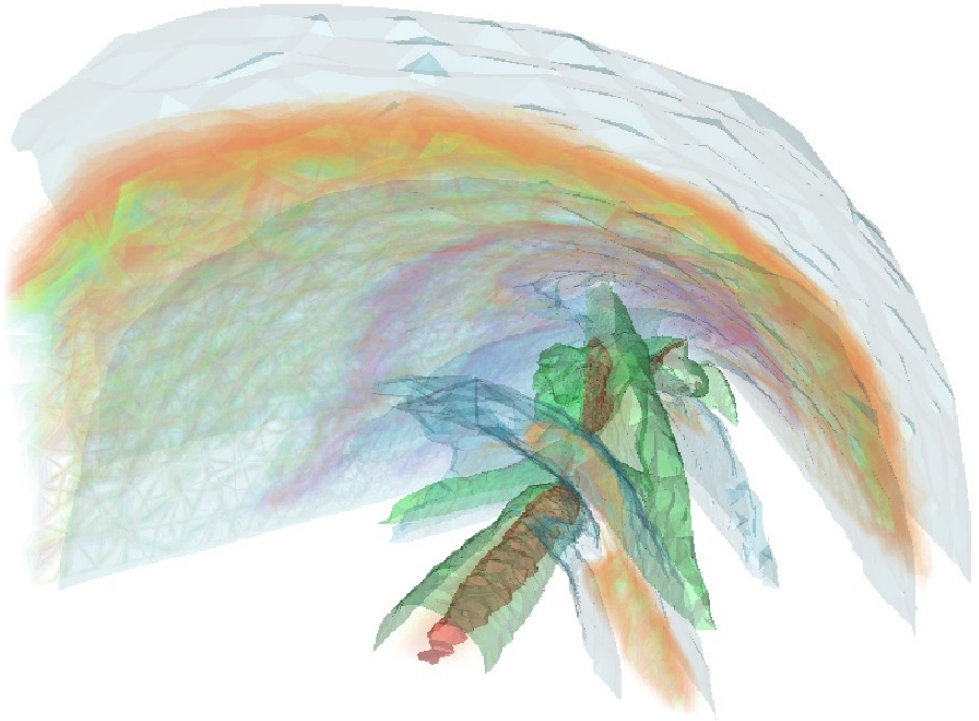
HAPT: Hardware-Assisted Projected Tetrahedra



Eurographics/IEEE Symposium on Visualization, June 9 - 11

EuroVis 2010

André Maximo

June, 2010
Bordeaux, France

motivation

main applications

Industry

Fluid Simulations

Geosciences

Mechanical Engineering

Medicine

Weather Forecasting

...

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main applications

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Geosciences

Mechanical Engineering

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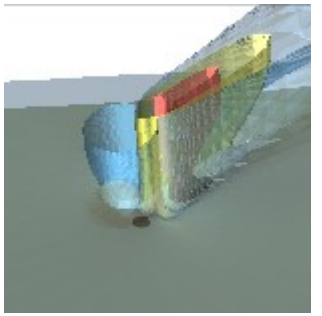
Indirect Volume Rendering

iso-surfaces



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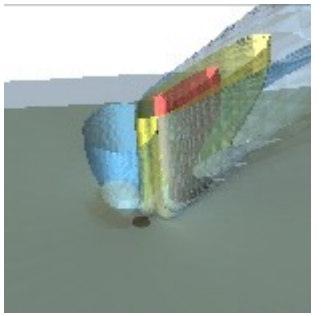

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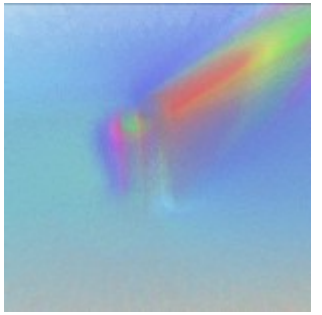
Direct Volume Rendering

semi-transparent material



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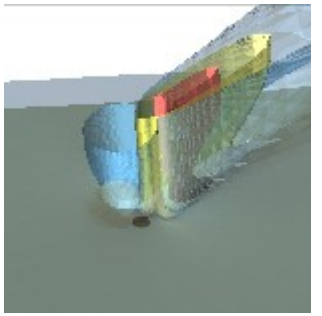
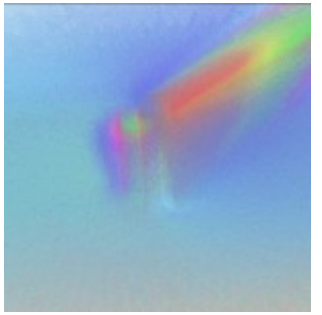
Indirect Volume Rendering

iso-surfaces

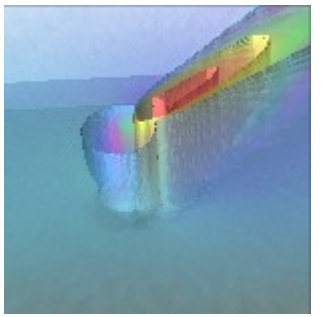


Direct Volume Rendering

semi-transparent material



Both



background

our method

What We Want

Simple and straightforward

High performance

Low memory consumption

Direct and Indirect rendering

Time-varying datasets

Implementation flexibility

Volume Rendering

background

Simple and straightforward

High performance

Low memory consumption

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Implementation flexibility

Cell Projection

Ray Casting

background

our method

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Cell Projection

×

Ray Casting

background

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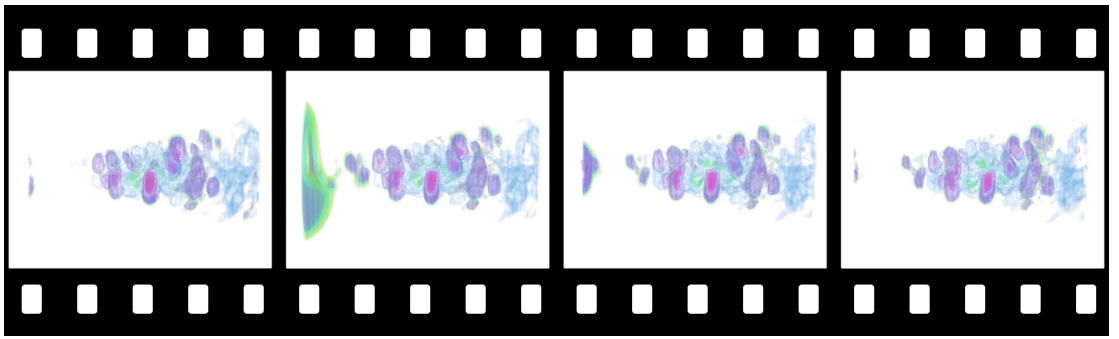
Sequence of Static Volumes



background

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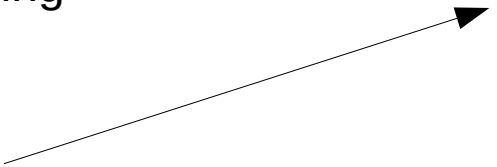
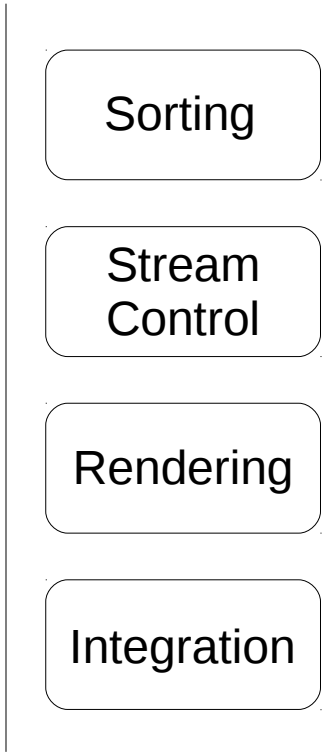


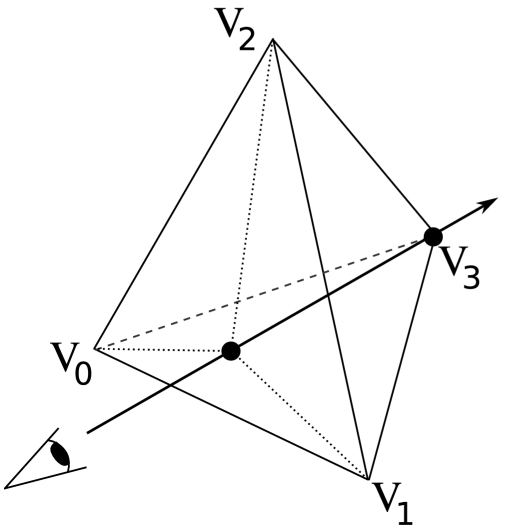


background

base method

PT algorithm [Shirley and Tuchman, 1990]

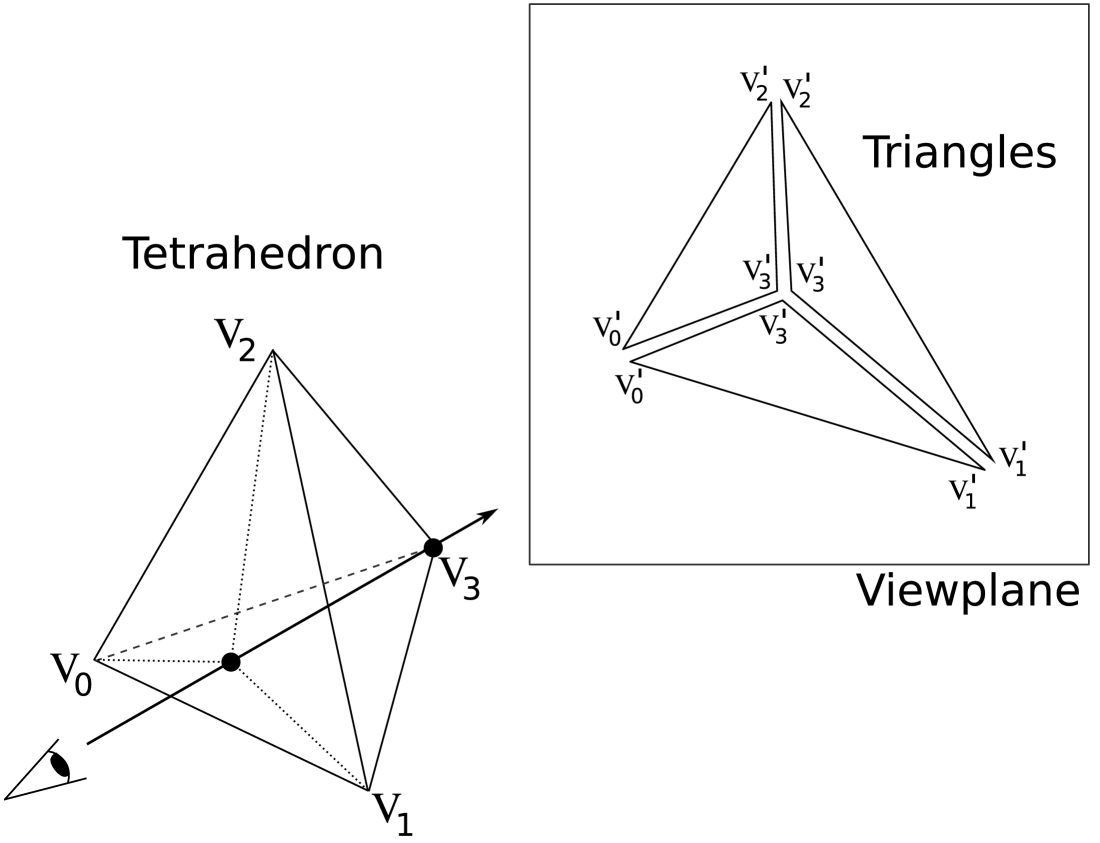
Tetrahedron



background

base method

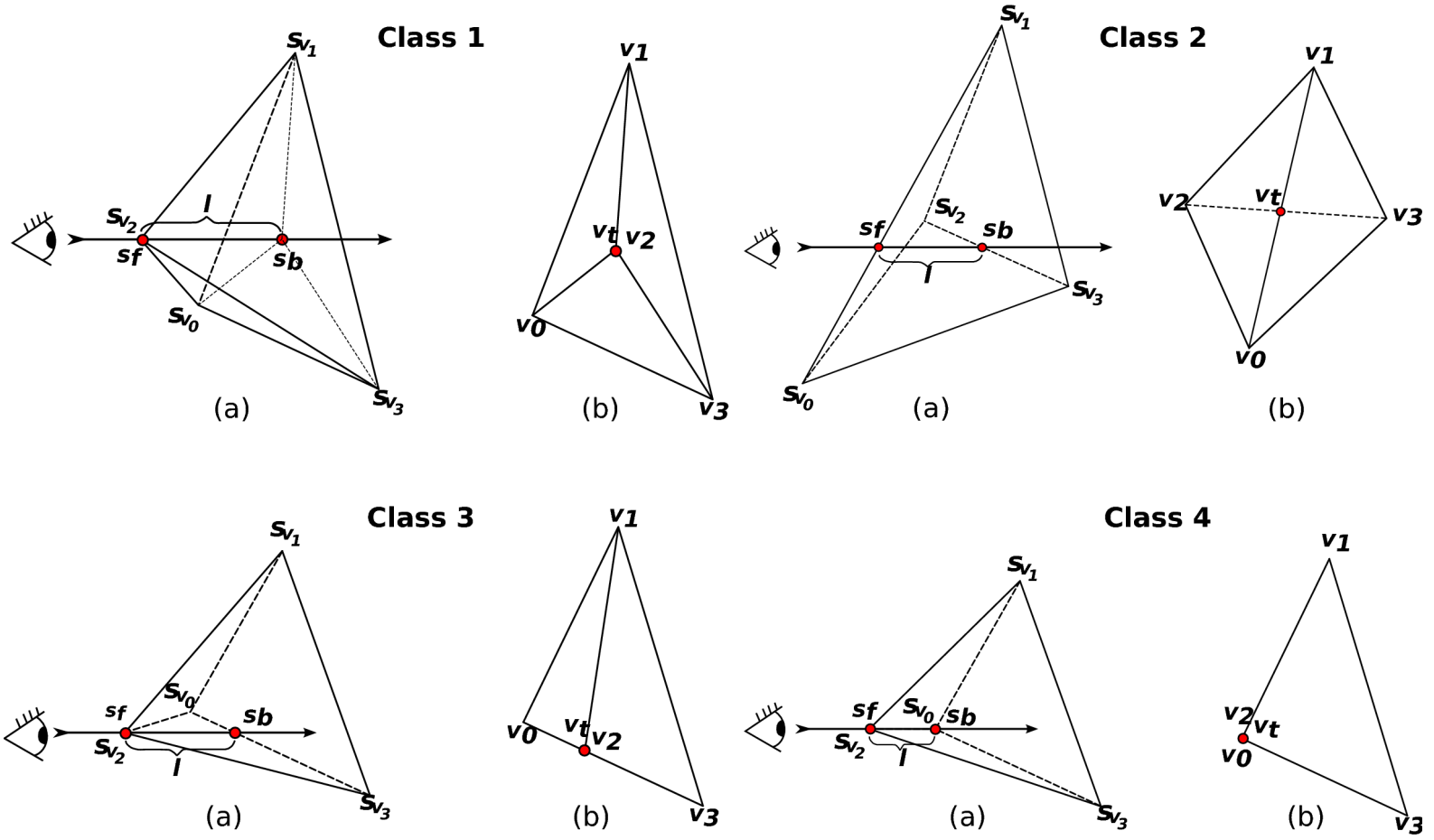
PT algorithm [Shirley and Tuchman, 1990]



background

base method

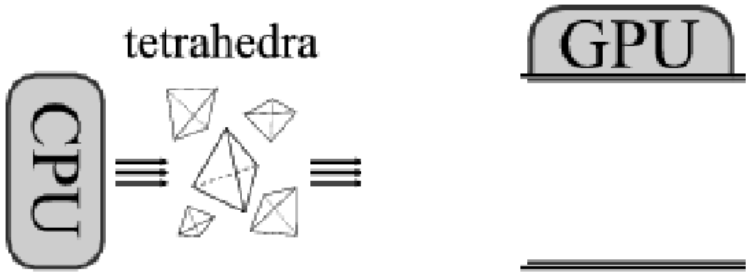
PT algorithm [Shirley and Tuchman, 1990]



hapt

the method

Hardware-Assisted Projected Tetrahedra



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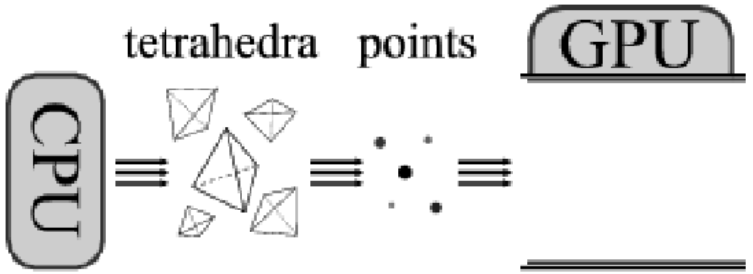
Hardware-Assisted Projected Tetrahedra



hapt

the method

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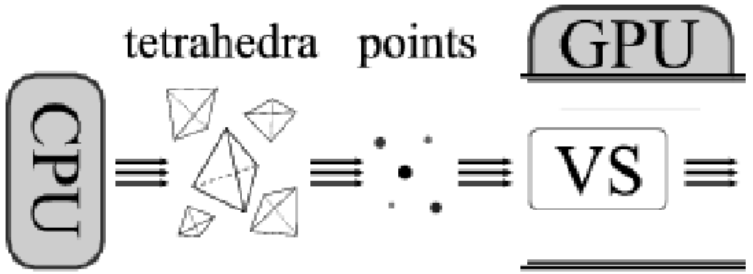
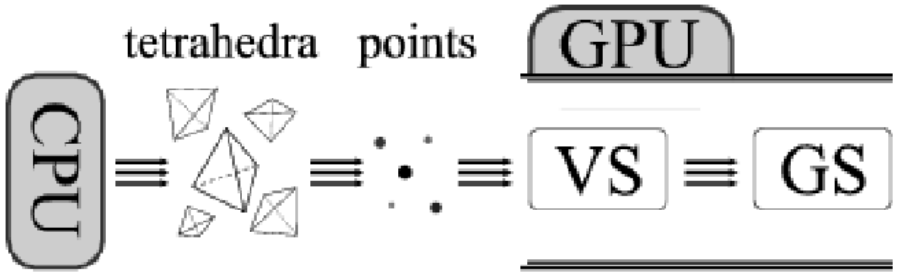


hapt

the method

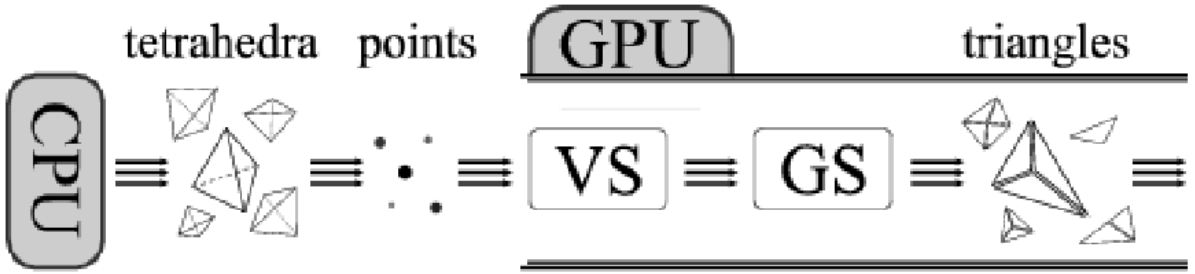
Hardware-Assisted Projected Tetrahedra



hapt

the method

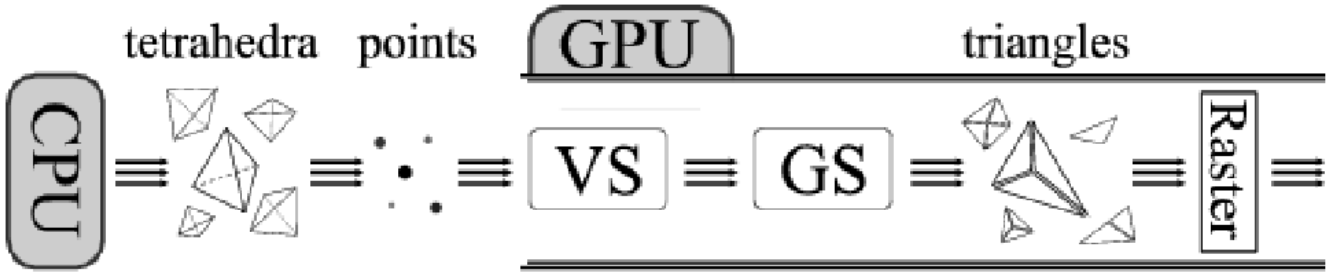
Hardware-Assisted Projected Tetrahedra



hapt

the method

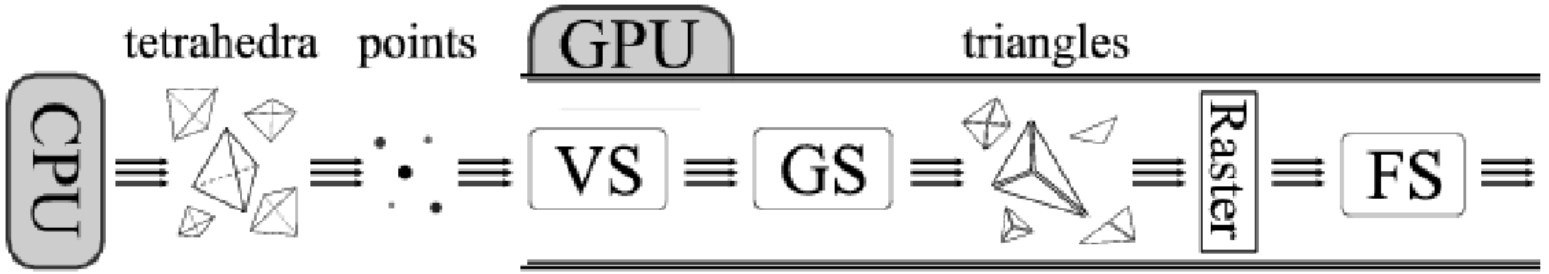
Hardware-Assisted Projected Tetrahedra



hapt

the method

Hardware-Assisted Projected Tetrahedra



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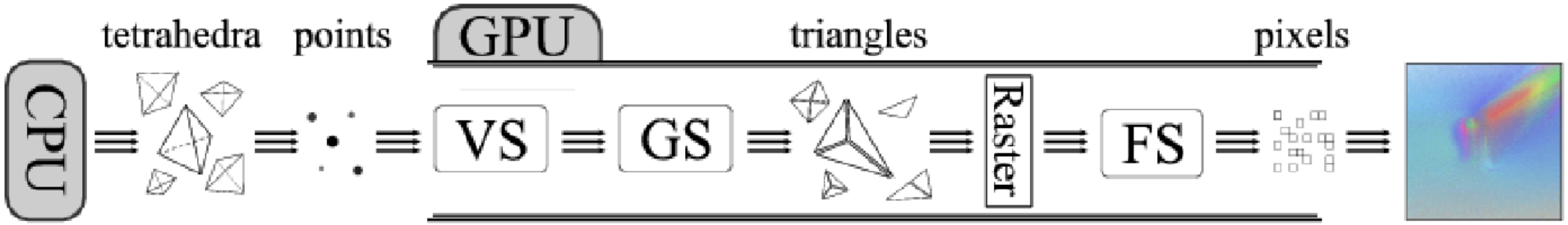
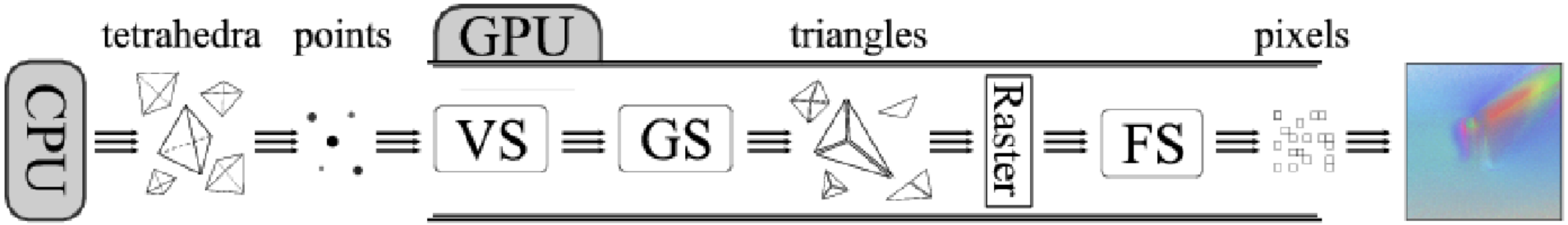


hapt

the method

Hardware-Assisted Projected Tetrahedra

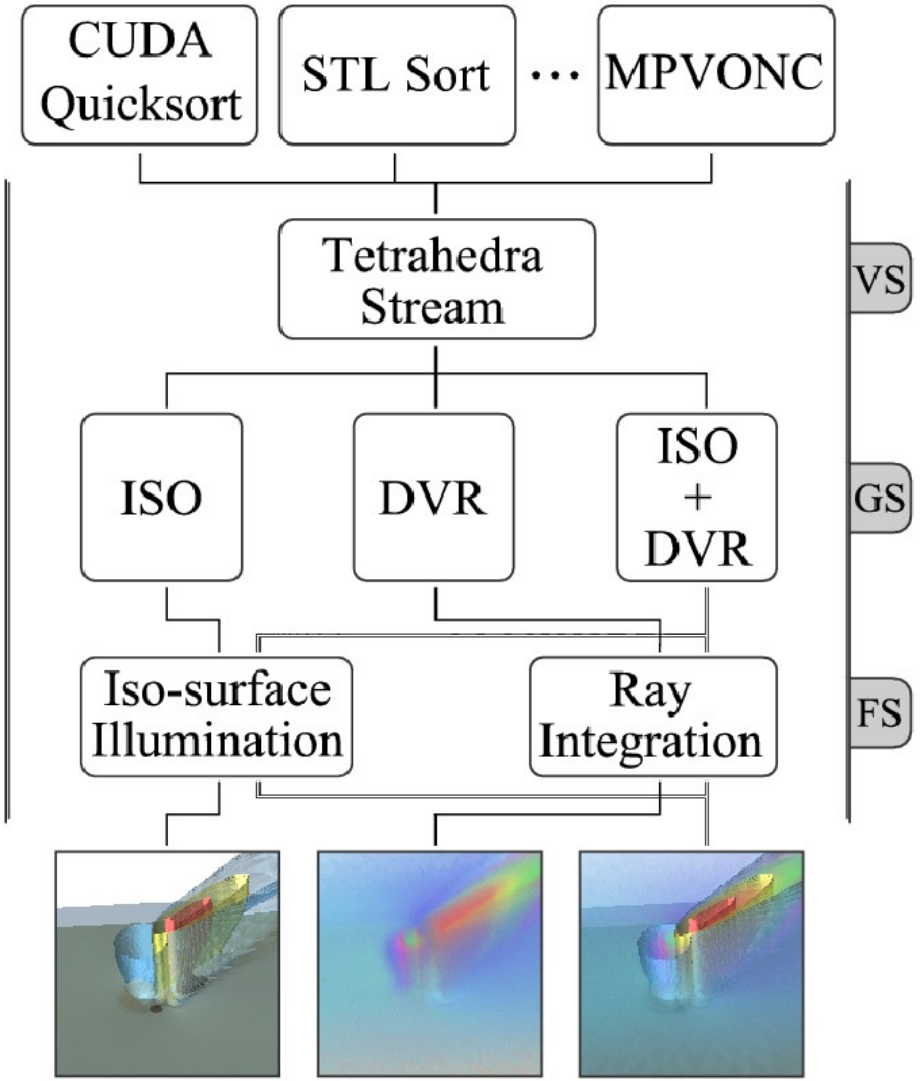


single pass

hapt

framework

Hardware-Assisted Projected Tetrahedra

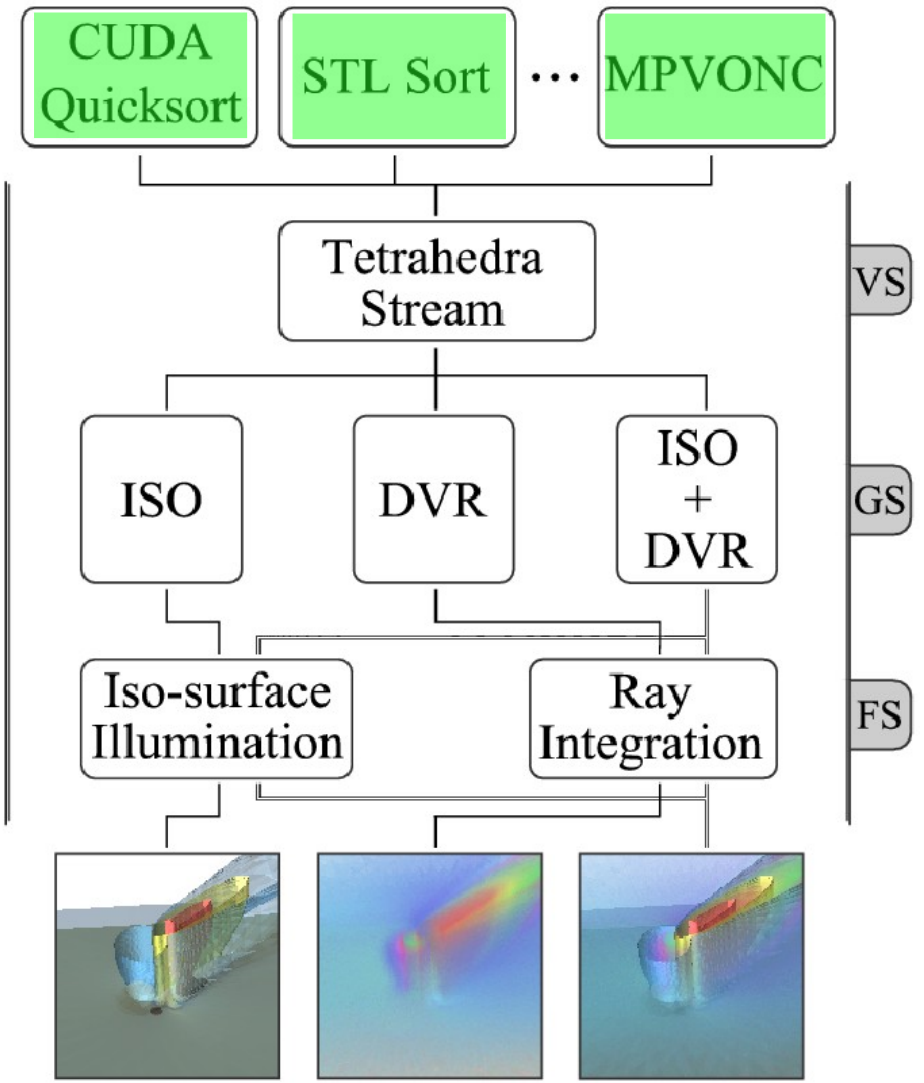


hapt

framework

Hardware-Assisted Projected Tetrahedra

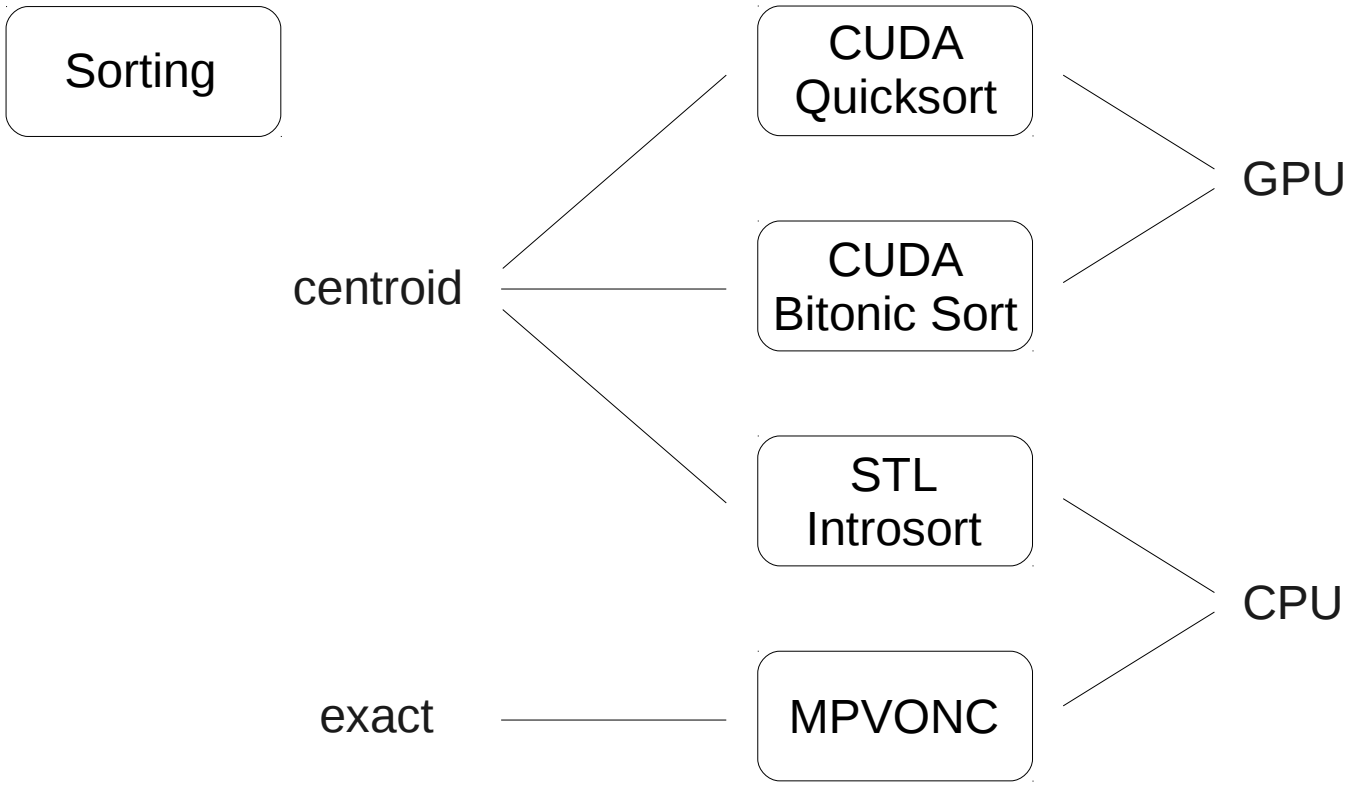
Sorting

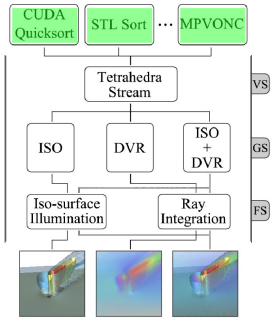


hapt

framework

Hardware-Assisted Projected Tetrahedra





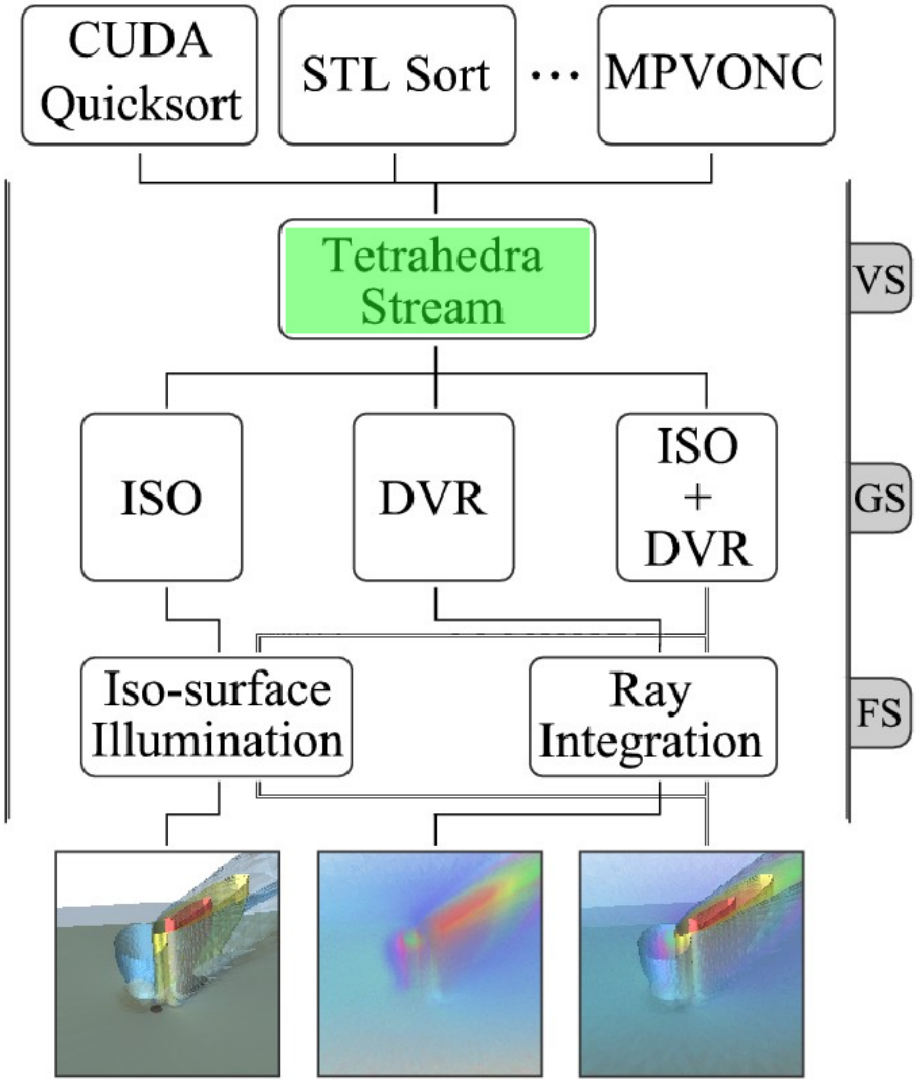
hapt

framework

Hardware-Assisted Projected Tetrahedra

Stream Control

e.g. Block Tetrahedra



hapt

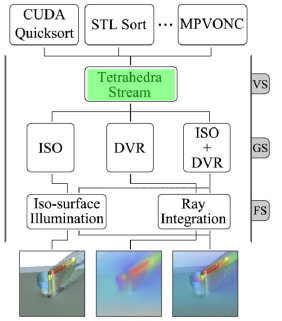
framework

Hardware-Assisted Projected Tetrahedra

Stream Control

Store — VBO

Streaming — send primitives



GPU memory consumption

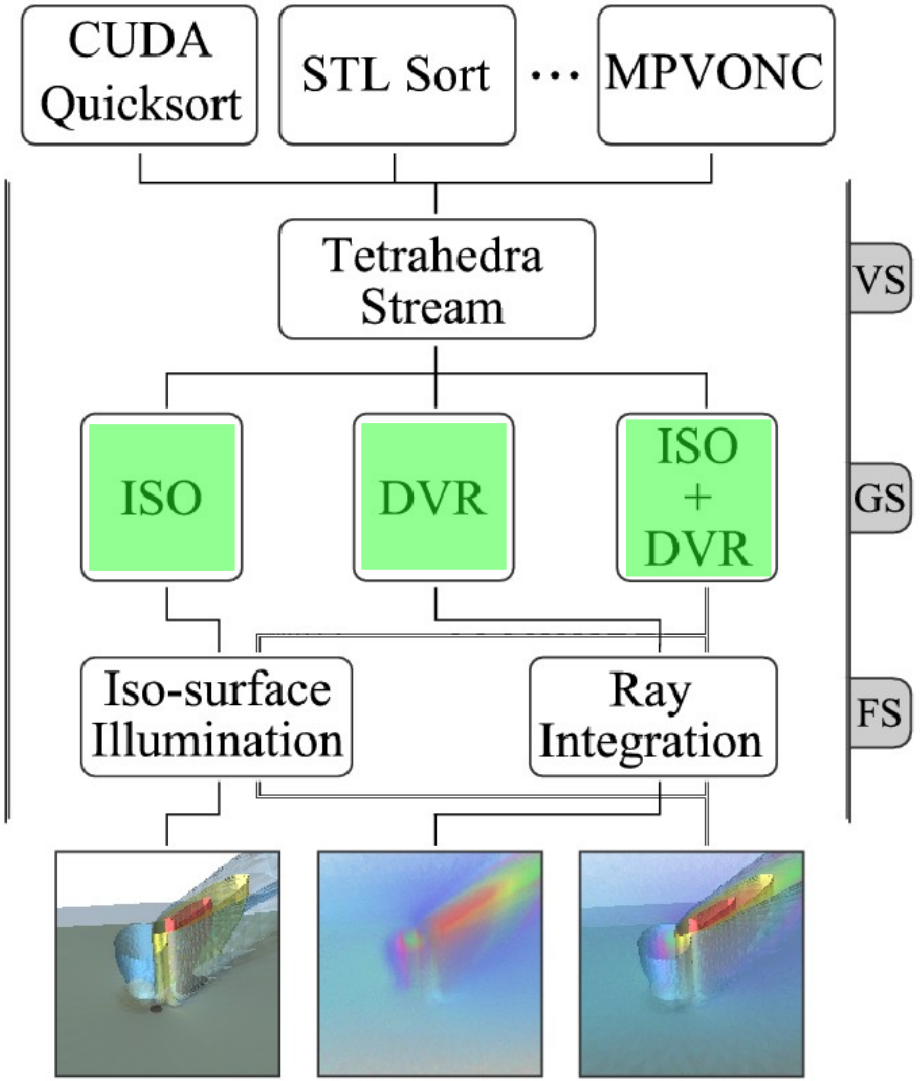
hapt

framework

Hardware-Assisted Projected Tetrahedra

Direct and Indirect Rendering

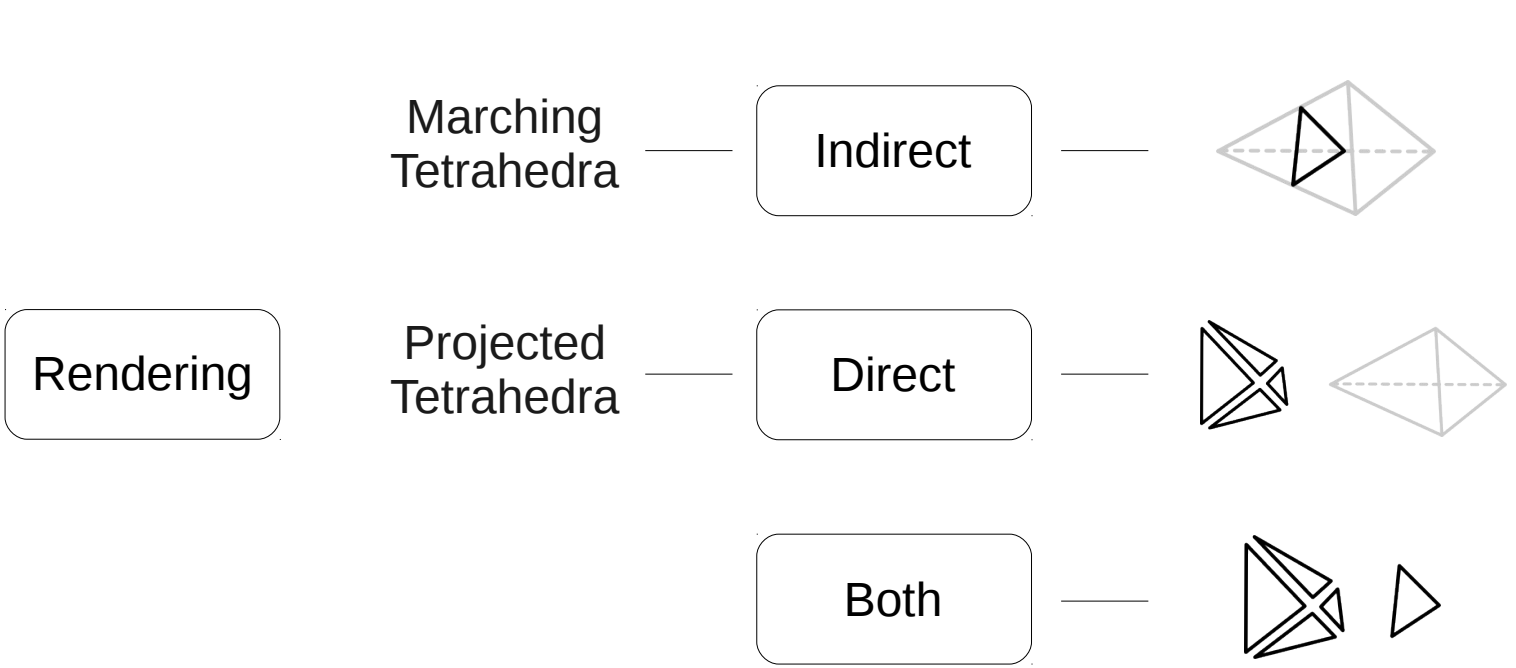
Rendering

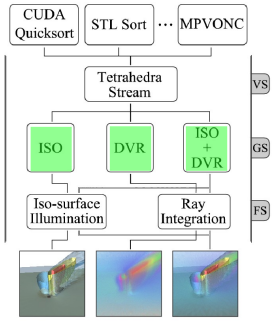


hapt

framework

Hardware-Assisted Projected Tetrahedra

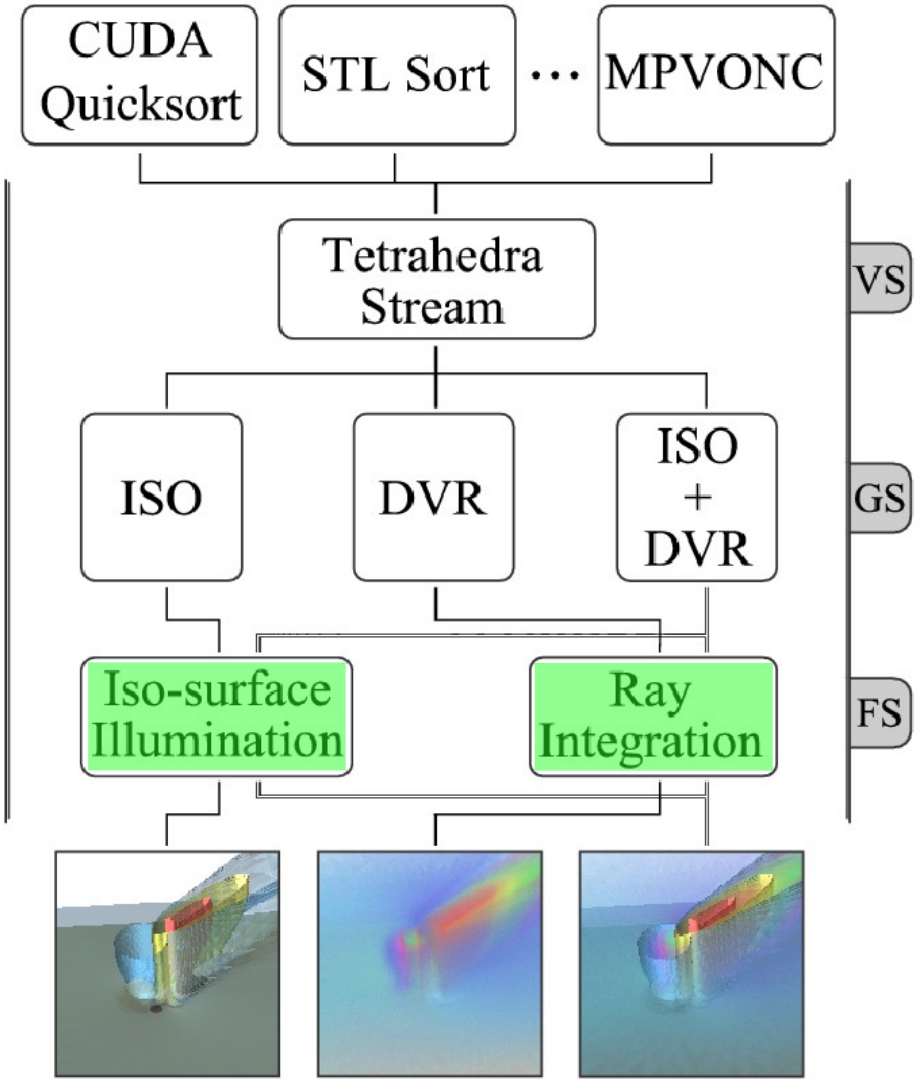




hapt

framework

Hardware-Assisted Projected Tetrahedra



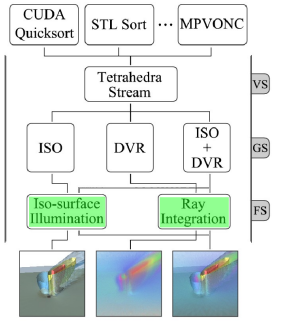
Integration

e.g. Partial Pre-Integration

hapt

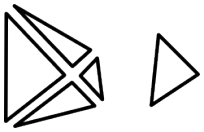
framework

Hardware-Assisted Projected Tetrahedra

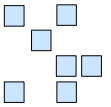


Lighting

Integration

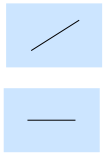


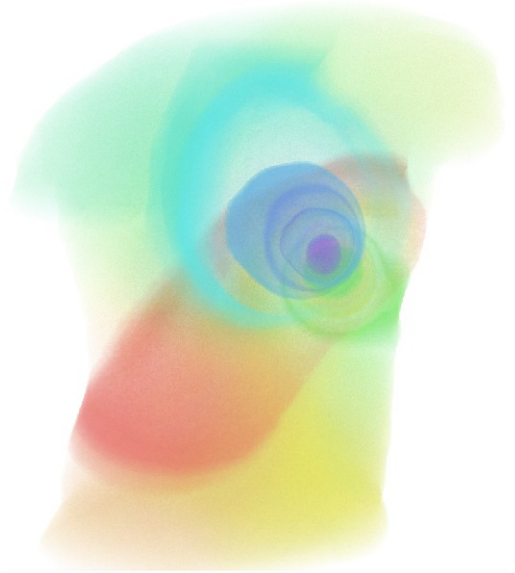
Pre-Integration

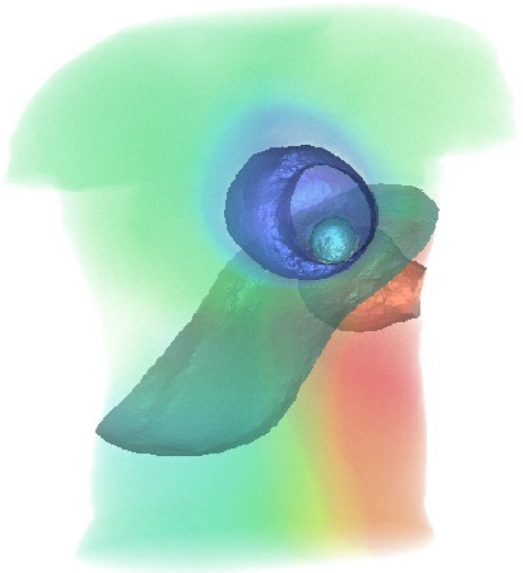


results

timings







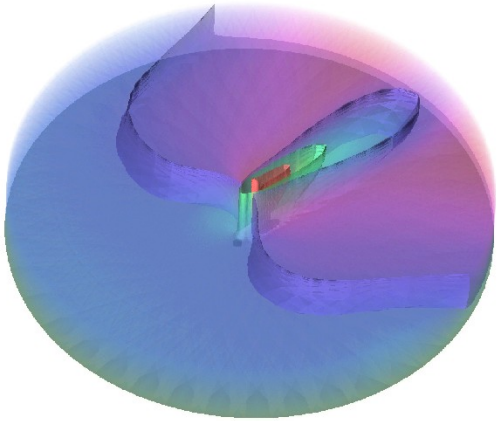
Datasets	Size		*Dir. Vol. Rend.*		*Iso-surface Rend.*		*DVR + ISO*	
	# Verts	*# Tet*	*FPS*	*M Tet/s*	*FPS*	*M Tet/s*	*FPS*	*M Tet/s*
blunt	40 K	187 K	19.2	3.59	25.5	4.78	7.7	1.44
post	110 K	513 K	8.1	4.15	11.9	6.10	3.0	1.51
spx2	150 K	828 K	7.4	6.11	8.2	6.76	1.9	1.57
delta	211 K	1 M	4.5	4.52	6.0	6.01	1.5	1.51
torso	168 K	1.08 M	5.6	6.08	7.2	7.78	1.7	1.82
fighter	256 K	1.40 M	4.2	5.83	5.0	7.06	1.1	1.60
turbjet	212 K	1.01 M	17.5	17.67	n/a	n/a	n/a	n/a

results

sorting

centroid

MPVONC



Dataset	Max. Error	Avg. Error	Diff. Pixels
blunt	1.961%	0.4069%	6.04%
post	2.353%	0.4245%	33.13%
spx2	1.569%	0.3985%	8.13%
delta	5.098%	0.5895%	14.25%
torso	1.176%	0.3933%	1.51%
fighter	1.569%	0.3943%	2.02%

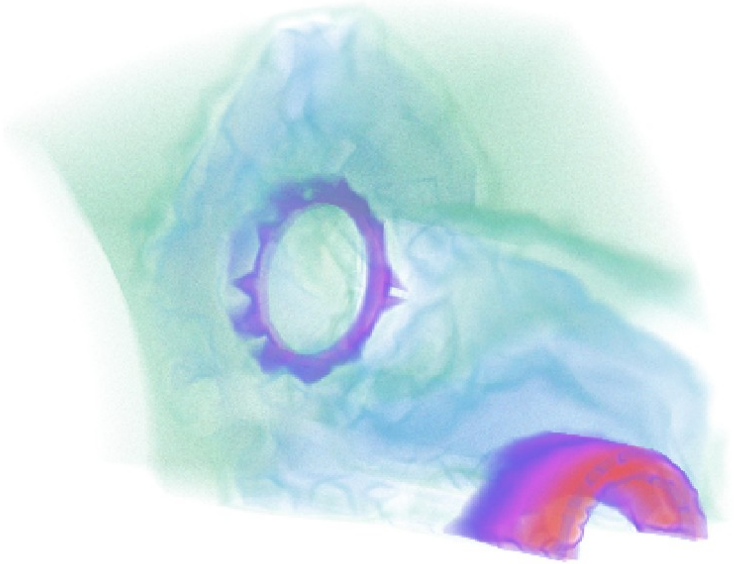
1/3 of the pixels

0.4% ~ 1 unit
[0, 255]

results

comparison

spx2
828 K Tet

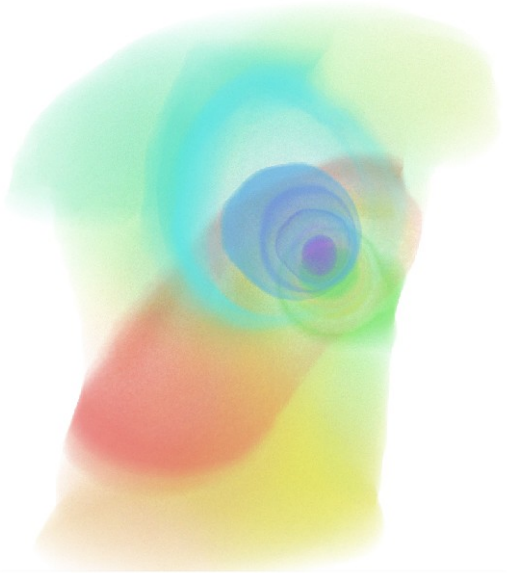


Algorithm	*Sort*	*Draw*	*FPS*	*M Tet/s*
HAPT^{Q}	0.03	0.09	7.4	6.11
HAPT^{B}	0.04	0.09	6.9	5.73
HAPT^{S}	0.08	0.09	5.4	4.50
HAPT^{M}	0.13	0.09	4.4	3.61
HAVS^{2}	0.09	0.11	5.0	4.14
HAVS^{6}	0.09	0.12	4.7	3.94
PTINT	0.19	0.20	2.4	2.06
GATOR	0.08	0.83	1.1	0.93
HARC^{n}	n/a	0.22	4.6	3.82
HARC^{p}	n/a	0.28	3.5	2.90

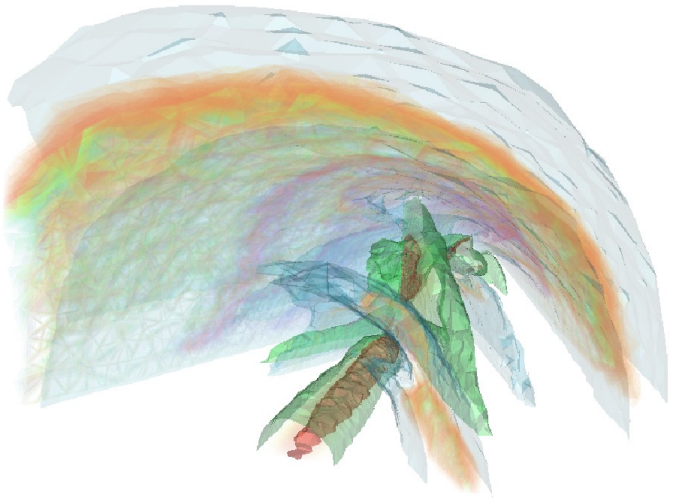
results

comparison

torso



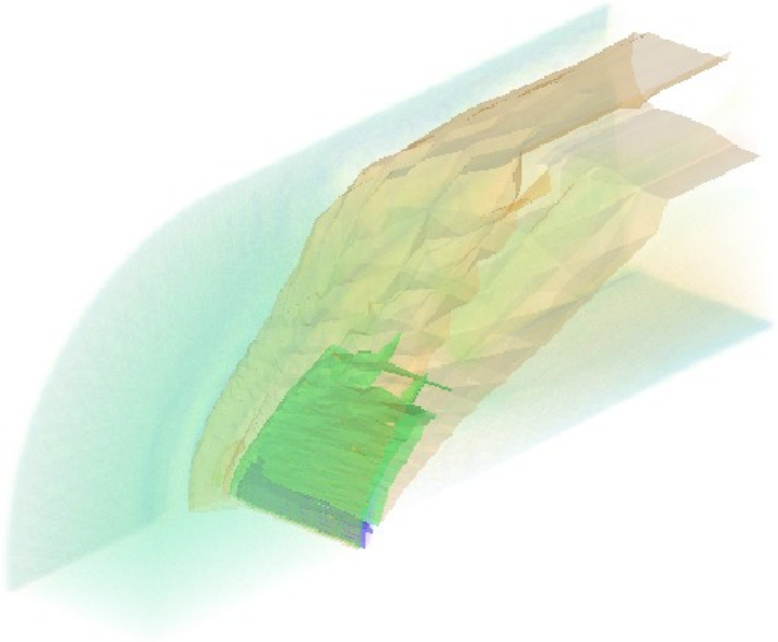
fighter



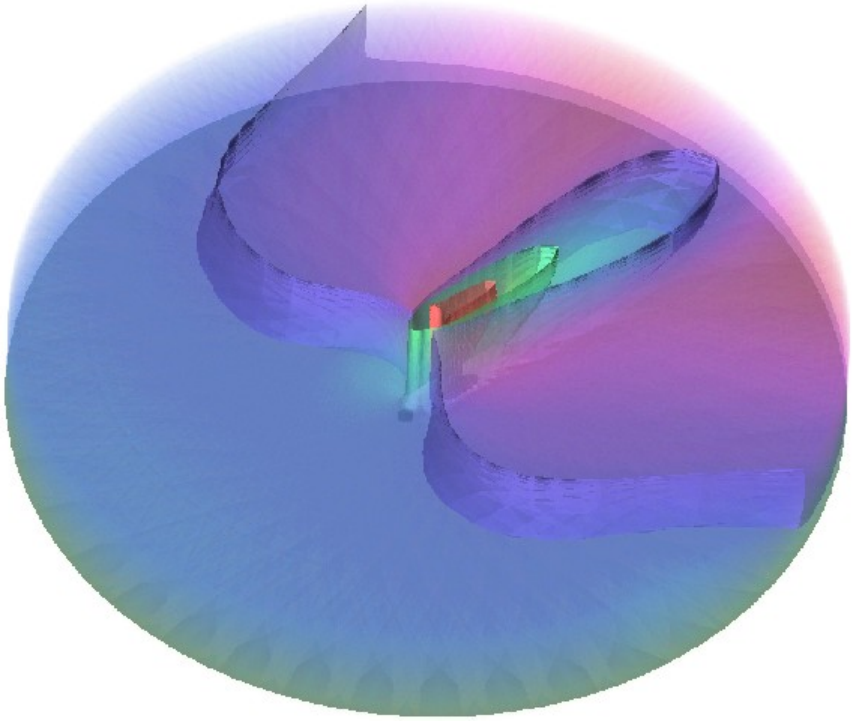
Algorithm	torso 1,082 K Tet		fighter 1,403 K Tet	
	FPS	*M Tet/s*	*FPS*	*M Tet/s*
HAPT^{Q}	5.6	6.08	4.2	5.83
HAPT^{B}	4.3	4.68	3.6	5.09
HAPT^{S}	3.9	4.25	2.9	4.10
HAPT^{M}	1.6	1.73	1.2	1.62
HAVS^{2}	3.7	4.01	2.9	4.12
HAVS^{6}	3.3	3.60	2.7	3.89
PTINT	1.3	1.47	0.9	1.31
GATOR	0.7	0.76	0.4	0.56
HARC^{n}	4.8	5.19	3.8	5.33
HARC^{p}	3.9	4.22	3.0	4.21

results

renderings



blunt fin
187 K Tet
19.2 *fps*



oxygen post
513 K Tet
8.1 *fps*

results

renderings

turbulent jet
1 M Tet per frame
150 frames
17.5 *fps*

results

video

conclusions

pros and cons

Greater flexibility

Fast rendering

Low GPU memory consumption

Direct and Indirect rendering

Render time-varying datasets

Flat shading

Centroid sorting

reproducible research

http://code.google.com/p/hapt

thank you

andmax@cos.ufrj.br

http://code.google.com/p/hapt

Hardware-Assisted Projected Tetrahedra

A. Maximo and R. Marroquim and R. Farias

LCG / PESC / COPPE / University of Rio de Janeiro, Brazil