GPU Accelerated Vessel Segmentation Using Laplacian Eigenmaps

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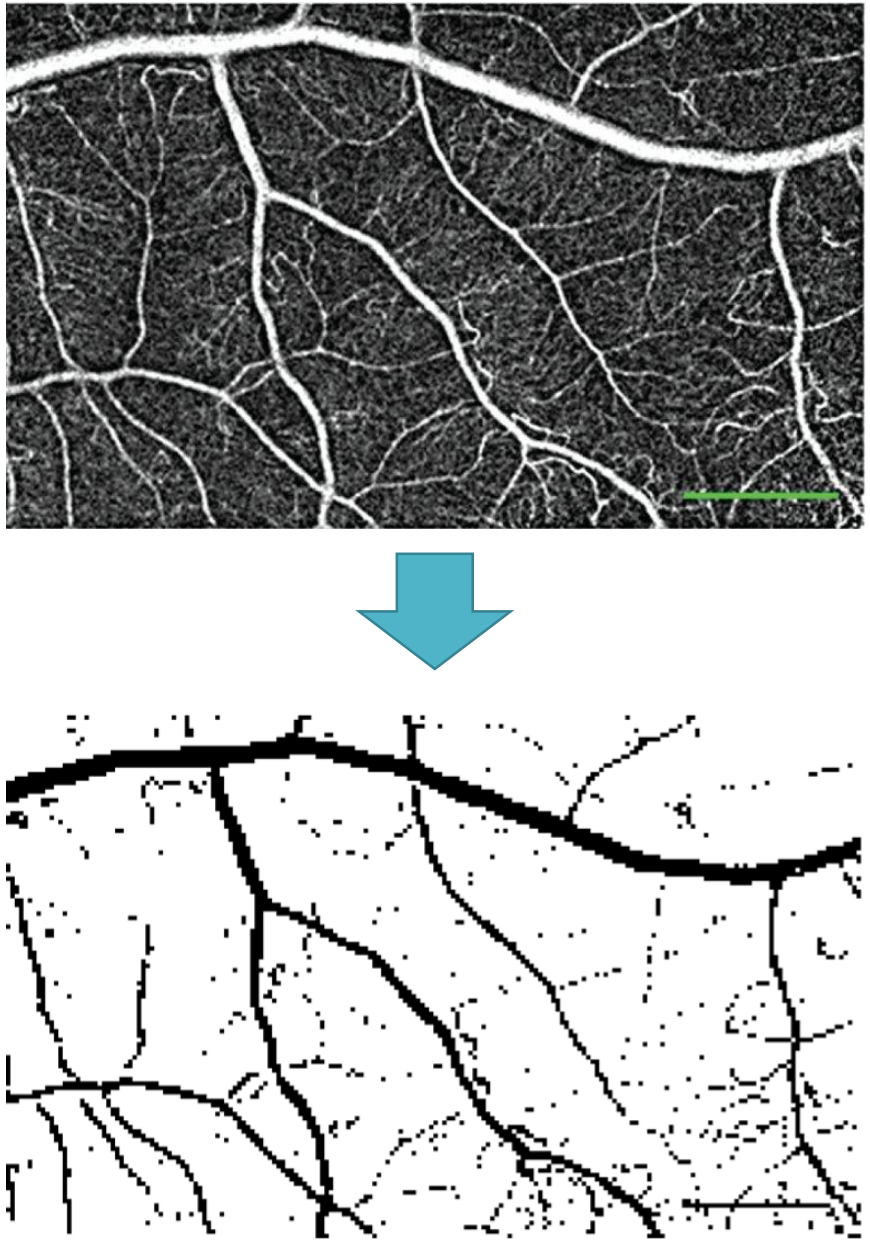
Problem

Image segmentation

Partition pictures of vessels into **segments**



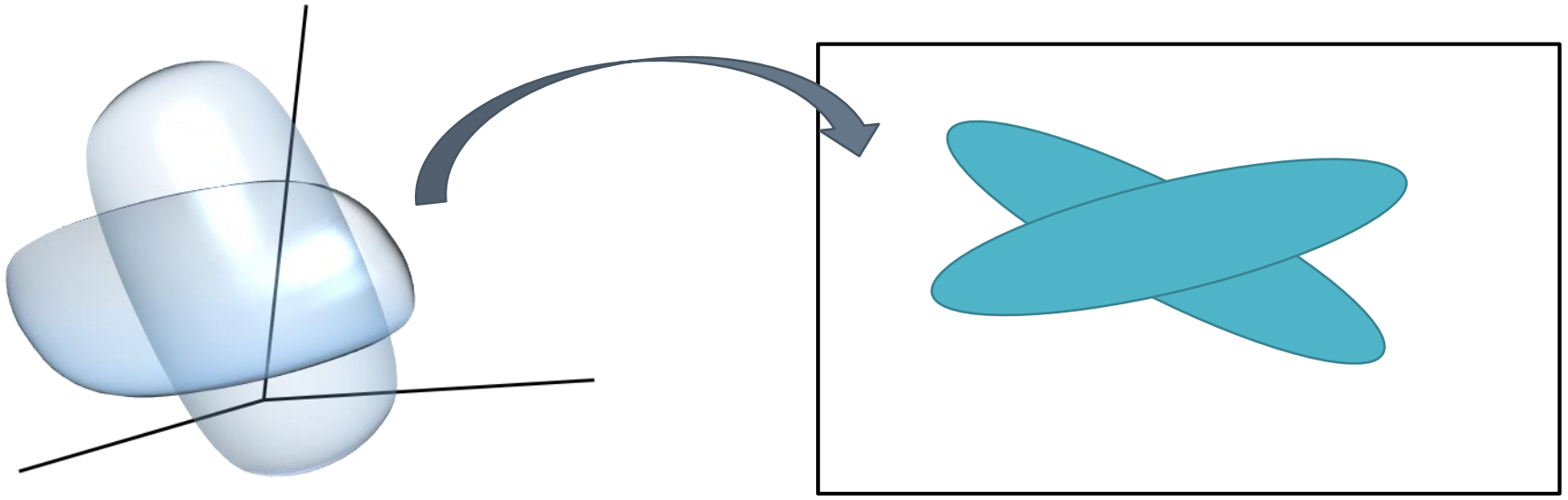
Laplacian eigenmap [1]

Local info embedded in **high dimensional space**

Project local info onto low-dimensional plane

Optimize the projection to preserve essential characteristics

Cluster the projected data points into segments



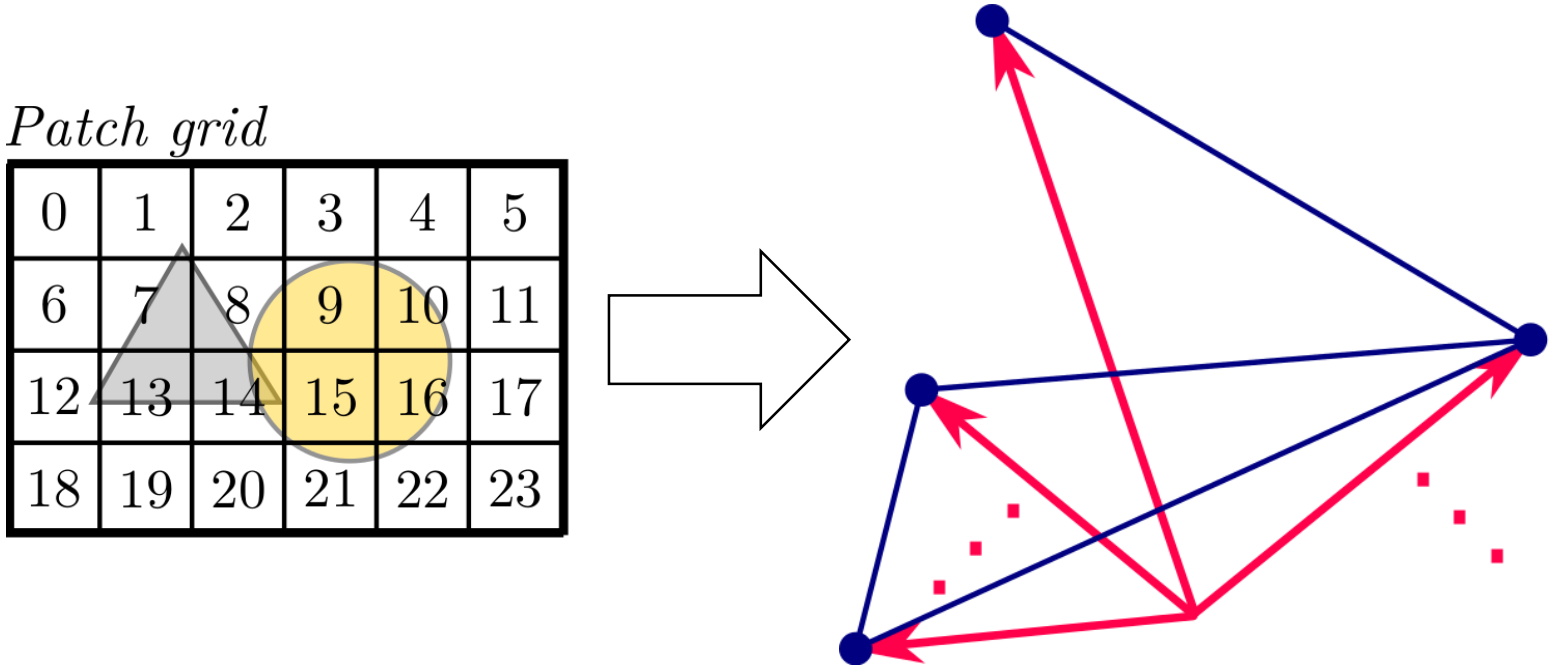
[1] Tziakos, Laskaris, and Fotopoulos

Segmentation process

Build graph of local info

Store the resulting graph in a **weight matrix**

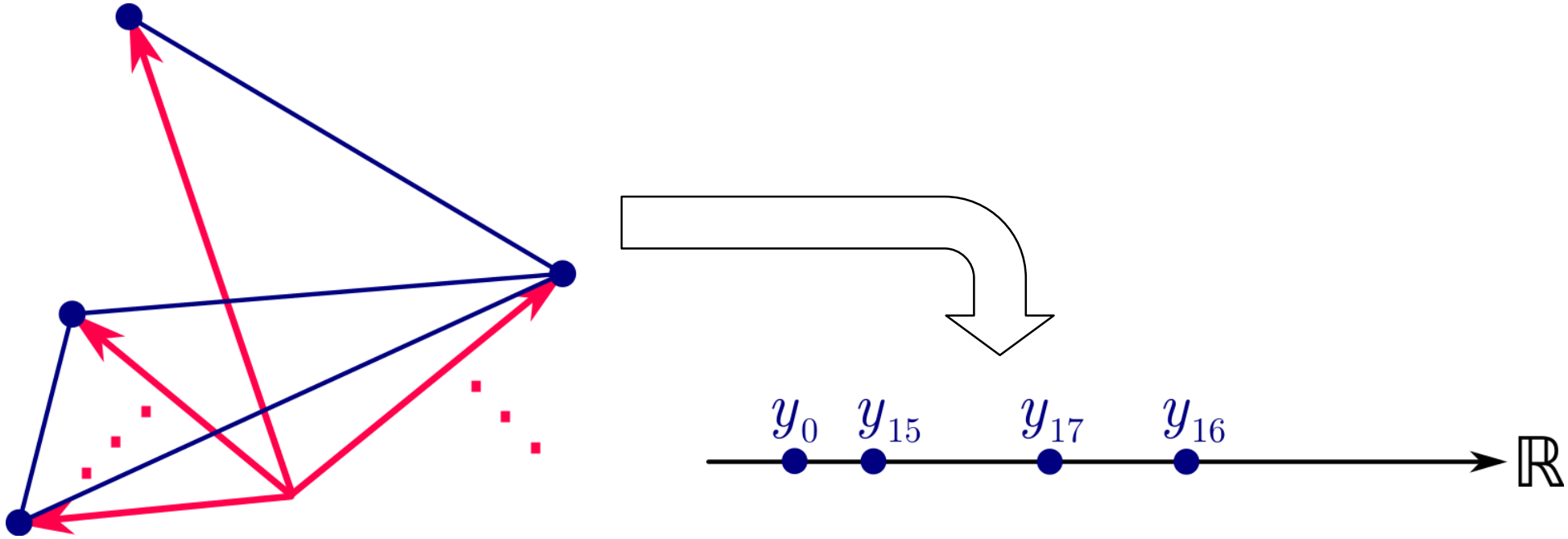
Edges reflect variations among different regions (global variation)



Apply Laplace operator

Form **Laplacian matrix** $L = I - D^{1/2}WD^{1/2}$ encoding the Laplace operator.

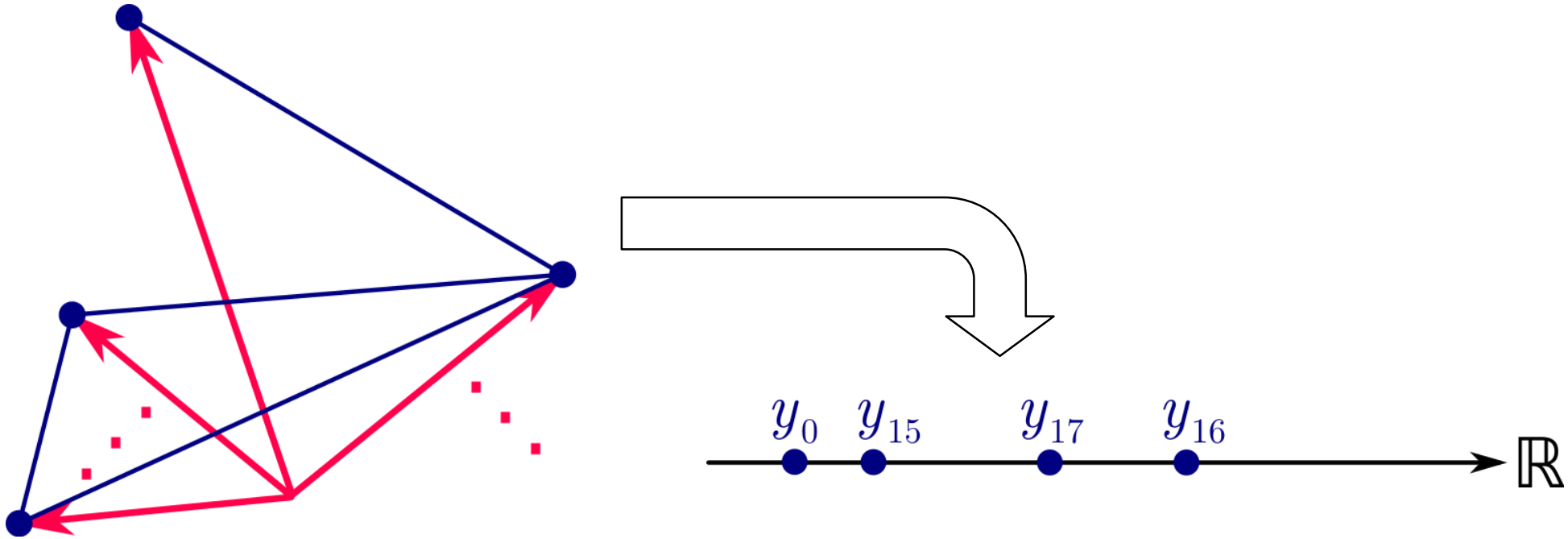
The operator formulates an **optimization problem**:
Projections of well-connected nodes should also be tightly clustered.



Solve optimization problem

Solutions to eigenvalue problem $L\mathbf{y} = \lambda\mathbf{y}$ are optimal solutions

If solutions are good, we can detect clusters

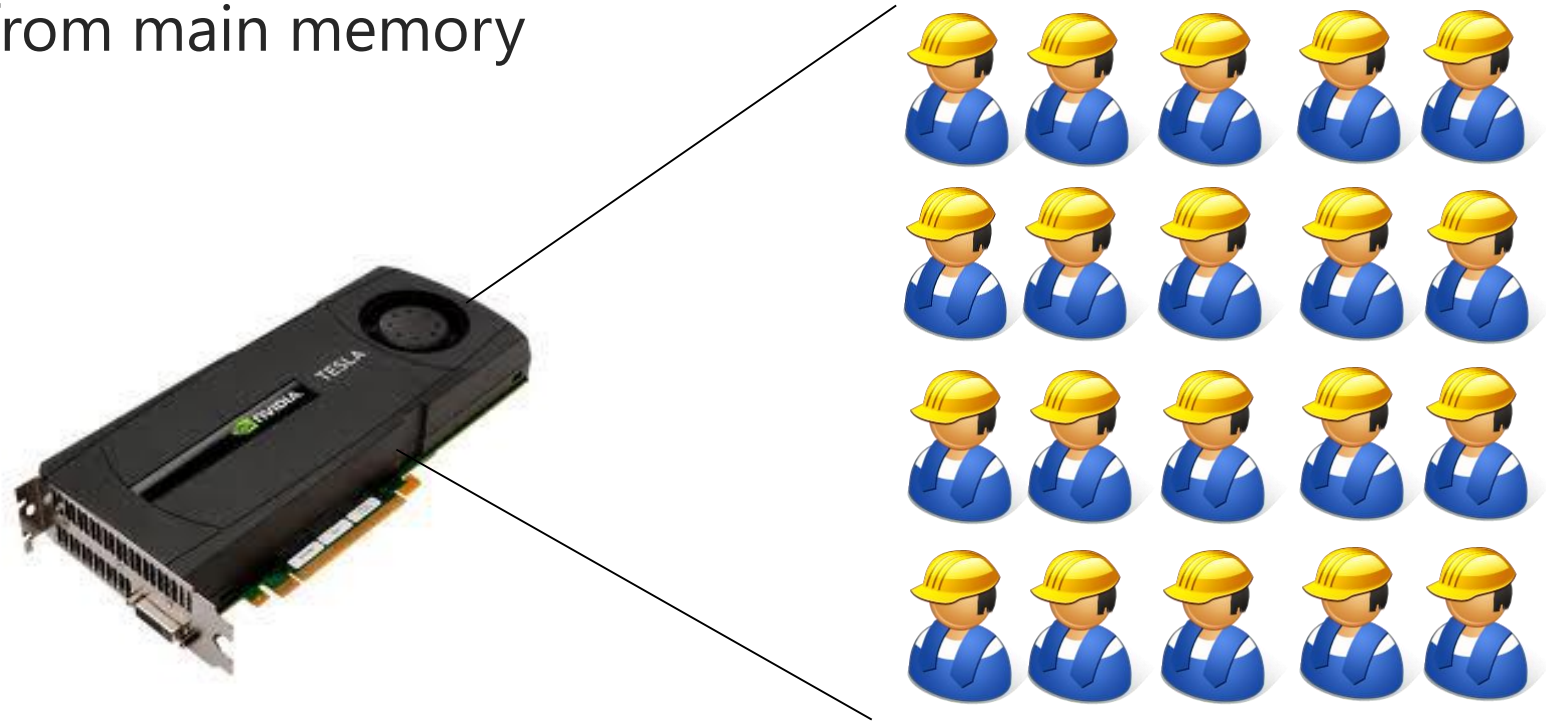


Characteristics of GPUs

Massively parallel – lots of small cores (workers)

Good for high-throughput, compute-bound tasks

Separate memory space from main memory



Strategy: Reduce memory footprint

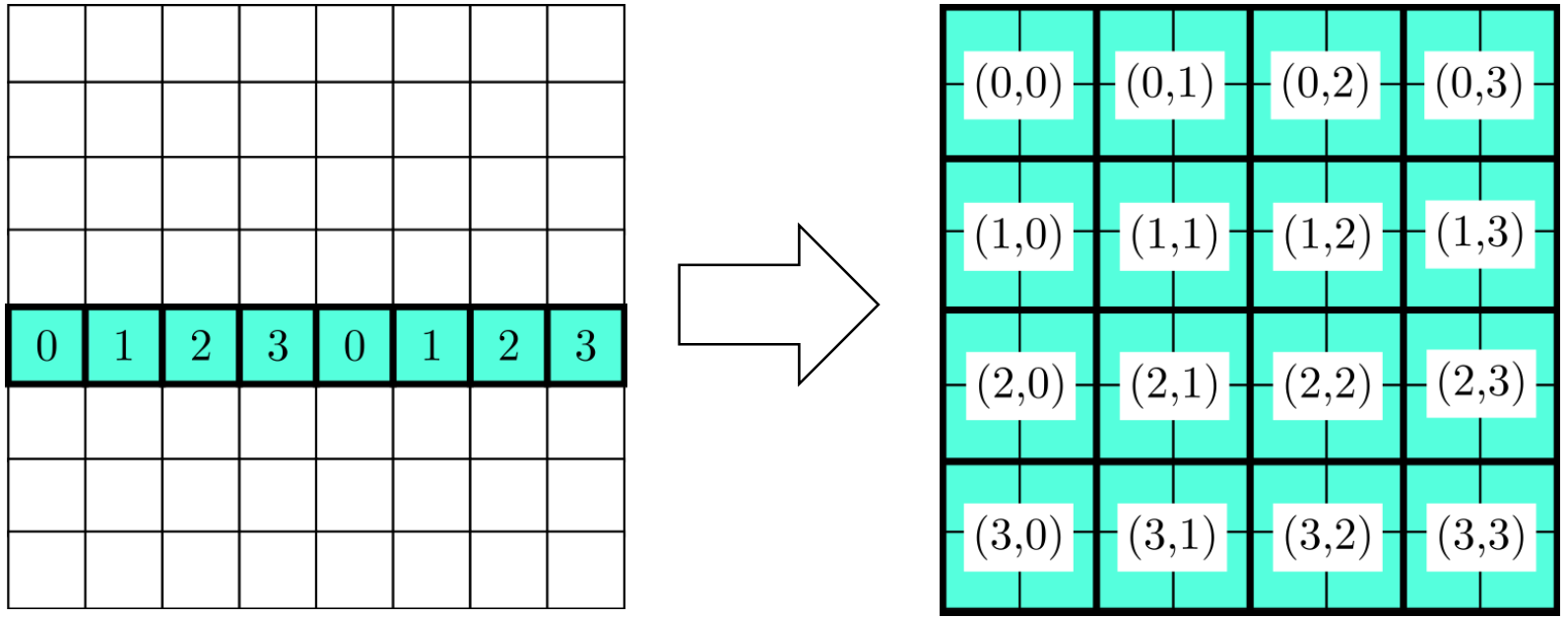
On-GPU memory is limited

Reduce memory usage and we can pack in more work into GPU

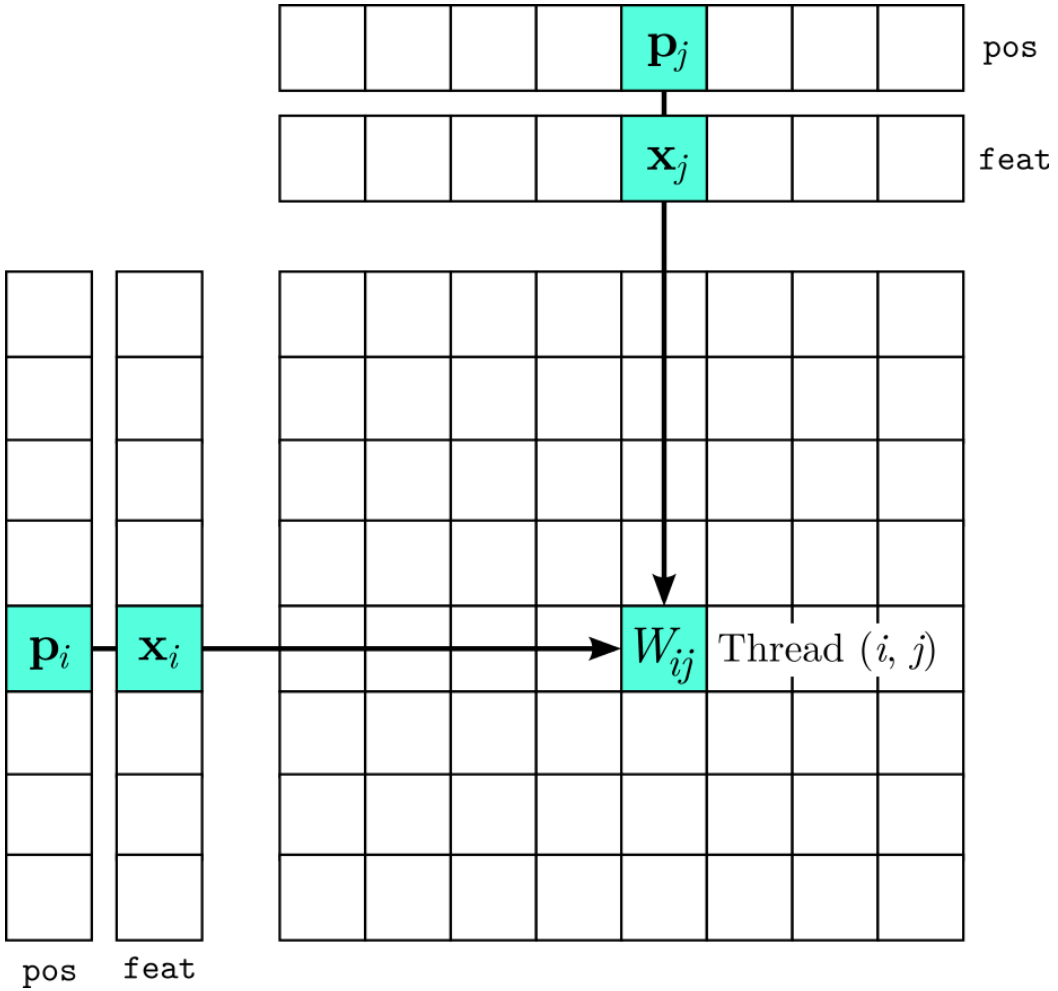
Strategy: Reduce memory footprint

Weight matrix generation:

- Do not store intermediate results
- More entries can be calculated in parallel; **10x faster**



Worker allocation

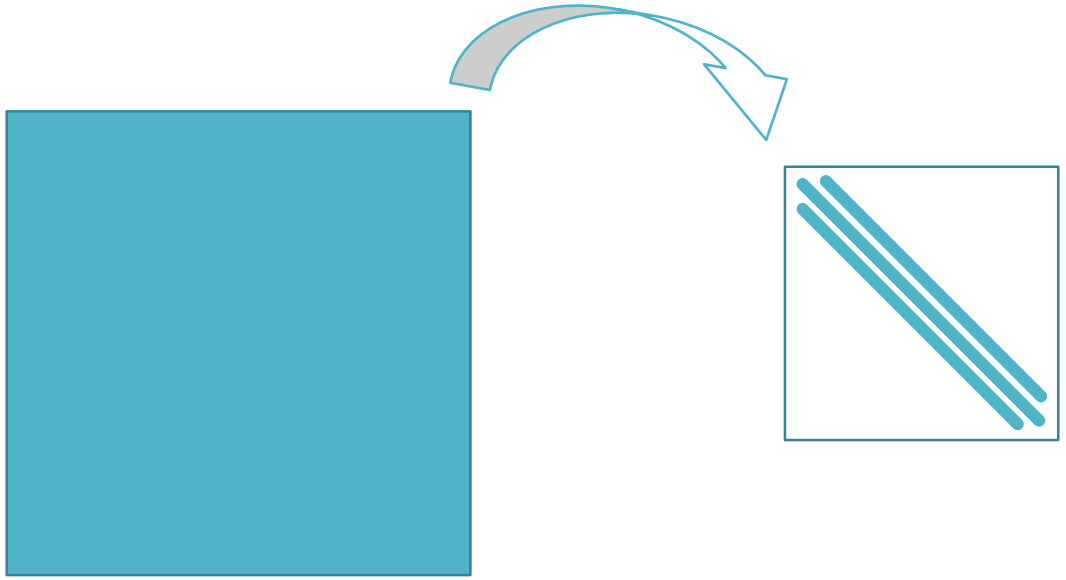


Strategy: use Lanczos method

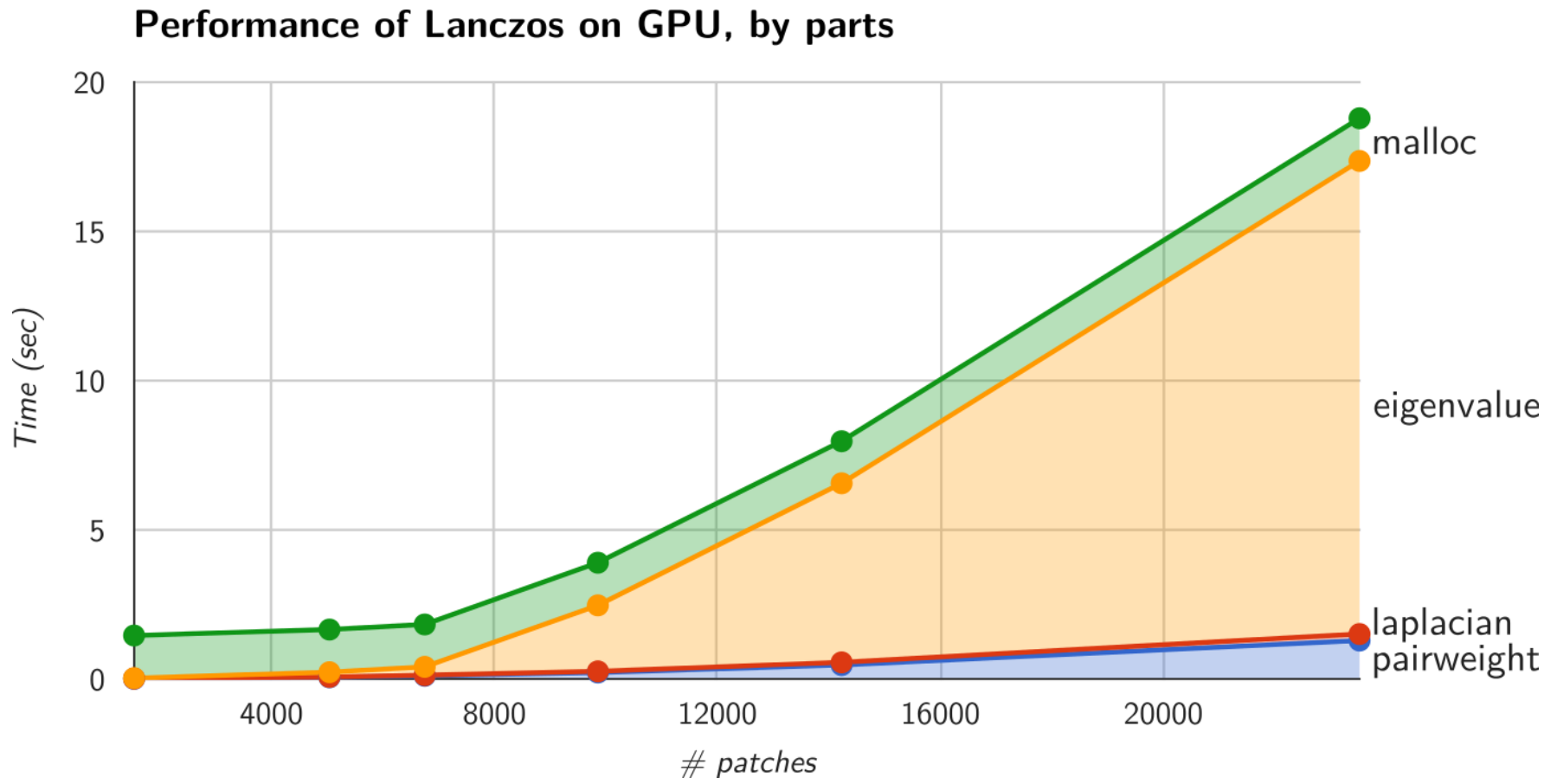
We need only a few smallest eigenvalues of *L*

Lanczos method iteratively solve for the eigenvalues needed

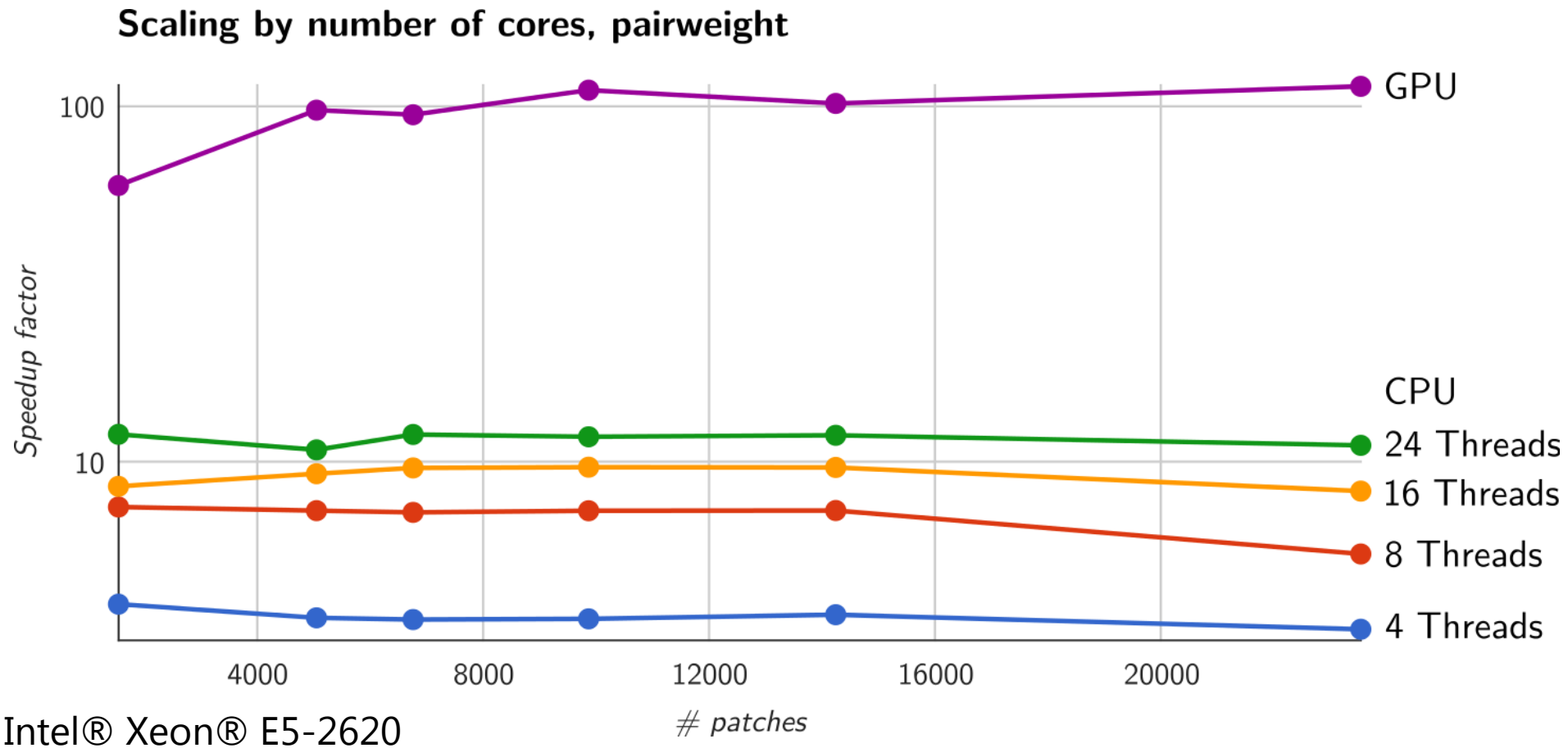
Takes 1/28 time of conventional method



Performance



Performance: vs. multicore CPUs



CPU: two Intel® Xeon® E5-2620
GPU: one Nvidia Tesla® K20c

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