LUDO: Low-Latency Understanding of Deformable Objects Using Point Cloud Occupancy Functions (Abstract Reprint)

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Abstract

Accurately determining the shape of deformable objects and the location of their internal structures is crucial for medical tasks that require precise targeting, such as robotic biopsies. We introduce LUDO, a method for accurate low-latency understanding of deformable objects. LUDO reconstructs objects in their deformed state, including their internal structures, from a single-view point cloud observation in under 30 ms using occupancy networks. LUDO provides uncertainty estimates for its predictions. Additionally, it provides explainability by highlighting key features in its input observations. Both uncertainty and explainability are important for safety-critical applications such as surgery. We evaluate LUDO in real-world robotic experiments, achieving a success rate of 98.9% for puncturing various regions of interest (ROIs) inside deformable objects. We compare LUDO to a popular baseline and show its superior ROI localization accuracy, training time, and memory requirements. LUDO demonstrates the potential to interact with deformable objects without the need for deformable registration methods.

References

Henrich, P.; Mathis-Ullrich, F.; and Scheikl, P. M. 2025. LUDO: Low-Latency Understanding of Deformable Objects Using Point Cloud Occupancy Functions. *IEEE Transactions on Robotics*, 41: 4283–4299.