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Bringing geometric methods to robot learning, optimization and control

IROS 2020 Workshop

Talk title:
State space representations for complex manipulation

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Abstract:
Modeling states of the system and transitions between them is fundamental for manipulation planning. Analytically devised representations of scenes and objects based on tools from computational geometry and topology are designed to capture the most essential information about the task. Unlike data-driven state representations, they also have the advantage of being naturally interpretable. However, the resulting algorithms can be computationally expensive, and thus not suitable for real-time applications. Recently, the idea of learning low-dimensional state representations from high-dimensional observations (such as images), has gained significant attention in the robotics community. For this, latent space models, such as variational autoencoders (VAE), are commonly used. However, this approach poses its own challenges. First, when no prior information about the problem is given, learning representations requires large amounts of data. Furthermore, standard metrics in the space of images or point clouds do not reflect similarities between the underlying states. Finally, most latent space models, and, in particular, VAEs, do not preserve the underlying geometric and topological structure of the input space, which is crucial for planning optimal paths, analyzing connectivity of the space, homotopy equivalence of paths, etc. In my work, I aim to bridge the gap between analytical and data-driven approaches by using the available information about the structure of the task when possible, and complementing it with machine learning tools when necessary. In my talk, I will present some geometric and topological tools for state representation in robotics and possible ways of integrating them with machine learning approaches in order to achieve robustness, high computational performance, and data efficiency.

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