A New Software Tool For The Analysis Of Rockfalls

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Introduction

Rockfalls are gravitationally driven geomorphic processes that occur rapidly on steep rocky slopes. They can have disastrous effects on human activities and infrastructure and therefore constitute a significant natural hazard. However, due to the complex nature of the phenomenon, the available analysis methods incorporate assumptions that can lead to oversimplifications. For example, the majority of the available software for rockfall analysis, simulate the impact with the Normal and Tangential Coefficients of Restitution (n_{COR} & t_{COR}, or R_n & R_t respectively). In those software, CORs are selected by some suggestive values which depend solely by the slope surface material. But other crucial parameters are neglected, even though they have been found to pose significant effects on the response of a block at impact with the slope.

The new software tool, presented herein, includes alternate methods to simulate the impact-rebound process, including some empirical methodologies found in literature and a new neural network algorithm.

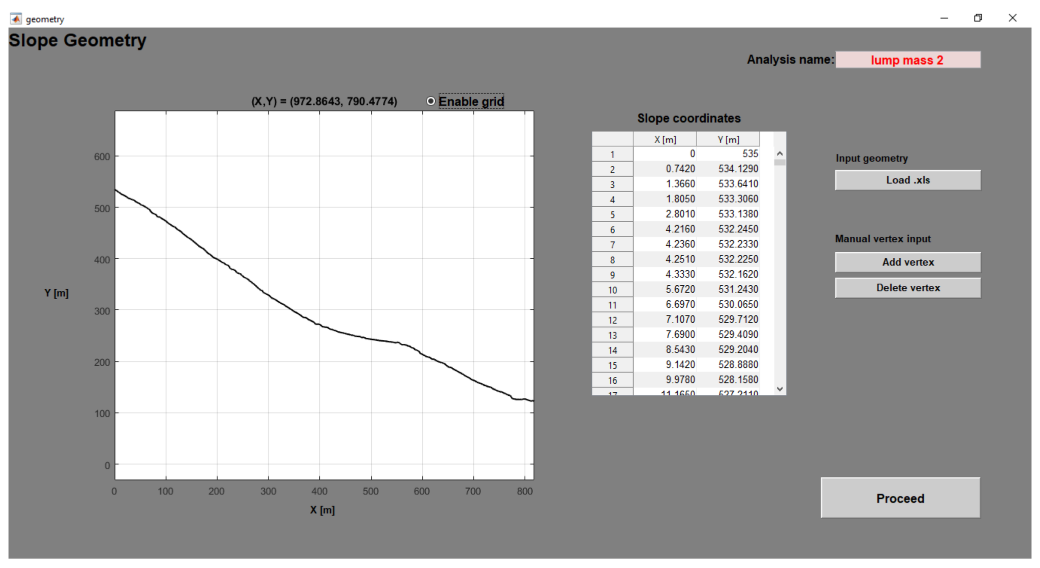
Software structure

The software was developed in MatLab. The user interacts with the software through the Graphical User Interface (GUI) environment, resulting to a user-friendly application. In order to perform an analysis, the user must go through the following stages:

Step 1: Slope Geometry

Slope's geometry can by defined by:

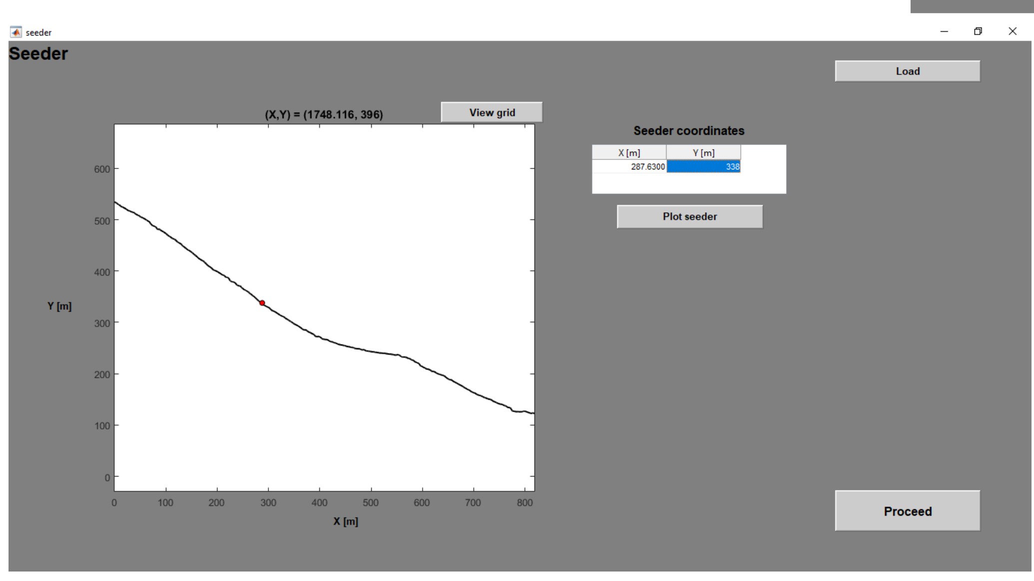
- importing an excel spreadsheet containing the vertex coordinates of each segment
- inputting the vertex coordinates in the GUI environment
- drawing the slope manually with the cursor



Step 2: Seeder position

Seeder position can by defined by:

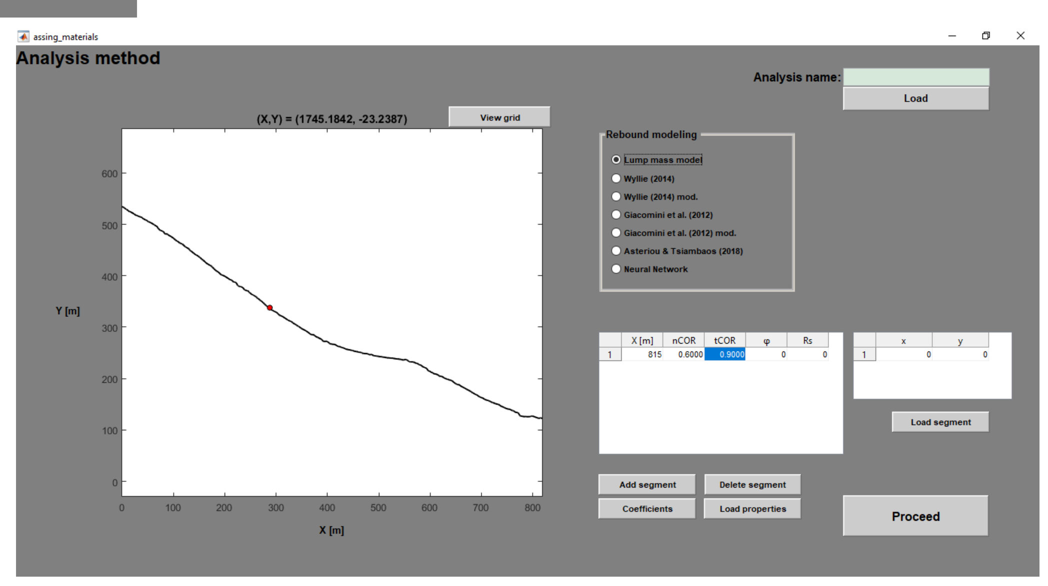
- inputting its vertex coordinates in the GUI environment
- selecting it manually with the cursor



Step 3: Analysis method

The analysis method is selected in a radio-button environment. Seven methods are available.

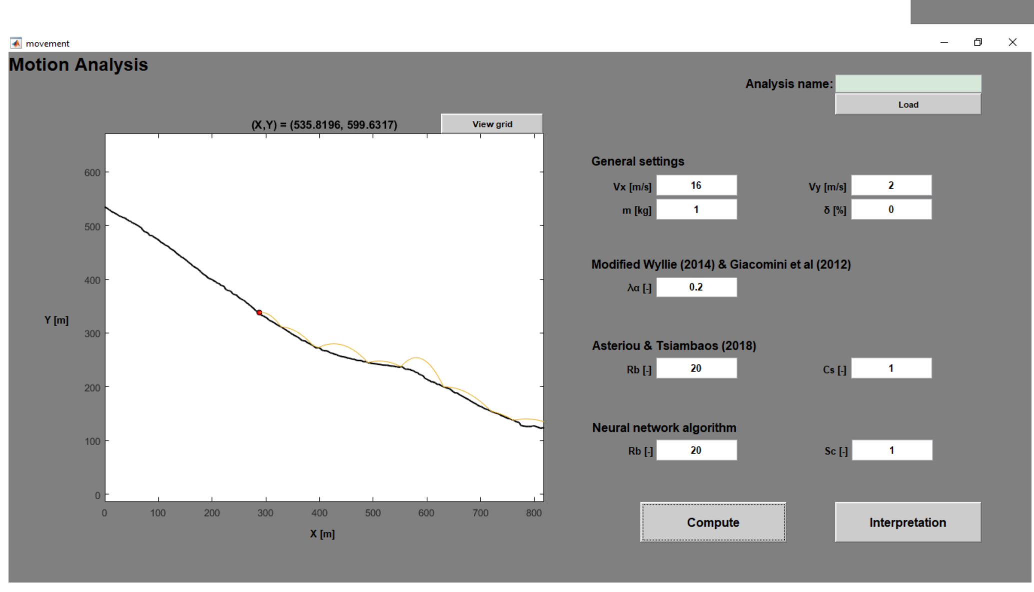
Slope properties are defined in the tabular environments



Step 4: Motion Analysis

Seeder properties are defined (Initial velocity, block mass)

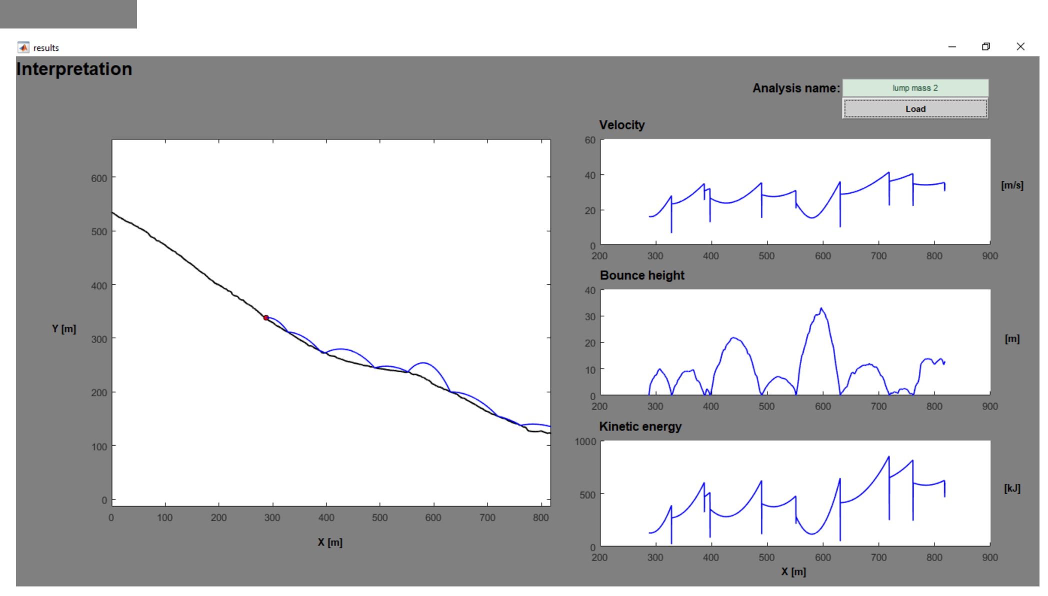
Block related properties must be defined for the selected analysis method



Step 5: Interpretation

Results are displayed in graphical environment

A results sheet is automatically generated and saved, containing the settings, the results and some figures depicting them.



Overview of the available analysis methods

In all available methods the impact is assessed with the lump-mass method. The rebound is calculated according to the coefficients of restitution (COR) which are overall values that take into account all of the characteristics of the impact and describe the change in the block's velocity magnitude. COR consists of two components which are defined as:

$$n_{COR} = \frac{v_{n,r}}{v_{n,i}} \quad \text{and} \quad t_{COR} = \frac{v_{t,r}}{v_{t,i}}$$

The available methods are:

- **Classical approach**

CORs are selected according to the material that consists the slope, most commonly referring to some "suggestive values" found in literature. This is the most common approach but omits many significant parameters.

- **Giacomini et al. (2012)**

After performing an extensive field investigation, Giacomini et al. (2012) stated that n_{COR} depends mostly on the impact angle and proposed the following correlation. No suggestions were made for t_{COR}. Therefore when using this model, the software assumes a constant t_{COR} = 0.9, which is in-line with the suggested values in the literature.

$$n_{COR} = 0.92e^{-0.046 \cdot \alpha_i}$$

- **Wyllie (2014)**

Wyllie gathered results from field tests around the world and proposed an empirical relationship. Again, no suggestions were made for t_{COR}. Therefore when using this model, the software assumes a constant t_{COR} = 0.9.

$$n_{COR} = 19.5\alpha_i^{-1.03}$$

- **Modified Giacomini et al. (2012) & Modified Wylie (2014)**

n_{COR} is calculated as above, but t_{COR} is connected to the rebound angle with the factor λ_α which has been derived by the author and connects impact and rebound angles with respect to the block shape.

- **Asteriou & Tsiambaos (2018)**

This method estimates both n_{COR} and t_{COR} taking into account the slope properties (inclination, Schmidt hardness), the block properties (mass, Schmidt hardness, shape) and the impact conditions (velocity, impact angle). A detail documentation of the method is also presented in this congress.

- **Neural Network Algorithm**

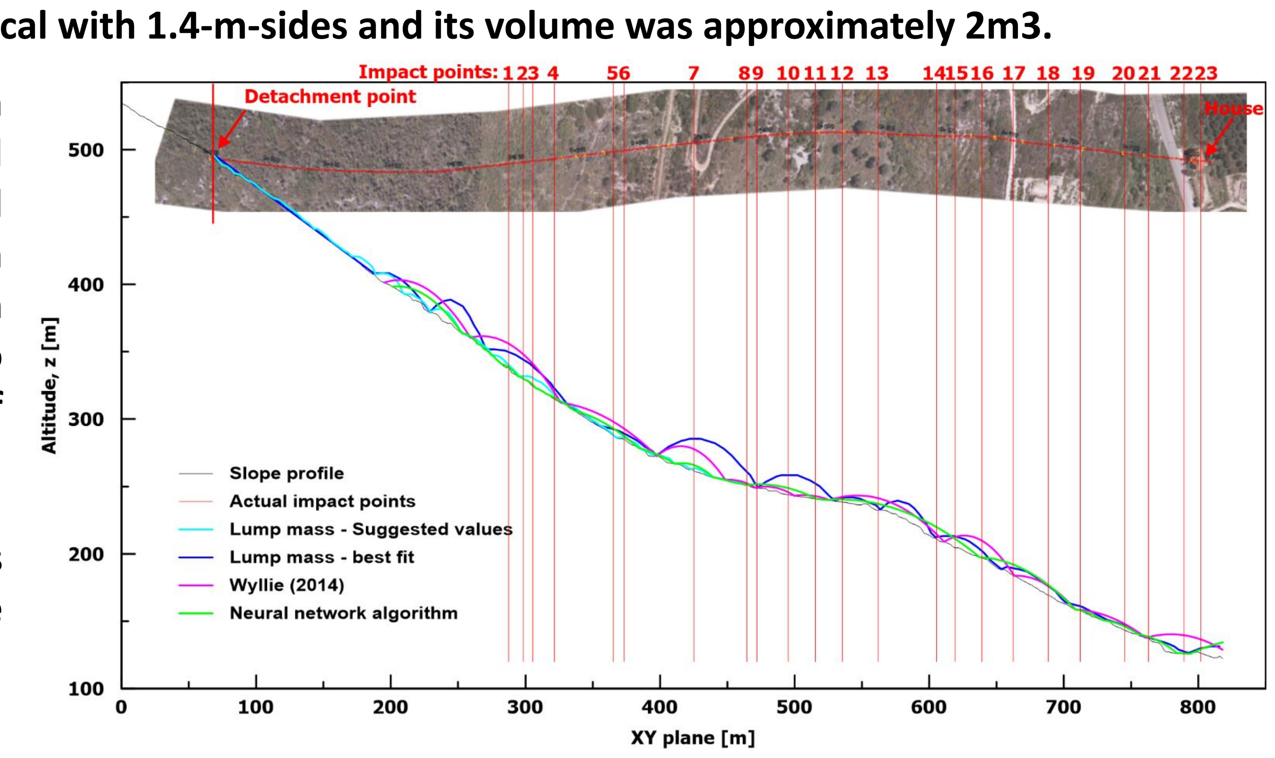
This algorithm is developed especially for this software and is based on the data acquired in Asteriou (2016). The model is a multi-layered back-propagation network that was trained by more than 2000 laboratory and field tests.

Case study: Ponti rockfall (17th Nov. 2015)

An earthquake (Mw 6.5) triggered rockfall in Ponti village, resulted a limestone block to detach at an elevation of 500m, roll ~250m, impact 22 times on the slope and finally on a family residence, penetrating two brick walls and killing a person inside the house. The slope overhanging the residence has its peak at 600m and an average slope angle of ~40°. The block was nearly cubical with 1.4-m-sides and its volume was approximately 2m3.

The rock path and the impact points on the slope were identified by a field survey, performed using an unmanned aerial vehicle (UAV) with an ultrahigh definition (UHD) camera, which produced a high-resolution orthophoto and a digital terrain model (DTM) of the slope (Saroglou et al., 2018).

Some indicative trajectories, as computed by the software, are presented in the figure.



References – Further reading

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