

# 3D Mapping of Glacier Moulins: Challenges and lessons learned

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## Context & Motivations

- ▶ Deploying robots in the cryosphere is still an open problem [1], and is a crucial source of data collection and analysis, essential for understanding problems such as climate change.
- ▶ Dante was the first robot successfully deployed in a remote hazardous setting, an Alaskan volcano [2], demonstrating feasibility
- ▶ Prior deployments have shown the hazardous conditions surrounding surveys within glaciers [3, 4] and have highlighted the potential of robotic platforms in monitoring changes.

## Experimental platform

- ▶ We designed and developed a measurement platform capable of sustaining significant forces caused by various extreme motions and collisions that can occur in extreme environments.
- ▶ The platform is built to record data from sensors needed to perform localization and mapping using a Raspberry Pi 4B.
- ▶ Data is then post-processed to complete the localization and mapping and evaluate its performances.
- ▶ To ensure no pollution is left on-site if anything breaks, a safety net was installed on the platform, thin enough not to cause any occlusions.

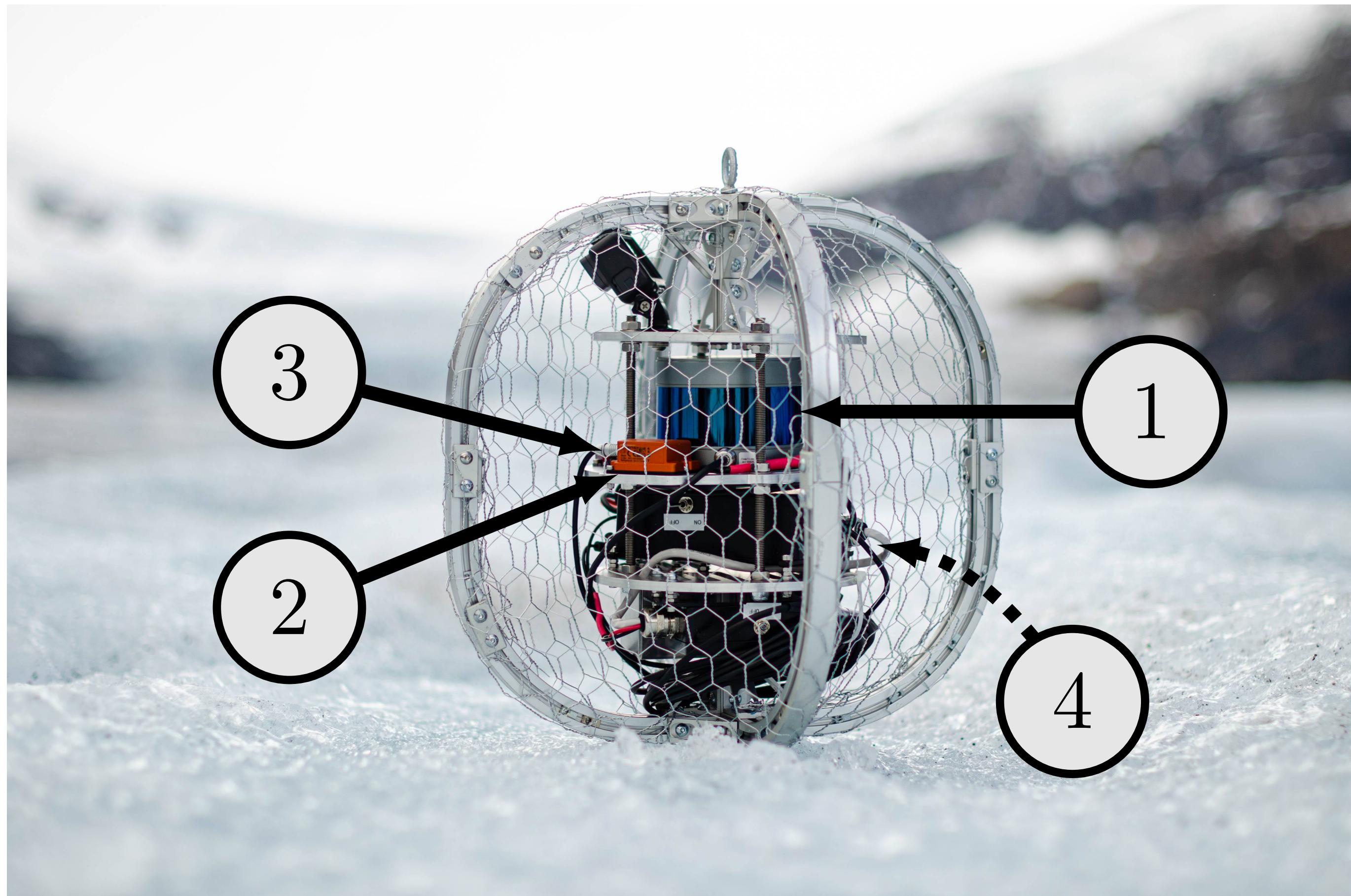


Figure 1: Data gathering platform with which sensor measurements were recorded to perform 3D localization and mapping, equipped with a lidar Robosense RS-16 (1), an Xsens MTi-10 IMU (2), a Vectornav vn100 IMU (3, behind the Xsens MTi-10) and a barometric pressure sensor DPS310 (4, on the other side of the platform).

## Experiments



Figure 2: The experimental platform rolled down a 30 m ice canyon.

### ▶ Ice canyon:

- ▶ Low difficulty experiment.
- ▶ The platform rolled down an ice canyon while recording sensor measurements.
- ▶ Environment with enough constraints and easy access to quickly validate the impact of ice and various factors on the platform.



Figure 3: The experimental platform was lowered in a glacial moulin, mapping its surroundings.

### ▶ Glacial moulin:

- ▶ Low feature environment.
- ▶ The platform is initially lowered down the moulin while recording sensor measurements.
- ▶ Ultimately, the platform was thrown in the moulin to record measurements through extreme motions such as free fall.

## Challenges and lessons learned

- ▶ **Extreme environments** lead to:
  - ▶ erratic weather conditions necessitating rugged equipment and dedicated specialized equipments,
  - ▶ stringent safety measures and extreme conditions that add additional stress on your body and mind.
- ▶ **Preparation** is key:
  - ▶ thorough and tested experimental and validation procedure are necessary,
  - ▶ spare equipment is crucial, everything that can break will break.

## Results

- ▶ Lidar and IMU measurements enabled us to compute 3D mapping and localization of the experimental platform throughout its slow descent in the moulin.
- ▶ Experiments were conclusive, but only low quality maps were obtainable.

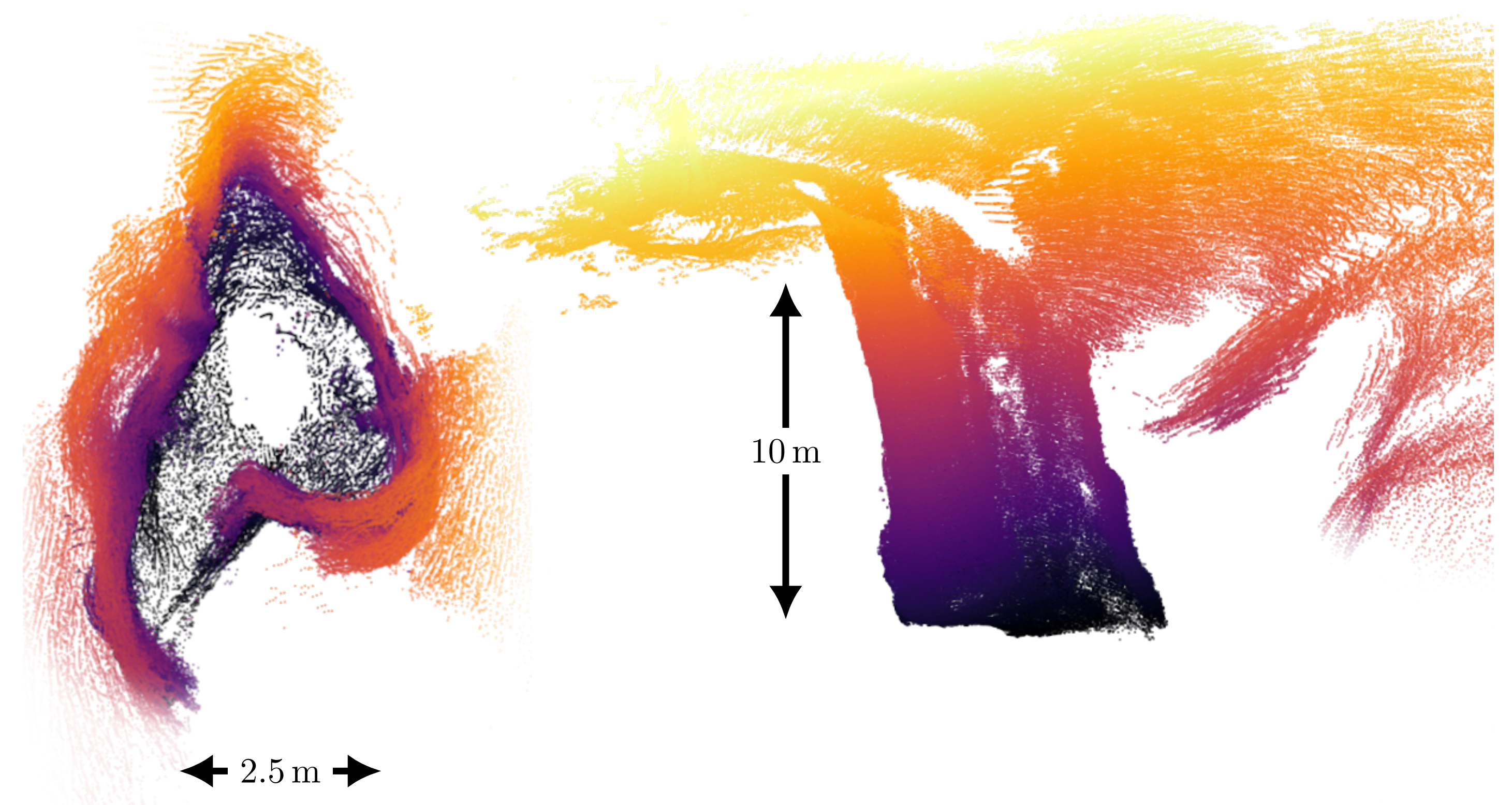


Figure 4: Map result (colored by elevation) from the moulin experiment. Left: top view; Right: Side view. The lack of features in the moulin makes the mapping of such environments challenging.

- ▶ Lack of features led to:
  - ▶ under-constrained and degraded registration solutions,
  - ▶ lower quality maps,
  - ▶ lower quality information about the surveyed environment.
- ▶ Addition of barometric pressure information can help gain constraints.

## Future works

- ▶ **Increase mapping performances and robustness** through fusion of information from several sensors, including atmospheric pressure.
- ▶ **Sensor fusion** will enable the recovery of constraints lost from the lack of features.
- ▶ **Improvement of the experimental platform** to increase its robustness and enable more experiments.

## Acknowledgments and References

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