

DENSE RELATIVE MAPPING

A novel approach to dense mapping for autonomous robots

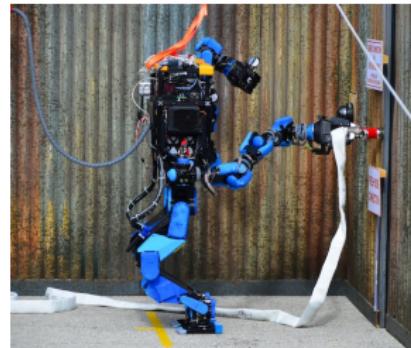
3rd November 2017

Clint D. Lombard
Dr C.E. van Daalen

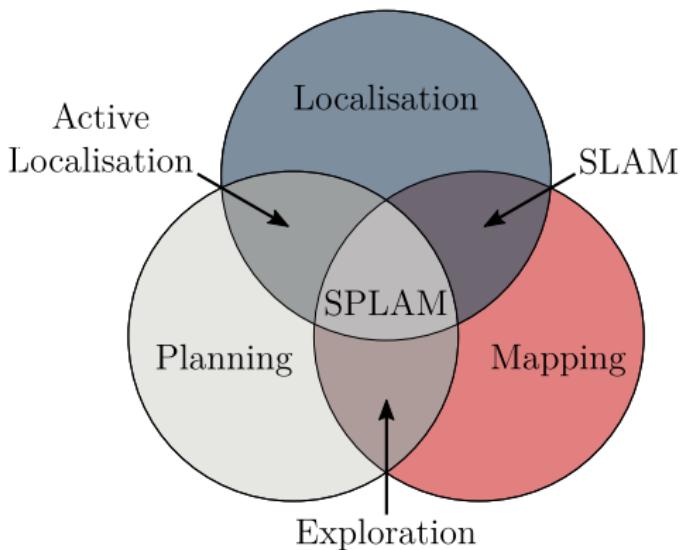
Electronic Systems Laboratory
Department of Electrical and Electronic Engineering, Stellenbosch University

BACKGROUND

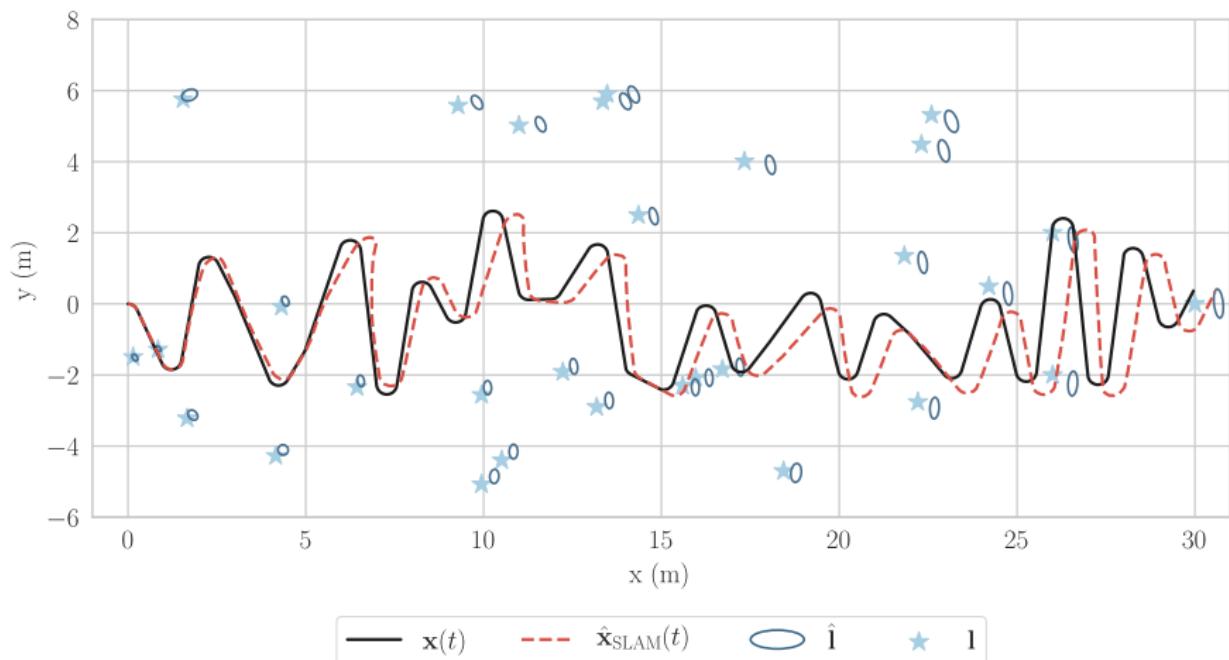
AUTONOMOUS ROBOTS



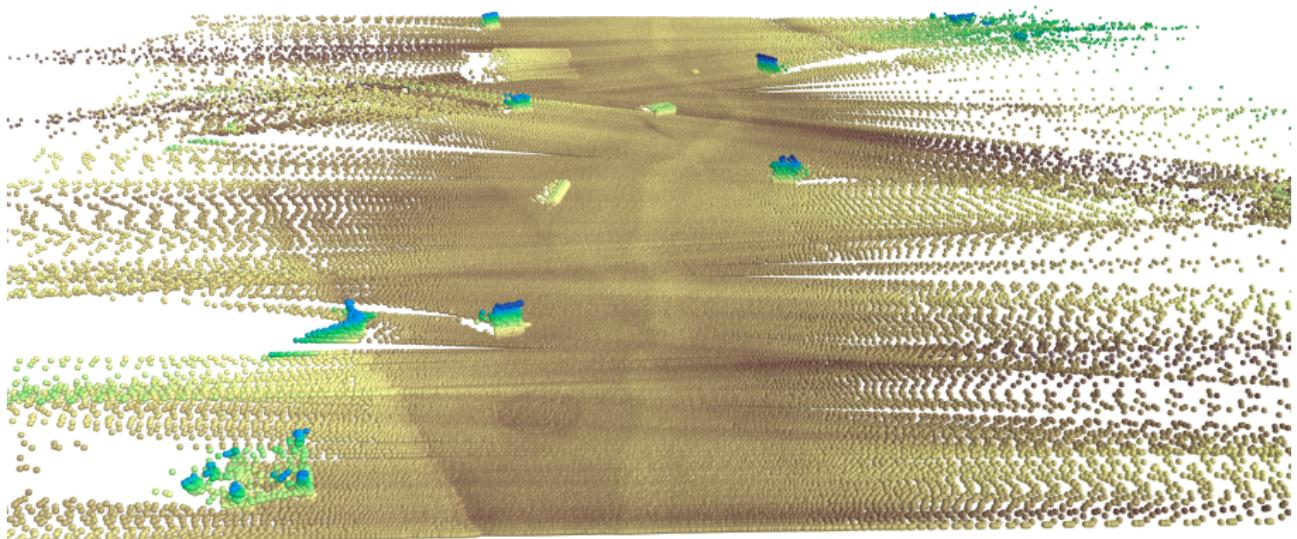
BUILDING BLOCKS OF AUTONOMOUS NAVIGATION



SPARSE LANDMARK MAPPING

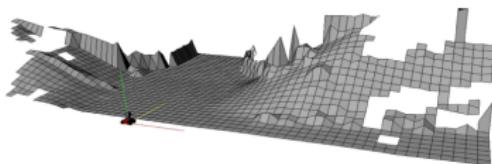


DENSE MAPPING

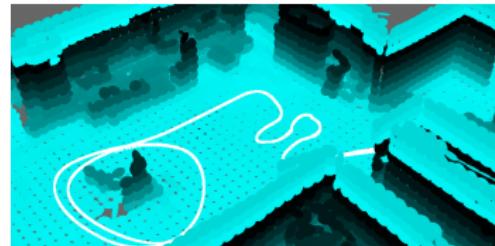


→ Raw dense measurements: 1.5 million points per minute

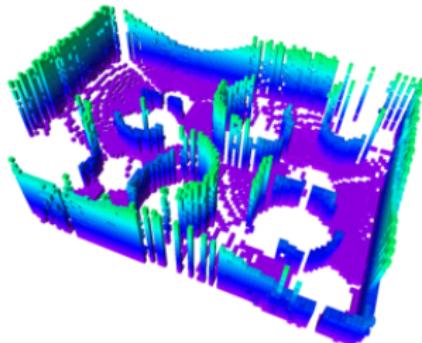
EXISTING DENSE MAPPING MODELS



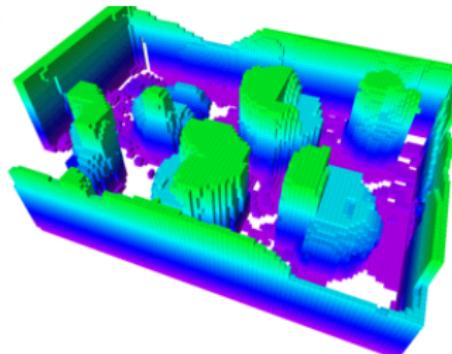
Elevation
(Pfaff et al.)



Normal Distribution Transform
(Saarinen et al.)



Occupancy grid
(Wang and Englot)



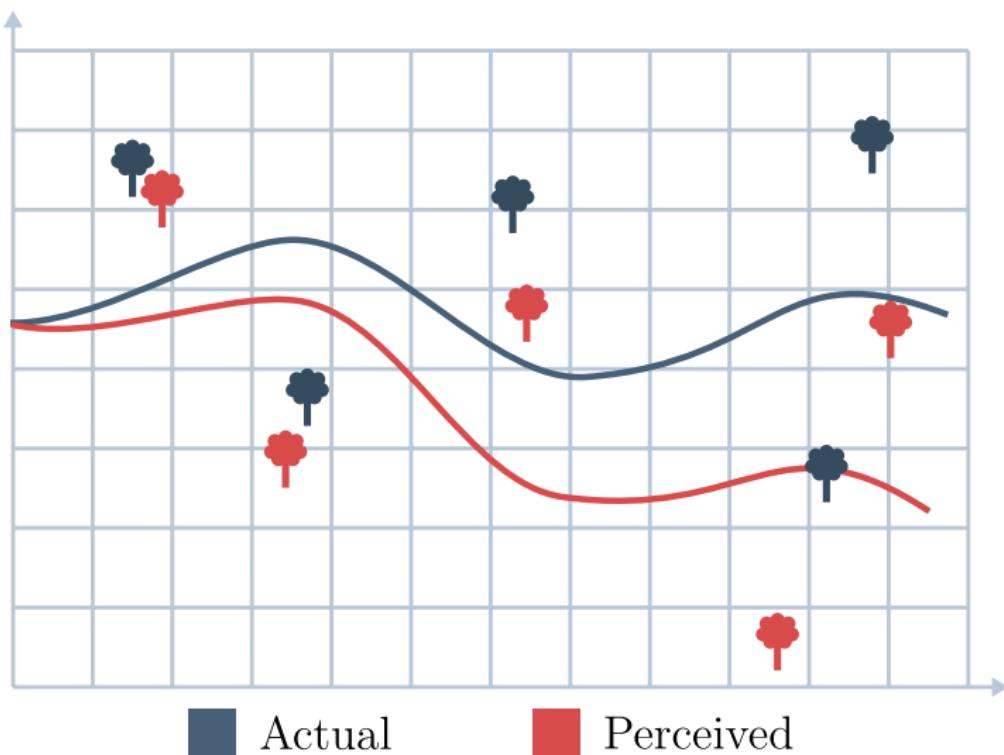
Gaussian process
(Wang and Englot)

CURRENT PROBLEMS IN DENSE MAPPING

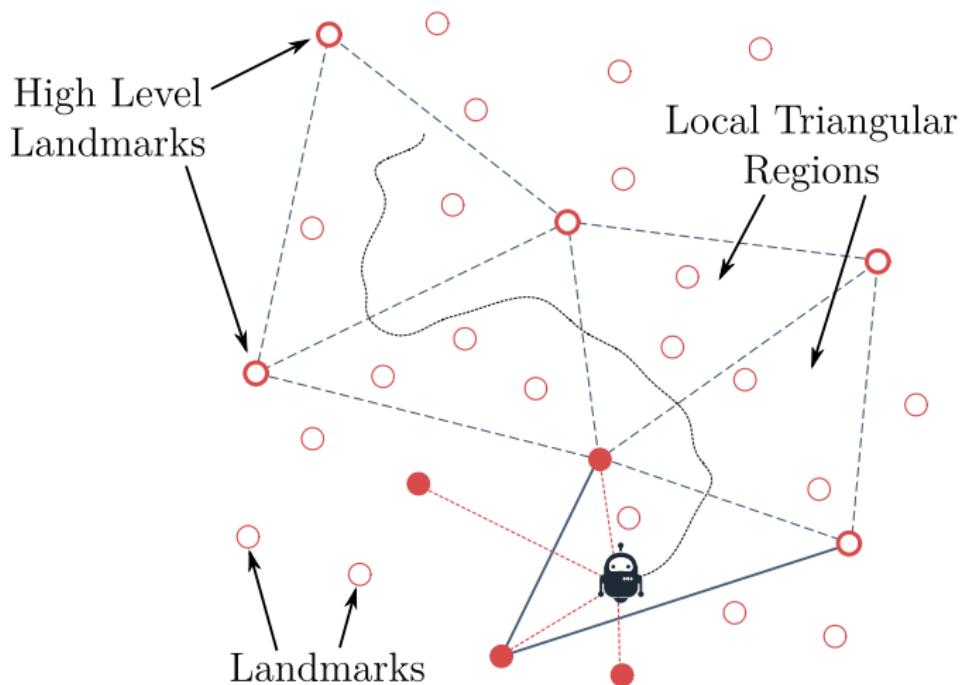
- Statistical independence assumption between mapping elements.
- The uncertainty in the robot pose is ignored in most cases.
- Mapping in a single inertial reference frame.
- Inability to deform maps.

RELATIVE COORDINATES

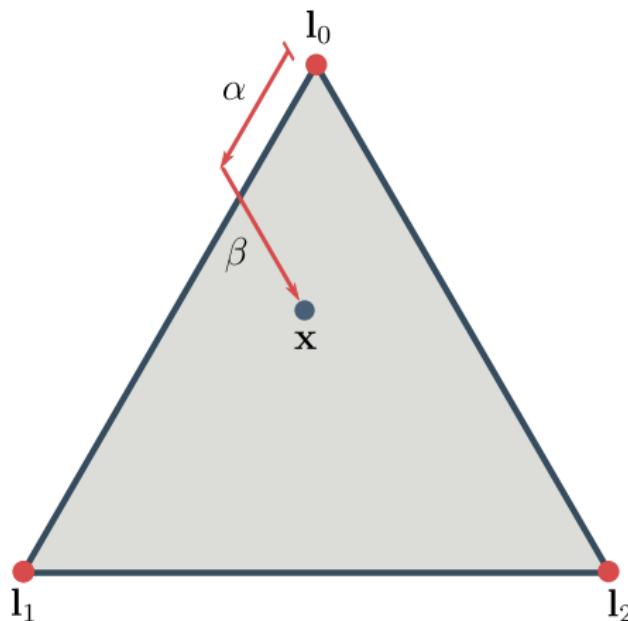
PROBLEMS WITH A SINGLE INERTIAL REFERENCE FRAME



HYBRID METRIC MAP FRAMEWORK

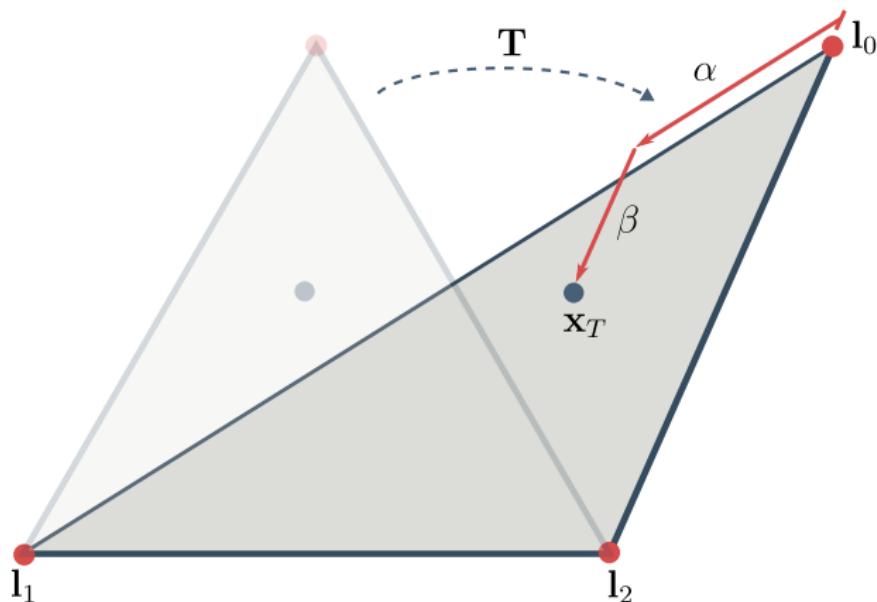


2D RELATIVE COORDINATES



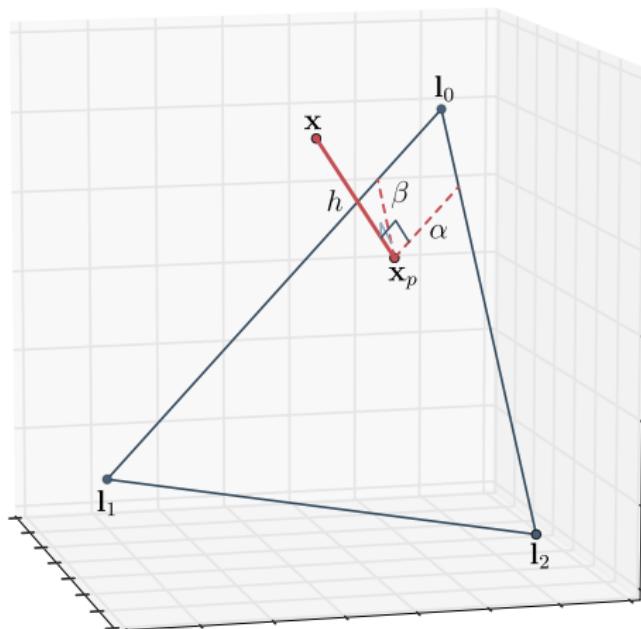
$$\mathbf{x} = \alpha(\mathbf{l}_1 - \mathbf{l}_0) + \beta(\mathbf{l}_2 - \mathbf{l}_0) + \mathbf{l}_0$$

2D RELATIVE COORDINATES



$$\mathbf{x} = \alpha(\mathbf{l}_1 - \mathbf{l}_0) + \beta(\mathbf{l}_2 - \mathbf{l}_0) + \mathbf{l}_0$$

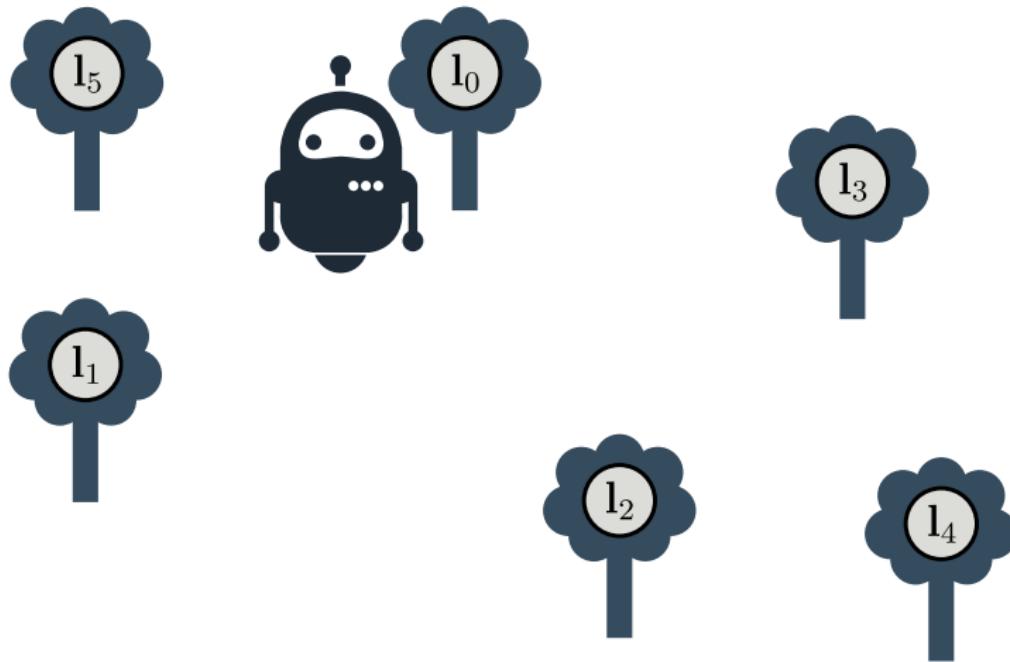
3D RELATIVE COORDINATES



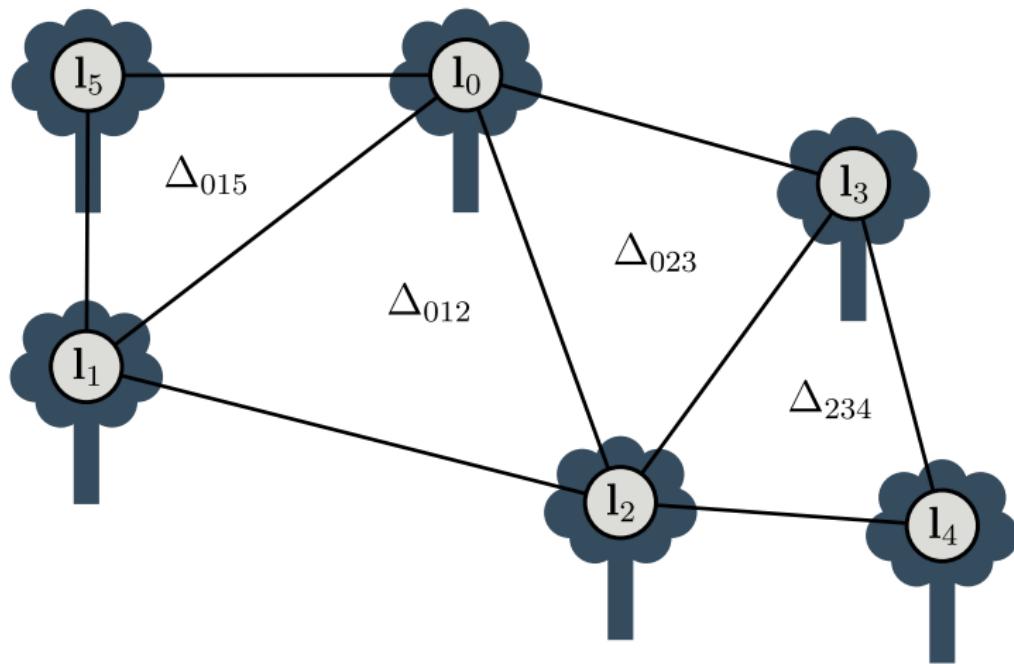
$$\mathbf{x} = \mathbf{x}_p + h \cdot \mathbf{n}$$

PROPOSED MAPPING FRAMEWORK

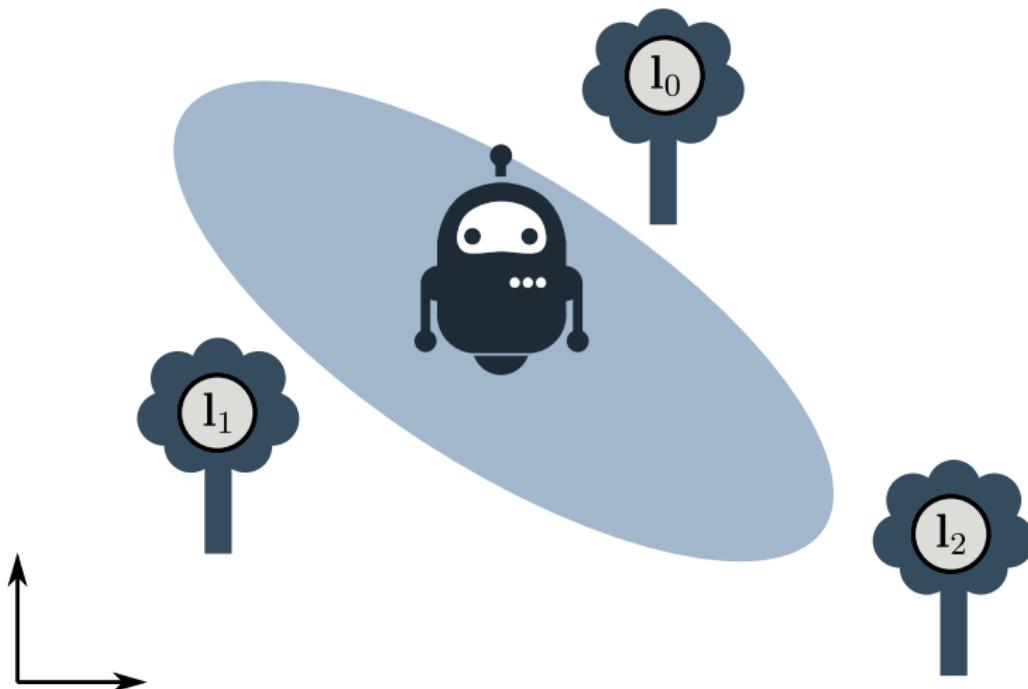
SUB-DIVIDING THE ENVIRONMENT



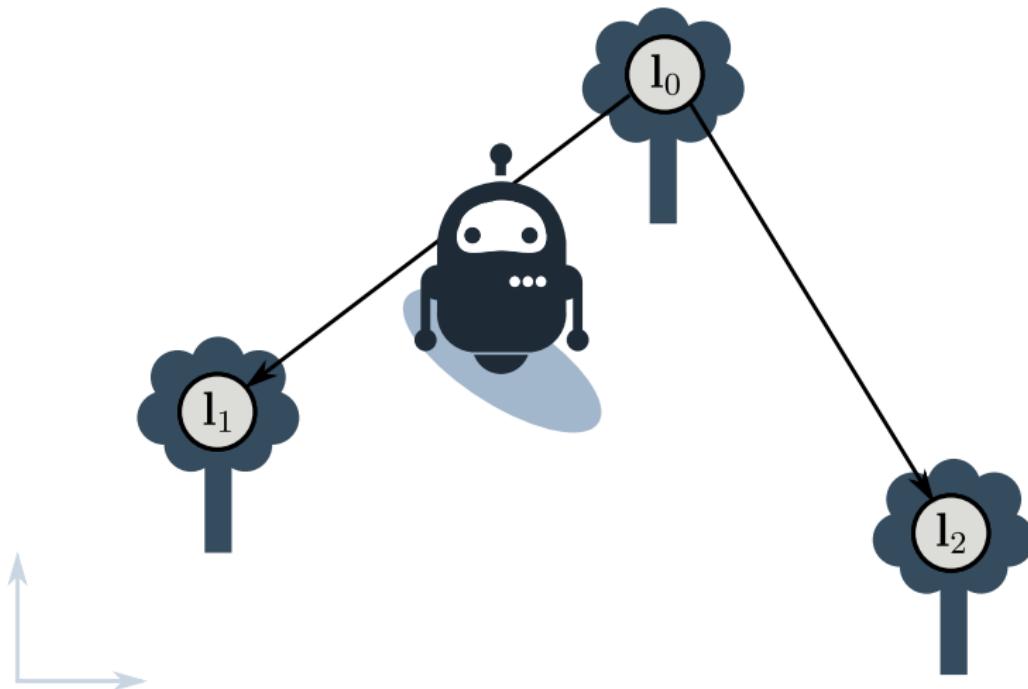
SUB-DIVIDING THE ENVIRONMENT



PROBABILISTIC POSE DECOUPLING



PROBABILISTIC POSE DECOUPLING



Background
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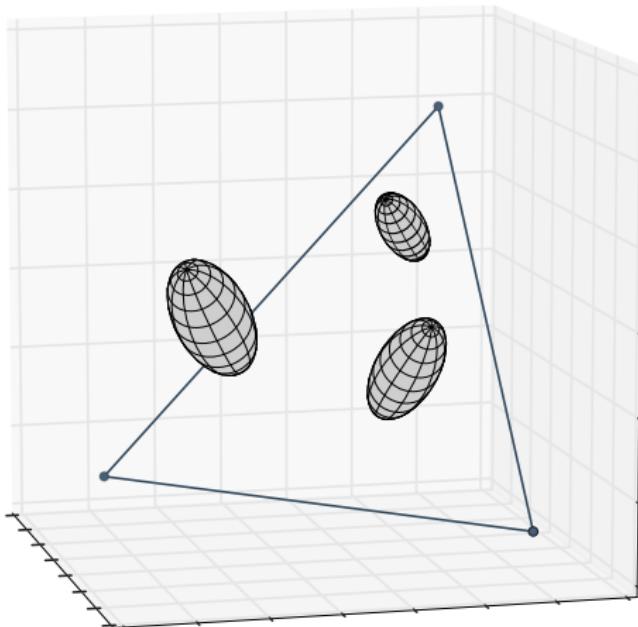
Relative Coordinates
oooo

Proposed Mapping Framework
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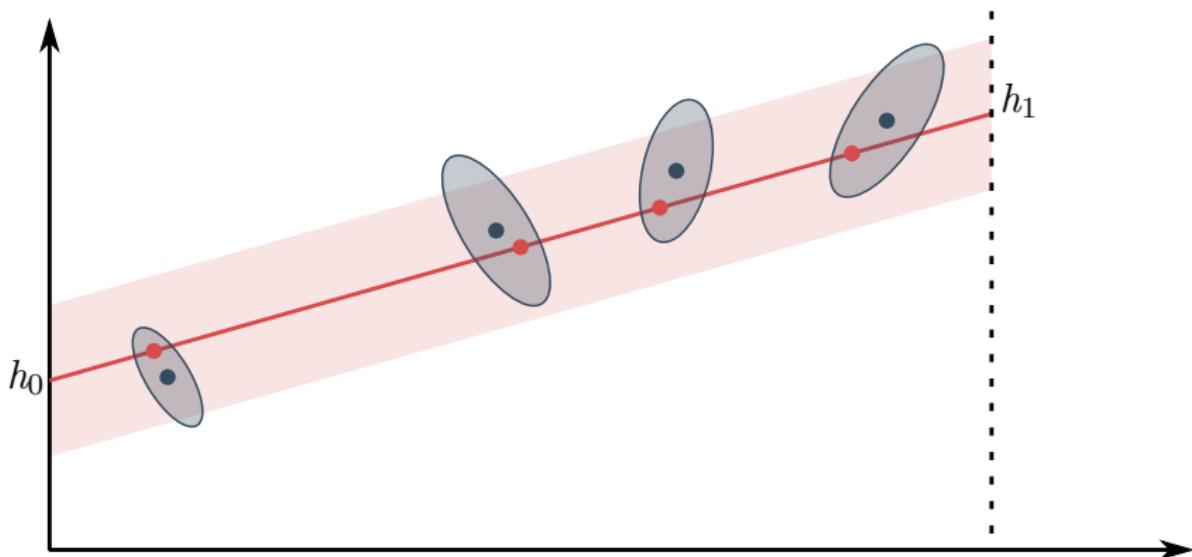
Practical Results
ooo

Questions?

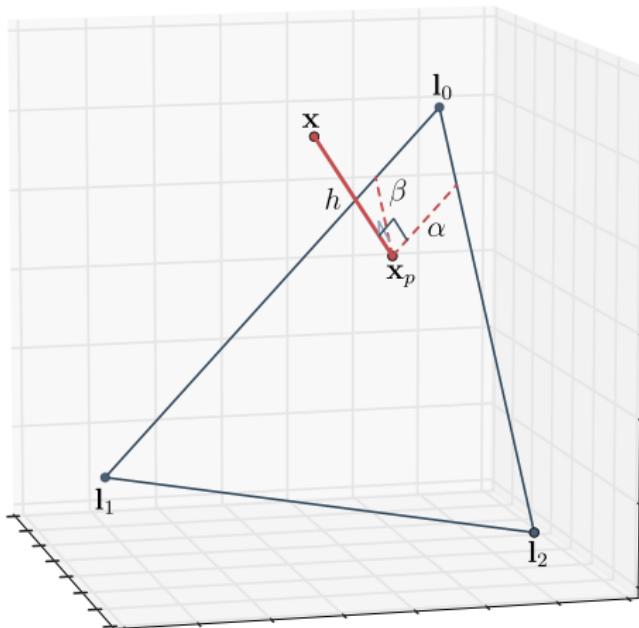
MAP REPRESENTATION



PROBABILISTIC SURFACE MODEL



MAP SUBLIMITS



Background
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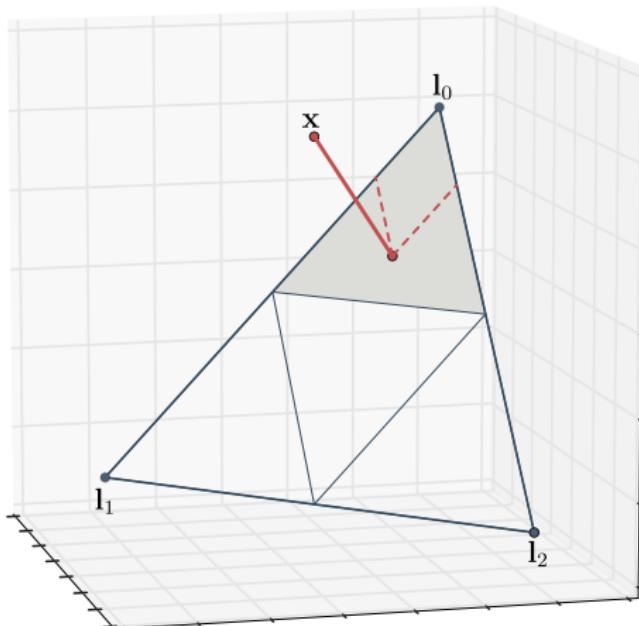
Relative Coordinates
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Proposed Mapping Framework
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Practical Results
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Questions?

MAP SUBELEMENTS



Background
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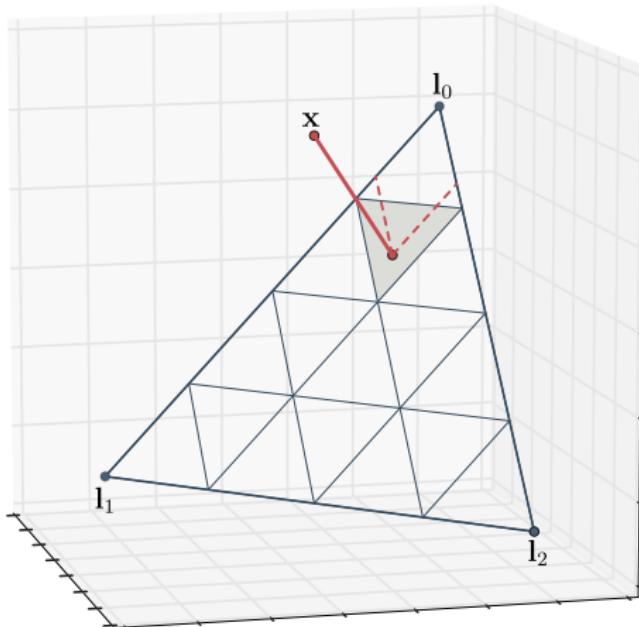
Relative Coordinates
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Proposed Mapping Framework
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Practical Results
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Questions?

MAP SUBELEMENTS



Background
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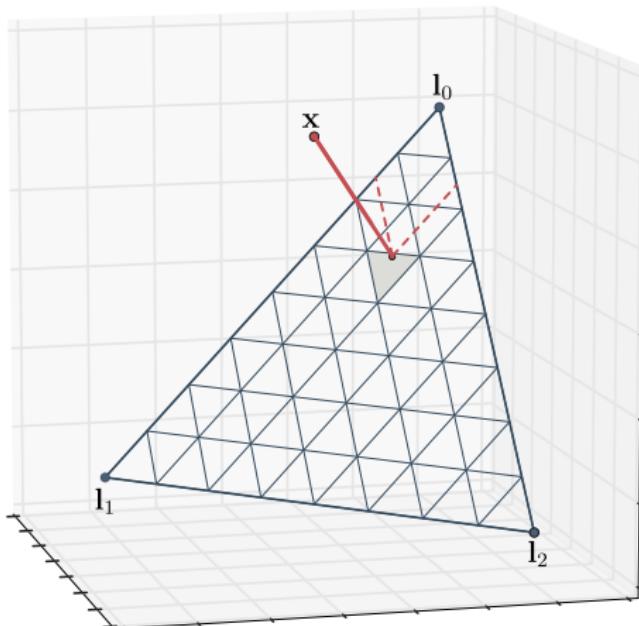
Relative Coordinates
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Proposed Mapping Framework
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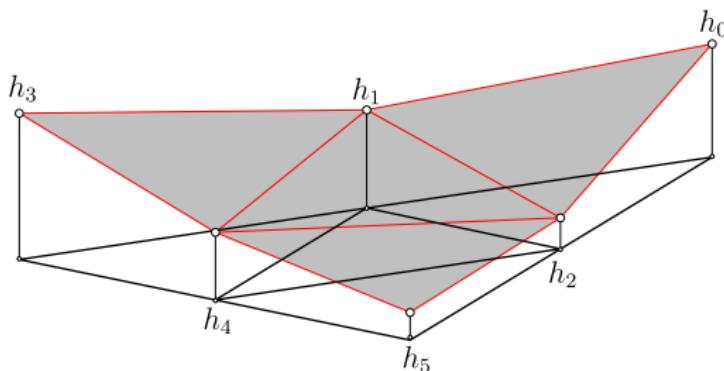
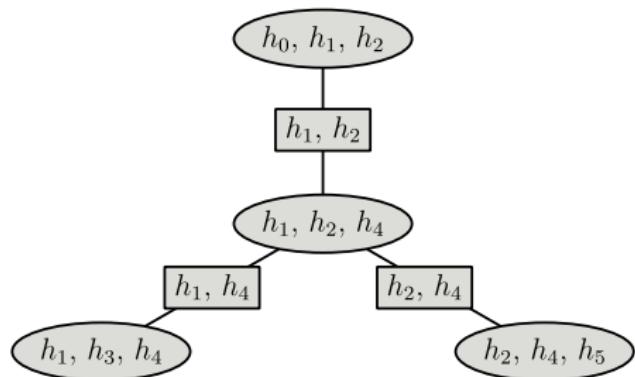
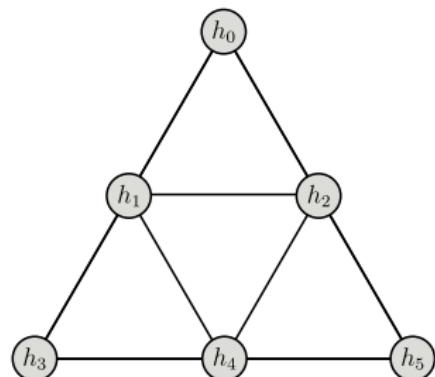
Practical Results
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Questions?

MAP SUBLTELEMENTS



GLOBALLY CONSISTENT MODEL



PRACTICAL RESULTS

Background
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Relative Coordinates
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Proposed Mapping Framework
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Practical Results
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Questions?

PRACTICAL TESTING PLATFORM



Background
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Relative Coordinates
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Proposed Mapping Framework
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Practical Results
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Questions?

PRACTICAL RESULTS



Background
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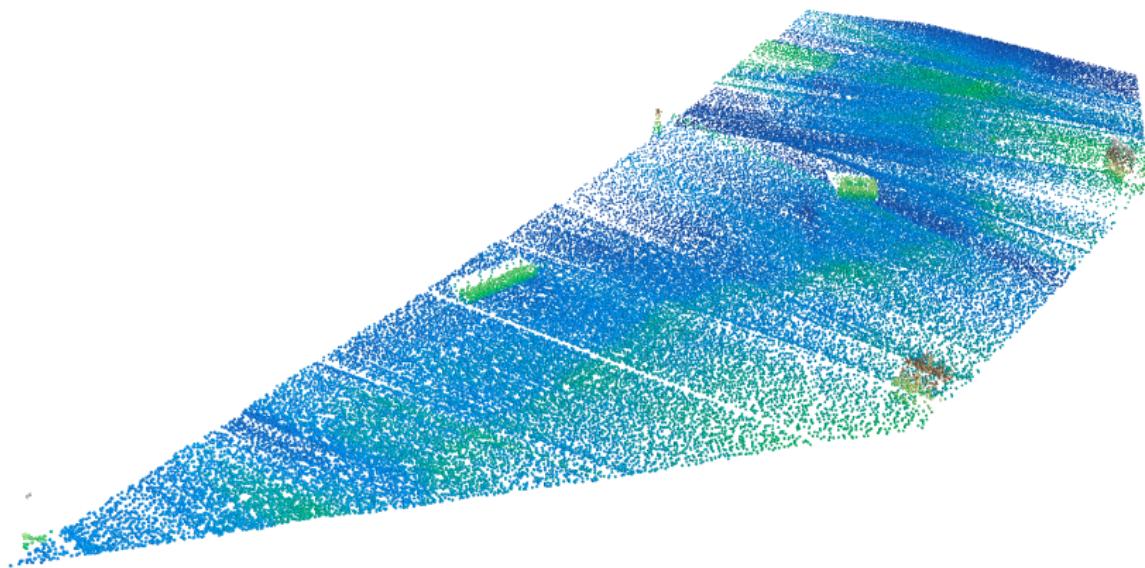
Relative Coordinates
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Proposed Mapping Framework
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Practical Results
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Questions?

PRACTICAL RESULTS



Background
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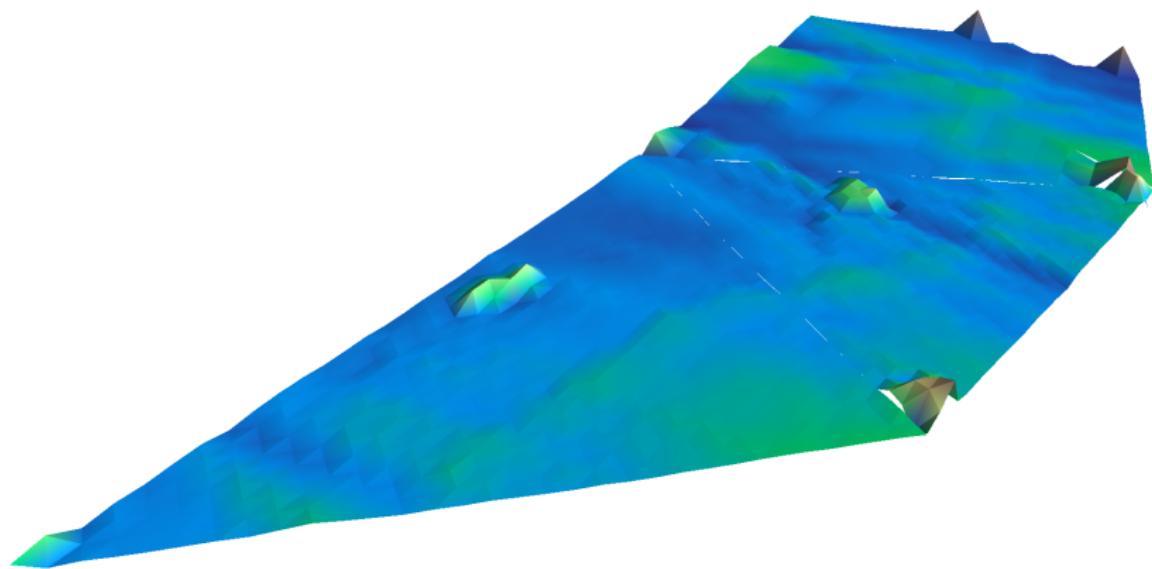
Relative Coordinates
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Proposed Mapping Framework
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Practical Results
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Questions?

PRACTICAL RESULTS



Background
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Relative Coordinates
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Proposed Mapping Framework
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Practical Results
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PRACTICAL RESULTS



Background
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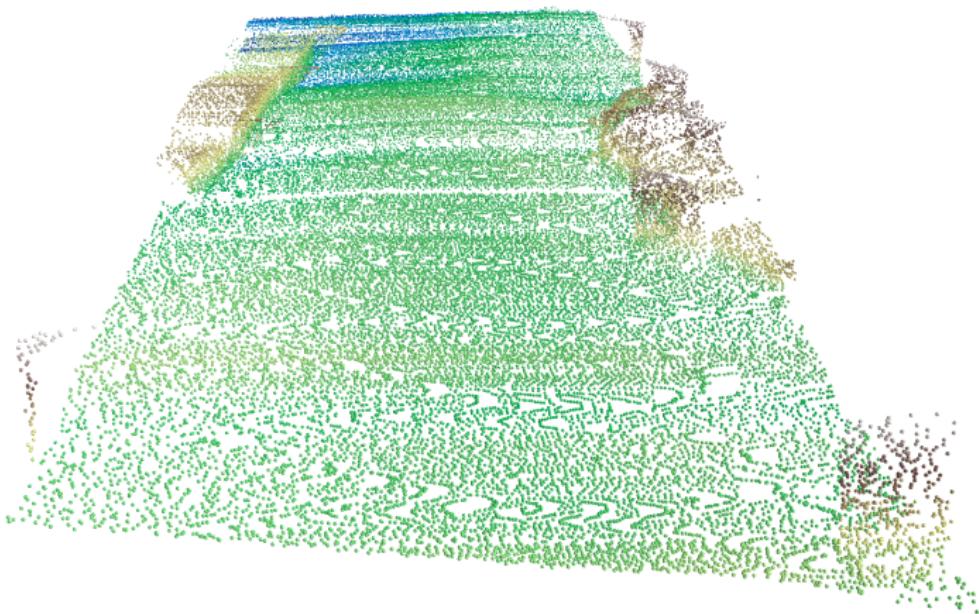
Relative Coordinates
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Proposed Mapping Framework
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Practical Results
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Questions?

PRACTICAL RESULTS



Background
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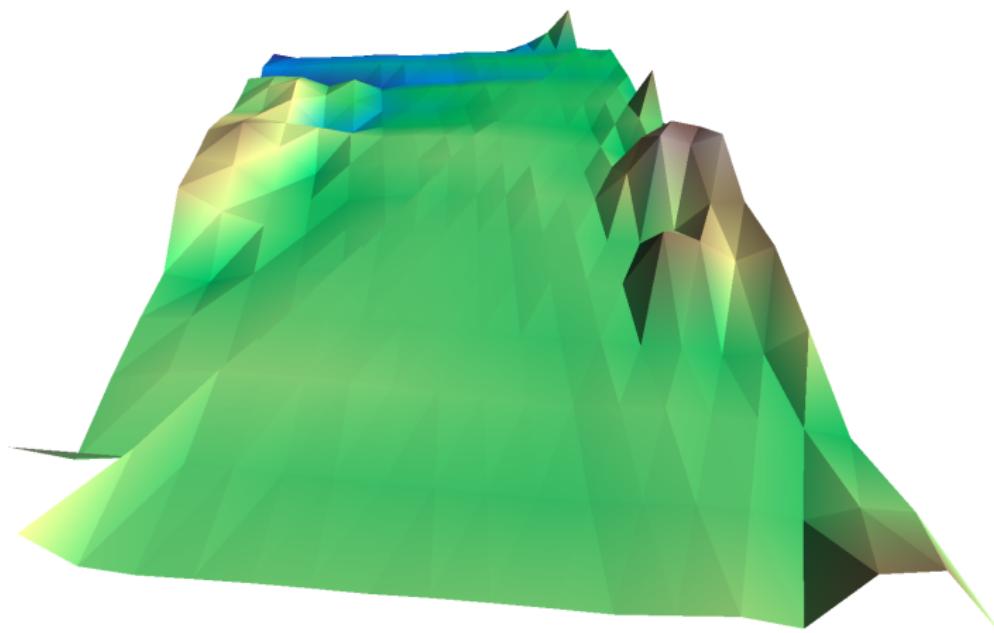
Relative Coordinates
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Proposed Mapping Framework
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Practical Results
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Questions?

PRACTICAL RESULTS



QUESTIONS?

REFERENCES

- P. Pfaff, R. Triebel, and W. Burgard, "An Efficient Extension to Elevation Maps for Outdoor Terrain Mapping and Loop Closing," *International Journal of Robotics Research*, vol. 26, no. 2, pp. 217–230, 2007.
- J. Saarinen, T. Stoyanov, H. Andreasson, and A. J. Lilienthal, "Fast 3D mapping in highly dynamic environments using normal distributions transform occupancy maps," in *IEEE/RSJ International Conference on Intelligent Robots and Systems*. IEEE, Nov. 2013, pp. 4694–4701.
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- J. Guivant, E. Nebot, J. Nieto, and F. Masson, "Navigation and Mapping in Large Unstructured Environments," *The International Journal of Robotics Research*, vol. 23, no. 4, pp. 449–472, 2004.