Modelling three-dimensional geoscientific datasets with the discrete Voronoi diagram

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Geoscientific datasets

- As found in meteorology and oceanography
- Continuous datasets (fields)
- Three-dimensional
- Samples have anistropic distro
- Rasters are usually used
  - voxels
  - octree

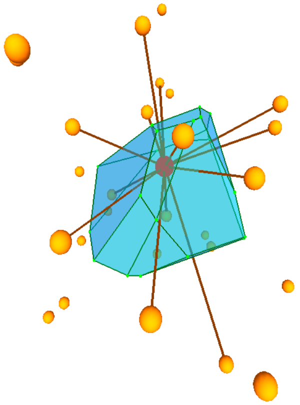
Alternative to raster: 3D Voronoi diagram

Several advantages

- tessellation of space = clear definition of neighbourhood
- adaptative to the spatial distribution
- continuity of field = VD-based interpolation
- locally modifiable

But:

- difficult to construct and manipulate
- requires specialised tools



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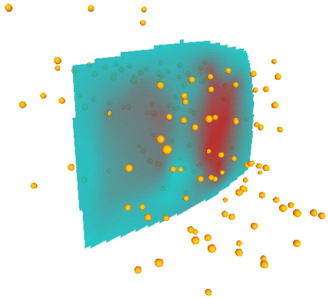

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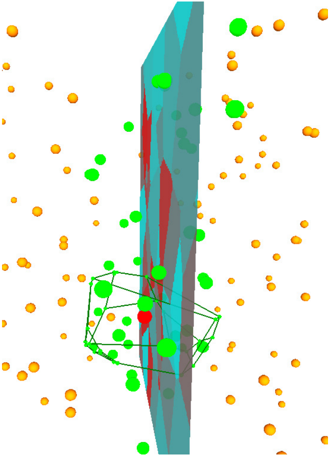
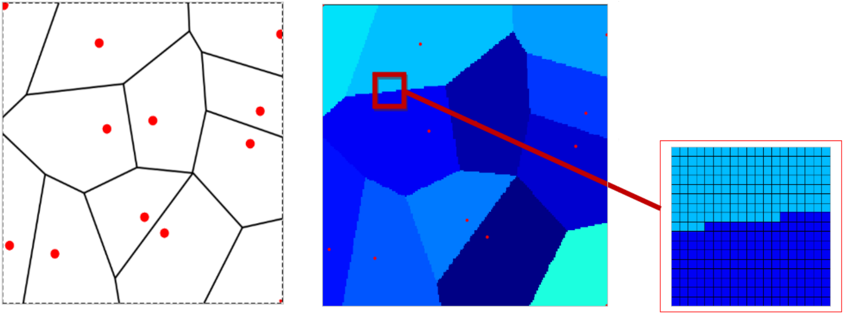
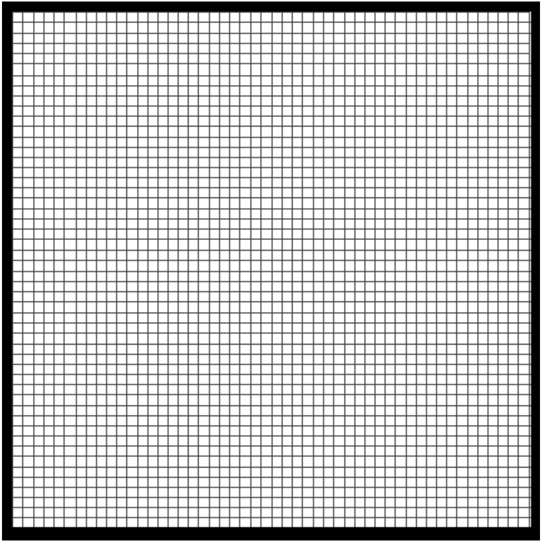


"Middle" solution: 3D *discrete* Voronoi diagram (DVD)



- One natural 'variant' of the VD
- Cells = groups of pixels with same ID
- Which properties are retained?

Discrete VD in two dimensions



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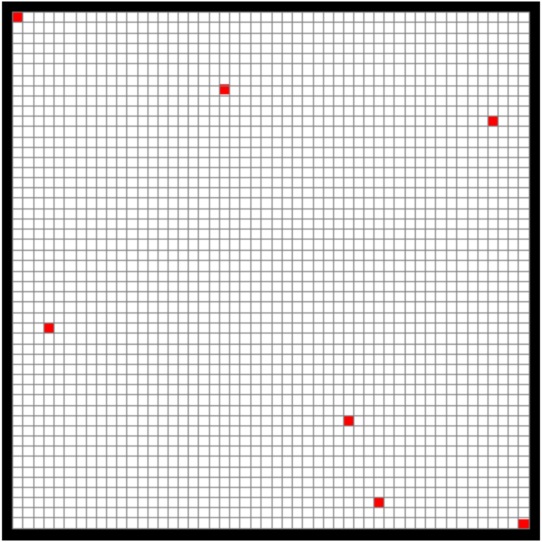

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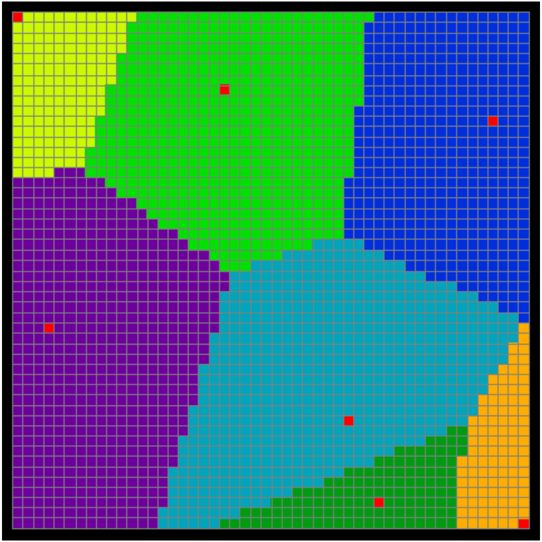
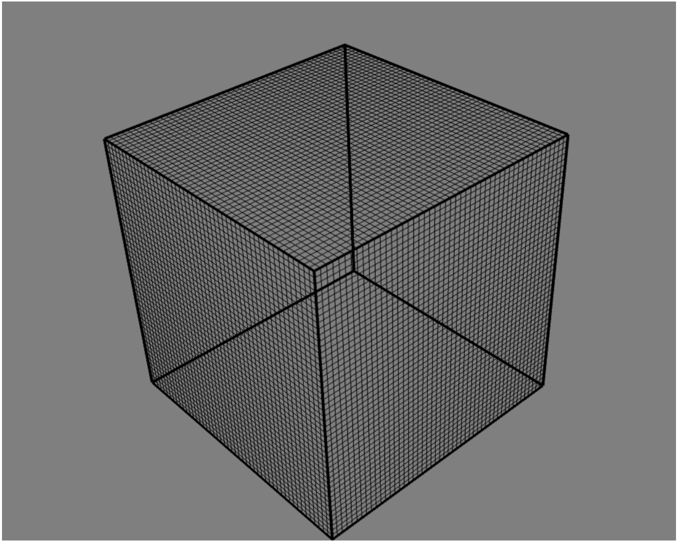
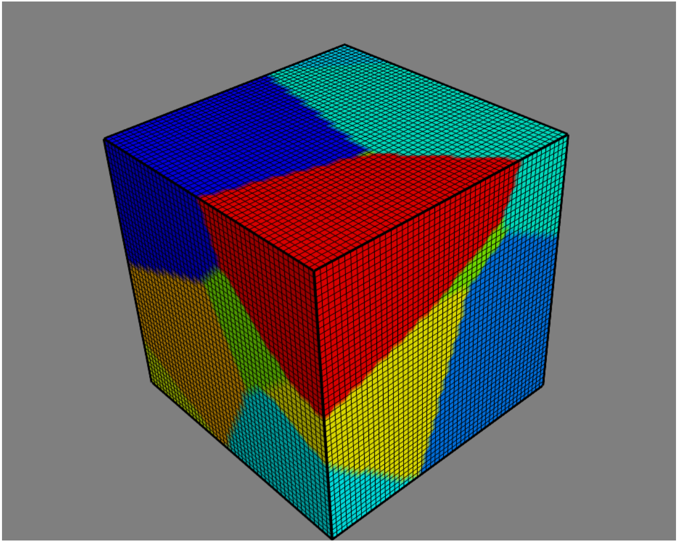


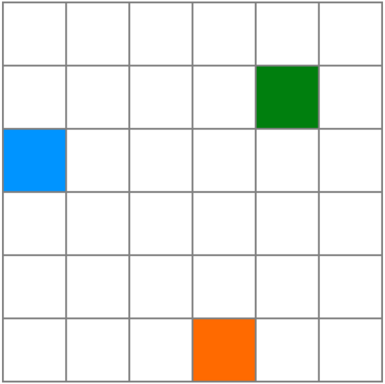
Discrete VD in three dimensions



Discrete VD in three dimensions



Explicit methods



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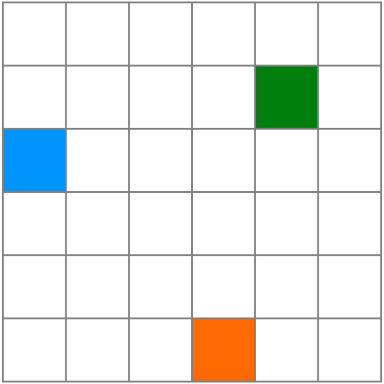
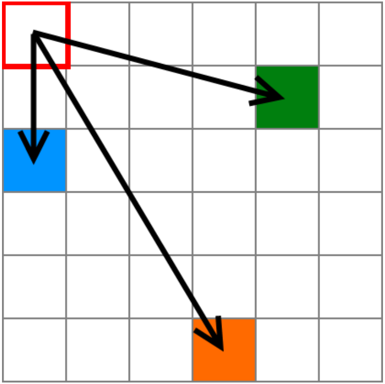


Constructing a DVD

Explicit methods



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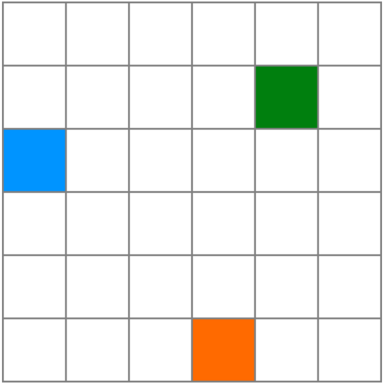

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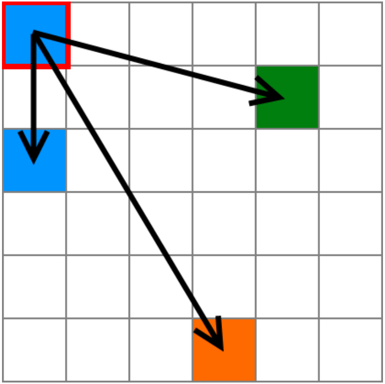

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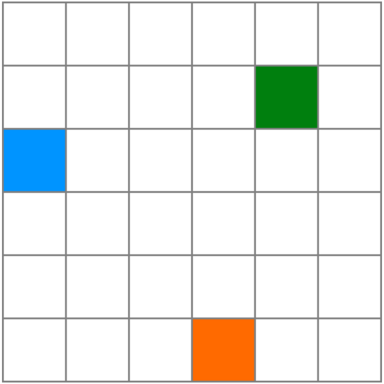

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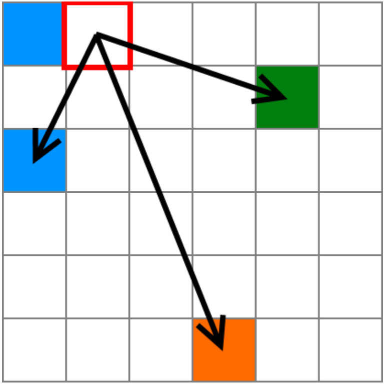

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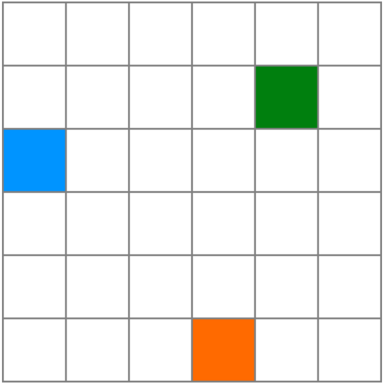

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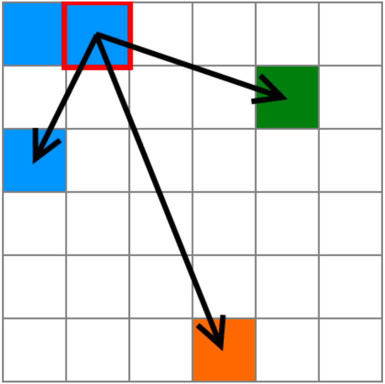

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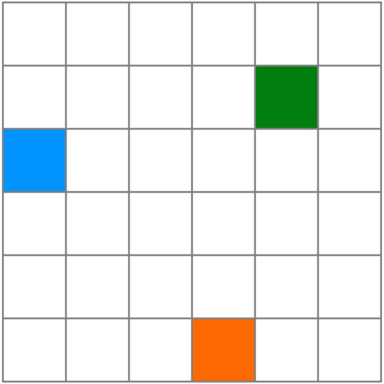

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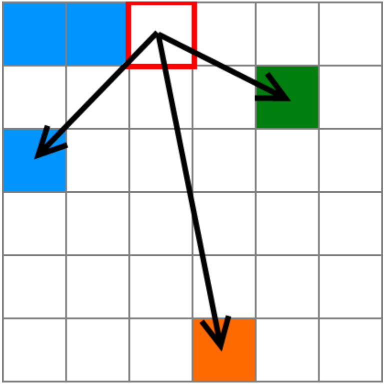

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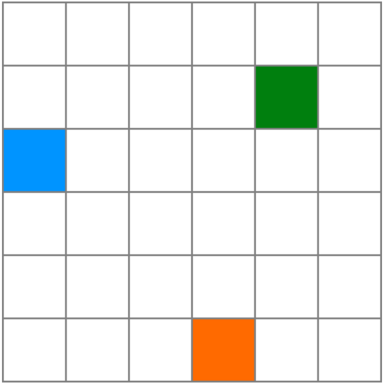

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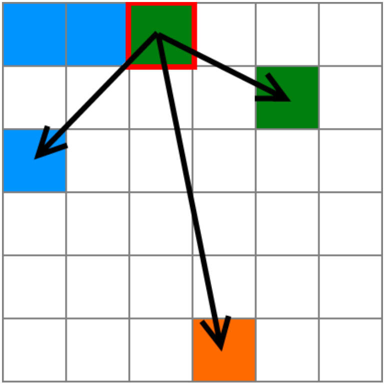

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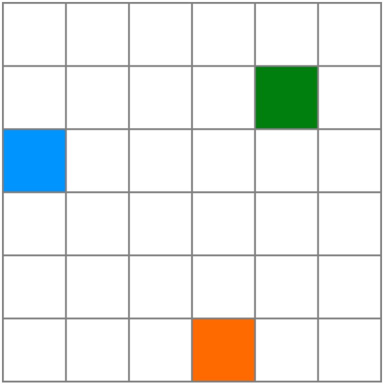

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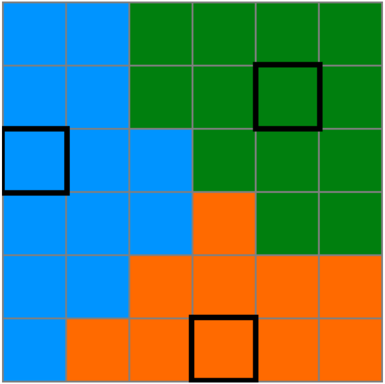

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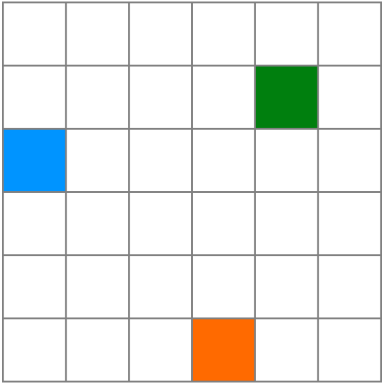

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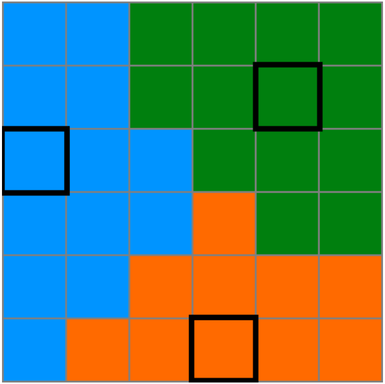

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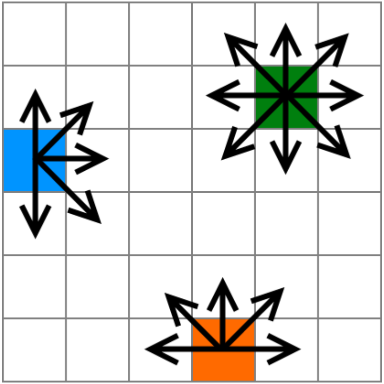

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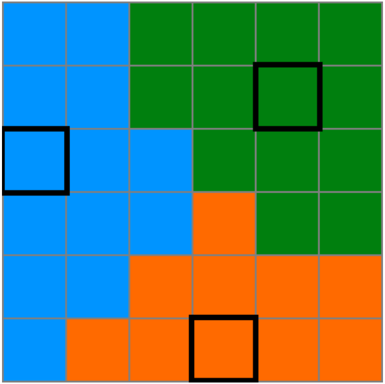

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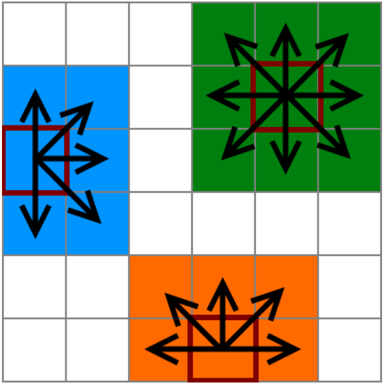

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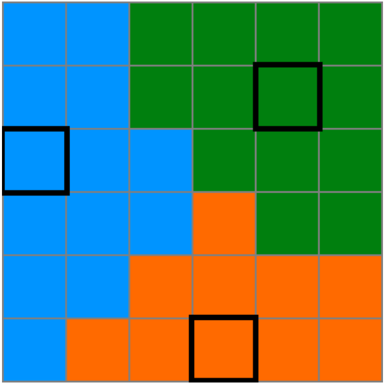

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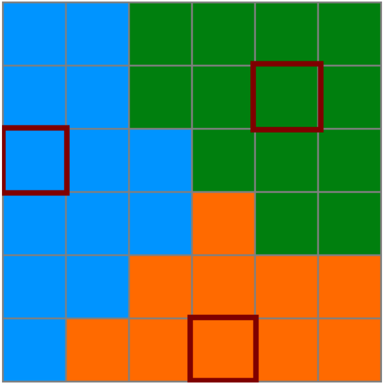
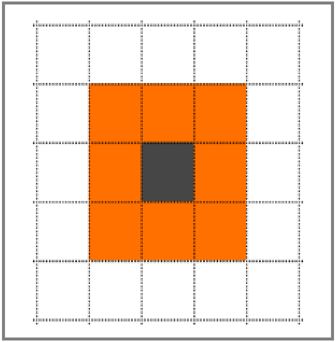
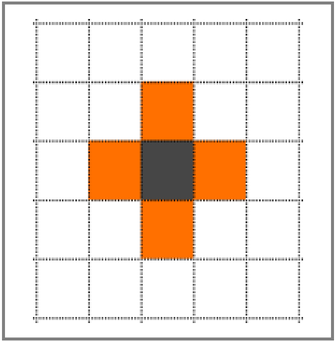


Our approach: Implicit + Dilation

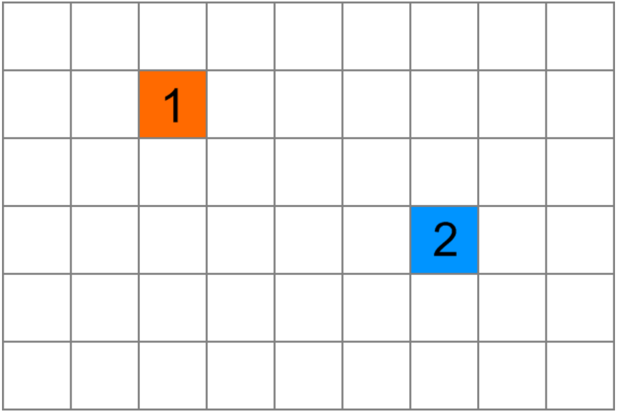


8-neighbours



4-neighbours

Resolving Conflicts



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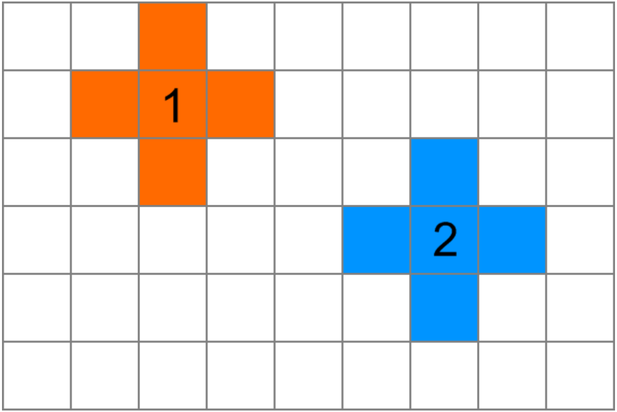

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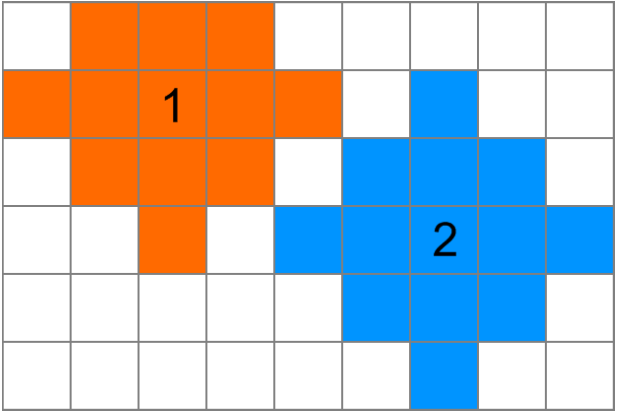

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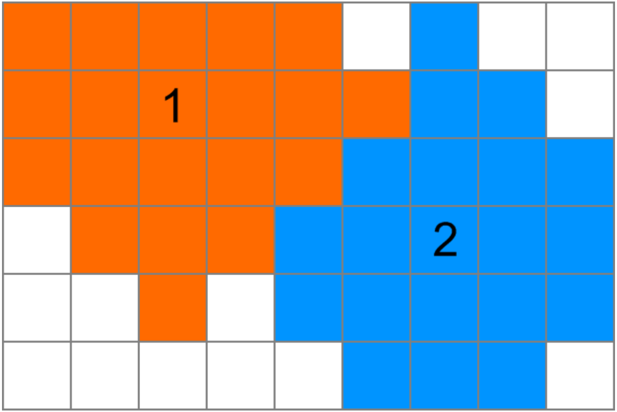

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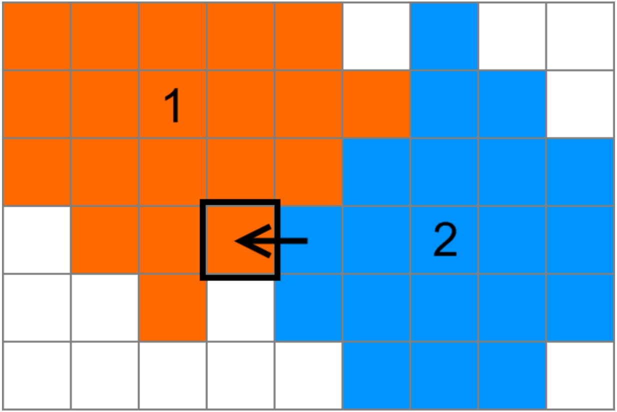

CONFLICT!

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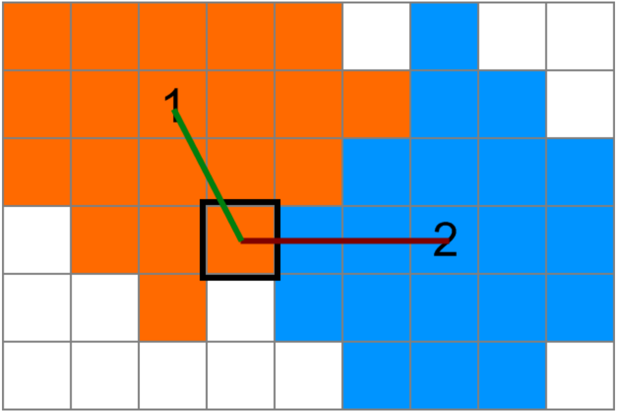

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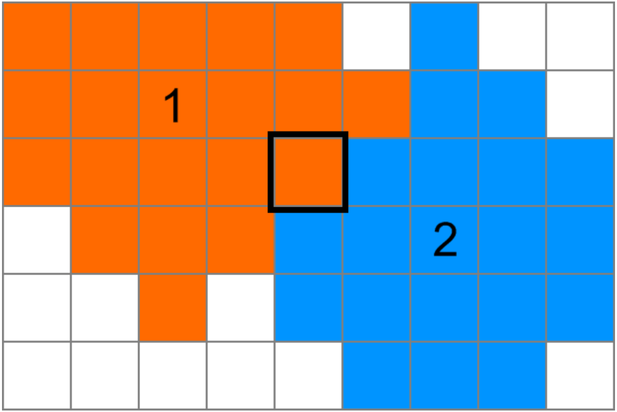

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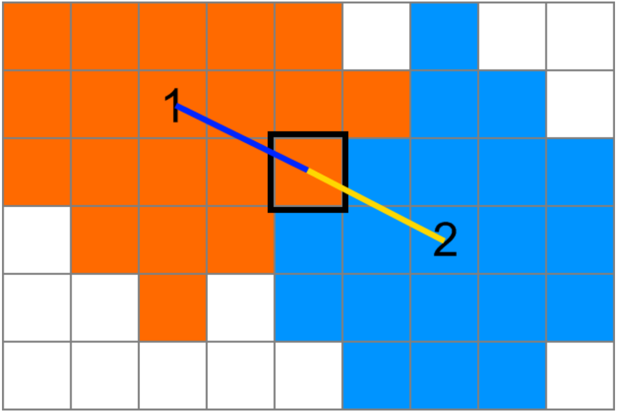

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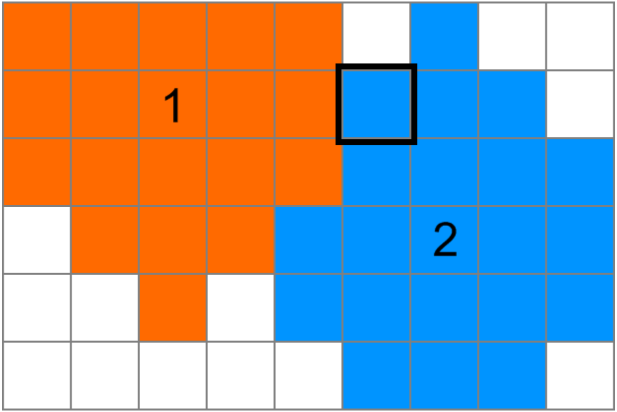

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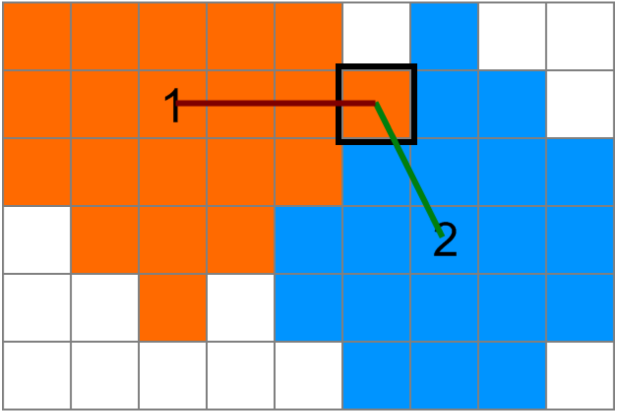

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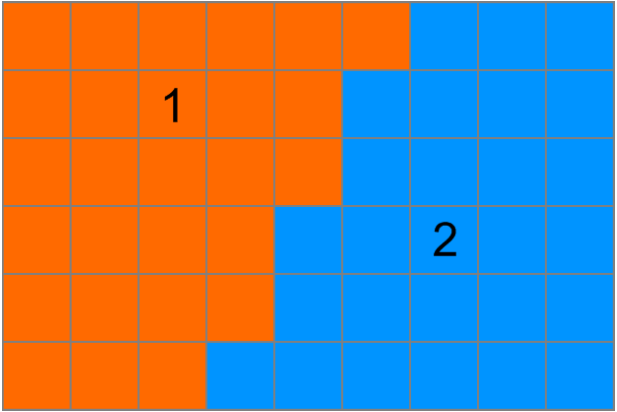
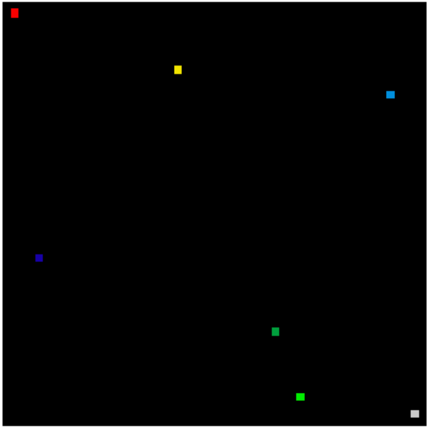
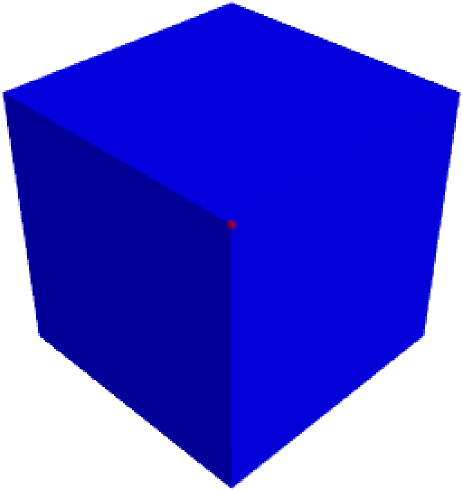


Our algorithm in 2D

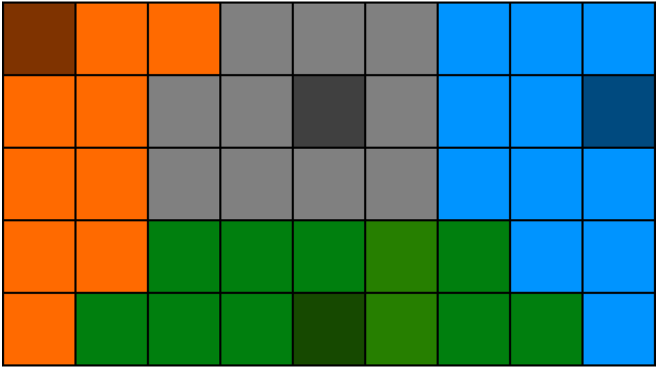


Our algorithm in 3D



Extra functions: deletion of points

- same operation as insert
- local reconstruction



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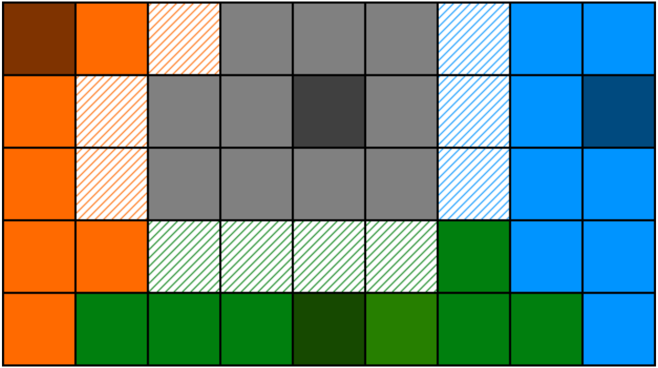

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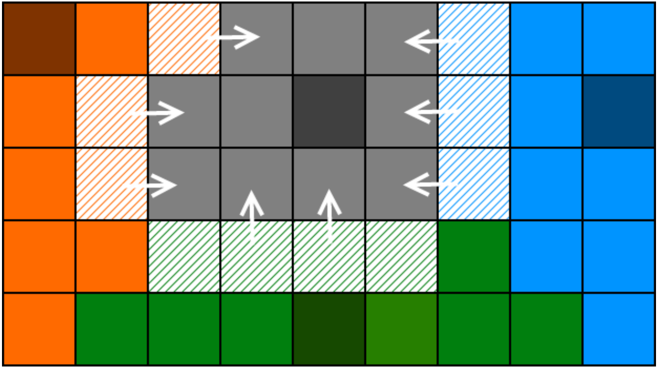

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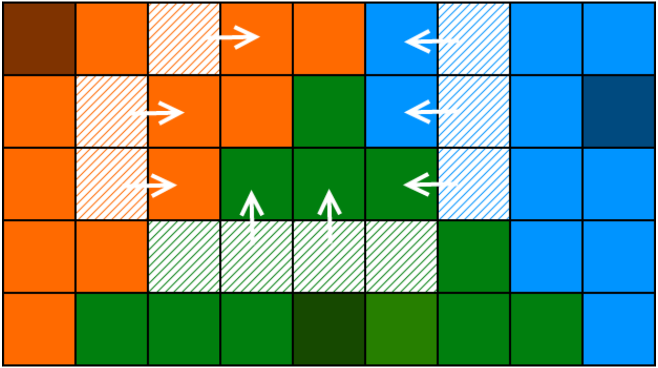

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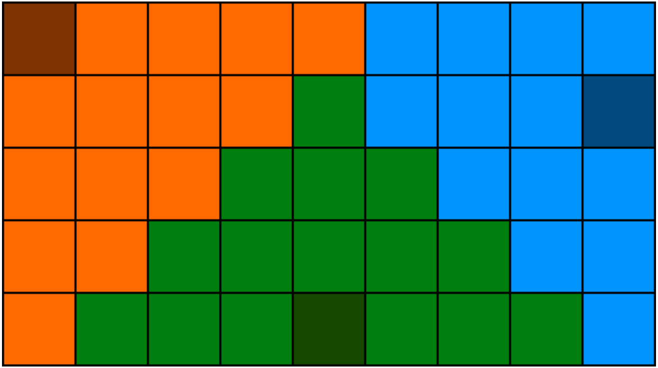
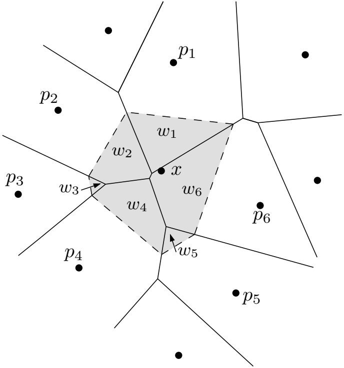


Extra functions: natural neighbour interpolation

- based on insert-delete
- easy to implement: volume = counting voxels



$w_i(x) = \mathit{stolen\ area}$

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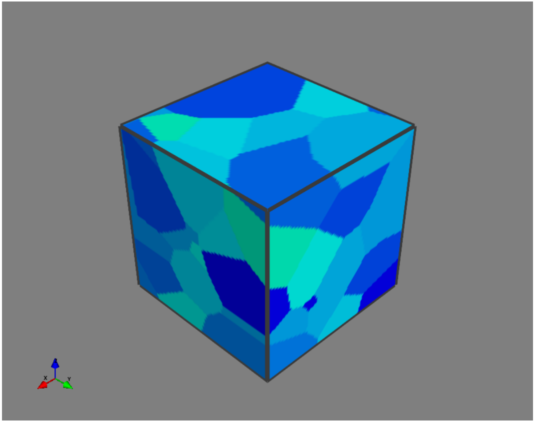

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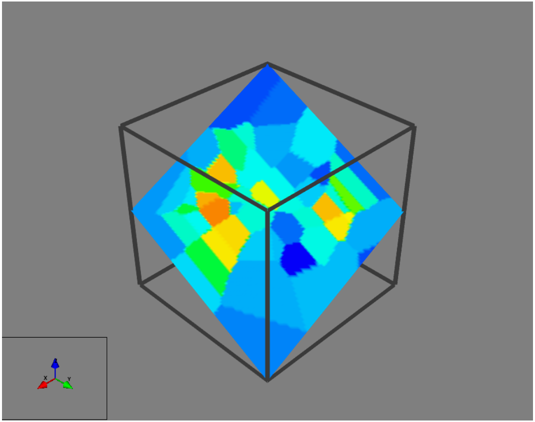

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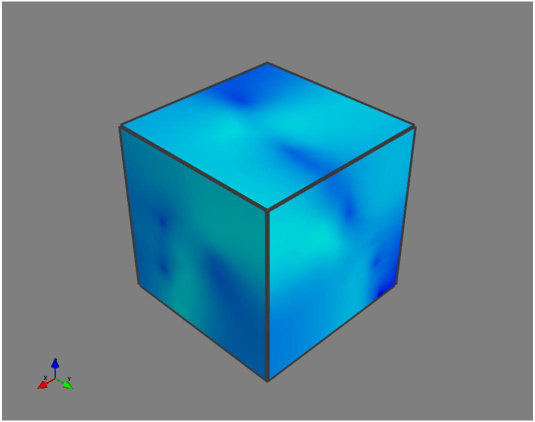

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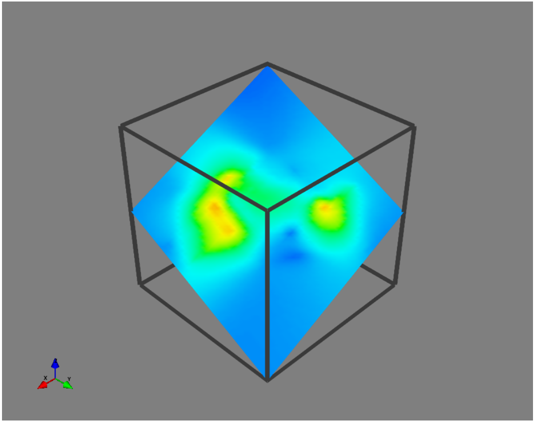
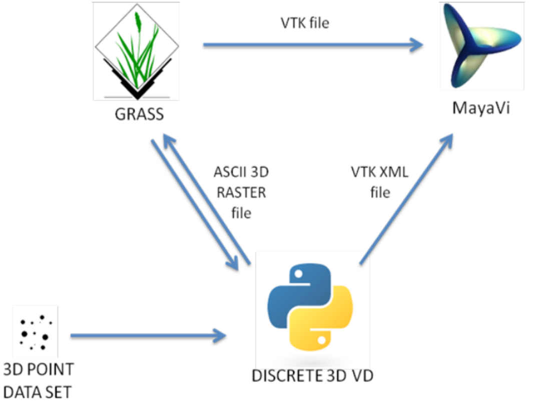
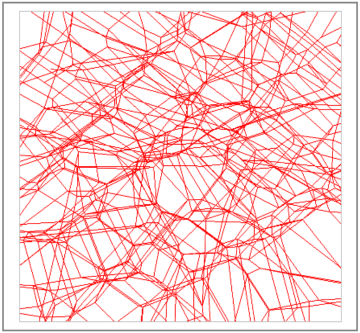
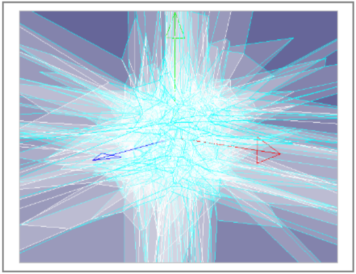


Prototype


GRASS
VTK file
MayaVi
ASCII 3D
RASTER
file
VTK XML
file
3D POINT
DATA SET
DISCRETE 3D VD

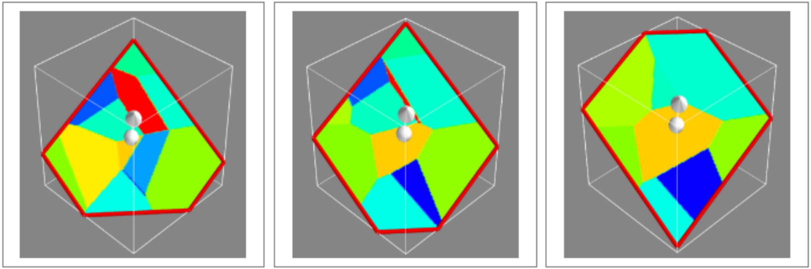
MayaVi for visualisation



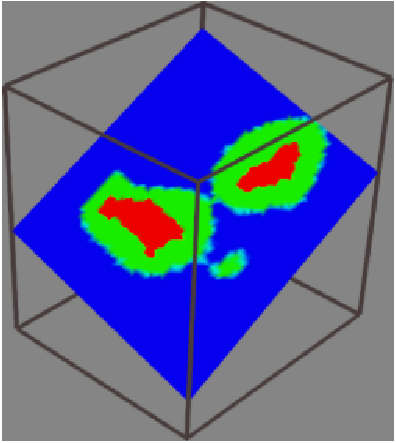


Visualisation of vector 3D VD = difficult

MayaVi for visualisation



Spatial analysis with GRASS's map algebra



Conclusions

- Simple but effective tool for modelling 3D continuous datasets
- Real alternative to rasters
- Algos less error-prone and simpler than exact 3D VD
- First step into construction of other VDs:
  - 3D VD for lines/planes
  - different metrics (e.g. Manhattan distance)
  - higher-order VDs

Thanks for your attention

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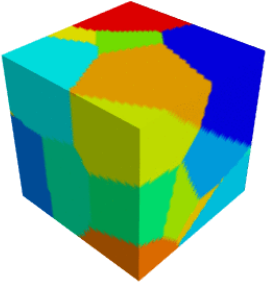
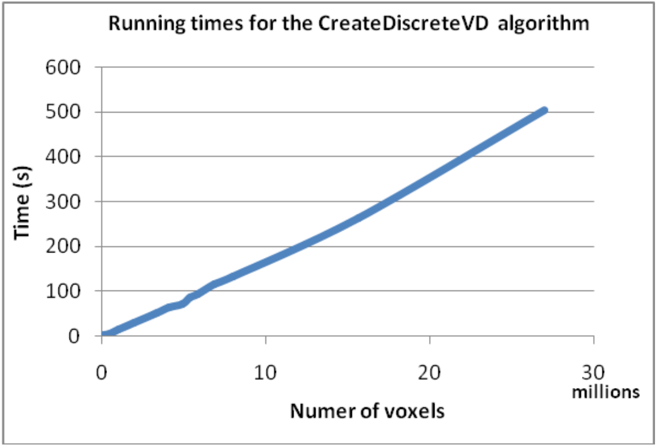
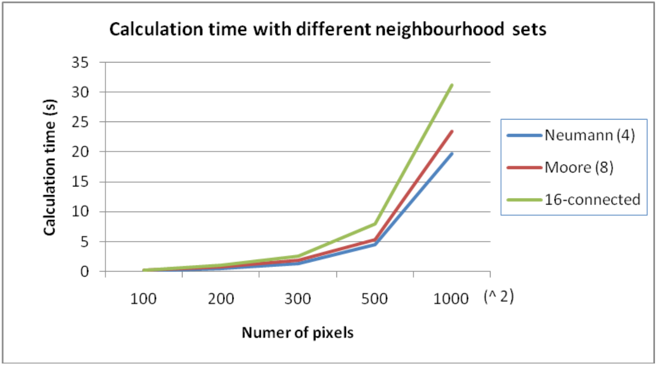


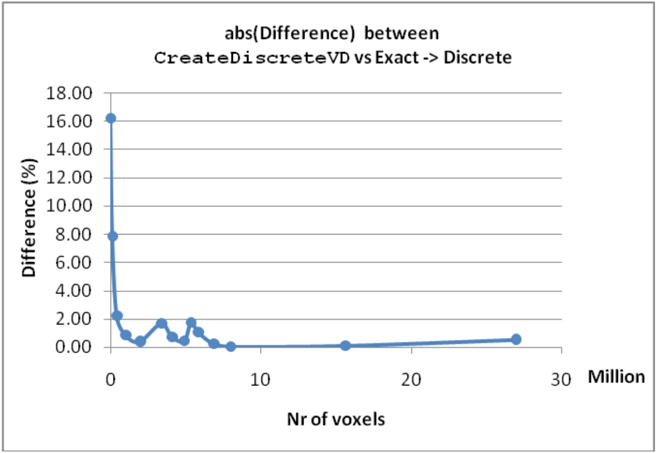
Running times for construction: *ramsbutt* (150pts)



Different neighbourhood sets (in 2D)



Error in volume calculation



Graph showing the relation between error in volume calculation of a random chosen Voronoi Cell for a 3D discrete Voronoi diagram. The error is the absolute relative difference between the exact volume and discrete volume of the same Voronoi cell in percentages.