

Cave map generation from 3D models

“A small matter of math and programming, with a sprinkling of AI”

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November 27, 2021

Background

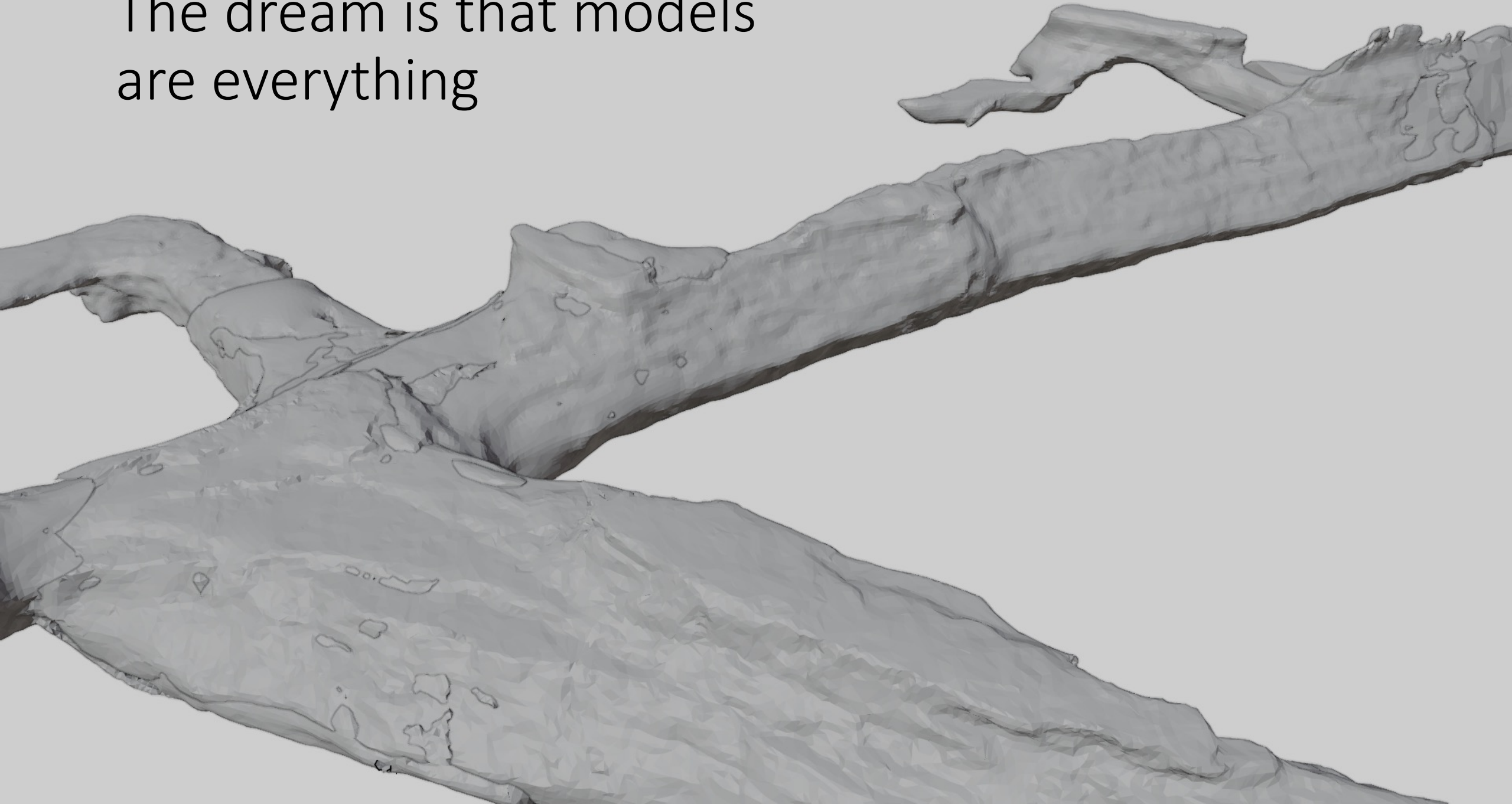
- Introduction of consumer devices that – in principle – make 3D modelling possible
- Could I use this technology to more easily explore and document caves?
 - Example: my Finnish cave map count: 100+ (maybe 5%)
- In practice there's a lot of obstacles: technique, lightning, applications, software, scaling, limits of accuracy
- A lot of interesting problems for researchers 😊



The Model Problem

- I thought that we'd be done once there's a model
- Gives an overview of the cave
- Can be used for navigation in the cave
- Has all the details needed

The dream is that models
are everything

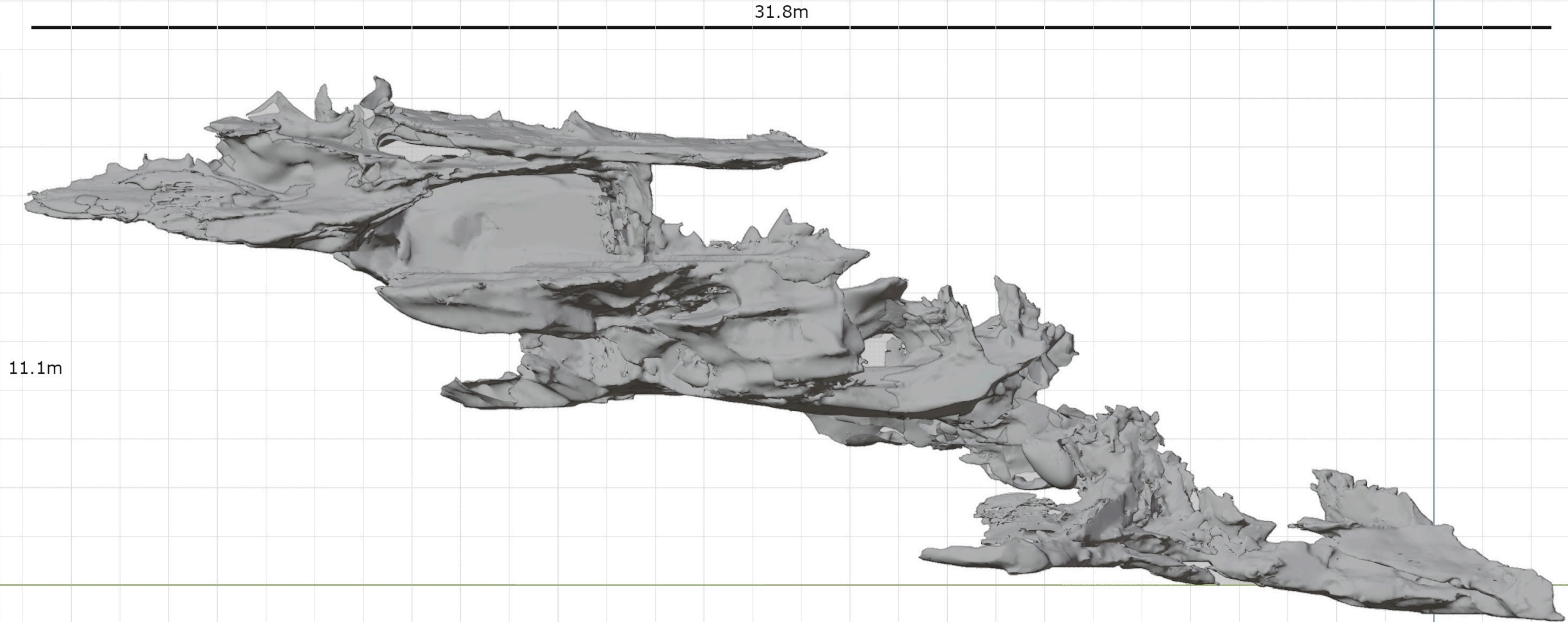


Nice straight tunnels

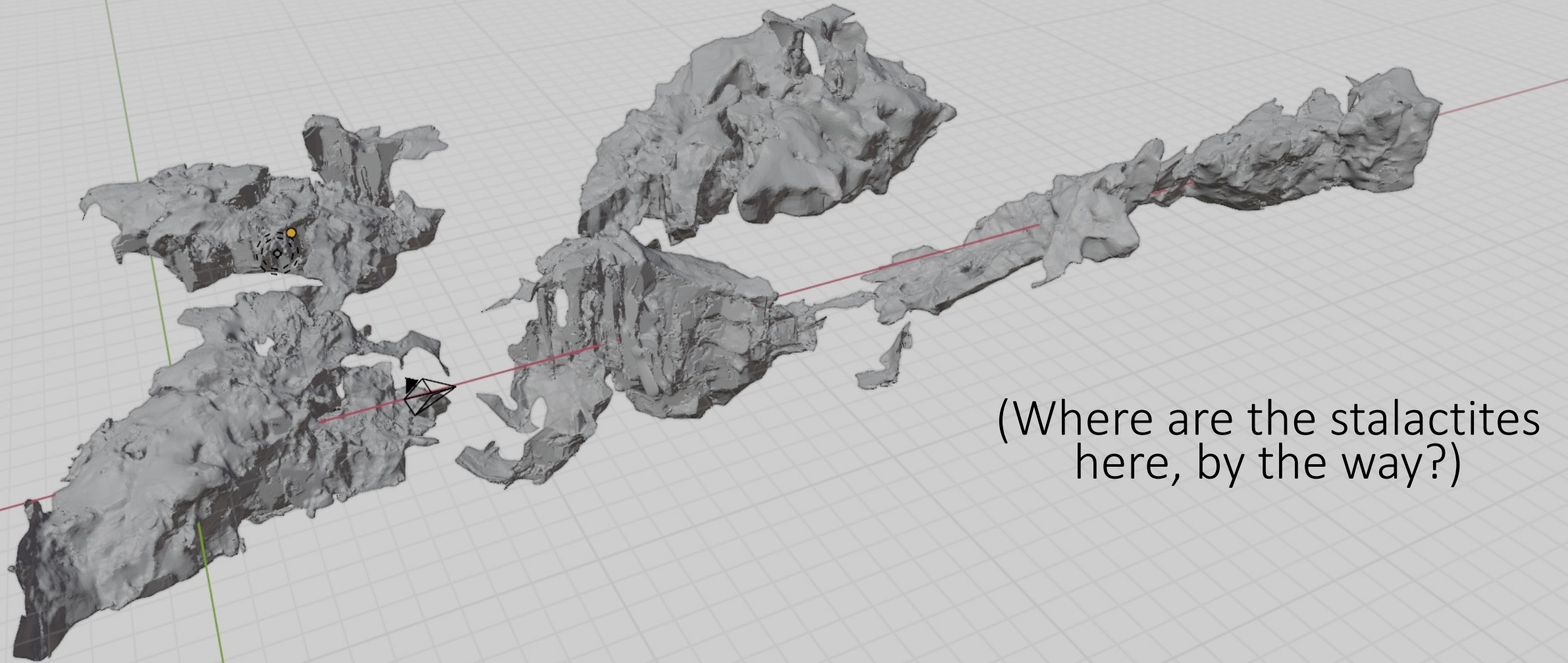
Lummelunda, Sweden



But: In practice it is often messy



Or even messier – I don't know
how to put these pieces together...

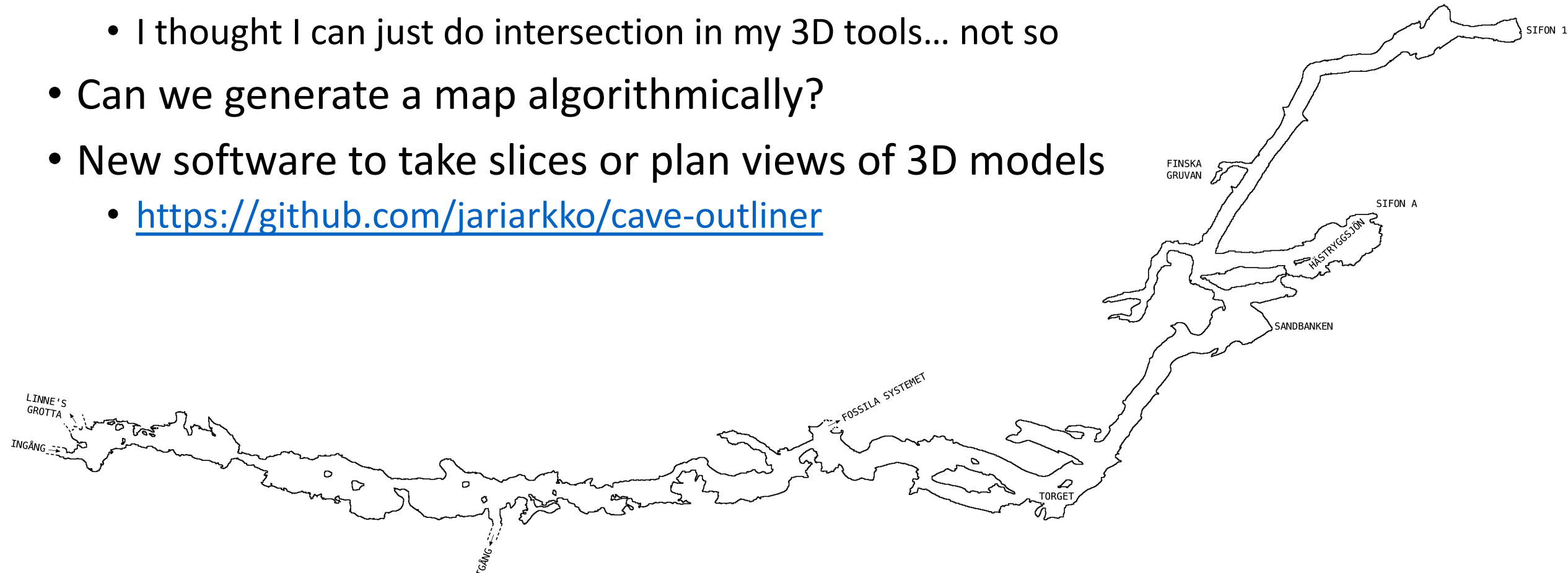


(Where are the stalactites
here, by the way?)

Kraljičina spilja (Queen's Cave), Croatia

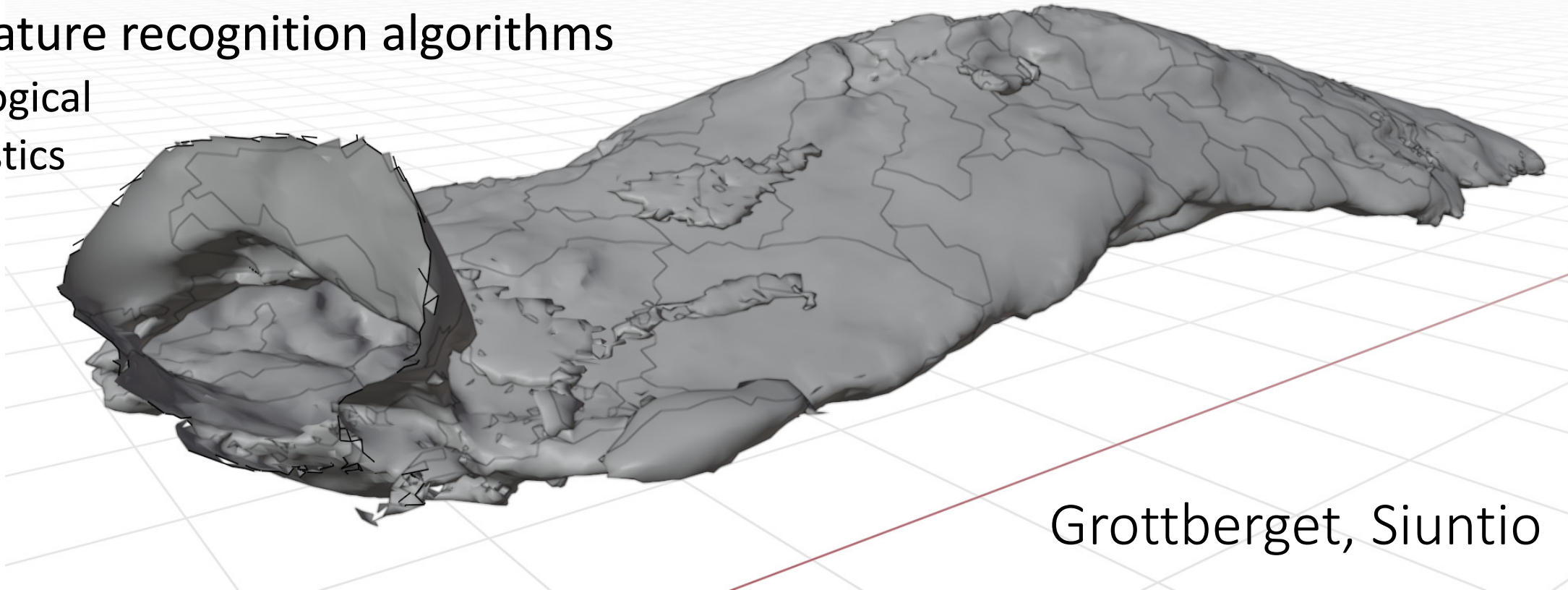
Going beyond 3D

- Models are not easy to deal with in all situations
 - For many situations I'd prefer a simpler plan view
 - I thought I can just do intersection in my 3D tools... not so
- Can we generate a map algorithmically?
- New software to take slices or plan views of 3D models
 - <https://github.com/jariarkko/cave-outliner>



Sketch for an approach

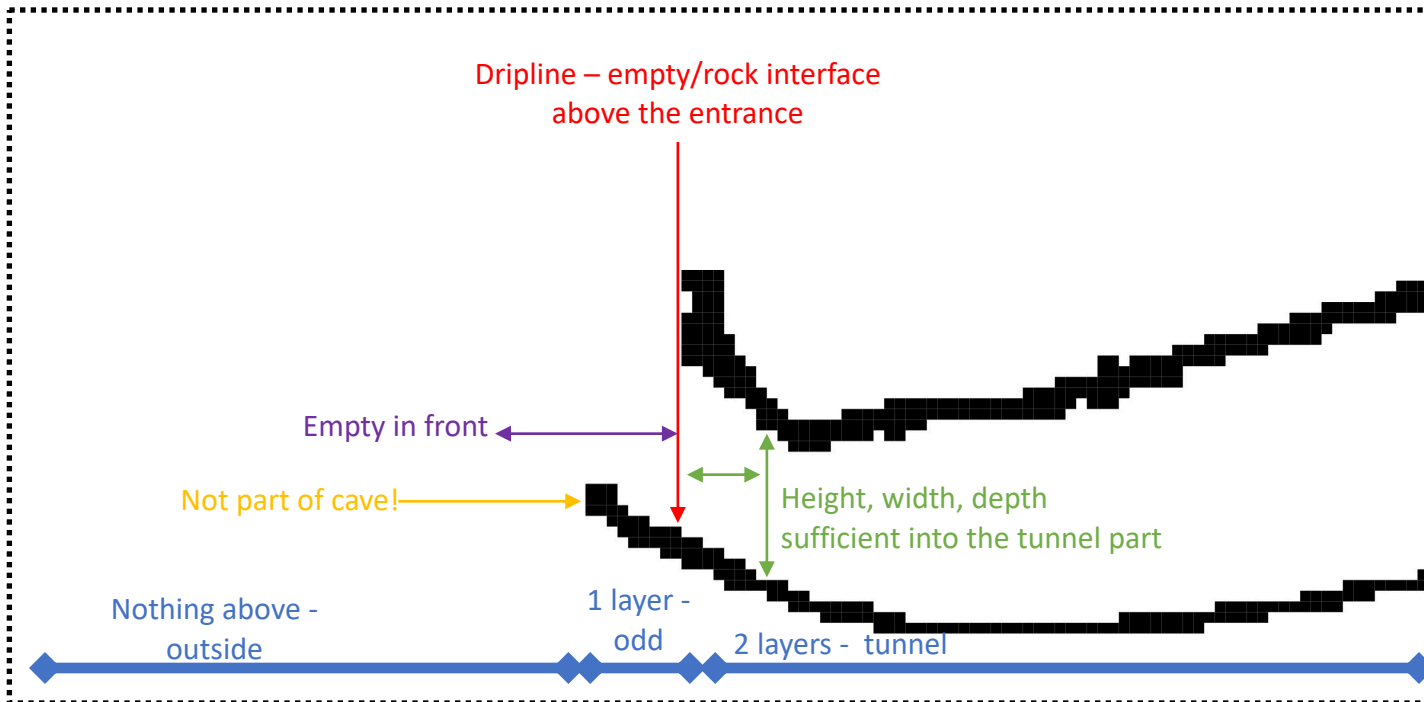
- Take a model as input
- Reduce information content (outlines vs. structure etc)
- Provide suitable views (plan, x-section)
- Apply feature recognition algorithms
 - Topological
 - Heuristics
 - ML



Grottberget, Siuntio

Some complications

- Going through 10^7+ objects is expensive => search structures
- Math sounds relatively easy, but ... is (x,y) in triangle?
- Models are imperfect – algorithms for filling holes
- What's a definition of an entrance?



$$\mathbf{v} = \mathbf{v}_0 + a \mathbf{v}_1 + b \mathbf{v}_2,$$

where a and b are constants. Solving for a and b gives

$$a = \frac{\det(\mathbf{v} \mathbf{v}_2) - \det(\mathbf{v}_0 \mathbf{v}_2)}{\det(\mathbf{v}_1 \mathbf{v}_2)}$$
$$b = -\frac{\det(\mathbf{v} \mathbf{v}_1) - \det(\mathbf{v}_0 \mathbf{v}_1)}{\det(\mathbf{v}_1 \mathbf{v}_2)},$$

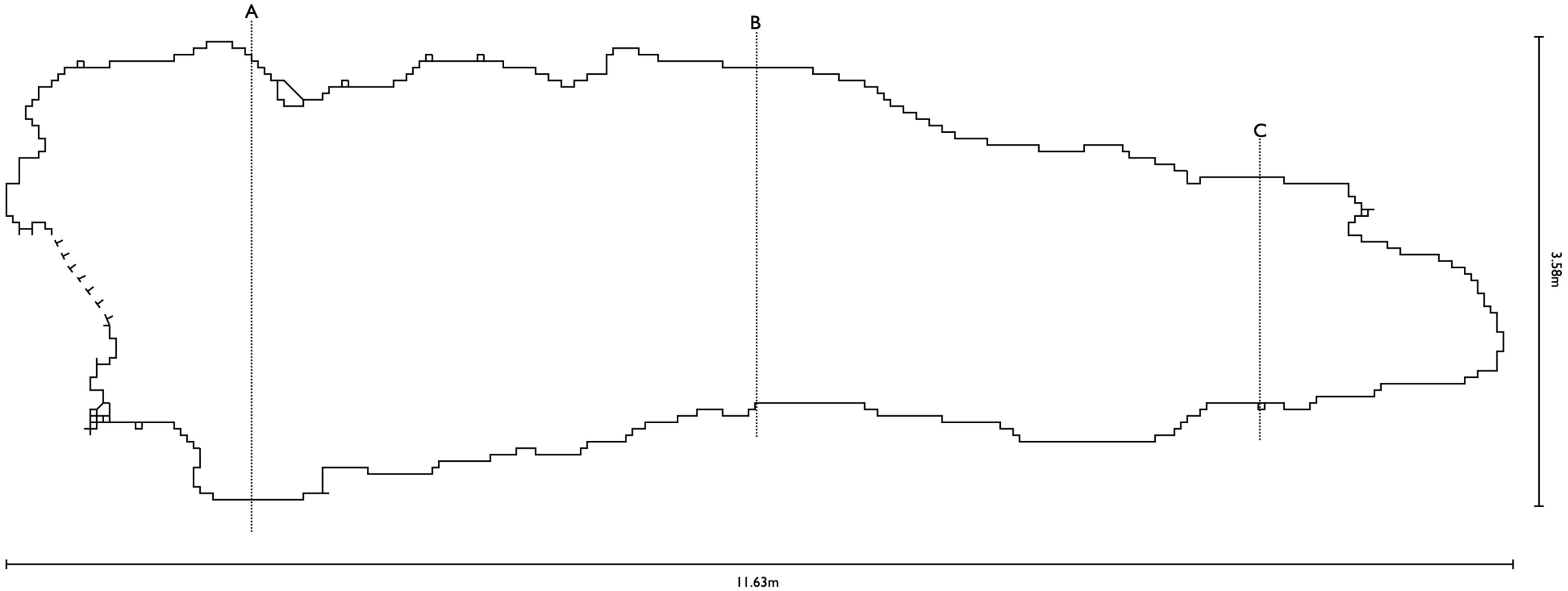
where

$$\det(\mathbf{u} \mathbf{v}) = \mathbf{u} \times \mathbf{v} = u_x v_y - u_y v_x$$

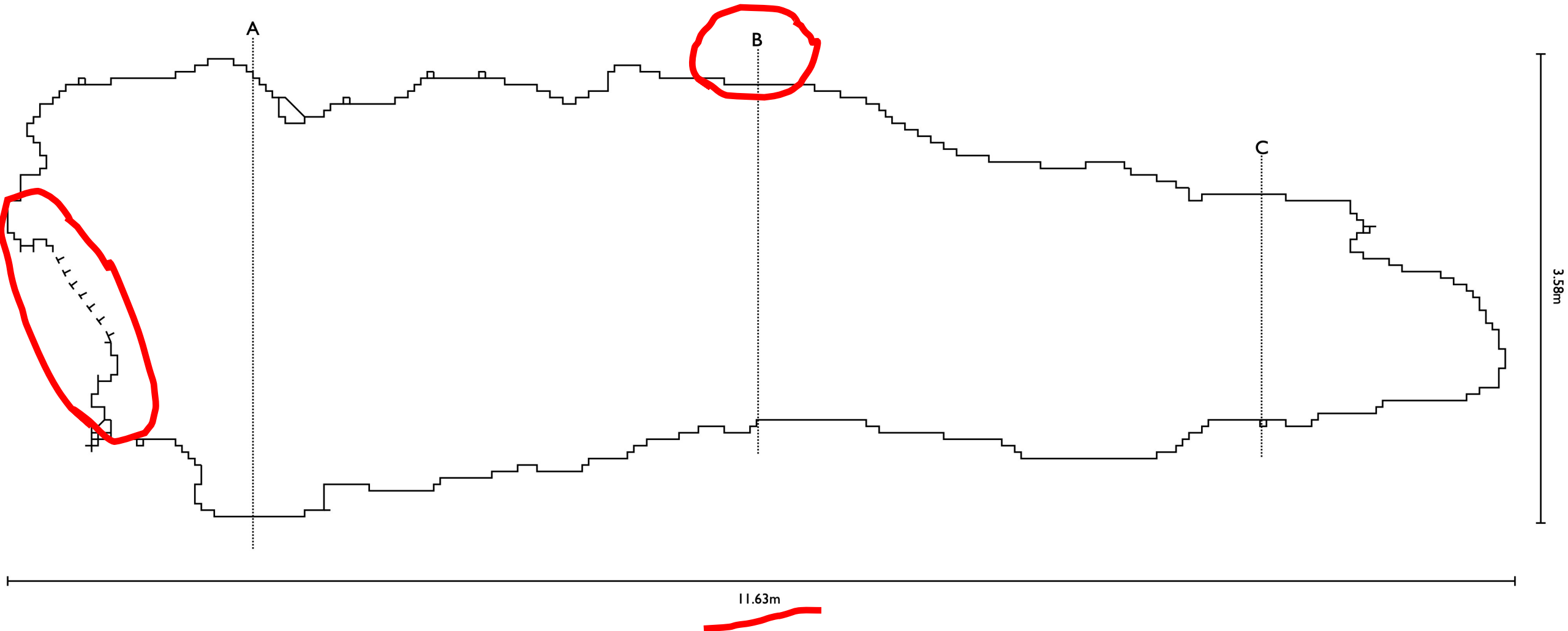
Here entrance is from the left

- But could be to any direction
- Including down... also up?
- Holes in roof are different!

Example plan view

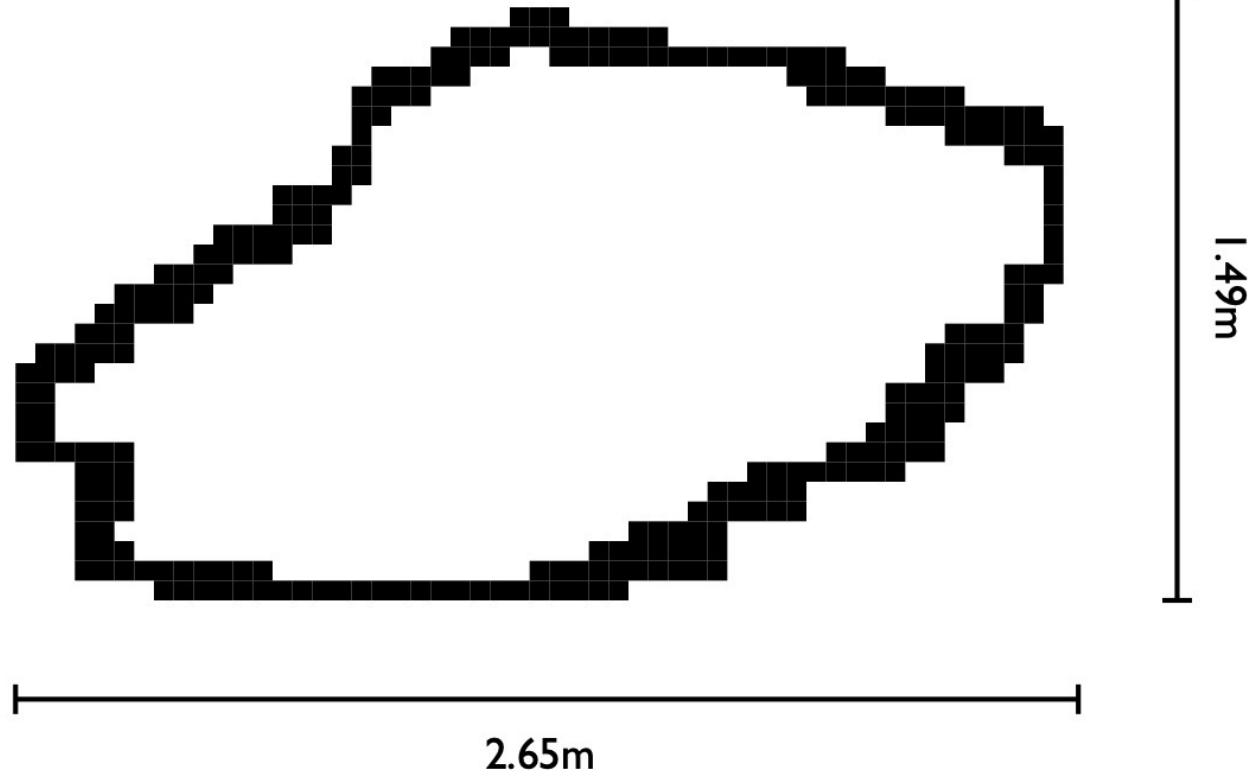


Example plan view



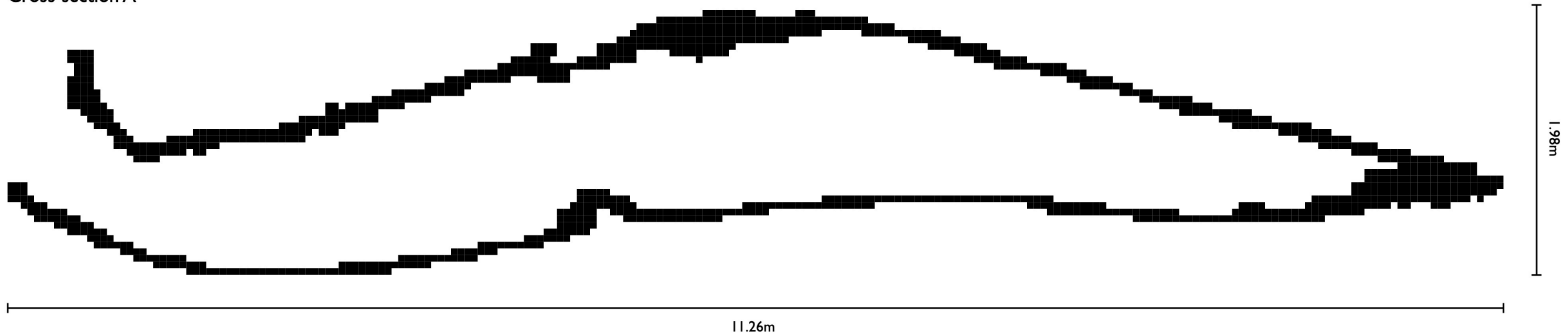
Example cross section view

Cross-section B



Longitudinal cross-section

Cross-section A



Machine-learning

- Work in progress
- Feeding 2D images (e.g., depthmaps as here)
- Or feeding 3D models (expensive and hard)
- Likely only bigger features can be recognised

Could perhaps be
recognised as rocks?

