Learned erosion models for synthetic landscape generation

Postdoctoral position

Guillaume Cordonnier, Inria Sophia-Antipolis (France)
guillaume.cordonnier@inria.fr
https://www-sop.inria.fr/members/Guillaume.Cordonnier/

Figure 1: Physically-based simulations of erosion (left) produce terrains that are geologically consistent but cannot capture the diversity of real landscapes (right, Google Earth, Pyrenees). We propose to learn generative erosion laws that enforce physical consistency and capture the diversity of real landforms.

Context

Synthetic landscapes not only offer striking vistas in computer graphics applications [1], but also serve as a basis for water and resources management, climate predictions, or natural risk assessment. In particular, we explore models for *terrain simulation*, where the landscapes emerge from the combination of geological and physical processes which allows us to enforce physical consistency (slope distributions, discharge continuity, etc.)

Terrains are primarily shaped by *erosion* [2], and our current approach to model erosion through geologically validated laws [3] is not enough to capture the diversity of the landscapes at different scales (Fig. 1). In this project, we propose to use machine learning to infer erosion laws from real landscape, while preserving a delicate balance between physical consistency and result diversity.

Approach :

We will process in a bottom-up approach, focusing on first erosion at small scales (a river, a valley, for instance from the 1m IGN elevation dataset), where the interaction between the erosion processes is the most visible. Applying existing erosion laws [4,5] to these terrains will allow us to evaluate what prevents them from capturing the diversity of real landscapes and what enables them to enforce physical consistency. We will deduce a physics-aware generative network architecture to ensure both consistency and diversity. Then, we will explore multi-scale training strategies, enabling us to propagate our small-scale results to large spatial and temporal scales, for instance to model the formation of mountain ranges on geological times.

Work environment and requirement.

The postdoc will take place at Inria Sophia Antipolis. Candidates should have a Ph.D. in computer science or quantitative geomorphology; and be willing to learn about physics and machine learning for geosciences.

The postdoc will be funded by the French National Research Agency (ANR) and can include collaborations in computer graphics and Earth sciences.

References:

[1] E. Galin, E. Guérin, A. Peytavie, G. Cordonnier, M.-P. Cani, B. Benes, J. Gain, *A Review of Digital Terrain Modeling*, Computer Graphics Forum, 38 (2), pp.553-577, 2019.

[2] K. X. Whipple, Bedrock rivers and the geomorphology of active orogens. *Annual Review of Earth and Planetary Sciences* 32, 1, 151–185, 2004.

[3] J. Braun and S. D. Willett, A very efficient O(n), implicit and parallel method to solve the stream power equation governing fluvial incision and landscape evolution, *Geomorphology*, vol. 180–181, pp. 170–179, 2013,

[4] G. Cordonnier et al., Large Scale Terrain Generation from Tectonic Uplift and Fluvial Erosion, *Computer Graphics Forum*, vol. 35, no. 2, pp. 165–175, 2016

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