Robust and Efficient Physics-based Learning and Reasoning in Degraded Environments

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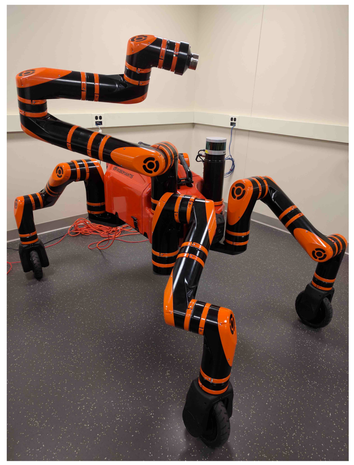
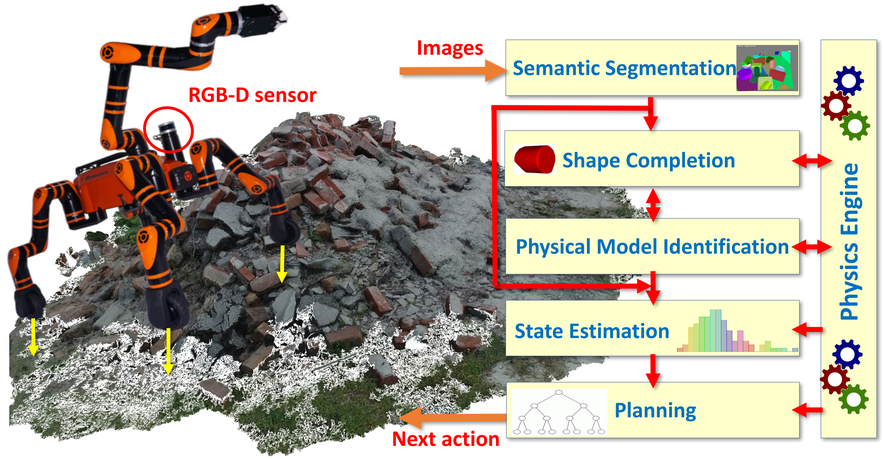
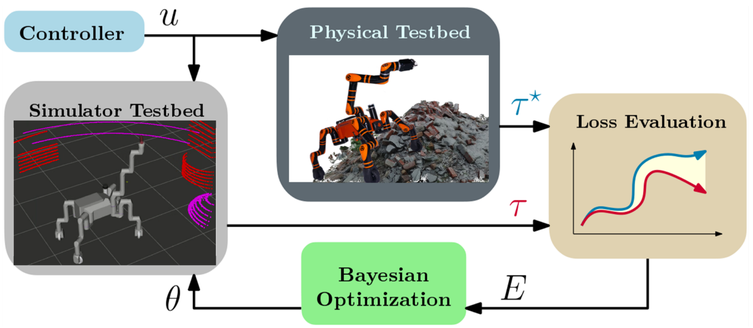
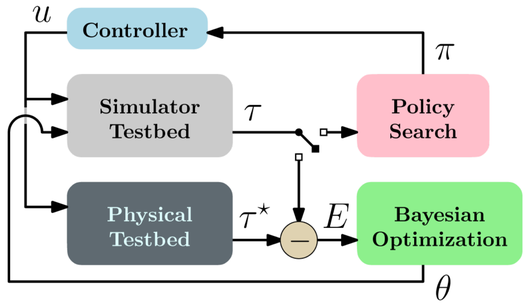
- We propose to develop and integrate model learning, simulation, and planning algorithms to enable the deployment of robots to unstructured and cluttered environments that occur around disaster sites.
- Specifically, we propose novel algorithms that can learn models of objects on the fly, quickly simulate the reactions of objects to robotic actions, and plan safe decluttering and navigation strategies accordingly, while accounting for partial knowledge and uncertainty.



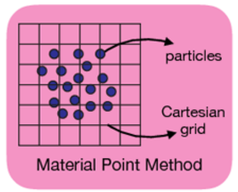


Overview of the integrated system with the four-legged *RoboMantis* .

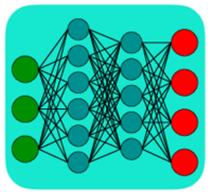




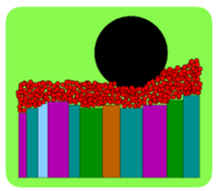
Model identification with Bayesian Optimization.



General Material Models



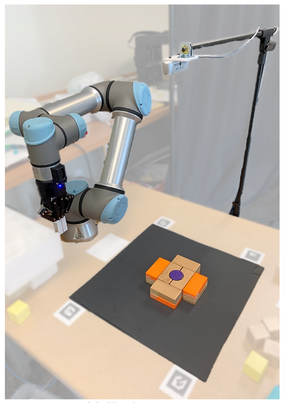
Differentiable Physics



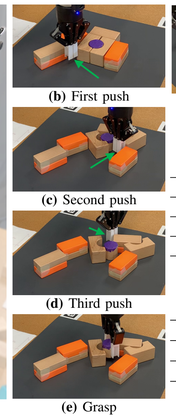
Adaptive Data Structures + Reduced-order Models

Cloud Computing

The material point method (MPM) is used for simulating the rubble, which can accommodate general material models and avoids costly remeshing operations with topology changes. We integrate this simulator inside a neural network for automatically inferring the material parameters of objects from sensor data. The framework uses adaptive data structures and reduced-order models for reducing the computational overhead, and the computing cloud for energy efficiency.



(a) Hardware setup



(b) First push
(c) Second push
(d) Third push
(e) Grasp

	Completion	Grasp Success	Number of Actions
gc-VPG	89.3%	41.7%	5.78
go-PGN	99.0%	90.2%	2.77
DIPN	100%	100%	2.30
Proposed	100%	100%	**2.00**

	Completion	Grasp Success	Num. of Actions
go-PGN	95.0%	86.6%	4.62
DIPN	100%	100%	4.00
Proposed	100%	100%	**2.60**

Preliminary results: Rendering of a vehicle driving on mud simulated using hybrid MPM.

Preliminary results: Object retrieval from clutter using learned models

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