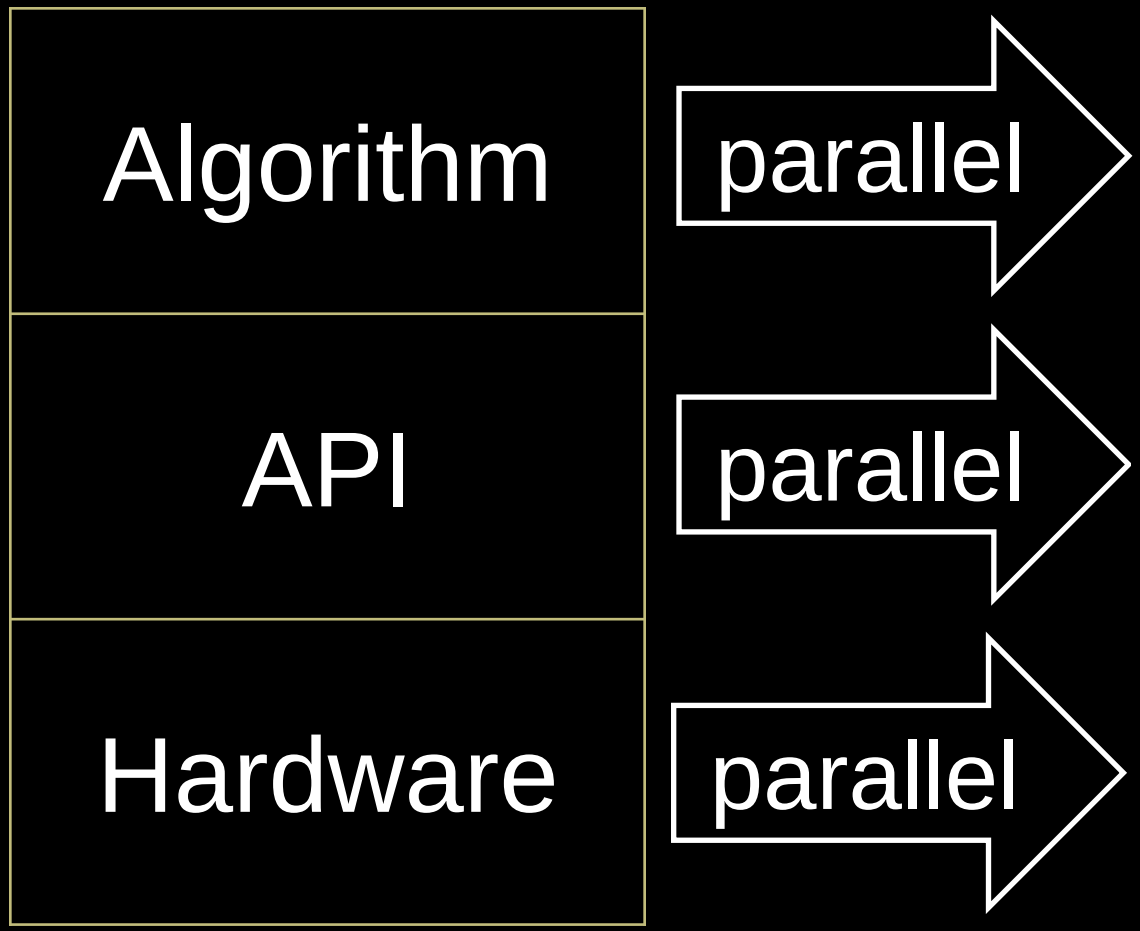
Semantics Consistent Parallelism

Li-Yi Wei

Microsoft Research

Parallelism

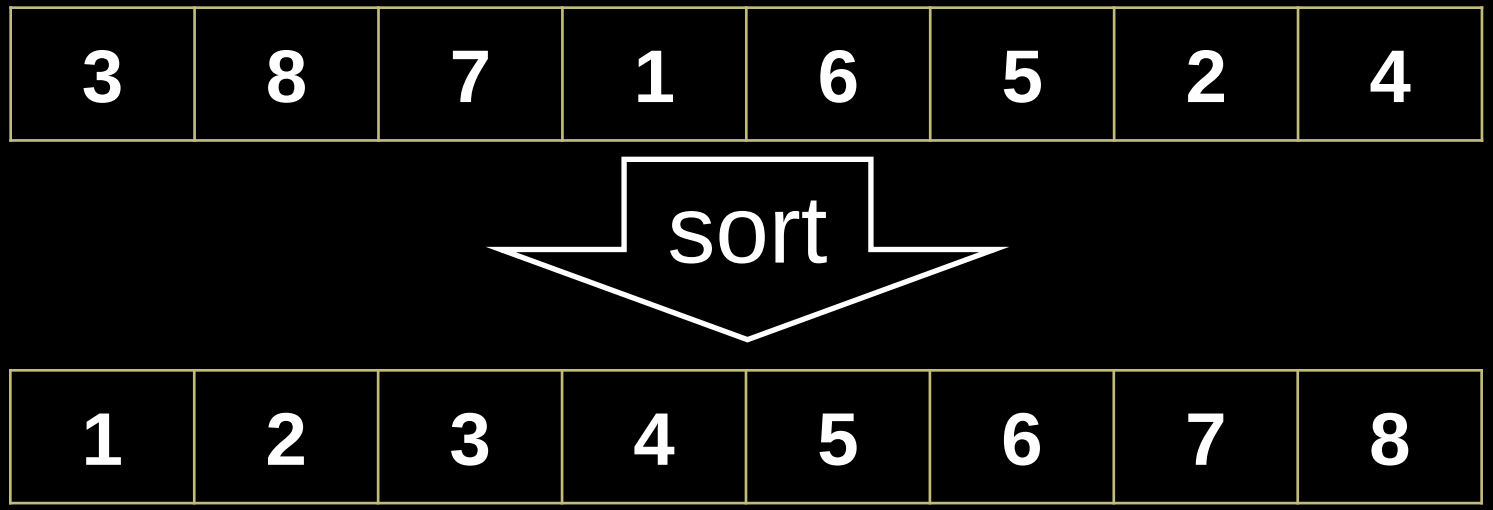


Traditional parallelization

Sequential consistency [Lampert]

parallel algorithms do NOT change result

sorting, FFT, matrix, etc.



New parallelization (cheating)

Not all algorithms need to be seq-consistent

- perception (graphics/vision/image/video), statistics
- approximate solutions might suffice → more parallel

Semantic consistency

Pseudo Random Number Generator

The main source of randomness in programs

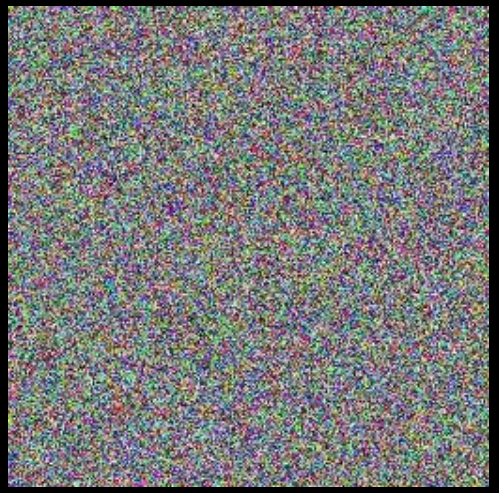
- e.g. rand() in c/c++

Desirable properties

- white noise statistics
- repeatable, fast computation

Traditional sequential method

- e.g. $x_n = (a\ x_{n-1} + b) \bmod c$



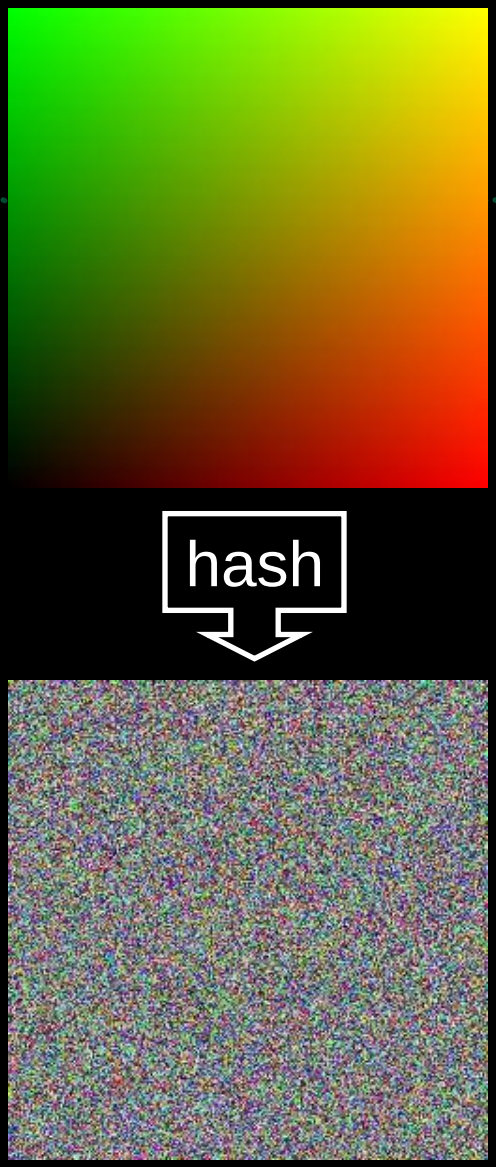
Parallel PRNG

1. input trivially prepared in parallel, e.g. linear ramp
2. feed input value into hash, independently & in parallel
3. output white noise

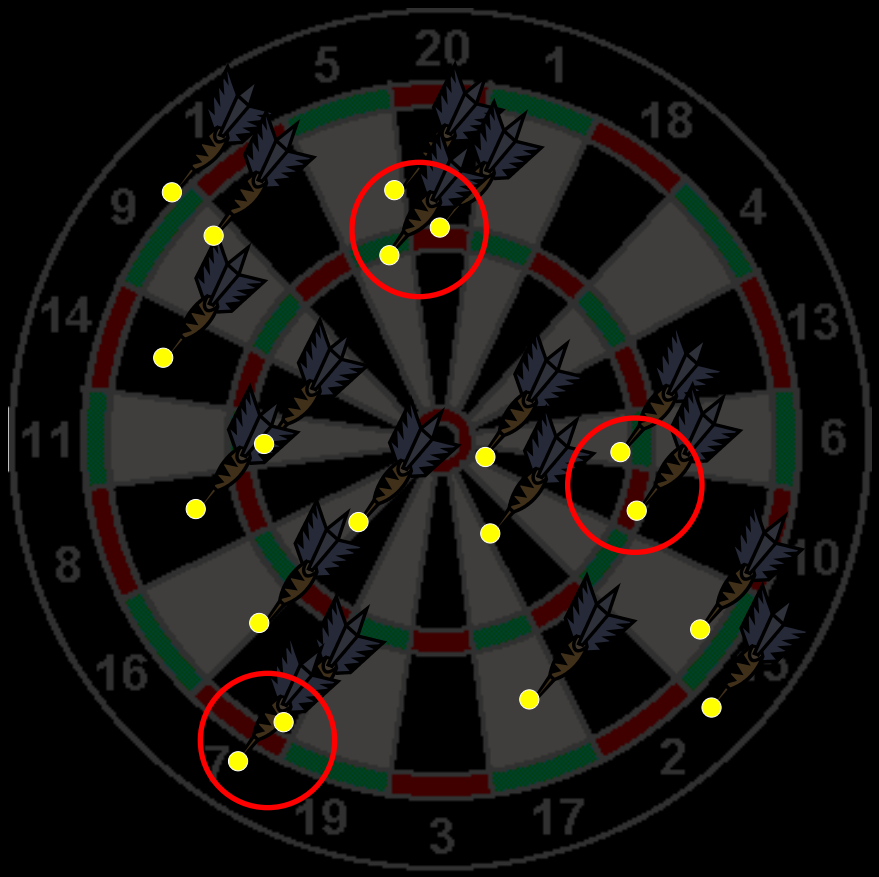
key idea:

borrow cryptographic hash!

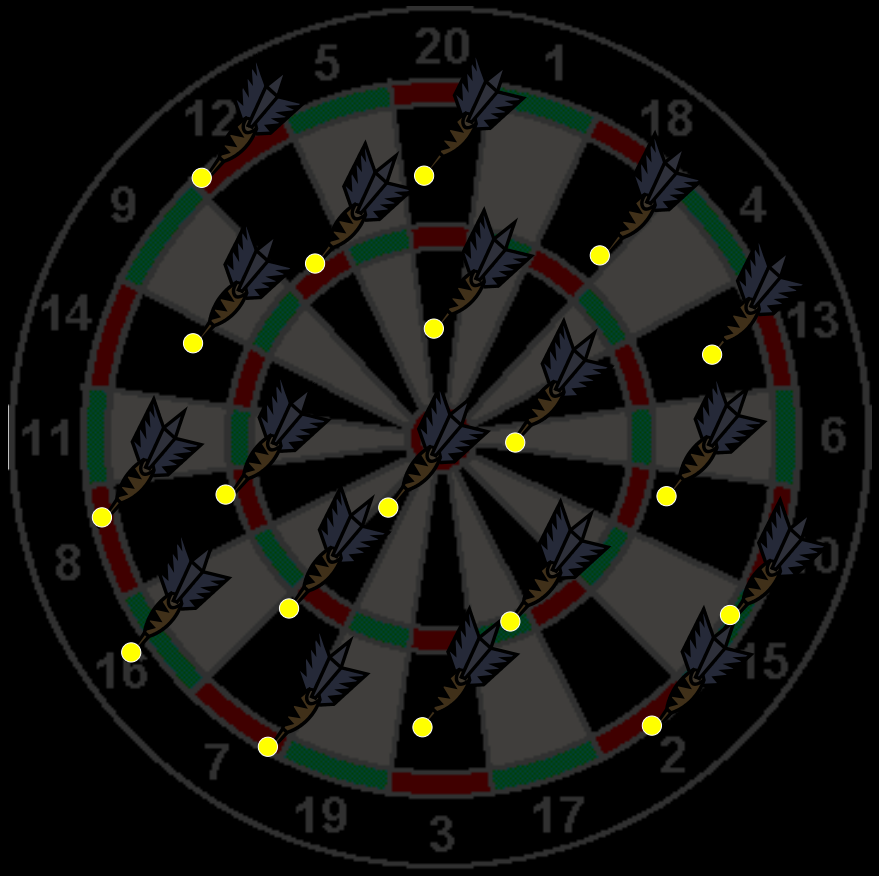
[Tzeng and Wei I3D 2008]

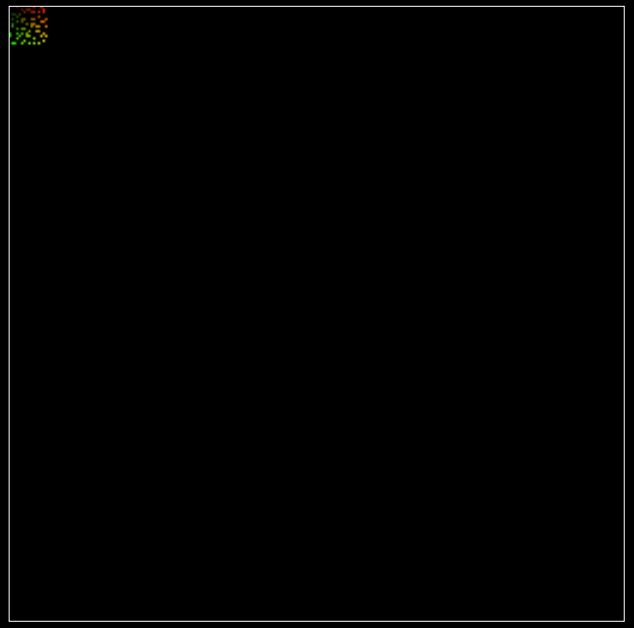


How to start a bar flight



How to stop the bar flight





Parallel GPU run time
(slow motion)
4M Poisson disk samples / sec
in parallel!

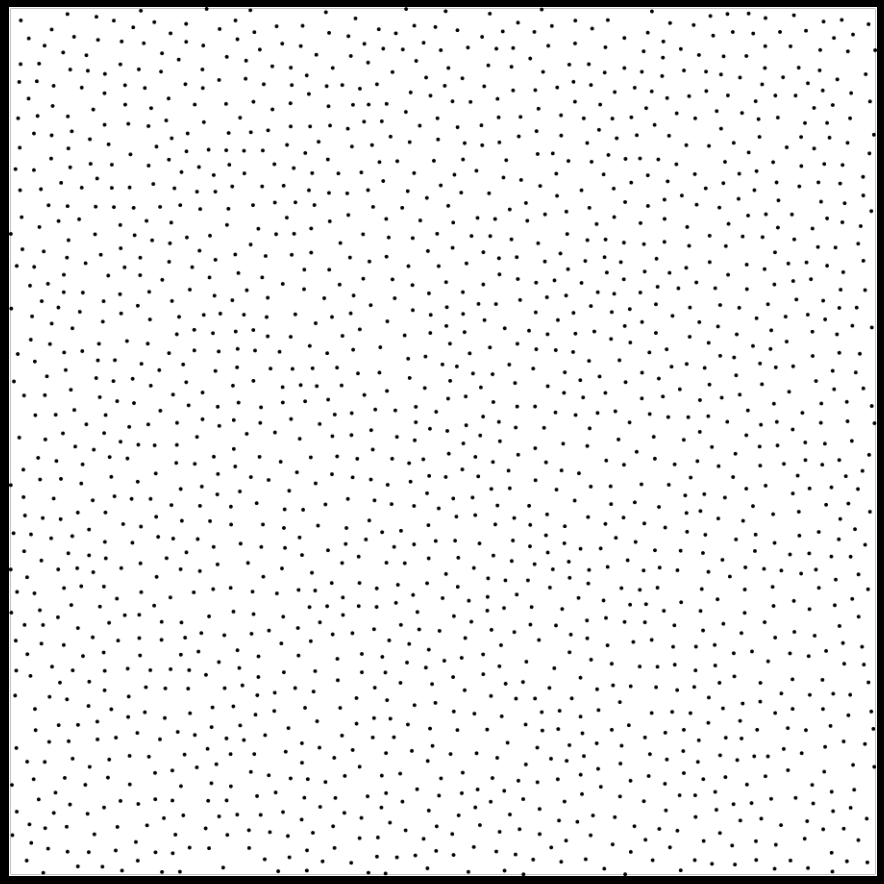
Poisson disk sampling

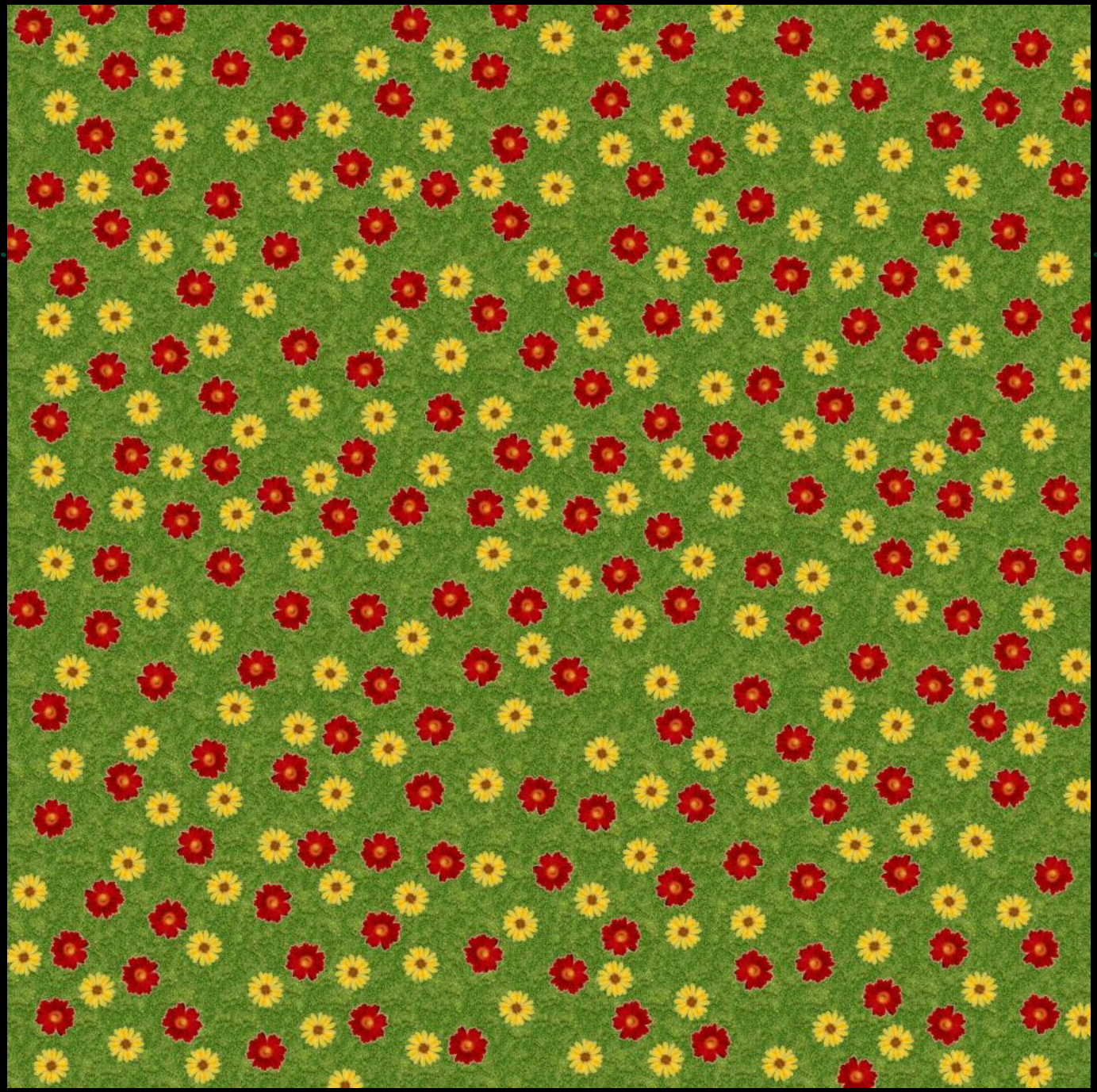
A set of samples that are

- as random as possible
- remain a minimum distance ***r*** away from each other

Why pick this problem?

- important algorithm
- - sampling, graphics, statistics
- seemly non-parallelizable





Dart throwing [Cook 1986]

Loop:

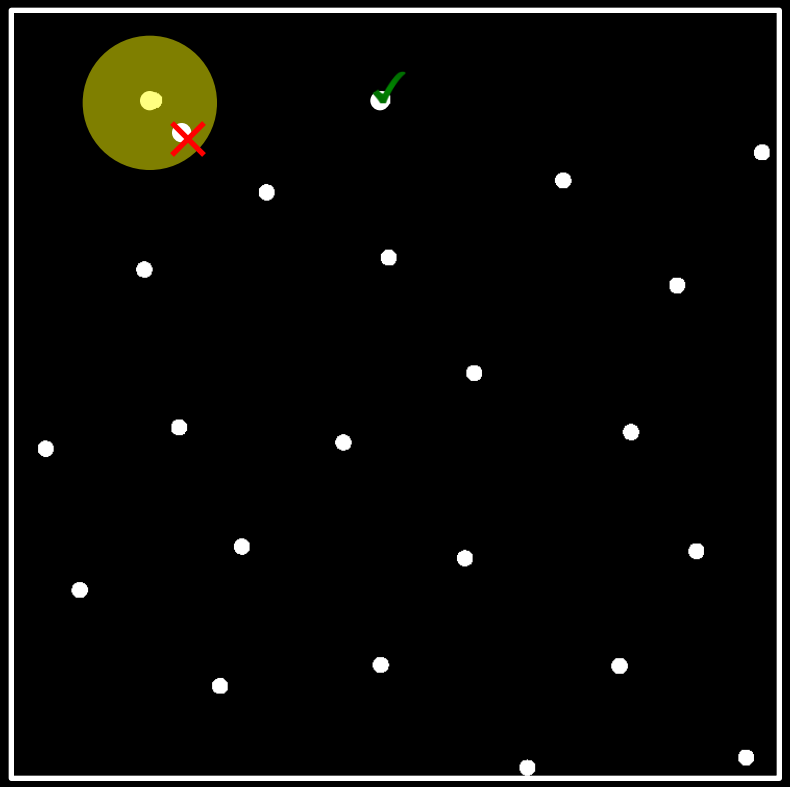
- random sample from the entire domain
- accept sample if not in conflict with existing ones

O High quality

- ground truth

X Slow speed

- inherently sequential

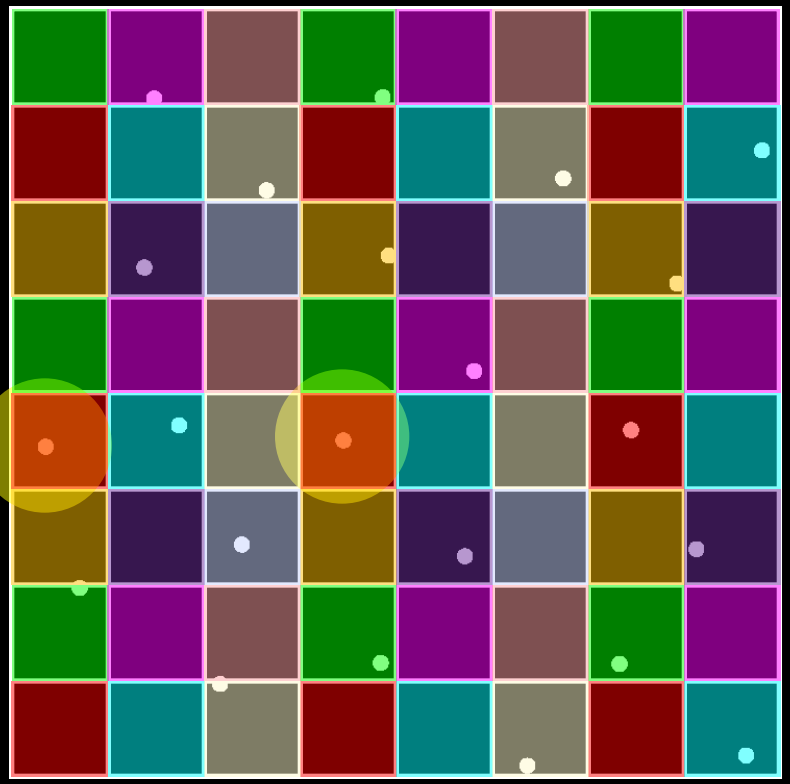


Parallel Poisson disk sampling [Wei SIGGRAPH 2008]

Samples from a grid

1 sample per grid cell

Sample grid cells far apart in parallel



Watch out for bias! 

Tricks to avoid bias

Image cloning

http://www.freewebs.com/cheesesandwiches/cloning.jpg
http://mahboubian.googlepages.com/dog-bird.jpg

Poisson image editing [Perez et al. SIGGRAPH 2003]

State-of-art for image cloning + other stuff

Solving Poisson equation

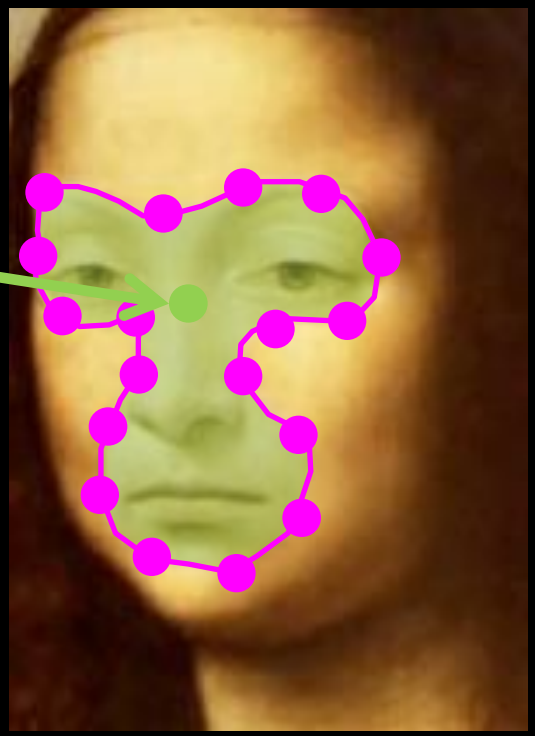
- interior detail (source)
- boundary condition (target)

Heavy computation

Coordinate interpolation

[Farbman et al. SIGGRAPH 2009]

$p = \sum w_i b_i$



Easy computation

Run parallel on a GPU

Summary

Conclusion

- sequential consistency too strict
- semantic consistency (perceptual, statistical, etc)

Future work

- parallelism via semantic consistency
- individual algorithms / applications
- general methodology?