foundations of spatial perception for robotics:

safety critical, high intensity + highly interactive environments

search + rescue, self-driving

rocket

· multi robot interaction w/ environment

robust estimation:

Used in Localization + Mapping problems

- key element of SLAM is to reconstruct the trajectory of your robot.

Loop closure: measurements of poses that are far away. (identifying previously visited locations and use them to correct accumulated errors)

Graduated Non-convexity:

Instead of solving the original optimization problem, you solve the convex approximation of the problem.

CAMP: robust lidar-based localization + mapping

Tartan Relative Navigation
↳ visual based pose estimation for robotics.

Hierarchical Representations

Kimera: real-time metric-semantic SLAM

metric-semantics: what's a table? what's a cup?
↳ may not be enough in certain contexts too, for example, if you want to find "the kitchen" if we're just mapping areas and semantically labelling, it'll not know what a kitchen is.

↳ thus, we require semantics beyond objects
→ need reason over relations between elements in the scene.

An alternative approach would be to generate 3D Scene Graphs:

Metric-Semantic Mesh → Objects + Agents → Places + Structures → Rooms → Buildings

With hierarchical representations, it's easier to scale, & graph-based structures are better at capturing relations.

Hydra: real-time scene graph construction

A language model will not have an immediate understanding of these rooms so they're not as reliable.

Neural field: convert graph into tree, neural message passing on H-tree. instead of GNN.

when it comes to doing this for outdoor environments, it's kind of difficult to identify what concepts to include.

to solve this, you can use an LLM to generate spatial ontology.

We also want to make sure consistency is kept, so you can use a LTN to create constraints for making reasonable connections in the ontology.

Self-Supervised Learning

real unlabeled data → pretrained sim → model fidelity

if the output is deemed correct, we can backprop that back