21th Mine Action Symposium
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Autonomous Mobile Manipulation for Safe and Efficient Landmine Disposal

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2. Goals and Contribution
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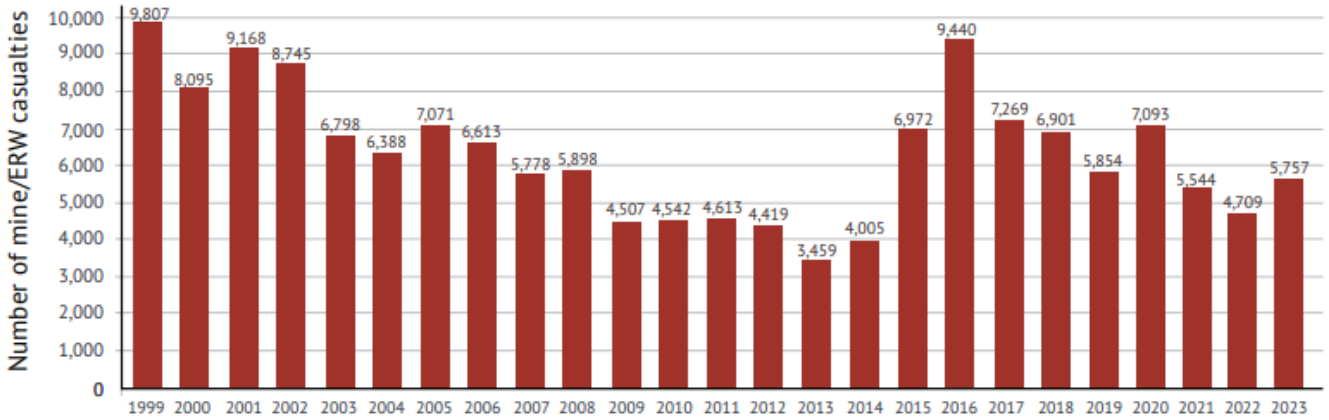
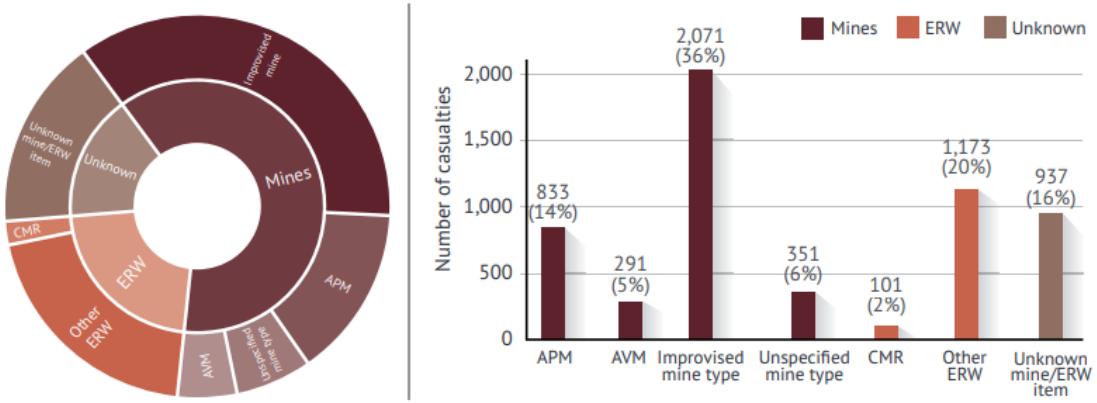
Introduction

In 2023:

- 5,757 causalities from landmines and explosive remnants
- 84 % of the victims were civilians



Number of mine/ERW causualties annually: 1999-2023 [1]



Note: APM=antipersonnel mines; AVM=antivehicle mines; CMR=cluster munition remnants; ERW=explosive remnants of war.

Casualties by type of mine/ERW in 2023 [1]

A deminer conducts manual clearance operations in a mountainous area in Khan Abad district, Afghanistan.

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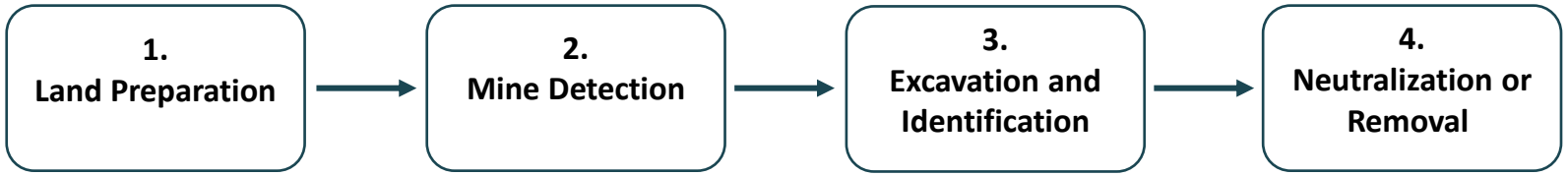
Manual mine clearance operation [1]

Introduction

Humanitarian Demining Process Steps:

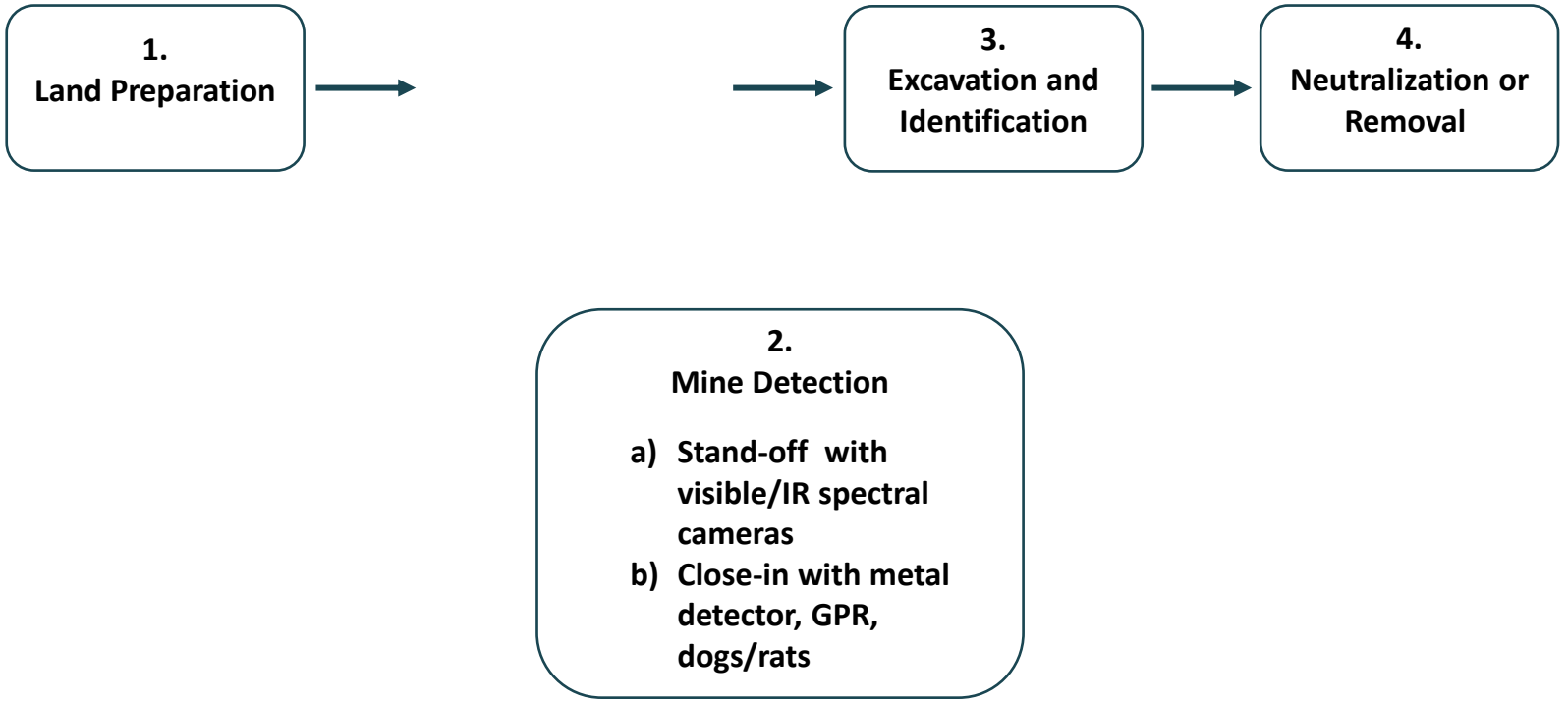


Introduction

1.
Land Preparation

a) Vegetation Removal
b) Soil softening
c) Tripwire neutralization

Introduction



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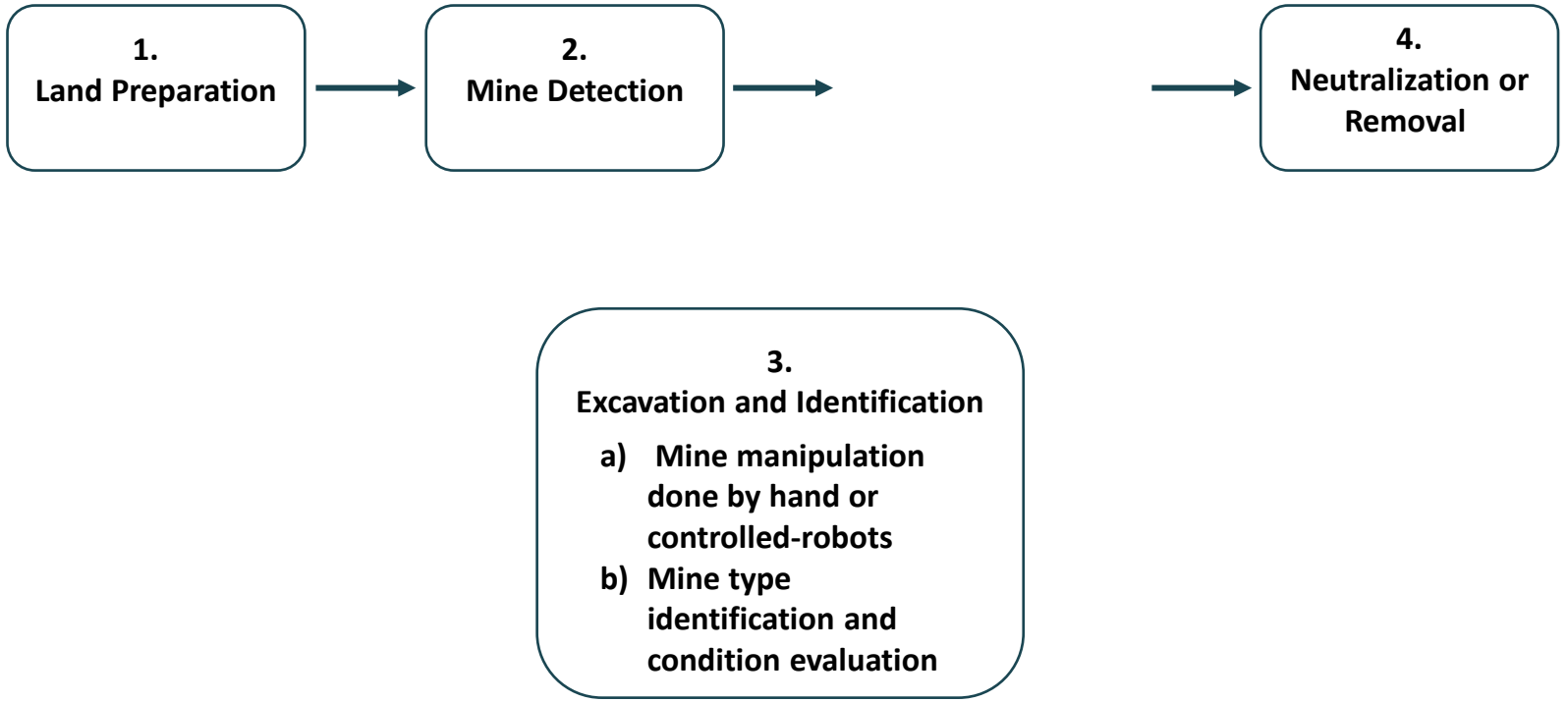
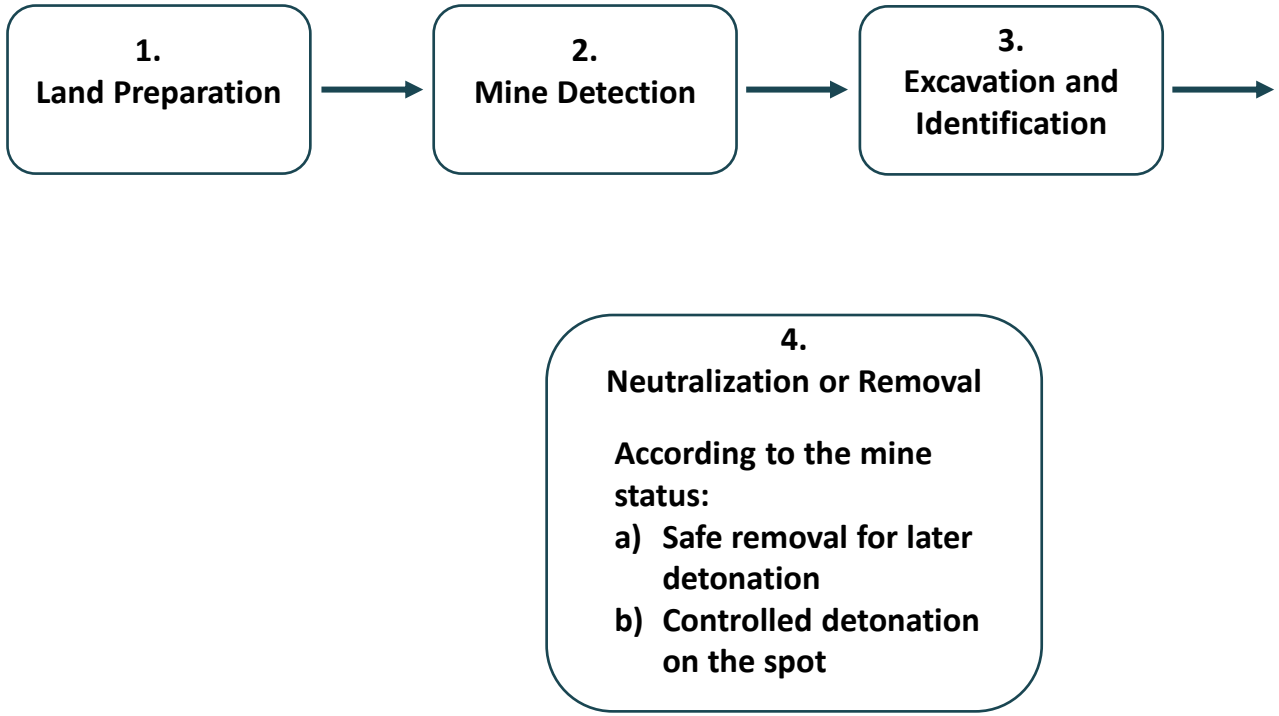


Introduction



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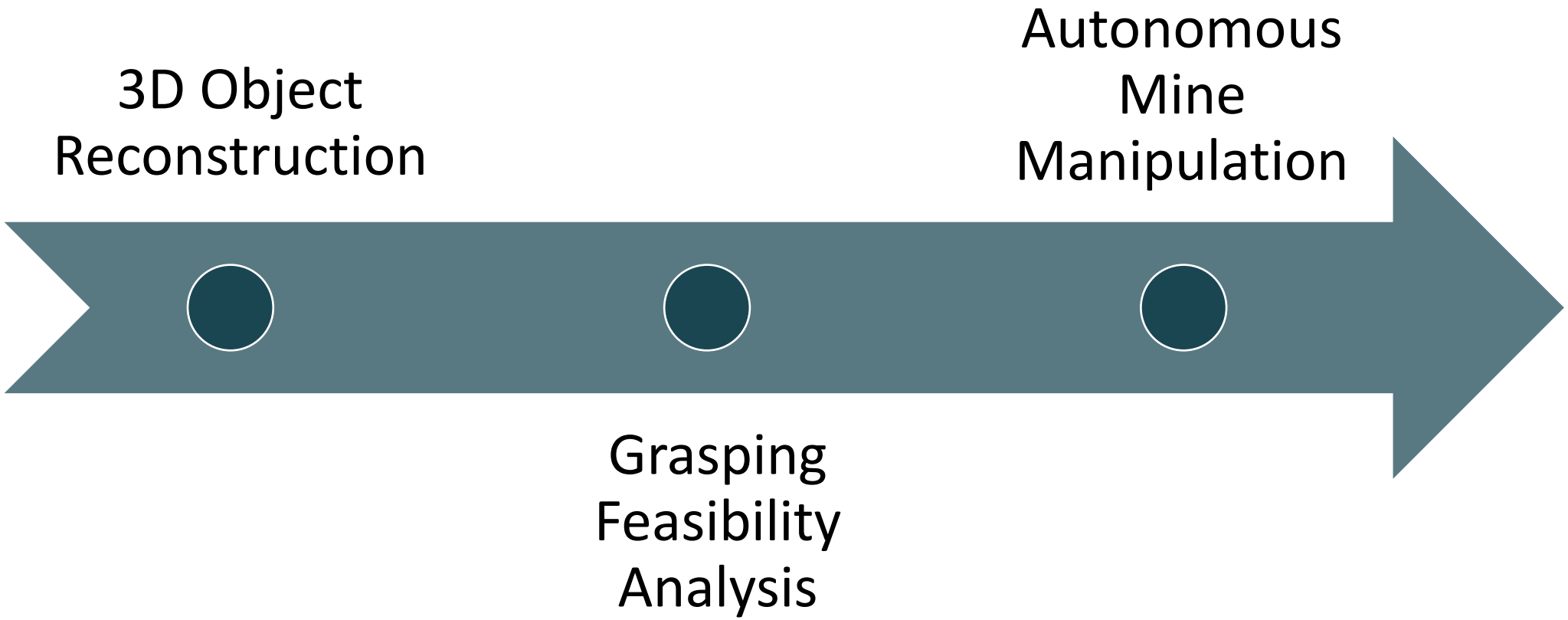
Goals and Contribution



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System Description

The Mobile Manipulator:

Manipulator

+

Mobile Platform

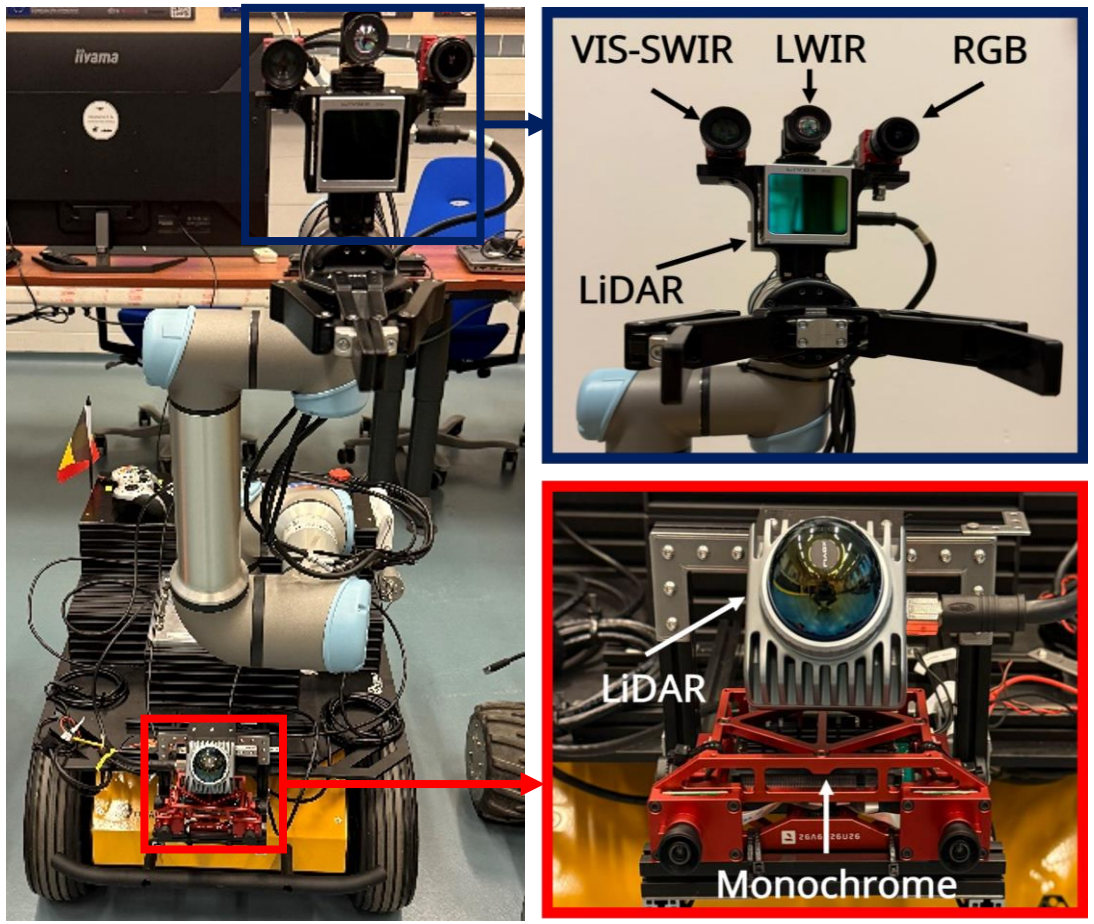
=

Combination of the mobility of the mobile platform with the dexterity of a manipulator

System Description

Sensors Layout:

- Exteroceptive sensors:
  LiDARs, RGB,
  IR Panchromatic spectral cameras
- Proprioceptive
  sensors: IMUs



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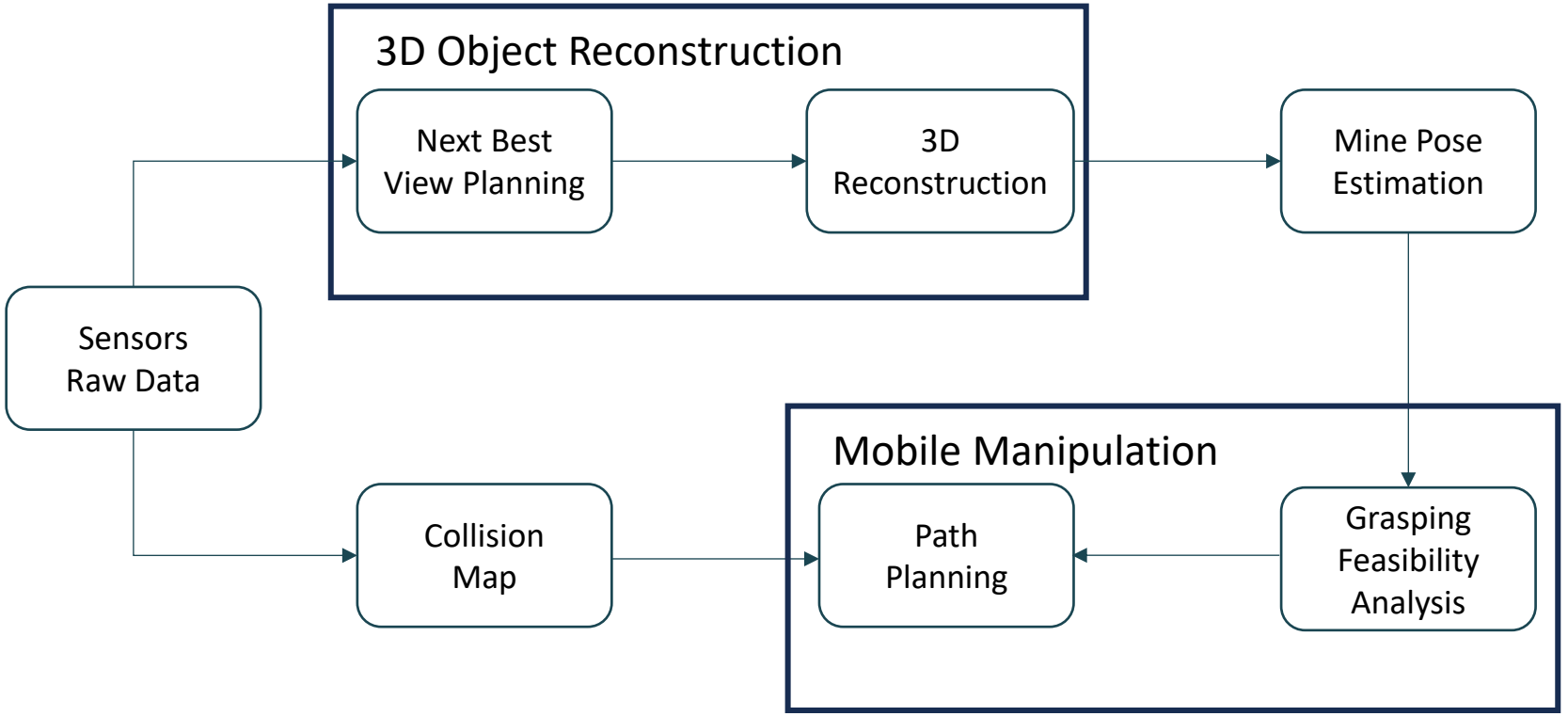
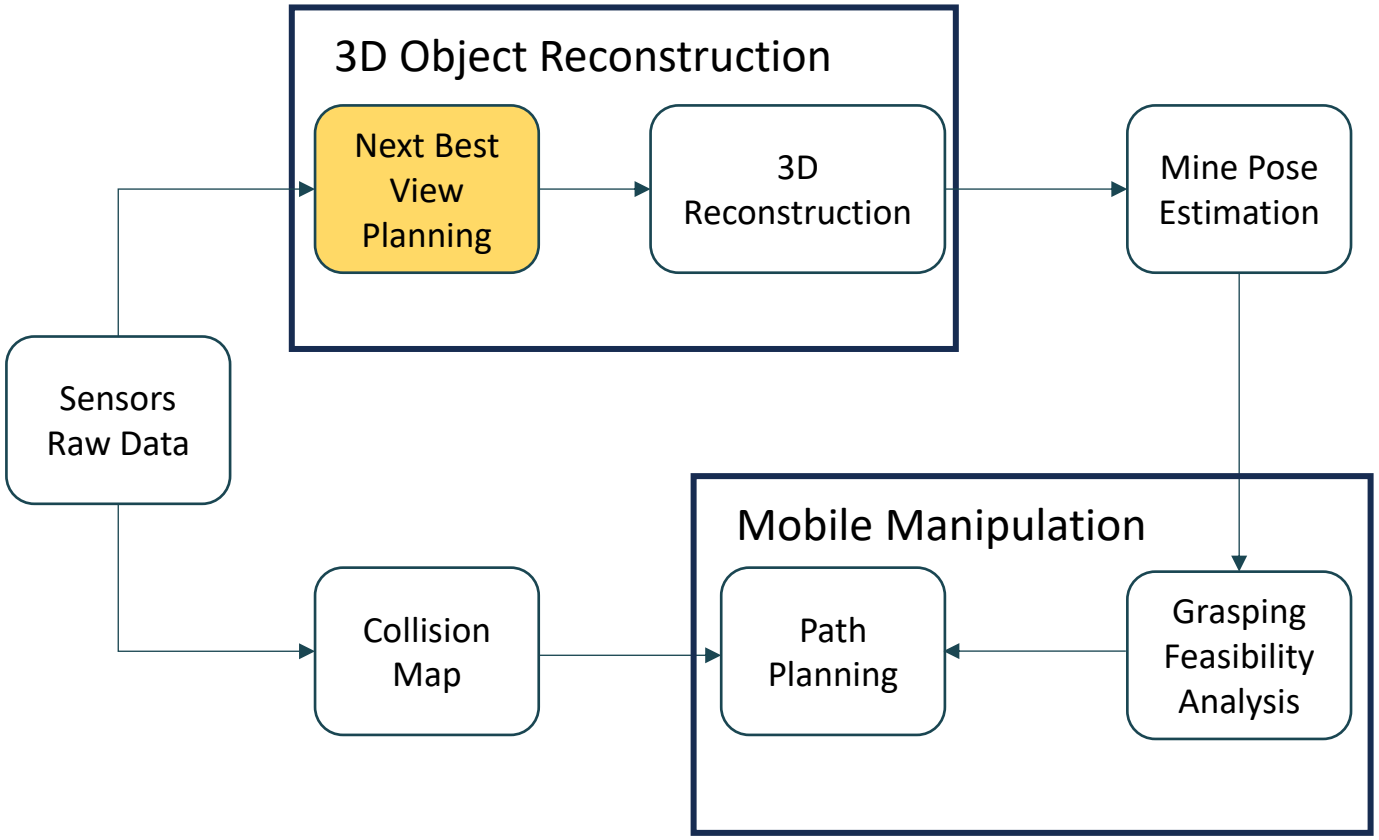
Methodology

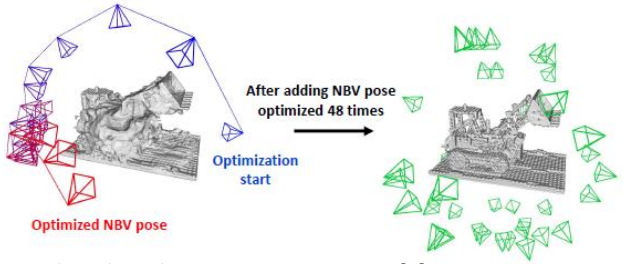


Methodology



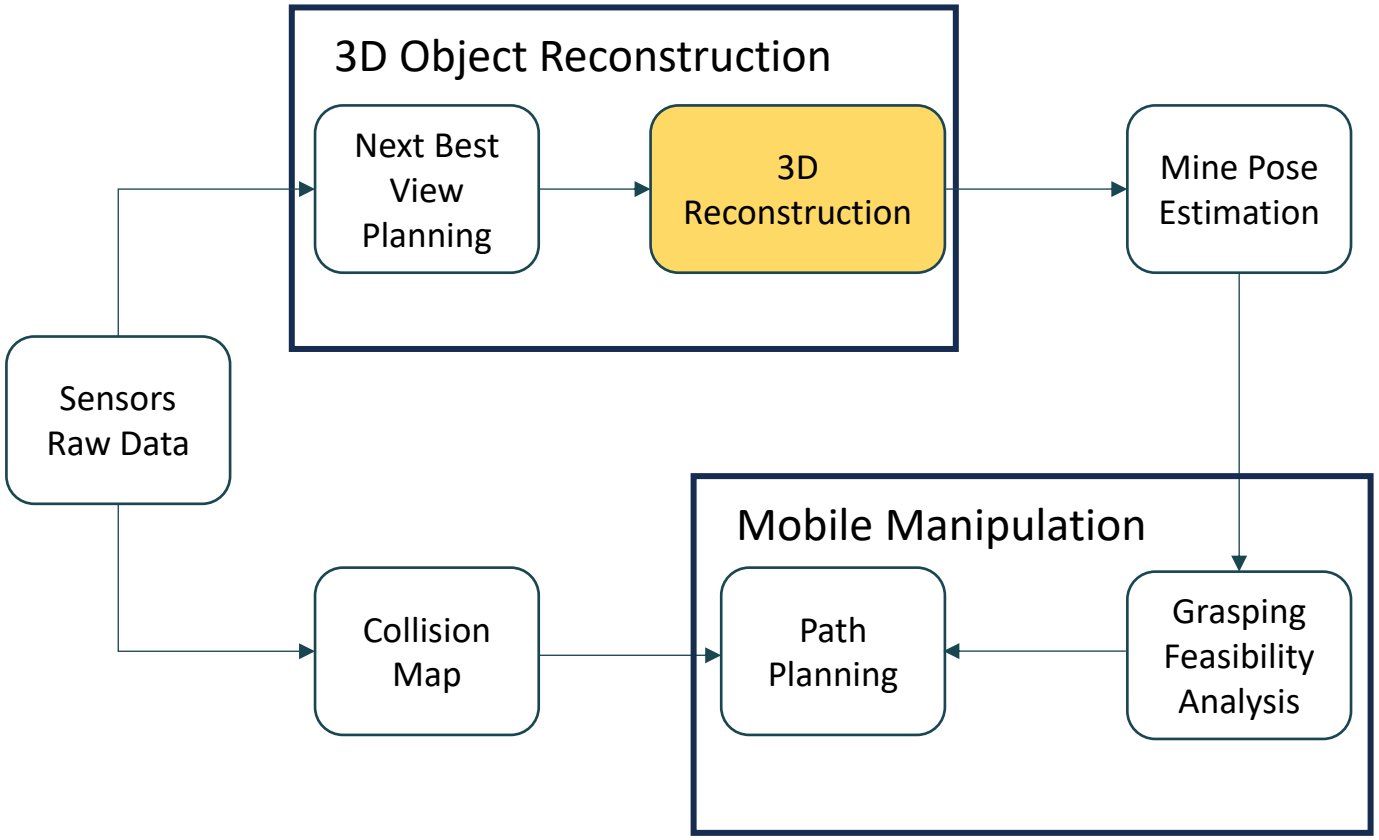
Next Best View Planning

Find the sequence of points that maximizes the coverage of unseen parts



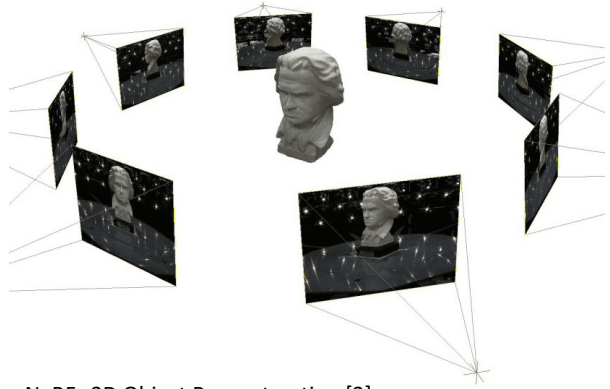
Gradient-based NBV pose optimization [2]

Methodology



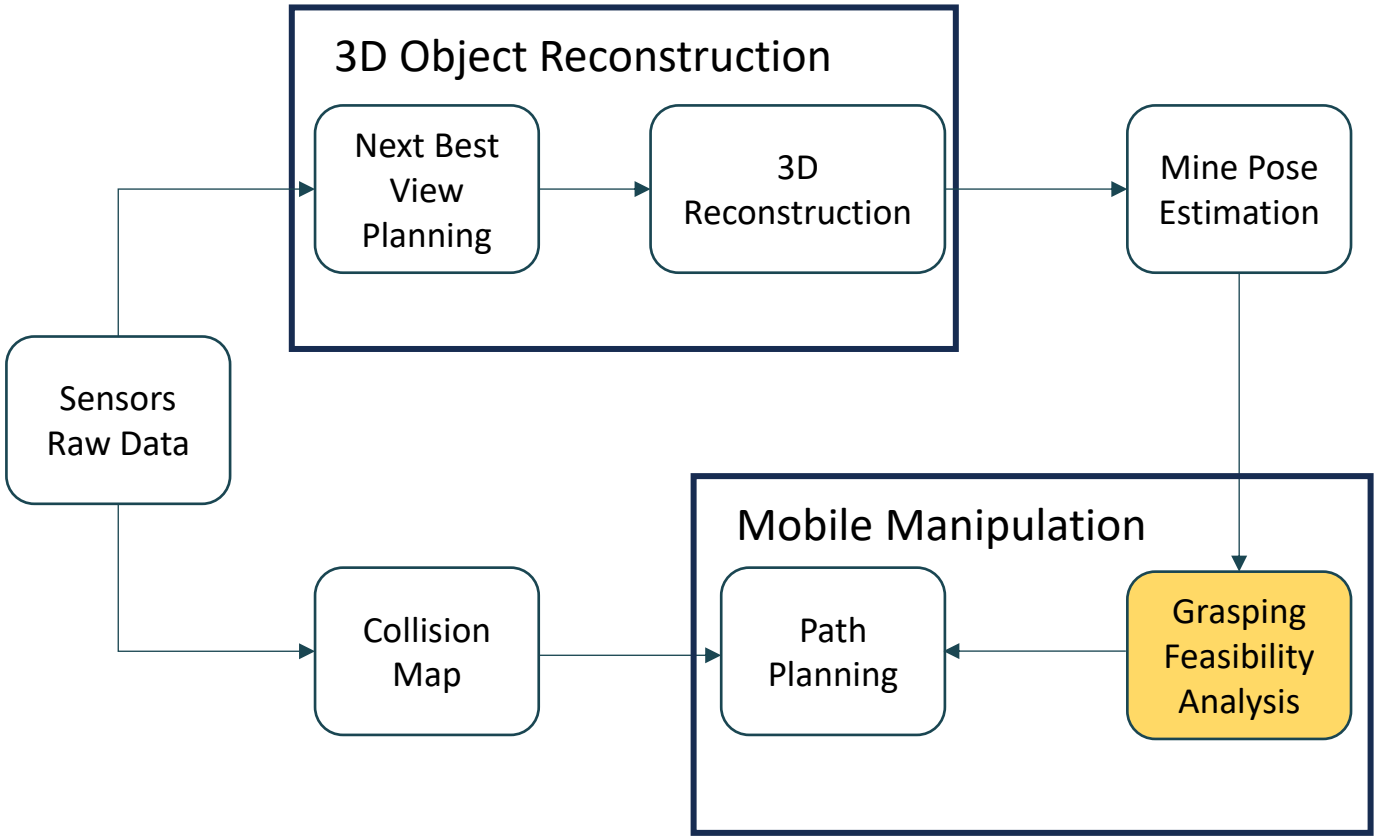
3D Reconstruction

Produce a 3D model starting from multi-view images



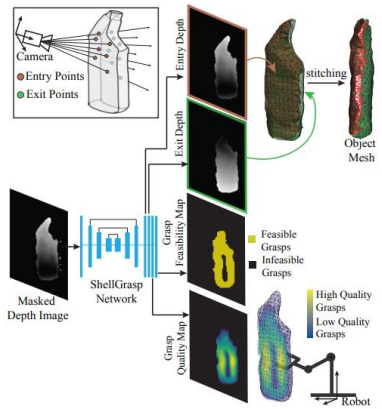
NeRFs 3D Object Reconstruction [3]

Methodology



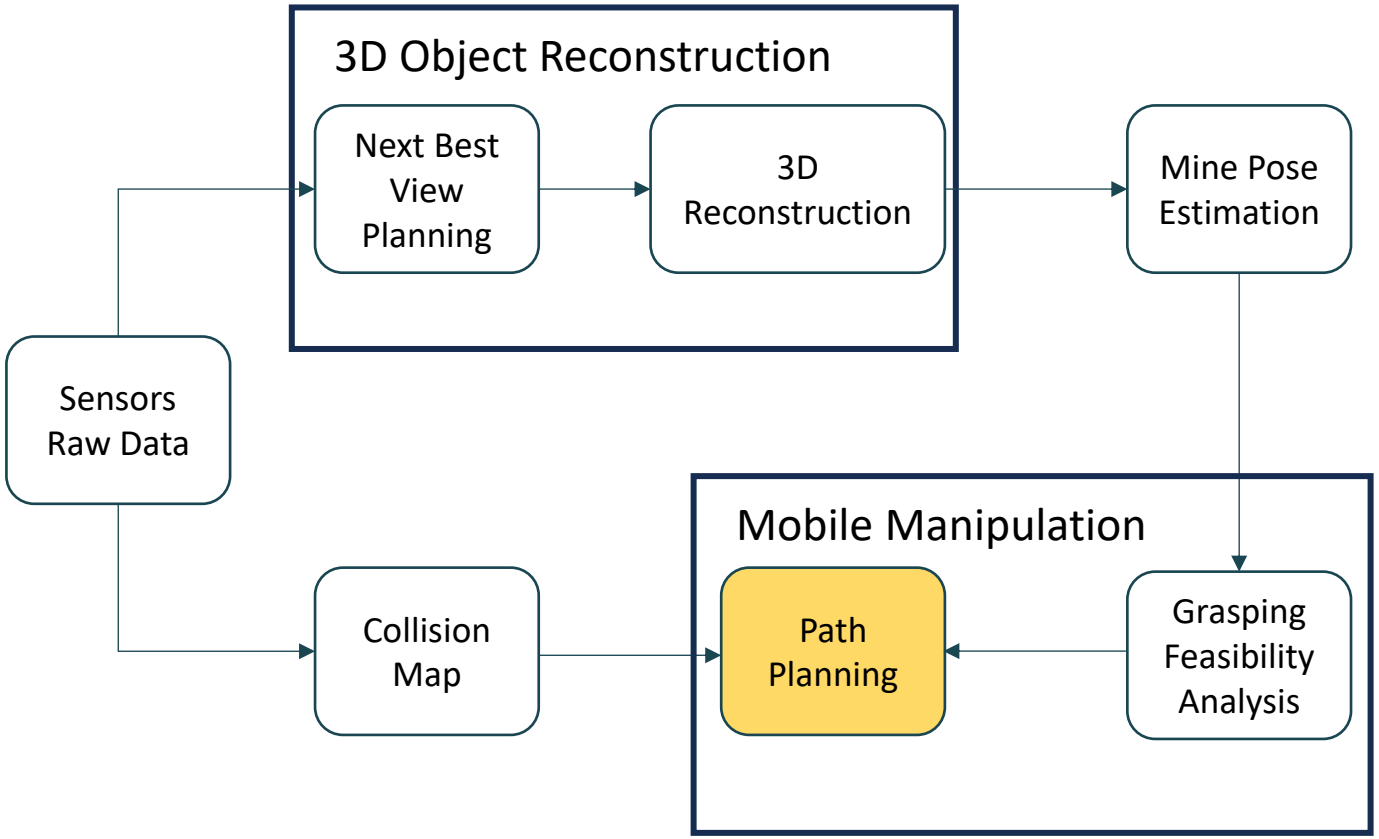
Grasping Feasibility Analysis

Identify grasp-feasible regions and relative grasp quality, aiding grasp planning and execution



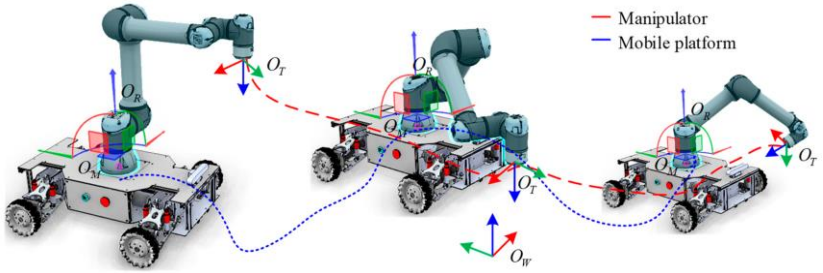
Shape Grasp Net [4]

Methodology



Path Planning

Compute the path to reach the views computed by the NVB planner and the grasping point, combining the platform and arm's movement



Mobile Manipulator Path Planning [5]

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Conclusion

- 3D Reconstruction of the surroundings of the mine.
- Mines mobile manipulation.
- Enhancing safety and efficiency in demining operations.

References

[1] Int Campaign to Ban. Landmines, "Landmine Monitor 2024," ICBL-CMC, Geneva, 2024, https://www.the-monitor.org/reports/landmine-monitor-2024

[2] Y. Hong, J. Kim, G. Cha, E. Kim, and K. Lee, “See-Then-Grasp: Object Full 3D Reconstruction via Two-Stage Active Robotic Reconstruction Using Single Manipulator,” *Applied Sciences*, vol. 15, no. 1, p. 272, Dec. 2024, doi: 10.3390/app15010272.

[3] The AI Summer. *NeRF: Neural radiance fields explained*, https://theaisummer.com/nerf/

[4] N. Chavan-Dafle, S. Popovych, S. Agrawal, D. D. Lee, and V. Isler, *Simultaneous Object Reconstruction and Grasp Prediction using a Camera-centric Object Shell Representation*, 2022, arXiv: https://arxiv.org/abs/2109.06837

[5] Zhang, Shijun, Shuhong Cheng, and Zhenlin Jin, "A Control Method of Mobile Manipulator Based on Null-Space Task Planning and Hybrid Control" Machines 10, no. 12: 1222, Dec. 2022, doi: 10.3390/machines10121222

Thank you for your attention