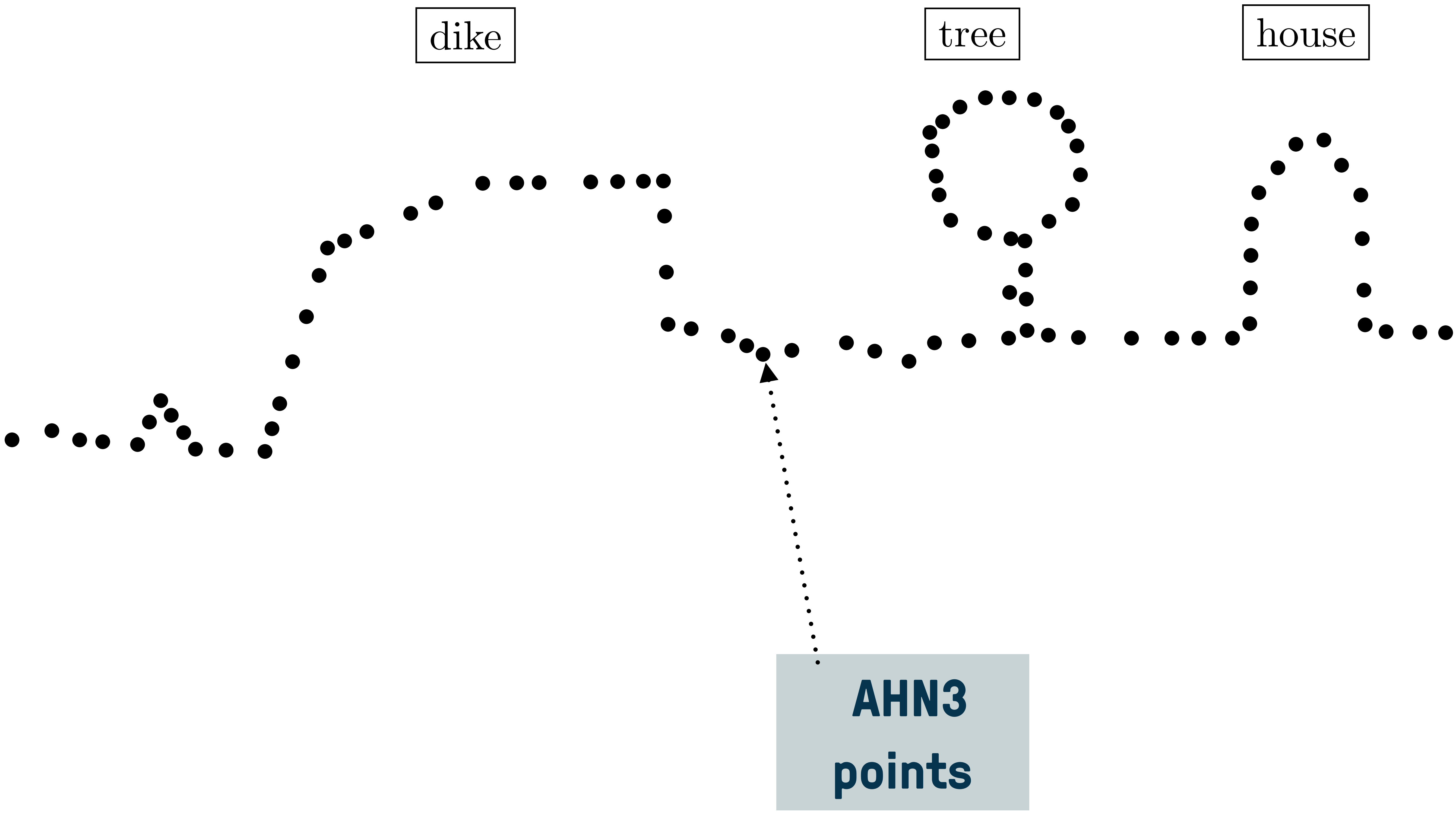
Simplification of digital terrain models using feature-based three-dimensional methods

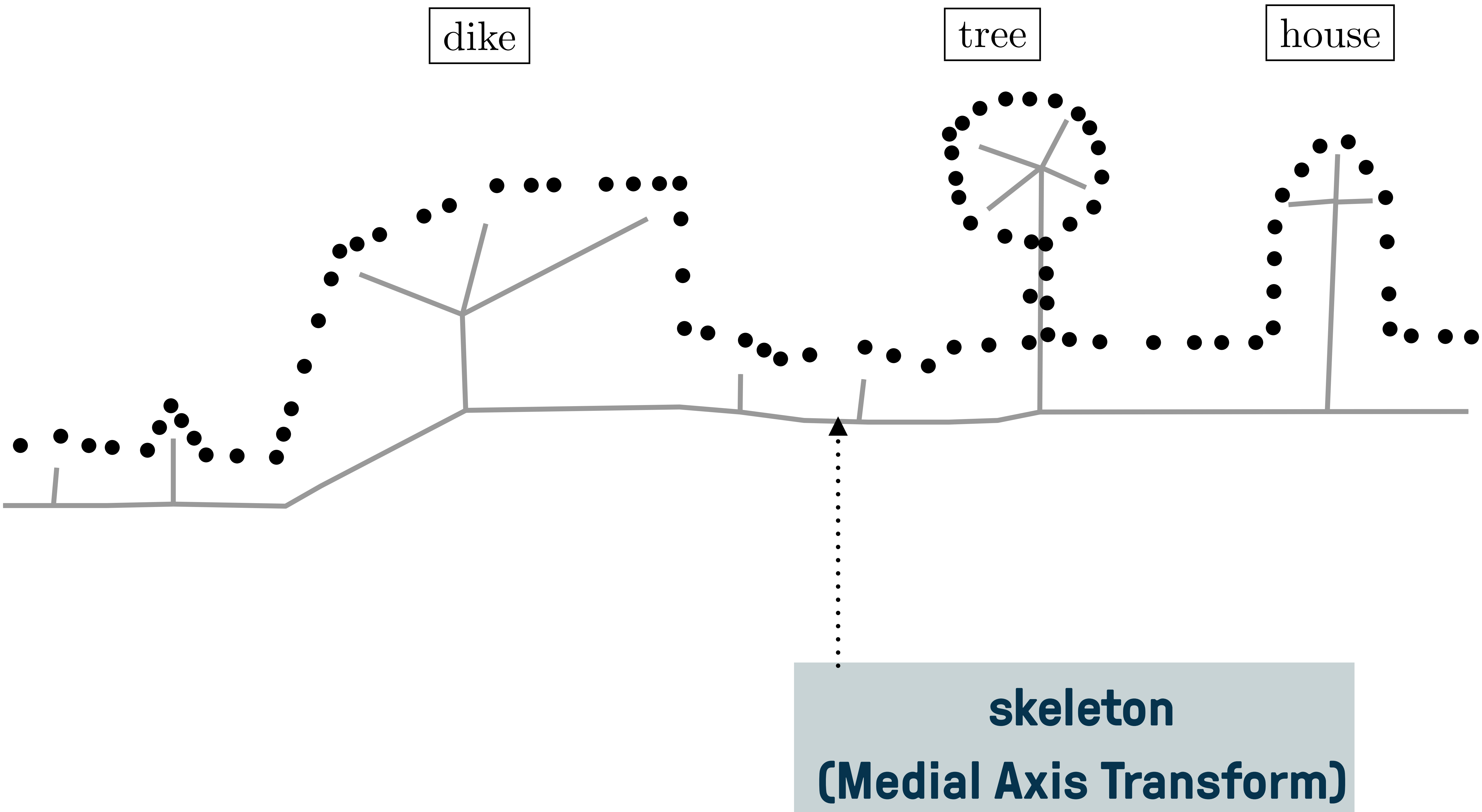
Hugo Ledoux, Ravi Peters and Jantien Stoter

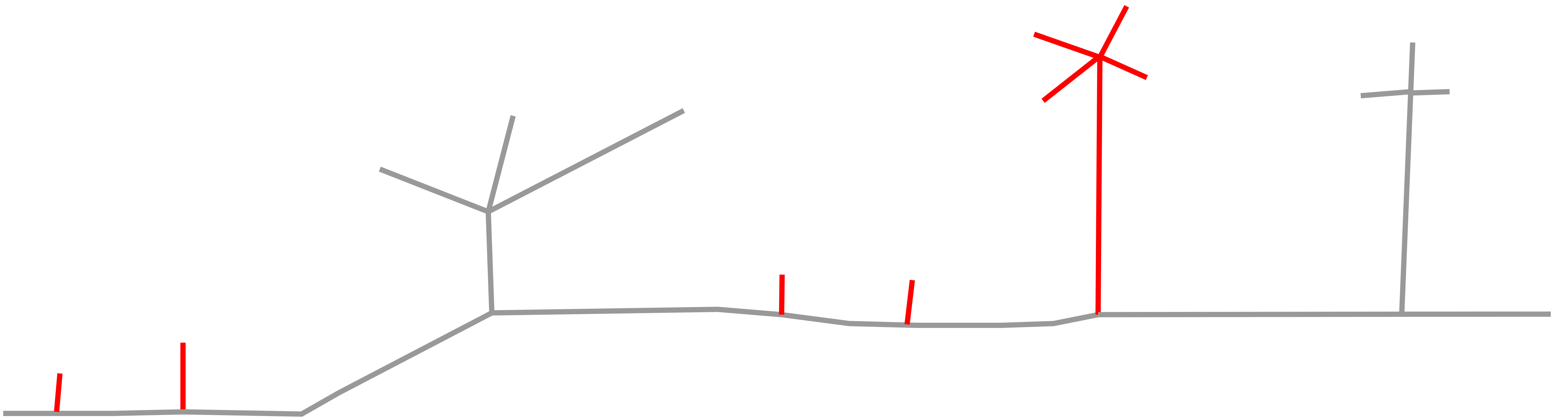
5th user committee meeting
2016-11-09
Delft

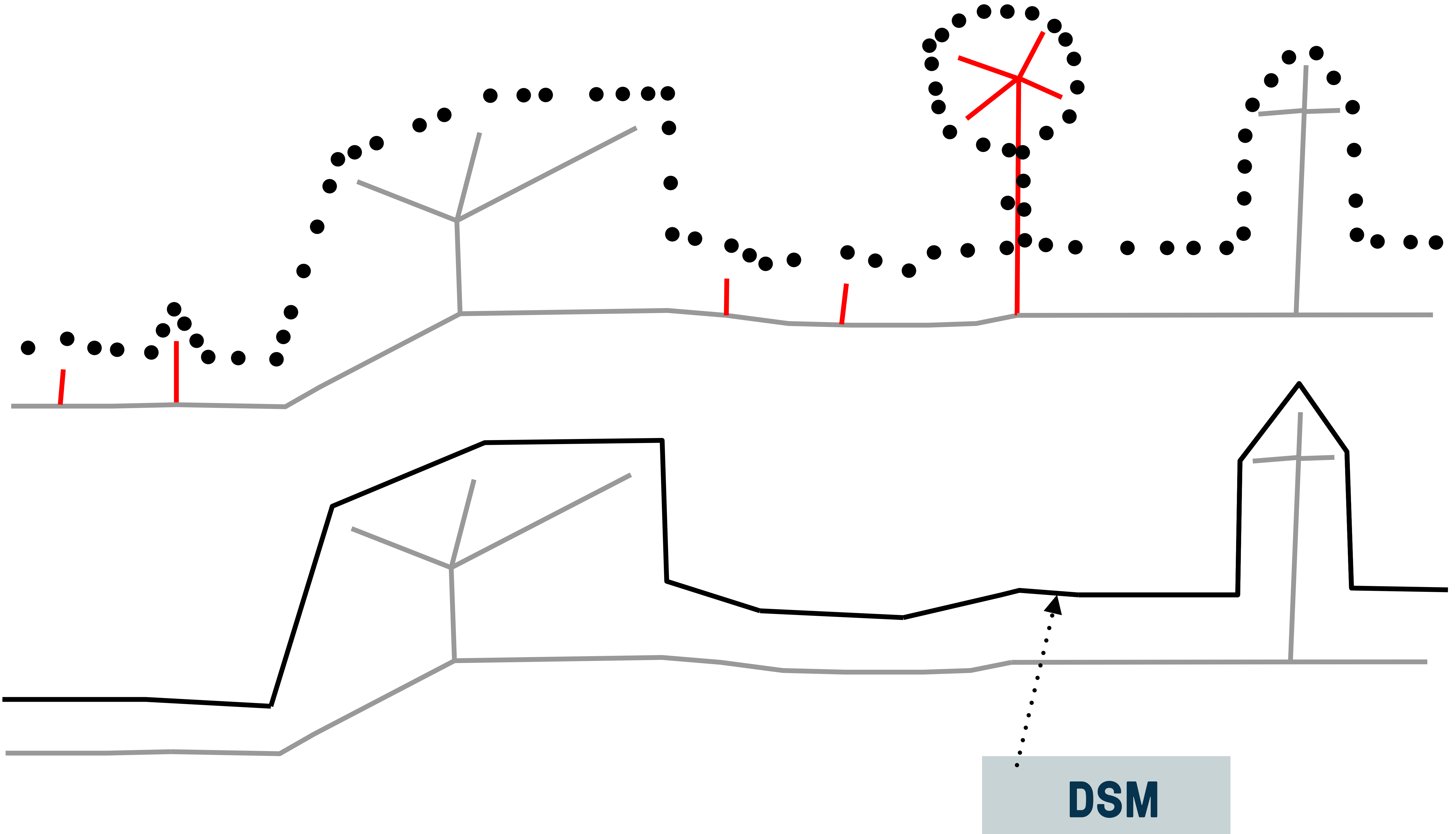
3D geoinformation
3d.bk.tudelft.nl
TU Delft Delft University of Technology

What was the project about again?

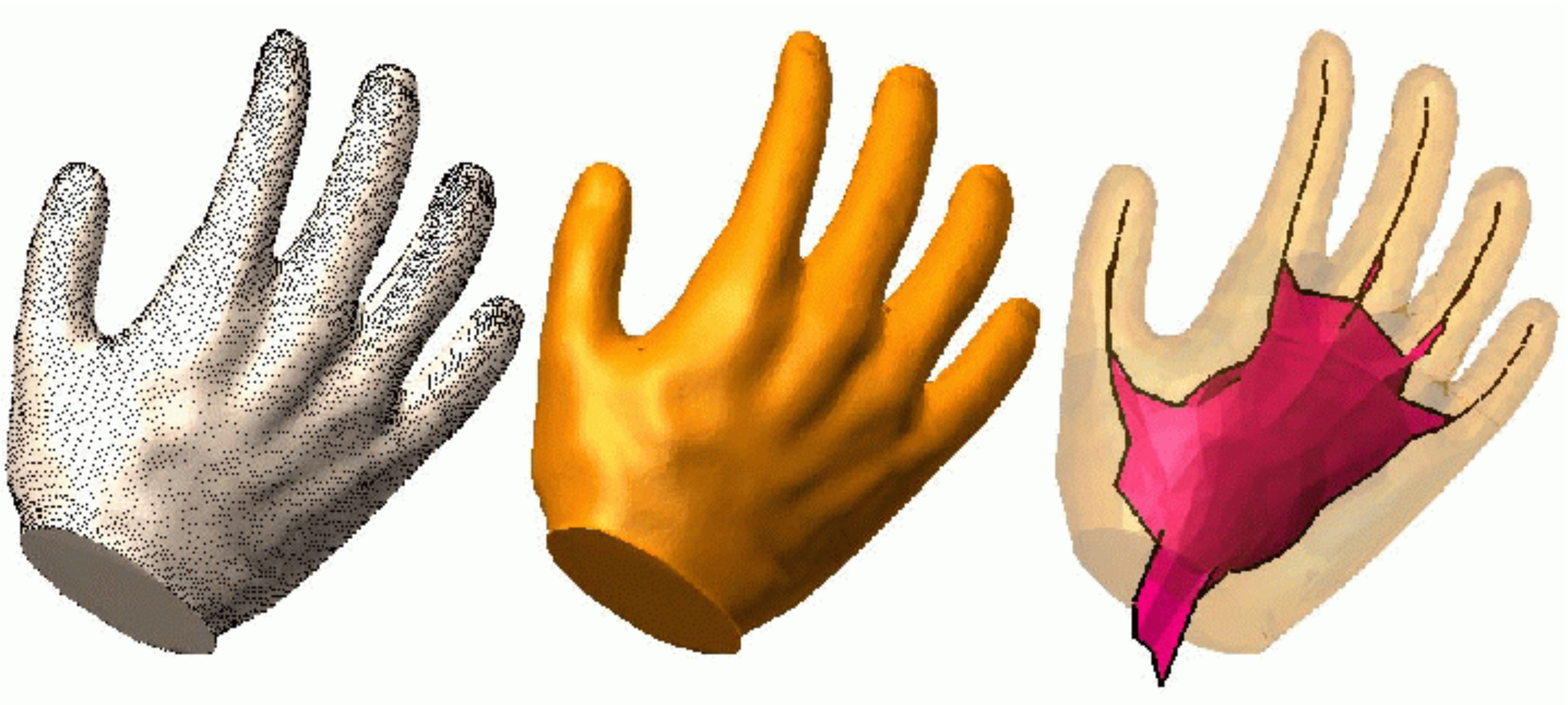

dike
tree
house
AHN3
points


dike
tree
house
skeleton
(Medial Axis Transform)

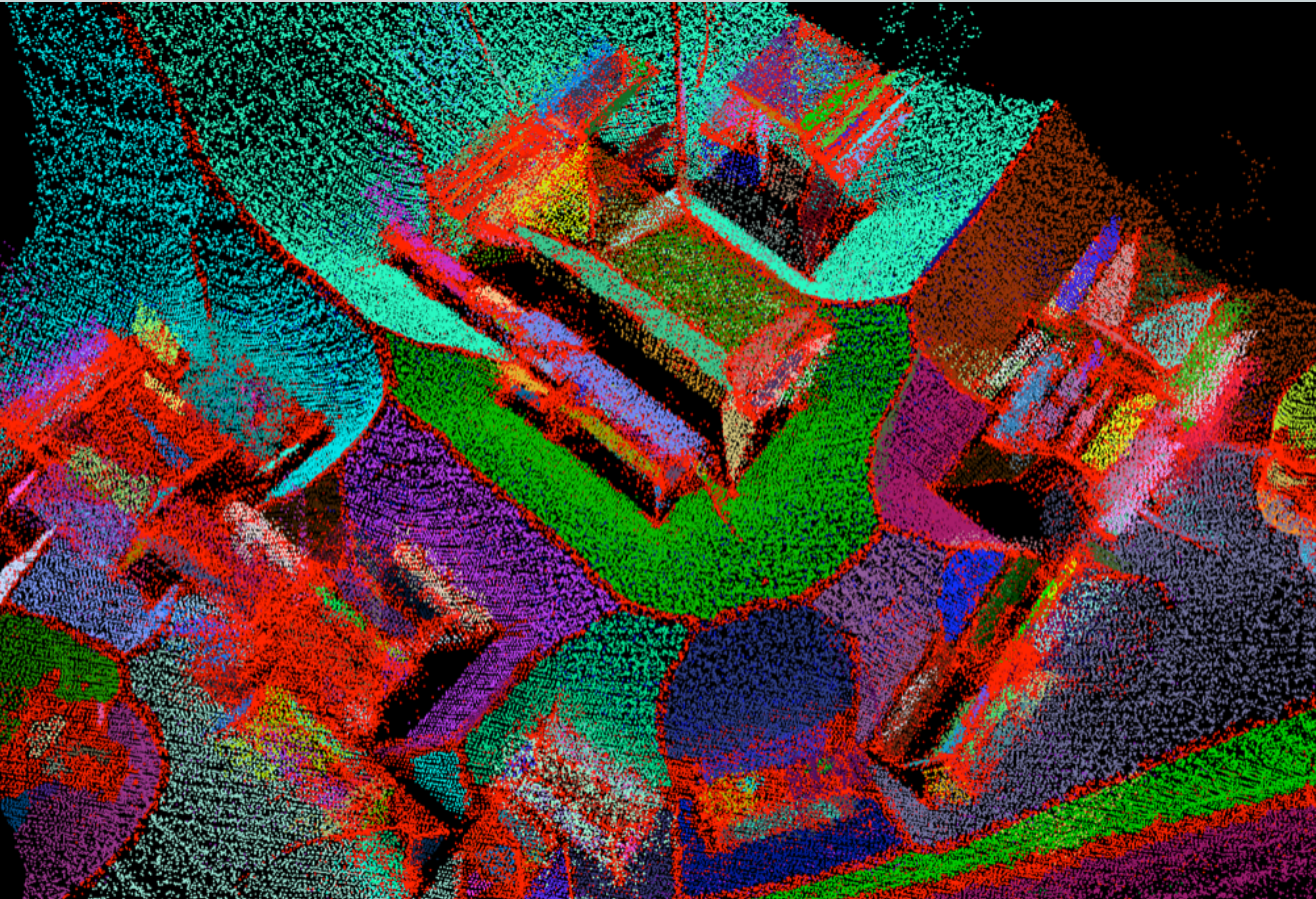



DSM

Medial axis transform (MAT) = skeleton



Medial axis transform (MAT) = skeleton



Main results in 2016

Milestones

1. First scientific article published in an ISI journal
2. Developed methods and algorithms for building identification and reconstruction in a point cloud (→ Ravi will present those)
3. Two MSc theses finished on topics directly related to the project
4. Reached practitioners with two different use-cases: identification of watercourses and of buildings.
5. Code for MAT simplification is open-source + one transformer in FME

Journal article summarising most results

Computers & Geosciences 90 (2016) 123–133

Contents lists available at ScienceDirect

Computers & Geosciences

journal homepage: www.elsevier.com/locate/cageo

ELSEVIER

Research paper

Robust approximation of the Medial Axis Transform of LiDAR point clouds as a tool for visualisation

Ravi Peters *, Hugo Ledoux

3D geoinformation, Delft University of Technology, Julianalaan 134, 2628BL Delft, The Netherlands

ARTICLE INFO

Article history:
Received 1 May 2015
Received in revised form
22 December 2015
Accepted 26 February 2016
Available online 2 March 2016

Keywords:
Point cloud
LiDAR
Simplification
Medial Axis Transform
Visualisation

ABSTRACT

Governments and companies around the world collect point clouds (datasets containing elevation points) because these are useful for many applications, e.g. to reconstruct 3D city models, to understand and predict the impact of floods, and to monitor dikes. We address in this paper the visualisation of point clouds, which is perhaps the most essential instrument a practitioner or a scientist has to analyse and understand such datasets. We argue that it is currently hampered by two main problems: (1) point clouds are often massive (several billion points); (2) the viewer's perception of depth and structure is often lost (because of the sparse and unstructured points). We propose solving both problems by using the Medial Axis Transform (MAT) and its properties. This allows us to (1) smartly simplify a point cloud in a geometry-dependent way (to preserve only significant features), and (2) to render splats whose radii are adaptive to the distribution of points (and thus obtain less "holes" in the surface). Our main contribution is a series of heuristics that allows us to compute the MAT robustly for noisy real-world LiDAR point clouds, and to compute the MAT for point clouds that do not fit into the main memory. We have implemented our algorithms, we report on experiments made with point clouds (of more than one billion points), and we demonstrate that we are able to render scenes with much less points than in the original point cloud (we preserve around 10%) while retaining good depth-perception and a sense of structure at close viewing distances.

© 2016 Elsevier Ltd. All rights reserved.

MSc thesis #1

CREATING THE MEDIAL AXIS TRANSFORM FOR BILLIONS OF LIDAR POINTS USING A MEMORY EFFICIENT METHOD

A thesis submitted to the Delft University of Technology in partial fulfillment of the requirements for the degree of

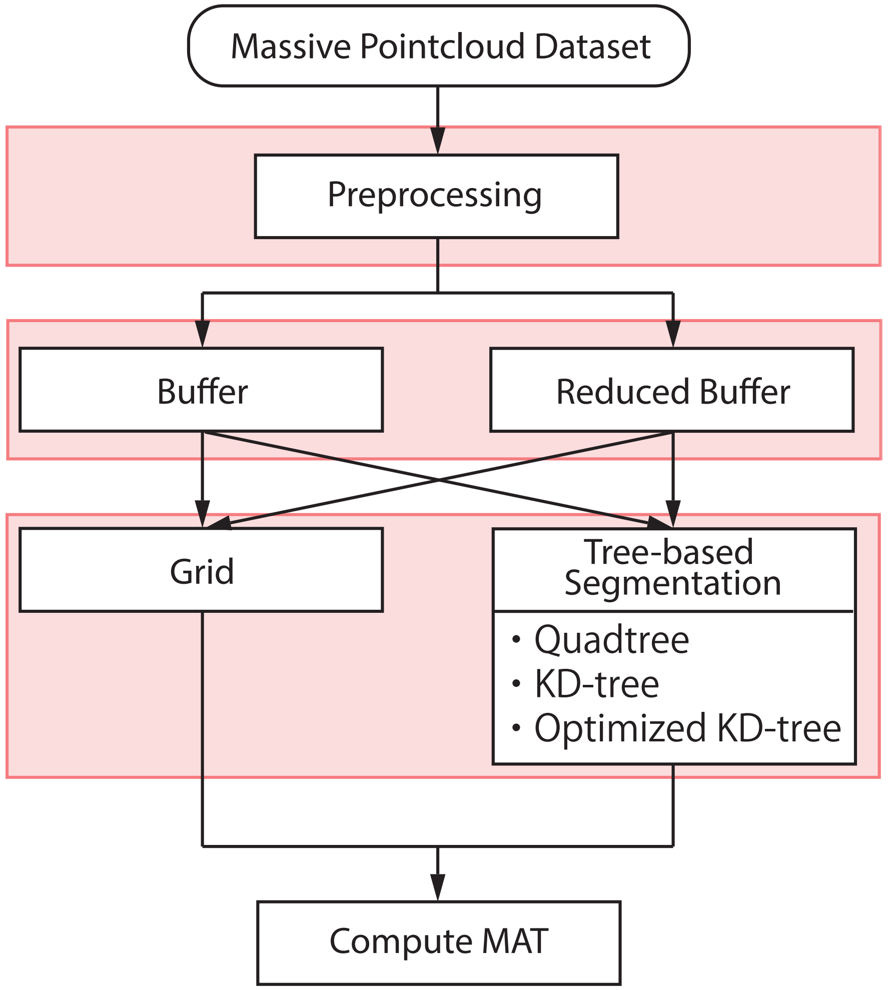
Master of Science in Geomatics

by

Marco Lam

January 2016

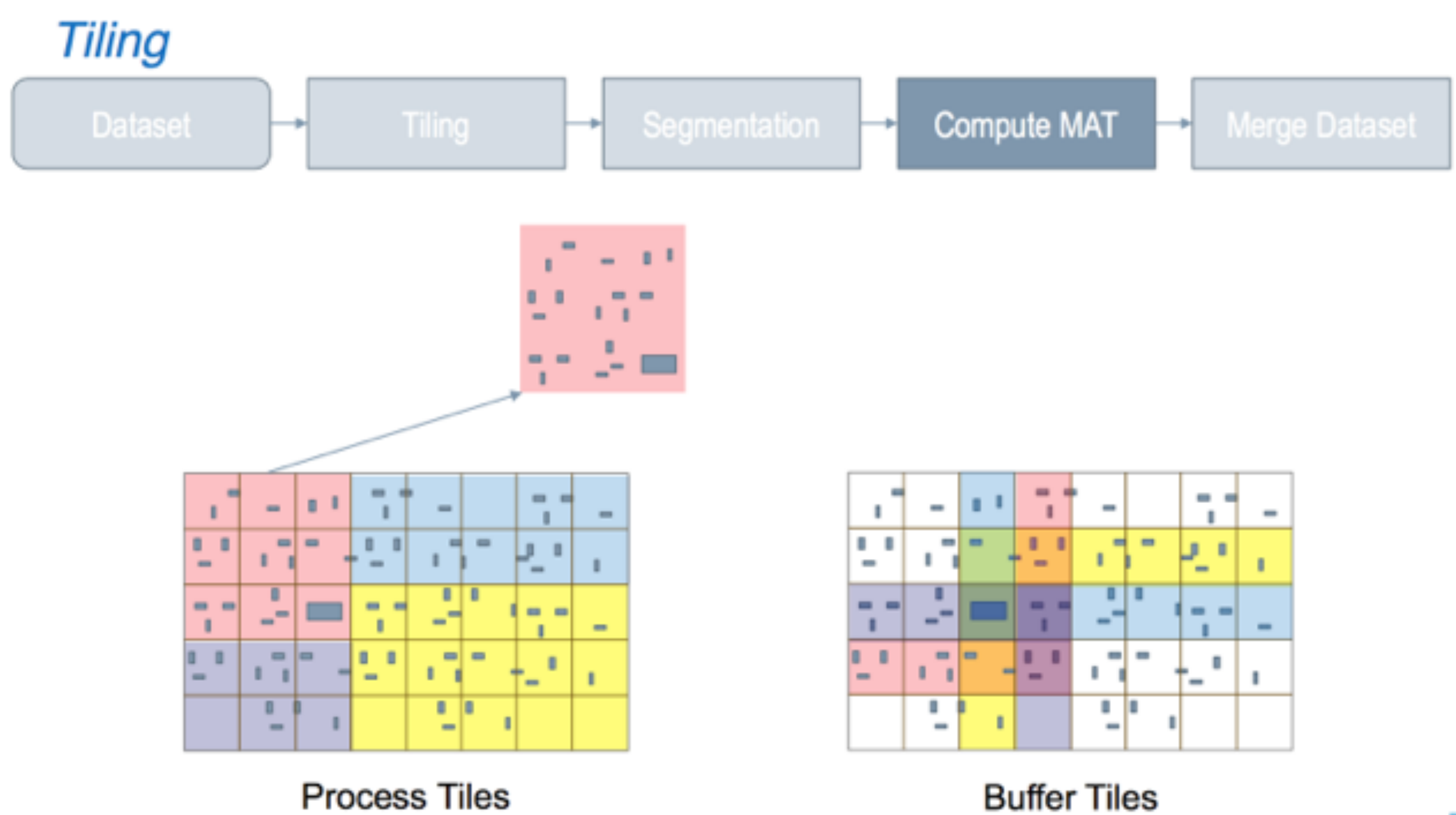
MSc thesis #1: tiling a dataset



Tiling
Computing normals

Buffer types

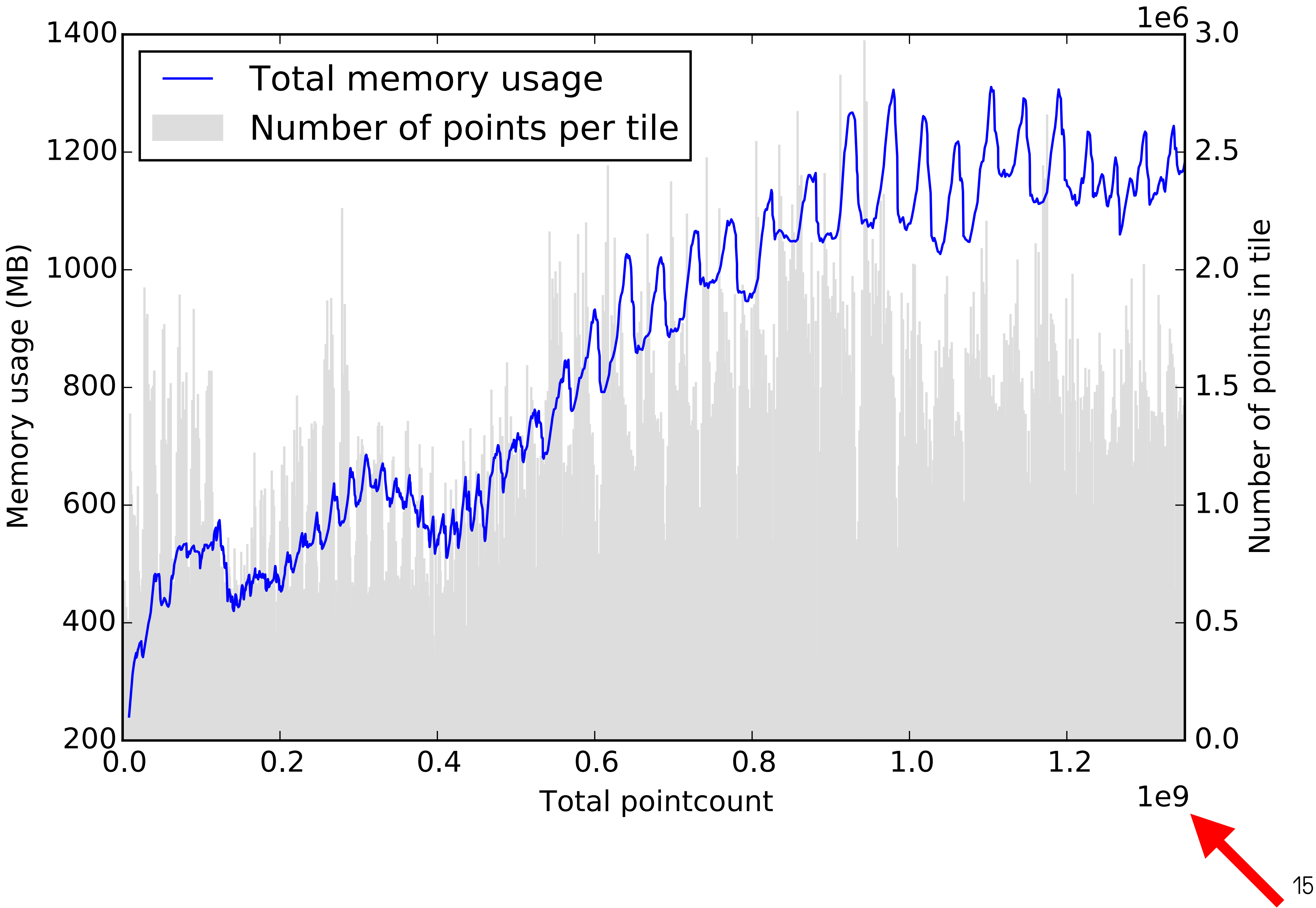
Segmentation



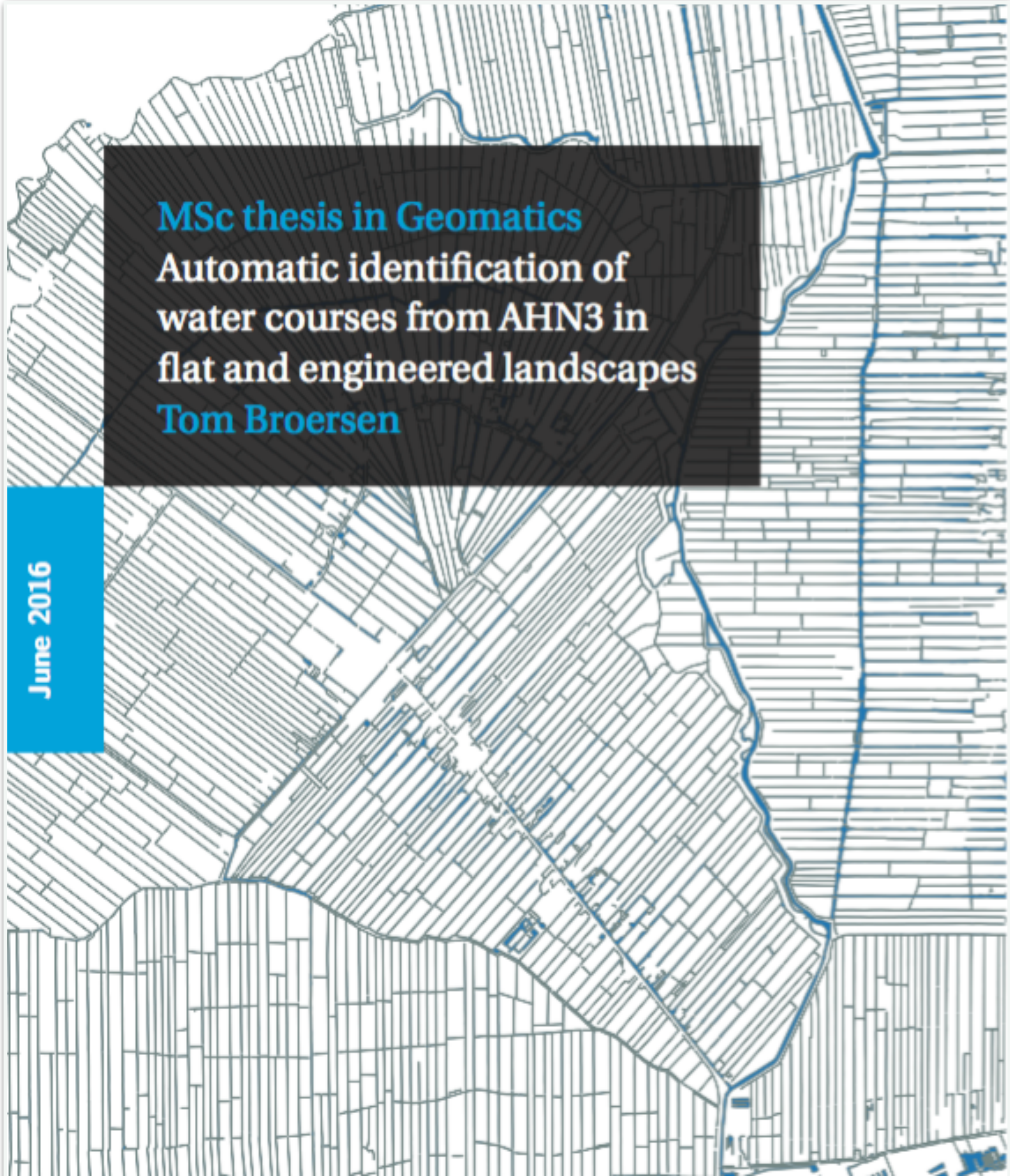
MSc thesis #1: tiling a dataset

Figure 3.4: Points with a successfully created medial axis are displayed in grayscale. Points which are not finished processing because they need to know the location of points outside the region are displayed in red or purple. They represent the inner and outer MAT respectively

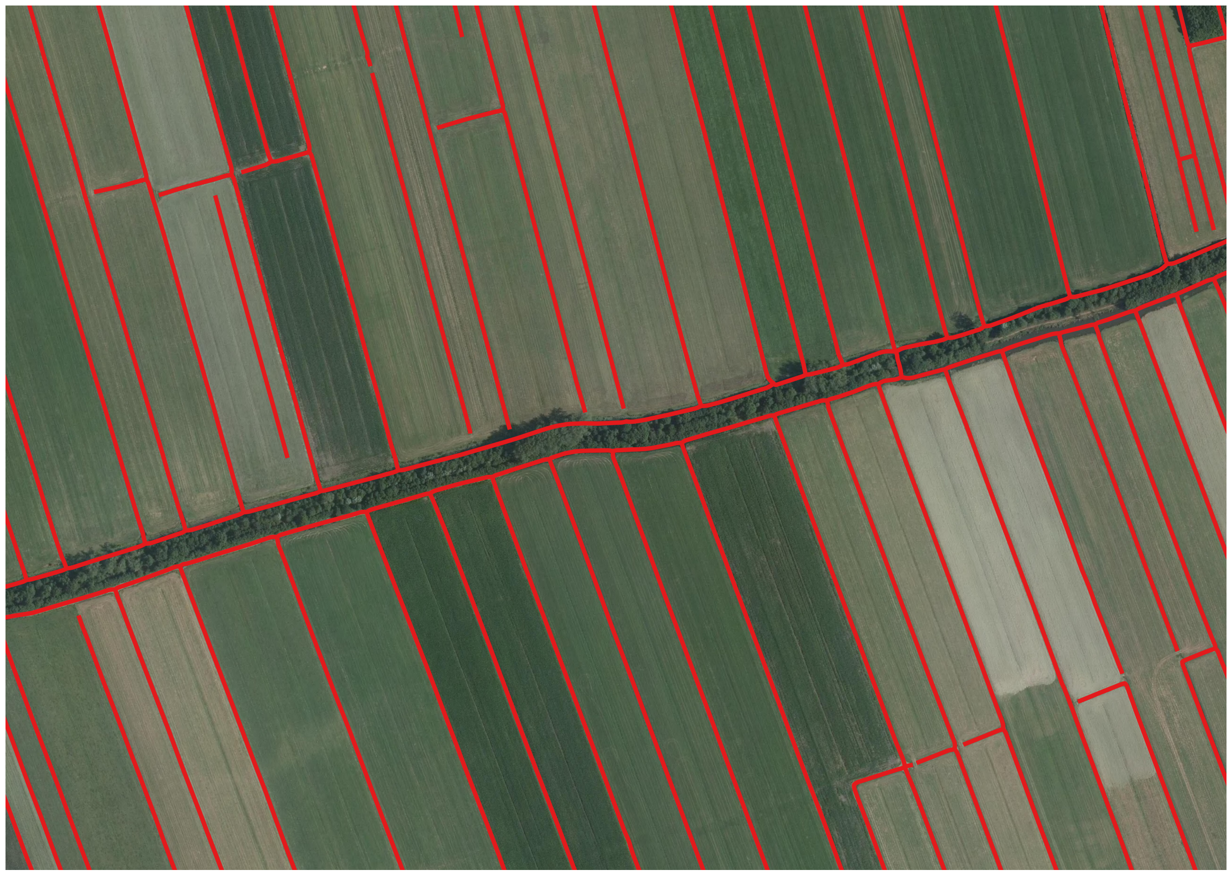
MSc thesis #1: scalability



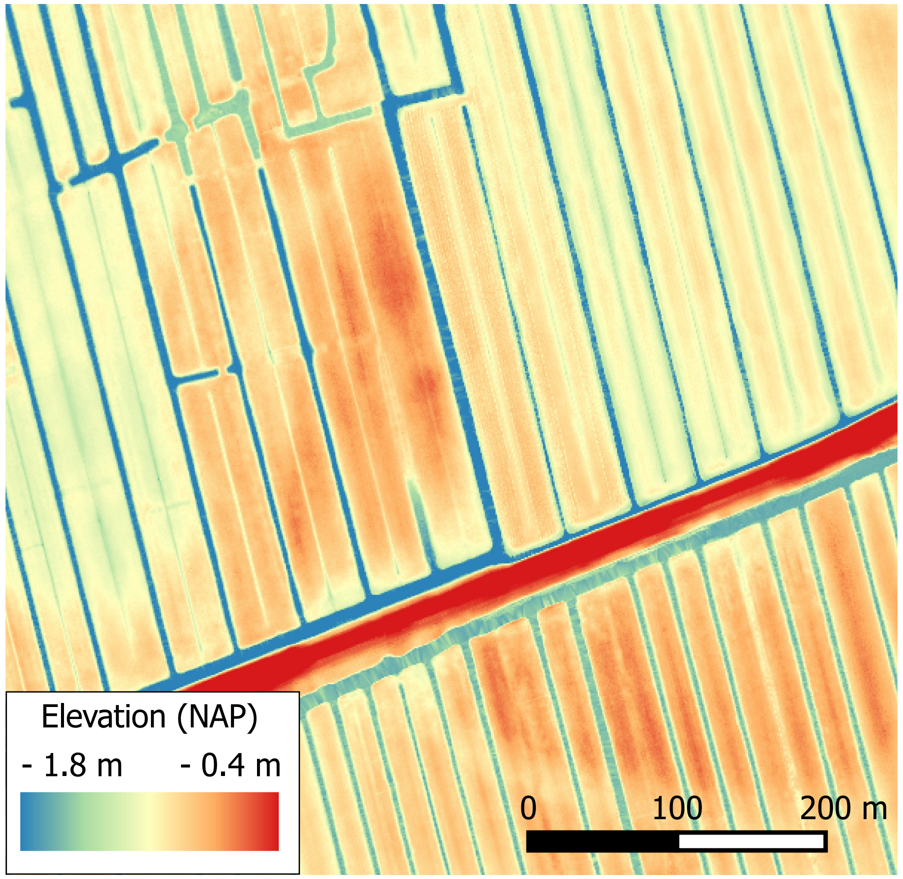
MSc thesis #2


MSc thesis in Geomatics
Automatic identification of water courses from AHN3 in flat and engineered landscapes
Tom Broersen
June 2016

Watercourses around Utrecht: manually extracted



(a)



(b)

Figure 1: A typical landscape in the Netherlands, for a region around Utrecht. **(a)** Watercourses identified in red over an aerial image. **(b)** Elevation obtained from aerial laser scanning.

Related work performs poorly

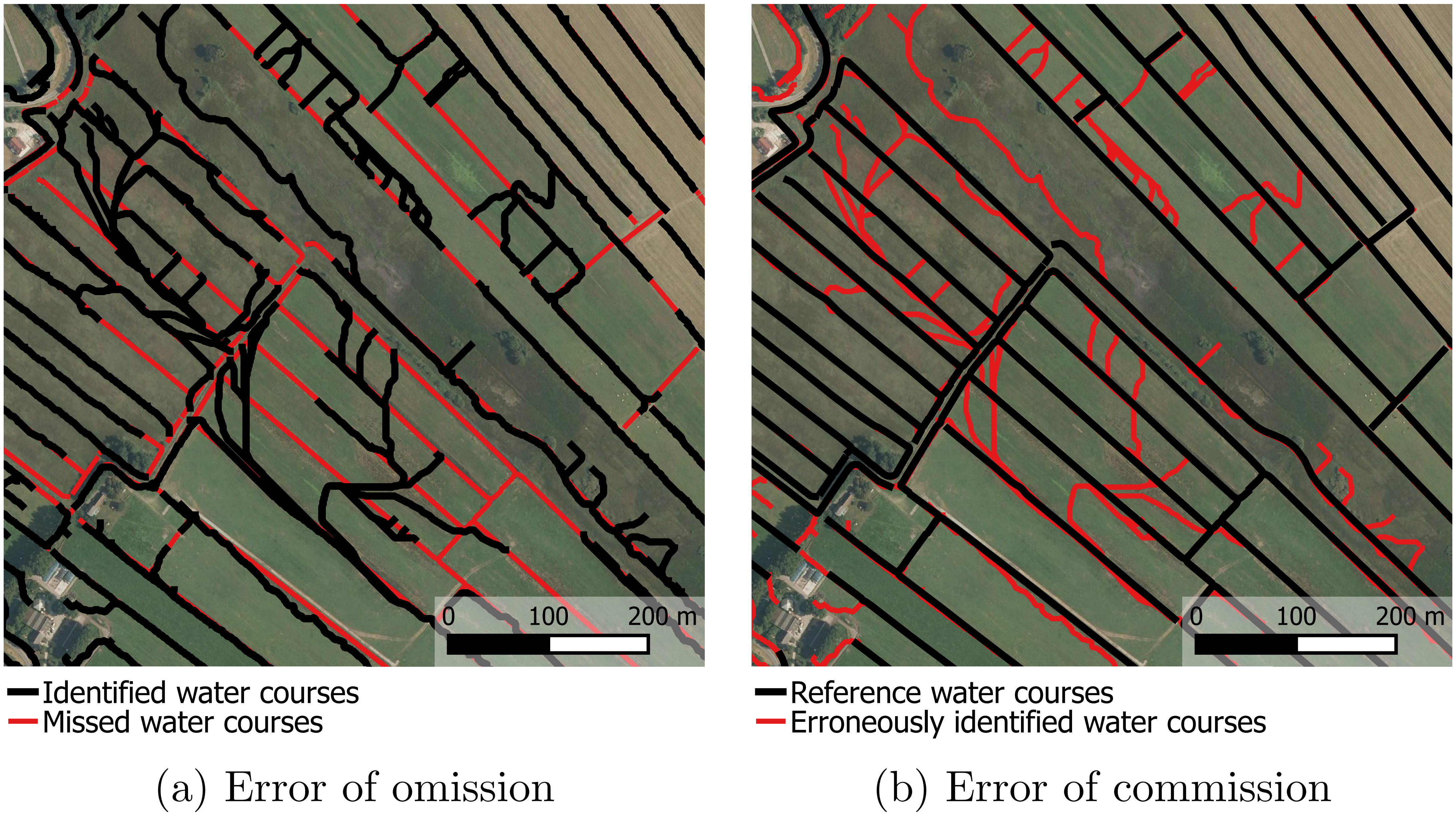
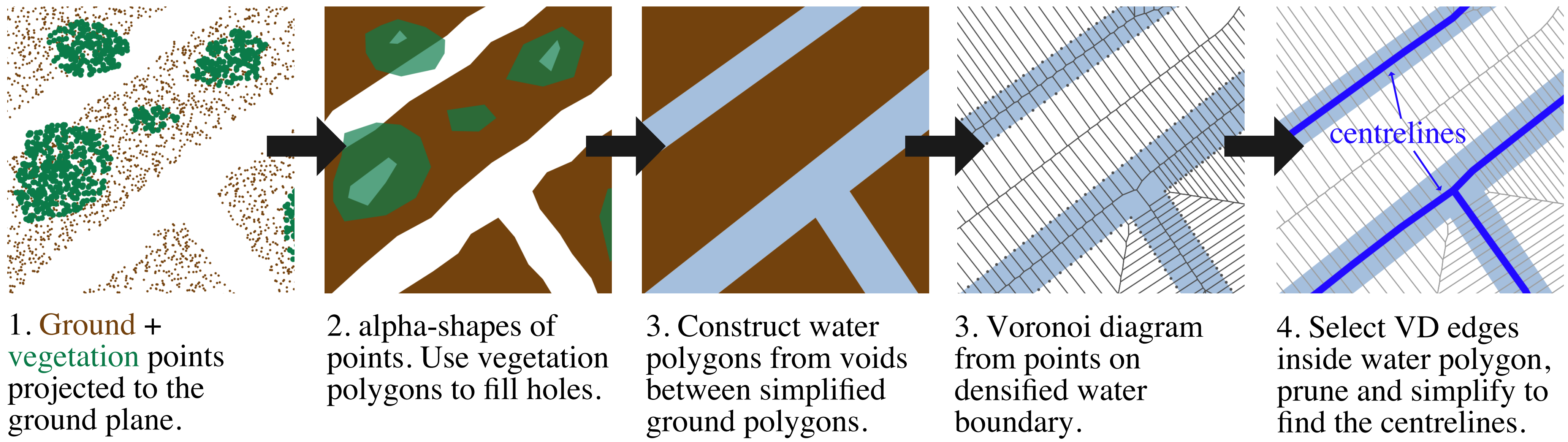
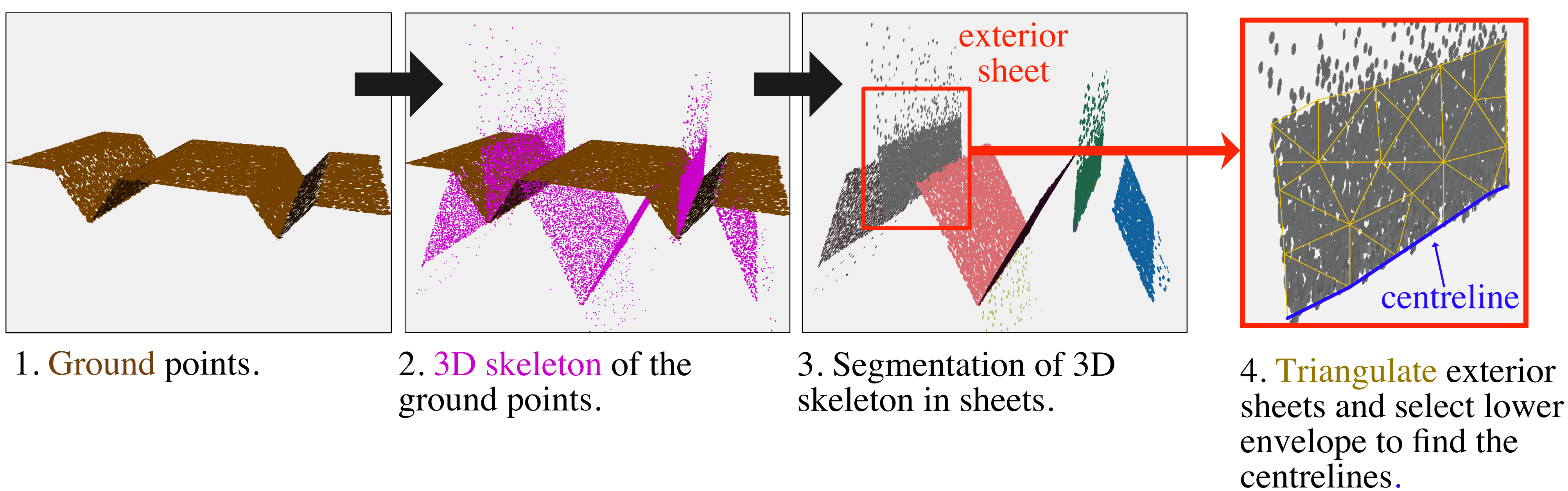


Figure 2: Identification of watercourses by Passalacqua et al. (2012) (with GeoNet software) for an area with peat soil near Utrecht in the Netherlands. The dataset is compared to a reference dataset provided by the HDSR (background aerial photo courtesy of `www.pdok.nl`).

2D MAT + 3D MAT = >95% identification



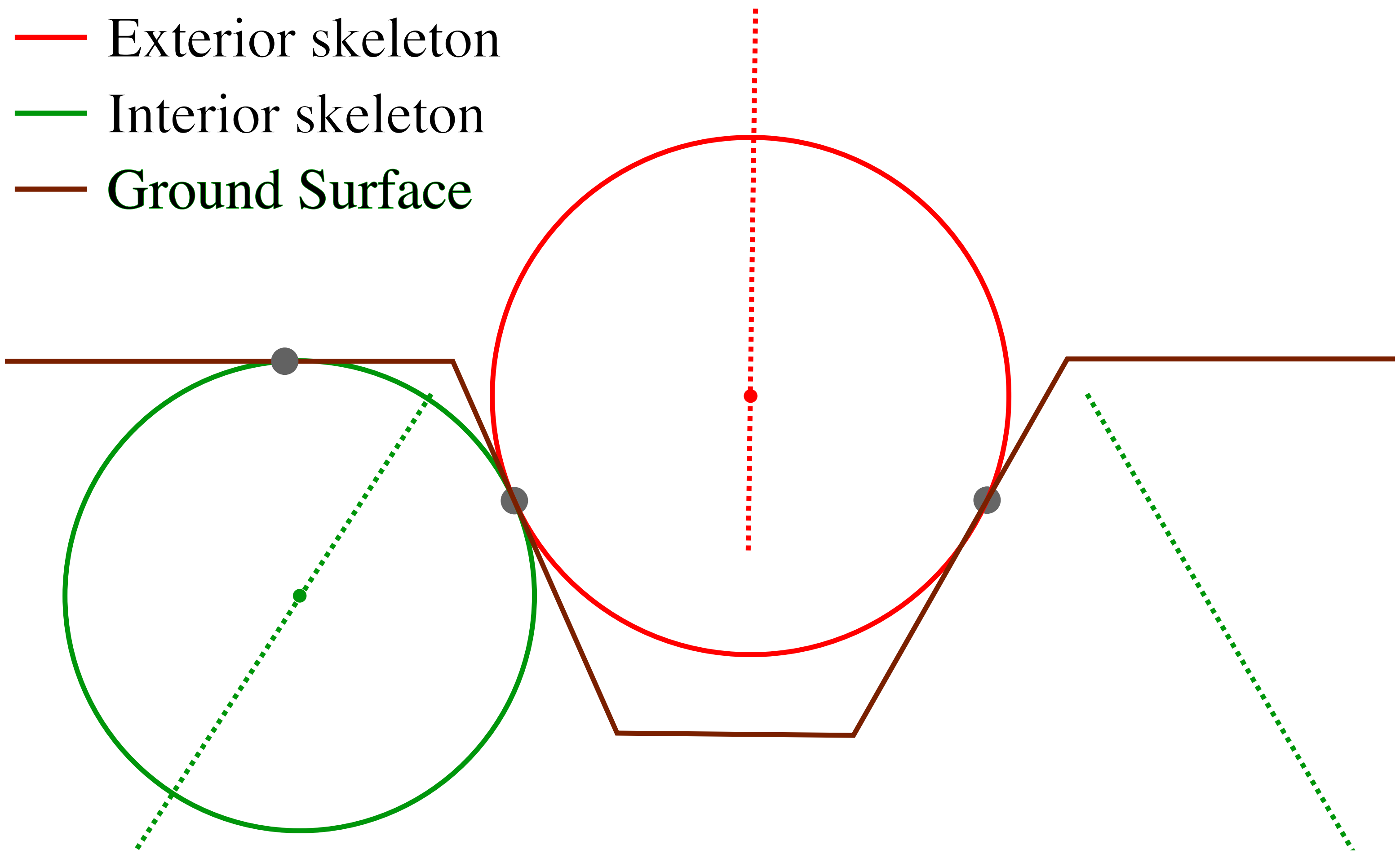
(a) Workflow to obtain watercourses from the 2D skeleton.



(b) Workflow to obtain watercourses from the 3D skeleton.

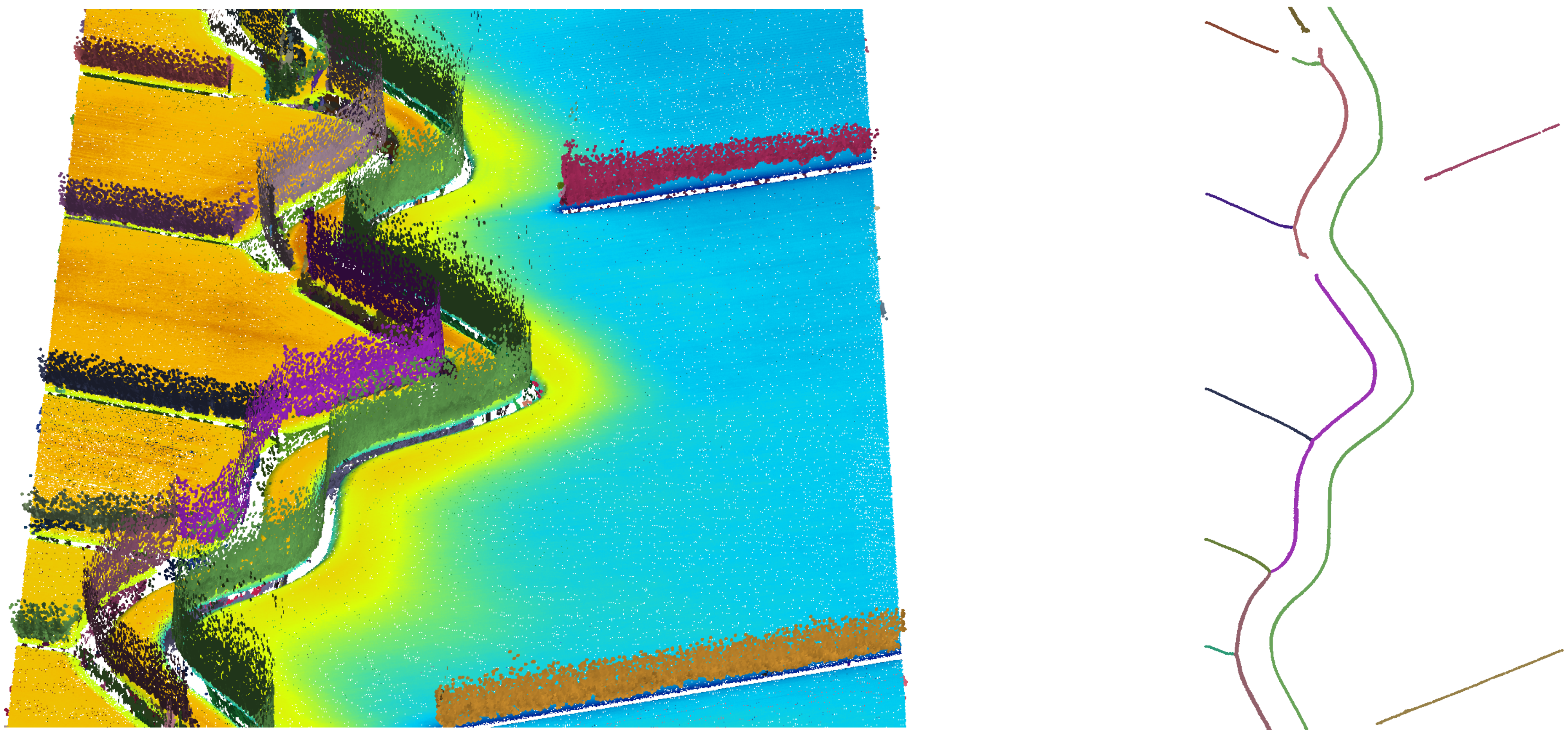
Figure 3: Our workflows that summarise how we extract the watercourses using 2D and 3D skeletons on a LiDAR point cloud.

2D MAT + 3D MAT = >95% identification



(a) Cross section of a watercourse. The 3D skeleton is obtained by reconstructing medial balls that touch the ground surface in two points.

2D MAT + 3D MAT = >95% identification



(a) Perspective view of skeleton and ground points.

(b) Plan view of exterior skeleton sheets.

Figure 10: Segmentation of 3D skeleton sheets. Each distinct sheet was assigned a random colour. The surface points are coloured by elevation.

Results with 4 diff soil types

Clay:
- Identified: **98%**
- Error: 8%
- Positional accuracy: 0.6m

Peat:
- Identified: **97%**
- Error: 8%
- Positional accuracy:
- 0.7m

Sand:
- Identified: 76%
- Error: 17%
- Positional accuracy: 0.9m

Urban:
- Identified: **95%**
- Error: 47%
- Positional accuracy: 1m

Journal paper submitted last month

Automatic identification of watercourses in flat and engineered landscapes by computing the skeleton of a LiDAR point cloud

Tom Broersen, Ravi Peters, Hugo Ledoux

Abstract

The knowledge of the drainage network in a given area is of the utmost importance to protect it against floods. To automatically identify watercourses, most previous work has used a derivative of a LiDAR point clouds (a gridded version) and has focused on natural landscapes, the slope and curvature of the terrain is mostly used. We focus in this paper on areas that are characterised by low-lying, flat and engineered landscapes, such that can be found in several parts of the Netherlands. We propose an automatic identification of watercourses methodology that uses solely a classified LiDAR point cloud as input. We show that by computing *twice* the skeleton of the point cloud — once in 2D and once in 3D — and that by using the properties of the skeletons we can identify most of the watercourses. We have implemented our methodology and tested it for three different soil types around Utrecht, the Netherlands. We were able to detect 98% of the watercourses for one soil type, and around 75% for the worst case, when we compared to a reference dataset that was obtained semi-automatically.

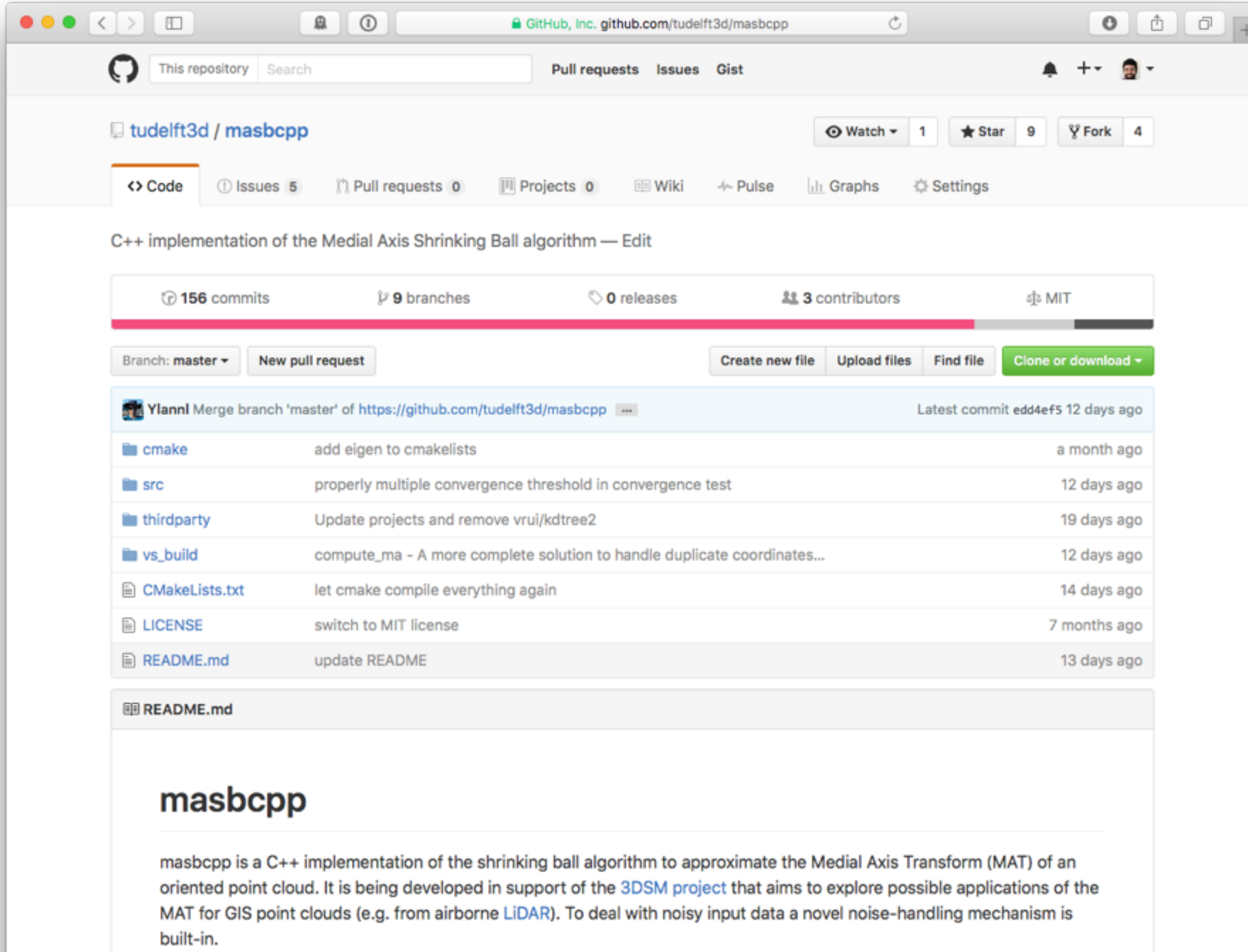
Keywords:

1. Introduction

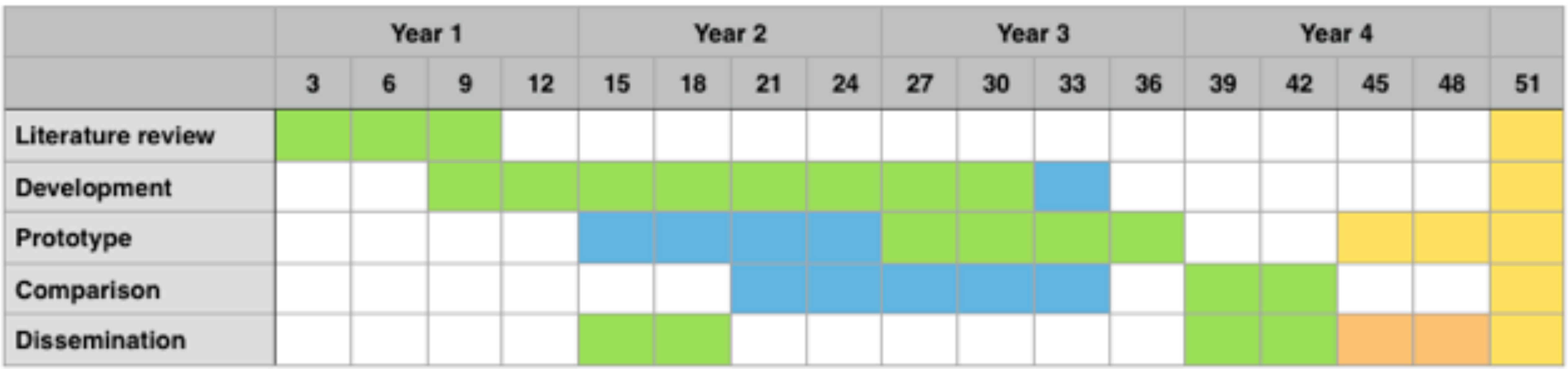
Several areas around the world, such as the Netherlands, are characterised by low lying, flat, and engineered agricultural lands. As shown in Figure 1a, the drainage network of these areas—which is artificial—consists of *connected linear features* such as channels, culverts, and reshaped gullies (Bailly et al., 2011); we refer to these hereafter as "watercourses". These form a network that transits water from the fields into larger canals (Bouldin et al., 2004).

Preprint submitted to Computers & Geosciences *October 24, 2016*

Simplification code open-source + FME transformer



Planning



*In **orange**: planned activities according to work plan*

*In **green**: planned activity accomplished*

*In **blue**: unplanned but accomplished*

In yellow: extra time and/or activities slide from January 2016

Activities coming year:

1. Algorithm to construct the hierarchical topological structure. That will allow us to explore how can features be identified in a point cloud (with the help of the MAT obviously). ✔
2. One journal article about this (in preparation)
3. For the visibility analysis, we plan to extend the work we presented at the workshop into a journal paper (we focused on other use cases)
4. Use-case of automatic identification of water courses (MSc thesis) ✔

Activities coming year (project ends March 1 2017 officially)

1. Finish the development and testing of methods to compute and utilise the hierarchy of the MAT, e.g. for buildings and watercourses.
2. Finish writing up the papers/methods:
   - 2.1. Use of the MAT hierarchy (to be submitted to a journal, not decided yet which one)
   - 2.2. maybe: orientation/estimation of normal based on MAT properties (with one "honour programme" MSc student)
3. Ravi must write up his PhD thesis

3dsm.bk.tudelft.nl