Assisted Object Placement

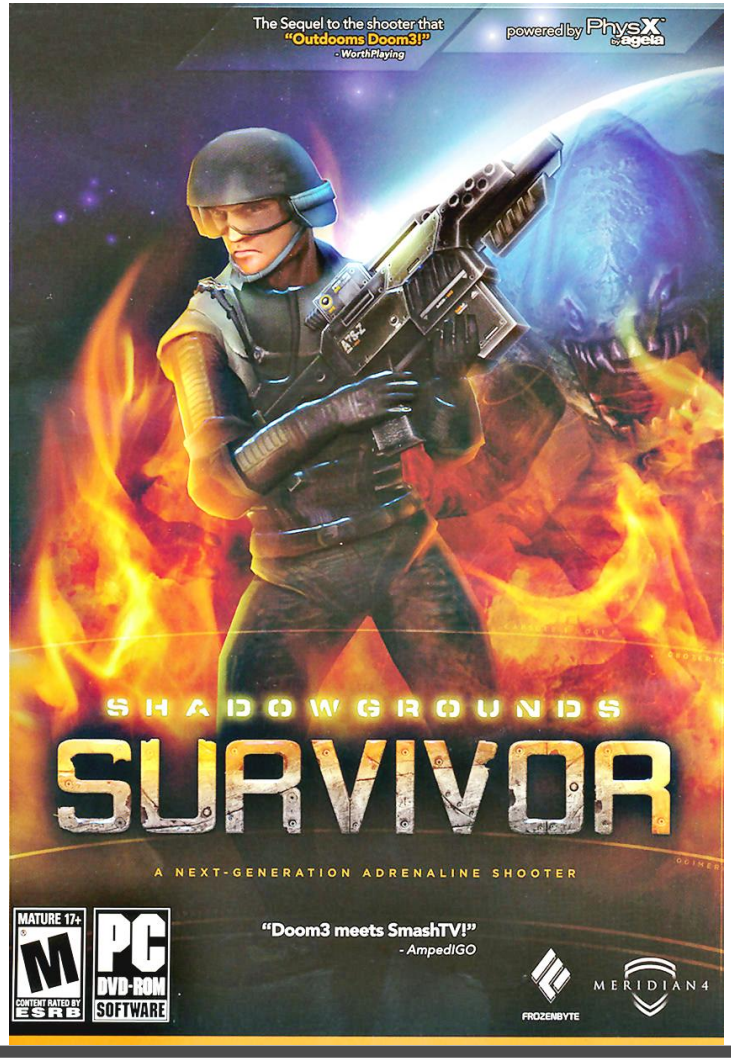
Master's Thesis – Andreas Kirsch

Motivation

Background

Background

Shadowgrounds Survivor

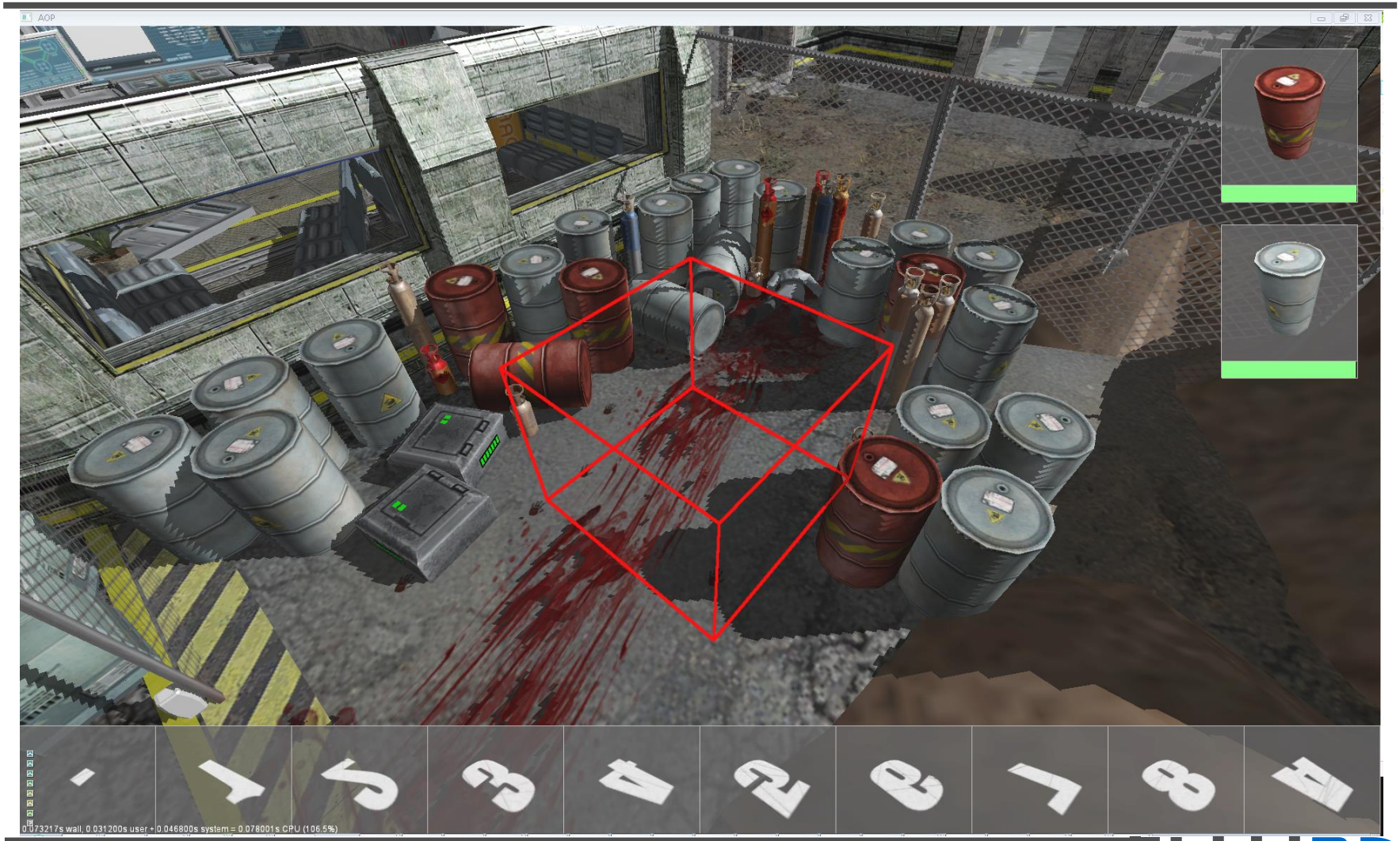


Goals

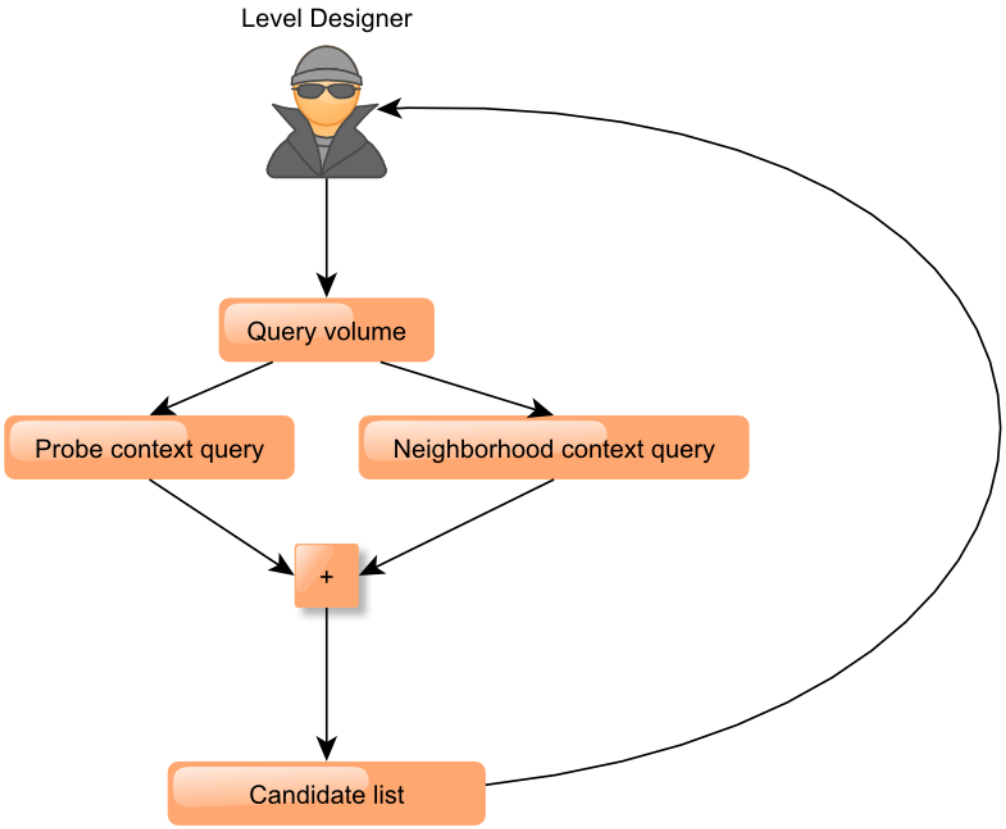
Assisted Object Placement

Andreas Kirsch

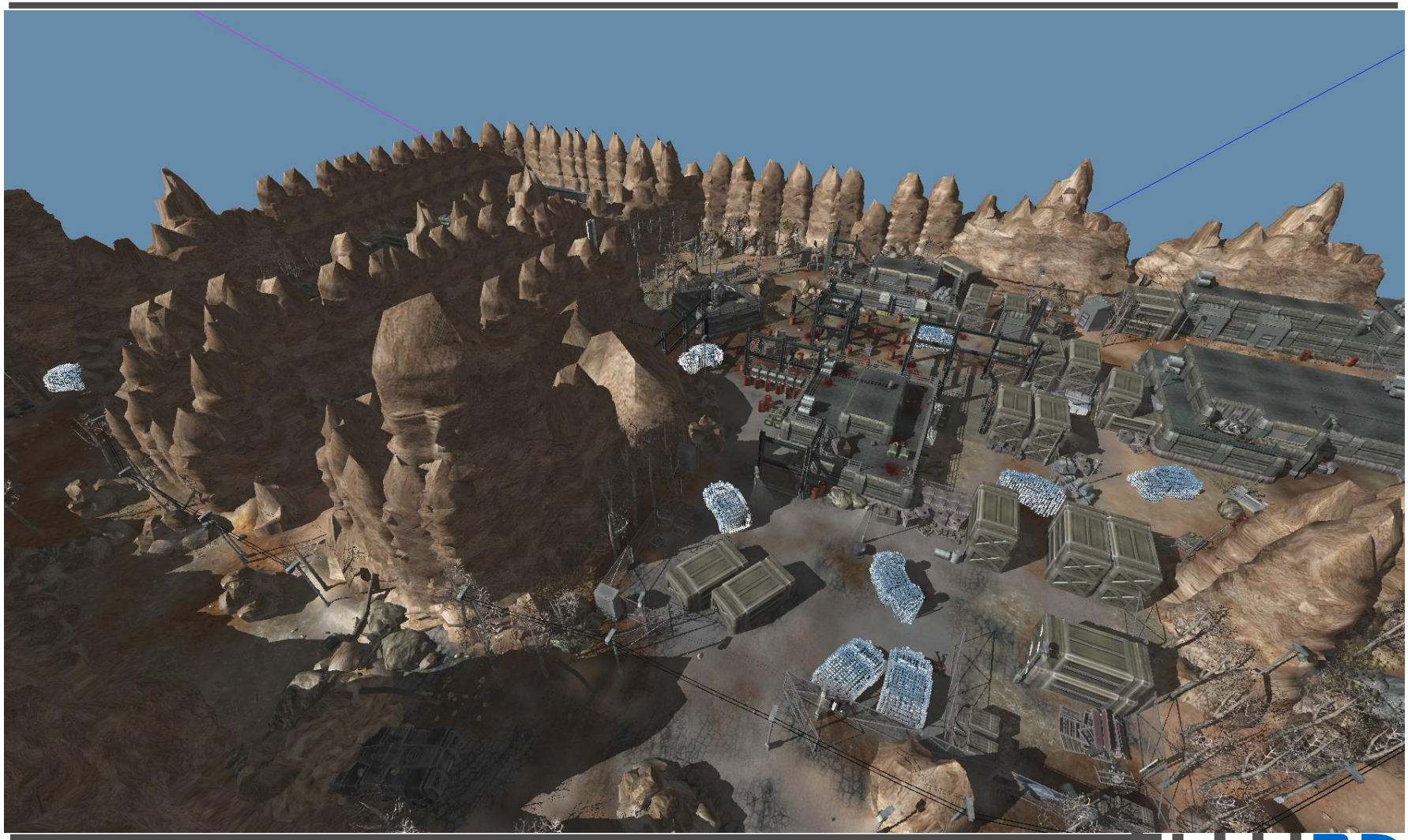
Goals


AOP
0.073217s wall, 0.031200s user + 0.046800s system = 0.078001s CPU (106.5%)

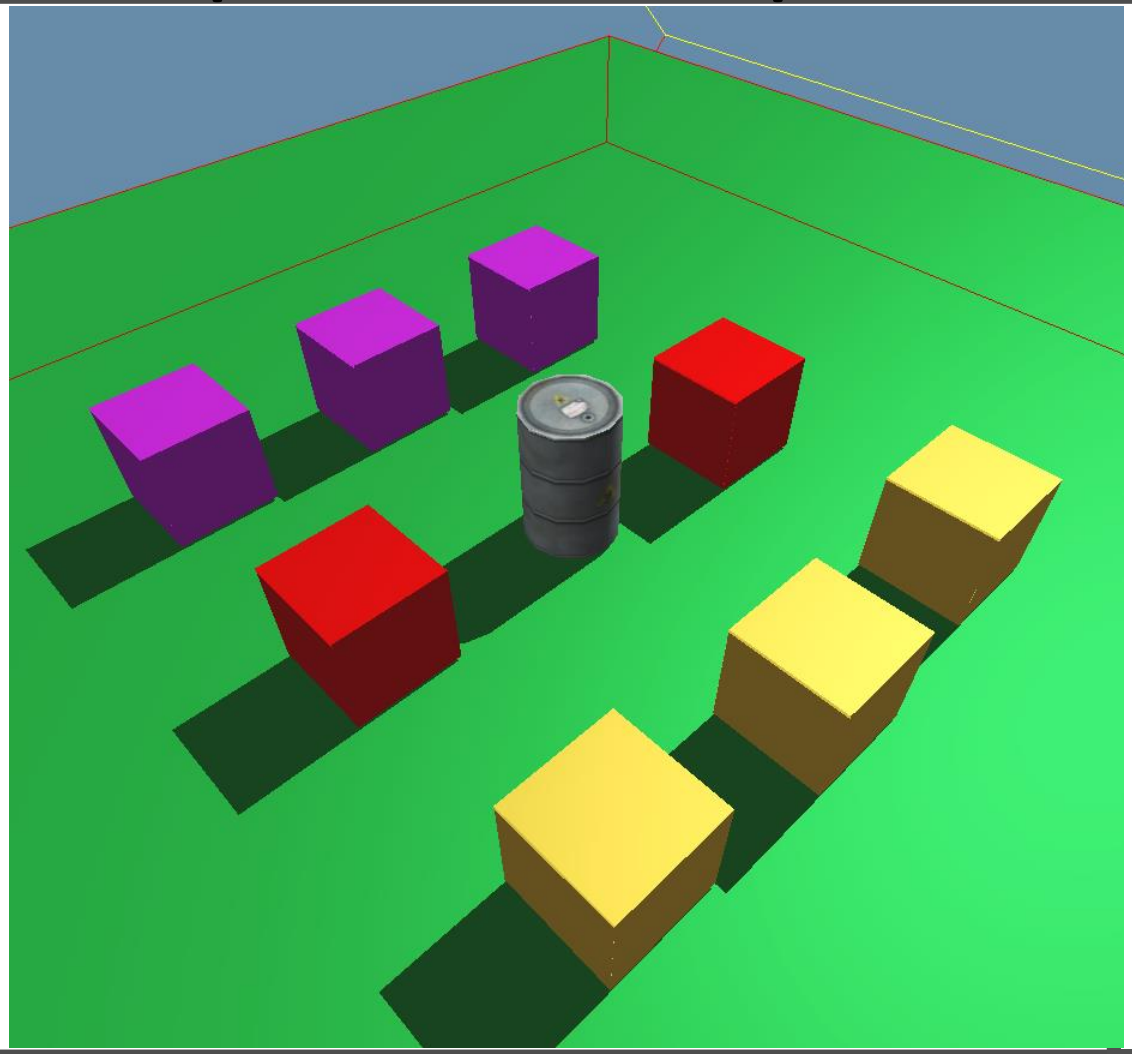
Overview


Level Designer
Query volume
Probe context query
Neighborhood context query
+
Candidate list

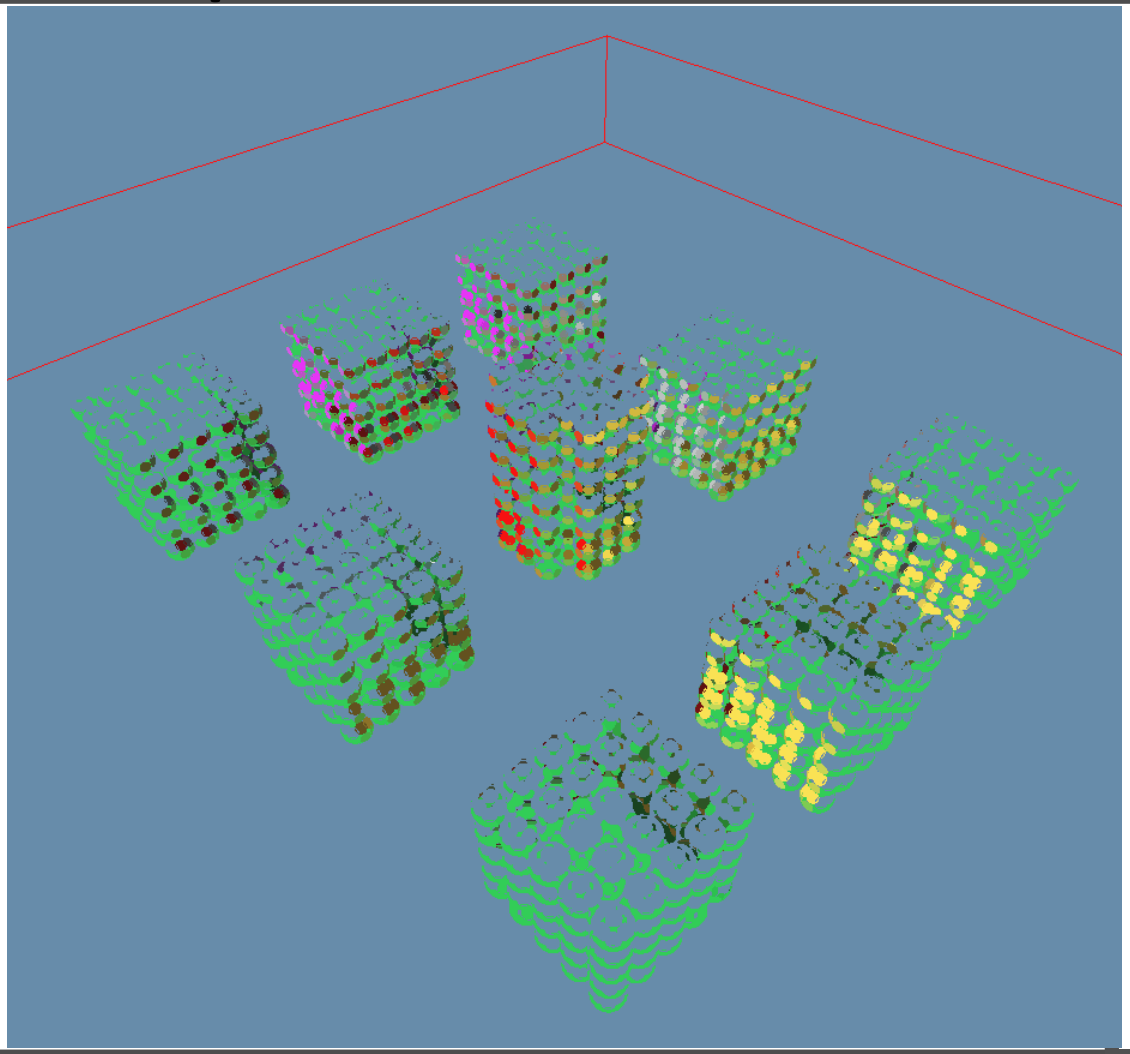
Probe context



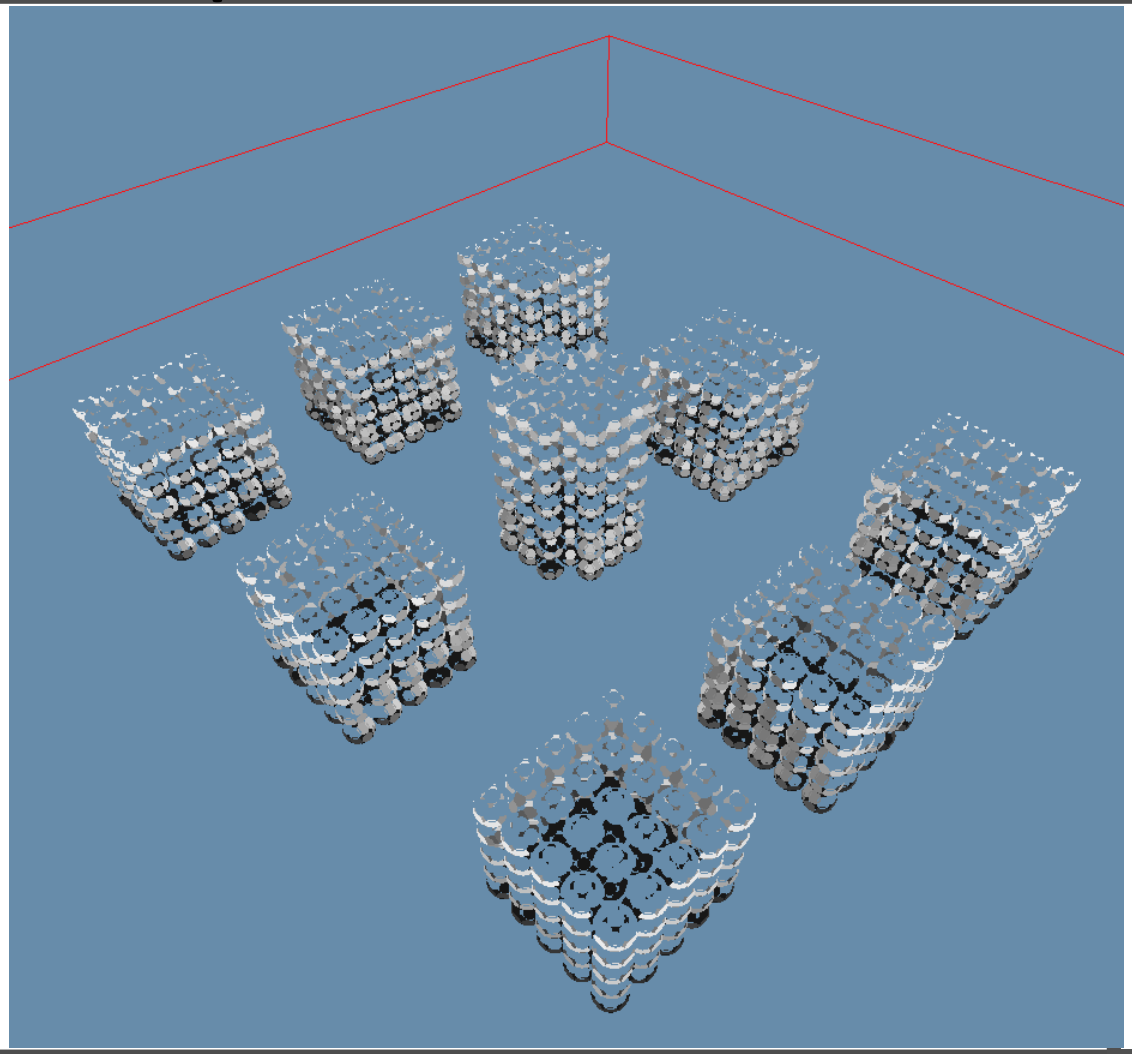
Probe samples – Example



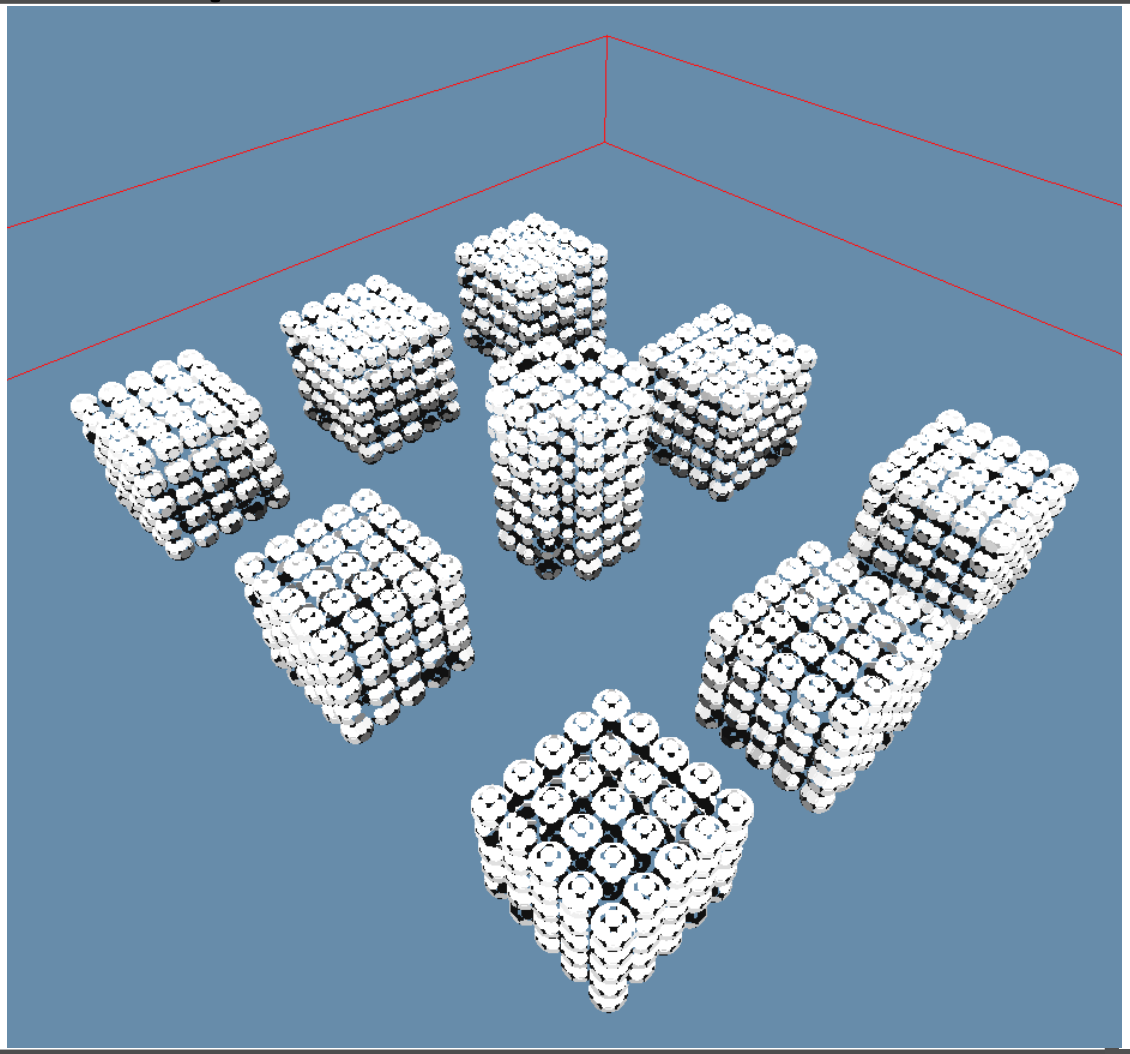
Probe samples – Color



Probe samples – Distance

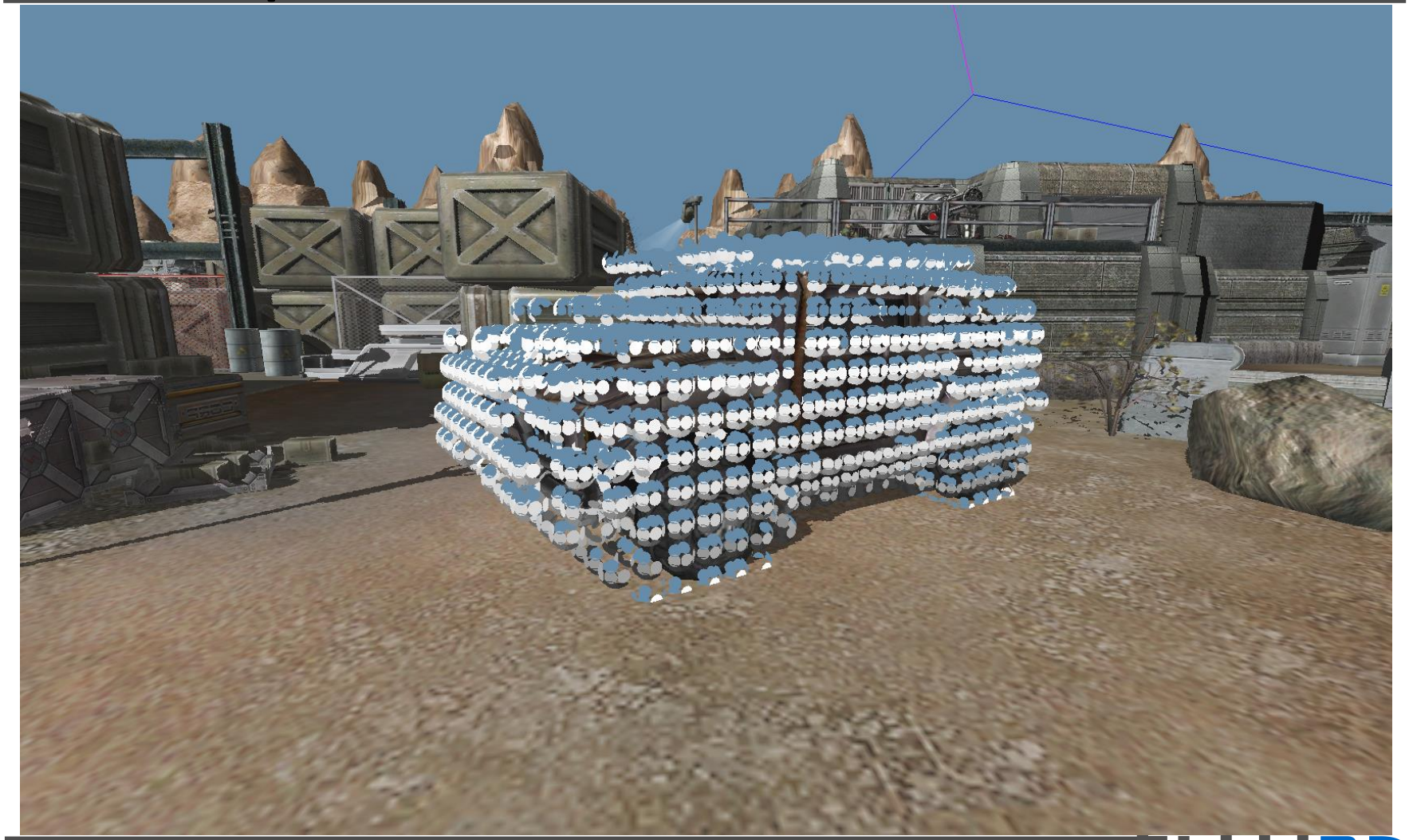


Probe samples – Occlusion

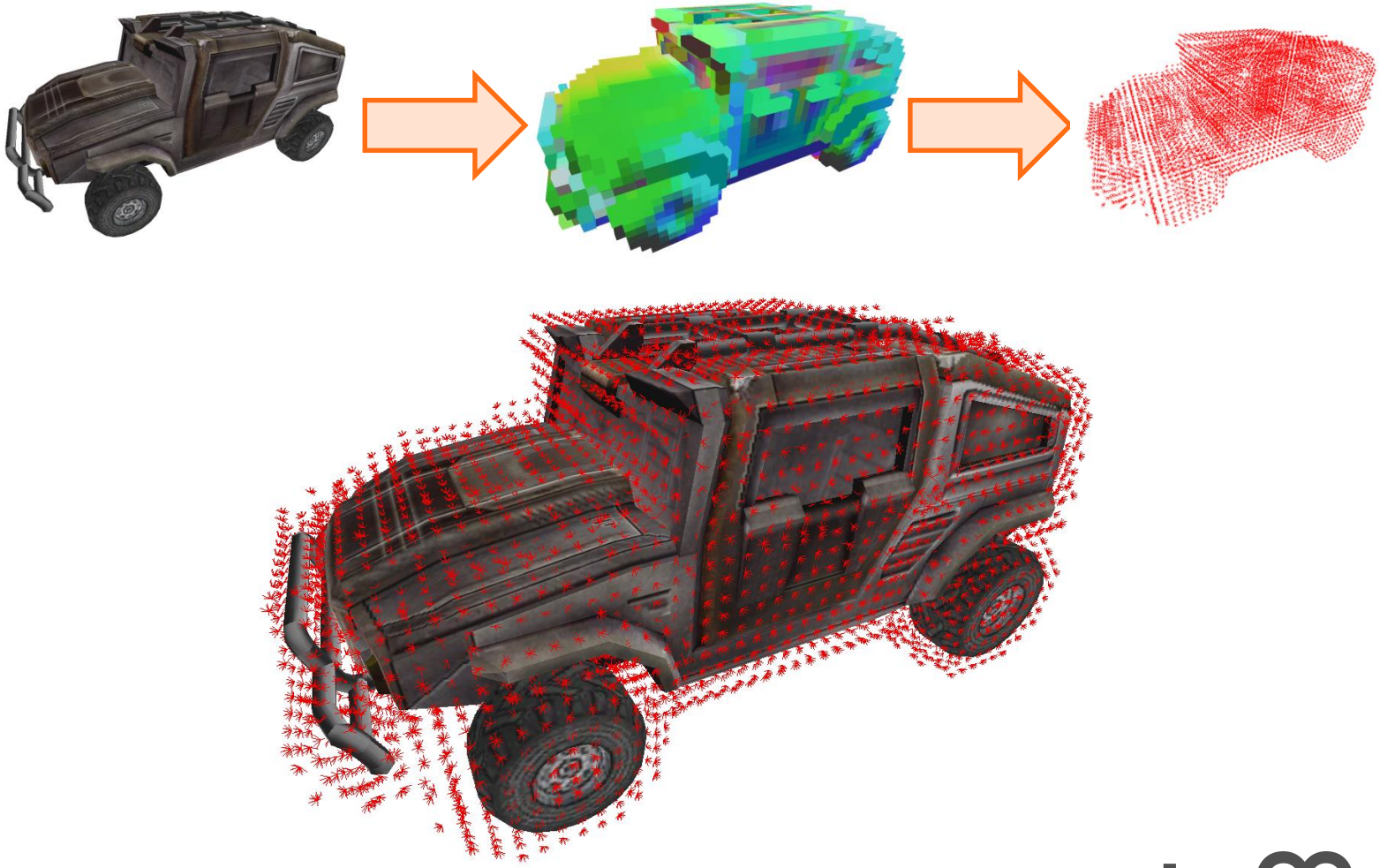


Probe placement

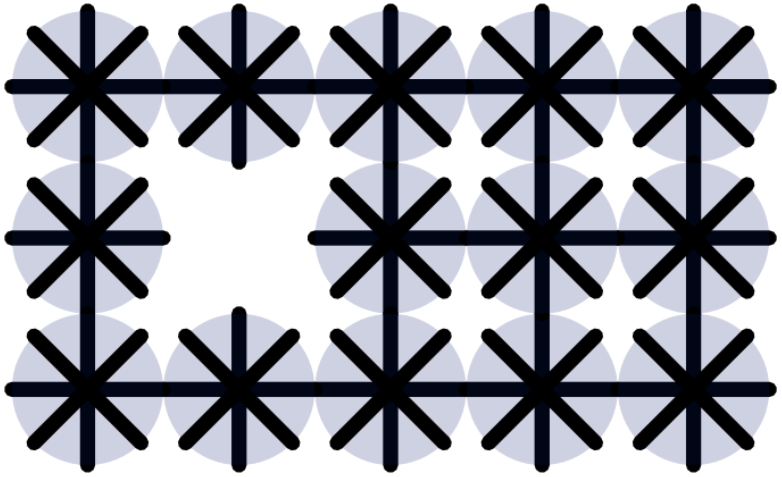
Probe placement



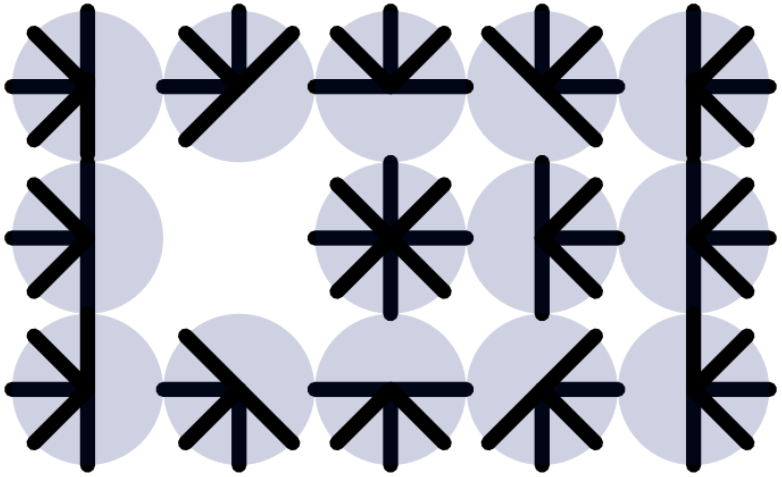
Probe placement



Probe placement – All directions

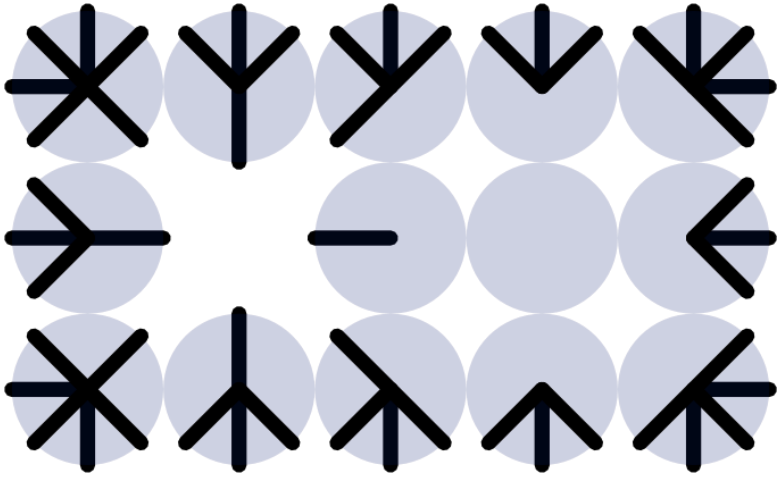


Probe placement – Relative position

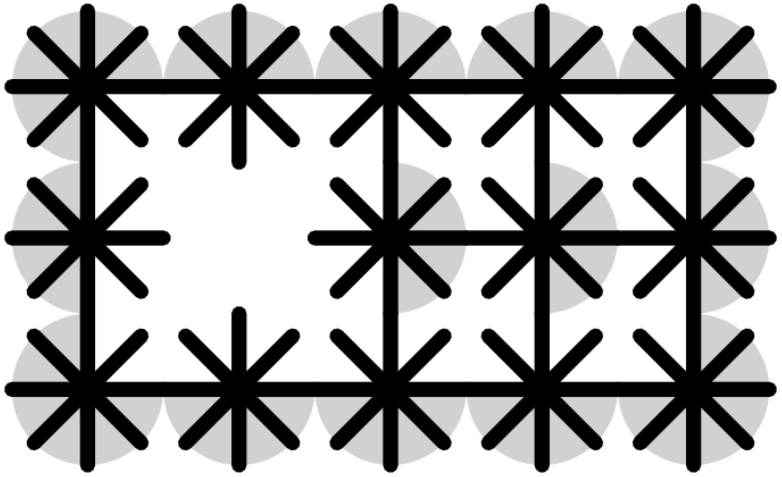


Probe placement – Neighbors

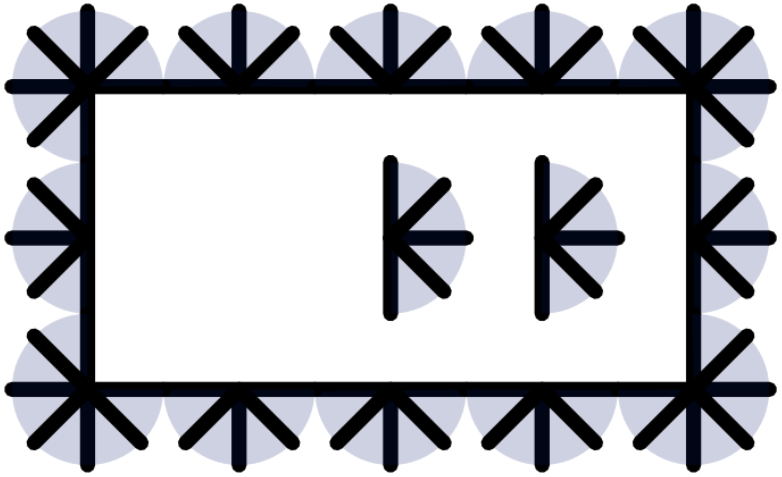
Probe placement – Neighbors



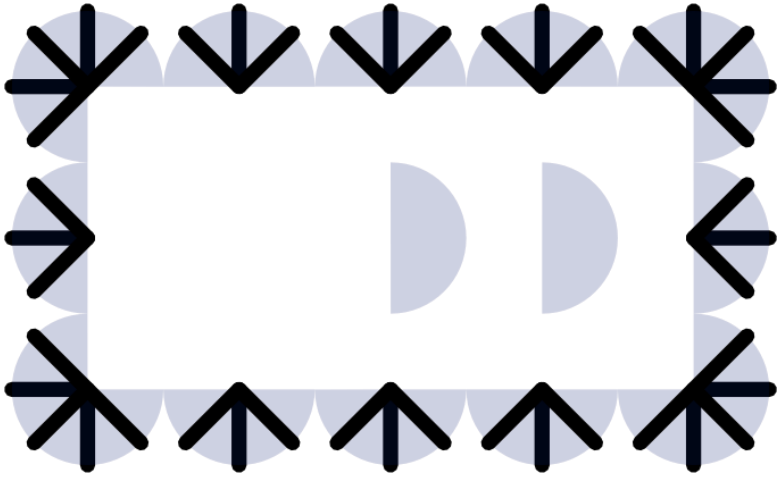
Probe placement – Avg normals



Probe placement – Avg normals

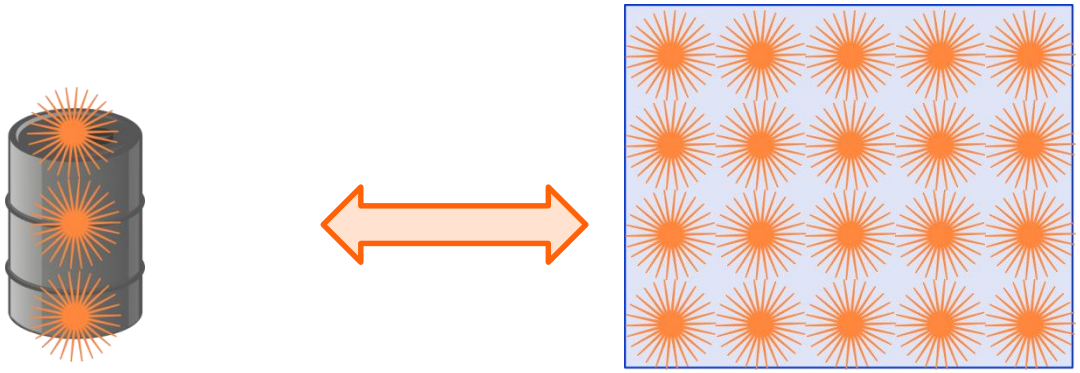


Probe placement – Combined

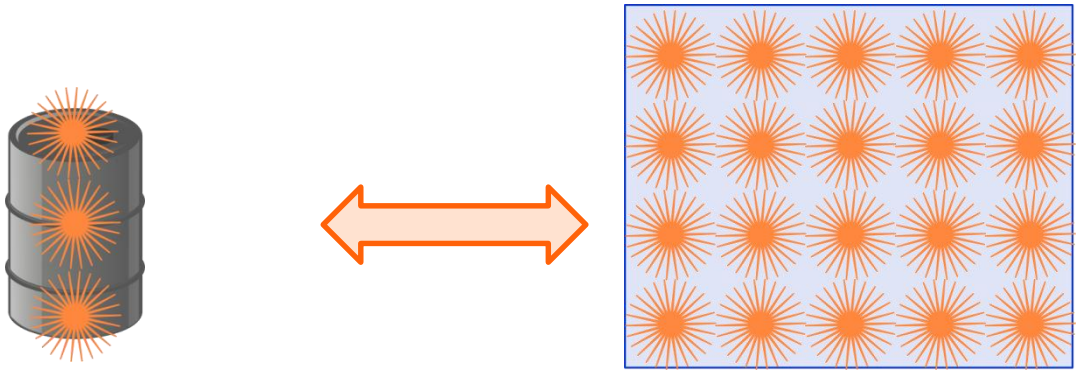


Queries

Bidirectional match query

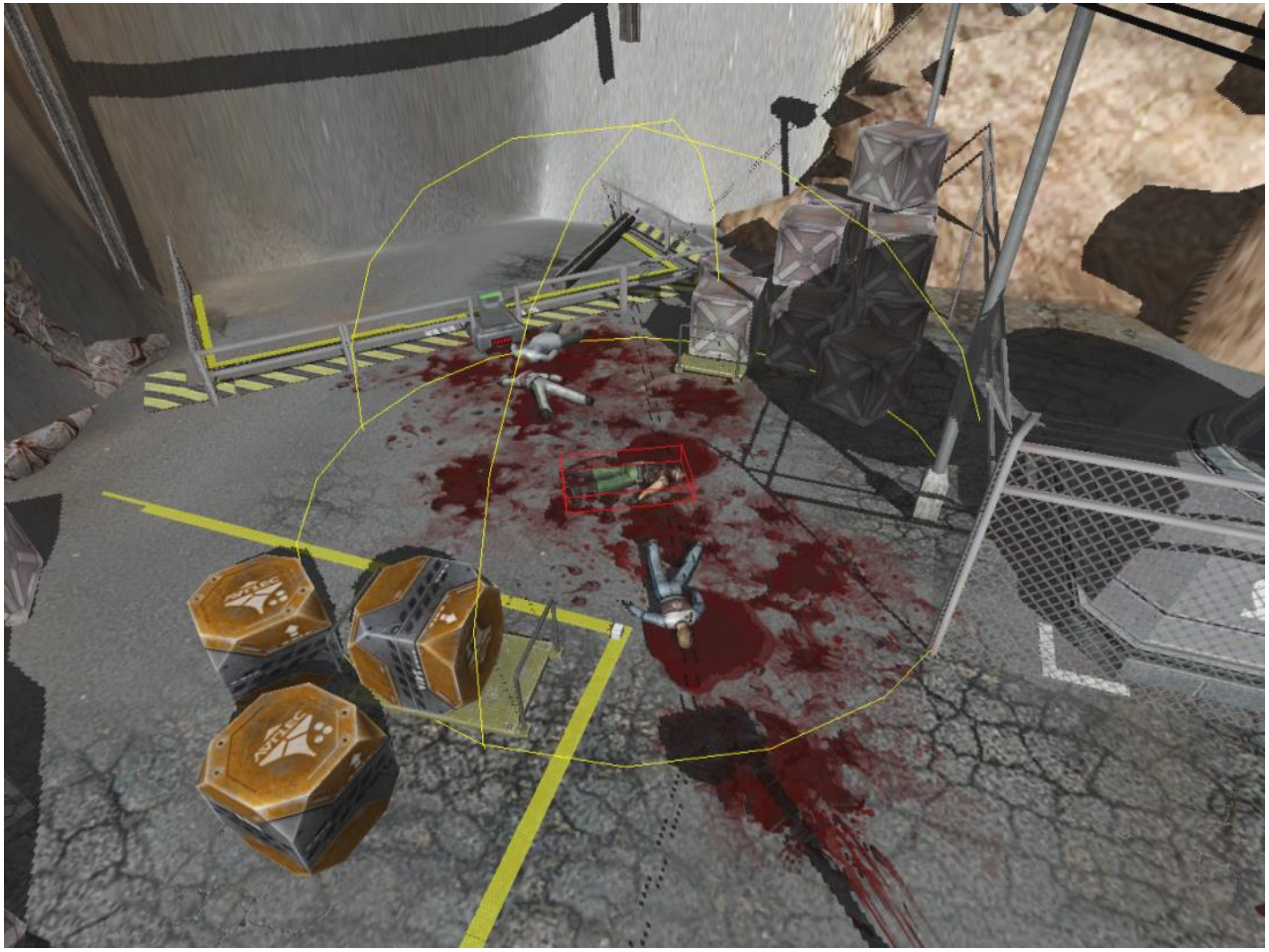


Bidirectional match query

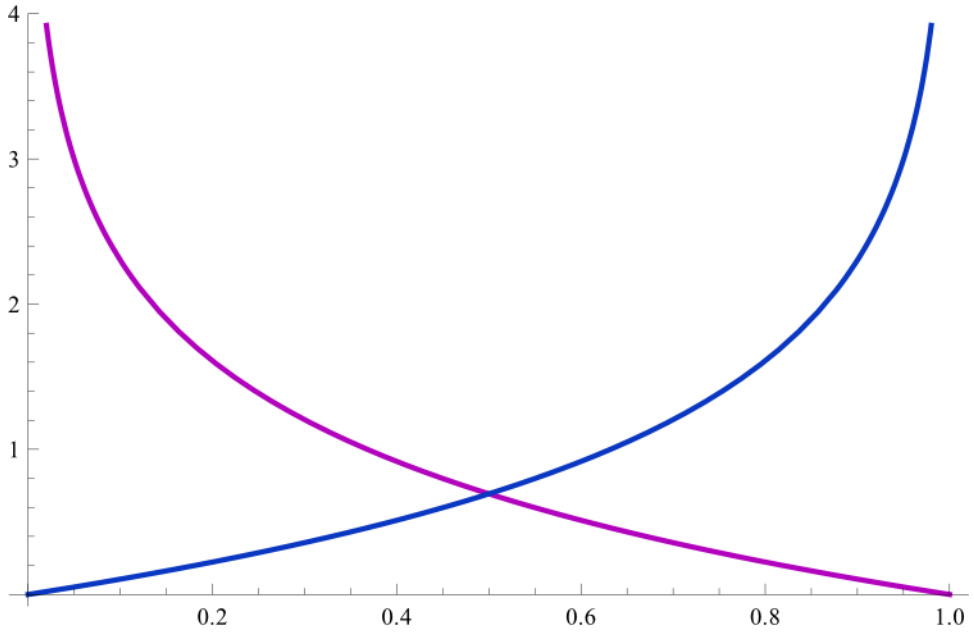


$$S = \frac{\#\text{matches model}}{\#\text{samples model}} \cdot \frac{\#\text{matches query}}{\#\text{samples query}}$$

Importance-weighted queries

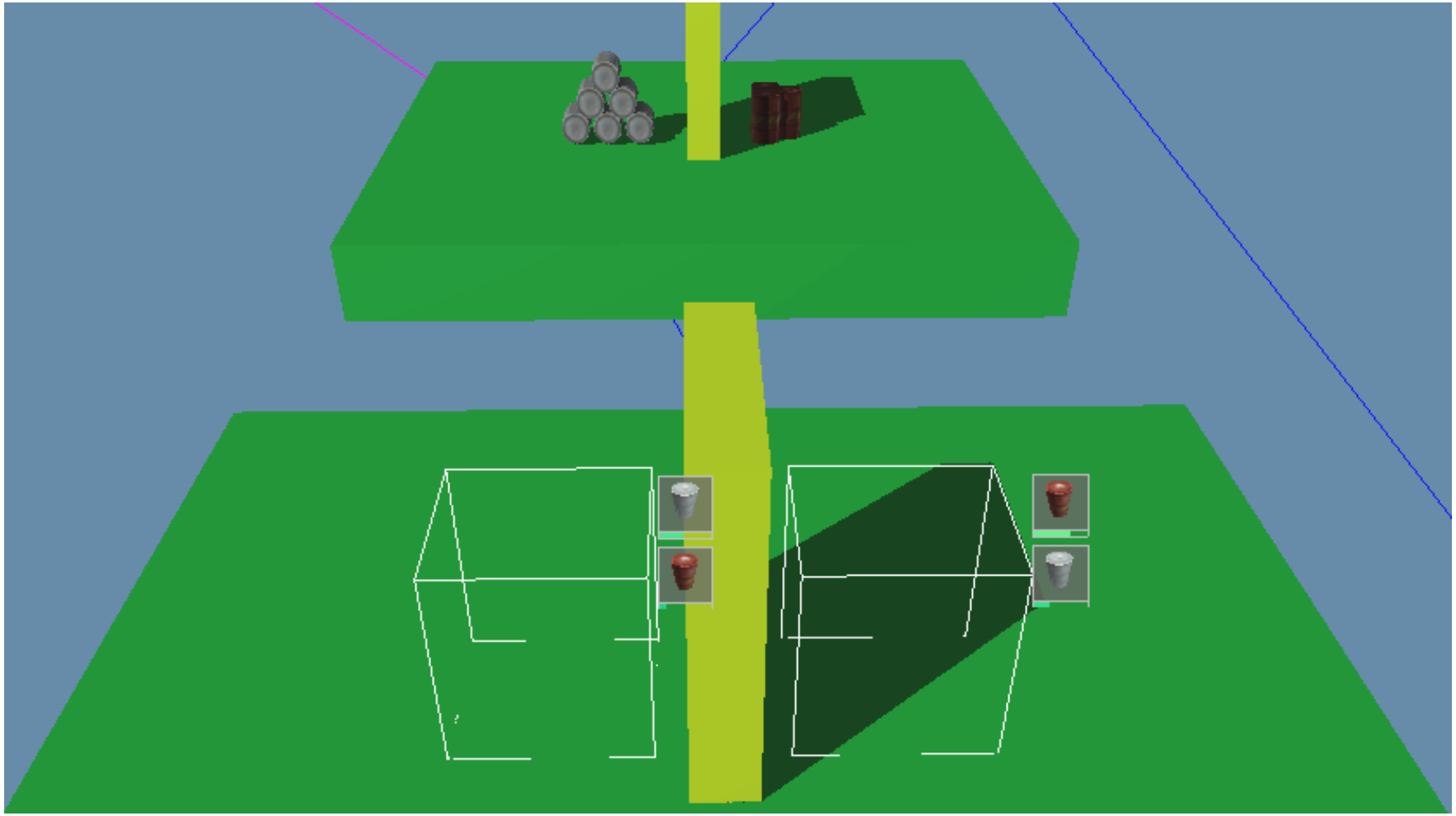


Importance-weighted queries

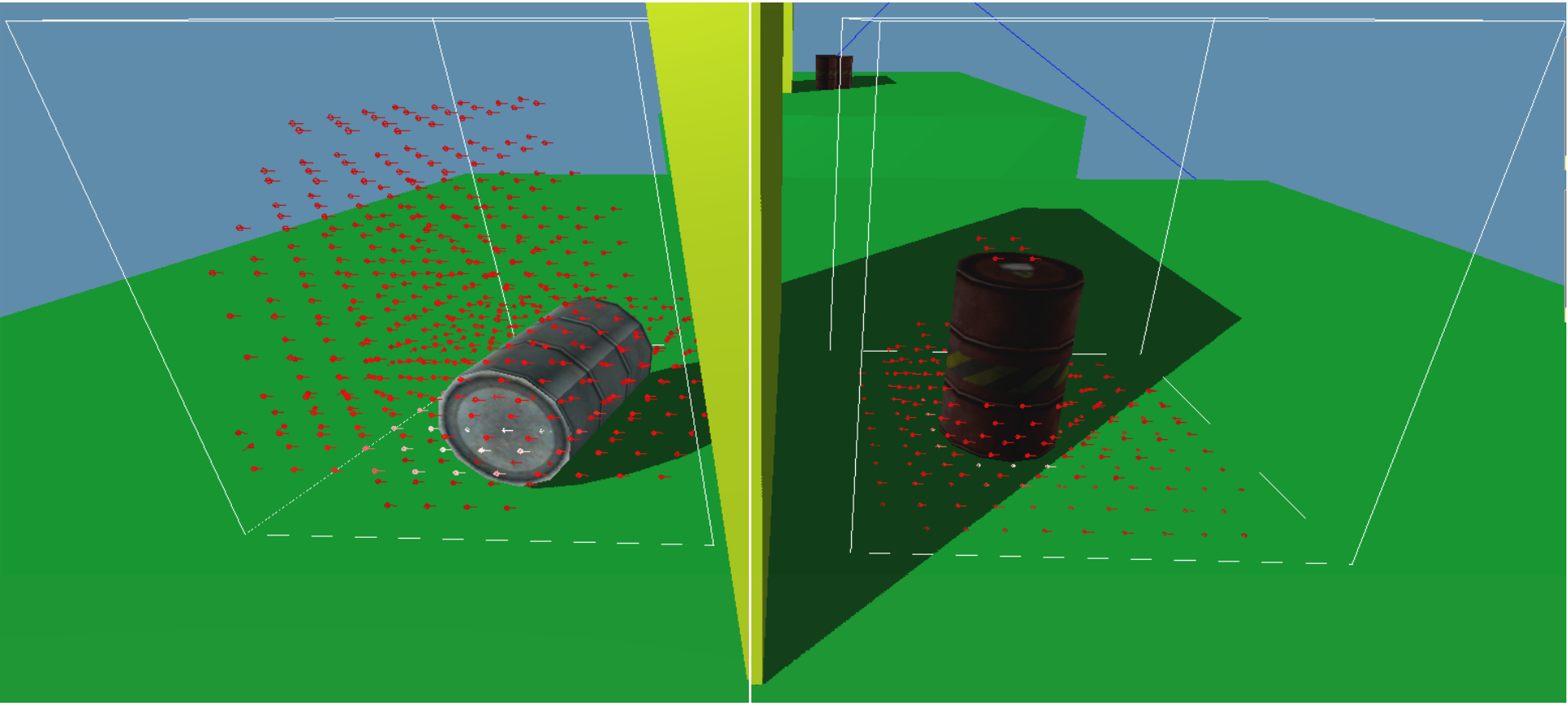


$$h(X) = -\ln P(X)$$

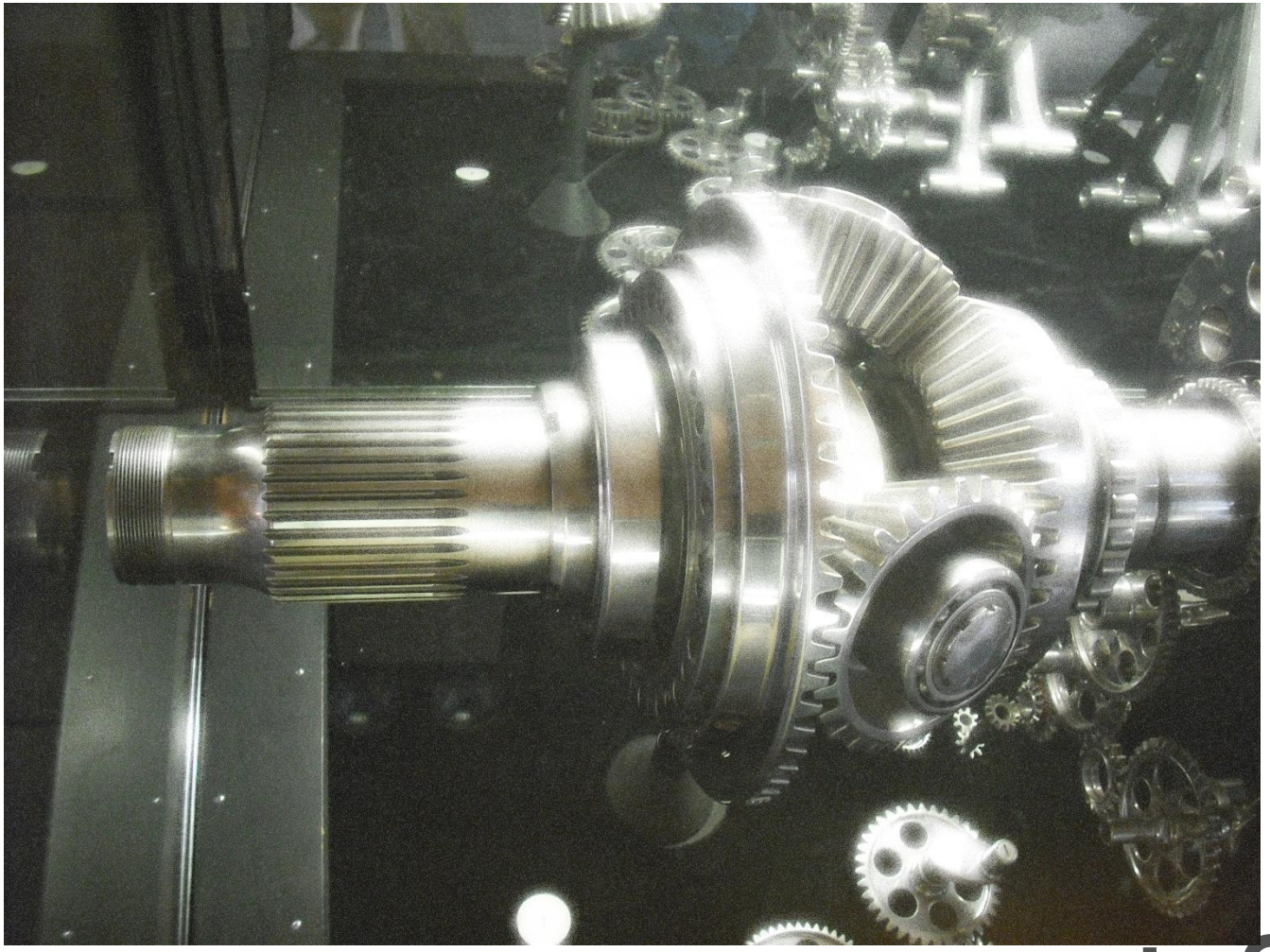
Configuration query



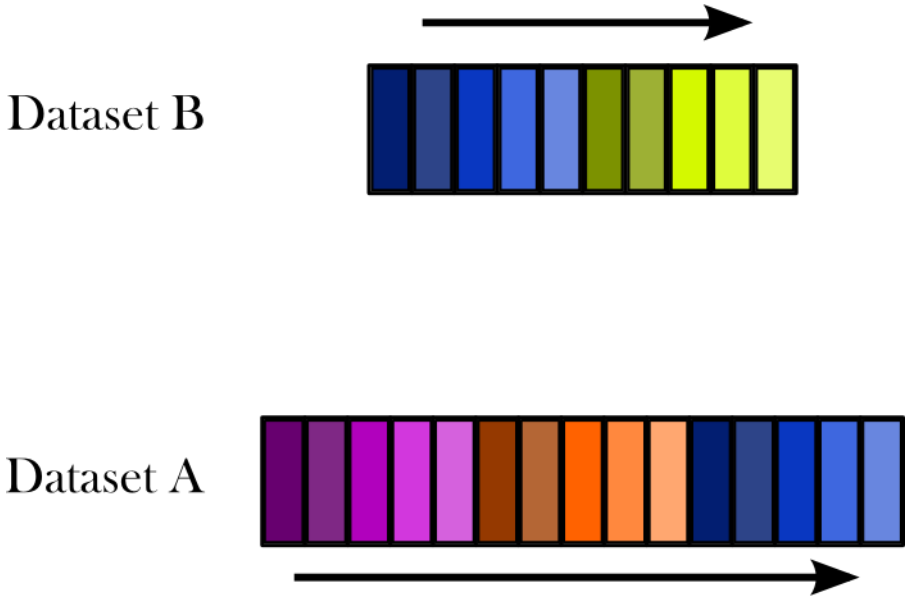
Configuration query



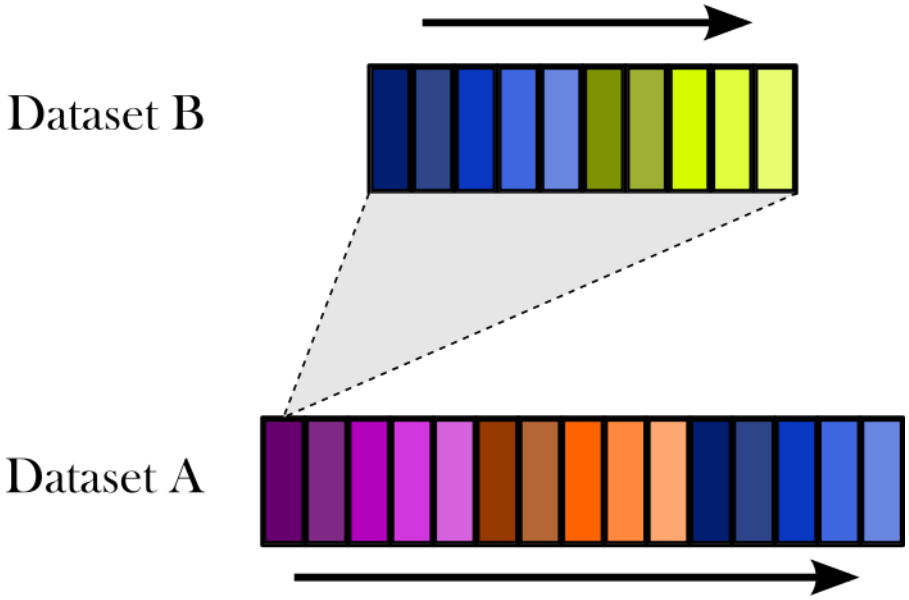
Algorithms



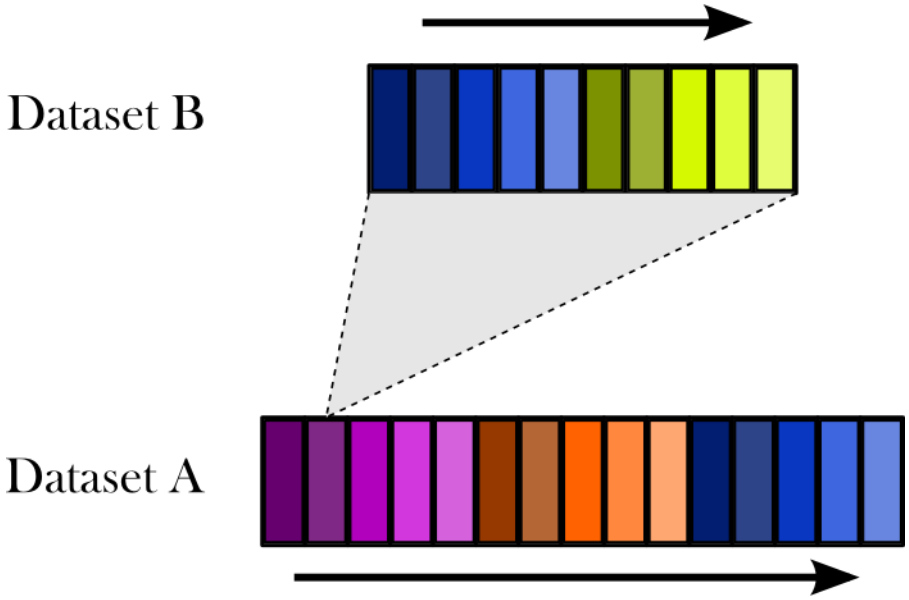
Naive implementation



Naive implementation

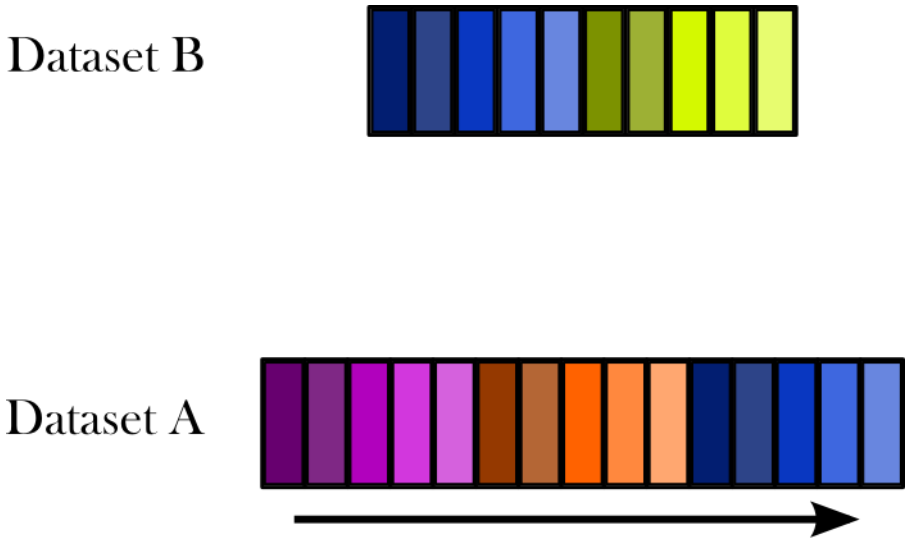


Naive implementation

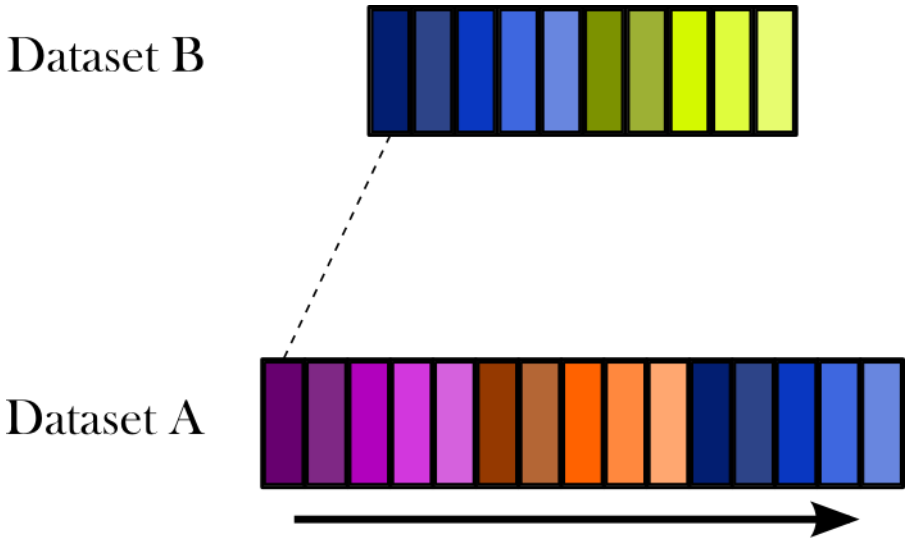


Optimizations

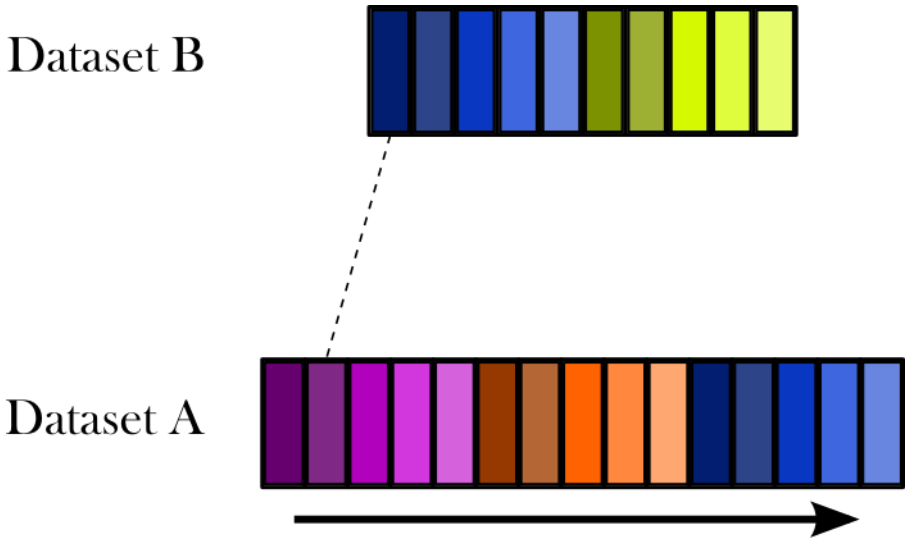
First optimization



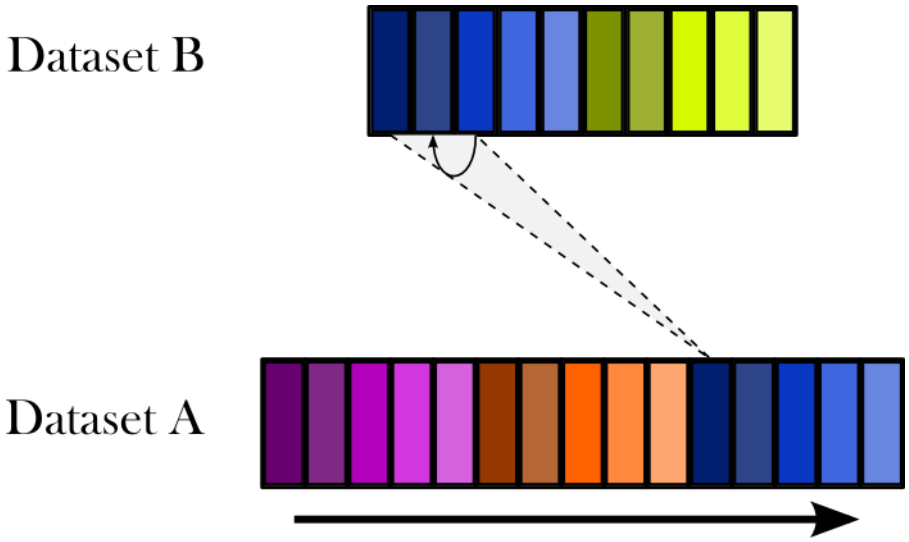
First optimization



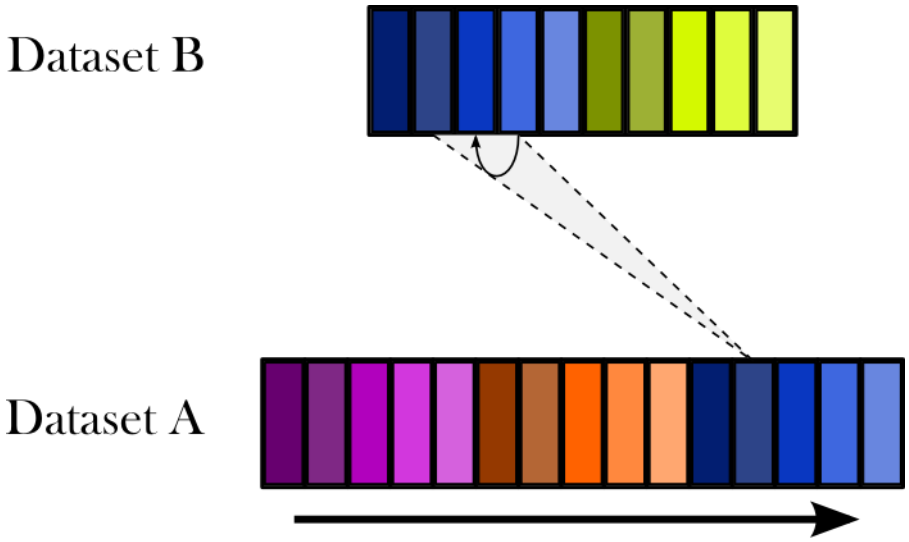
First optimization



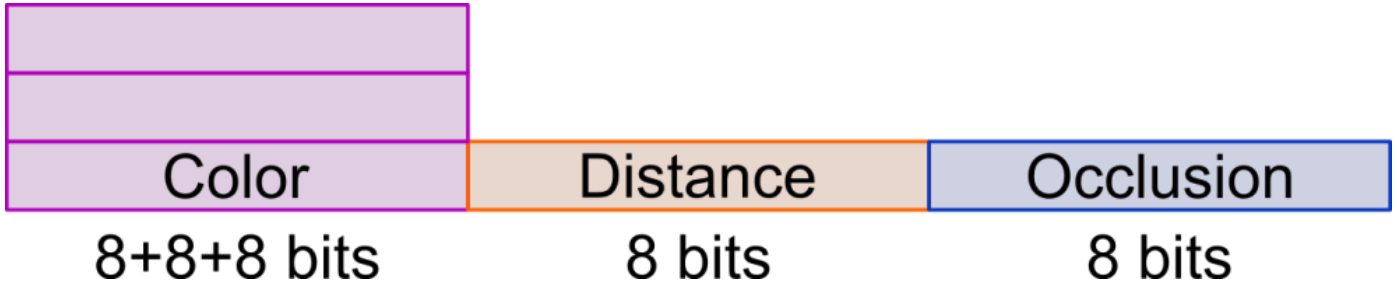
First optimization



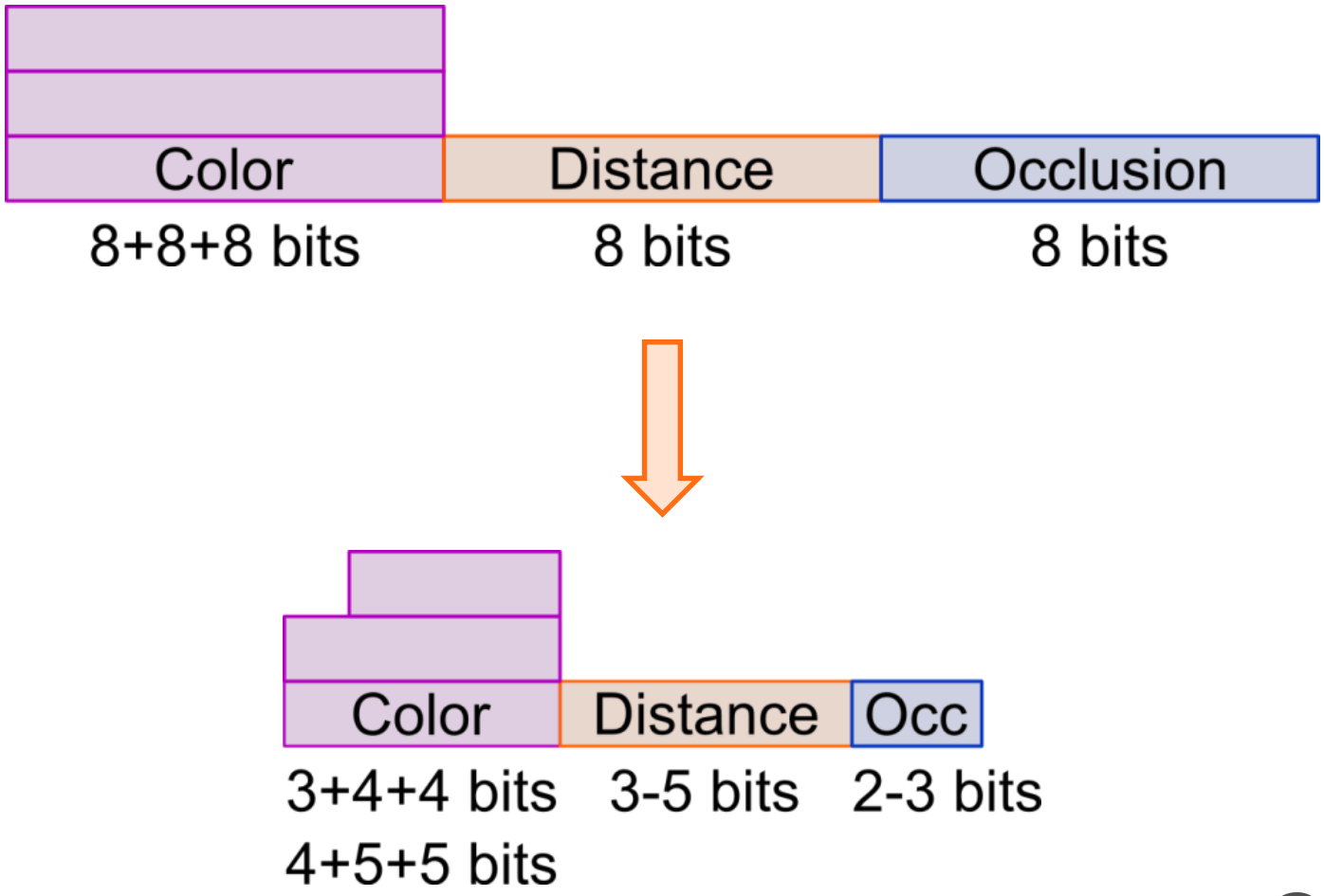
First optimization



Second optimization



Second optimization

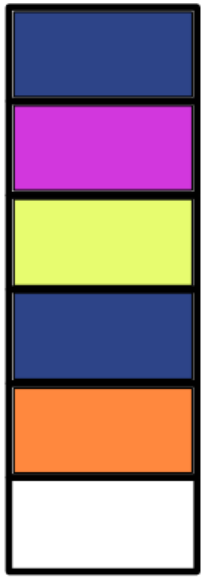


Second optimization

Packed probe sample bit set

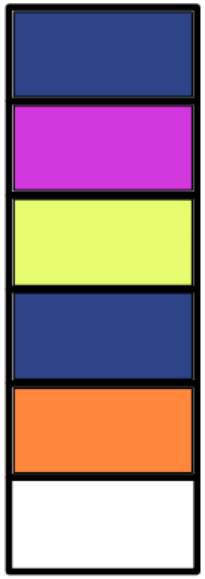
Second optimization

Packed probe sample sequence



Second optimization

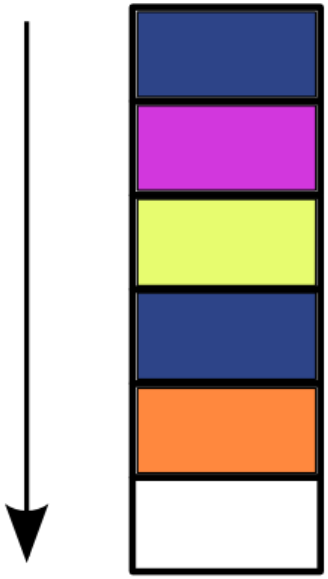
Sampled model



Query volume

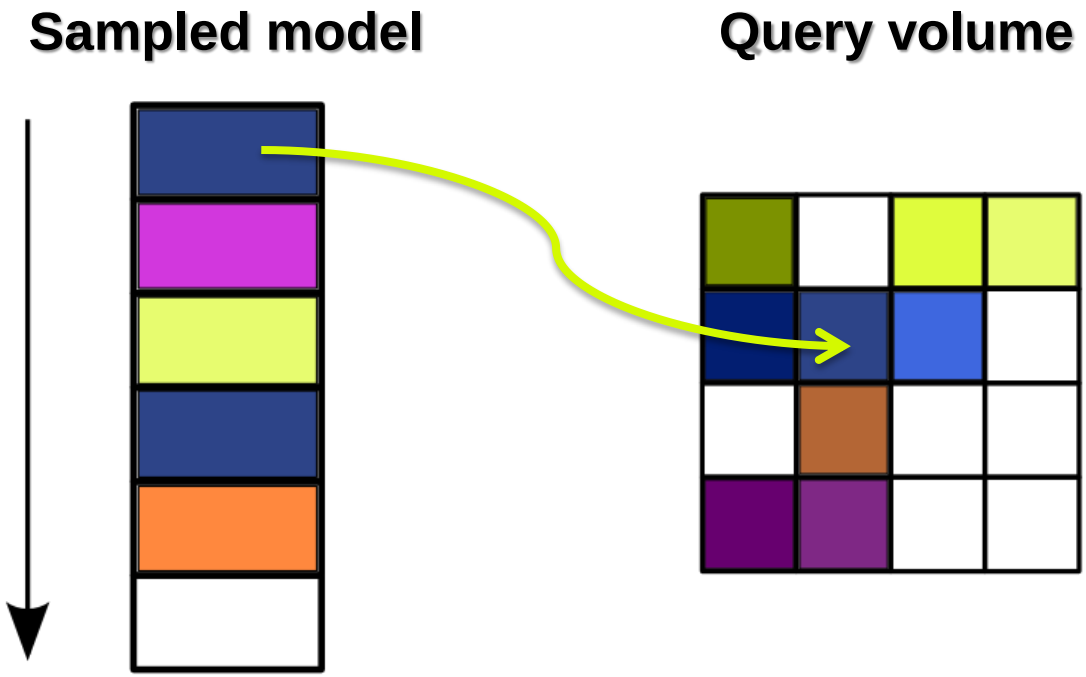
Second optimization

Sampled model

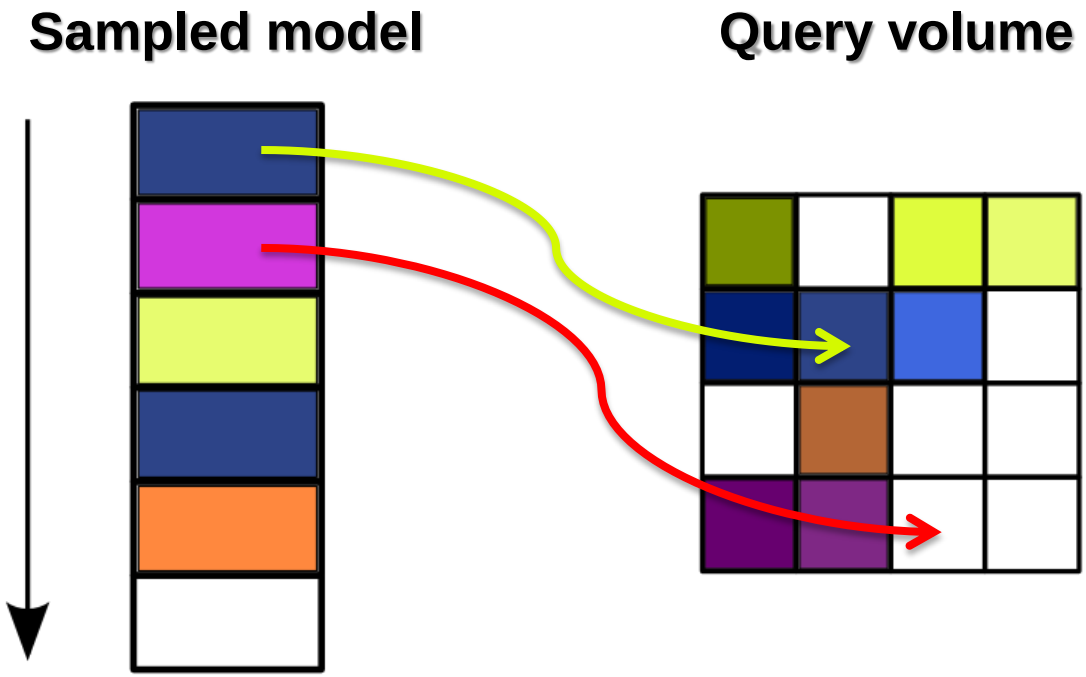


Query volume

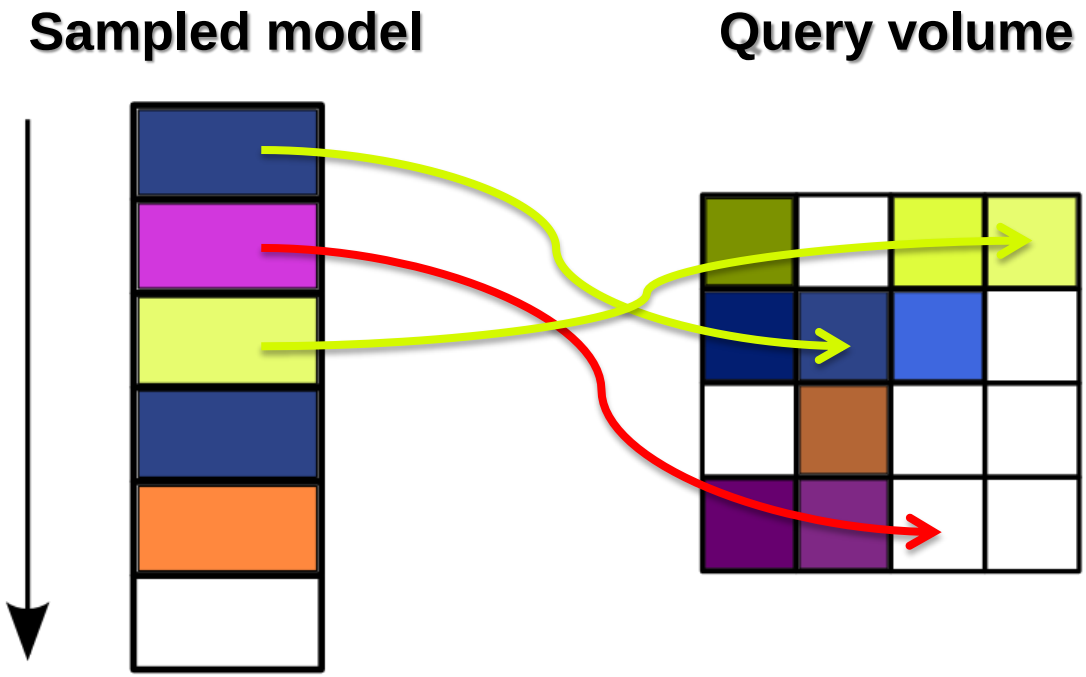
Second optimization



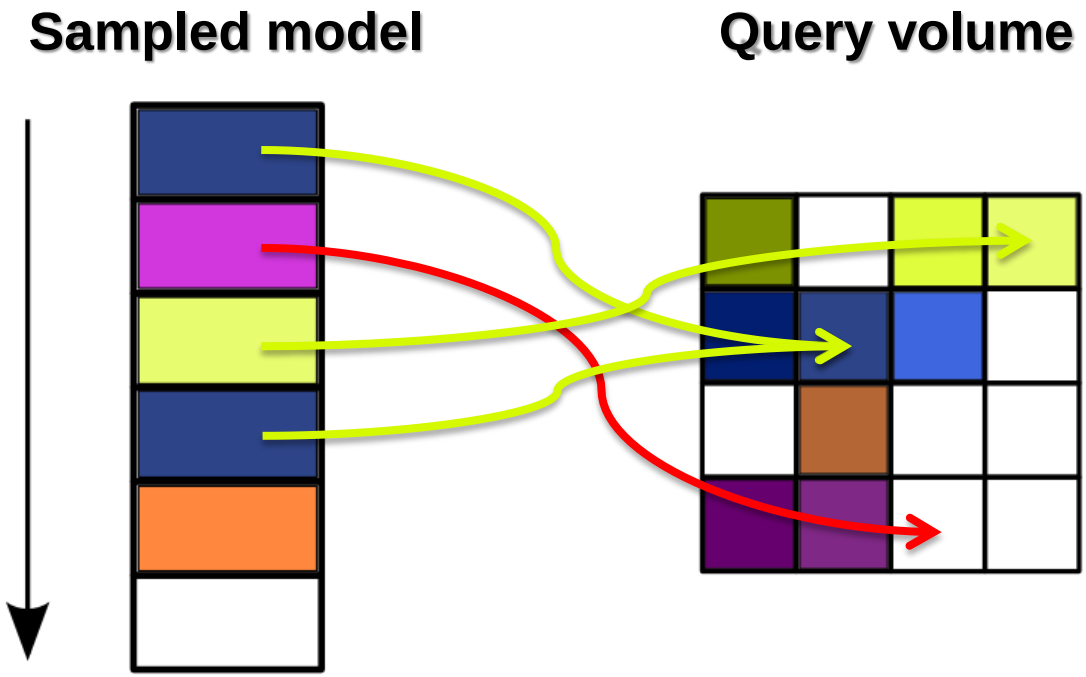
Second optimization



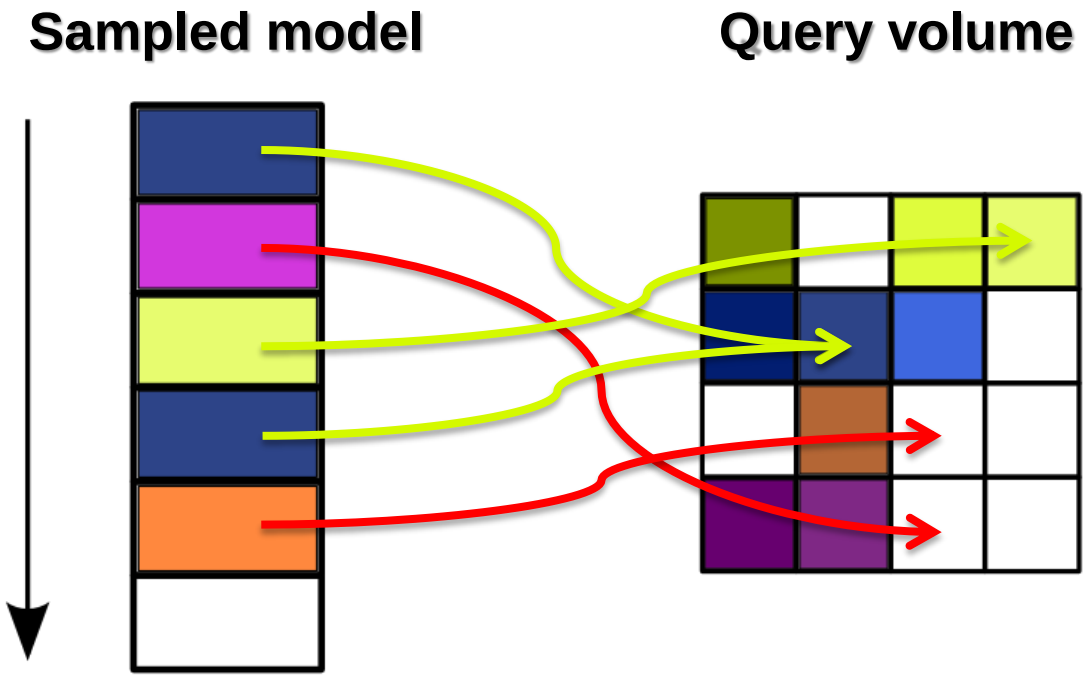
Second optimization



Second optimization



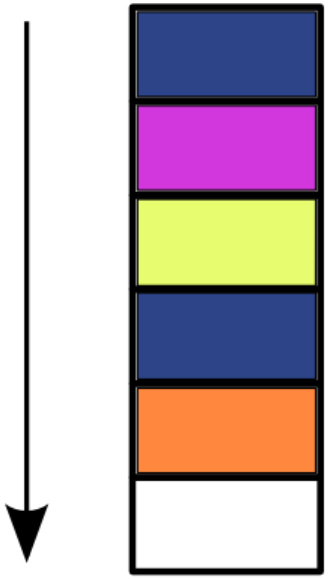
Second optimization



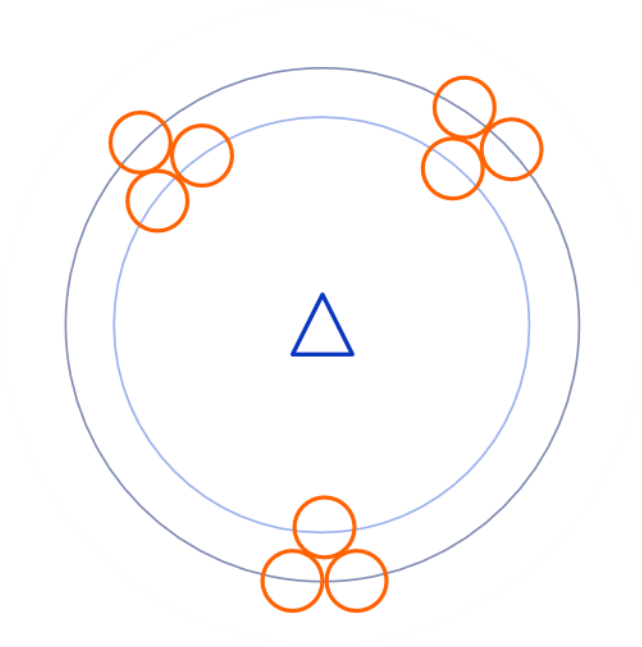
Second optimization

Sampled model

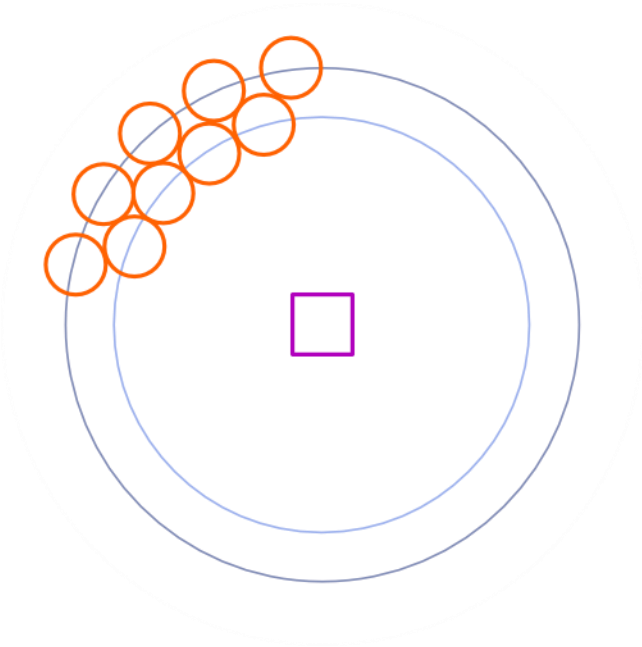
Query volume



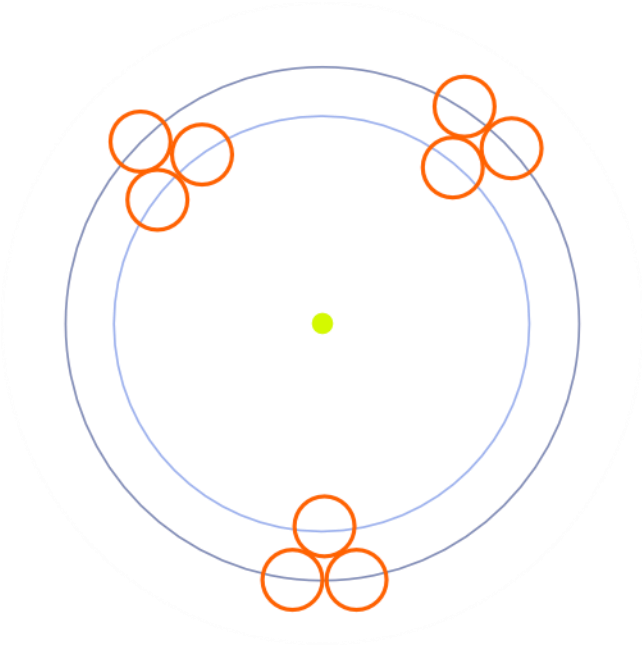
Neighborhood context



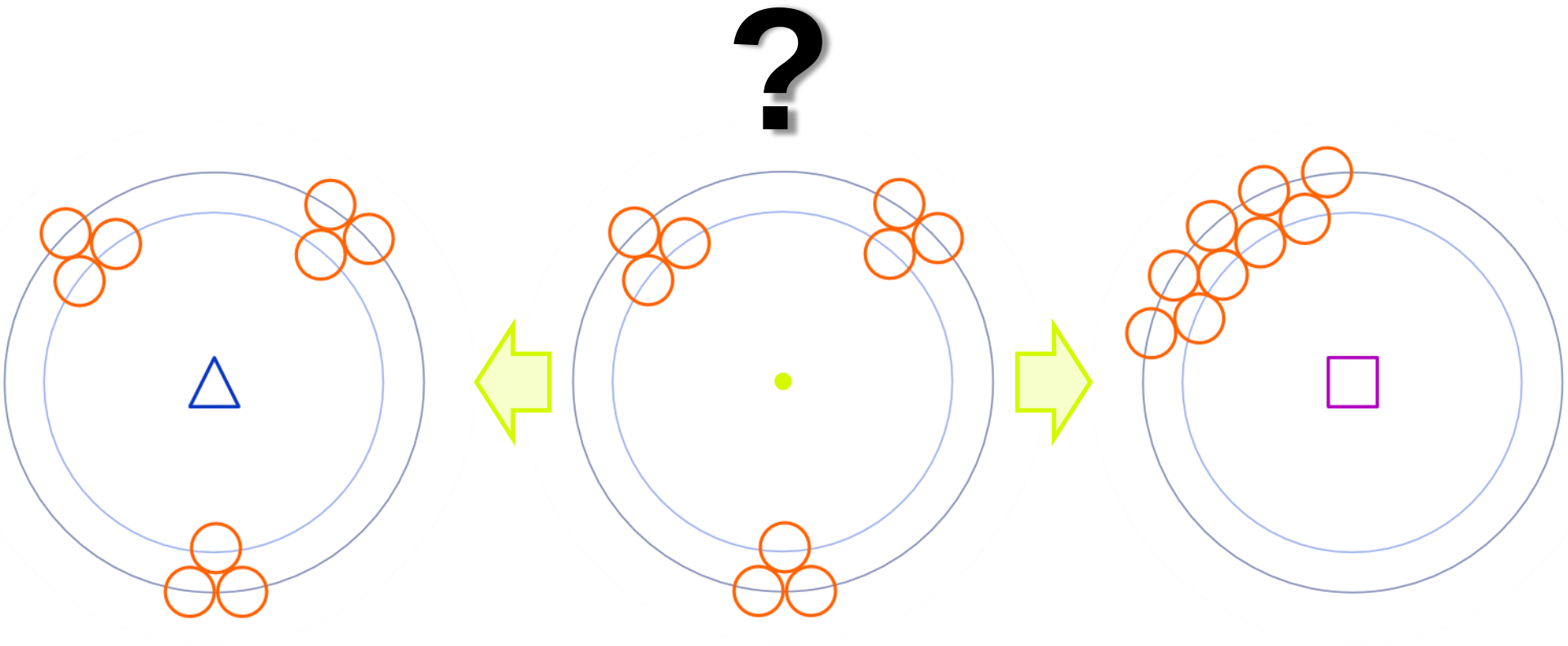
Neighborhood context



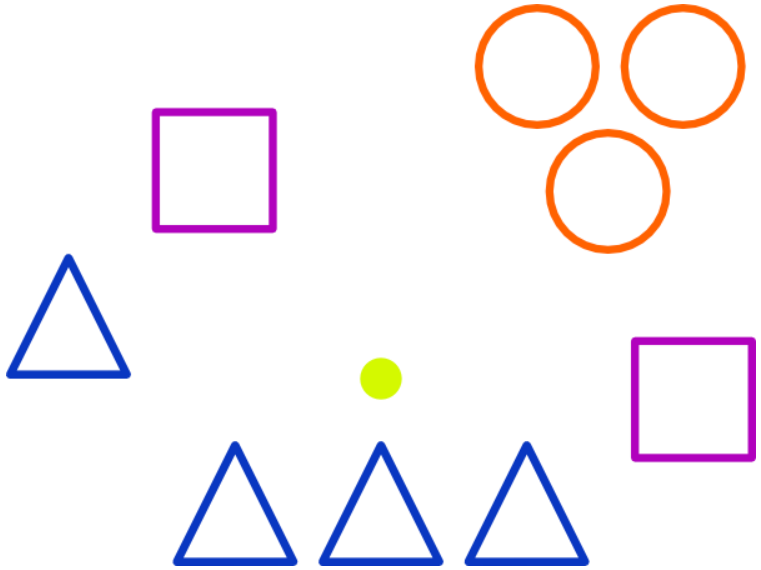
Neighborhood context



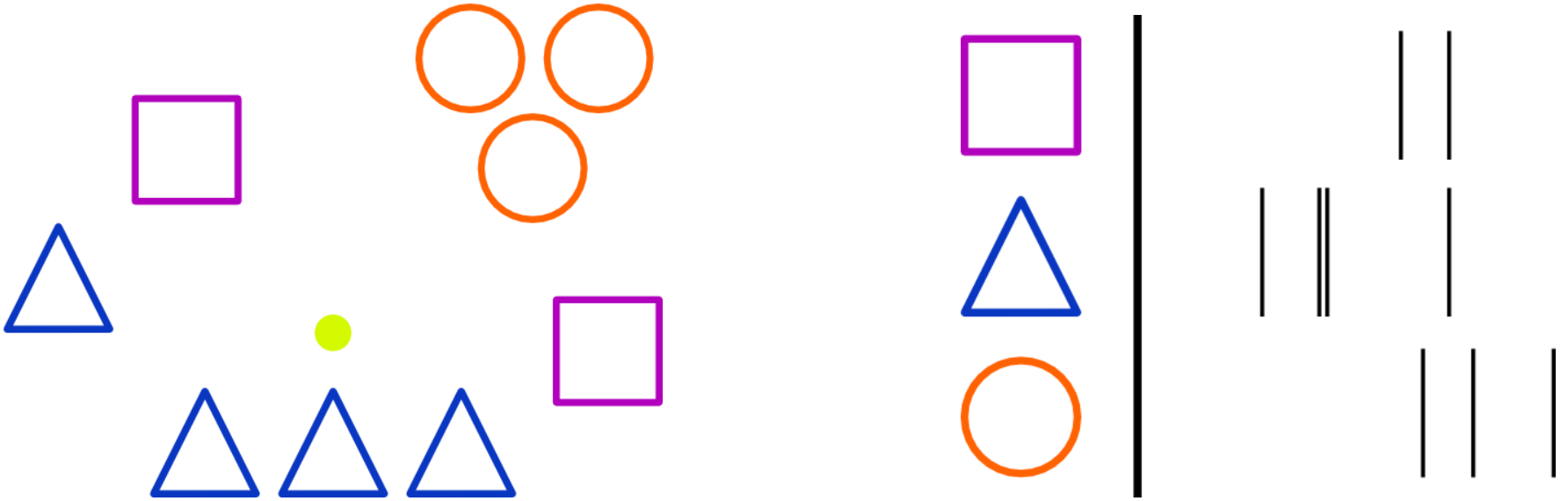
Neighborhood context



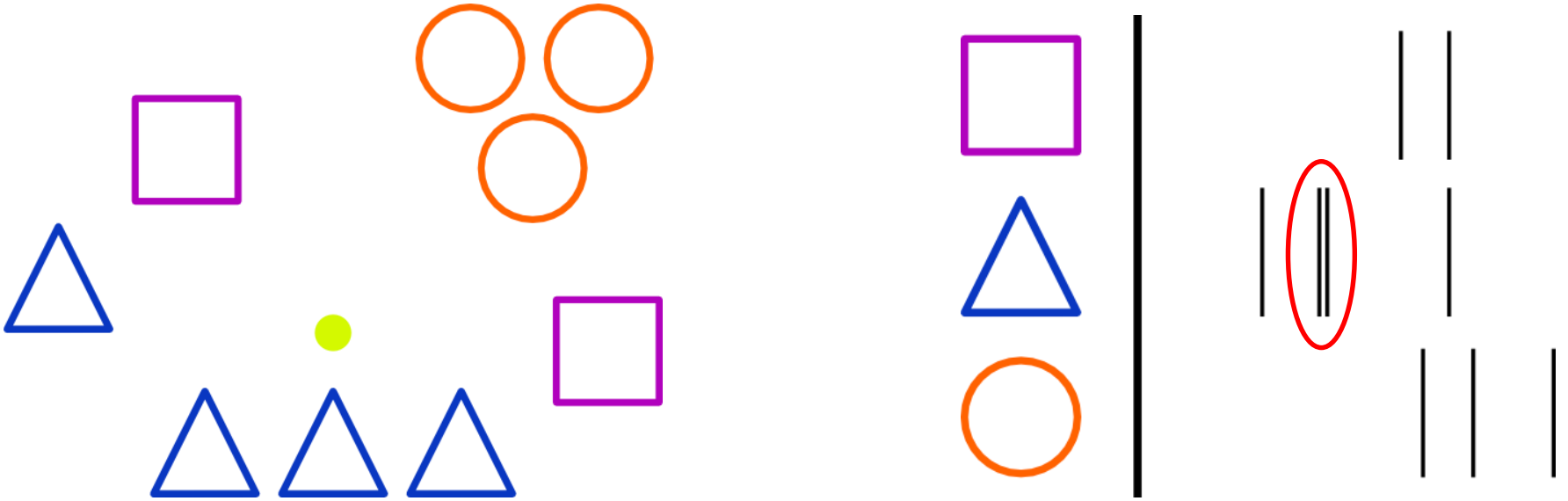
Comparing neighborhoods



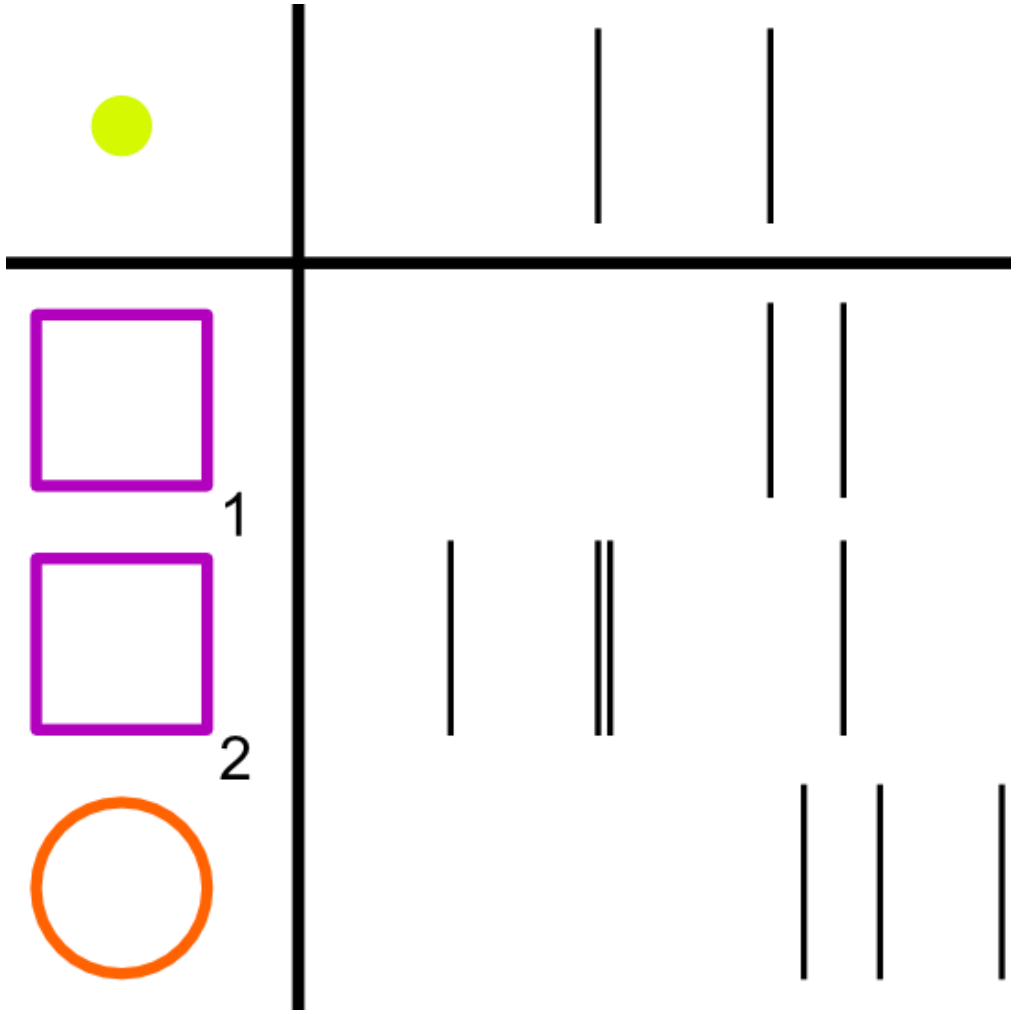
Comparing neighborhoods



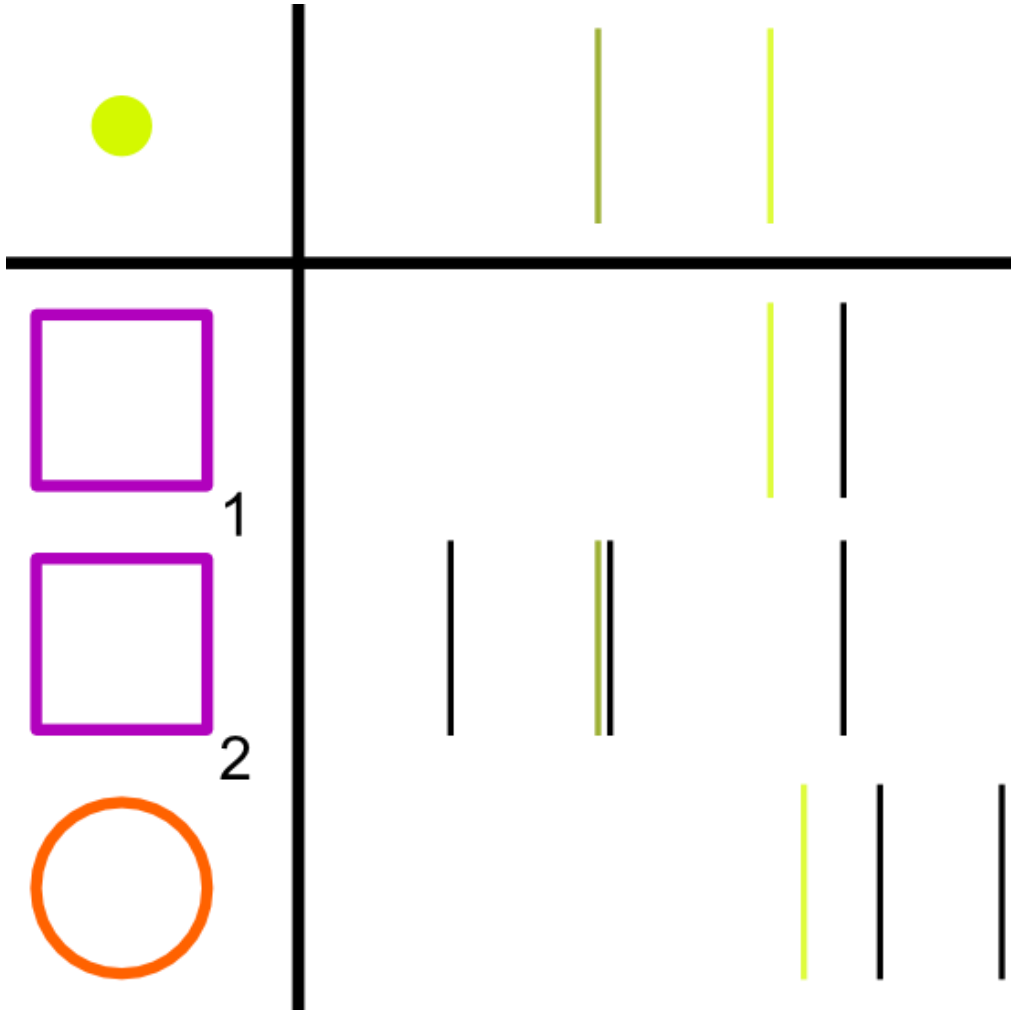
Comparing neighborhoods



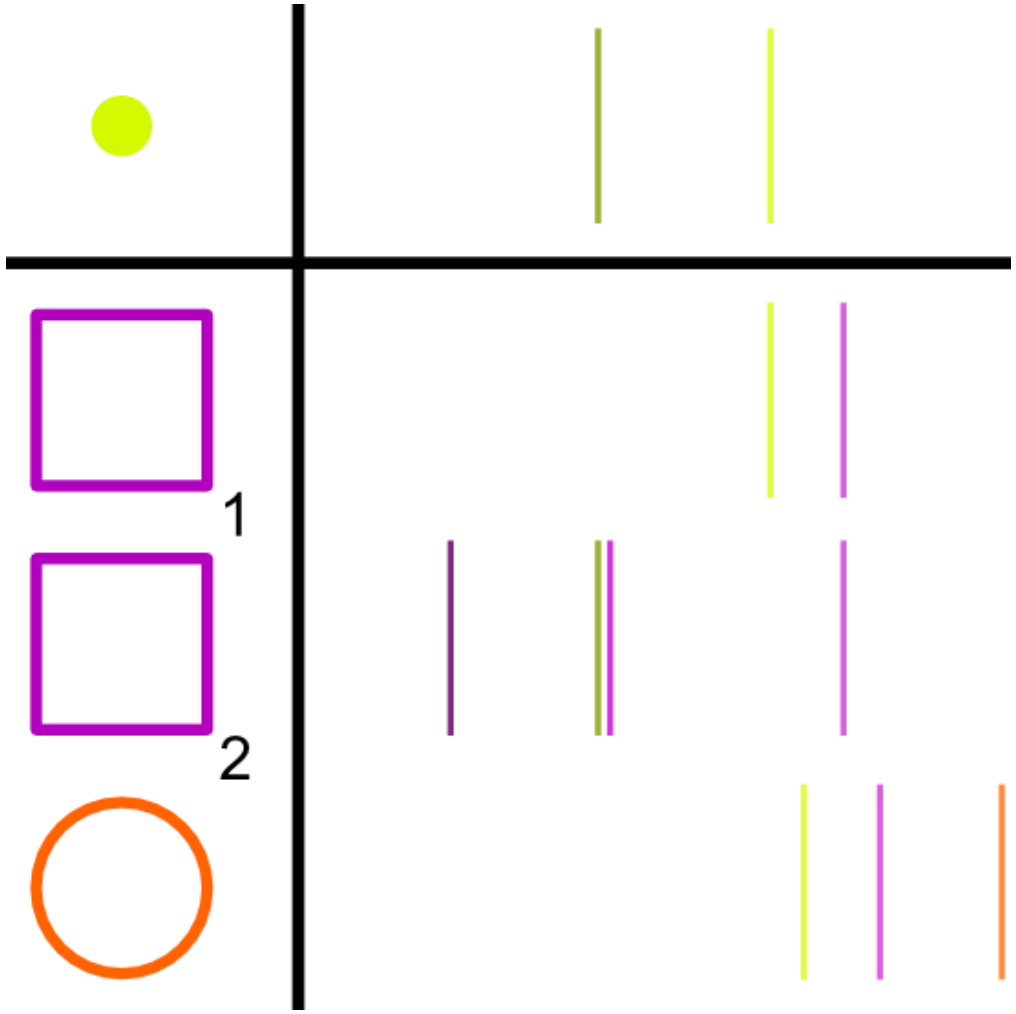
Matching distance groups



Matching distance groups

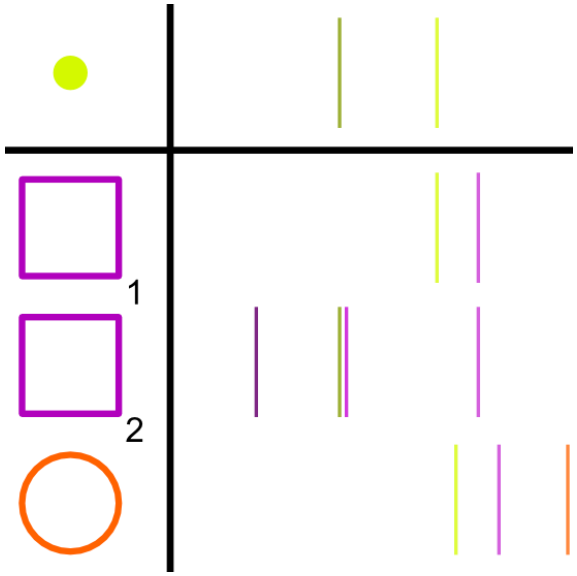


Matching distance groups

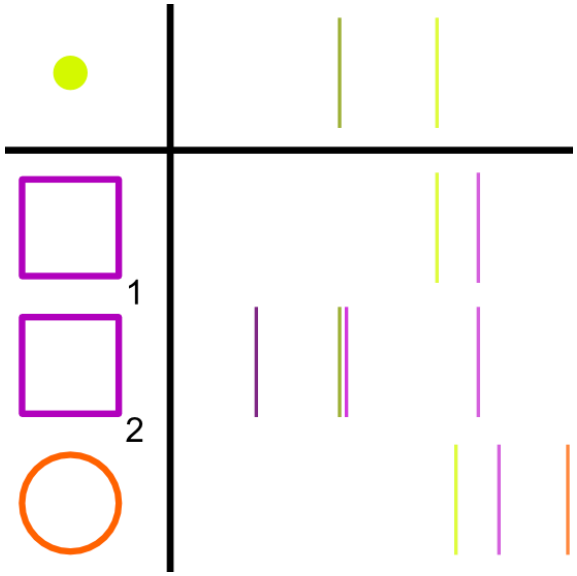


tum.3D
computer graphics & visualization

Matching distance groups



Matching distance groups



	0	1	0	1	0	0
1	0	0	0	1	1	0
2	1	1	1	0	1	0
	0	0	0	1	1	1

Similarity measures

●	0	1	0	1	0	0
□$_1$	0	0	0	1	1	0
□$_2$	1	1	1	0	1	0
○	0	0	0	1	1	1

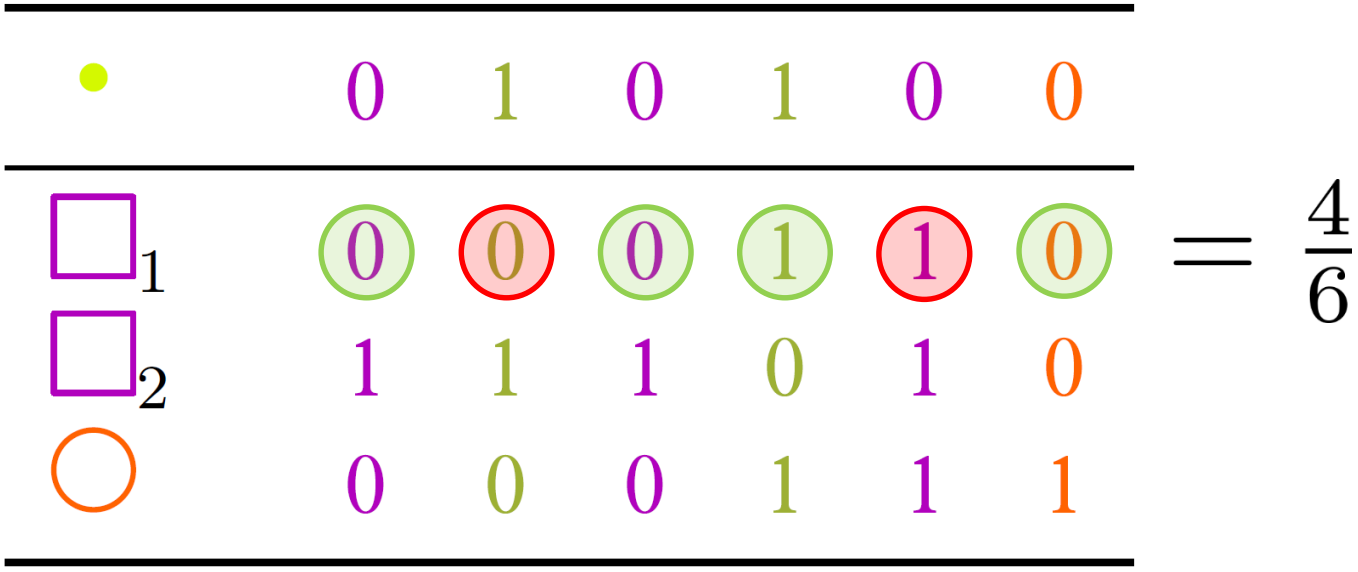
Rand similarity measure

$$R = \frac{m_{11}+m_{00}}{m_{11}+m_{10}+m_{01}+m_{00}}$$

●	0	1	0	1	0	0
□$_1$	0	0	0	1	1	0
□$_2$	1	1	1	0	1	0
○	0	0	0	1	1	1

Rand similarity measure

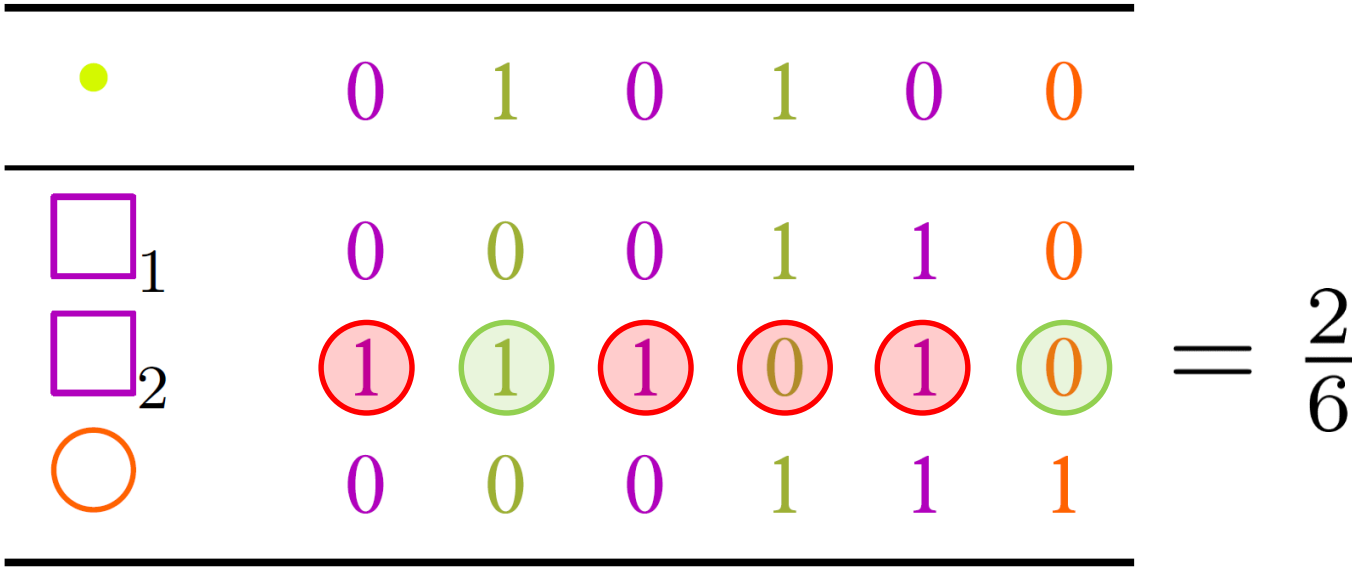
$$R = \frac{m_{11}+m_{00}}{m_{11}+m_{10}+m_{01}+m_{00}}$$



$$= \frac{4}{6}$$

Rand similarity measure

$$R = \frac{m_{11}+m_{00}}{m_{11}+m_{10}+m_{01}+m_{00}}$$



Rand similarity measure

$$R = \frac{m_{11}+m_{00}}{m_{11}+m_{10}+m_{01}+m_{00}}$$

●	0	1	0	1	0	0
□$_1$	0	0	0	1	1	0
□$_2$	1	1	1	0	1	0
○	0	0	0	1	1	1

$$= \frac{3}{6}$$

Jaccard index

$$R = \frac{m_{11}}{m_{11}+m_{10}+m_{01}}$$

●	0	1	0	1	0	0
□$_1$	0	0	0	1	1	0
□$_2$	1	1	1	0	1	0
○	0	0	0	1	1	1

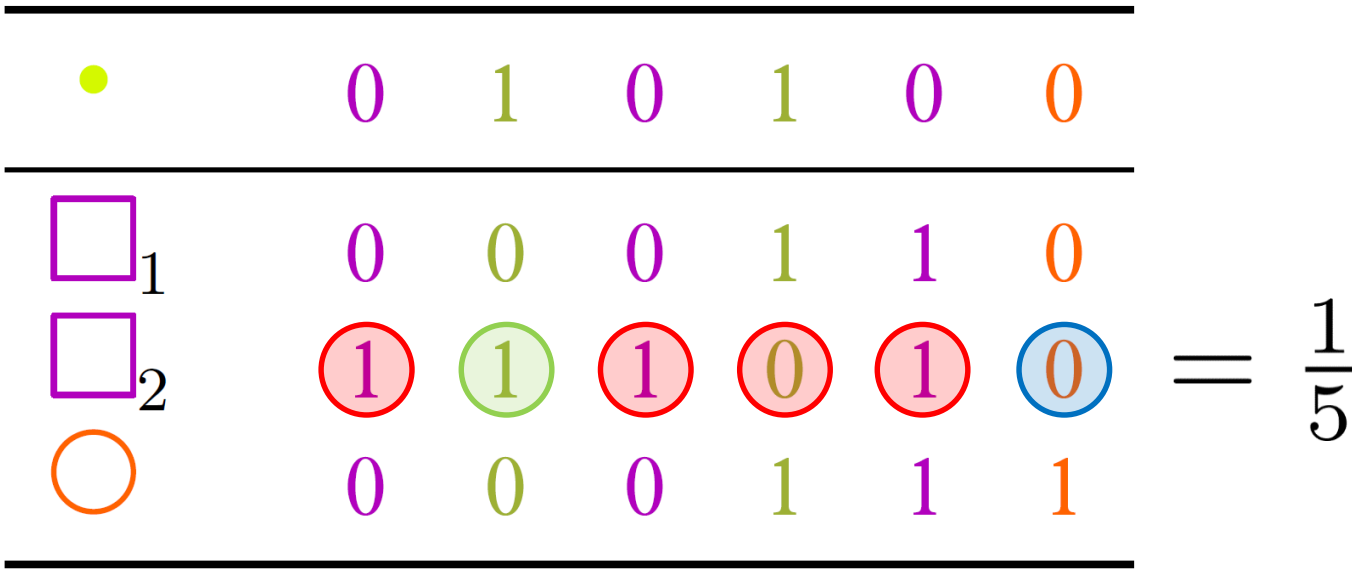
Jaccard index

$$R = \frac{m_{11}}{m_{11}+m_{10}+m_{01}}$$

●	0	1	0	1	0	0	
□$_1$	0	0	0	1	1	0	$= \frac{1}{3}$
□$_2$	1	1	1	0	1	0	
○	0	0	0	1	1	1	

Jaccard index

$$R = \frac{m_{11}}{m_{11}+m_{10}+m_{01}}$$



Jaccard index

$$R = \frac{m_{11}}{m_{11}+m_{10}+m_{01}}$$

●		0	1	0	1	0	0
□$_1$		0	0	0	1	1	0
□$_2$		1	1	1	0	1	0
○		0	0	0	1	1	1

$$= \frac{1}{4}$$

Importance-weighted Rand measure

$$R = \frac{\sum \Phi_k \, \mathbb{1}_{\{\text{query}_k = \text{instance}_k\}}}{\sum \Phi_k}$$

$$\Phi_k = h(\text{query}_k) + h(\text{instance}_k)$$

●	0	1	0	1	0	0
□$_1$	0	0	0	1	1	0
□$_2$	1	1	1	0	1	0
○	0	0	0	1	1	1

Importance-weighted Rand measure

$$R = \frac{\sum \Phi_k \, \mathbb{1}_{\{\text{query}_k = \text{instance}_k\}}}{\sum \Phi_k}$$

●	0	1	0	1	0	0
□$_1$	0	0	0	1	1	0
□$_2$	1	1	1	0	1	0
○	0	0	0	1	1	1

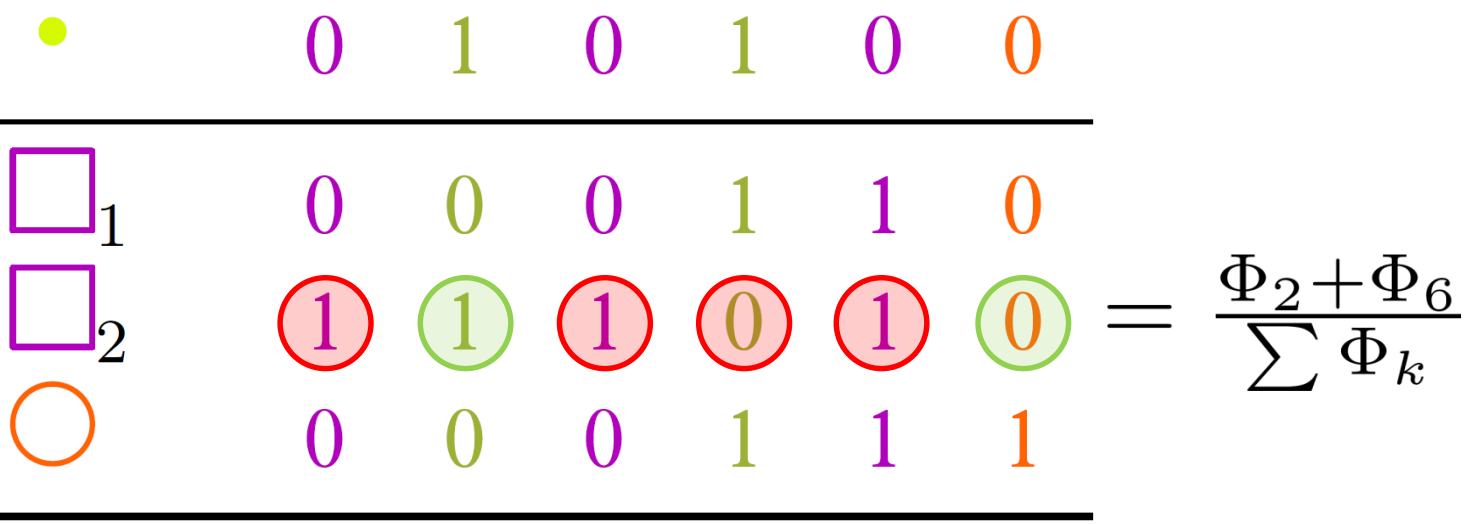
Importance-weighted Rand measure

$$R = \frac{\sum \Phi_k \, \mathbb{1}_{\{\text{query}_k = \text{instance}_k\}}}{\sum \Phi_k}$$

●	0	1	0	1	0	0	
□$_1$	0	0	0	1	1	0	$= \frac{\Phi_1+\Phi_3+\Phi_4+\Phi_6}{\sum \Phi_k}$
□$_2$	1	1	1	0	1	0	
○	0	0	0	1	1	1	

Importance-weighted Rand measure

$$R = \frac{\sum \Phi_k \, \mathbb{1}_{\{\text{query}_k = \text{instance}_k\}}}{\sum \Phi_k}$$



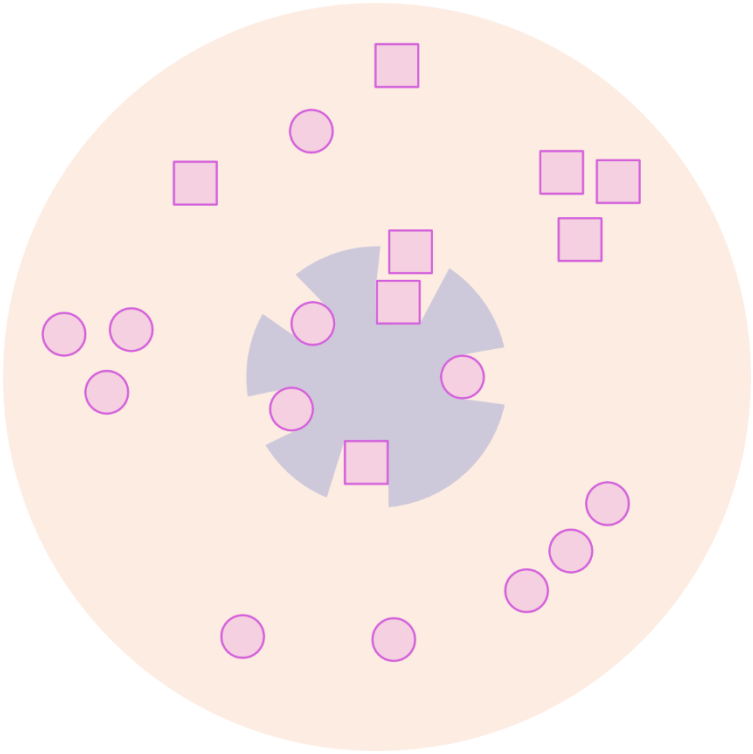
$$= \frac{\Phi_2 + \Phi_6}{\sum \Phi_k}$$

Importance-weighted Rand measure

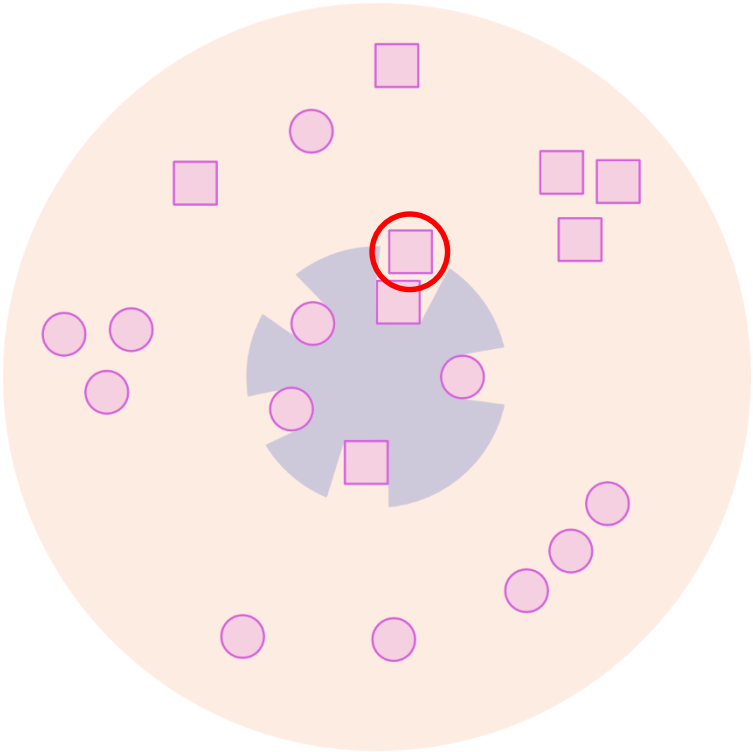
$$R = \frac{\sum \Phi_k \, \mathbb{1}_{\{\text{query}_k = \text{instance}_k\}}}{\sum \Phi_k}$$

●	0	1	0	1	0	0	
□$_1$	0	0	0	1	1	0	
□$_2$	1	1	1	0	1	0	
○	0	0	0	1	1	1	$= \frac{\Phi_1+\Phi_3+\Phi_4}{\sum \Phi_k}$

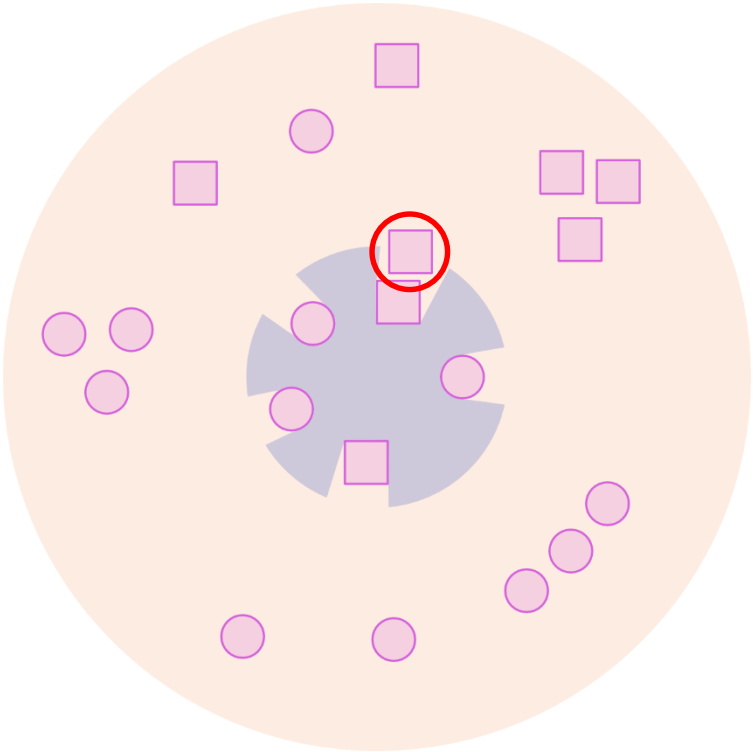
Combining context scores



Combining context scores



Combining context scores

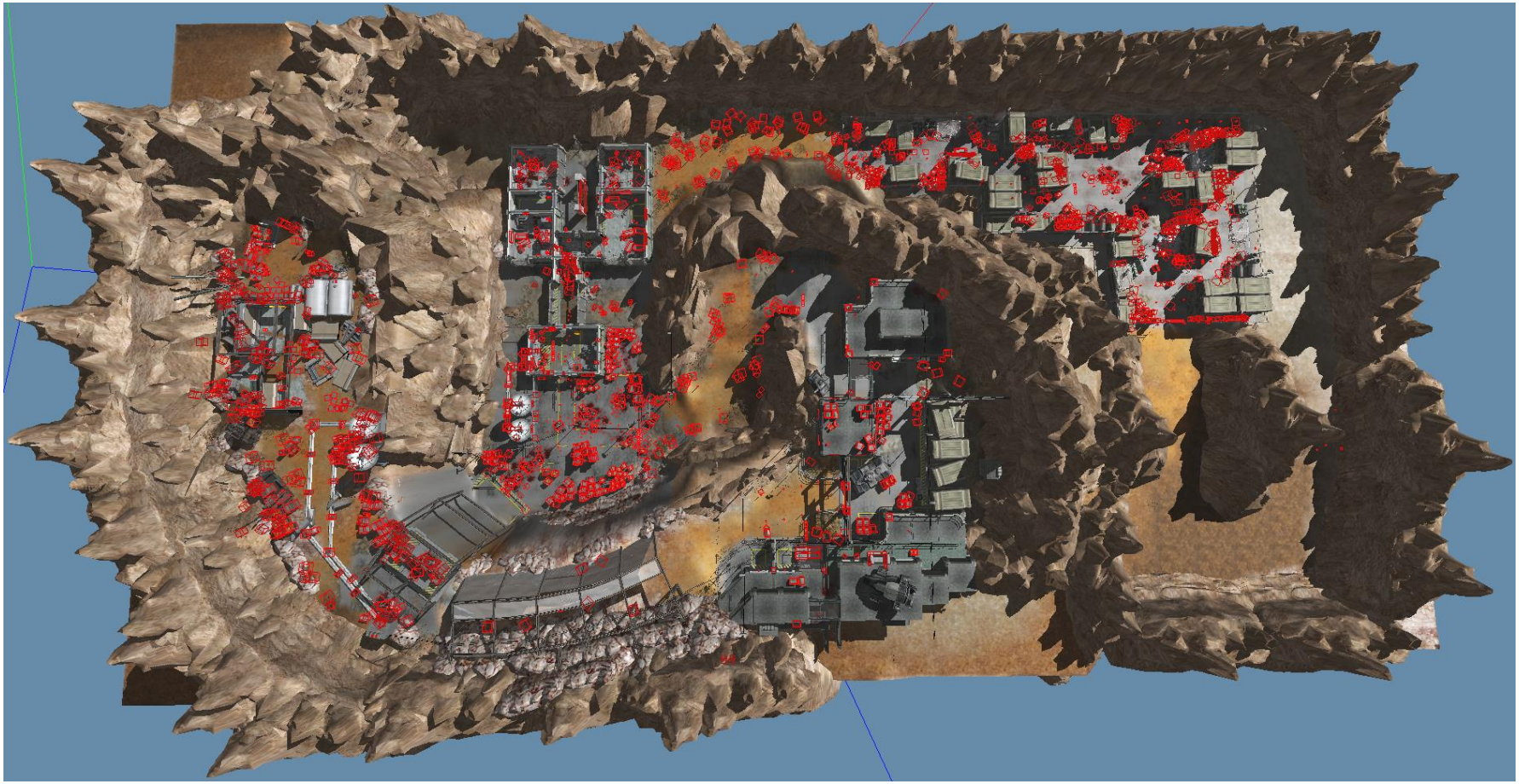


$$S_{\text{final}} = S_{\text{probe}} \cdot S_{\text{neighborhood}}$$

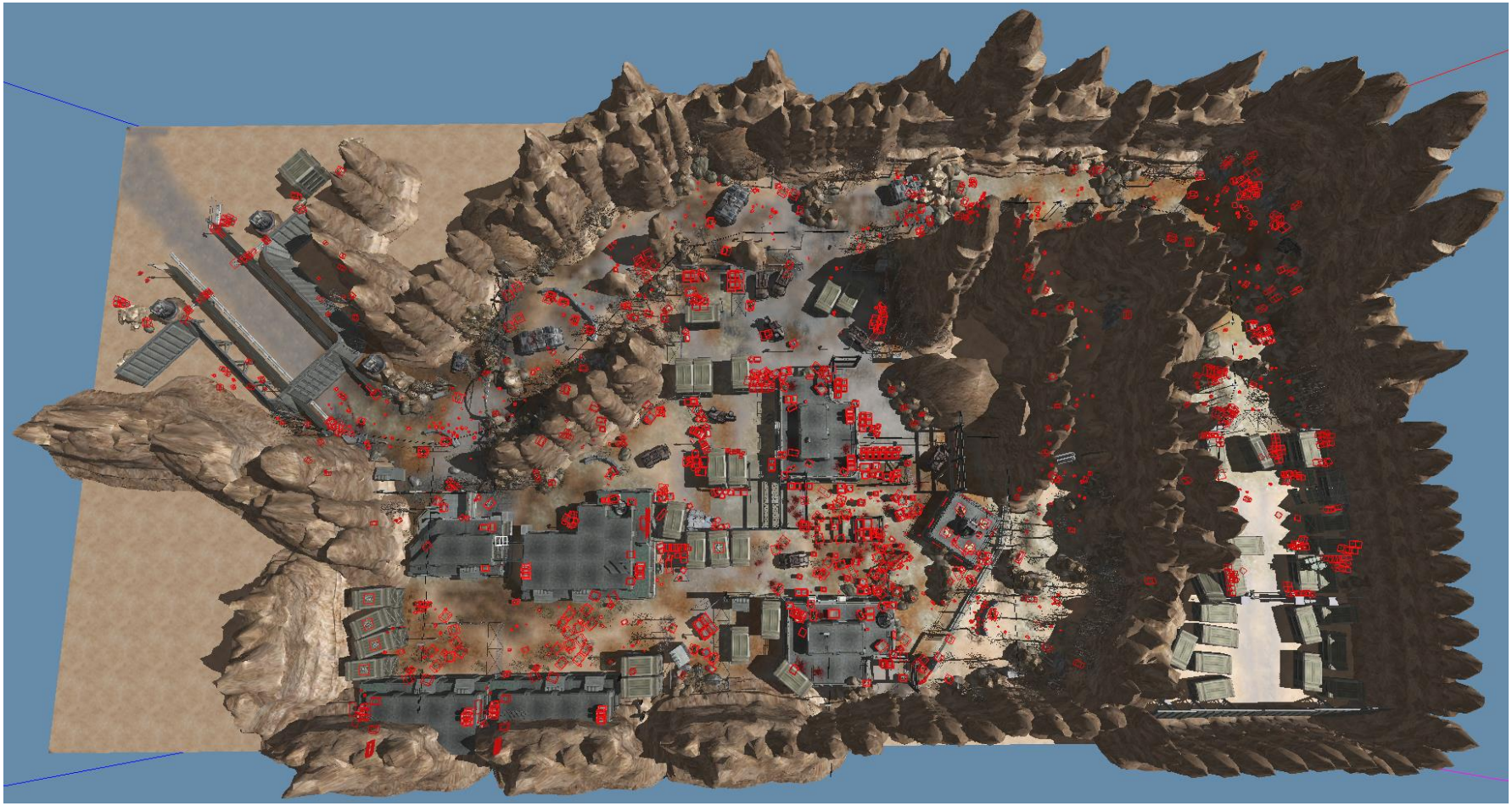
Results

Validation

marine01_wakeup



marine02_road



Validation: probe context

	# models	# instances	avg rank (model frequency)
marine02_road	94	1396	17.15
marine01_wakeup	150	2066	21.10

Level	marine02_road	marine02_road (5)	marine01_wakeup
Uniform bidirectional match	14.1	17.7	15.2
IW bidirectional match	12.9	17.6	14.3
Configuration	10.5	16.0	10.4

Validation: neighborhood context

	# models	# instances	avg rank (model frequency)
marine02_road	94	1396	17.15
marine01_wakeup	150	2066	21.10

Max random shift	2			4			8		
Max distance	10	20	60	10	20	60	10	20	60
Rand measure	0.38	0.43	0.46	1.16	1.20	1.23	3.38	2.90	2.91
IW measure	0.40	0.42	0.45	1.23	1.21	1.21	3.57	2.92	2.90
Jaccard index	0.38	0.43	0.46	1.14	1.20	1.23	2.86	2.88	2.90

Validation: combined contexts

	# models	# instances	avg rank (model frequency)
marine02_road	94	1396	17.15
marine01_wakeup	150	2066	21.10

	marine02_road			marine02_road (5)			marine01_wakeup		
	Rand	IW	Jaccard	Rand	IW	Jaccard	Rand	IW	Jaccard
Uniform bidirectional	7.14	11.0	**0.230**	7.34	12.6	**0.176**	8.85	12.3	**0.651**
IW bidirectional	8.09	11.0	**0.399**	9.81	14.4	**0.320**	9.79	12.5	**0.926**
Configuration	11.1	11.5	**4.40**	15.9	16.5	**5.83**	21.8	22.2	**15.2**

Performance

	Rand measure	Importance-weighted measure	Jaccard index
marine02_road	9.5	11	9.5
marine01_wakeup	38	44	39

	Bidirectional query	IW bidirectional query	Configuration query
marine02_road	1.2	5.4	900
marine02_road (5)	14	93	18000
marine01_wakeup	2.4	11	1500

Summary

Post Mortem

Questions?

Demo