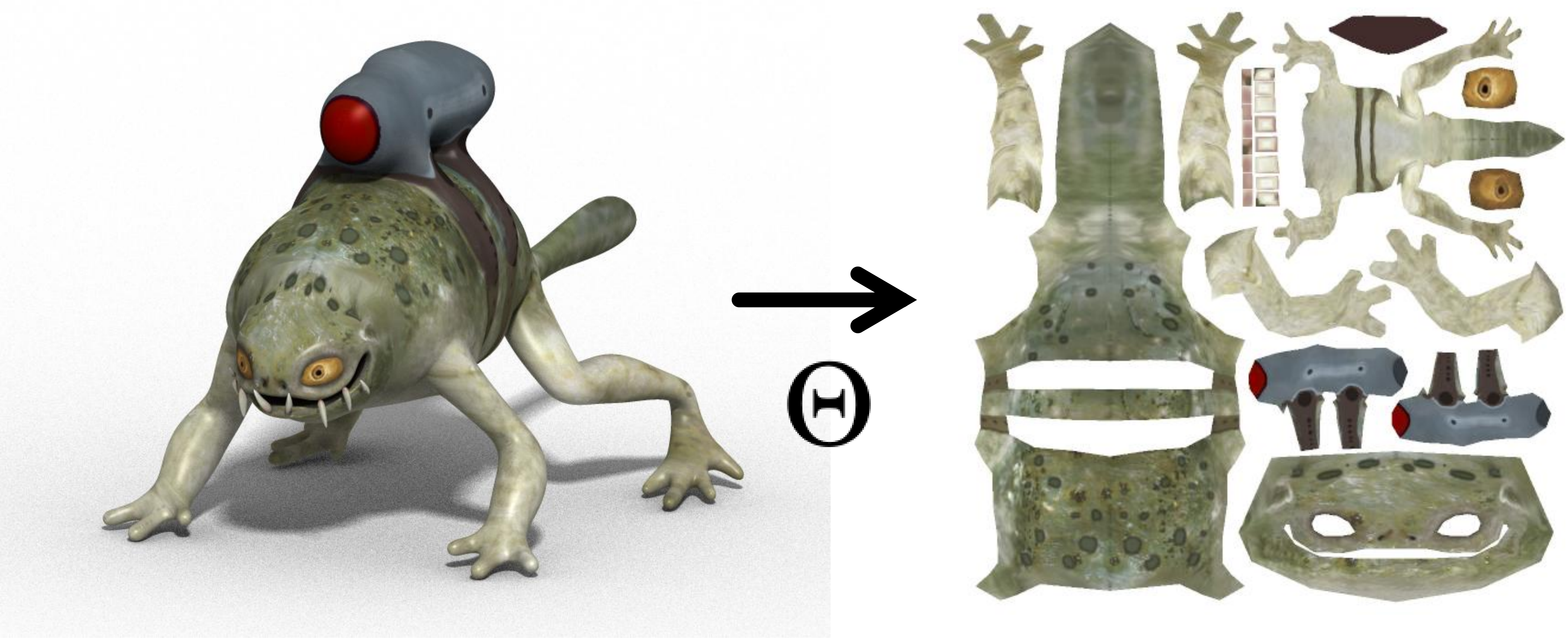


Texture Parameterization



MIP-Mapping

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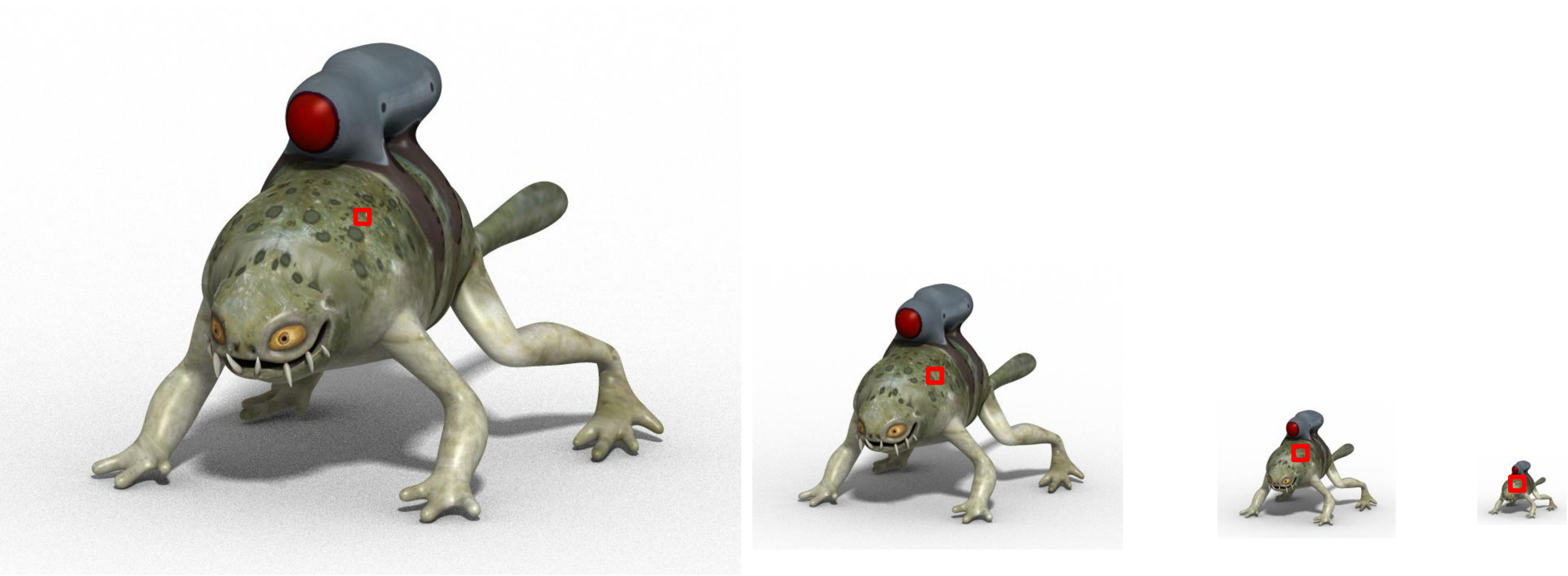
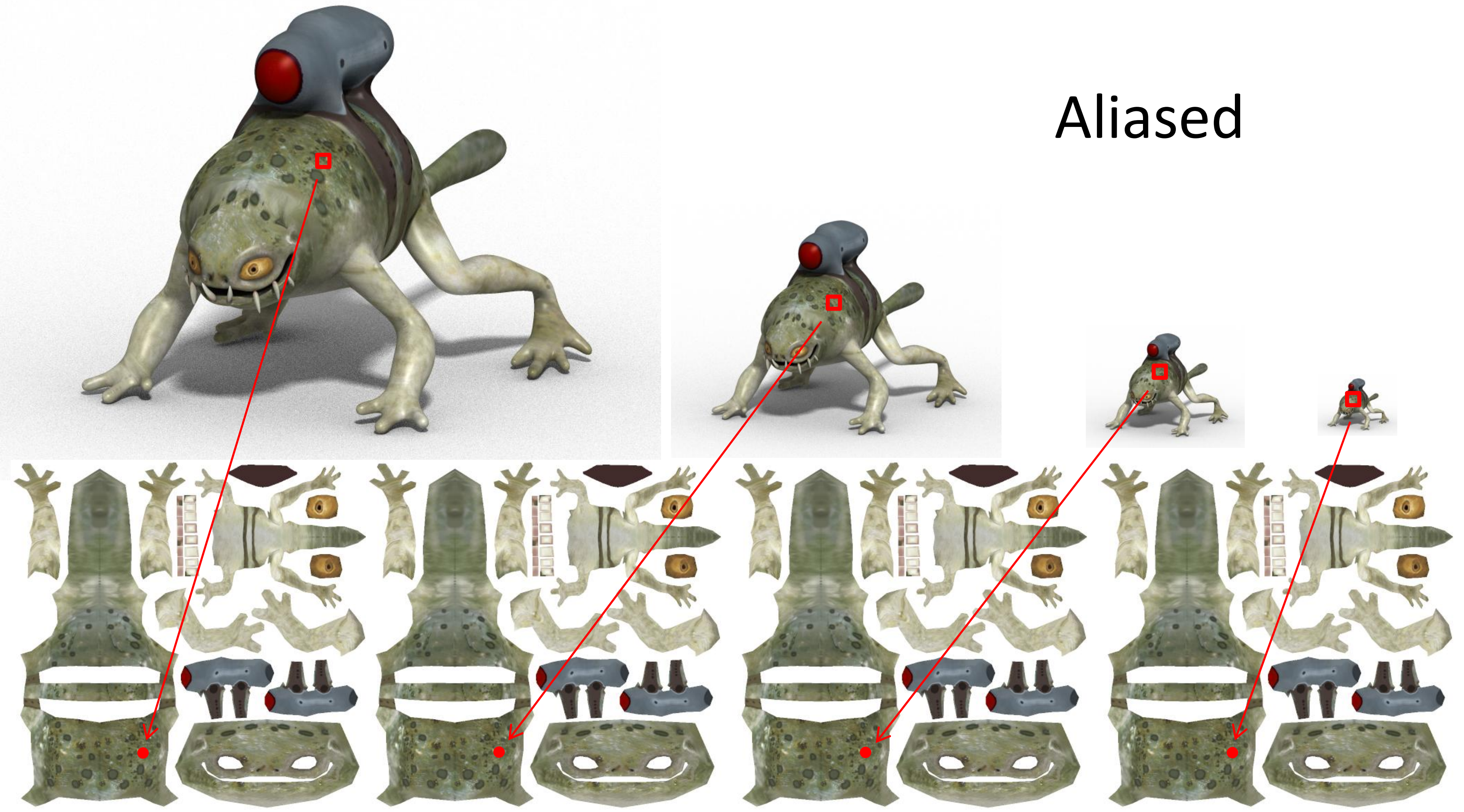
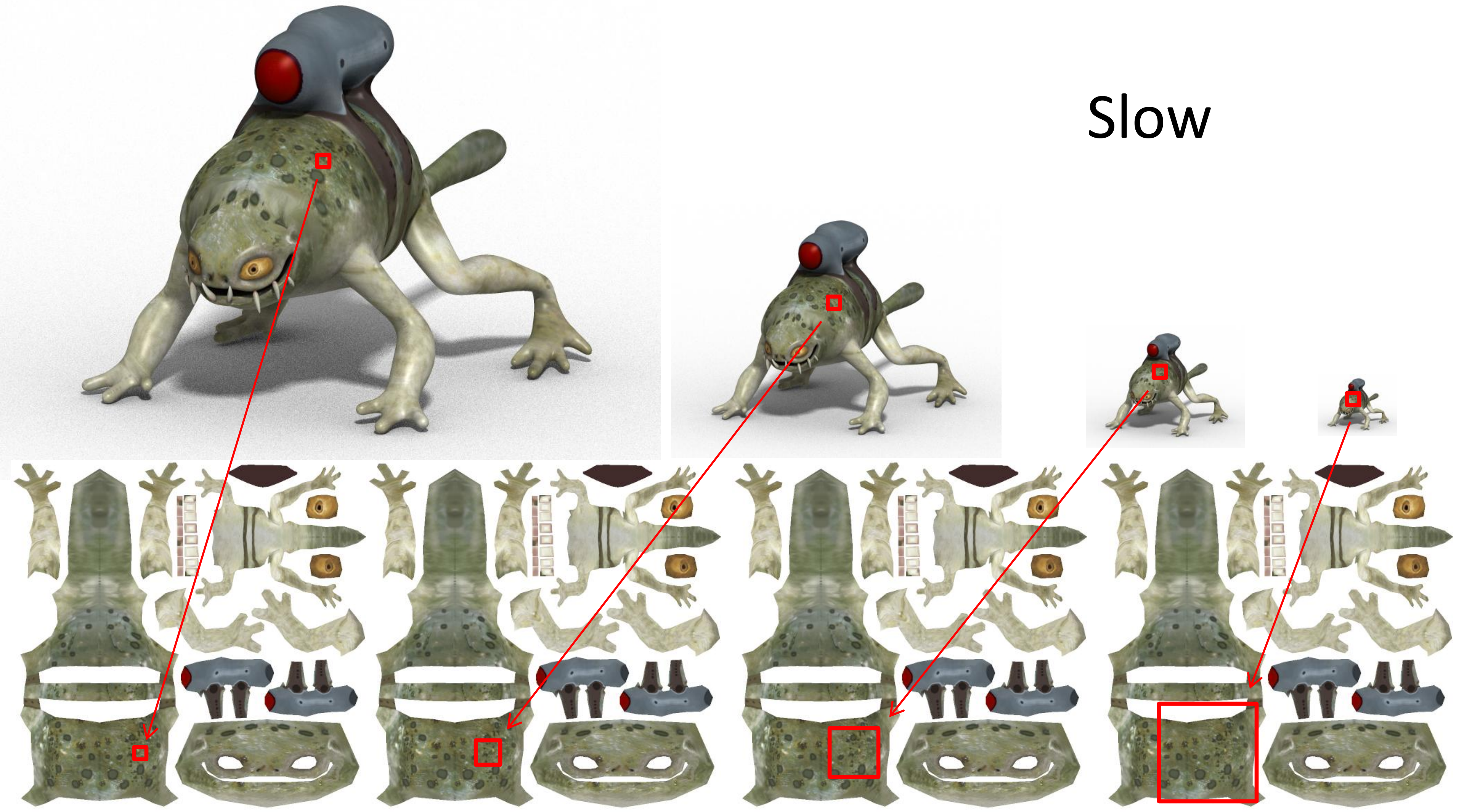


MIP-Mapping



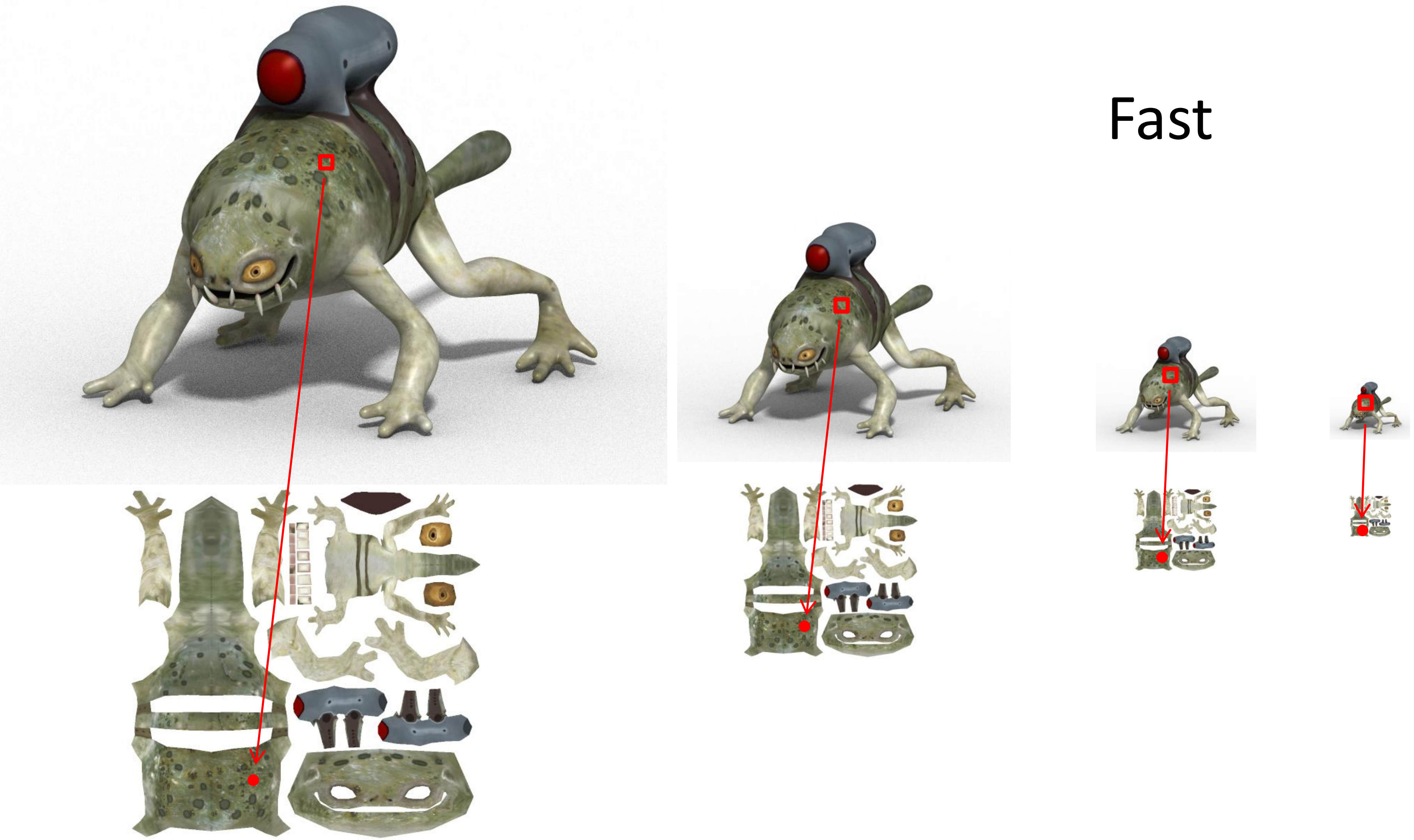
MIP-Mapping

Slow

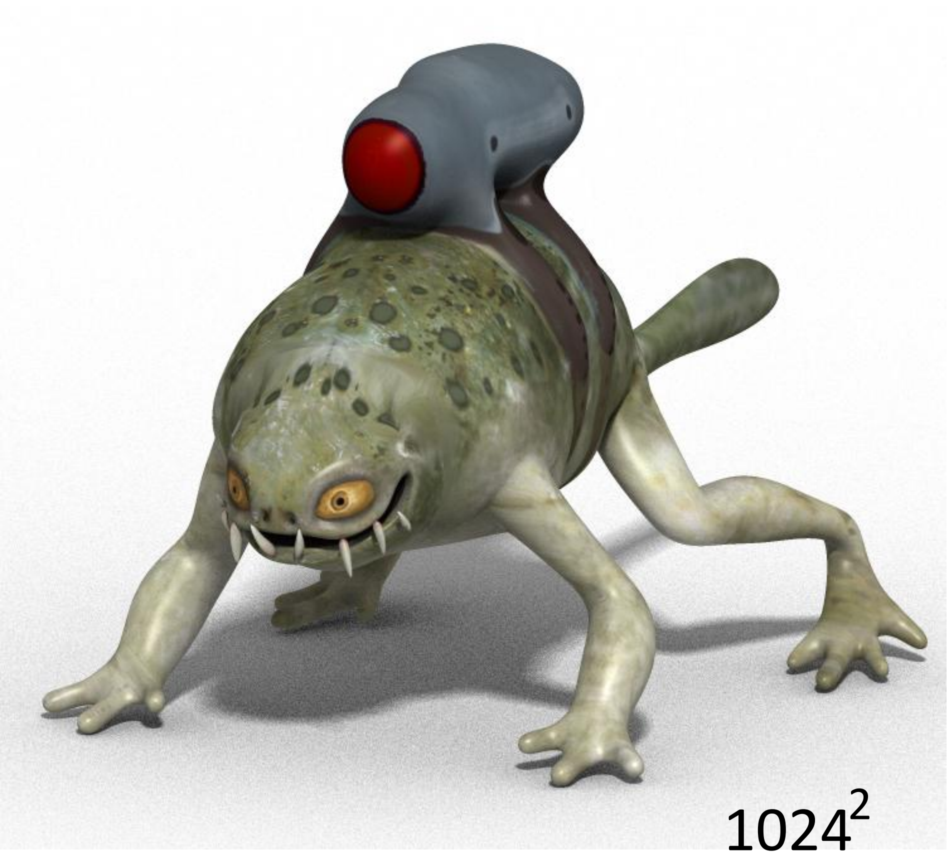


MIP-Mapping

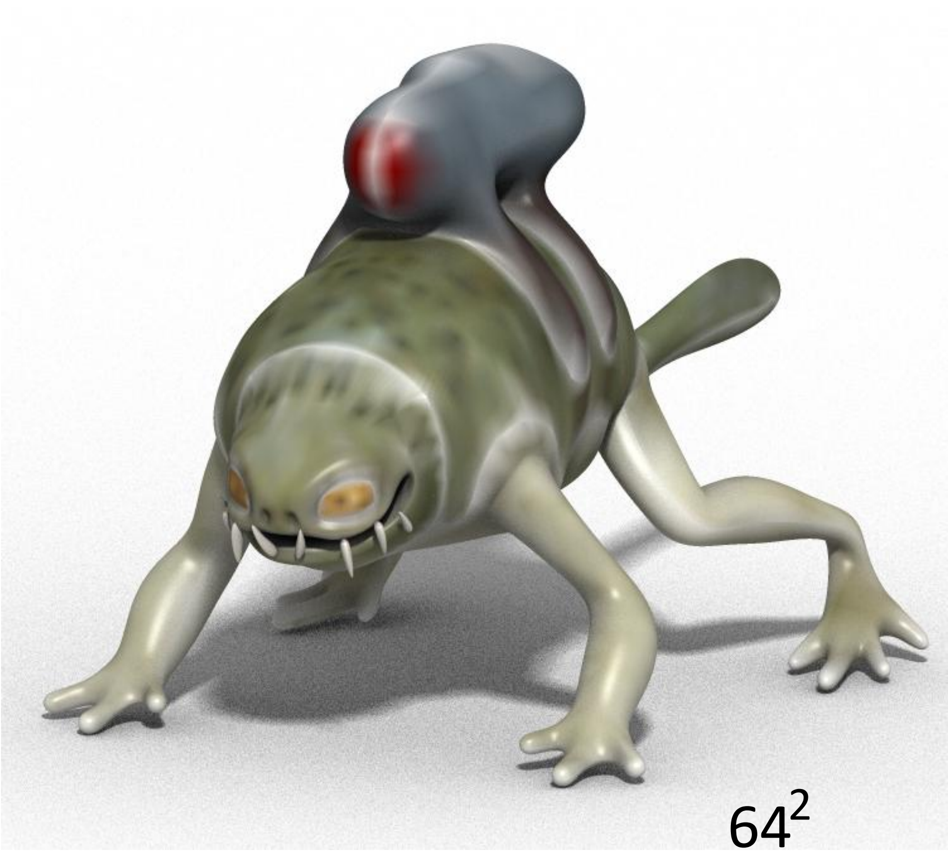
Fast



Filtering

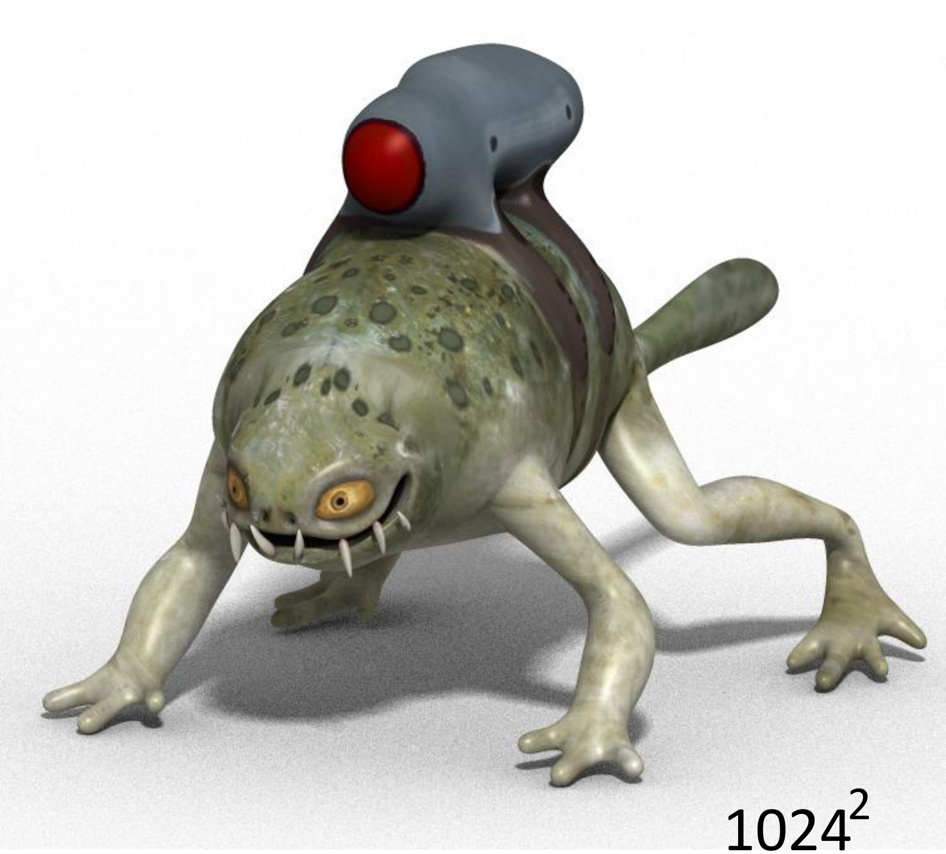


Original

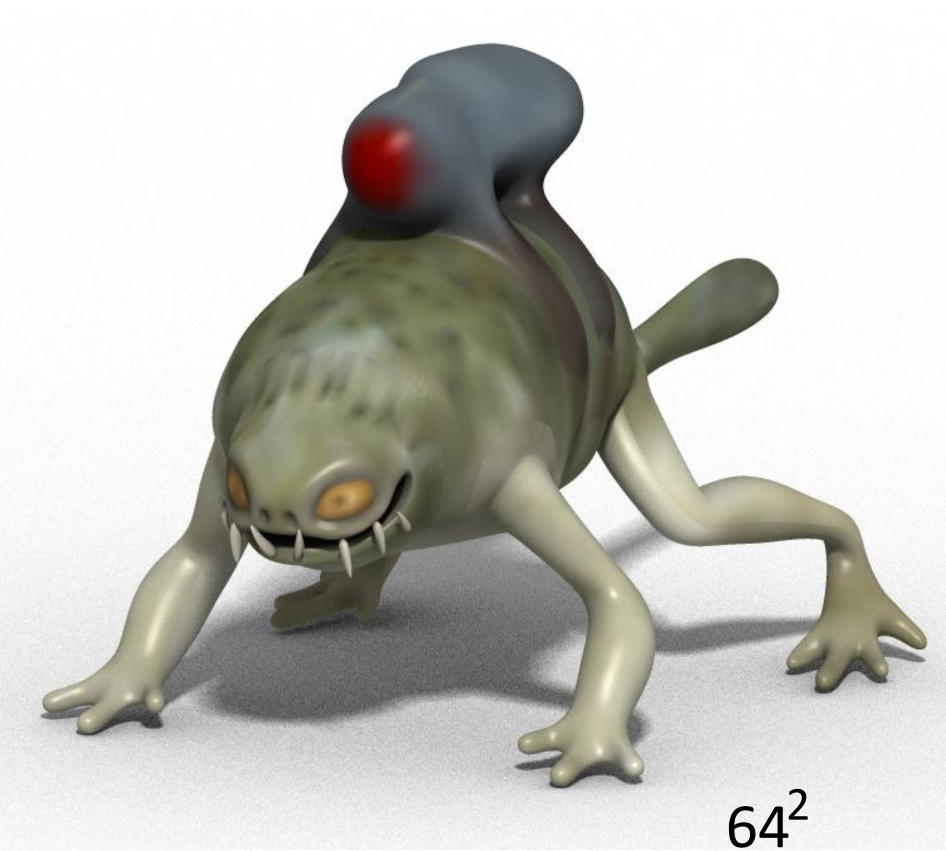


Box

Filtering

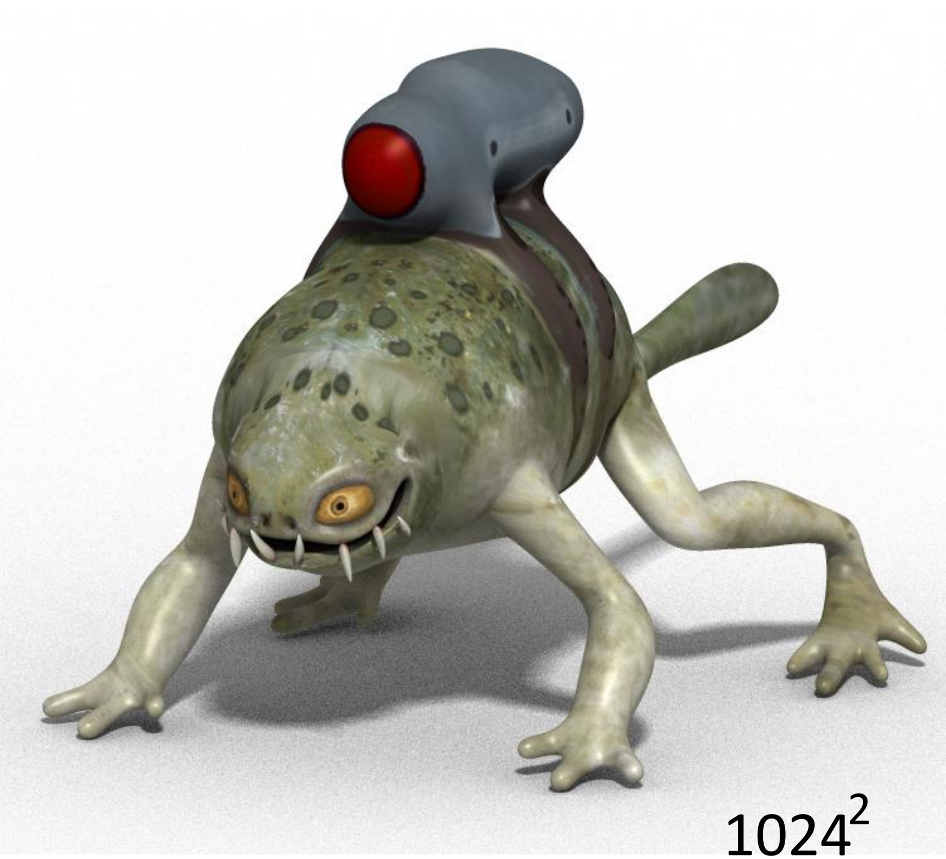


Original

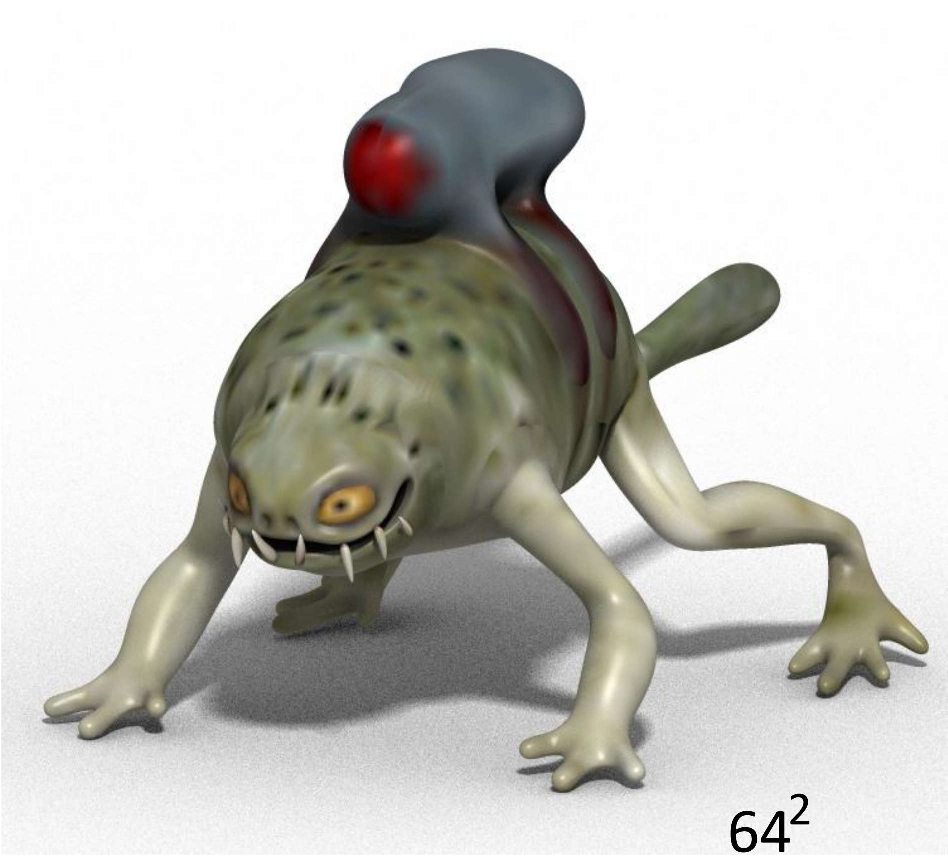


Box Ignore

Filtering



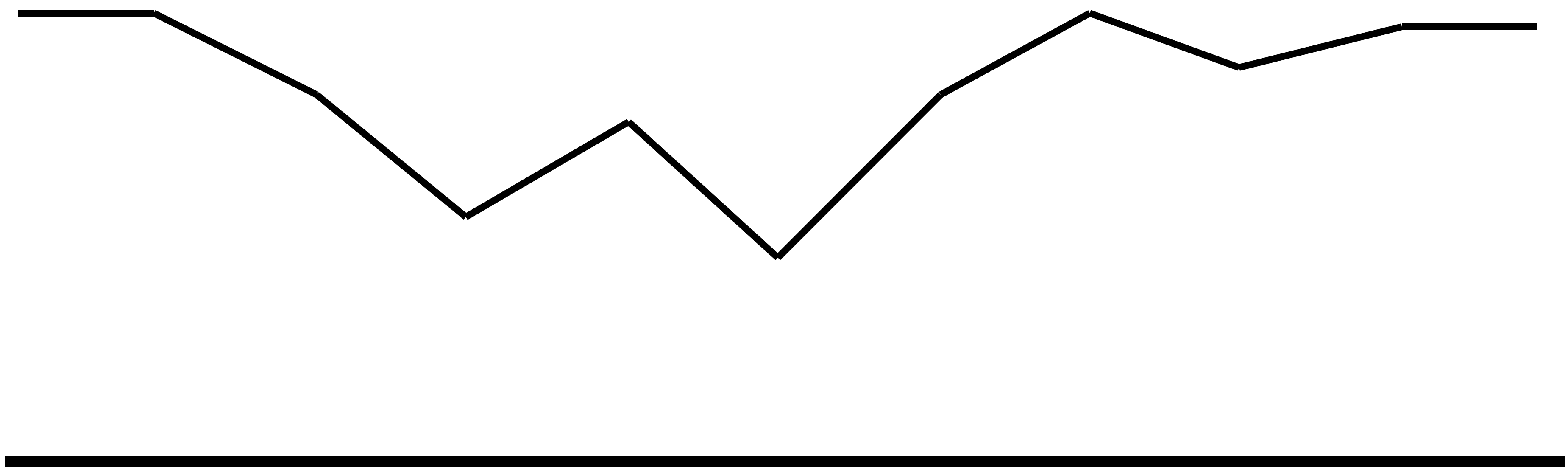
Original



PAM Bilinear

Parameterization-Aware Filtering

$$c_h = \iint_{\mathbb{R}^2} h(u,v) \sum_i \hat{c}_i \hat{b}_i(u,v)\, du\, dv$$



Parameterization-Aware Filtering

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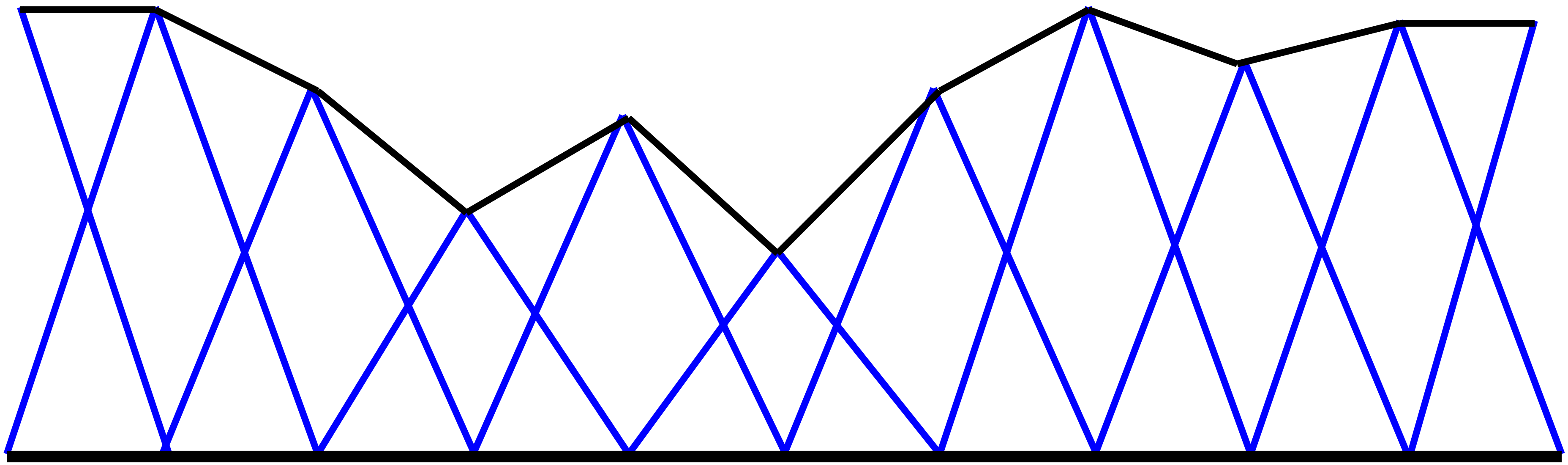
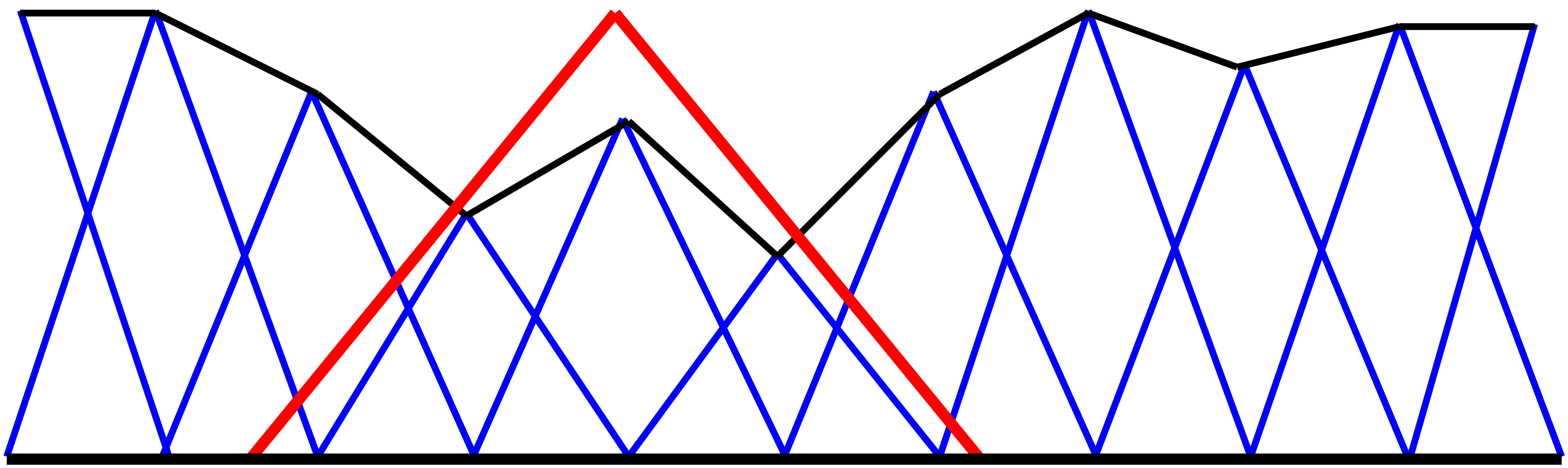


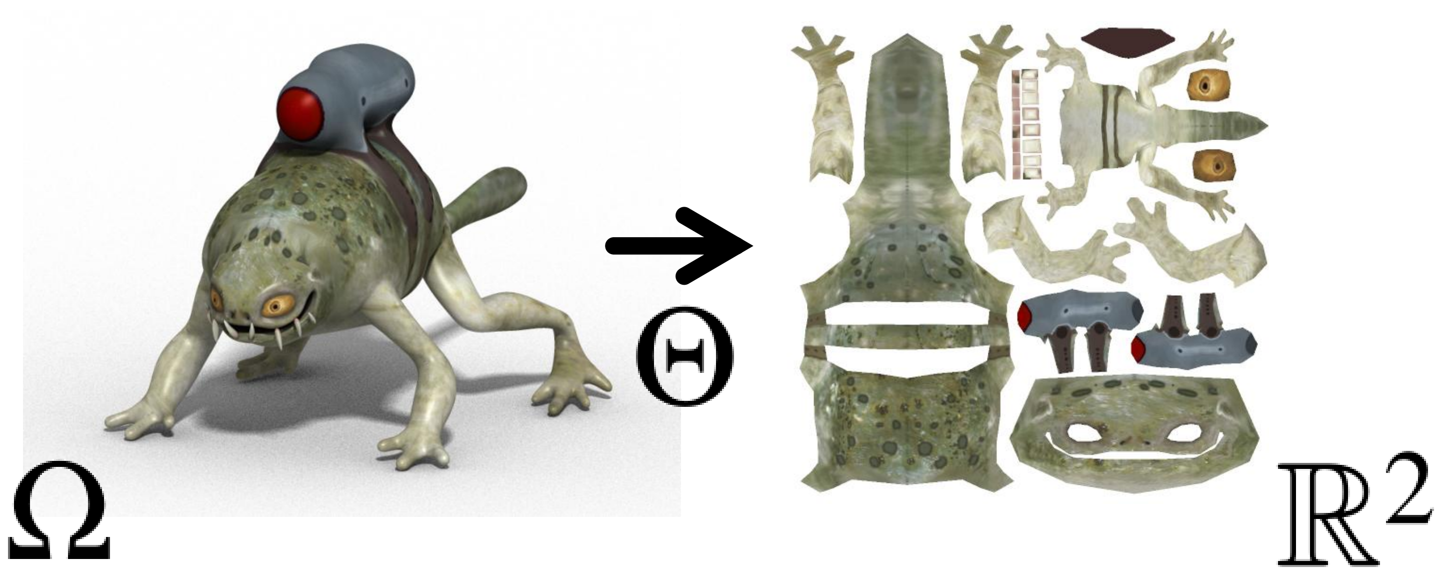
Parameterization-Aware Filtering

$$c_h = \iint_{\mathbb{R}^2} h(u,v) \sum_i \hat{c}_i \hat{b}_i(u,v)\, du\, dv$$



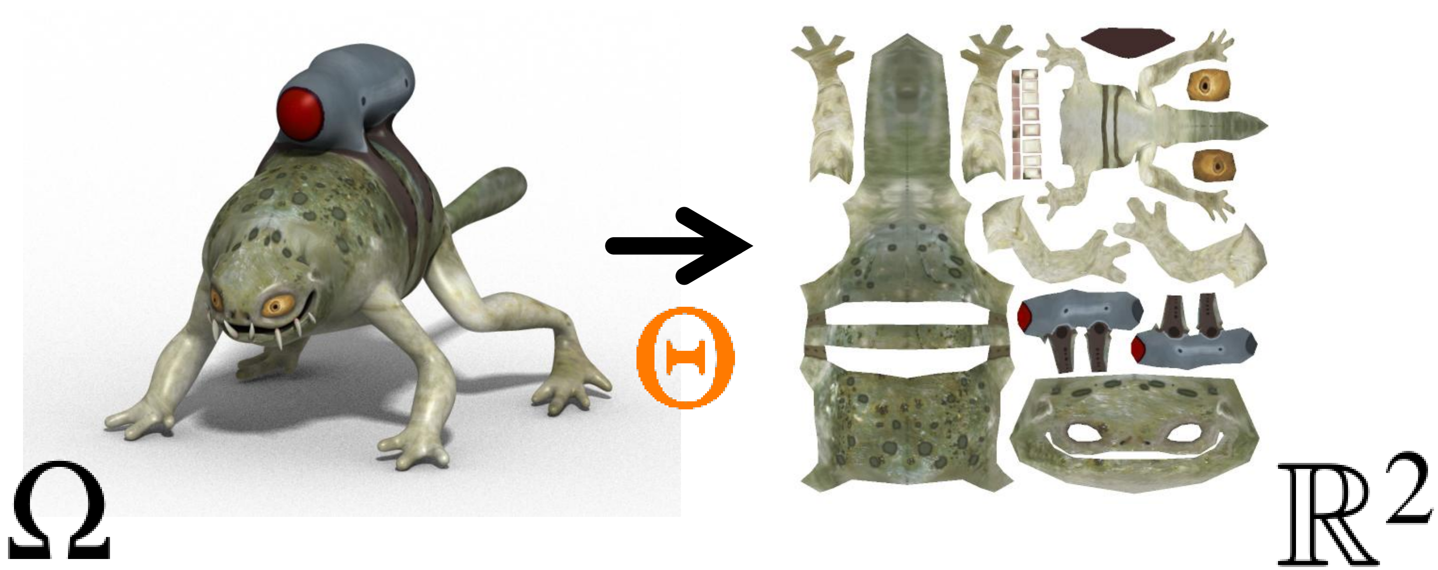
Parameterization-Aware Filtering

$$c_h = \iint_\Omega h(\Theta(p)) \sum_i \hat{c}_i \hat{b}_i(\Theta(p))\, dp$$



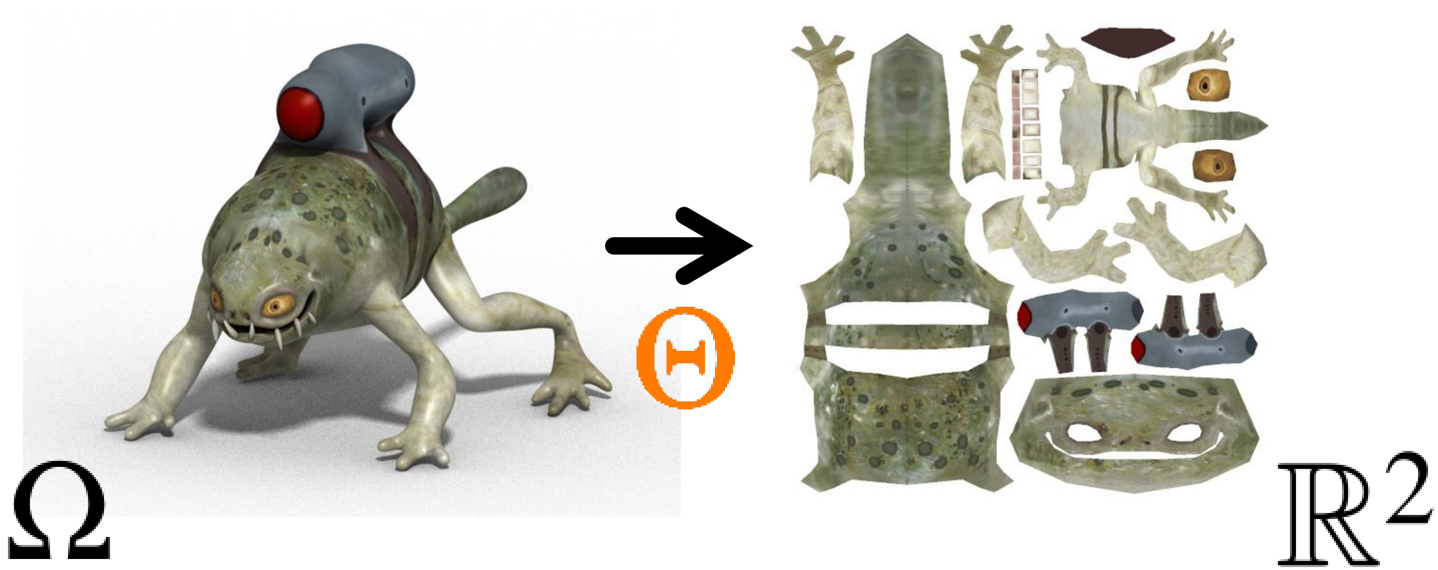
Parameterization-Aware Filtering

$$c_h = \iint_{\Omega} h(\Theta(p)) \sum_i \hat{c}_i \hat{b}_i(\Theta(p))\, dp$$

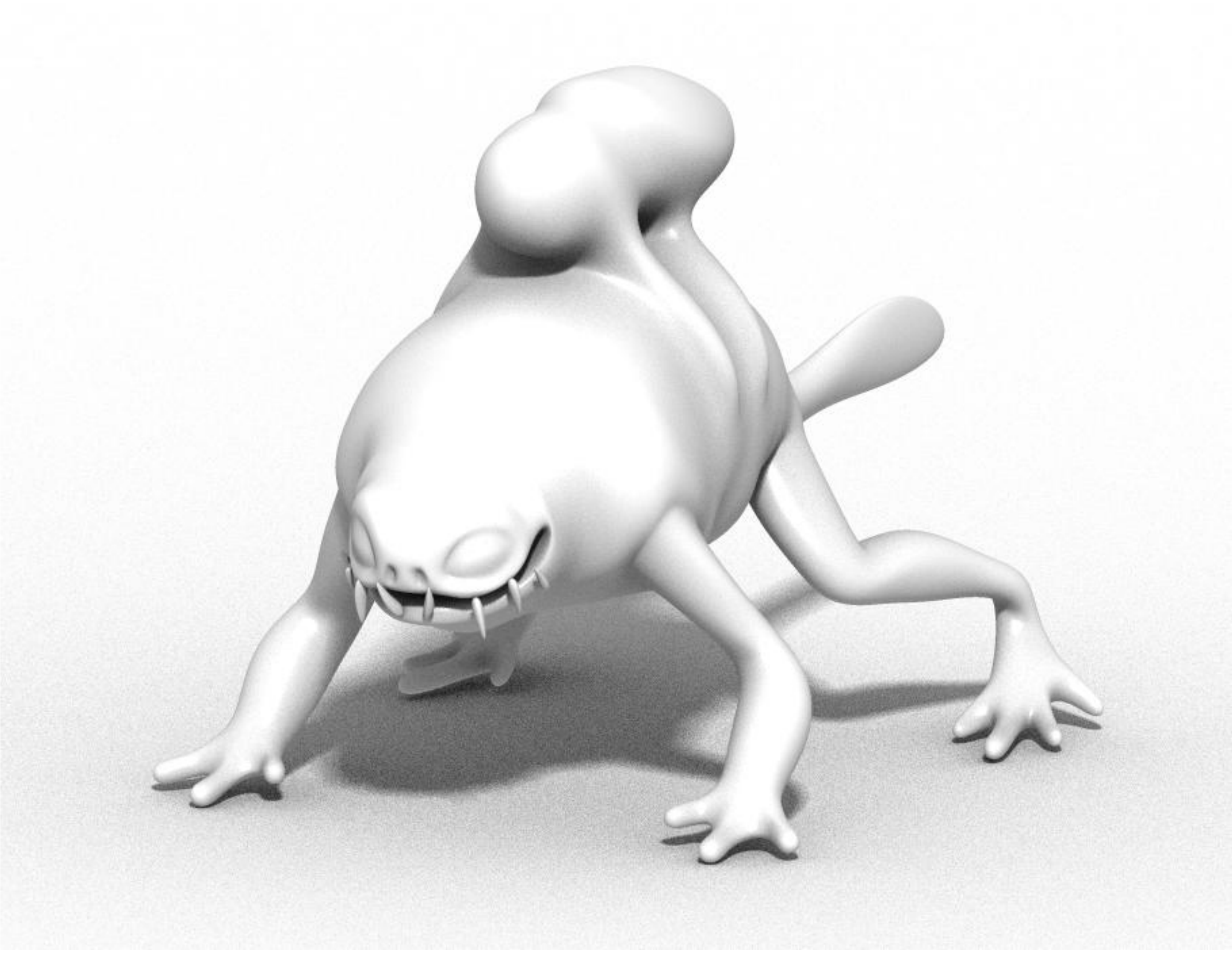


Parameterization-Aware Filtering

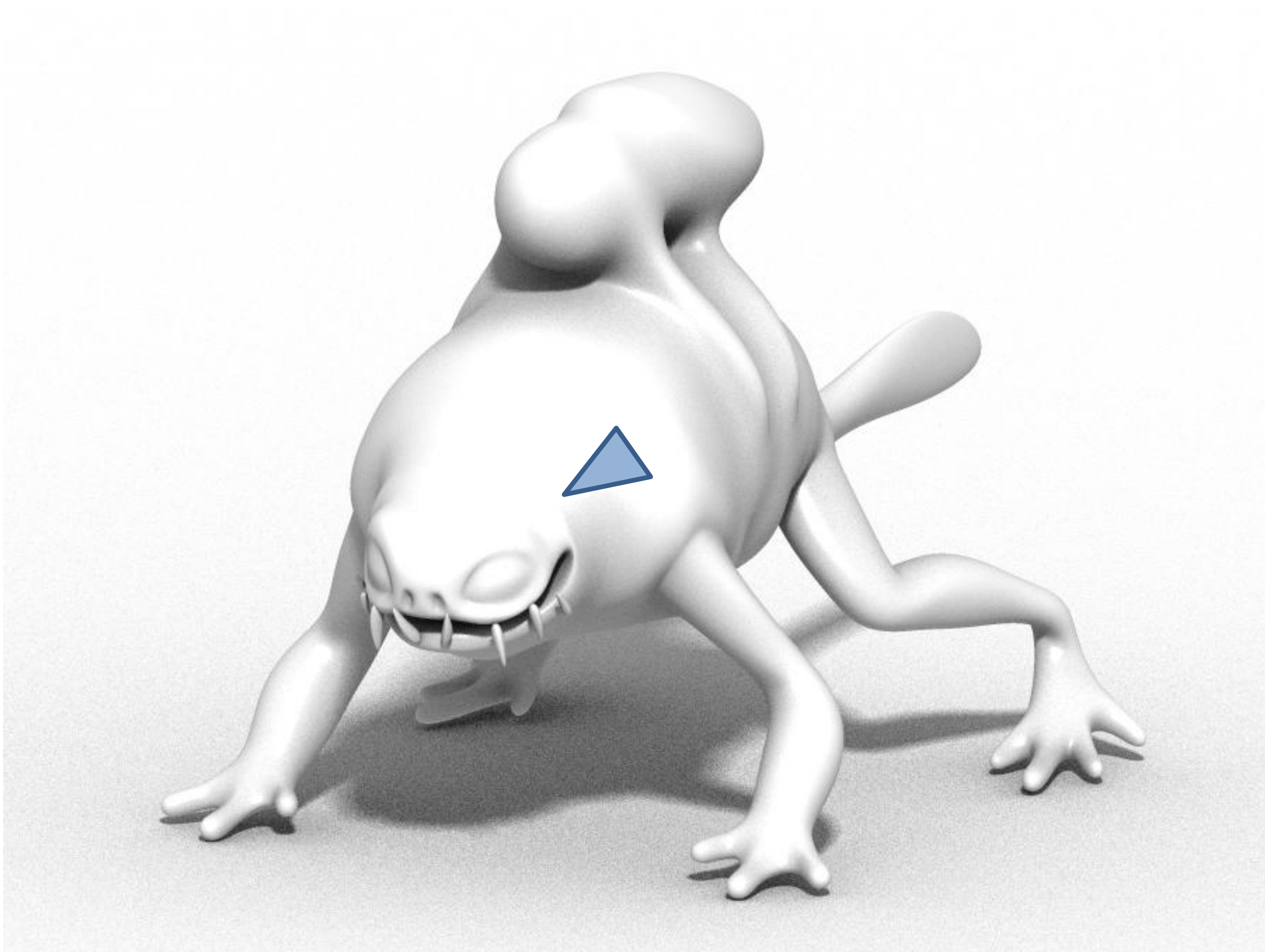
$$c_h = \frac{\iint_\Omega h(\Theta(p)) \sum_i \hat{c}_i \hat{b}_i(\Theta(p))\, dp}{\iint_\Omega h(\Theta(p))\, dp}$$



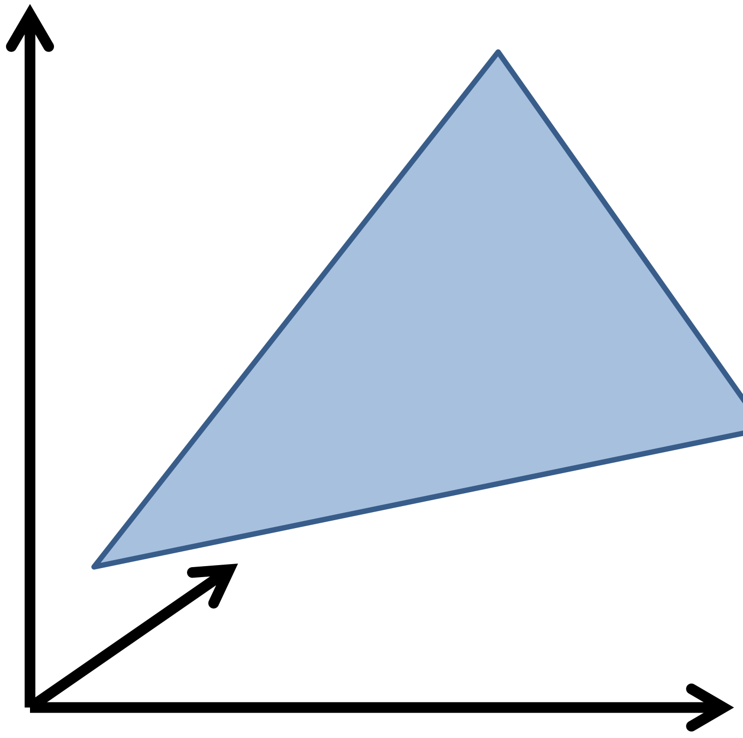
Implementation



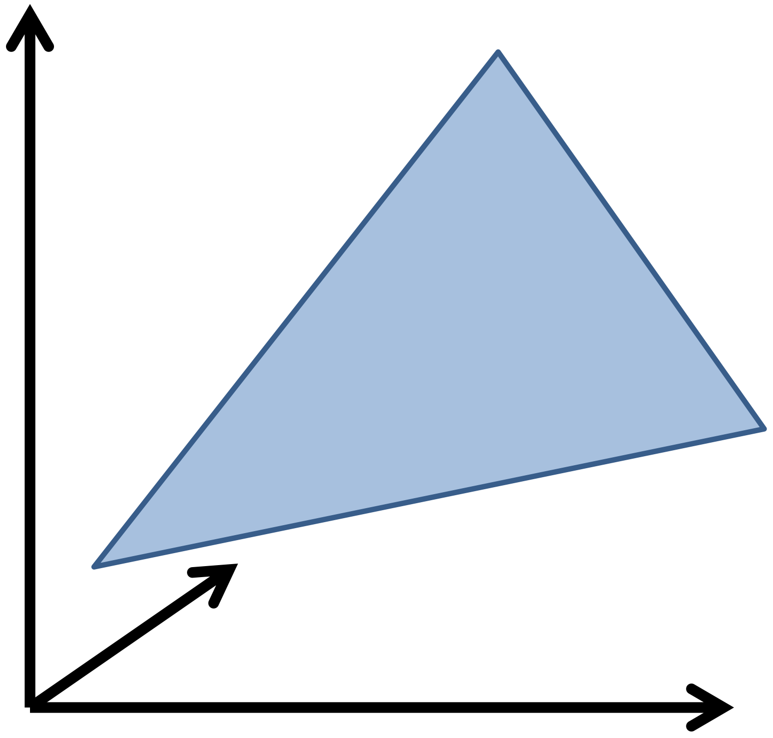
Implementation

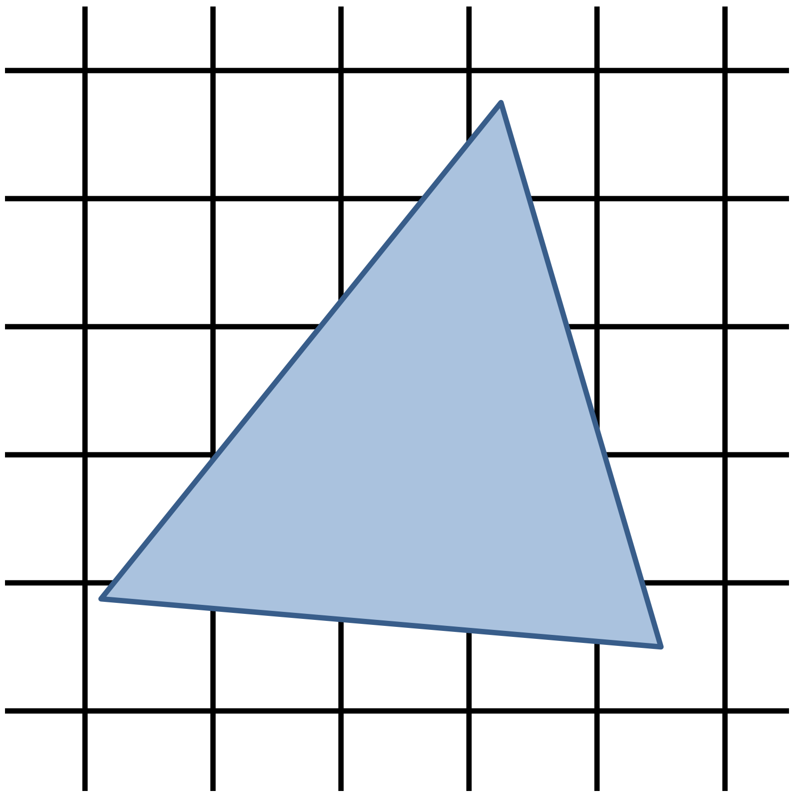


Implementation

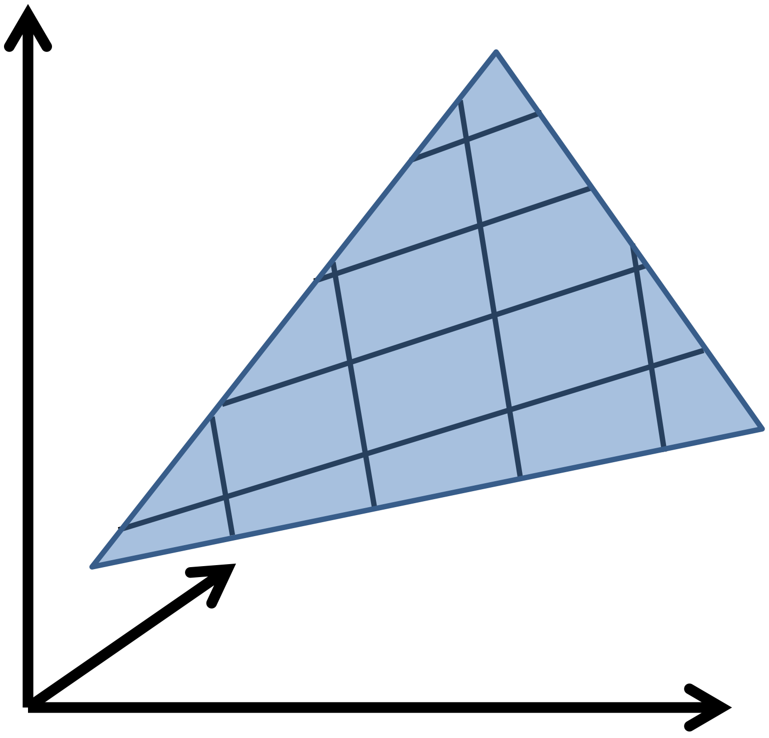


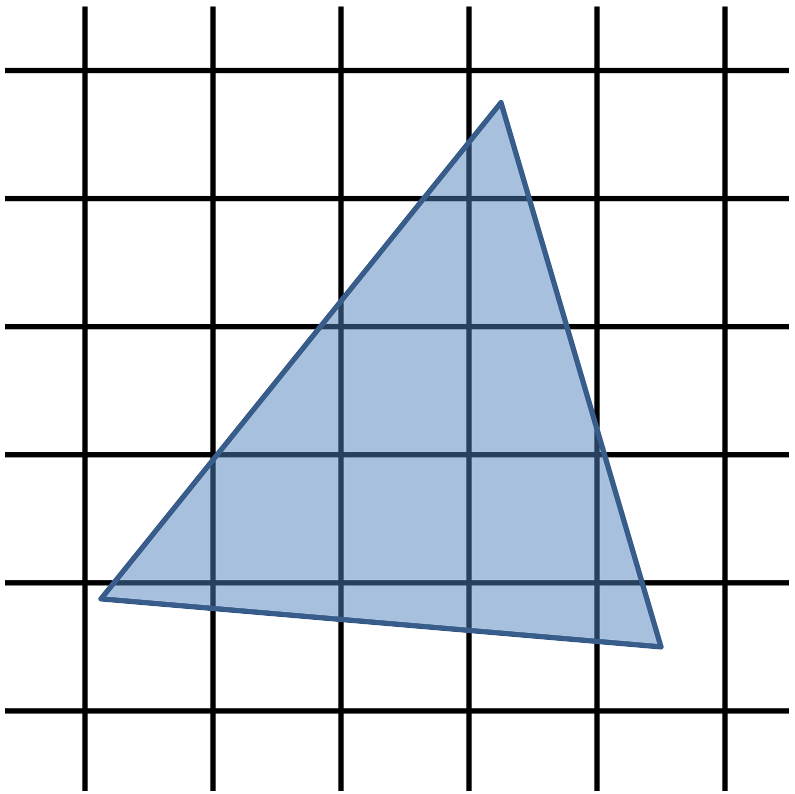
Implementation



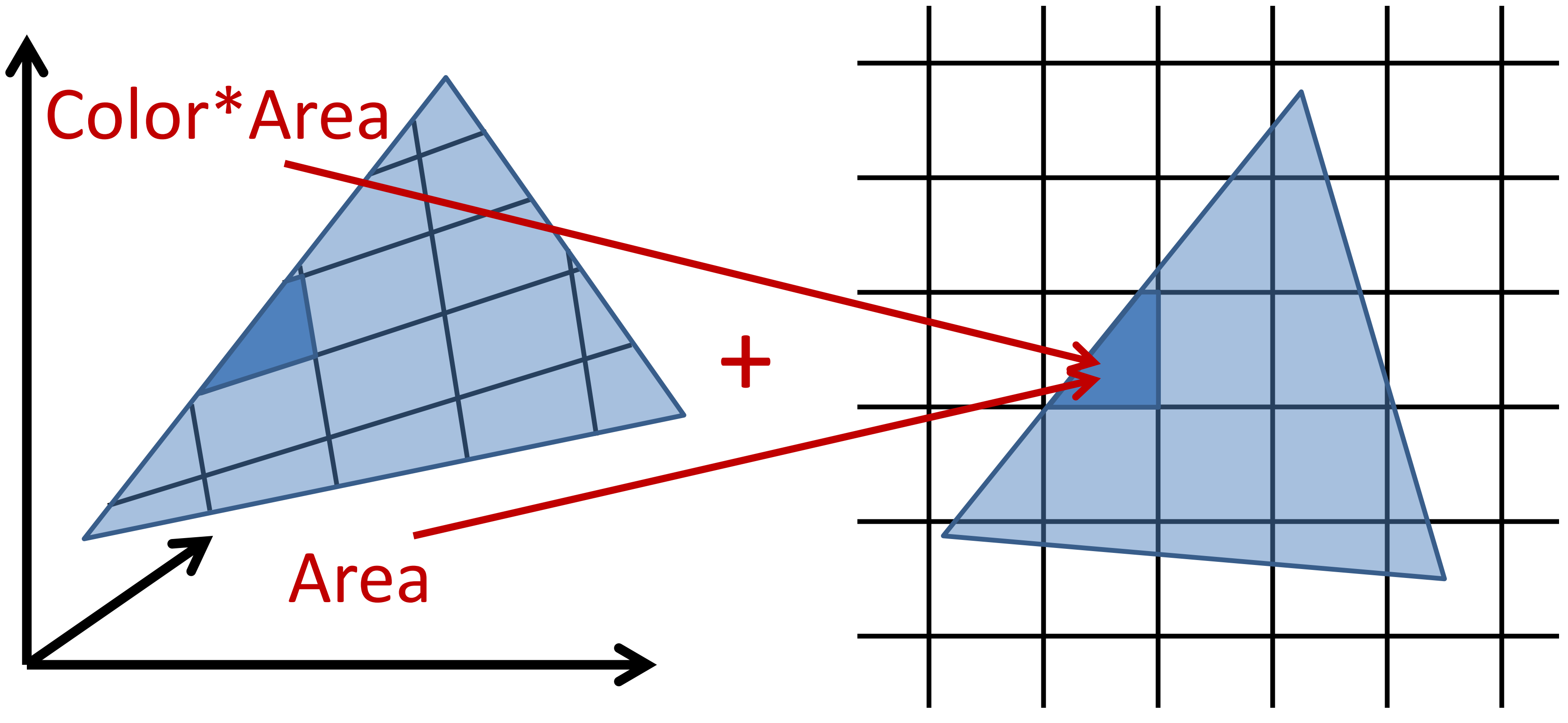


Implementation

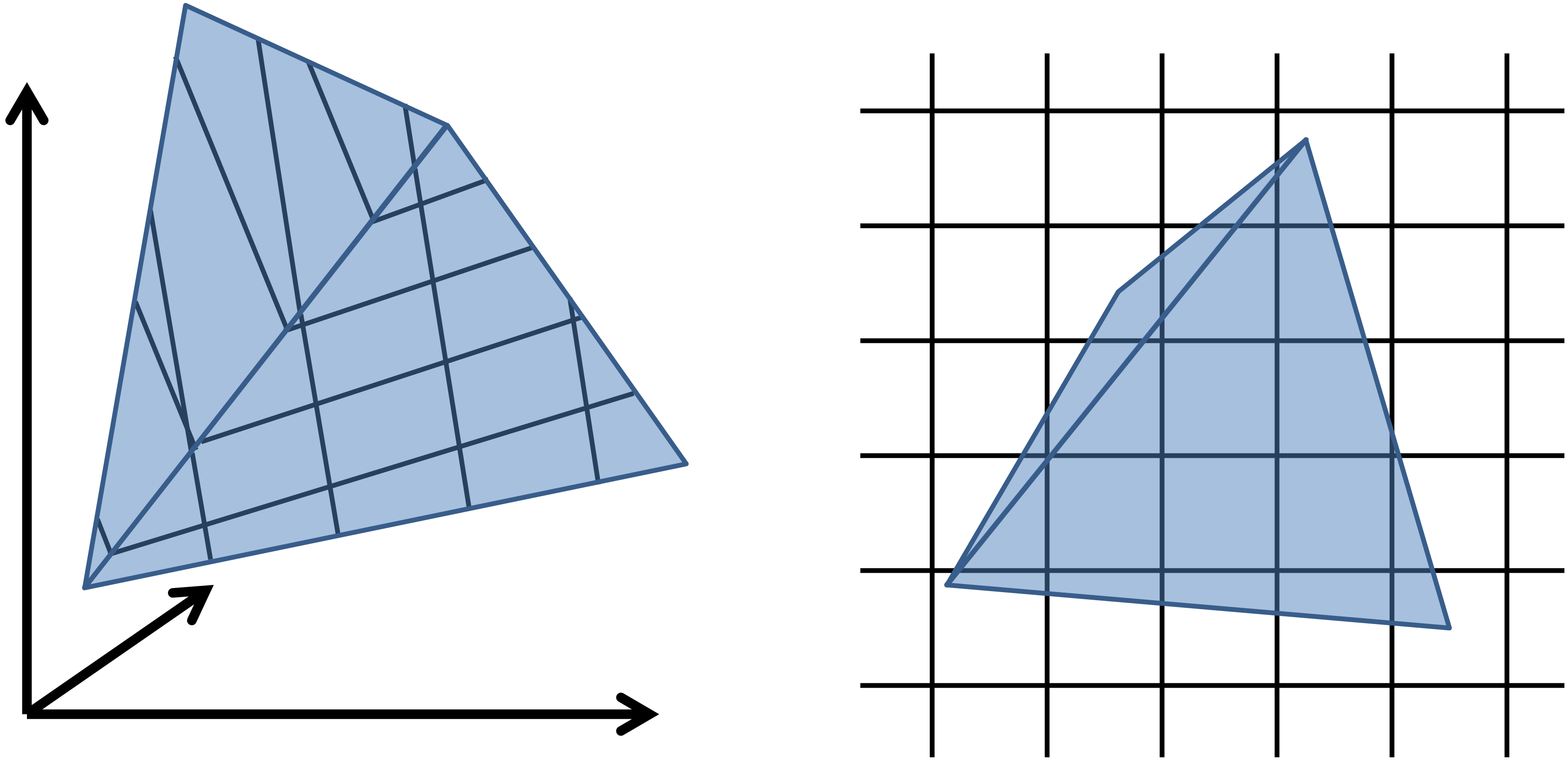




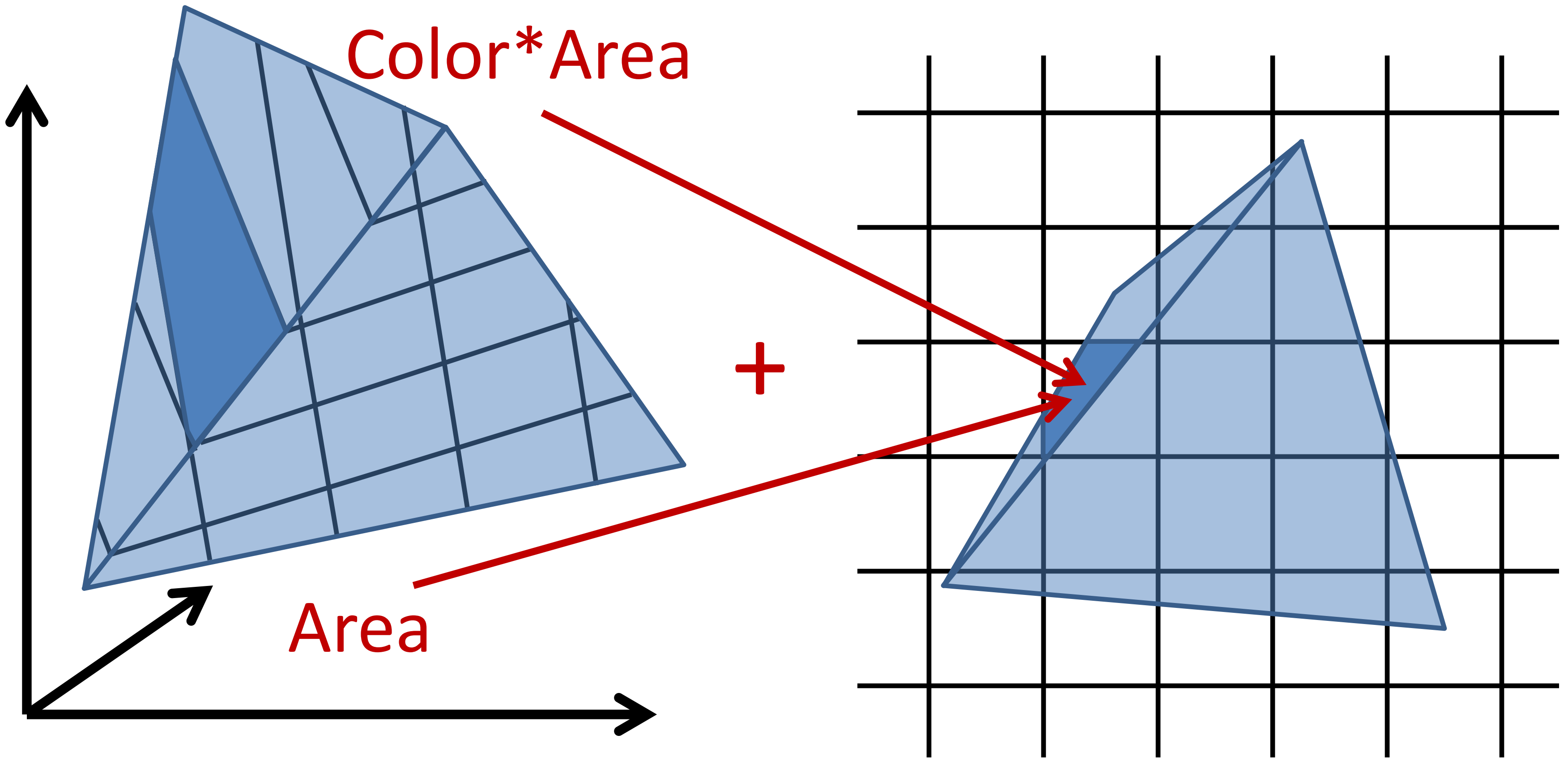
Implementation



Implementation

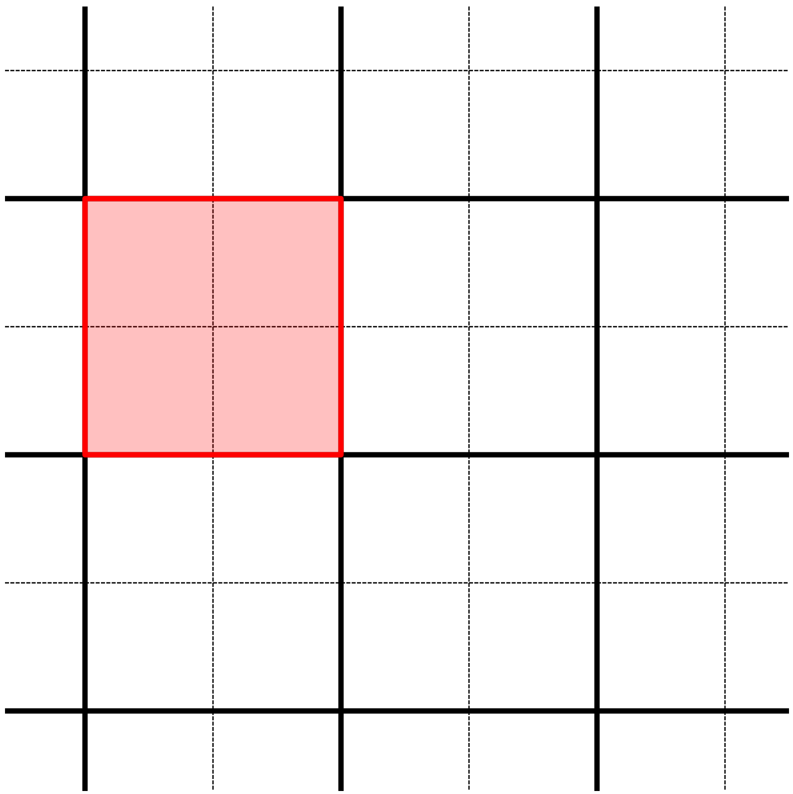


Implementation



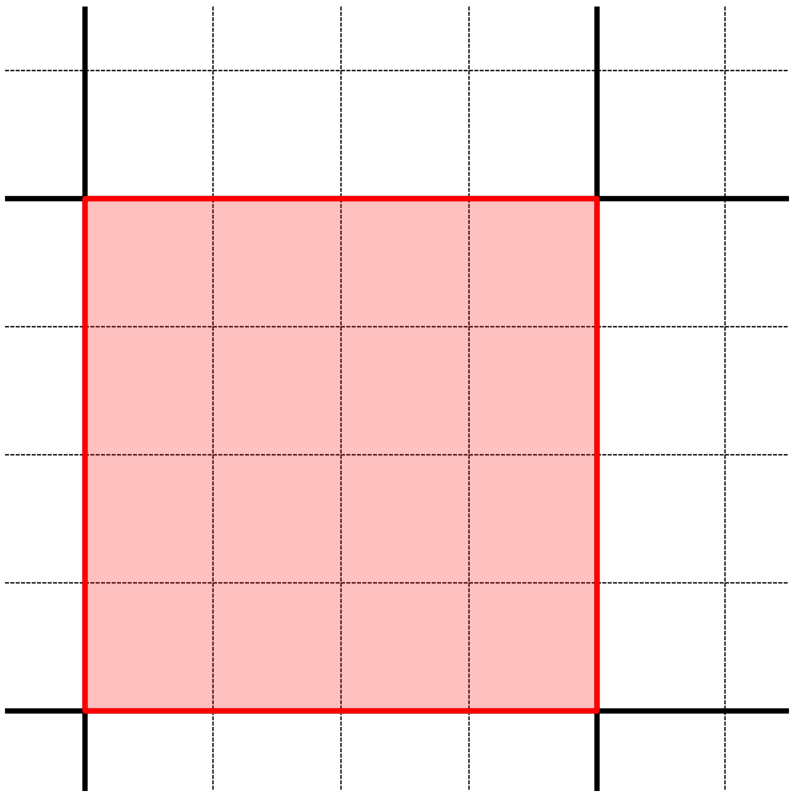
Implementation

$$\frac{\sum \text{Color} * \text{Area}}{\sum \text{Area}}$$

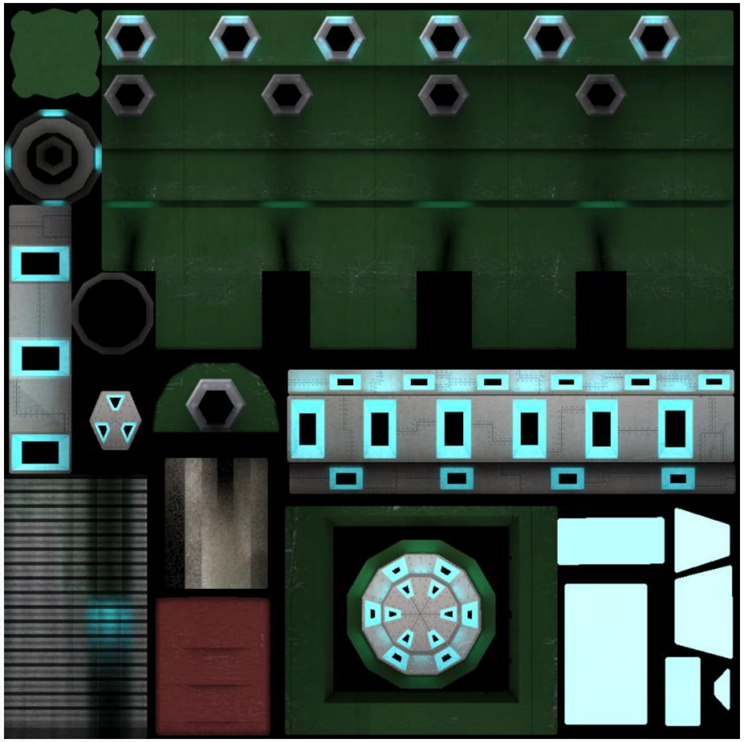


Implementation

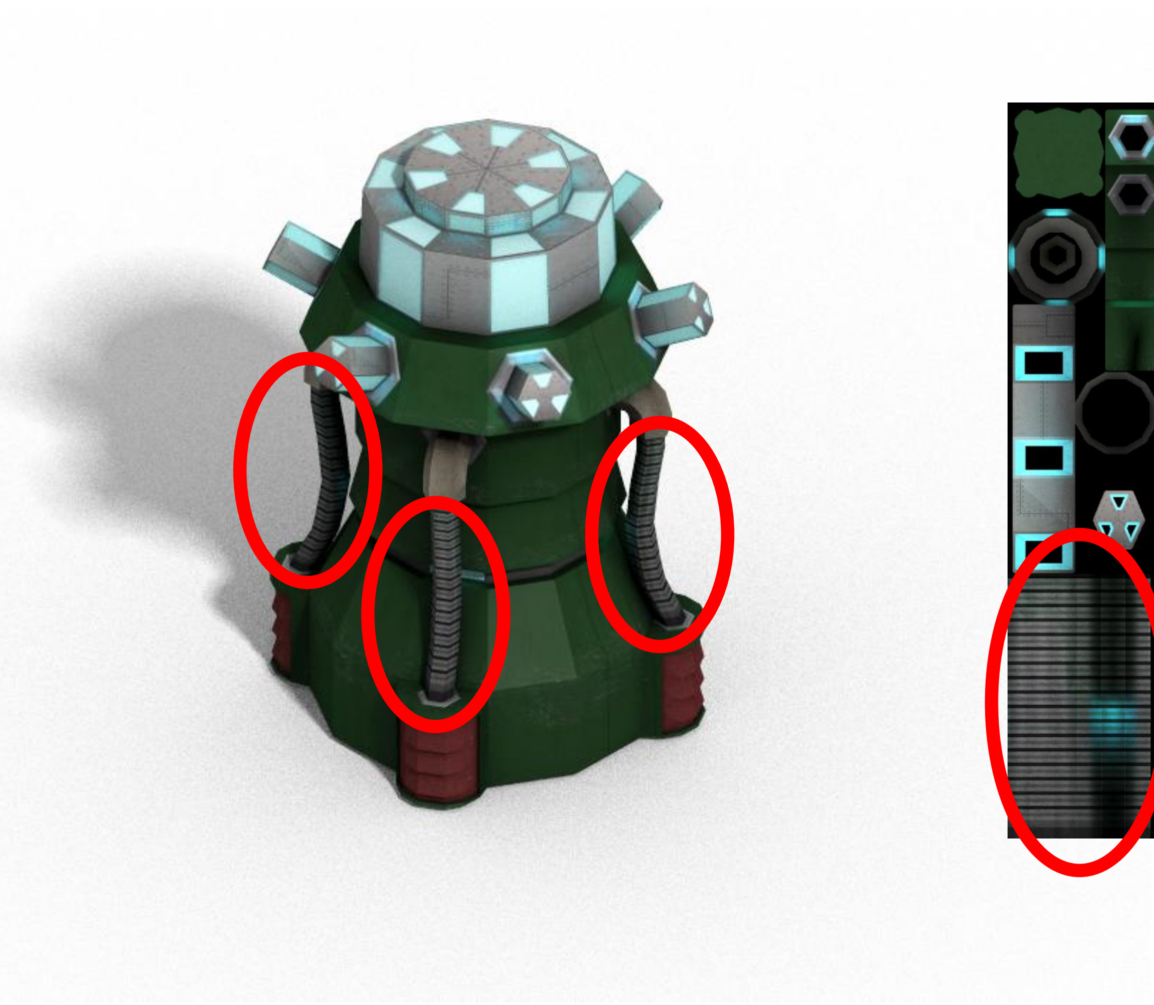
$$\frac{\sum \text{Color*Area}}{\sum \text{Area}}$$

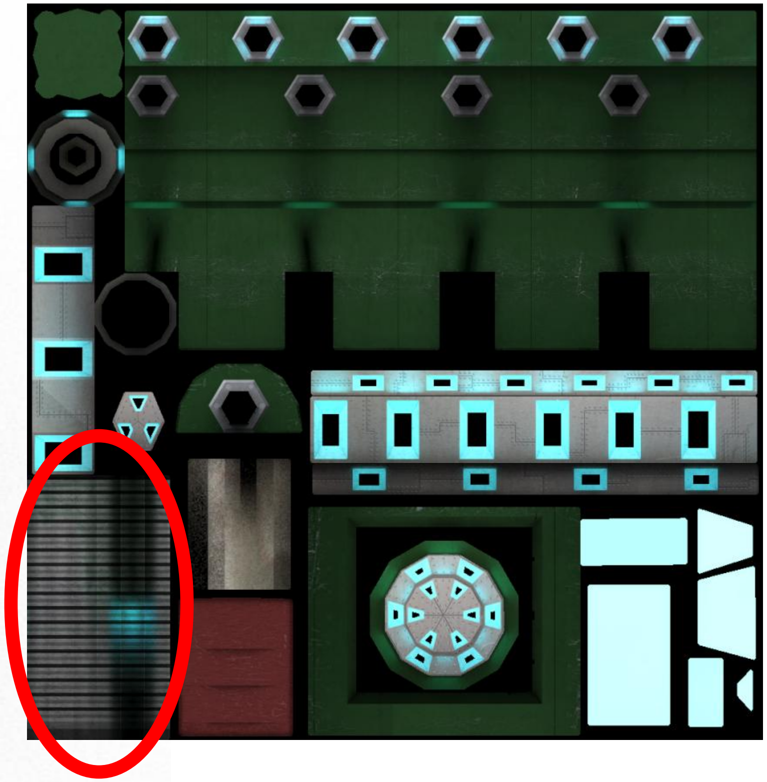


Example

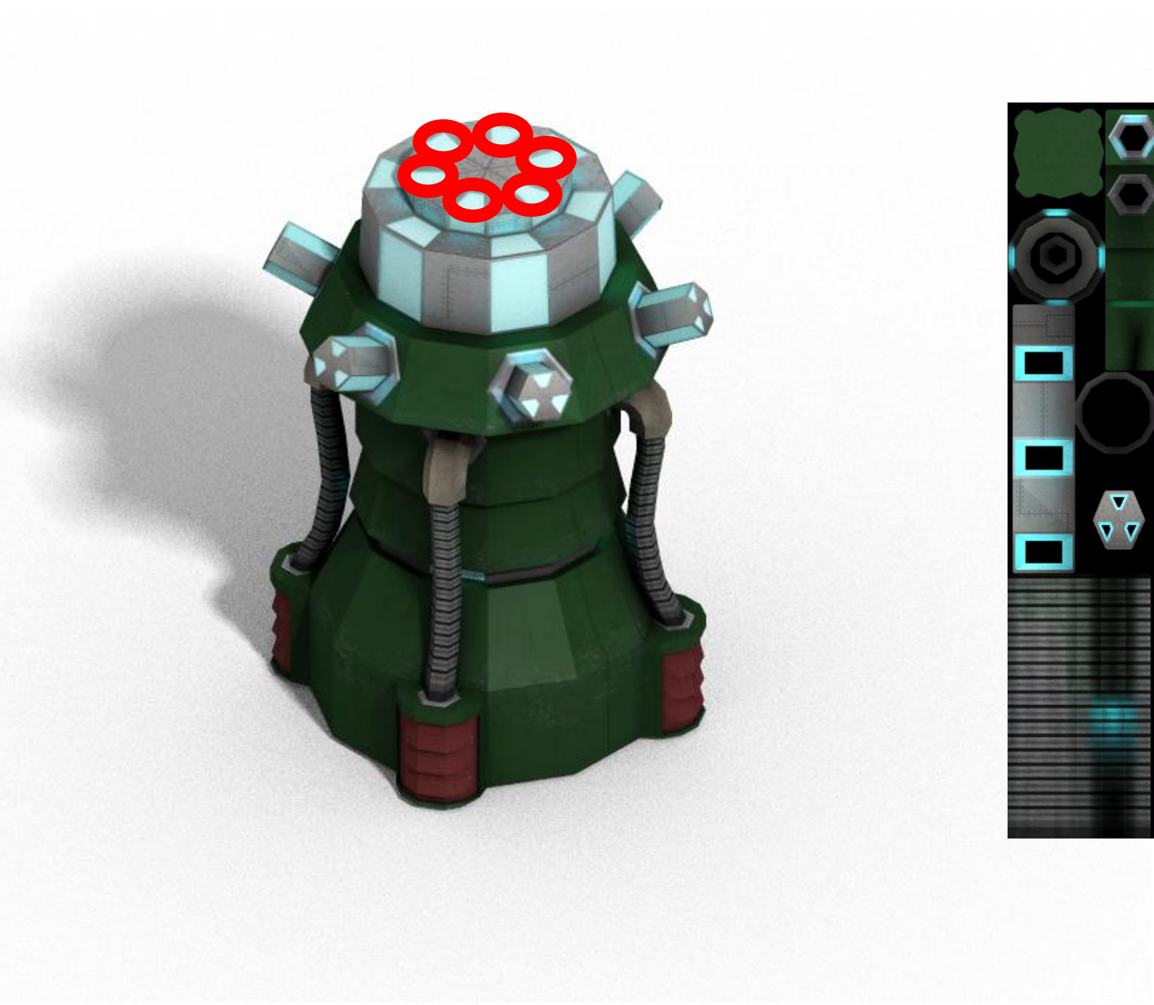


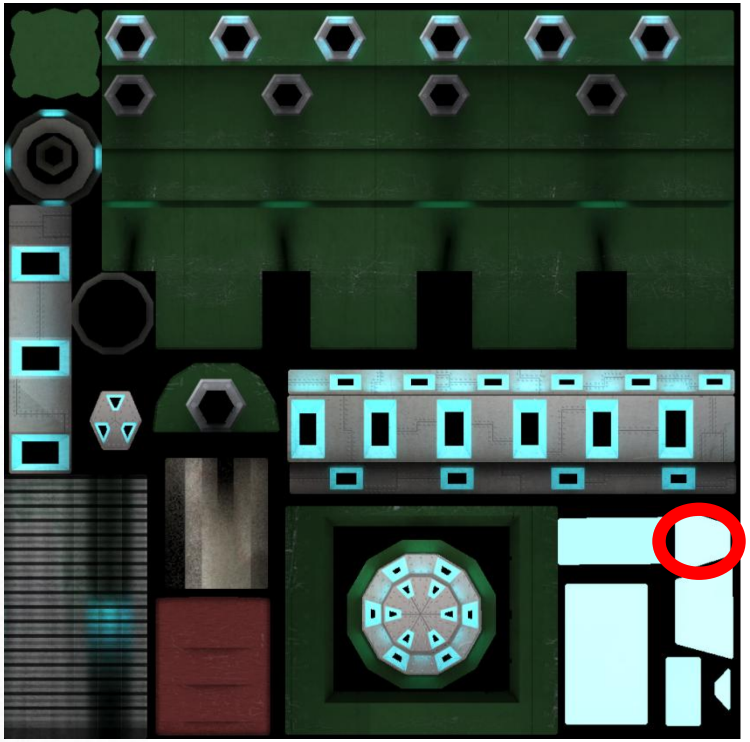
Example





Example





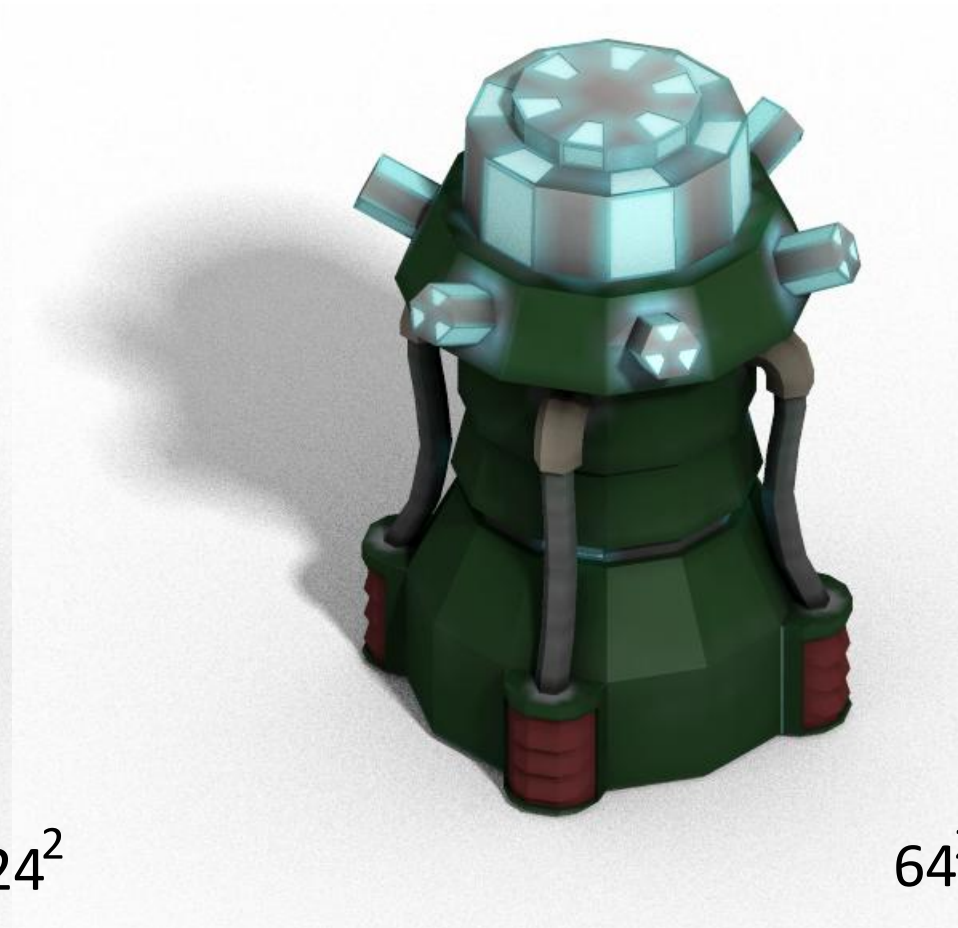
Example

Original

Box

Example

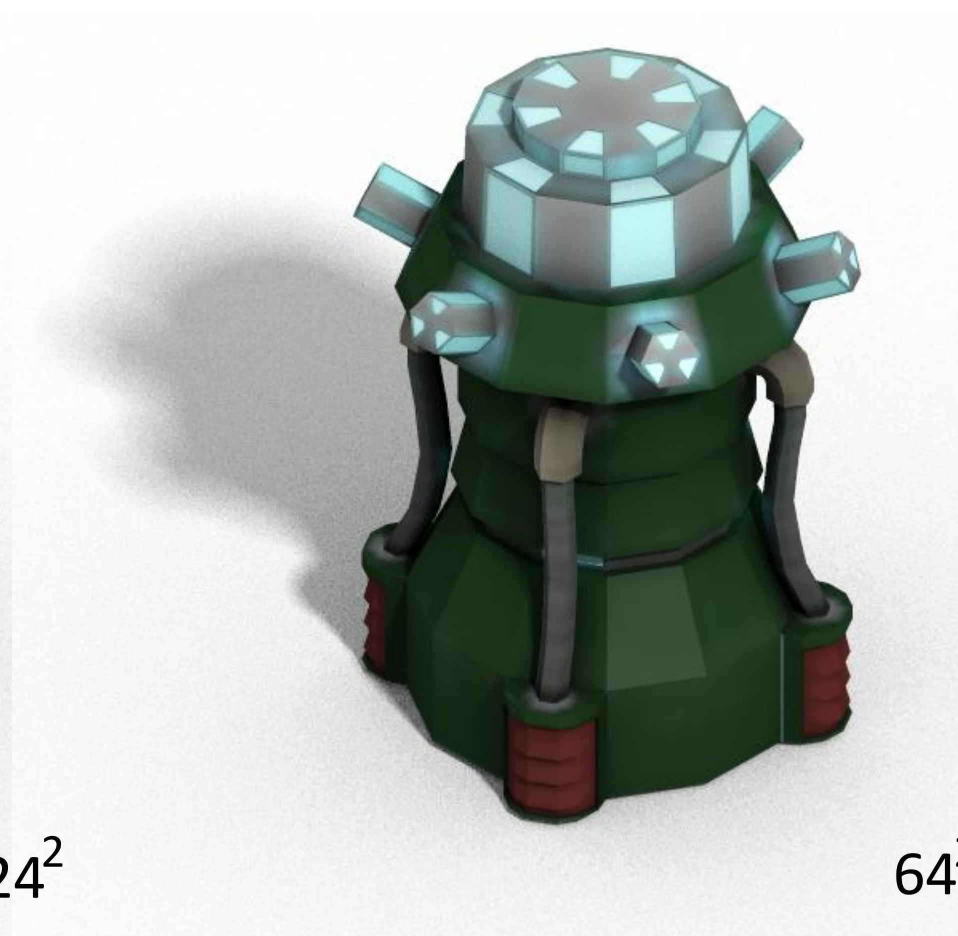
Original



Box Ignore

Example

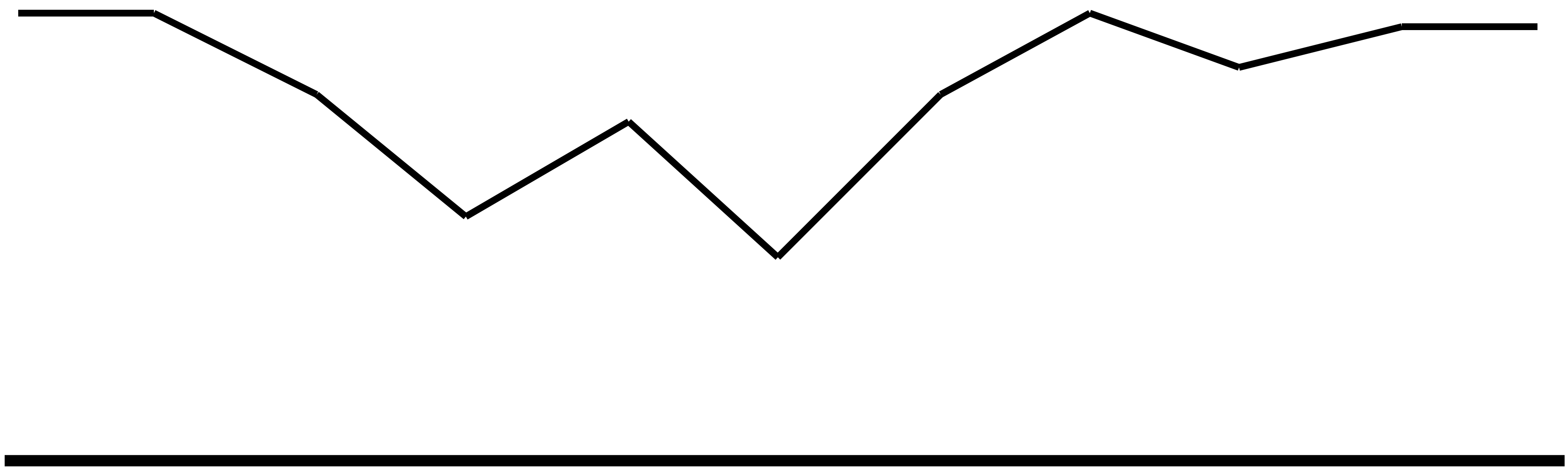
Original



PAM Box

Basis Projection

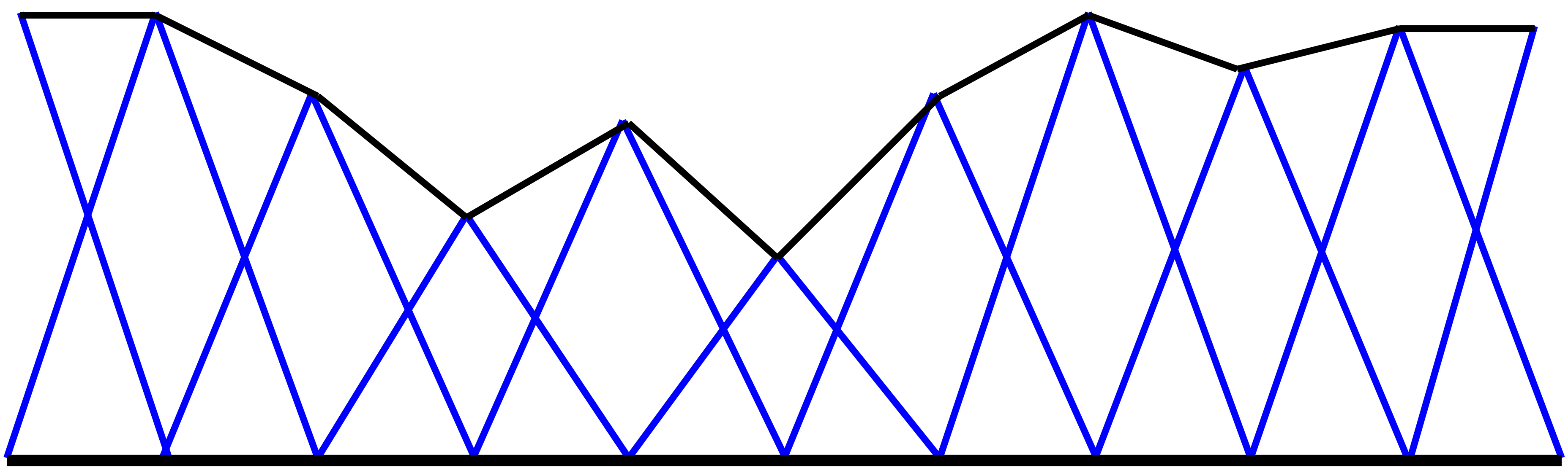
$$\min_{c_j} \int_0^1 \int_0^1 \left| \sum_j b_j(u,v) c_j - \sum_i \hat{b}_i(u,v) \hat{c}_i \right|^2 \, du \, dv$$



[Kajiya and Ullner 1981]

Basis Projection

$$\min_{c_j} \int_0^1 \int_0^1 \left| \sum_j b_j(u,v) c_j - \sum_i \hat{b}_i(u,v) \hat{c}_i \right|^2 \, du \, dv$$



[Kajiya and Ullner 1981]

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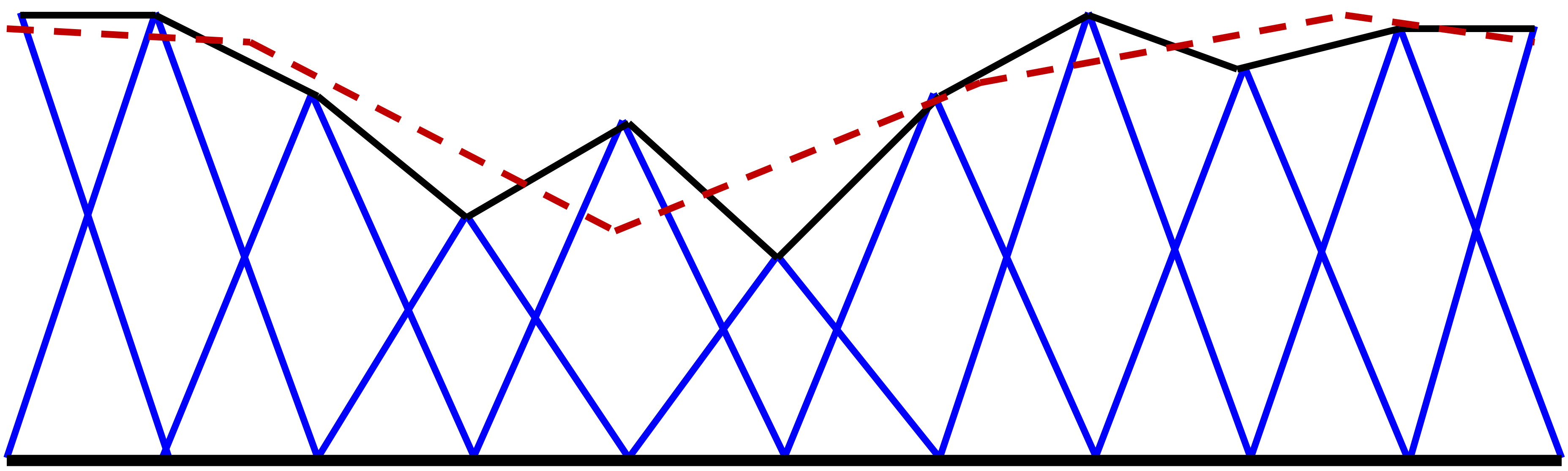

[Kajiya and Ullner 1981]

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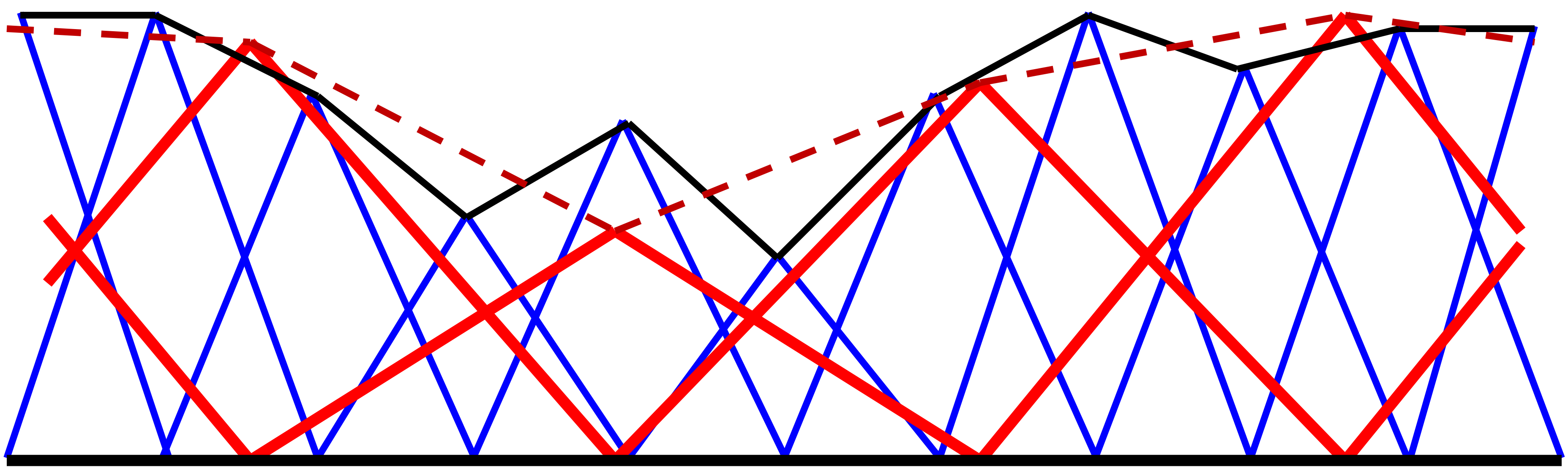
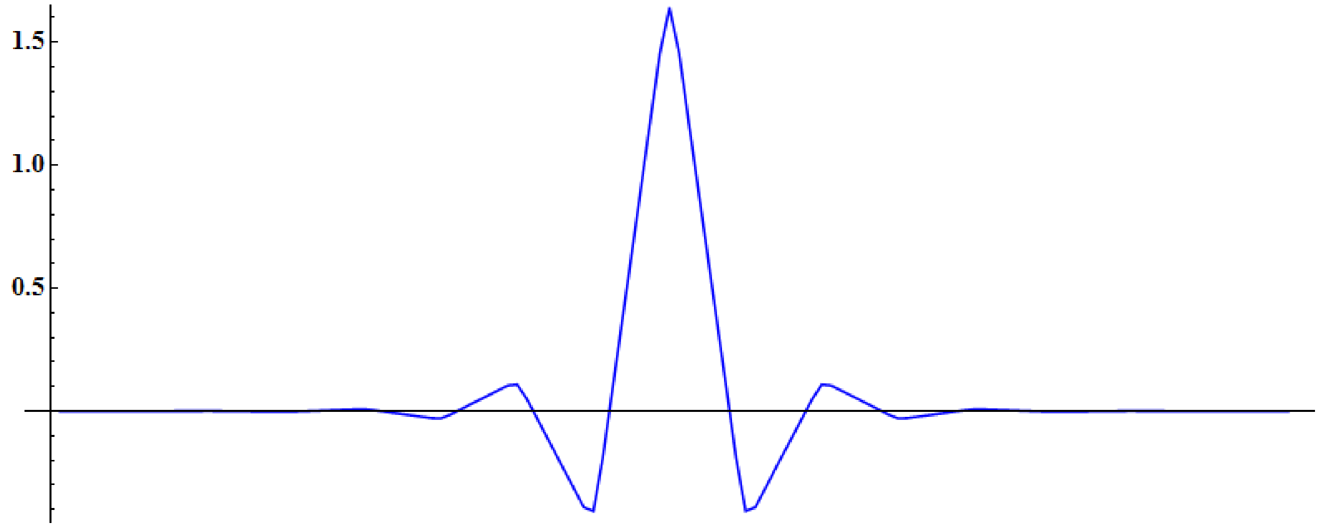
$$\min_{c_j} \int_0^1 \int_0^1 \left| \sum_j b_j(u,v)c_j - \sum_i \hat{b}_i(u,v)\hat{c}_i \right|^2 du\, dv$$



[Kajiya and Ullner 1981]

Pre/Post-filter Convolution

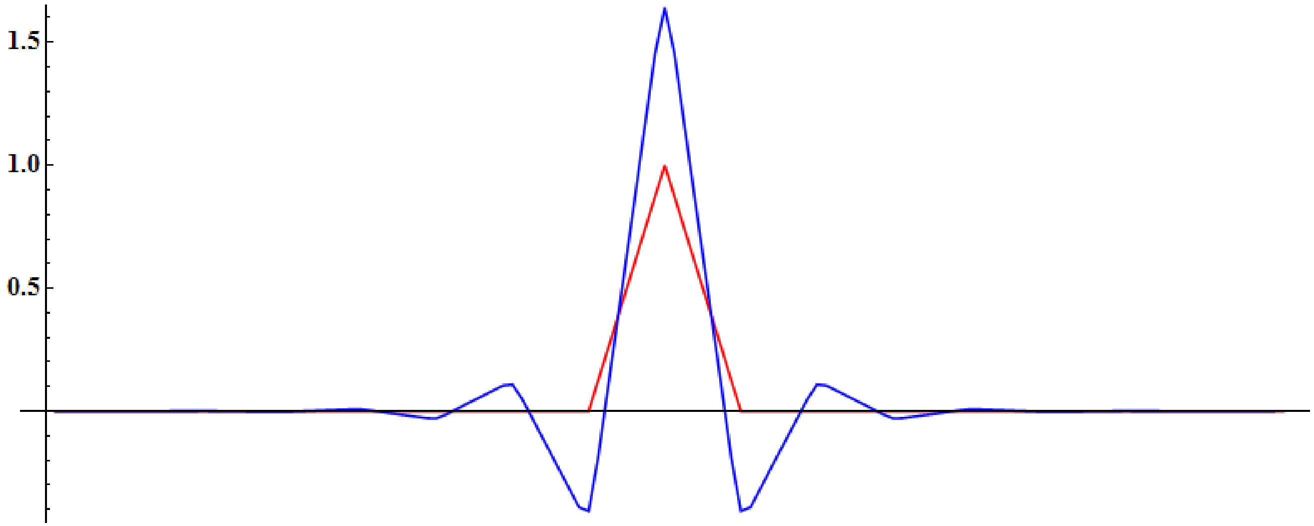
Real



[Kajiya and Ullner 1981]

Pre/Post-filter Convolution

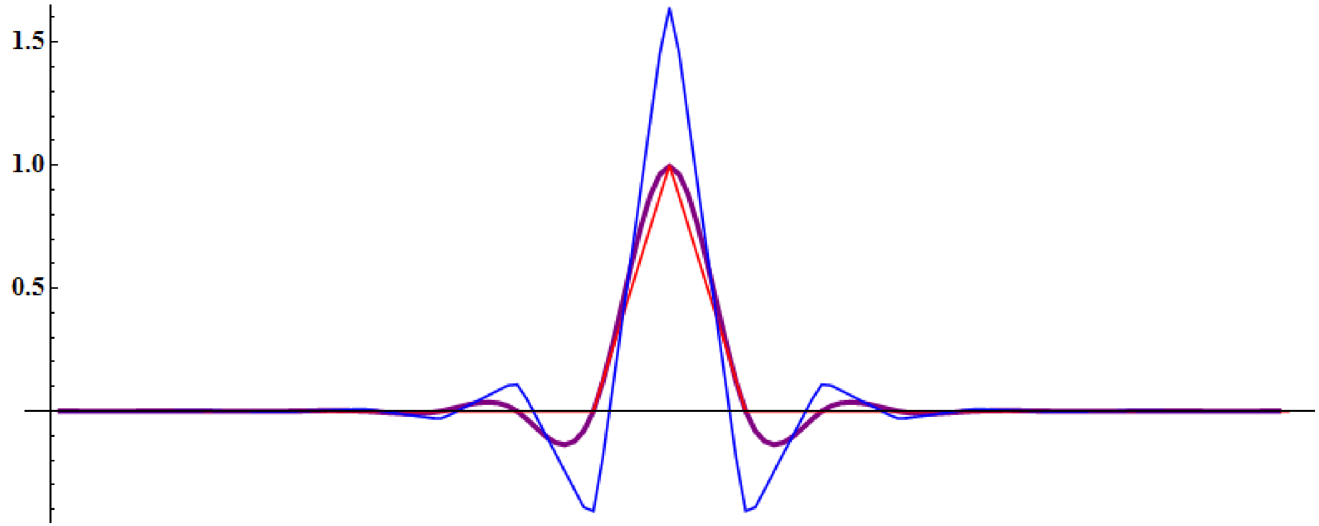
Real



[Kajiya and Ullner 1981]

Pre/Post-filter Convolution

Real

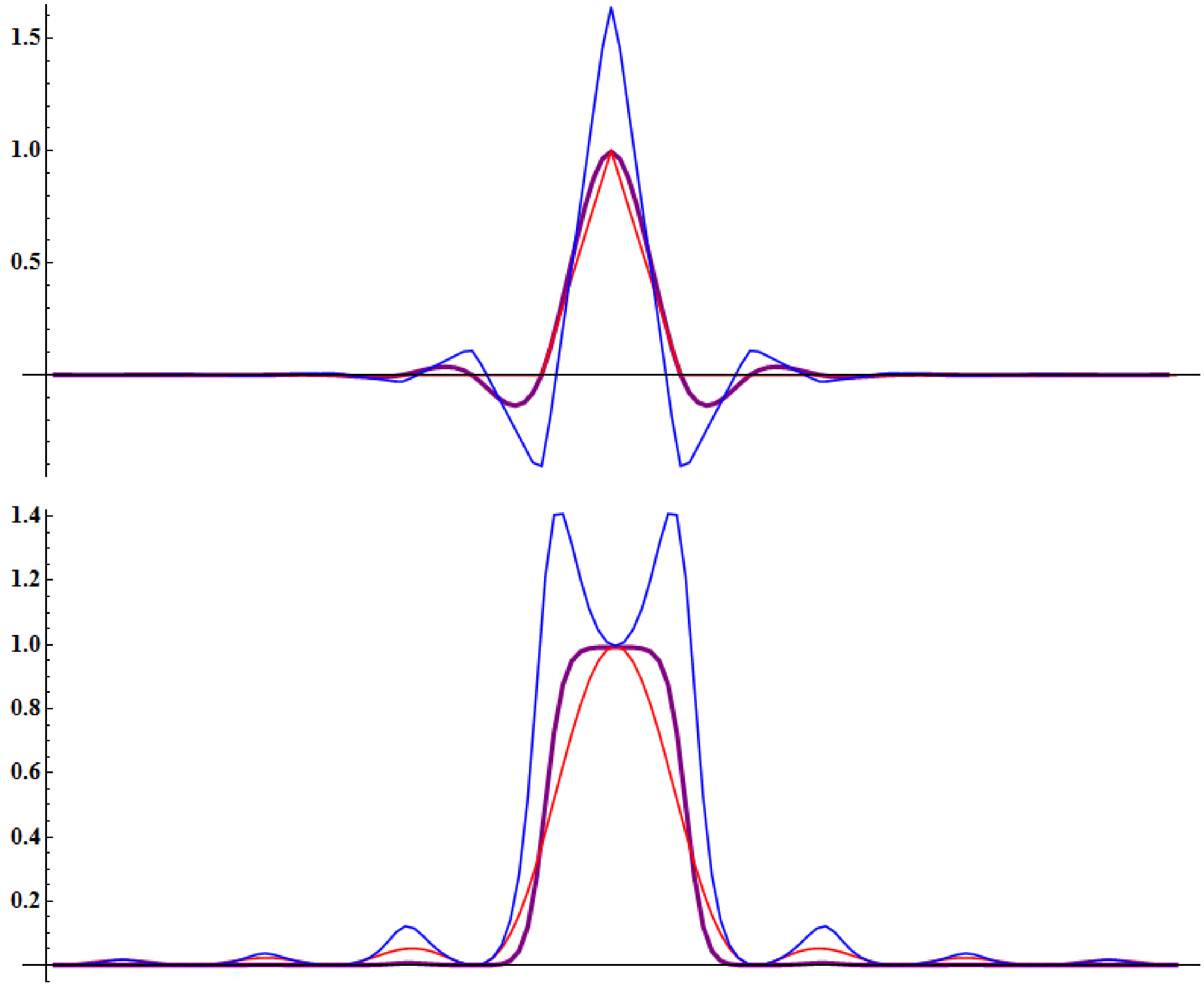


[Kajiya and Ullner 1981]

Pre/Post-filter Convolution

Real

Fourier



[Kajiya and Ullner 1981]

Optimized Filtering

256^2

Original

64^2

Box

Optimized Filtering

256^2

Original

64^2

Optimized Bilinear

Optimized Filtering

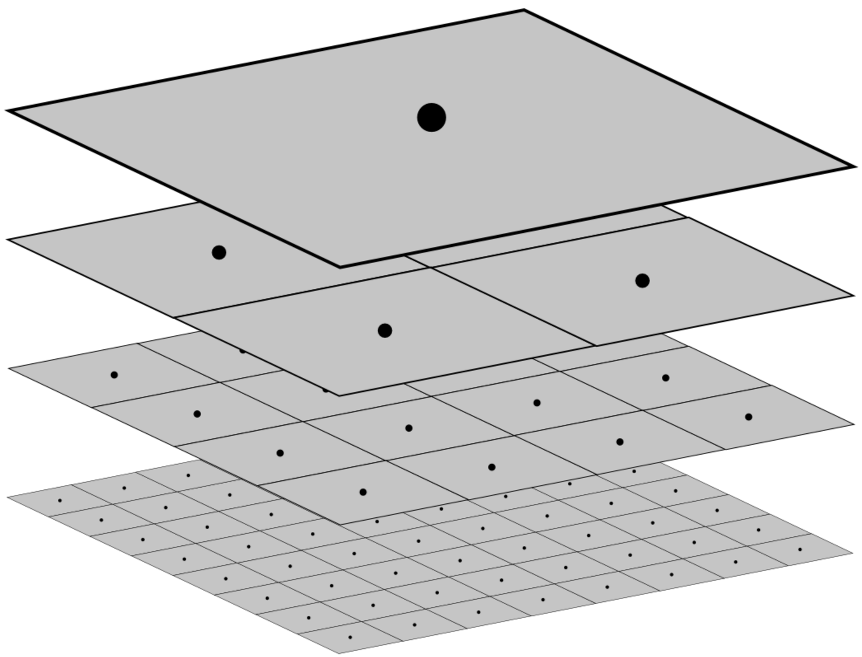
256^2

Original

64^2

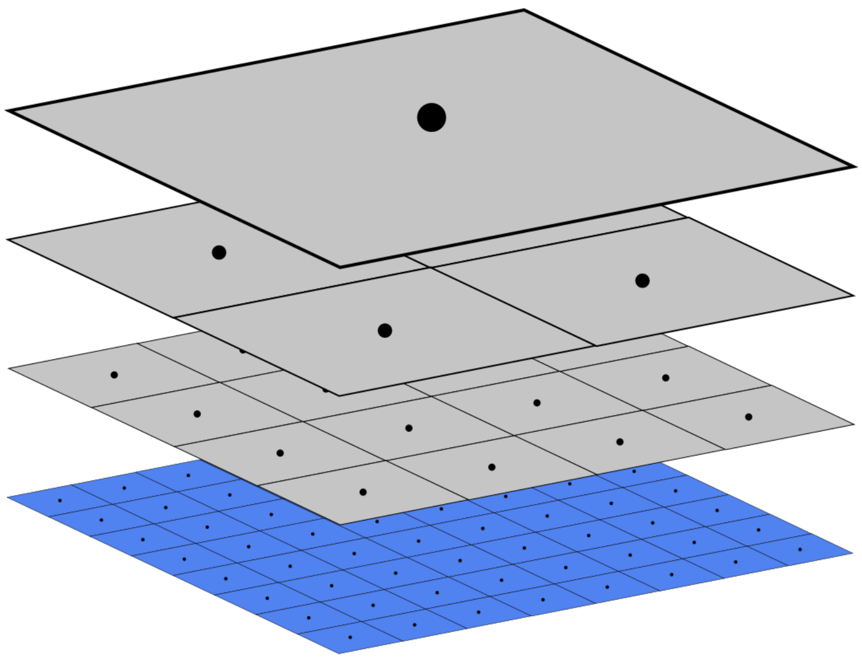
Constrained Bilinear

Trilinear Basis



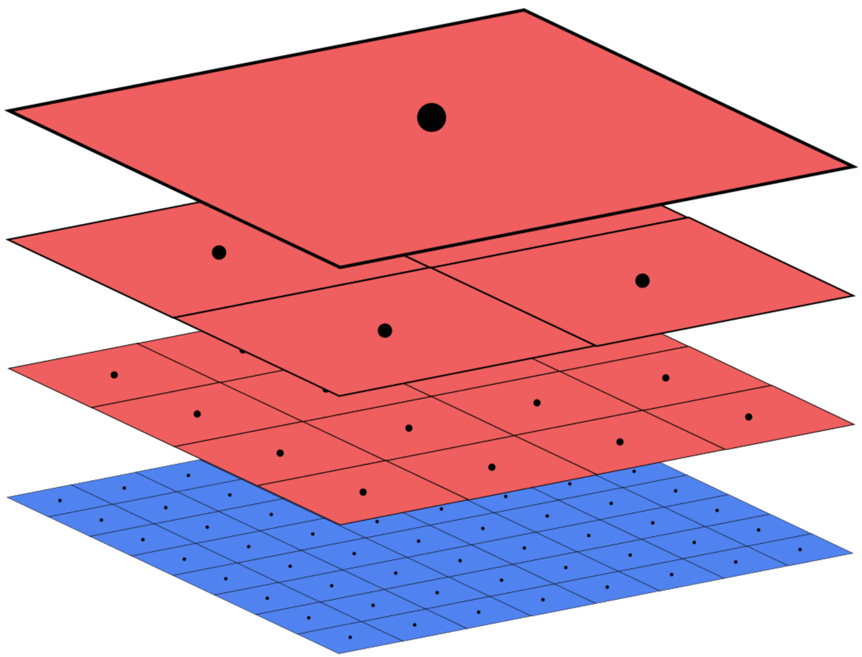
$$\min_{c_j} \int_0^1 \iint_\Omega \left| \sum_j b_j(\Theta(p), w) c_j - \sum_i \hat{b}_i(\Theta(p)) \hat{c}_i \right|^2 \, dp \, dw$$

Trilinear Basis



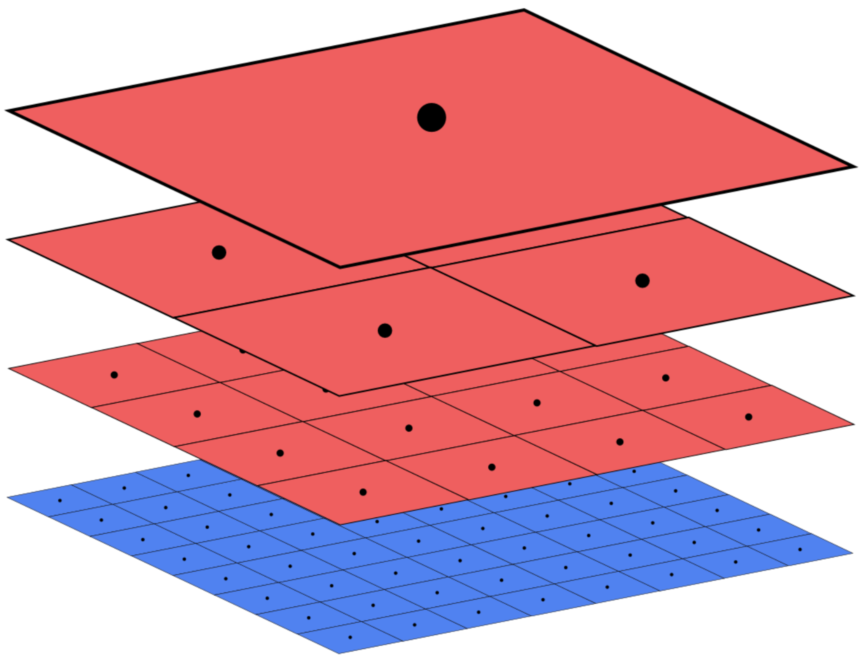
$$\min_{c_j} \int_0^1 \iint_\Omega \left| \sum_j b_j(\Theta(p), w) c_j - \sum_i \hat{b}_i(\Theta(p)) \hat{c}_i \right|^2 \, dp \, dw$$

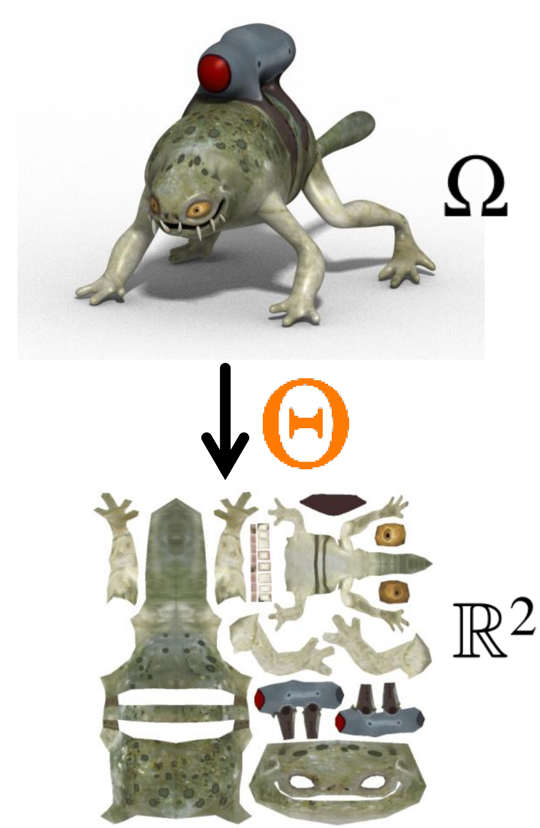
Trilinear Basis



$$\min_{c_j} \int_0^1 \iint_\Omega \left| \sum_j b_j(\Theta(p), w) c_j - \sum_i \hat{b}_i(\Theta(p)) \hat{c}_i \right|^2 \, dp \, dw$$

Trilinear Basis





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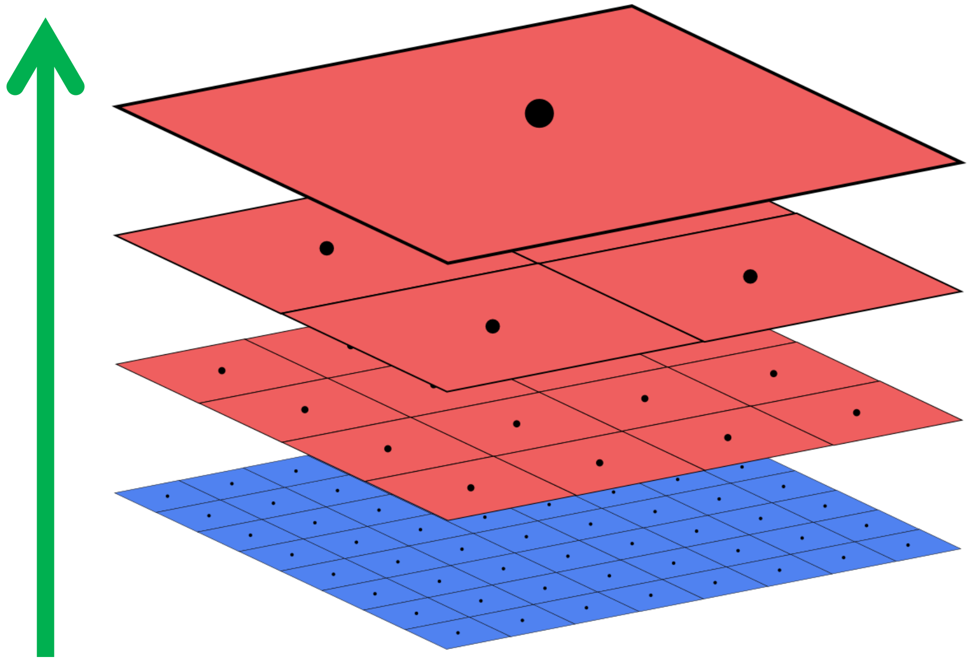
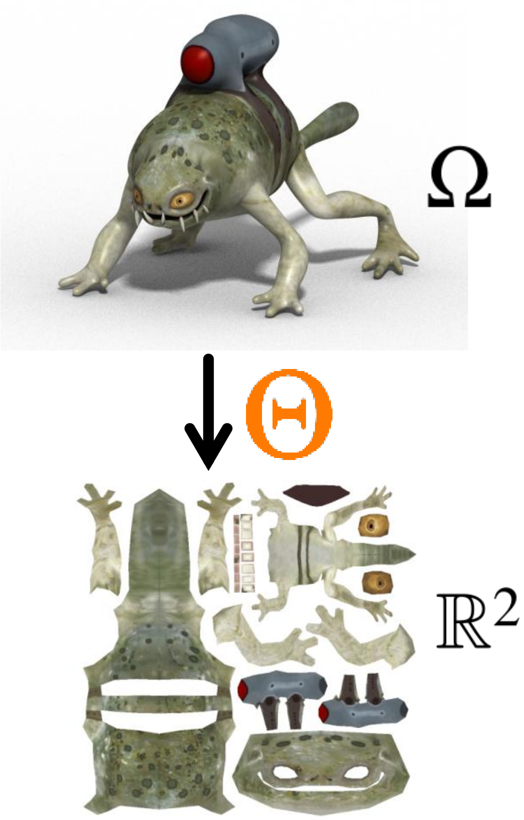
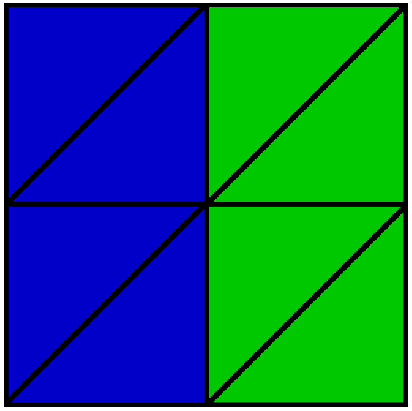
Trilinear Basis





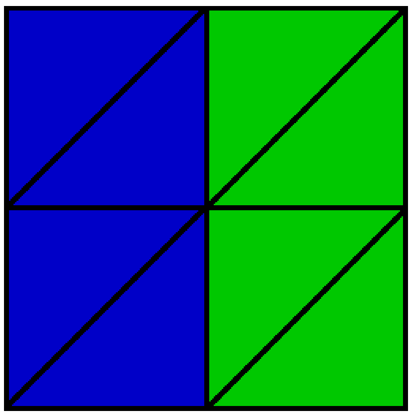
$$\min_{c_j} \int_0^1 \iint_\Omega \left| \sum_j b_j(\Theta(p), w) c_j - \sum_i \hat{b}_i(\Theta(p)) \hat{c}_i \right|^2 dp\, dw$$

Nonuniform Plane

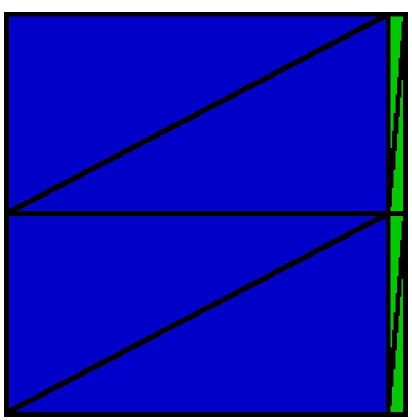


Object Mesh

Nonuniform Plane

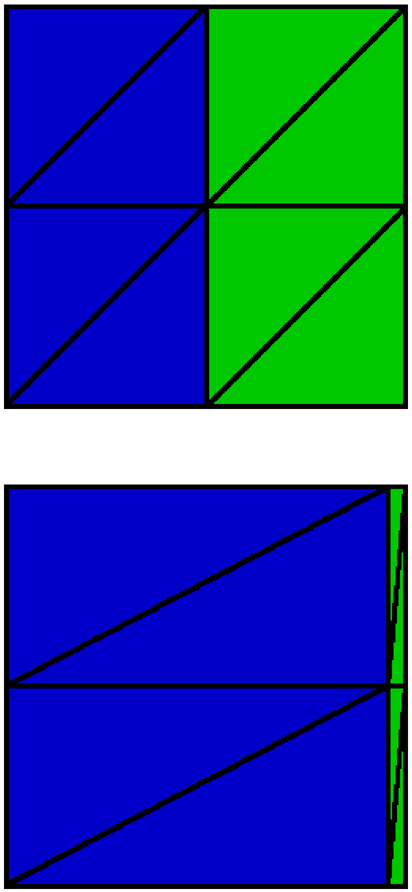


Object Mesh

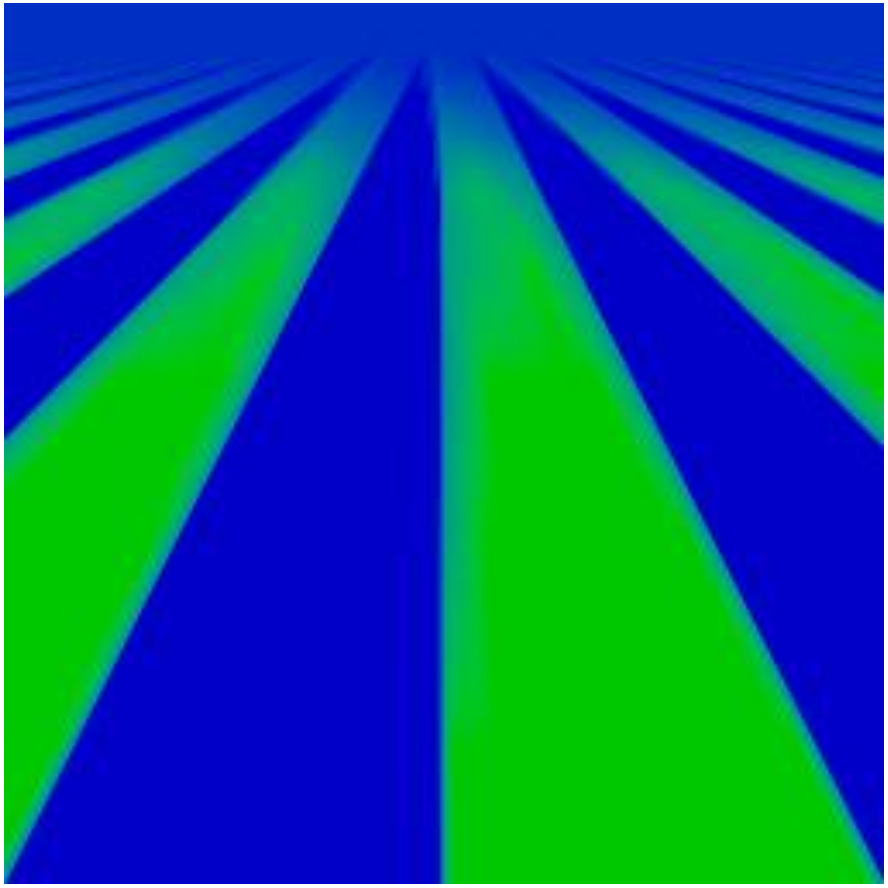


Texture Map

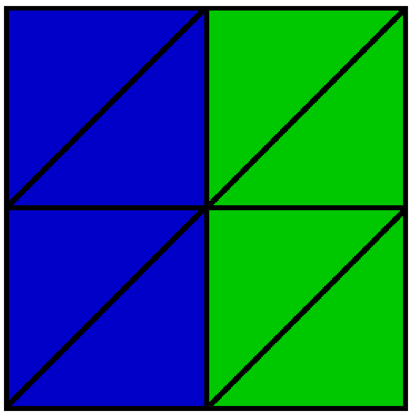
Nonuniform Plane

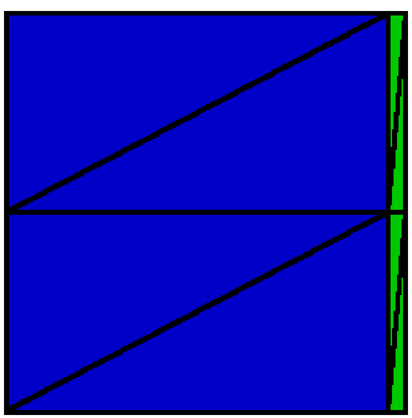


Box

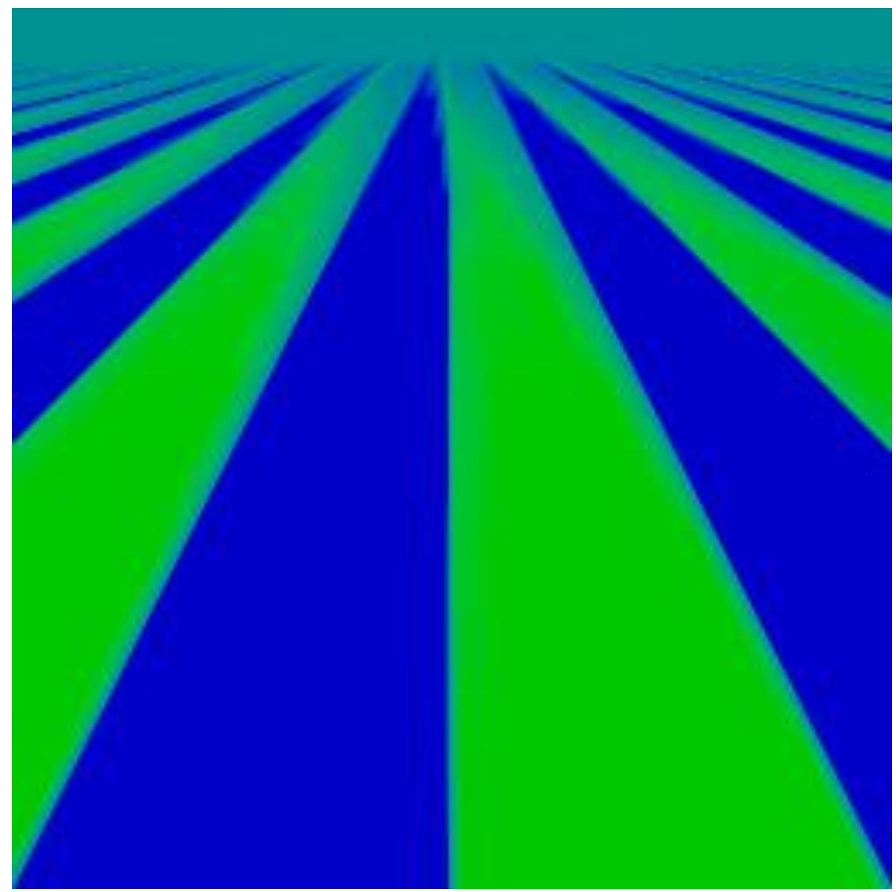


Nonuniform Plane

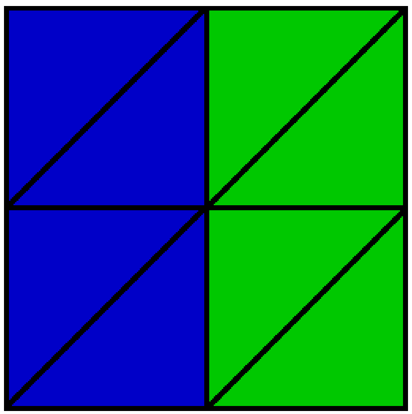


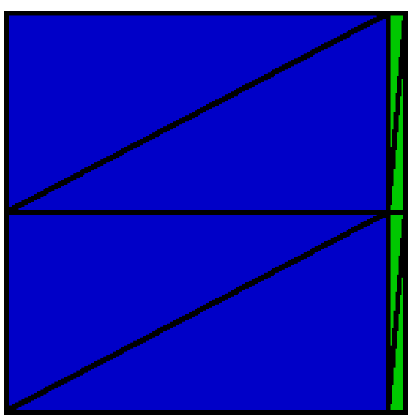


PAM Box

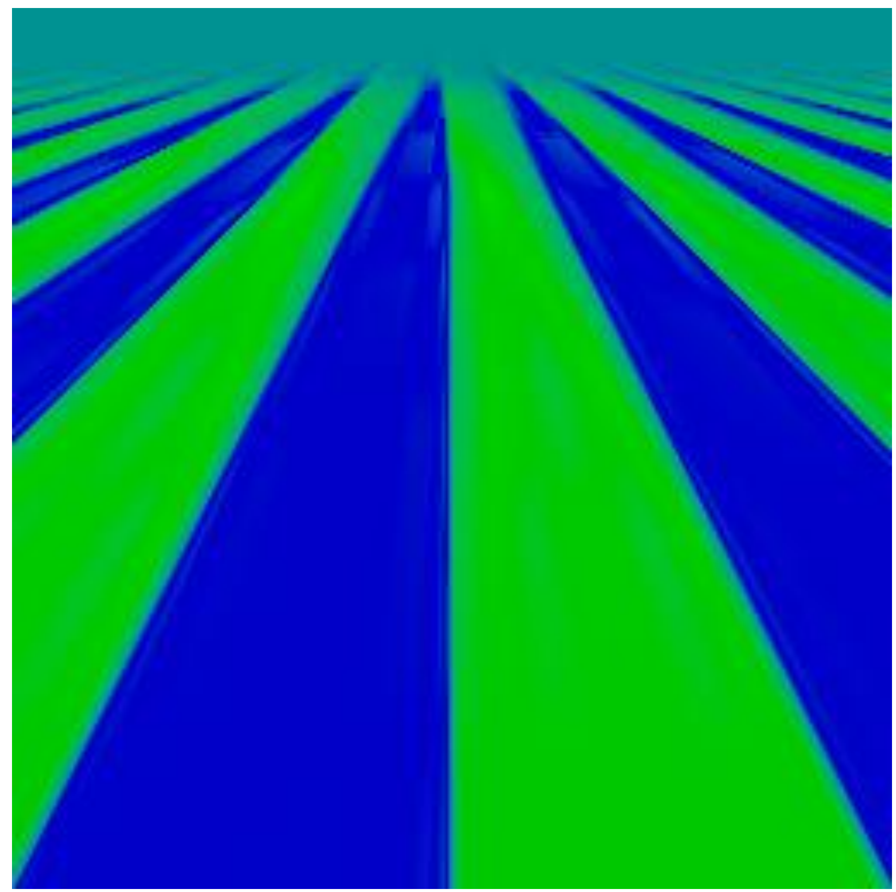


Nonuniform Plane

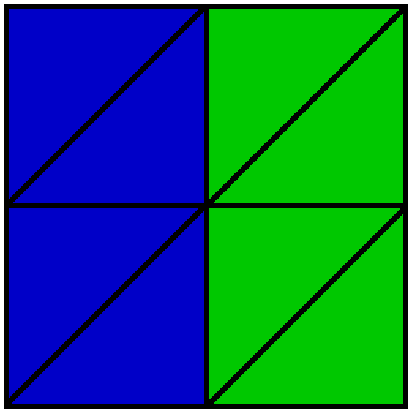


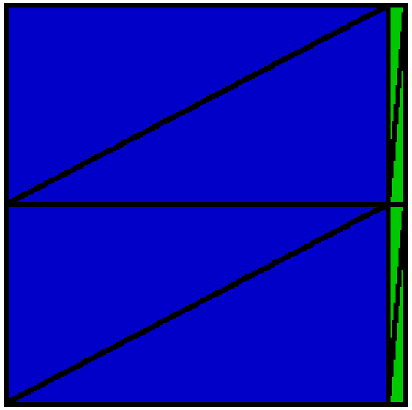


PAM Trilinear

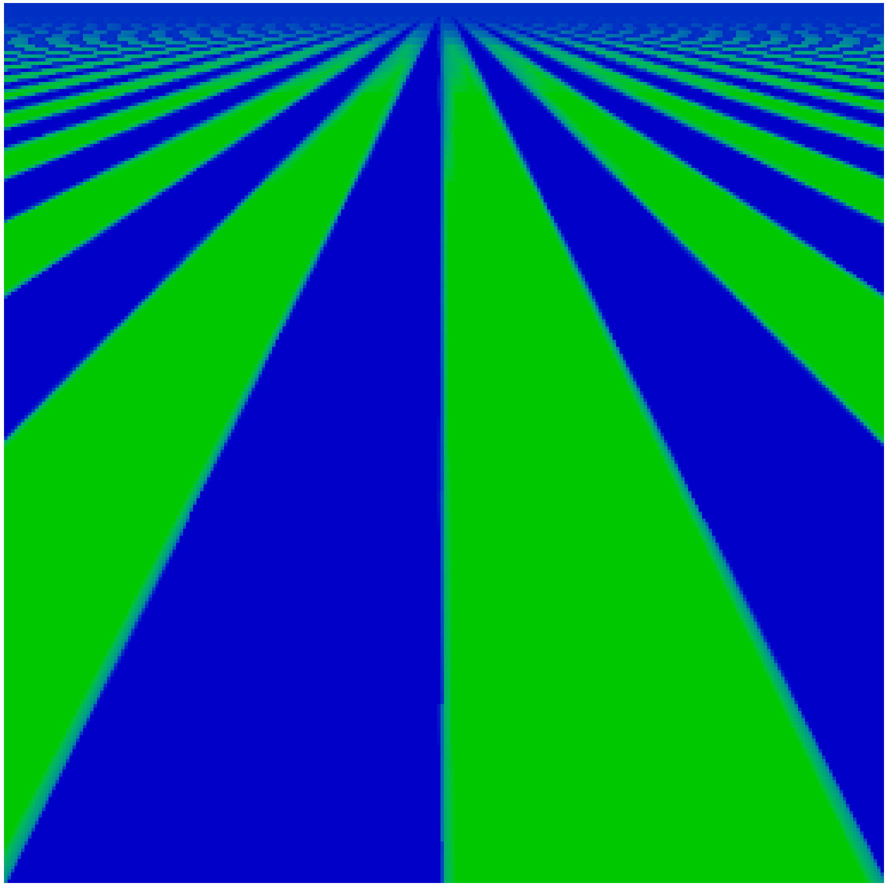


Nonuniform Plane

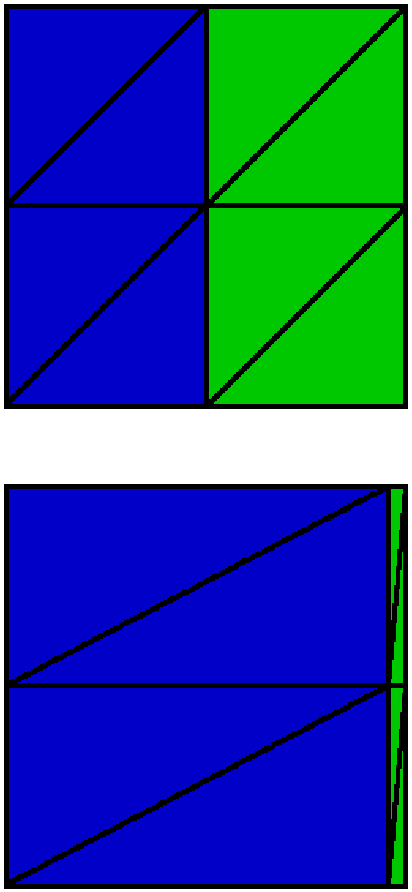




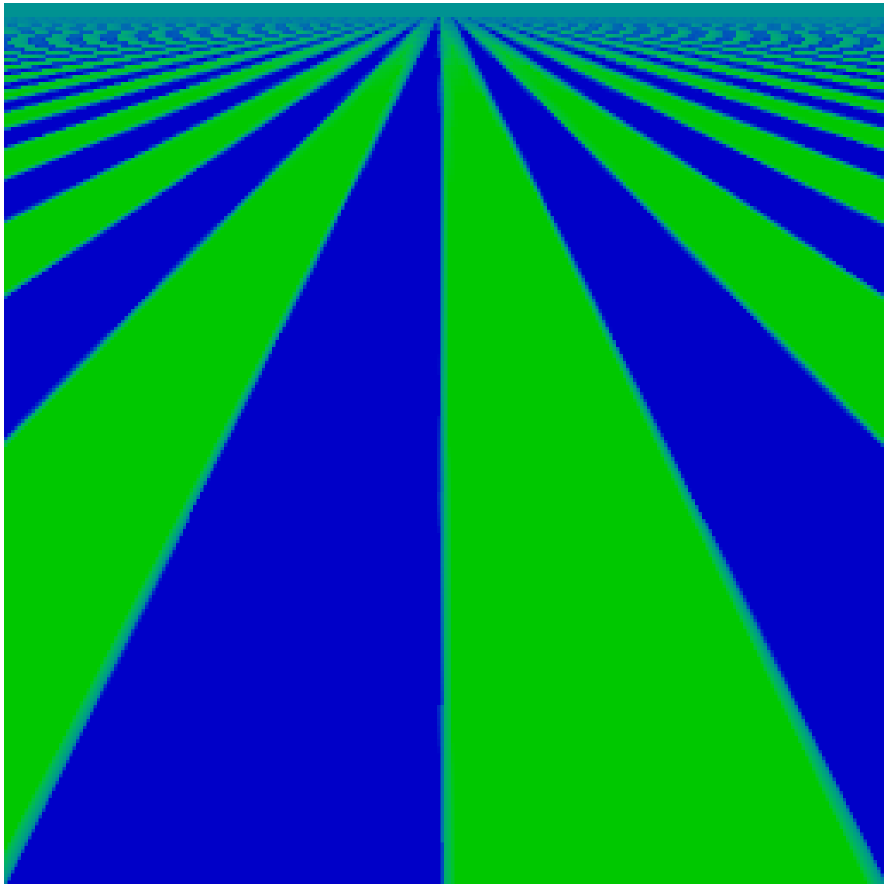
Box (Anisotropic 16x)



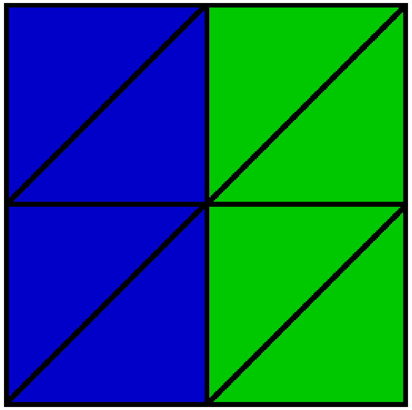
Nonuniform Plane

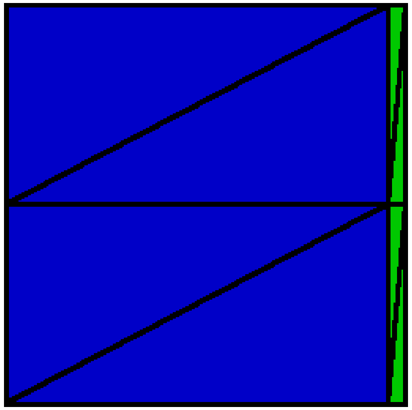


PAM Box (Anisotropic 16x)

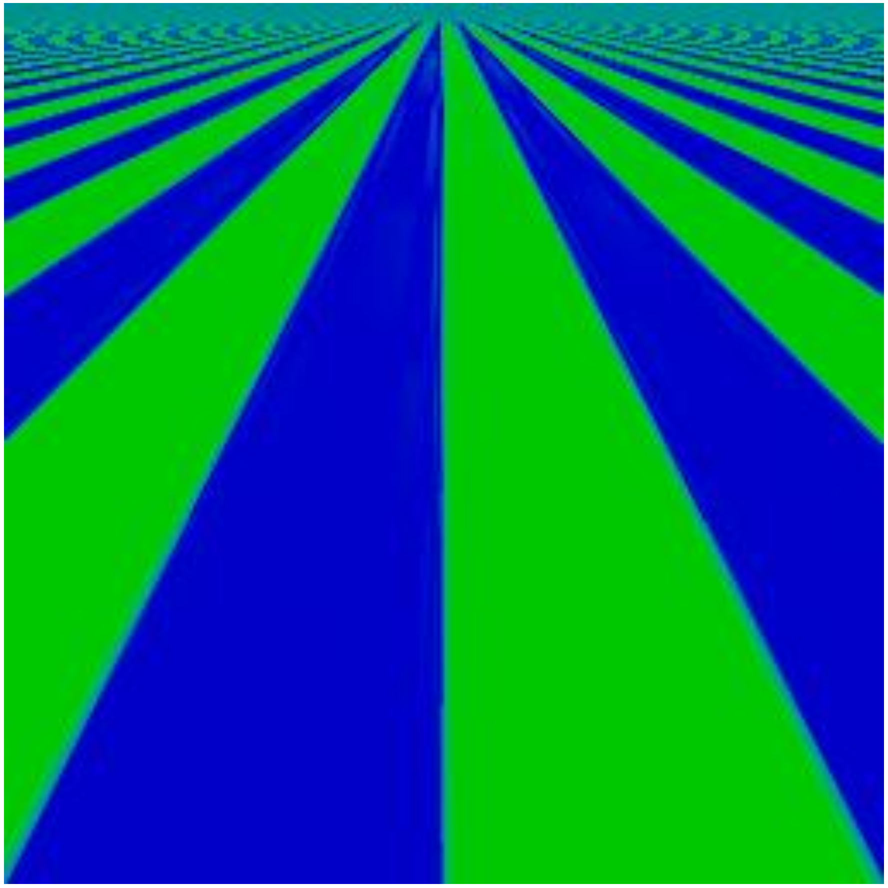


Nonuniform Plane

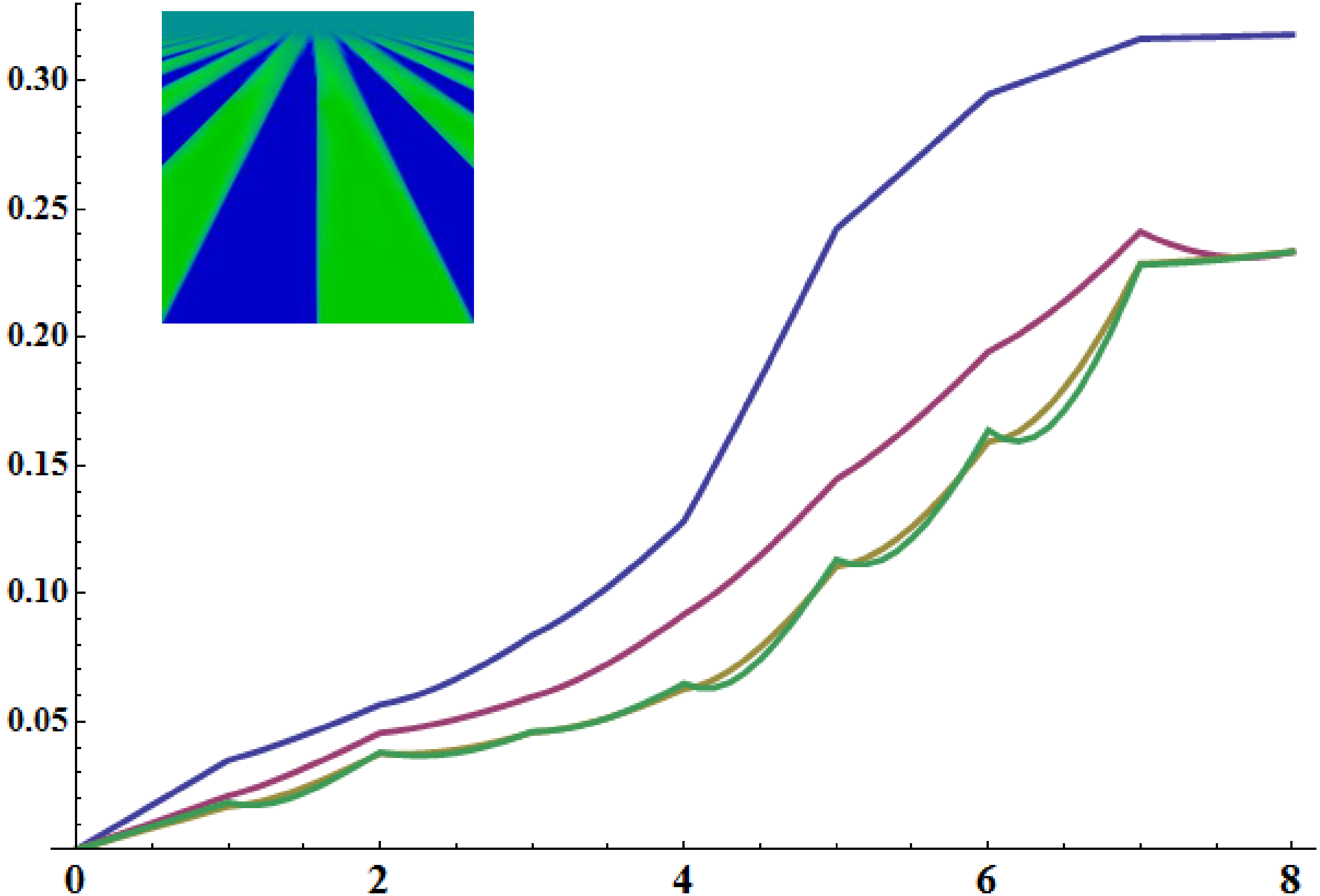




PAM Trilinear (Anisotropic 16x)



Errors



Box PAM Box PAM Bilinear PAM Trilinear

Preprocessing Times

	64	128	256	512	1024
box	0.000	0.000	0.001	0.002	0.010
tent	0.001	0.006	0.029	0.131	0.584
Lanczos 3	0.032	0.151	0.695	3.140	13.99
PAM box	0.001	0.002	0.006	0.021	0.078
PAM bi.	0.111	0.304	0.971	3.906	21.40
PAM tri.	0.296	0.880	3.101	12.571	61.21

Conclusion

- Correct for parameterization of surface
- Project onto trilinear basis
- Never decreases image quality
- No changes to rendering or artwork
- Less than tenth of a second for PAM box
- Try it http://josiahmanson.com