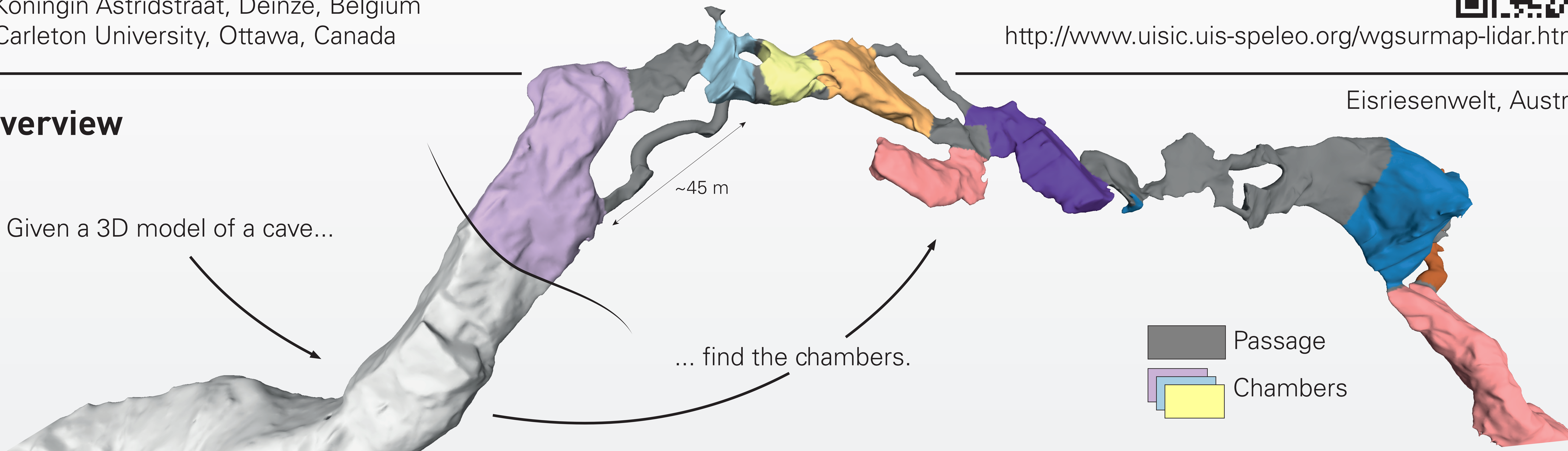
Deterministically Defining Chambers in 3D-Scans of Caves

Nico Schertler[1], Manfred Buchroithner[1], Donald McFarlane[2], Guy van Rentergem[3], Joyce Lundberg[4], Stefan Gumhold[1]

[1] TU Dresden, Germany
[2] Keck Science Center, The Claremont Colleges, California, USA
[3] Koningin Astridstraat, Deinze, Belgium
[4] Carleton University, Ottawa, Canada

http://www.uisic.uis-speleo.org/wgsurmap-lidar.html

Overview



Eisriesenwelt, Austria

Introduction

Laser scanners allow highly detailed acquisition of a cave's geometry, which can be used for accurate size calculation. However, chambers must be identified manually, making the resulting chamber sizes strongly subjective. Obviously, such subjective measures cannot be used for objective comparison of chambers.

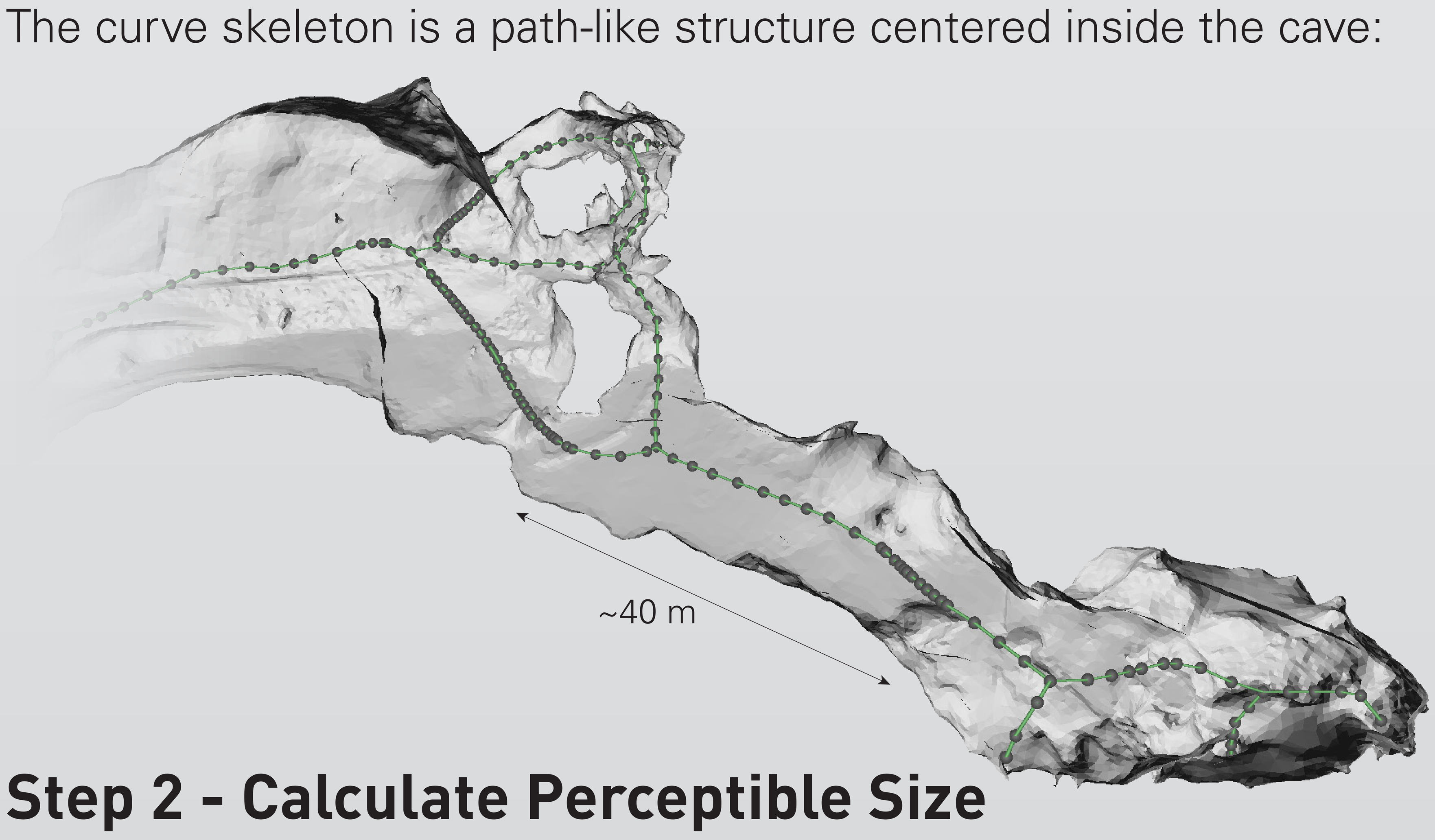
We present an algorithm that overcomes this subjective step by automatically detecting chambers in a 3D model of a cave. Creating such 3D models from a laser scanning survey is straight-forward once the individual scans have been brought into a common coordinate system and most scanning software packages even provide functionality to export 3D models.

Our algorithm takes such a 3D model and marks every point on the surface as belonging either to a passage or to a chamber.

Step 1 - Extract Curve Skeleton

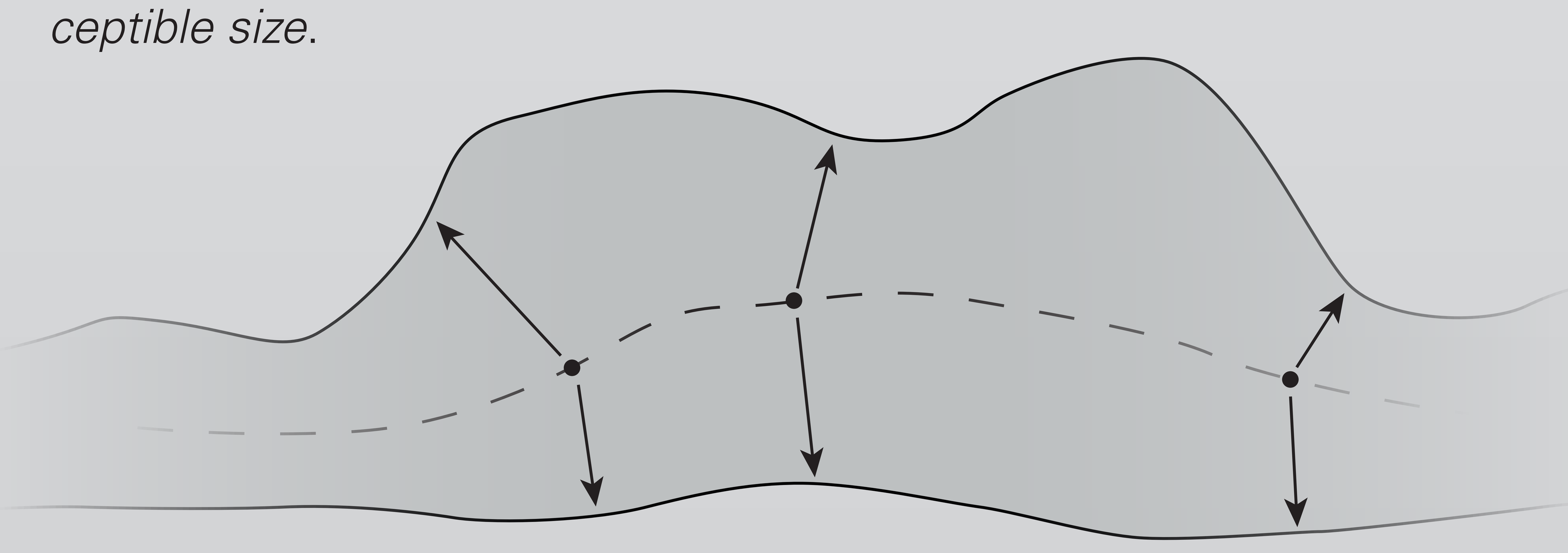
Instead of labeling the surface directly, our algorithm calculates a curve skeleton inside the cave, labels its nodes, and projects the labels back onto the surface.

The curve skeleton is a path-like structure centered inside the cave:



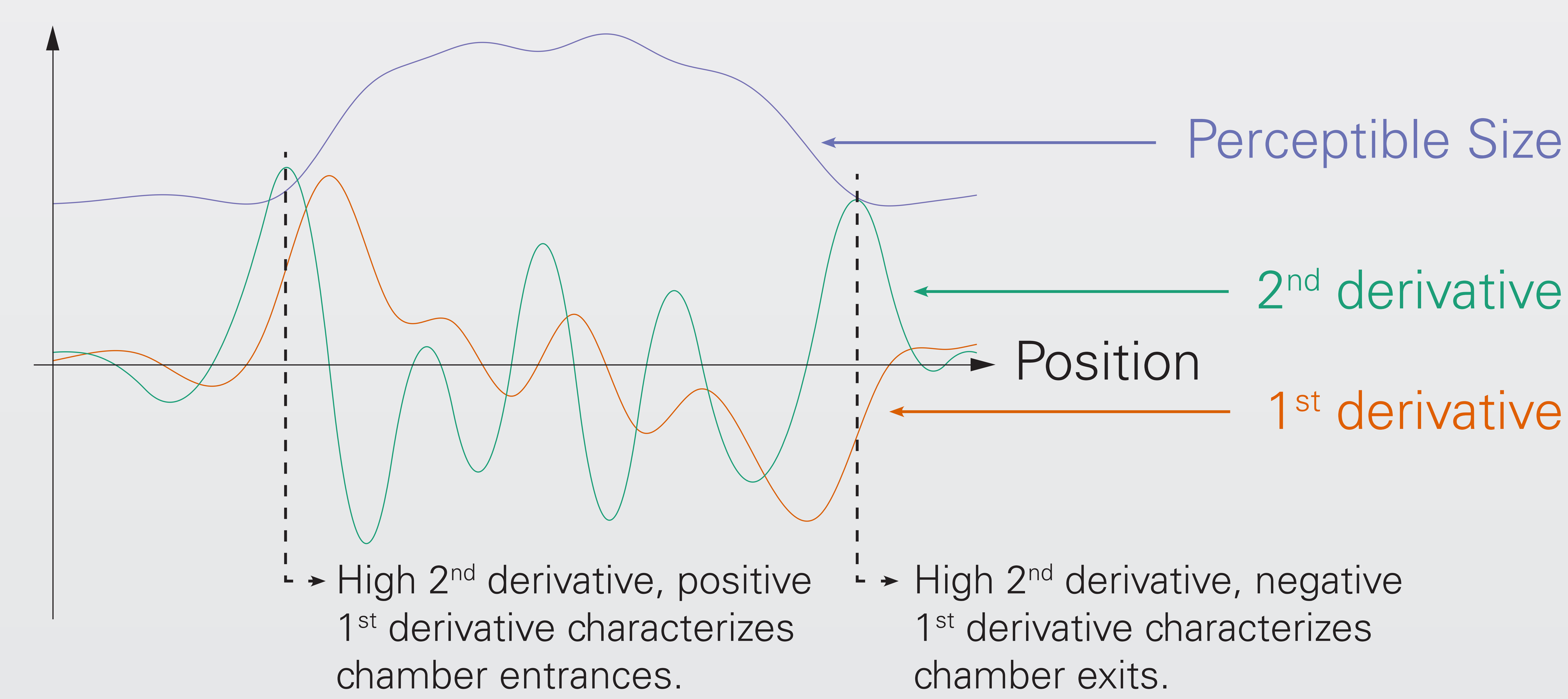
Step 2 - Calculate Perceptible Size

The algorithm then calculates a local size measure for every point of the curve skeleton. This is a radius-like measure and we call it the *Perceptible size*.



Step 3 - Derive Characteristics

Our algorithm derives local characteristics by differentiating the perceptible size twice with respect to the position on the skeleton.



Step 4 - Segment the Skeleton

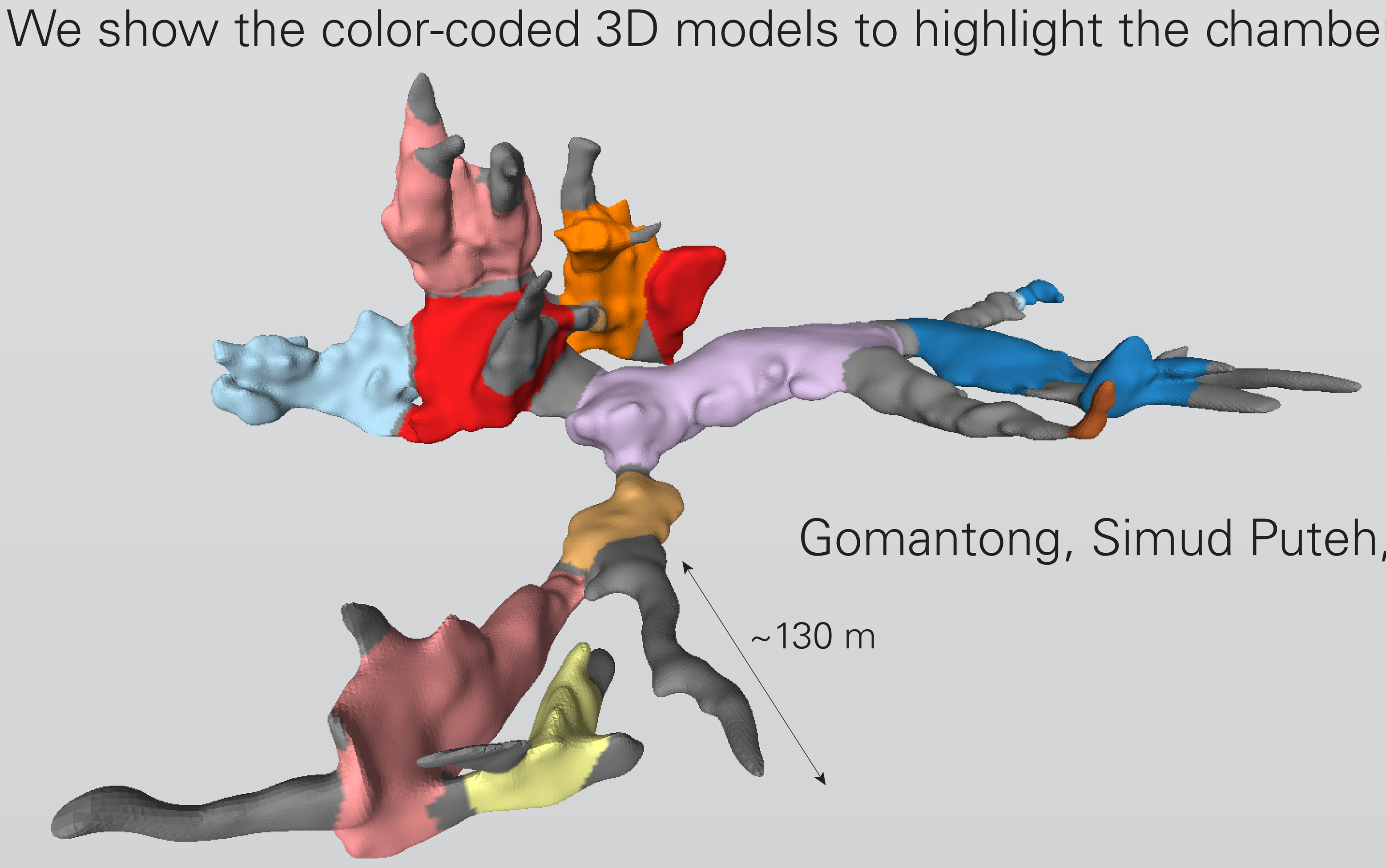
Using the derived characteristics, we calculate probabilities for every edge in the skeleton for each of the four possible label combinations of the incident nodes (passage-to-passage, passage-to-chamber, chamber-to-passage, chamber-to-chamber). E.g., if there is a high second derivative and a positive first derivative on an edge, the edge's probability of being a passage-chamber transition is very high, whereas all other transitions have a low probability.

This probabilistic model allows us to calculate the overall probability of any labeling given the cave characteristics by multiplying the individual edge probabilities. We find the node labels that result in the highest probability and finally project these labels back onto the cave surface.

Results

Our results, which we verified against previously-allocated subjective classifications by cavers familiar with our test caves, were found to be highly reliable.

We show the color-coded 3D models to highlight the chambers.



Gomantong, Simud Puteh, Borneo