TU WIEN Informatics

Digital Surveying of Large-Scale Multi-Layered Terrain

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Introduction

Digital surveying allows exploring terrains and quantifying terrain surface properties. Data sizes larger than the available memory are common, thus efficient out-of-core algorithms are required. Terrain streaming is one solution for out-of-core processing of terrains. To carry out measurements, the surface profile needs to be evaluated. Doing this exactly is not always feasible for streamed large-scale terrain, therefore the surface profile is subsampled. Fixed-rate subsampling (FRSS), which samples the surface profile at equidistant points [1], is one strategy used, but a lack of a sufficent number of samples causes uncertainty.

In this work, we present a streaming algorithm for large-scale terrains in general 3D-mesh representation, as well as an improved subsampling strategy, and an uncertainty metric to quantify the uncertainty.

Contributions

Our contributions are:

- A streaming algorithm for terrain in general 3D-mesh representation. Our algorithm achieves interactive frame-rates for scenes with 775 M triangles and 156 GB on their finest level-of-detail (LOD), and a total size of 222 GB.
- Variable-rate subsampling using Shared Edge Detecton (VRSS+SED), and an improved subsampling strategy for poyline-based measurements. Compared to FRSS, VRSS+SED terminates earlier and with higher accuracy at equal number of samples when compared to FRSS.
- An uncertainty metric to quantify the uncertainty of polyline-based measurements, called On-Data Ratio (ODR). ODR allows raising awareness of uncertainty due to early termination of subsampling algorithms.

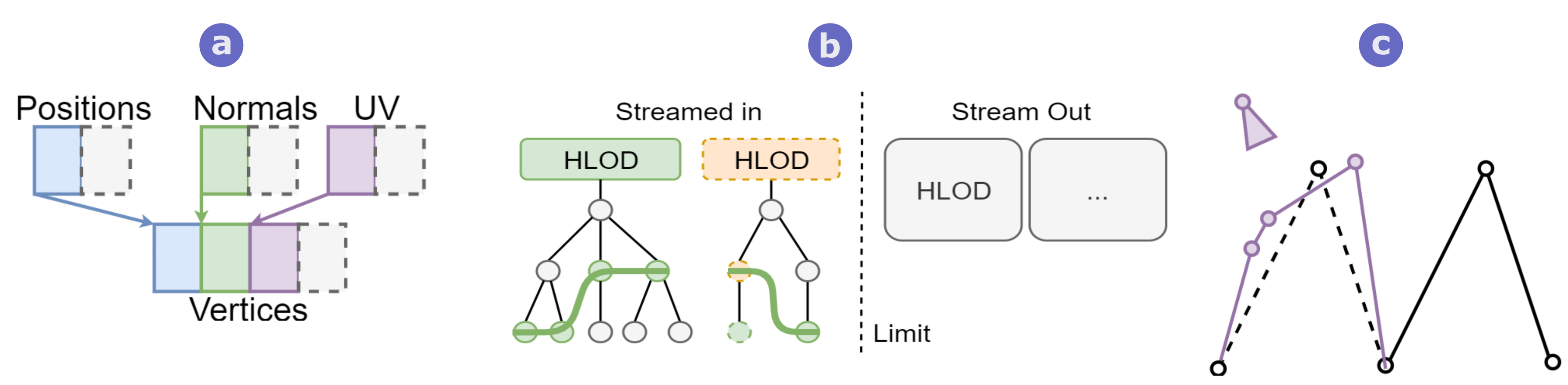
Method - Streaming of Large-Scale Multi-Layered Terrain

The out-of-core streaming of large-scale terrains is achieved by:

a) Preprocessing scenes into a custom streaming-efficient file format.

b) Parallelization of rendering and measurement across multiple hierarchical levels-of-detail (M-HLOD).

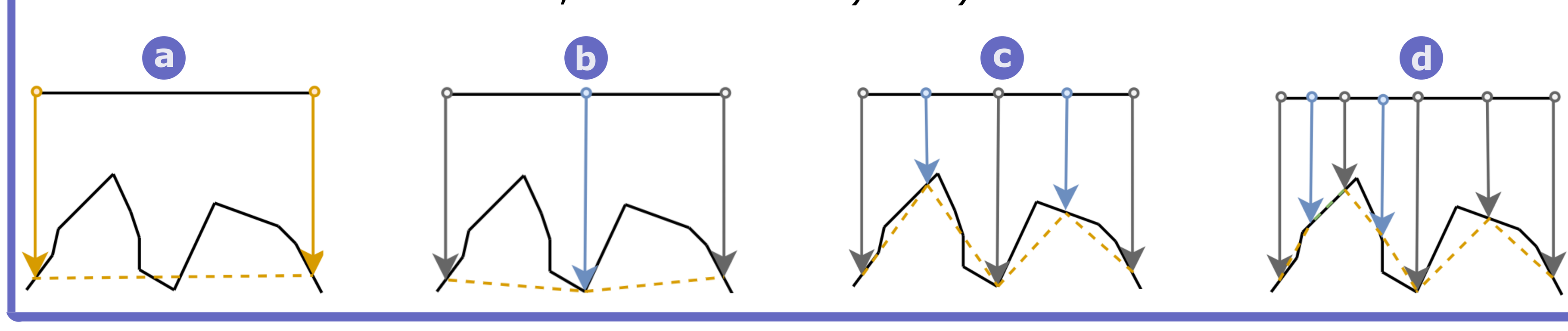
Multi-layer terrain is supported via priority rendering, as shown in c). Priority layers are considered for both rendering and measurement across priority layers and contribute to ODR as source of uncertainty when measured across two different layers.



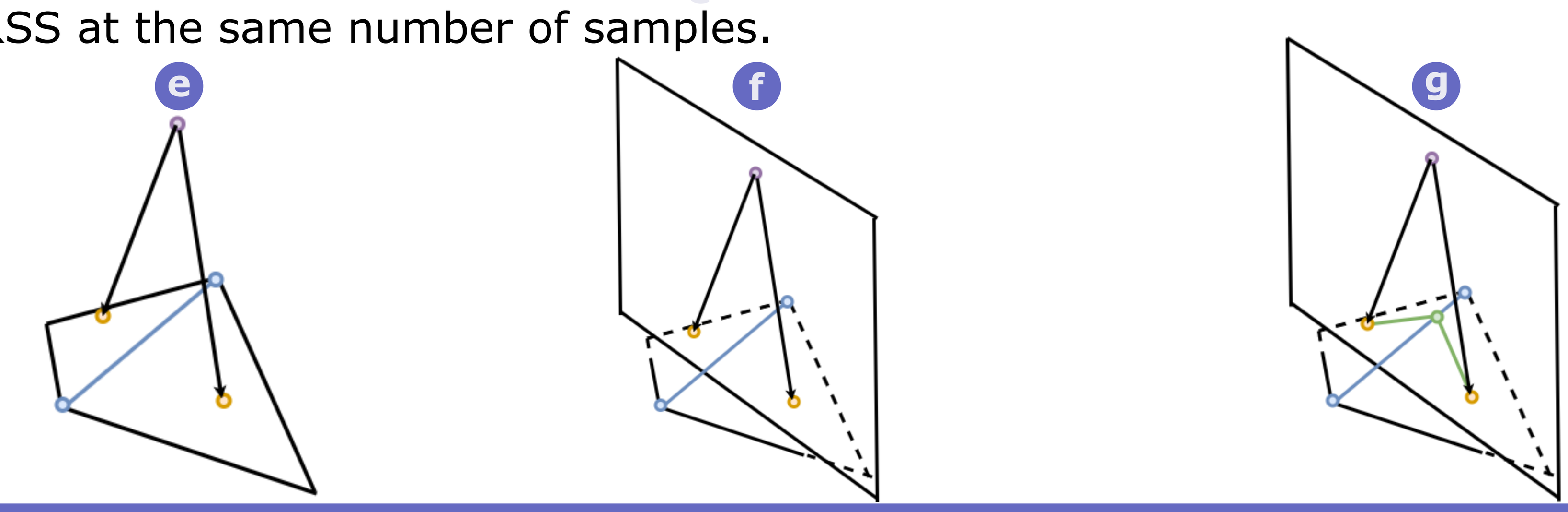
Method - Variable-Rate Subsampling using Shared Edge Detection (VRSS+SED)

User-drawn polylines are projected onto the terrain via ray casting. Axis-aligned bounding boxes are used during a broad phase to detect candidates, which are streamed in and tested during the narrow phase. The surface profile is reconstructed via straight lines.

VRSS casts additional subsamples recursively between two samples until a termination criterion is met, as shown in a) to d).



SED detects edges between neighbouring primitives, as shown in e). The ray casting plane is constructed, as shown in f). The exact midpoint is calculated analytically as the intersection of shared edge and ray casting plane, as shown in g). This way SED terminates earlier and with higher accuracy than FRSS at the same number of samples.

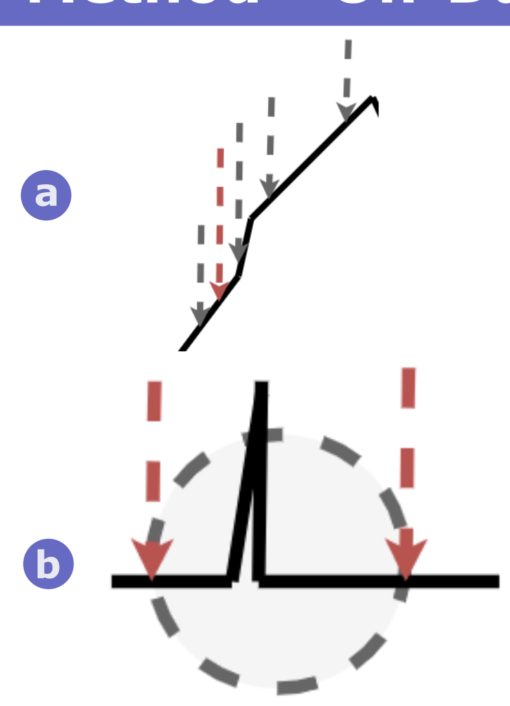


Method - On-Data Ratio (ODR)

ODR is defined as the ratio of the length of certain polyline segments over the total length of a polyline. Polyline segments are certain if they are on-data and exactly represent the surface profile. Termination criteria that cause early termination, and therefore uncertainty, are:

a) Reaching the maximum recursion depth or sample count.

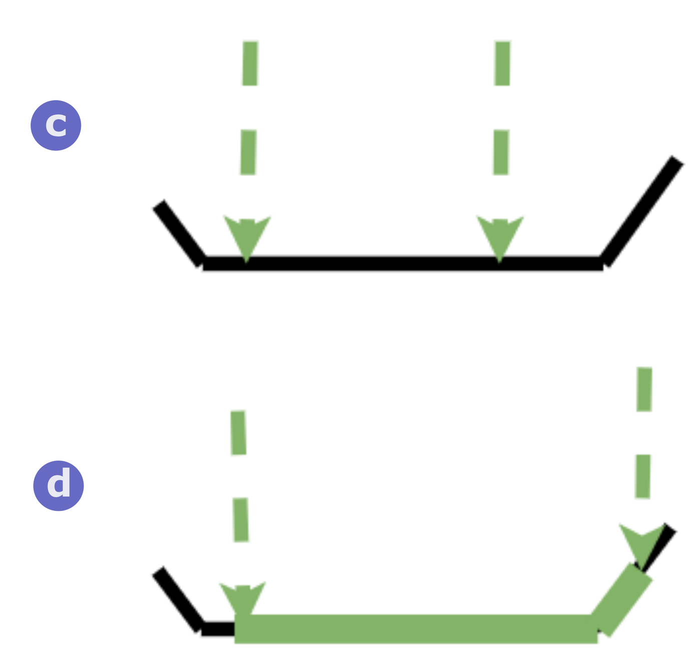
b) Detecting a distance between results that is below an epsilon threshold.



Termination criteria that result in exact surface profile reconstructions, and thus certain segments, are:

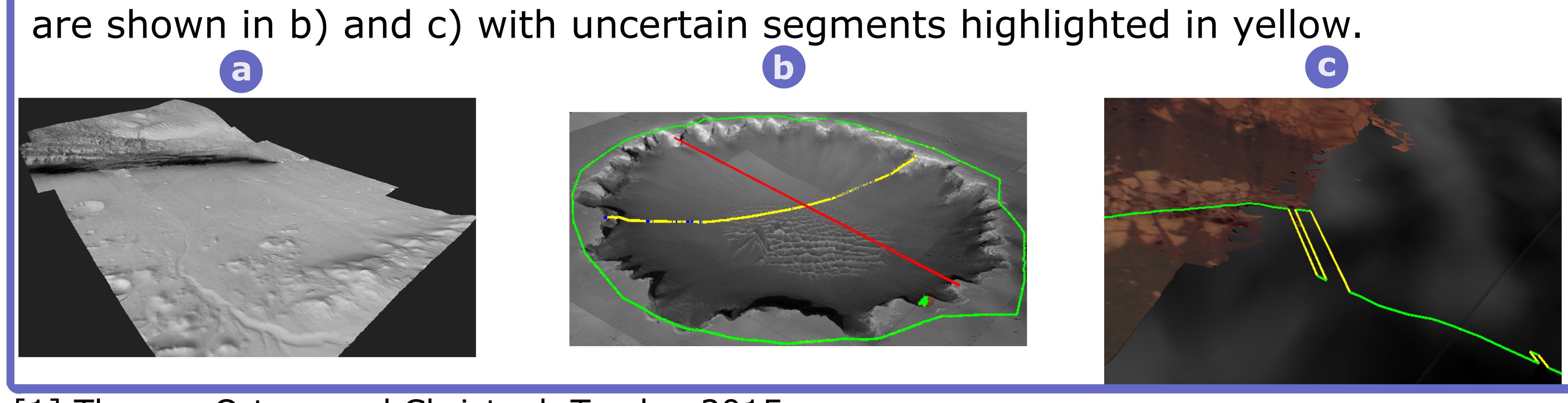
c) Hitting the same primitive.

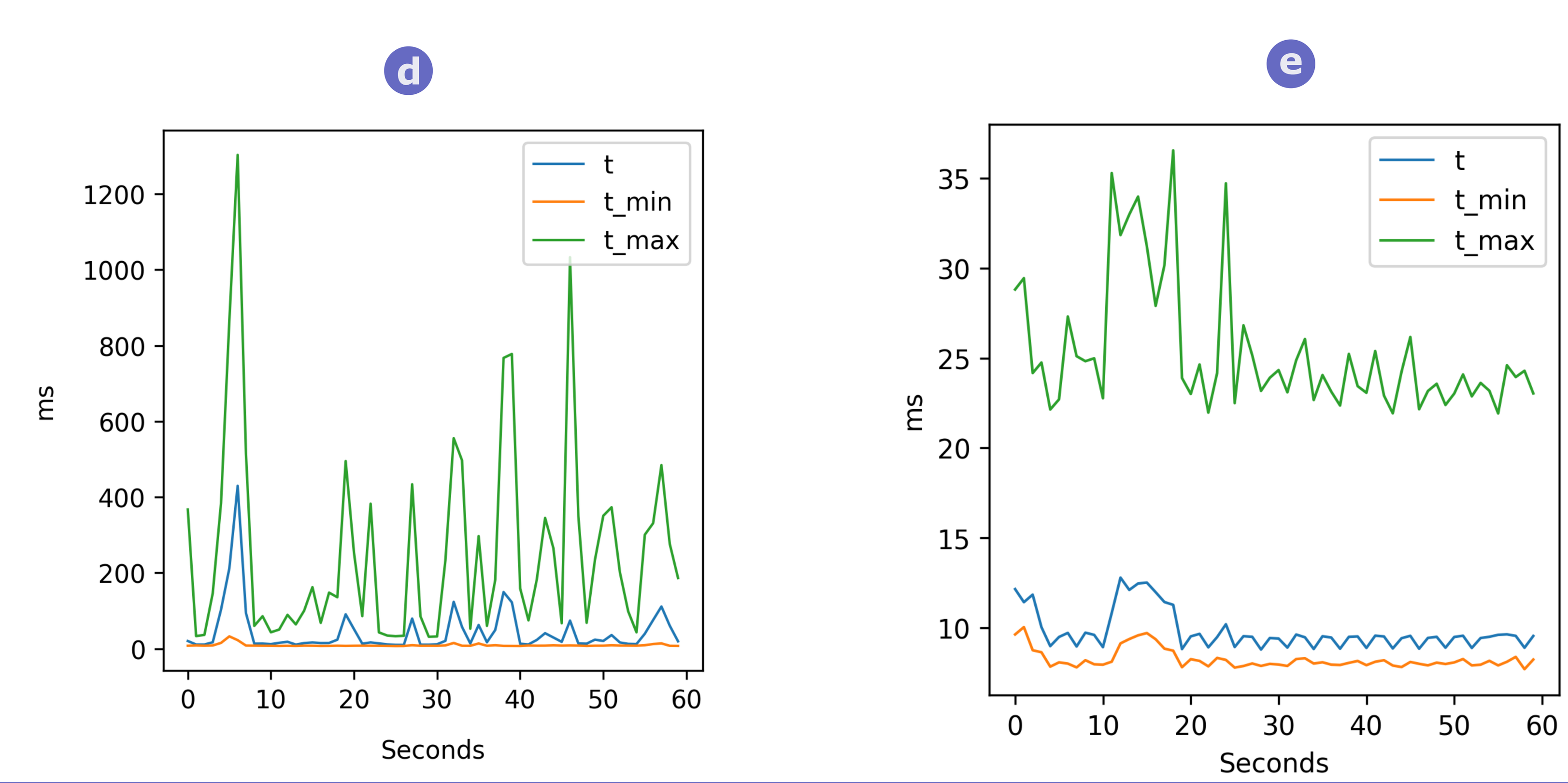
d) Termination with SED resulting in an exact midpoint.



Results

The result of this work is the prototype of a digital terrain surveying tool for large-scale multi-layered terrain, Visionary. It supports measurements using VRSS+SED and ODR across streamed large-scale terrain. The Gale Crater scene, with 222 GB and 775 M triangles at its finest LOD, is shown in a). The render time for a 60 s flyover of this scene are shown d), and e) shows the render times for a static camera. Measurements using VRSS+SED and ODR are shown in b) and c) with uncertain segments highlighted in yellow.





[1] Thomas Ortner and Christoph Traxler. 2015
PRo3D – a tool for remote exploration and visual analysis of multi-resolution planetary terrains. European Planetary Science Congress (2015)