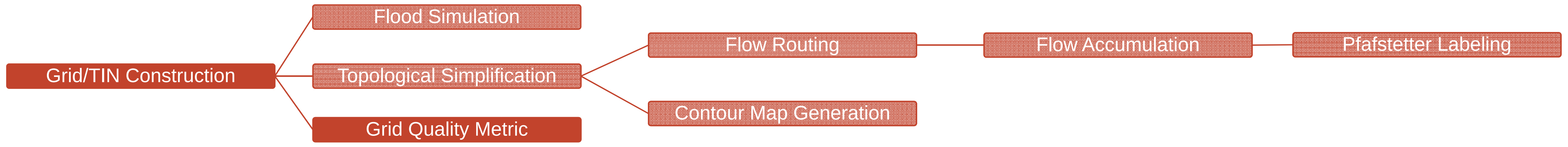
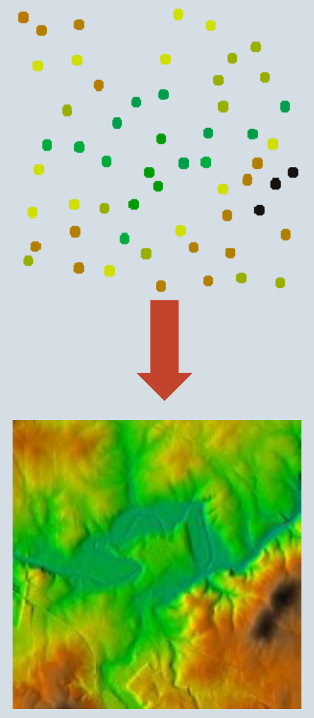
MADALGO
CENTER FOR MASSIVE DATA ALGORITHMICS



TerraSTREAM: Grid DEM Construction and Quality Metric

Digital Elevation Models (DEMs)



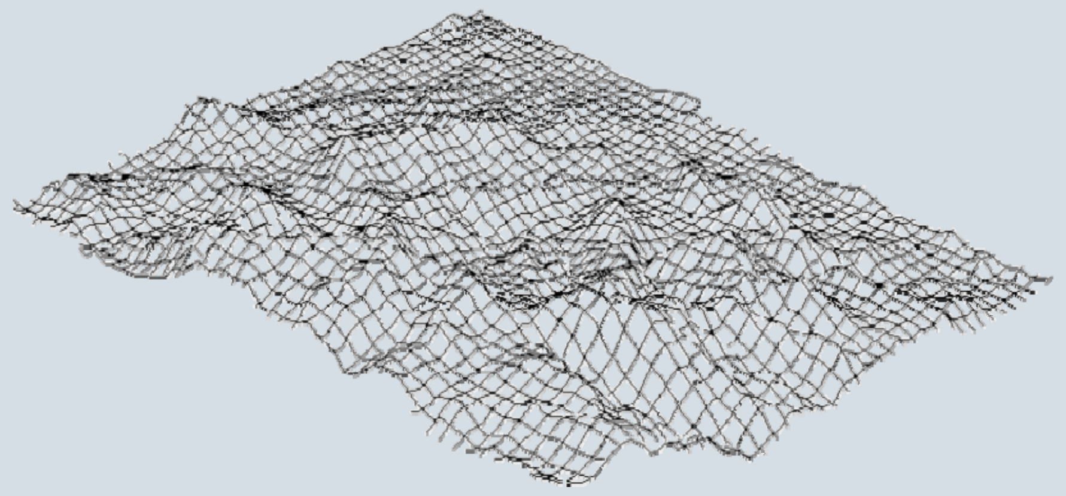
- Digital Elevation Model (DEM) is a representation of a terrain
- Two main DEM models
  - Uniform grid (Grid)
  - Triangulated irregular network (TIN)
- A DEM is usually constructed from a finite set of height measurements (e.g., LAS LIDAR data)

Grid DEMs and construction basics

- Grid DEM is a uniform grid of height values

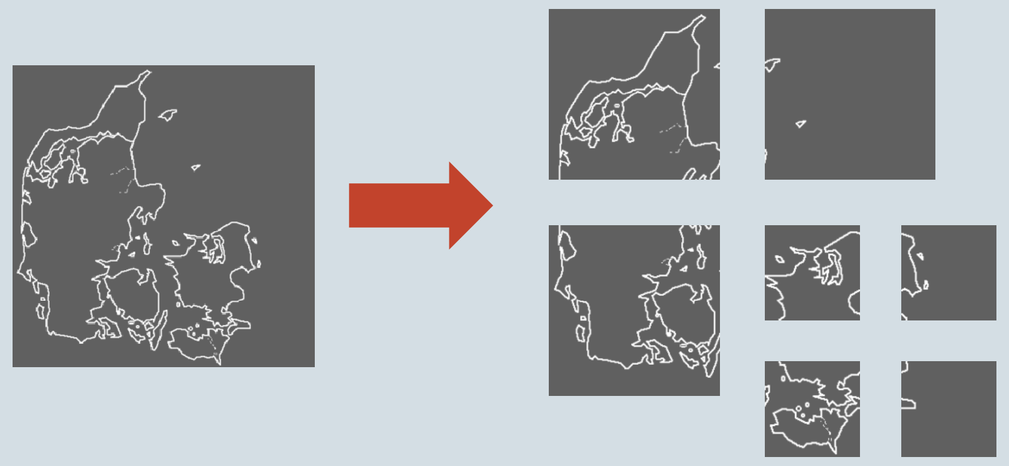
3	2	4	3	2	4
7	5	8	7	5	8
7	1	9	7	1	9
3	2	4	3	2	4
7	5	8	7	5	8
7	1	9	7	1	9

Height grid



3D visualization of a height grid

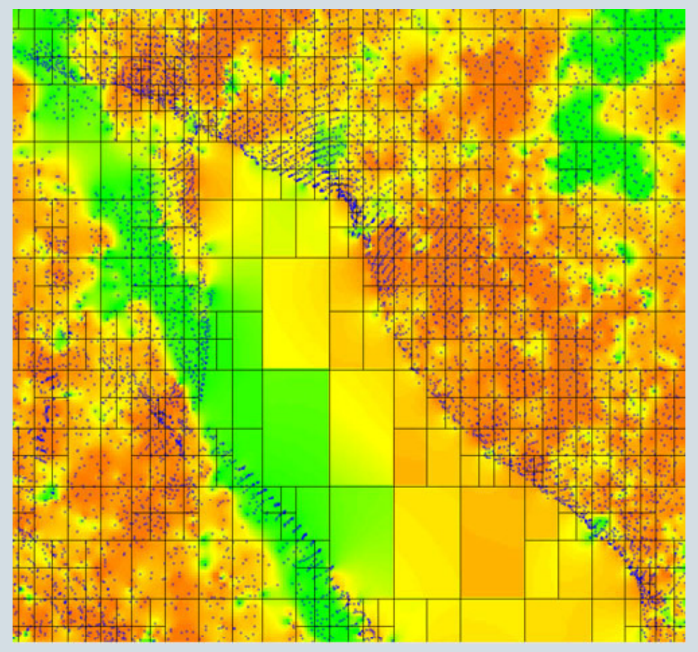
- **Advantage**: Simple terrain analysis algorithms
- **Drawbacks / Challenges:**
  - Inefficient representation of highly varying terrain
  - Need to interpolate input data points when constructing grid DEM
- **Adaptive construction:**



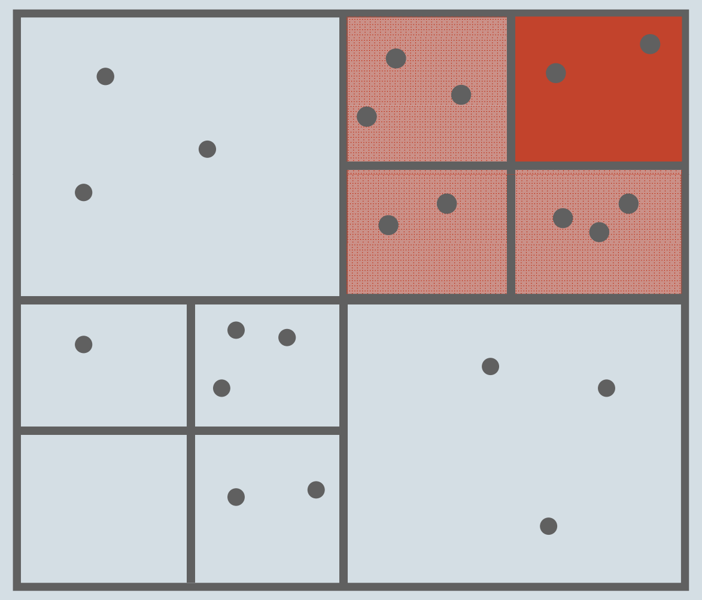
  - We adaptively break grid into tiles containing “few” input data points
  - We interpolate in each tile independently, also considering data points in neighbor tiles (to ensure smoothness along boundaries)

I/O-efficient adaptive Grid DEM construction

- **Observation**: One can compute tiling I/O-efficiently to be able to process massive amount of input data [1,2]

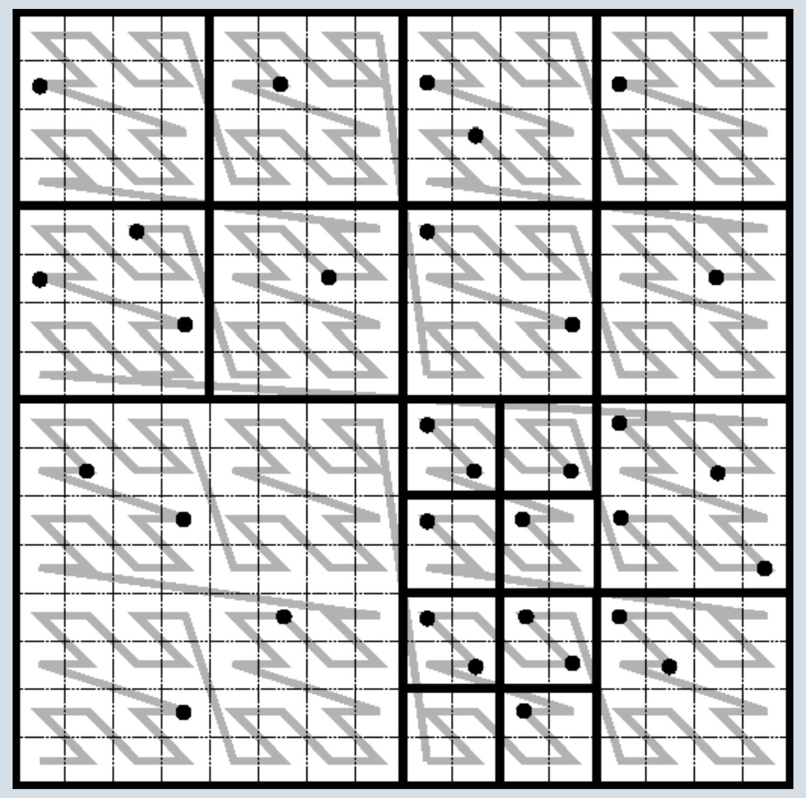


Tiling of a point data set

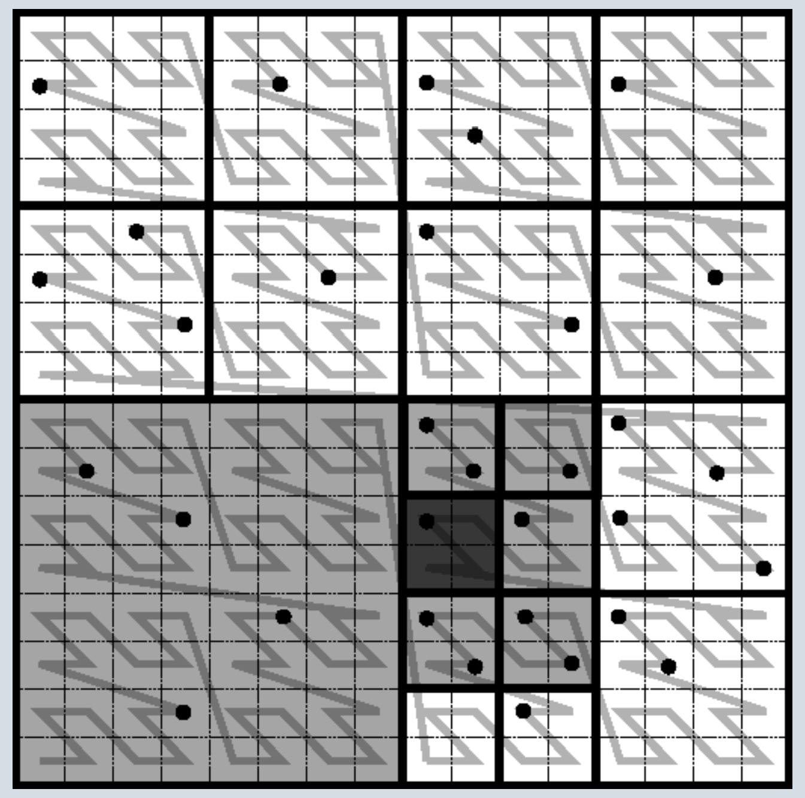


A tile to interpolate and its neighbors

- **Improved algorithm**: Cache-oblivious processing of z-ordered tiles in a single main pass [2]:
  - Presort points according to their order along Z-curve so to resemble on disk the spatial locality of input
  - Scan through z-ordered points, constructing tiles “on the fly”.
  - During scan: For interpolation in each tile its neighbors can be accessed efficiently using a cache-oblivious priority queue



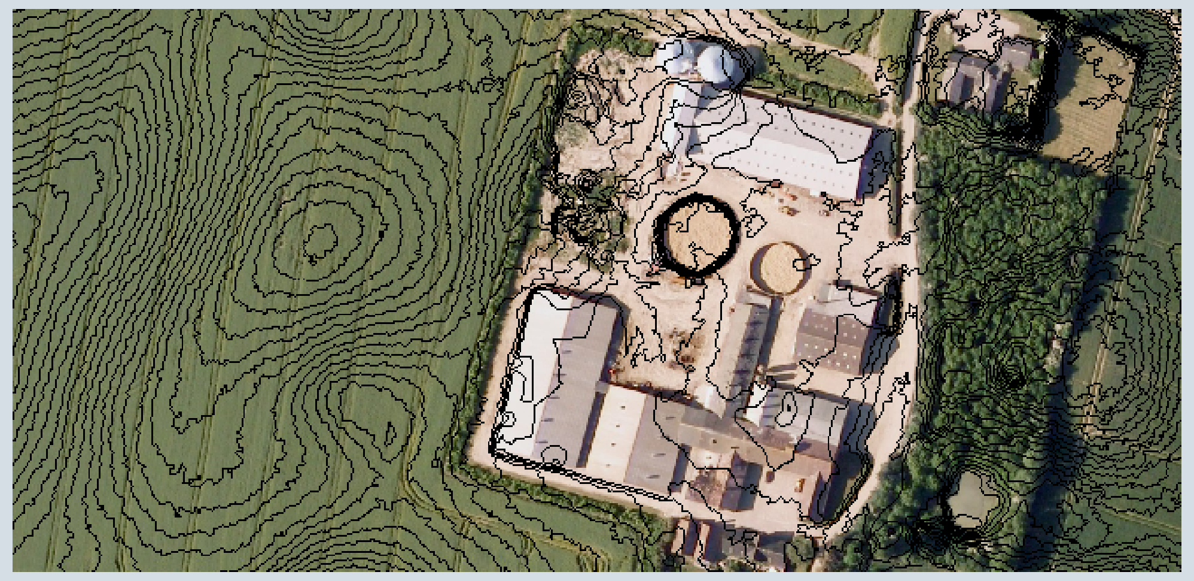
Points in Quadtree ordered along Z-curve



Neighbors of a quadtree cell

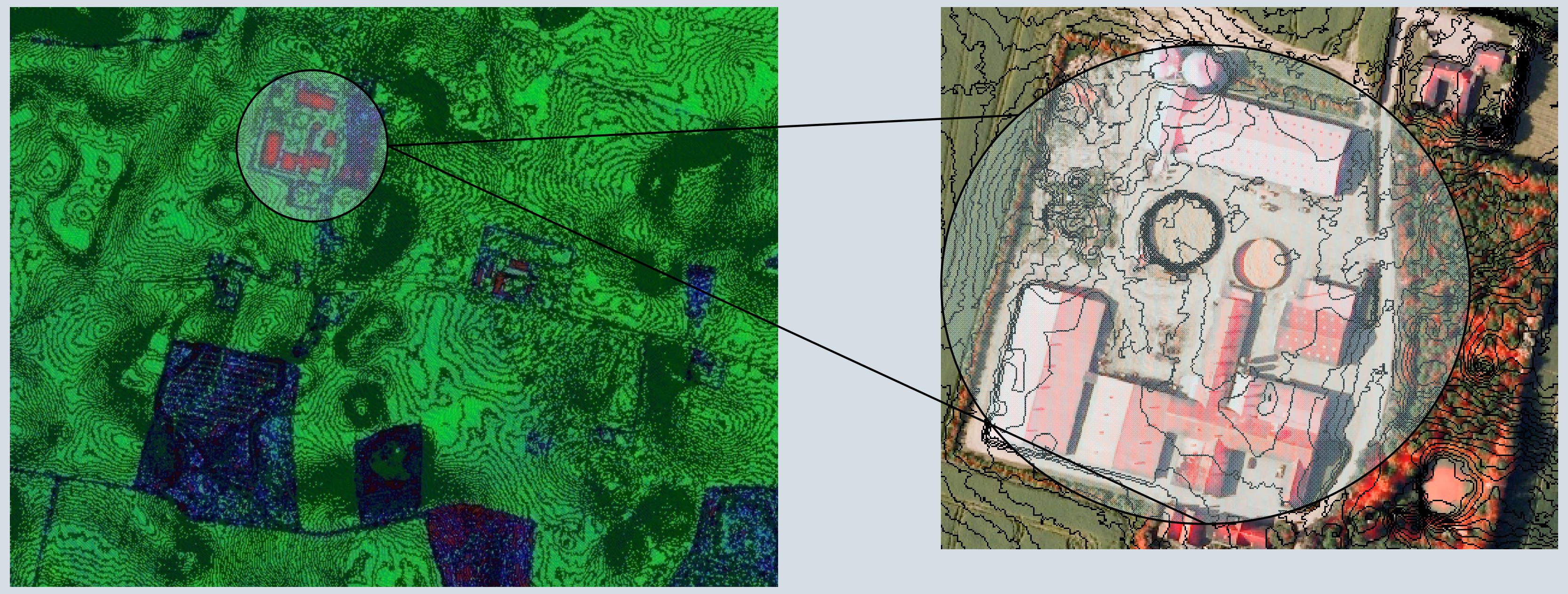
Grid DEM quality metric

- **Problem**: Often grid DEM points are interpolated from very distant input points. User would like to know “trustworthiness” of each grid point



Contour line visualization of a grid. There are obvious flaws in the vicinity of buildings (where no input points are available)

- **Our approach:** We compute nearest input point for each grid DEM cell
- **I/O-efficient algorithm:** We compute nearest points by adapting known nearest-neighbor algorithms and exploiting uniformity of grid [3]



Visualizations of our measure. Areas with very close input points are green, areas with relatively close input points are blue and areas with distant input points are red

References

[1] Pankaj Agarwal, Lars Arge and Andrew Danner. *From Point Cloud to Grid DEM: A Scalable Approach*. In Proc. 12th Intl. Symp. on Spatial Data Handling (SDH), 2007

[2] Lars Arge, Henrik Blunck and Anders Hesselund-Jensen, "*I/O-efficient Quadtree Construction and Leaf Neighbor Finding*“, draft.

[3] Lars Arge, Henrik Blunck and Anders Hesselund-Jensen, "*I/O-efficient Nearest Neighbor Algorithms for Grid DEM Quality Evaluation*, draft.

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