ARCHIBALD – SOFTWARE FOR CREATING DIGITAL TERRAIN AND ITS GEOTECHNICAL APPLICATION

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Abstract

A key role in successful slope stability analysis is establishing accurate digital terrains. Better accessibility and precision of input data also increase demands for software processing particularly in terms of processing times and area dimensions. Newly developed software must provide user variability, which is necessary for the further geotechnical analysis. This paper discusses the current progress and development problems of my geotechnical software.

Keywords

Ground filtering, digital terrain, geotechnical applications, heightmaps, particle simulation

1 INTRODUCTION

With the increasing computing power and availability of field scanning equipment, there are more advanced possibilities for complex modelling of geotechnical tasks. The commonly used 2D geotechnical analyses for assessing large, morphologically dissected areas often lack sufficient accuracy and must be solved with 3D analyses [1], [2]. Geotechnical practice requires software capable of handling the preparation of digital terrain models of large linear structures and perform geotechnical calculations (such as stability calculations) with ease [3], [4]. Users appreciate the advantages of such complex software in the form of more efficient and clear work, with full control over both input and output data at the time of creation.

These reasons led to the development of my comprehensive geotechnical software called Archibald. The software combines individual sub-procedures and calculations programmed by the author in previous years, ensures their compatibility, and creates open outputs for further addition of extension software modules. This article is divided into:

2 METHODOLOGY

The basic input data for digital terrain creation are point clouds typically obtained through 3D laser scanning, terrestrial laser scanning, or air-born laser scanning. Most of the scanned terrains contain scanned vegetation cover that needs to be digitally removed.

Vegetation removal

The TDPF (two-dimensional parallel filter) algorithm was developed to identify terrain in a data cloud based on specific performance and data structure requirements (Fig. 1). This algorithm determines the lowest terrain points in each cross-section, which are prepared using a graphically accelerated subtask programmed in CUDA [5]. This subtask is a one-time process, and the remaining cross-section evaluation is done using a single-core task on the CPU. For larger areas, the task can also be executed with graphically accelerated features, resulting in further reducing computation time.

The user has also the option of selecting sensitivity parameters to achieve specific removal requirements. These parameters are:

- total point reduction in locations where adequate information about terrain is known. This parameter thus reduces the computing time and computational capacity for post-processed square uniform mesh,

- angles and distances of the searched terrain points, providing the ability to remove specific objects with sharp interfaces.

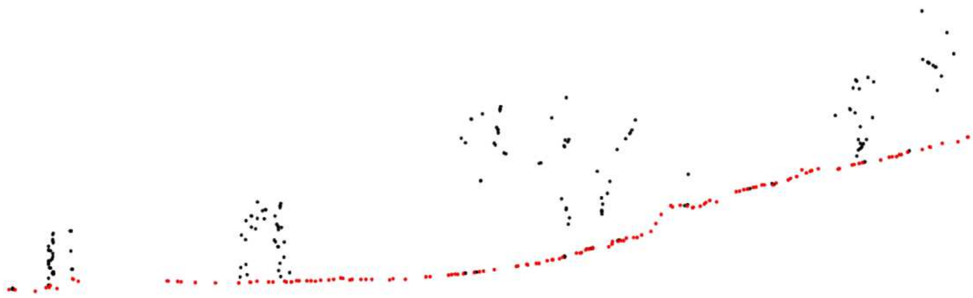

Fig. 1 Red points represent selected data as terrain with TDPF, black points are other not selected points.

Data sorting and meshing

The first step in the process is to clean the digital data. Once the data is cleaned, it is structured into a regular square grid. This is achieved by recalculating the heights and positions of each point in the data set. The square grid is chosen because it allows for faster and more organized access when using geotechnical applications.

To select a specific area, the user can enter the appropriate coordinates. Then, they can select the size of the basic square grid object, known as the raster. The processing is fully graphically accelerated and the output data is provided in the form of a Zt file, which includes the initial coordinates and information about the dimensions of the basic element. This approach significantly reduces the total space required for data storage.

Height maps - ContourMaps

This module was created for geological/geotechnical analysis. The user defines the respective color contrasts for each elevation level, which can lead to the detection of predispositions in a given area. The output formats can be displayed, for example, using the ParaView [6] software. The input data consists of an organized square grid.

Surface water flow (S-WFlow)

The S-WFlow module is an auxiliary module for the large-scale particle simulations module currently under development. Its purpose is to familiarize the user with the runoff directions and indicative volumes from a selected area and then serve as a preliminary validation for the particle module.

The computation is performed on a constructed organized square grid with very fine resolution. The algorithm allows particles to fall independently on a perfectly impermeable terrain where particles cannot interact with each other. The system then records the number of particles that pass through a given point in space. The output is a graphical representation of the area's navigable path system.

3 RESULTS

Vegetation removal

The test area for TDPF was the steep rock slope of the Zbraslav site with passive protection systems against mudflows and falling rock debris. Laser scanning of the area was performed terrestrially from different positions [7]. The total size of the scanned area is 50 × 80 m, with a total point number of 6.5 million. The TDPF performance is shown in Fig. 2 and Fig. 3.

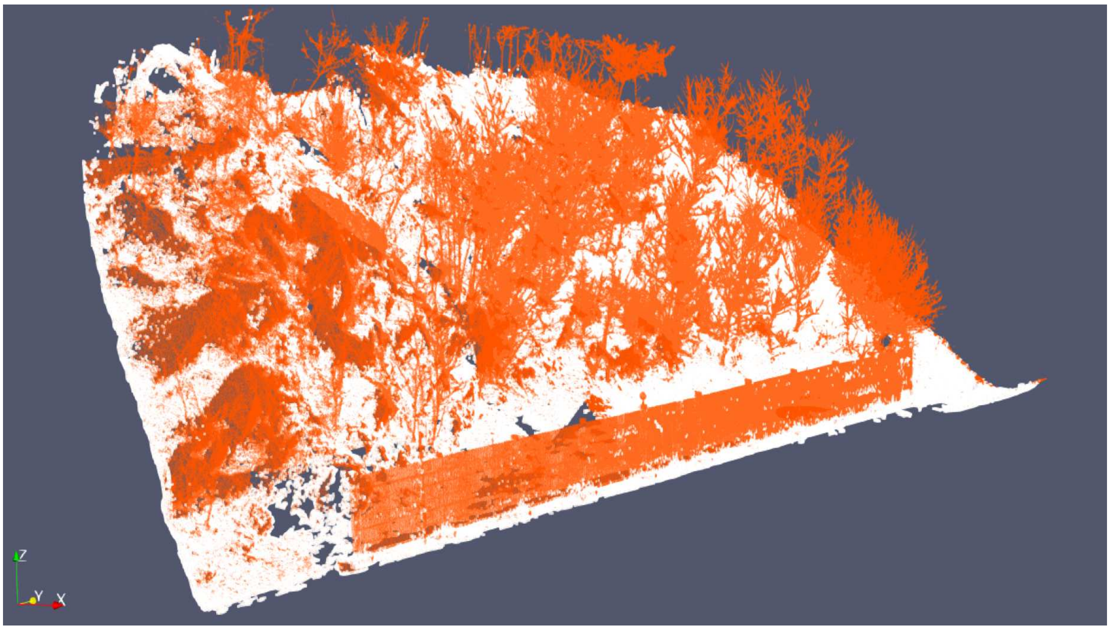

Fig. 2. Point cloud of the scanned area.

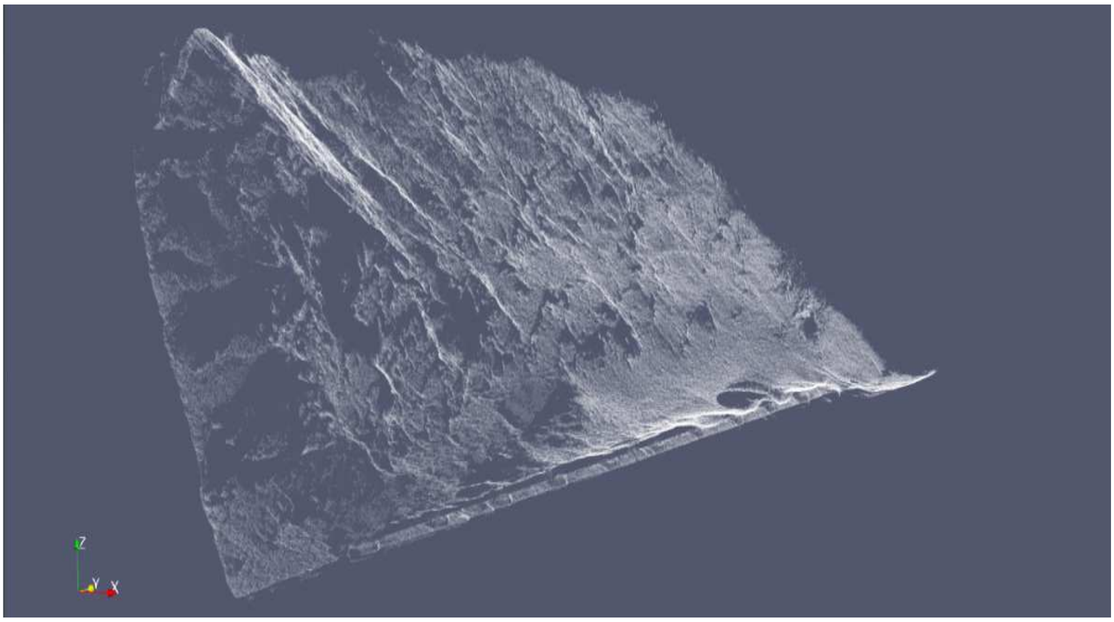

Fig. 3 Scanned area after applying the TDPF algorithm.

S-WFlow

The analysis was applied to the same Zbraslav area. The computational area was 200 × 200 m, and the input data were used from the DMR 5G terrain [8], which were unorganized and unsorted. The total number of particles was 50 000. Fig. 5 and Fig. 4 show the erosion furrows (concentrated runoff path). The erosion furrows, in the center of Fig. 5, had the highest water particle collection, with a total particle count of up to 70%. In Fig. 4, a water puddle can be seen in the lower left part.

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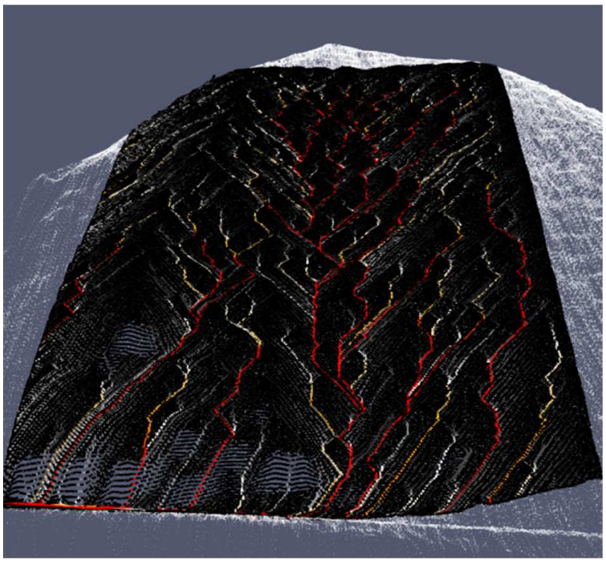

Fig. 5 Erosion furrows of Zbraslav area.

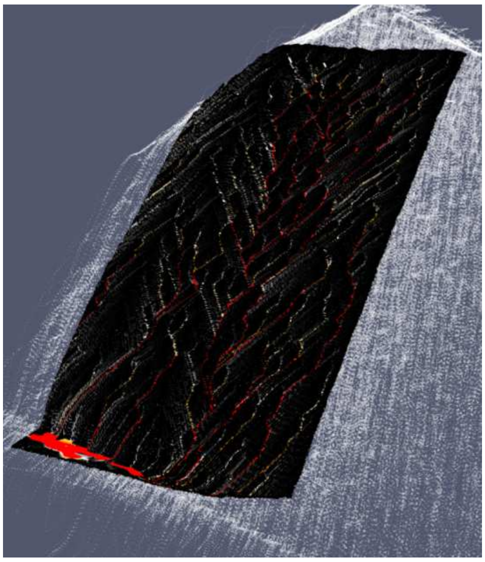

Fig. 4 Erosion furrows – side view.

Height Maps – Contour Maps

Software Archibald was used to process a large square grid of 30 km × 60 km (Fig. 6), generated from 8 million points. The input data for this application were unsorted and unorganized DMR 5G points [8].

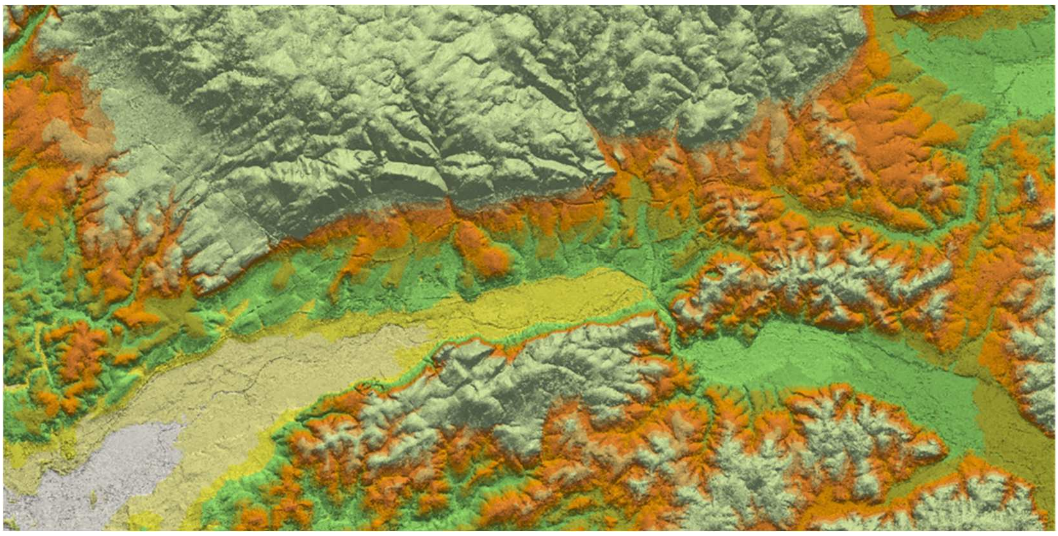

Fig. 6 User defined heightmap.

4 DISCUSSION

Practical tests of TDPF proved the advantages of using user-specific sensitivity parameters to achieve the required object removal. These situations arise when nearby rock outcrops are close to the objects to be removed. Simplifying the scanned areas with sufficient information while maintaining accuracy about elevation position plays a significant role in speeding up the overall post-applications.

The S-WFlow module, in which individual particles are not affected, provides sufficient information on possible directions and quantities of runoff for initial familiarisation with the studied area of interest. However, in future developments of Archibald, with particle simulation module creation, it will be necessary to consider full particle interaction and other physical aspects for a more accurate water flow analysis.

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Similar to the vegetation removal module, graphical acceleration played a critical role in the development of other modules as well. It was essential to build algorithms that could be fully parallelized, which helped to significantly reduce the computation times of individual processes. Additionally, the individual tasks and codes were streamlined to improve overall efficiency.

5 CONCLUSION

The software Archibald is specifically designed to meet the practical needs of engineering professionals. Its strongest feature is the ability to create digital terrains for large areas of interest. The software comprises individual modules that help prepare data for sub-analyses and provide relevant information to become familiar with the site under consideration. The methodology used in digital terrain clearance will be further validated and refined on reference sections. The next important step in the development of this application is to complete the true particle simulation module, which will make full use of the existing software modules and complement the geotechnical analysis of slope stability assessment.

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