



REVECTORIZATION-BASED SHADOW MAPPING

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AGENDA

- Introduction;
- Revectorization-Based Shadow Mapping:
 - Revectorization Pipeline;
 - Single-Pass Shadow Map Silhouette Revectorization;
 - Revectorization-Based Shadow Map Silhouette Smoothing;
 - Revectorization-Based Percentage-Closer Filtering;
- Results and Discussion;
- Conclusion and Future Work;



INTRODUCTION

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CONTEXT

No Shadow



Shadow Mapping



CURRENT SCENARIO

Filtering



Low Computational Cost

Silhouette Recovery



High Computational Cost



CONTRIBUTIONS

- We introduce the Revectorization-Based Shadow Mapping (RBSM) for real-time rendering of high-quality, anti-aliased hard shadows;
- Three methods are presented:
 - Shadow Map Silhouette Revectorization (SMSR);
 - Revectorization-Based Shadow Map Silhouette Smoothing (RSMSS);
 - Revectorization-Based Percentage-Closer Filtering (RPCF);



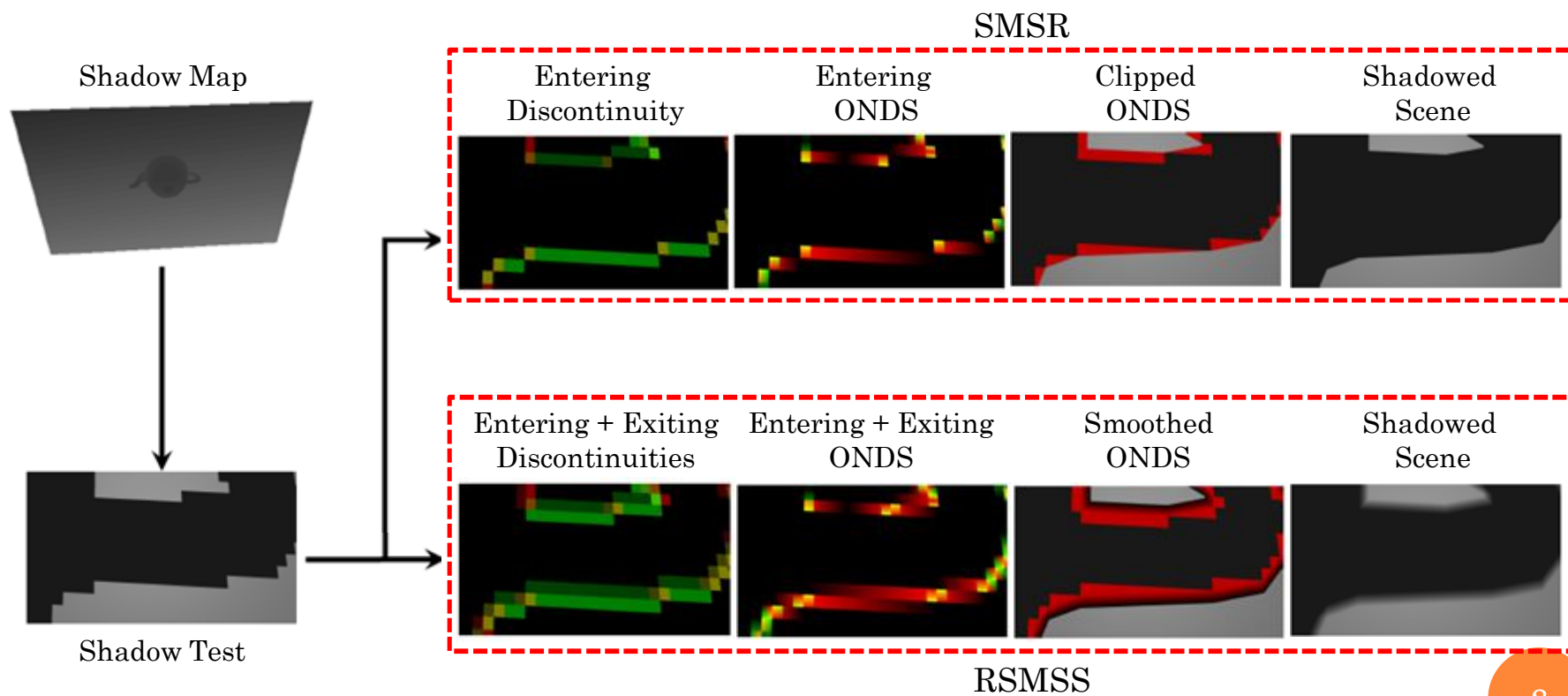
REVECTORIZATION-BASED SHADOW MAPPING

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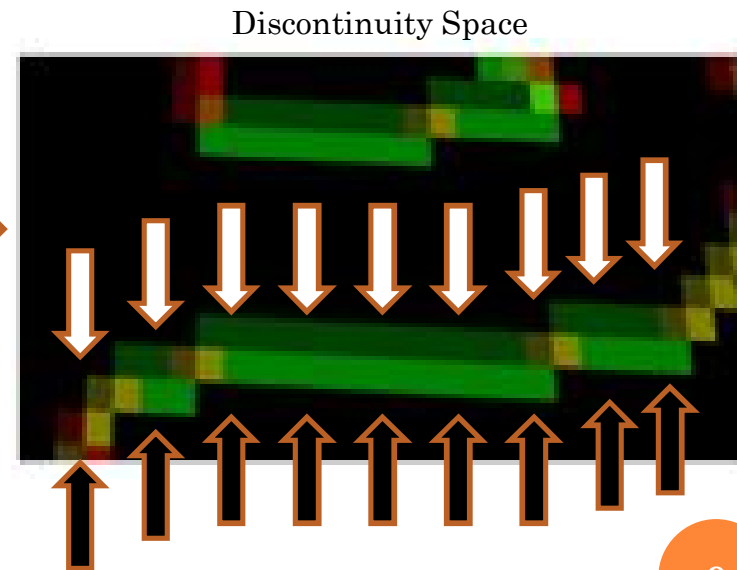
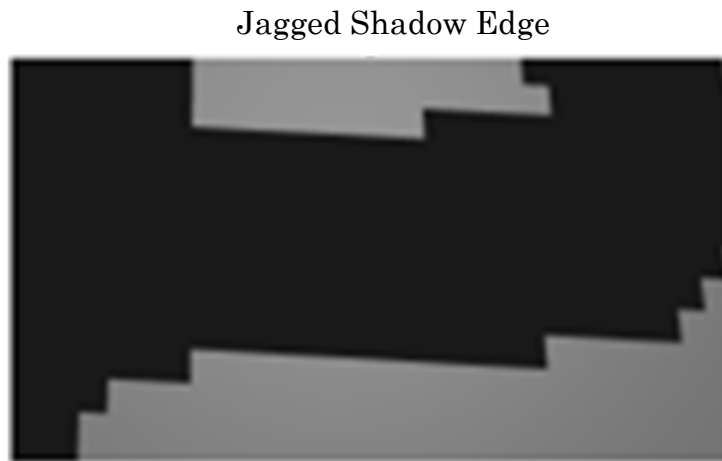
REVECTORIZATION PIPELINE

- Overview:



REVECTORIZATION PIPELINE

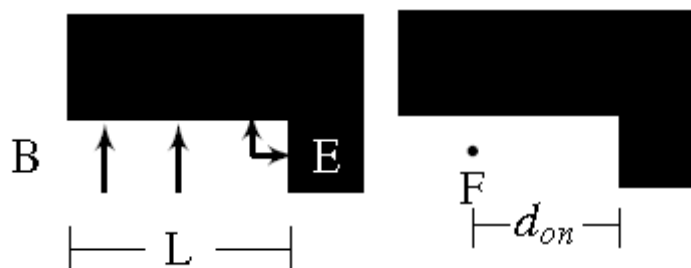
- Discontinuity:
 - Entering;
 - Exiting;



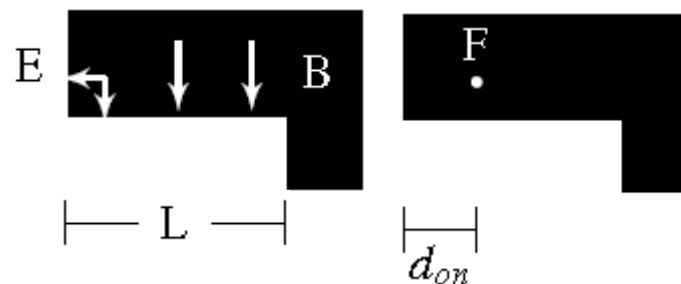
REVECTORIZATION PIPELINE

- Oriented Normalized Discontinuity Space (ONDS):

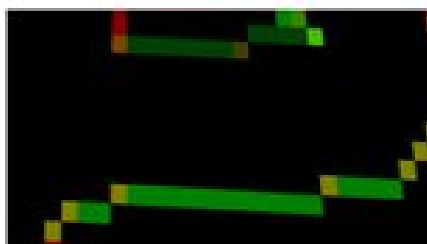
Entering Discontinuity



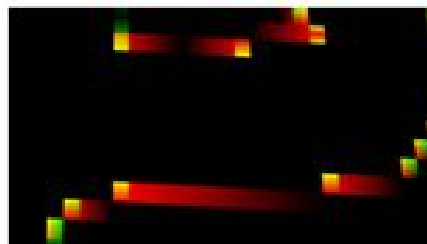
Exiting Discontinuity



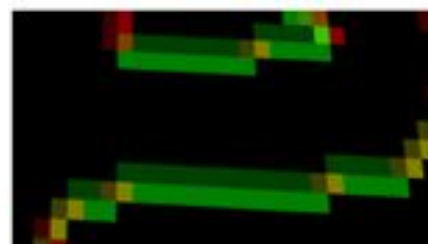
Entering Discontinuity



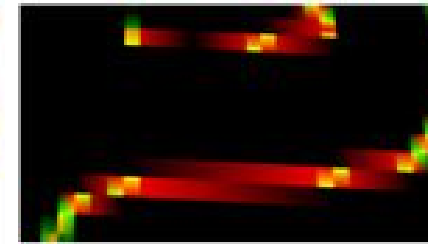
Entering ONDS



Entering + Exiting Discontinuities

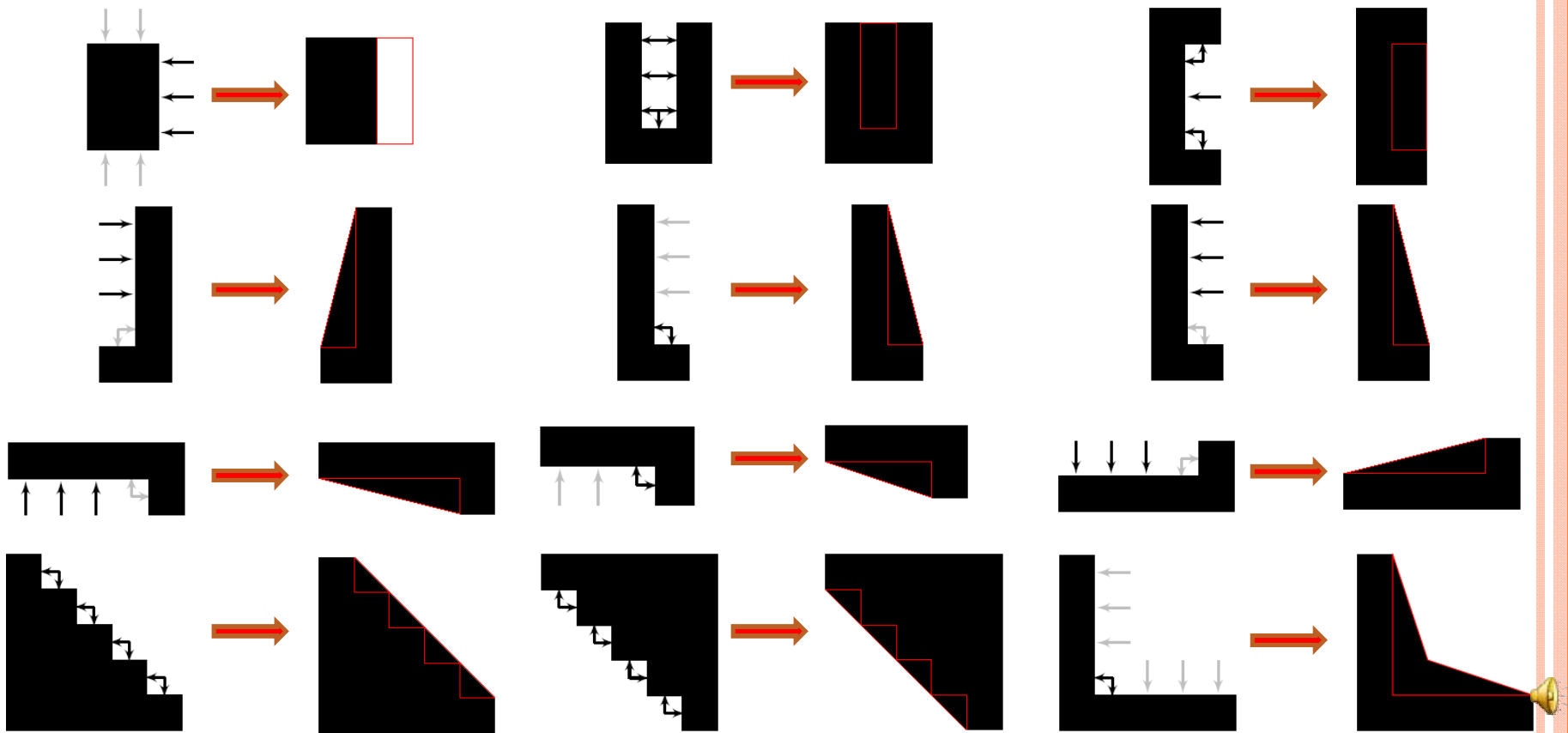


Entering + Exiting ONDS



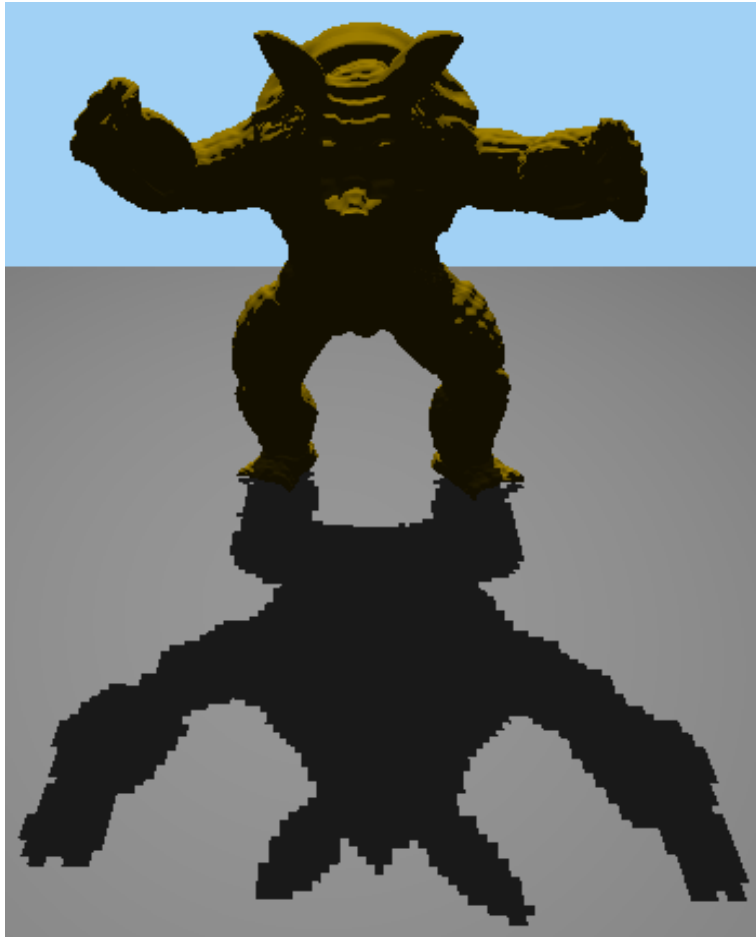
SHADOW MAP SILHOUETTE REVECTORIZATION (SMSR)

- Visibility Function:
 - Deal with 12 different shadowing configurations;

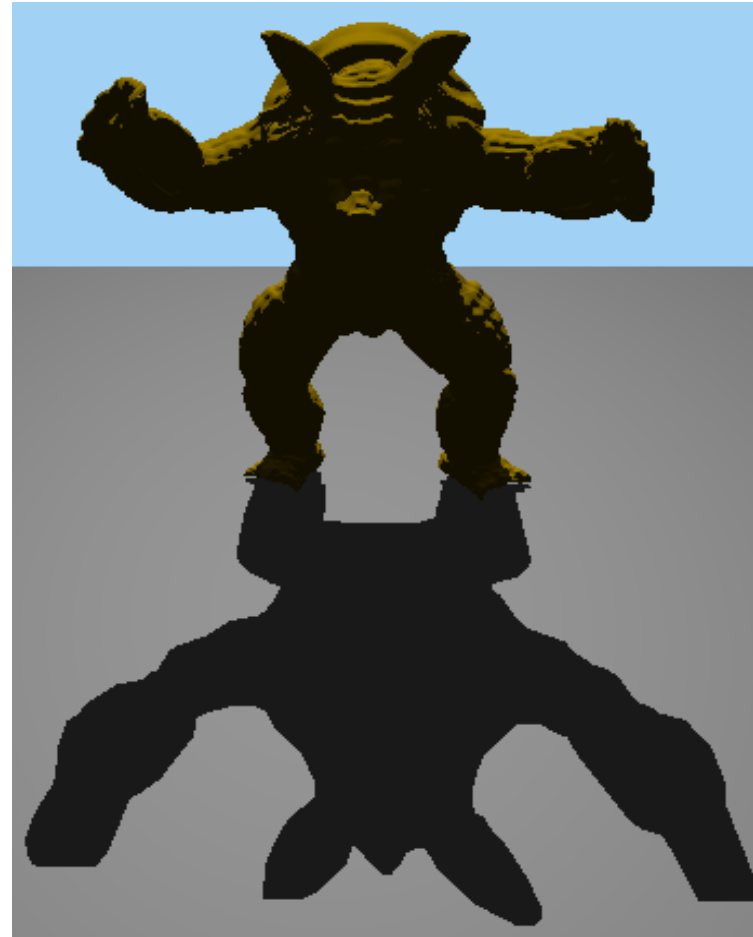


SHADOW MAP SILHOUETTE REVECTORIZATION (SMSR)

Shadow Mapping

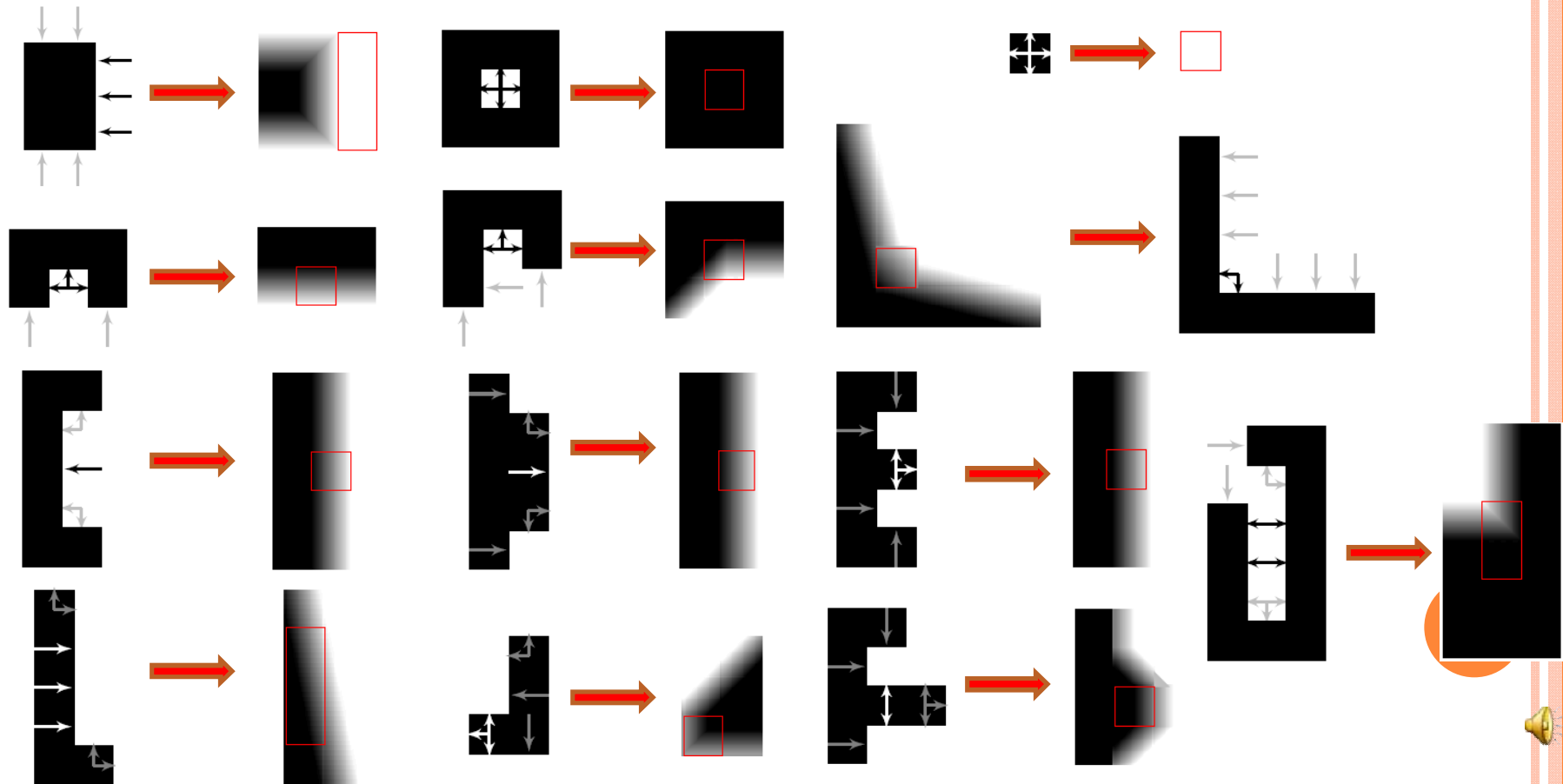


SMSR



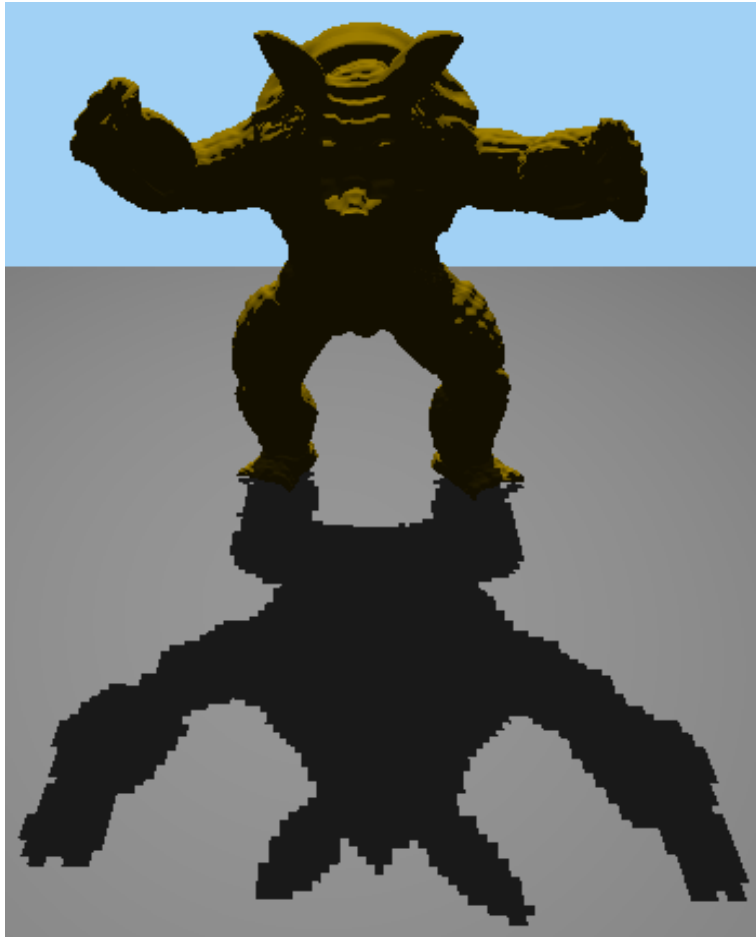
REVECTORIZATION-BASED SHADOW MAP SILHOUETTE SMOOTHING (RSMSS)

- Visibility Function:
 - Deal with 31 different shadowing configurations;



REVECTORIZATION-BASED SHADOW MAP SILHOUETTE SMOOTHING (RSMSS)

Shadow Mapping



RSMSS



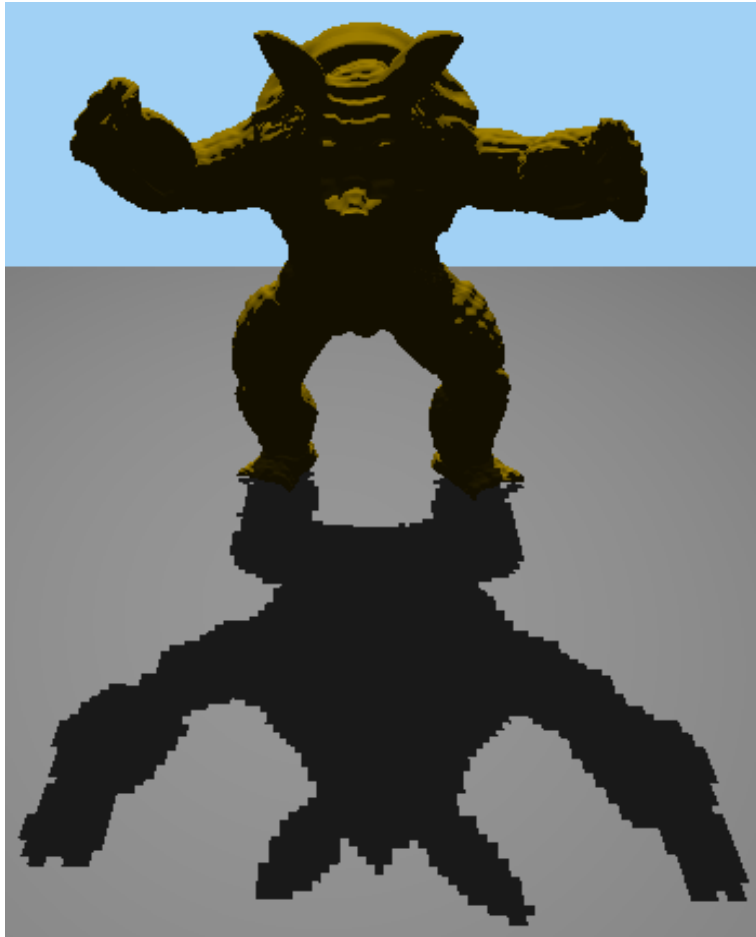
REVECTORIZATION-BASED PERCENTAGE-CLOSER FILTERING (RPCF)

- Goal:
 - Enable control over the filter size;
- Algorithm:
 - Evaluate the revectorization-based visibility function for every texel inside the RPCF kernel;
 - Compute the averaged final shadow intensity;

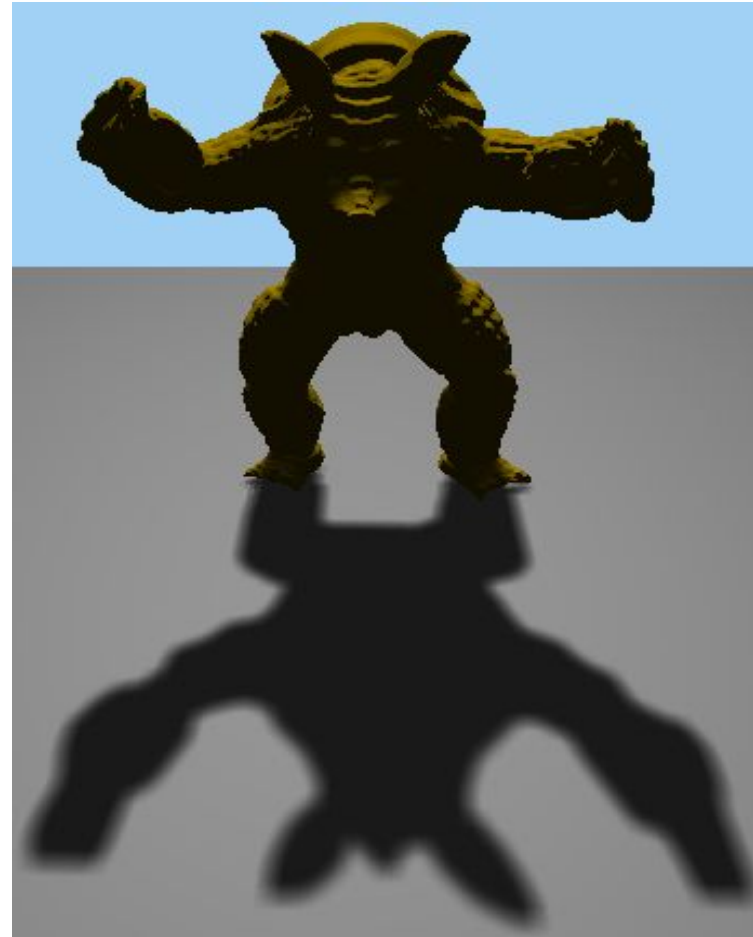


REVECTORIZATION-BASED PERCENTAGE-CLOSER FILTERING (RPCF)

Shadow Mapping



RPCF + RSMSS



RESULTS AND DISCUSSION

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EXPERIMENTAL SETUP

- For all tests we used an Intel® Core™ i7-3770K CPU @3.50Ghz, 8GB RAM, NVIDIA GeForce GTX 660;
- Memory requirements were computed considering the mip-map overhead by a factor 1.3;
- Filtering techniques were tested using a 3x3 box filter;



RENDERING QUALITY

- Temporal Coherence:



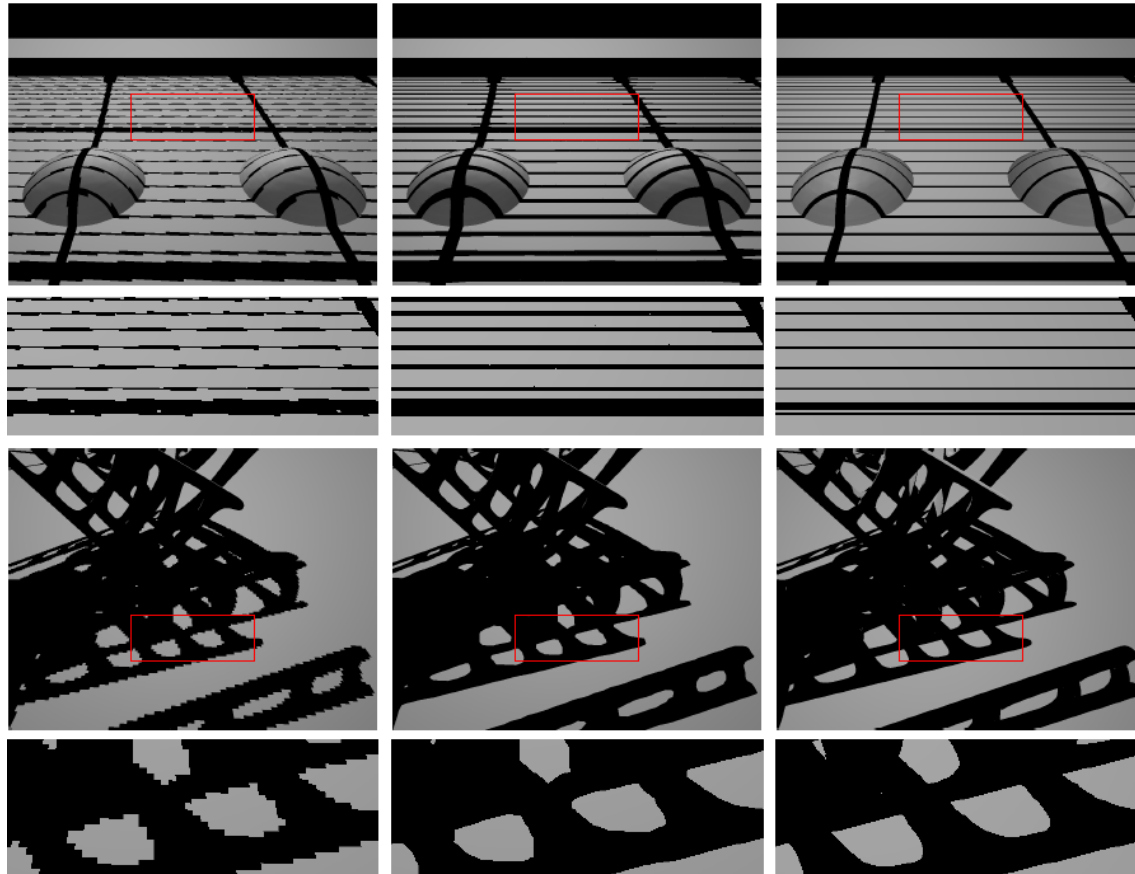
RENDERING QUALITY

- Silhouette Recovery:

Shadow Mapping

SMSR

Shadow Volumes



PERFORMANCE

- Silhouette Recovery:

	Shadow Map Resolution			
Technique	512 ²	1024 ²	2048 ²	4096 ²
Shadow mapping	1.9	2.0	2.4	3.7
SMSR	2.4	2.6	3.3	5.9
Shadow volumes	28.0	28.0	28.0	28.0

	Output Resolution		
Technique	SD	HD	Full HD
Shadow mapping	1.9	2.0	2.3
SMSR	2.2	2.6	3.3
Shadow volumes	25.0	28.0	40.0

	Number of Polygons		
Technique	15 000	100 000	750 000
Shadow mapping	0.6	2.0	10.0
SMSR	0.9	2.6	10.1
Shadow volumes	5.5	28.0	200.0



RENDERING QUALITY

- Filtering:

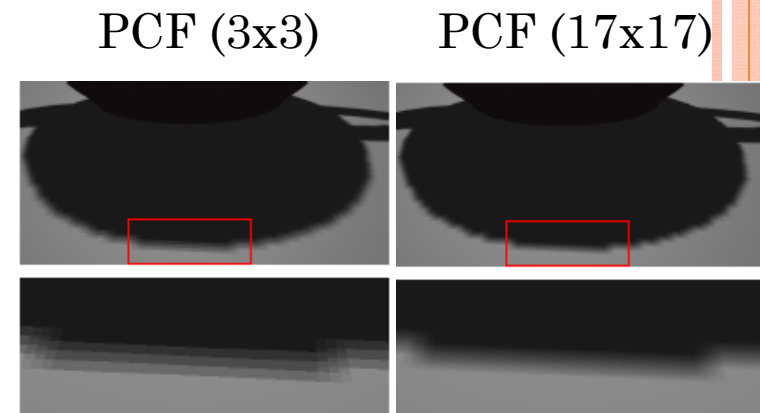
Exponential Blending
Linear Blending
Bilinear Filtering
Trilinear Filtering
Mipmapping



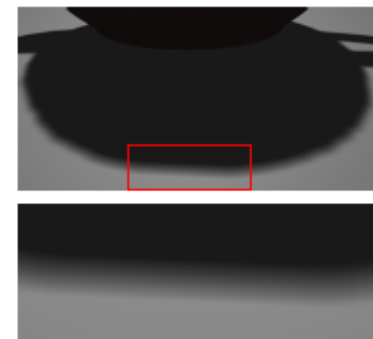
PERFORMANCE

○ Filtering:

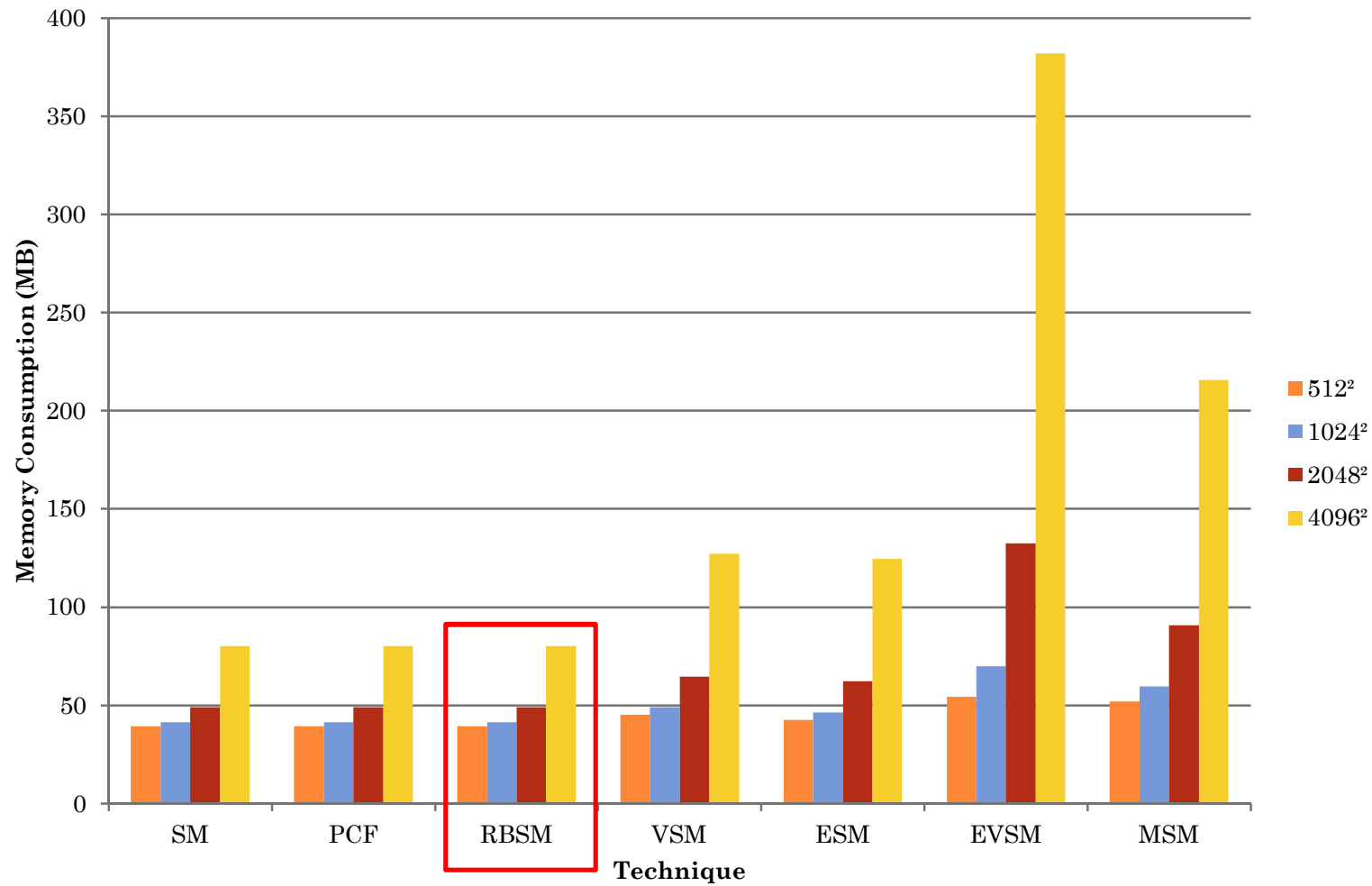
Filter Size	Technique	Shadow Map Resolution			
		512 ²	1024 ²	2048 ²	4096 ²
	Shadow mapping	520	490	410	270
	RSMSS	260	240	210	145
3 × 3	PCF	470	445	410	270
	Pre-filtering	335	295	230	135
	RPCF + SMSR	180	165	145	110
	RPCF + RSMSS	90	85	80	70
10 × 10	PCF	200	180	150	90
	Pre-filtering	300	240	190	115
	RPCF + SMSR	40	36	32	30
	RPCF + RSMSS	13	13	13	13
17 × 17	PCF	85	80	70	40
	Pre-filtering	250	190	160	100
	RPCF + SMSR	20	16	15	13.5
	RPCF + RSMSS	5.5	5.5	5.5	5.5



RPCF + RSMSS (3x3)



MEMORY CONSUMPTION



RENDERING QUALITY

- Fine Details + Complex Crossing Edges:

Tree

Number of triangles: 150 000
Shadow map resolution: 4096 x 4096



CONCLUSION AND FUTURE WORK

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FINAL CONSIDERATIONS

- Conclusion:
 - Our techniques are accurate, provide consistent real-time frame rates, and do not suffer from light leaking artifacts;
 - Our approach is useful for games and other interactive applications;
 - We believe that the RPCF is a good alternative to the PCF algorithm;
- Future Work:
 - Extend the use of revectorization for soft shadows;
 - Improve accuracy by incorporating additional geometric information into the revectorization pipeline;



ACKNOWLEDGMENTS

- We are grateful to:
 - Vladimir Bondarev - for discussing the ideas behind his original implementation of the two-pass SMSR method;
 - CAPES – for financial support;



Thank You!

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