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Poster Session 1 - WePoS

Uncertainty Analysis for Curved Surface Contact Patches

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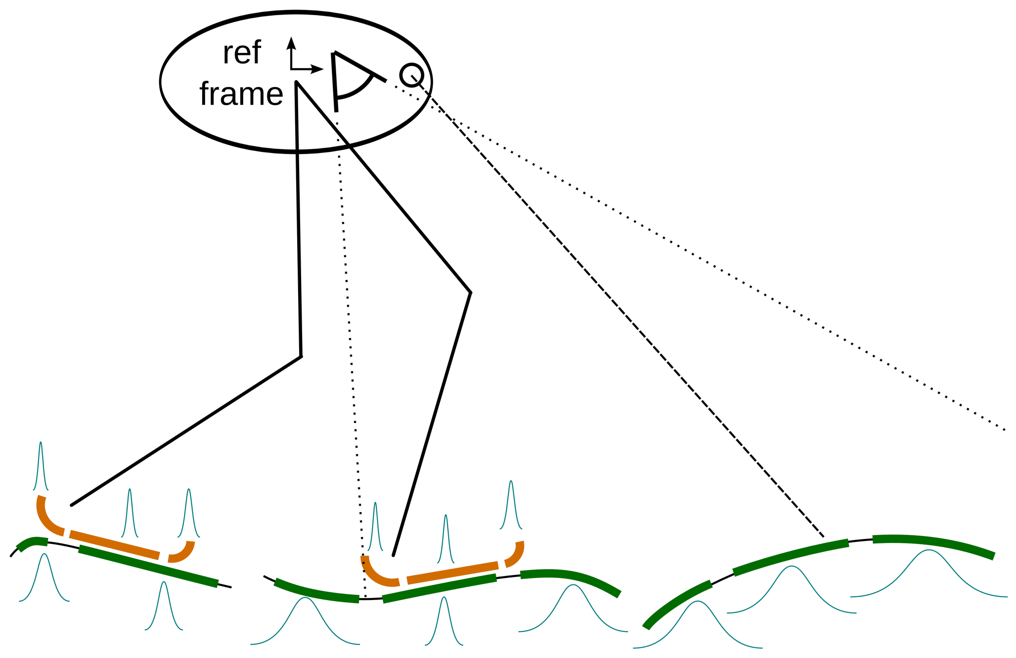
All Sourcecode Provided as the Open-Source Surface Patch Library (SPL): http://dkanou.github.io/projects/spl/index.html [1,2]

Contact with Rough Terrain & Free-Formed Objects



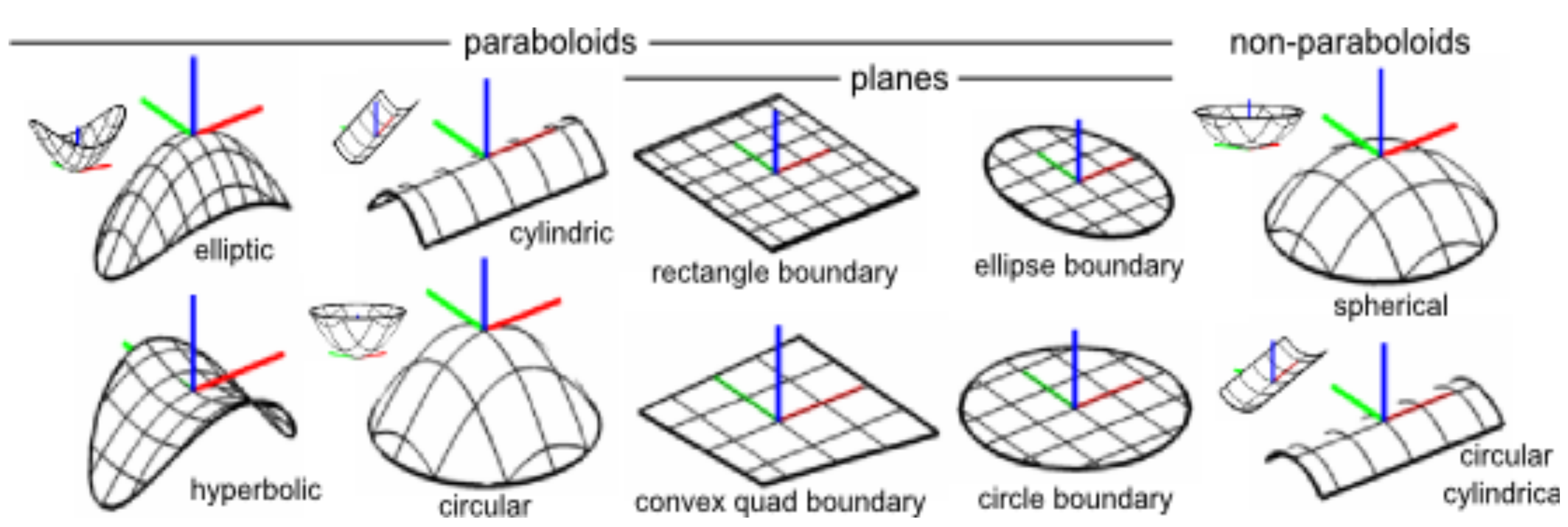
Hypothesis

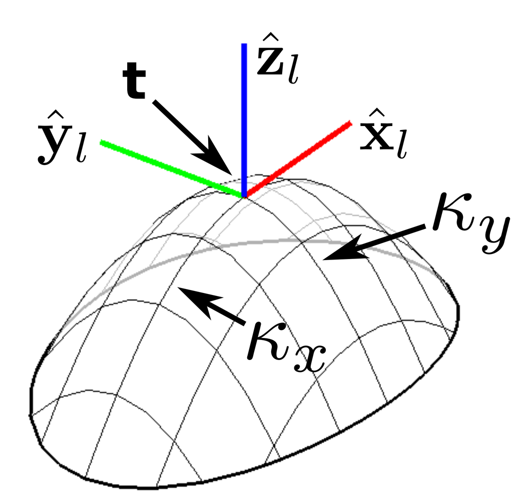
Sparse 3D foothold/handhold contact affordances can be detected, modeled, and mapped in real-time using ***curved surface patches***.

Sparsity of Contact Affordances Robots requires

1. Modeling local contact surface areas
2. Online perception algorithms to find them
3. **Handling uncertainty**

Environment Representation

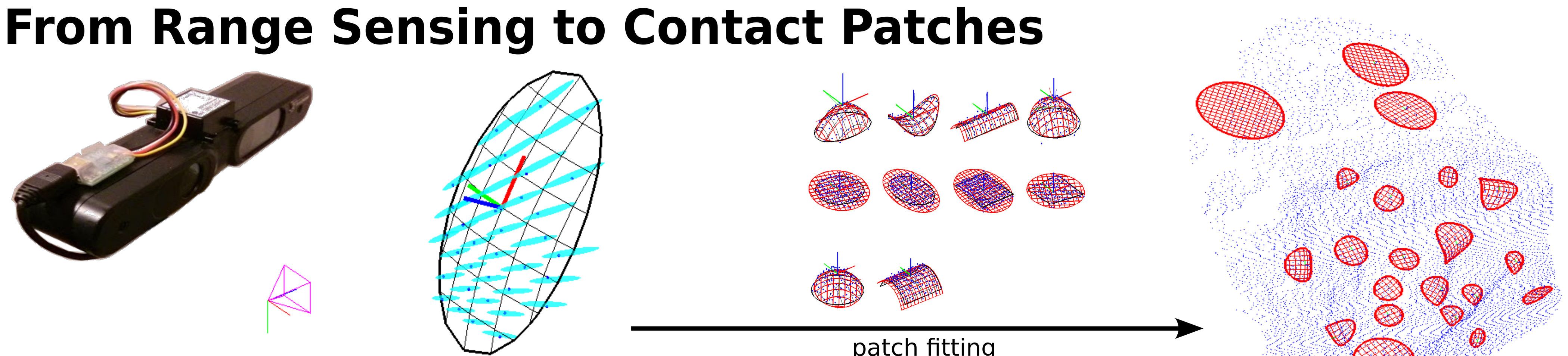




Curved Patch Modeling [1]

- Detailed models for 10 bounded curved-surface patch types for contact regions
- Minimal geometric parametrizations: curvature, spatial pose, and bounds
- Foot/hand-sized boundaries

From Range Sensing to Contact Patches



Point Clouds and their Gaussian Uncertainty Modeling

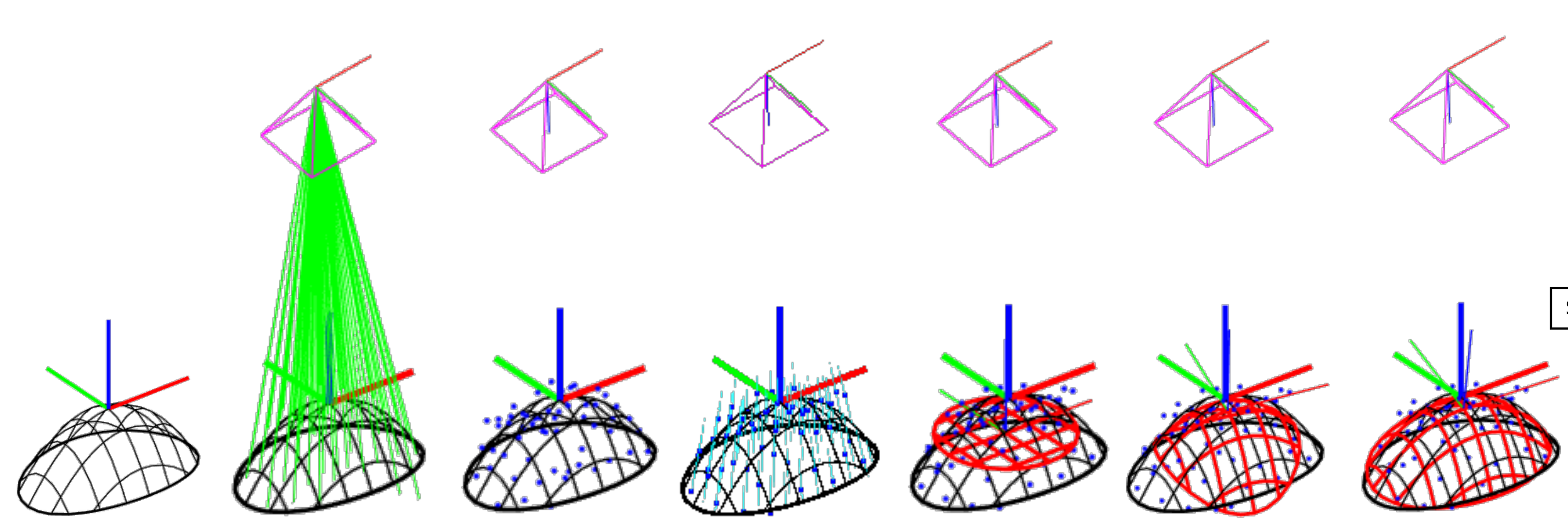
Input

- 3D point cloud from a range sensor
- The corresponding Gaussian uncertainty as a covariance

Output

The fitted curved patches and their Gaussian distribution model uncertainty (covariance) in patch parameter space

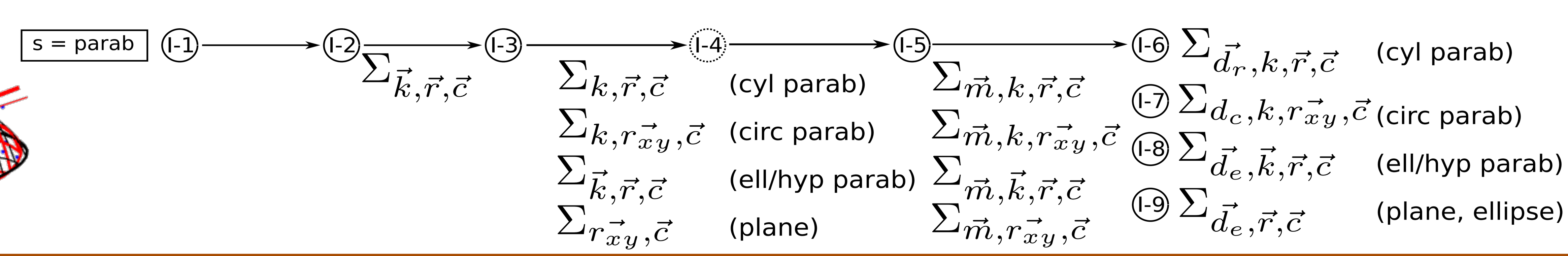
Patch Fitting with First-Order Uncertainty Propagation



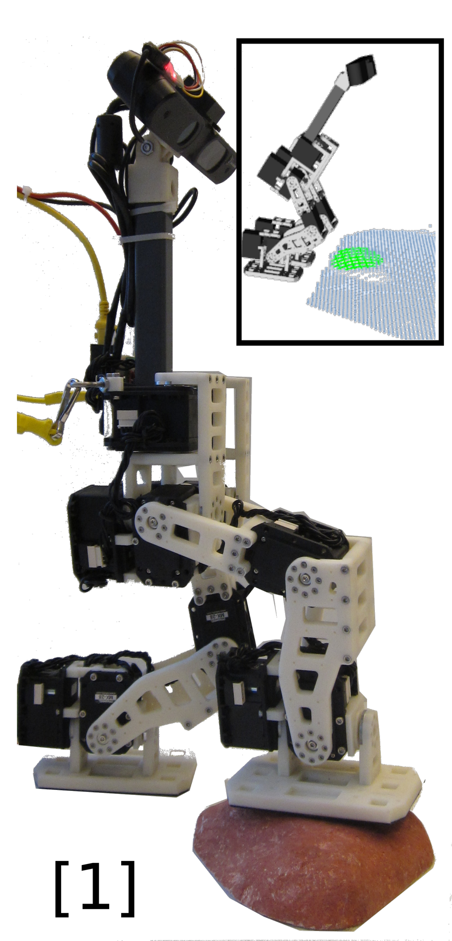
Patch Fitting

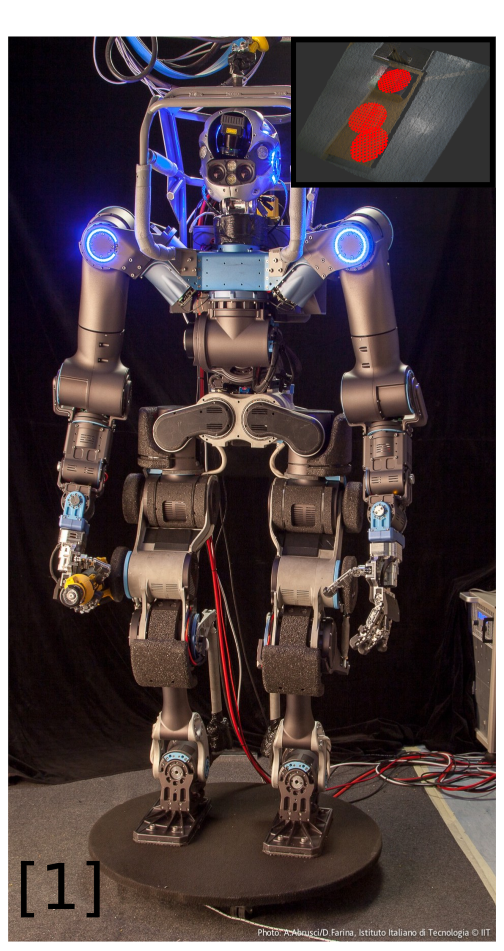
Real-time nonlinear fitting algorithm to neighborhoods of range data, including quantified uncertainty (~0.6ms)

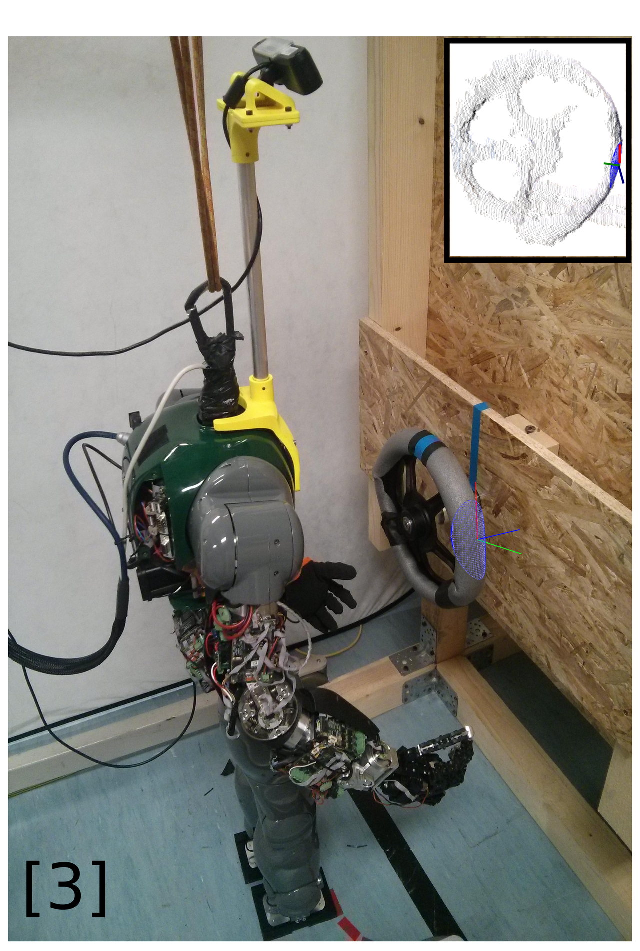
First-Order Uncertainty Propagation: $\mathbf{\Sigma^f = J\Sigma^x J^T}$, for $\mathbf{f(x)}$



Applications to Foothold/Handhold Contacts]







Applications

- Contact **risk analysis** using *Multivariate Gaussian Distribution Metrics* to measure the magnitude of uncertainty
- Reasoning about contacts by integrating the patch-system into a **path planner**
- A time/space efficient **patch-based SLAM** system for locomanipulation tasks

References

[1] "Curved Surface Patches for Rough Terrain Perception", *D. Kanoulas, PhD Thesis, 2014.*

[2] "The Surface Patch Library (SPL)," D. Kanoulas and M. Vona, ICRA'14.

[3] "Visual Grasp Affordance Localization in Point Clouds using Curved Contact Patches", D. Kanoulas, J. Lee, D. Caldwell, and N. Tsagarakis, IJHR'16.