

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.

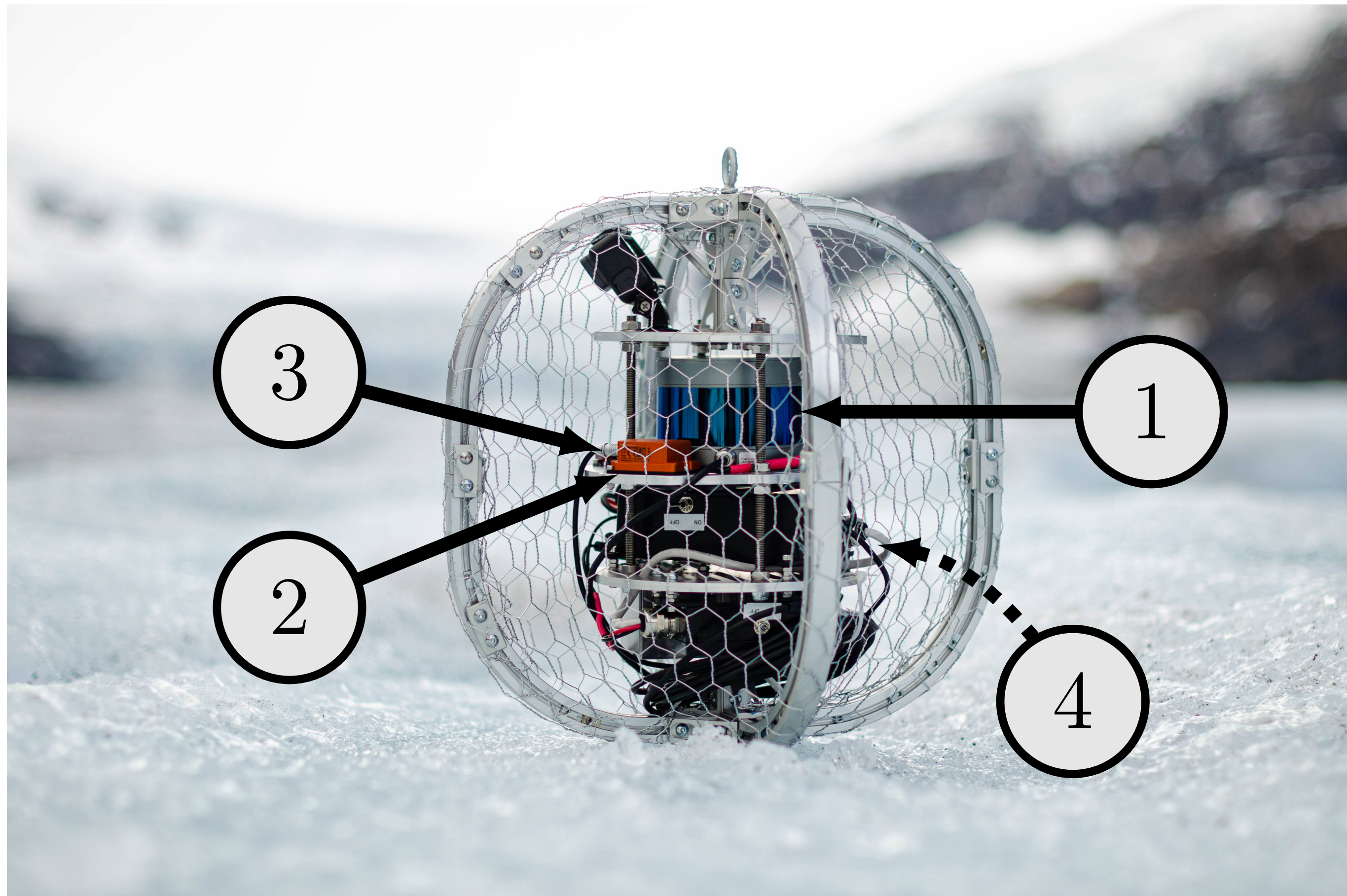


Figure 1: Data gathering platform with which sensor measurements were recorded to perform 3D localization and mapping, equipped with a lidar Robosense RS-16 (1), an Xsens MTi-10 IMU (2), a Vectorsnav vn100 IMU (3, behind the Xsens MTi-10) and a barometric pressure sensor DPS310 (4, on the other side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

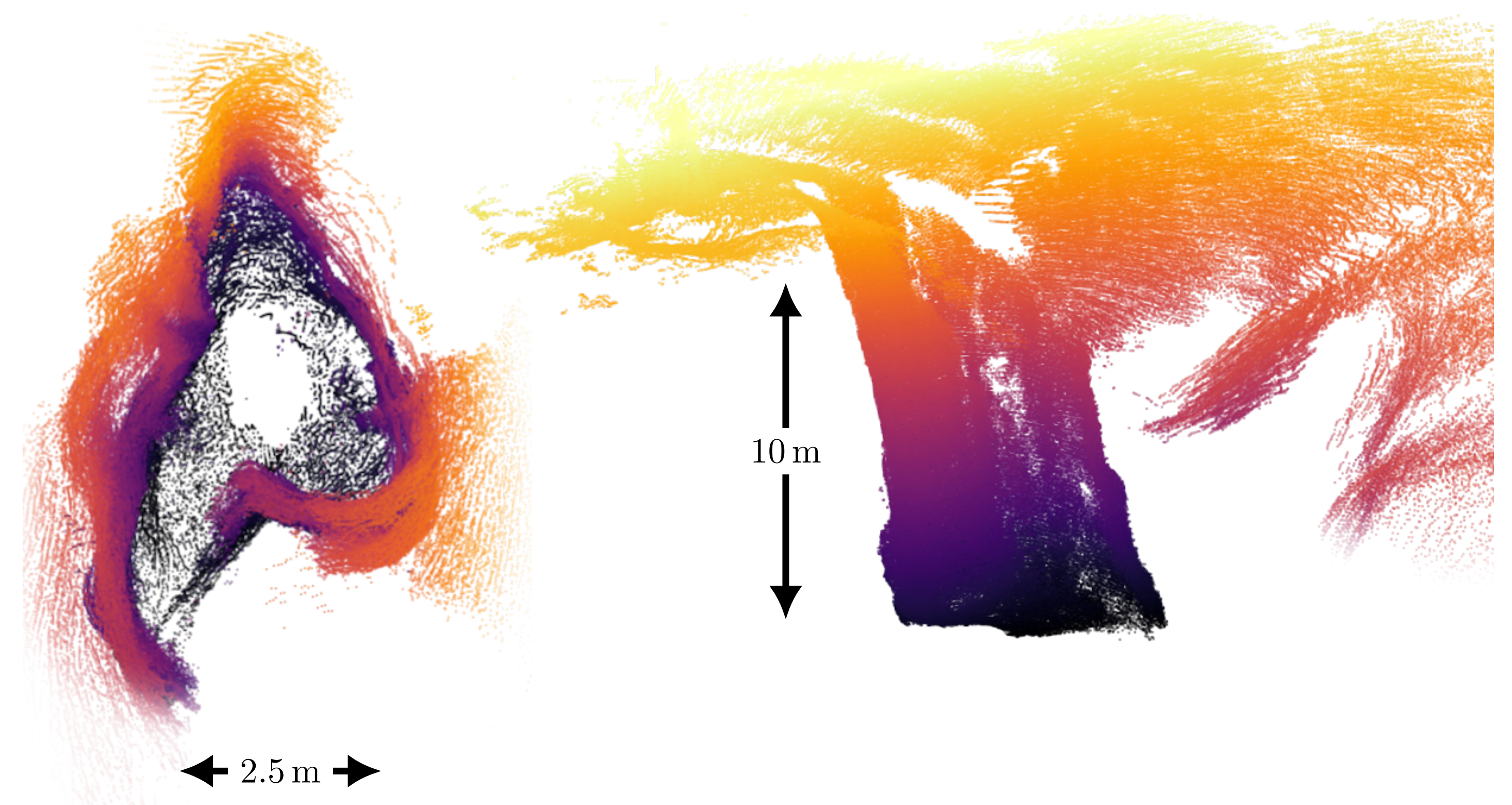


Figure 4: Map result (colored by elevation) from the moulin experiment. Left: top view; Right: Side view. The lack of features in the moulin makes the mapping of such environments challenging.

- ▶ 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.
- ▶ **Improvement of the experimental platform** to increase its robustness and versatility.

Acknowledgments and References

This research was supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) through the General Research Fund (GRF) from Université Laval.

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