

Topic Areas:	Motion Planning, Legged Robotics, 3D Scene Graphs
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Prerequisites/Prior Knowledge:	Optimization, Python

3D scene graphs (3DSGs) have emerged as a powerful representation for spatial AI by combining geometric grounding with semantic and relational abstractions of the environment. Functional scene graphs are a recent extension that capture how robots physically interact with their environment using functional elements (knobs, handles, or switches) [1]. Such elements are stored as separate graph nodes, optionally enriched with kinematic attributes that describe the articulated motion of the interactive subparts (Fig.1).

Within this project, we aim to move beyond purely kinematic representations of functional elements such as doors, drawers, and switches and instead model them as articulated objects with mass, inertia, friction, and other dynamic properties.

These richer representations will enable the optimal planning and execution of mobile manipulation tasks. These can be made robust to uncertainties in the dynamic model while also accommodating secondary objectives, such as maximizing information gain (for example, during the opening of furniture in object search scenarios). Finally, information obtained through physical interaction during task execution, such as interaction forces and joint torques, can be leveraged to continuously refine and improve the internal object representation. The overall goal is to give robots a better understanding of the functionality of their physical surroundings and to develop motor skills that leverage this understanding to interact with articulated objects.

To keep the workload of the project mana-

geable, we will provide the functional scene graph, as well as the robot platforms (Unitree H1 and/or Boston Dynamics Spot) along with their manipulators and APIs.

Your tasks include:

- Literature review, familiarization with the robot platform and scene graph APIs
- Extension of functional scene graphs with dynamic properties
- Theory review for dynamic motion planning and execution for manipulation
- Integration and validation of optimal motion planning on a robot of choice
- Possible extensions include motion optimization for robustness or information gain and using information from the physical interaction for augmentation of the scene graph

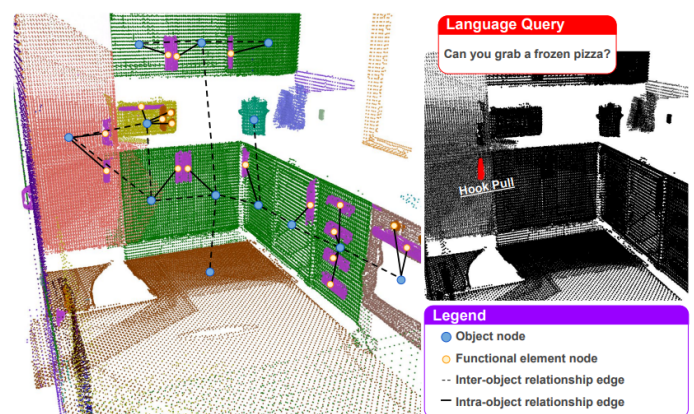


Figure 1: An example of a generated 3D scene graph and its application

[1] Rotondi, D., et al. *Fungraph: Functionality aware 3D scene graphs for language-prompted scene interaction*, IEEE/RSJ International Conference on Intelligent Robots and Systems, IEEE, 2025.