

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
- ▶ item

Experimental platform

- ▶ We designed and developed a measurement platform capable of sustaining significant force 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 for it not to cause any occlusions.

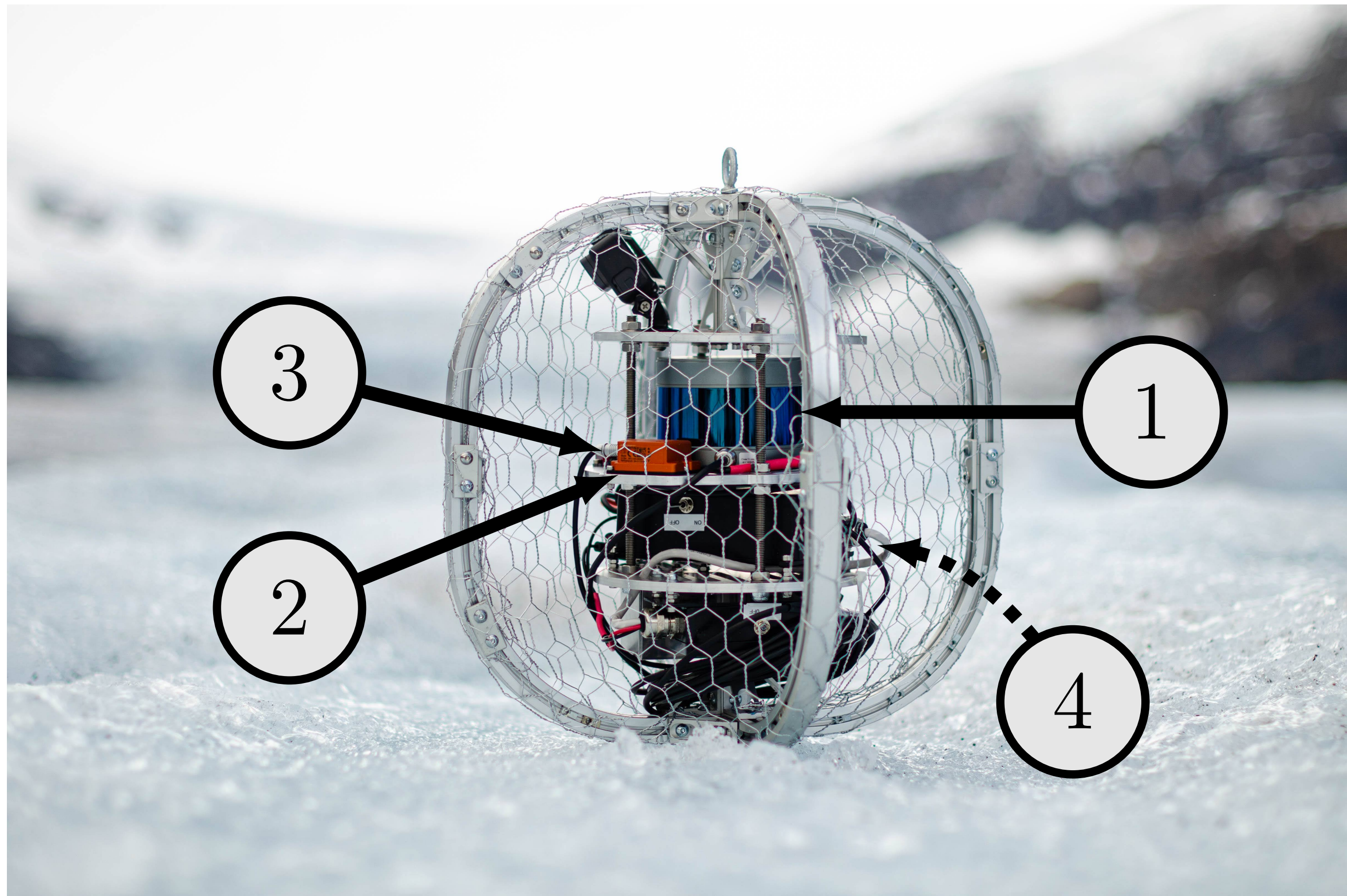


Figure 1: Data gathering platform with which sensor measurements were recorded to perform 3D localization and mapping, equipped with a lidar Robosense RS-16 (1), an Xsens MTi-10 IMU (2), a Vectorsnav vn100 IMU (3, behind the Xsens MTi-10) and a barometric pressure sensor DPS310 (4, on the other side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

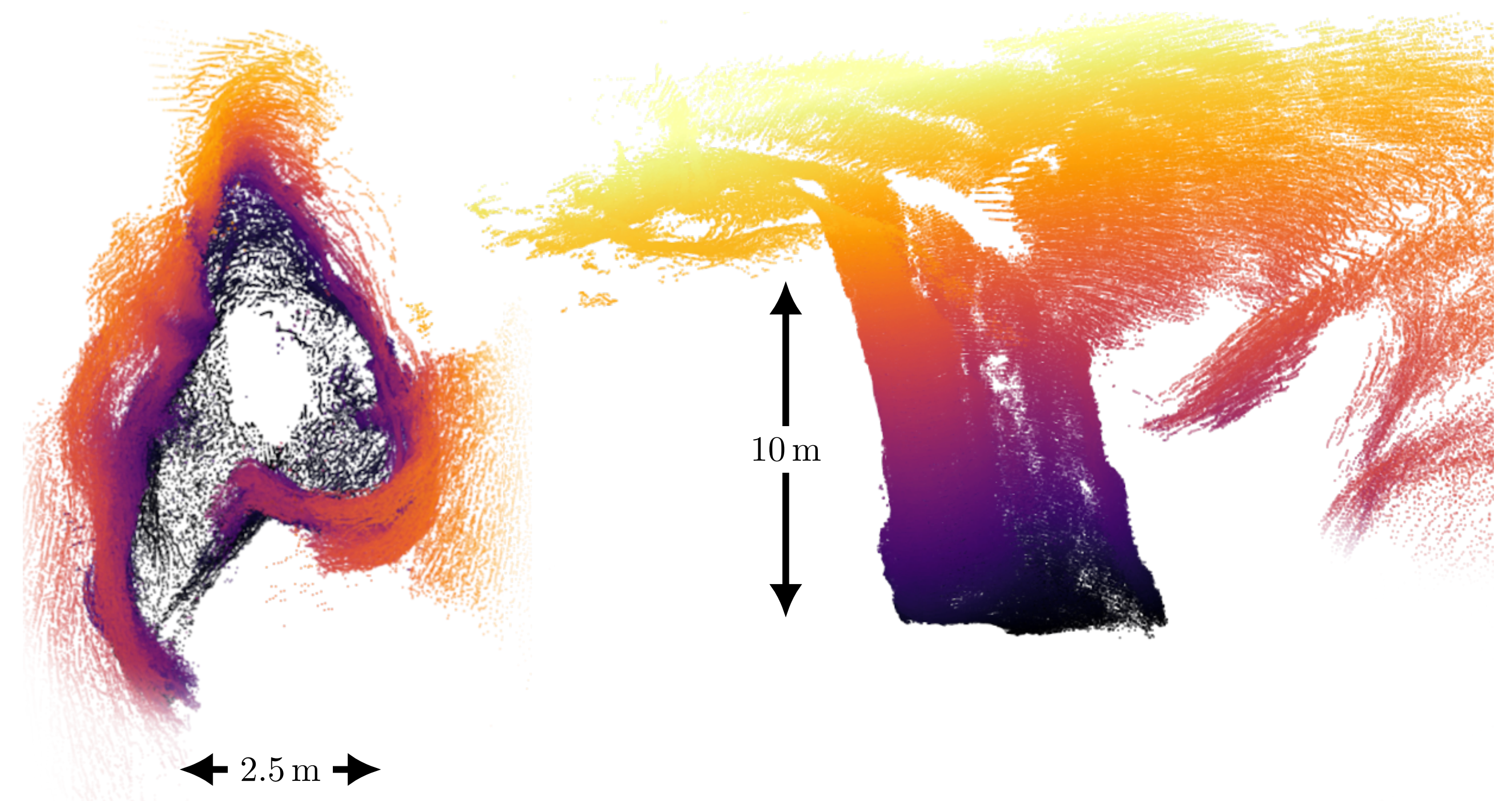


Figure 4: Map result (colored by elevation) from the moulin experiment. Left: top view; Right: Side view. The lack of features in the moulin makes the mapping of such environments challenging.

- ▶ 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 helps 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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