PLUME: Procedural Layer Underground Modeling Engine

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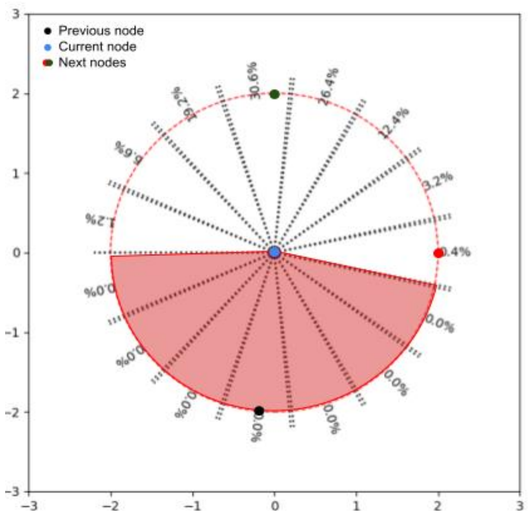
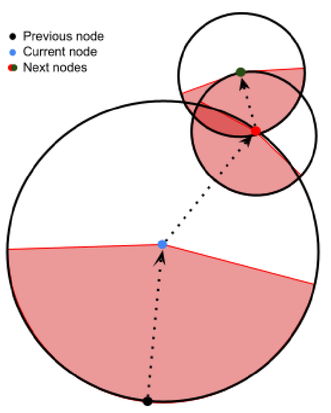
Introduction

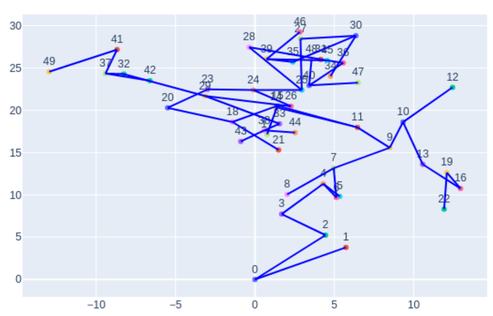
Underground environments are not easily accessible for experiments as they can require extensive administrative overheads, go through strict security protocols and necessitate well-planned experiments. As a result, experimenting in such experiments is tedious, and simulation is often preferred. Nevertheless, acquiring a realistic 3D underground environment is complicated, with many mines refusing to share their precise topologies. This leads to the fact that the quantity and variety of such resources available are not enough to tackle the vast diversity of the environment that can be found below our feet.
This poster presents PLUME, a procedural generator of underground environments that enables users to easily and quickly create 3D underground environments. The generated environments can be used for AI training, evaluation of robotics algorithms, 3D rendering and more. Furthermore, they can be used to iterate very quickly on developed exploration algorithms.

Graph generation



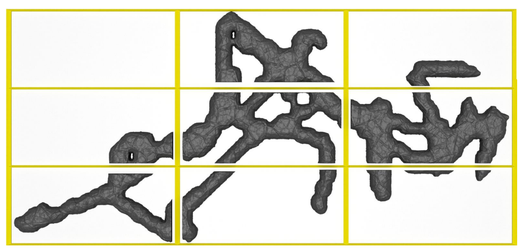
PLUME start the generation with a graph-based algorithm. Each node of the graph has a normal distribution of probability distributed in a circle. Hence, every angle that is facing toward the previous node cannot generate a new node; on the other side, every angle that spreads away from the graph has more chance to create a node. This algorithm prevents the graph from circling on itself.





The desired graph can be generated in 2D or in 3D depending on the mission scenario

Mesh generation



Once the graph is successfully generated, PLUME uses the API of the software Blender to create the mesh around it as a tube. Close nodes create big chambers, whereas distant nodes long corridors. After mesh completion, the mesh is sliced into different chunks, where the procedural texture is generated and applied. PLUME allows fine-tuning, different numbers of polygons and texture resolution, resulting in generations ranging from computer-friendly to highly realistic environments.

Outcomes

Generation types:

- **Mines**
- **Caves**
- **Lava tubes**

Software used:

- **Blender API** [1]
- **User friendly config file**
- **Python**

Potential outcomes:

- **Mine industry**
- **Space industry**
- **Robotic research**
- **AI research (challenging environments)**

Future work

PLUME now has all the required features to start generating procedural underground environments such as caves or mines but still needs refinement for lava tubes. Moreover, PLUME would need to have different layers of "physical textures" that need to be applied. Those textures are not intended for rendering but for the simulation software to simulate different surface physics, such as stickiness or slipperiness. Future studies will compare real data collected in Luxembourg's underground with the generated environments of PLUME. Therefore, different metrics will be applied, such as the number of common features in mines and caves, the overall topology match, or the visual realism of the generated texture.

[2]

[1] Blender logo, blender.org, https://www.blender.org/about/logo/
[2] Walferdange Mine

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