Centrum Wiskunde & Informatica

Universiteit Leiden

Data partitioning strategies for 3D tomographic imaging

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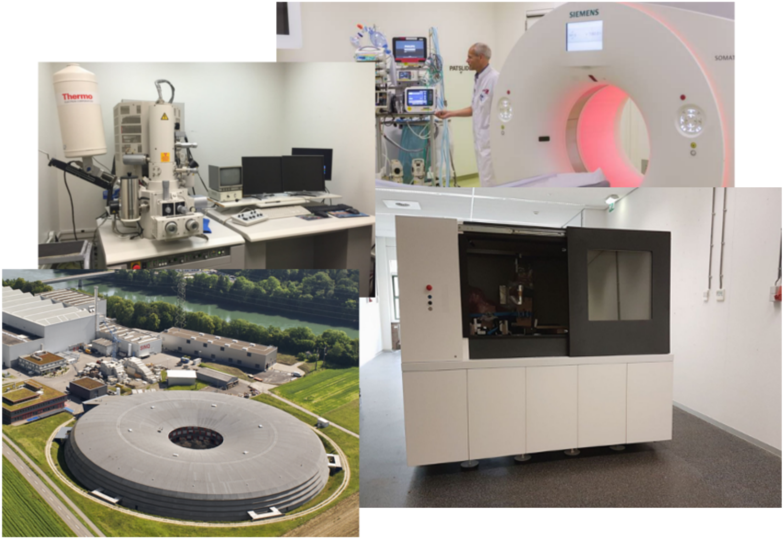
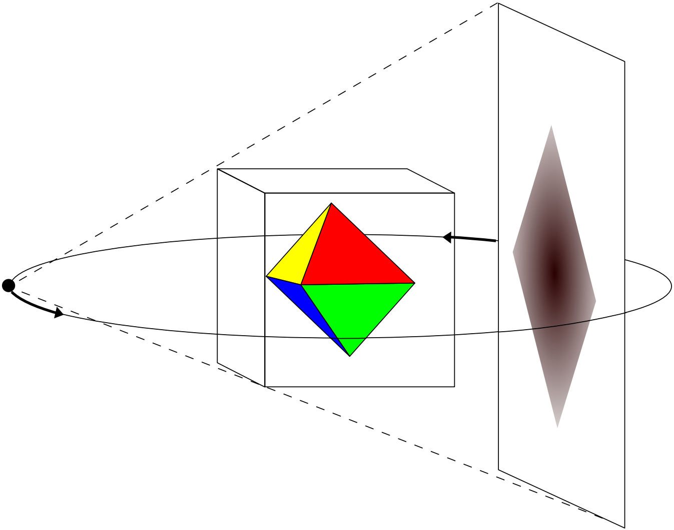
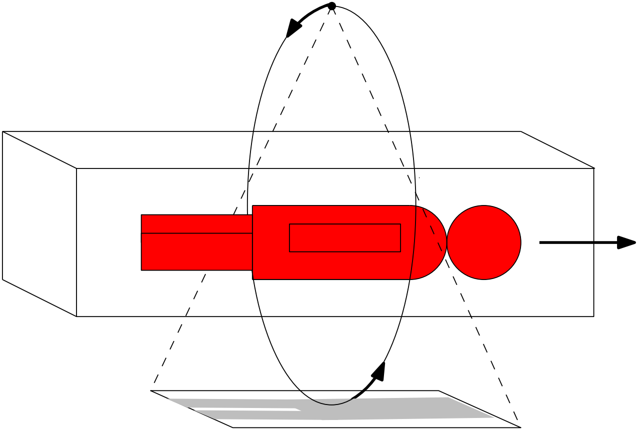
3D imaging



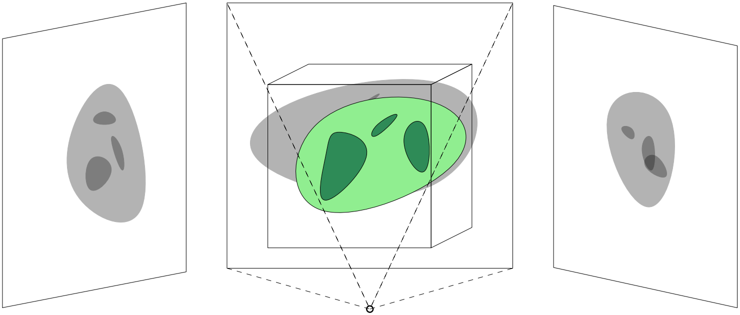
Tomography



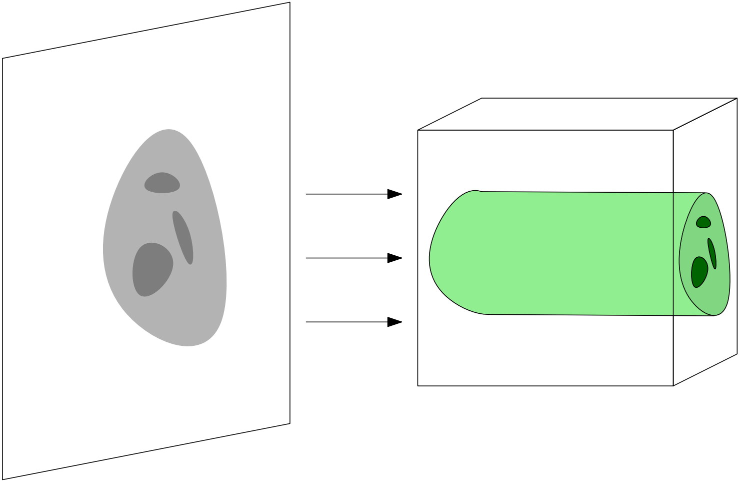
Helical CT



Forward projection



Backprojection



Partitionings

Definition

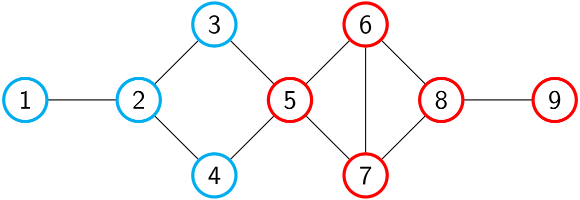
A *partitioning* Π_V of a set V is a collection of subsets $V_i \subset V$:

$$\Pi_V = \{V_1, \ldots, V_p\},$$

such that

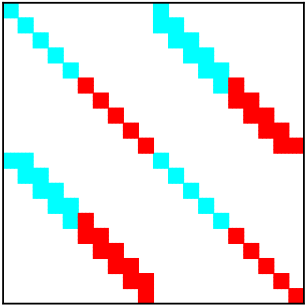
1. $V_i \neq \emptyset$ (non-empty),
2. $\bigcup_i V_i = V$ (complete),
3. $i \neq j \implies V_i \cap V_j = \emptyset$ (mutually disjoint).

Partitionings of graphs



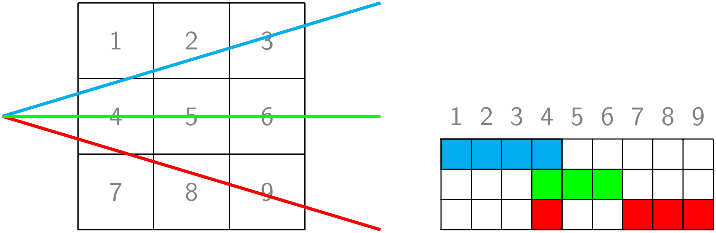
- Graph: partition vertices while minimizing the *edge cut*
- An edge is *cut* if it is between two different parts
- All parts should be roughly the same size

Partitionings of sparse matrices



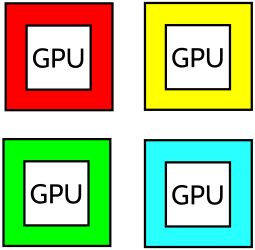
- Sparse matrix: partition nonzeros while minimizing the *net cut*
- The *nets* are the rows and columns
- The net cut is the number of additional parts in a net

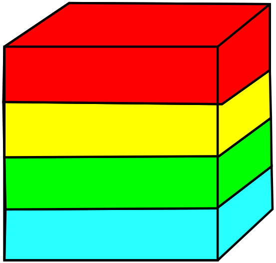
Projection matrix



$\mathcal{V}$ A

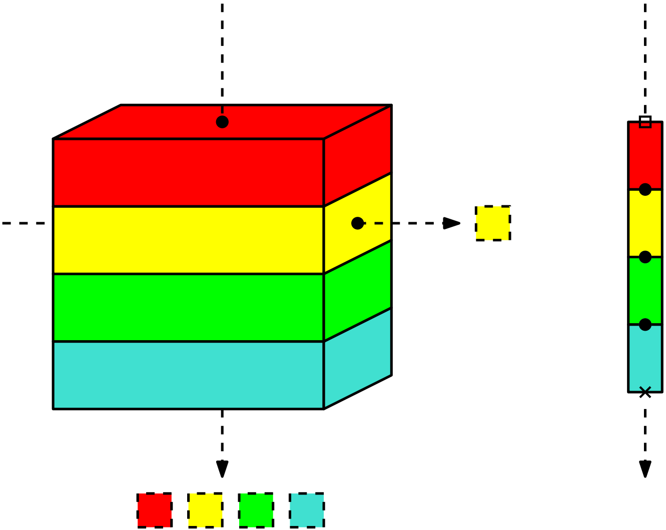
Partitionings in tomography



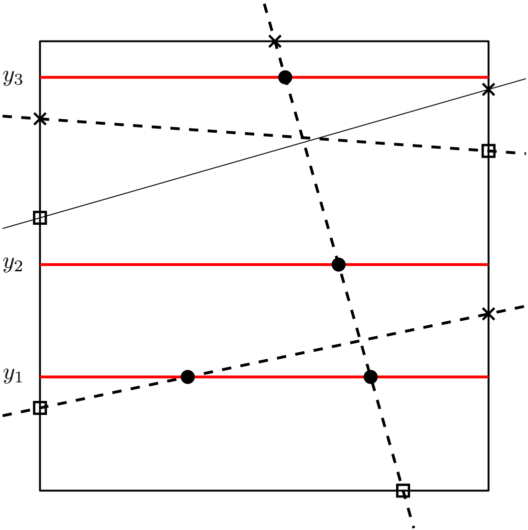


- Tomography: partition 3D volume while minimizing the *line cut*
- The line cut is the number of additional parts a line crosses

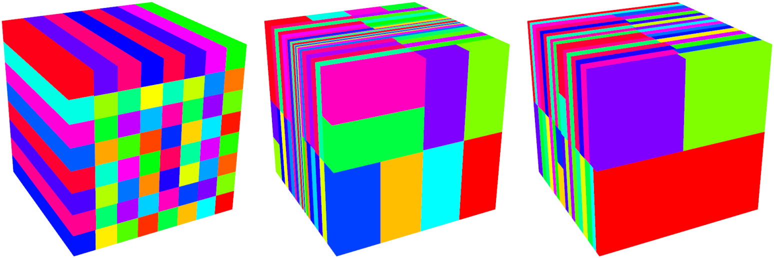
Communication



Algorithm



Partitioning results



Results & Reference

- Communication reduced by between 60% and 90%
- Each GPU guaranteed to perform the same amount of work

A geometric partitioning method for distributed tomographic reconstruction.
Jan-Willem Buurlage, Rob Bisseling, Joost Batenburg. Parallel Computing, 2019.
doi:10.1016/j.parco.2018.12.007

Conclusion

- 3D image reconstruction involves large data sets
- Because lines couple opposite sides of 3D volume, it is not easy to parallelize
- Using ideas from computational geometry, we are able to scale our algorithms beyond what was possible before

Thank you for your attention!