Rough Terrain Perception for Bipedal Robots using Curved Contact Patches

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All Sourcecode Provided as the Open-Source Surface Patch Library (SPL)

Perceiving Rough Terrain

Input Data: Range and IMU Sensing

Environment Representation

Curved Patch Mapping & Tracking

Hypothesis [1]
Sparse 3D footfall affordances can be detected, modeled, and mapped in real-time using curved surface patches.

Sparsity of Footholds for Legged Robots requires
1. modeling local contact surface areas
2. online perception algorithms to find them
3. handling uncertainty

Input
1. 3D point cloud from depth camera
2. unity gravity vector from IMU

3D Point Cloud Uncertainty
1. outlier points
2. stereo error as a covariance matrix

Patch Modeling
- detailed models for 10 bounded curved-surface patch types for contact regions
- minimal geometric parametrizations: curvature, spatial pose, and bounds
- foot-sized boundaries

Patch Fitting
real-time nonlinear fitting algorithm to neighborhoods of range data, including quantified uncertainty

Patch Validation
1. patch fit quality (residual)
2. fidelity to data (coverage)
3. max curvature

Timing: ~0.6ms per neighborhood with 50 points

Future Work
Integrate a path planning approach for foothold selection during walking in rough terrain

References