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Active Machine Learning for Projection Multi-photon 3D Printing

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The rapidly developing frontiers of additive manufacturing, especially multi-photon lithography, create a constant need for optimization of new process parameters. Multi-photon lithography is a 3D printing technique which uses the nonlinear absorption of two or more photons from a high intensity light source to induce highly confined polymerization. The process can 3D print structures with submicron features. However, the serial scanning nature of the typical process is slow. The recently developed projection multi-photon lithography process used in this work has presented a way to increase throughput by several orders of magnitude. Yet, like all additive manufacturing techniques, the process can require time-consuming experimentation and costly measurement techniques to determine optimal process parameters. In this work, an active machine learning based framework is presented for quickly and inexpensively determining optimal process parameters for the projection 3D printing process. The framework uses Bayesian optimization to guide experimentation for collection of the most informative data for training of a Gaussian process regression machine learning model. This model serves as a surrogate for the projection multi-photon lithography manufacturing process by predicting optimal patterns for achieving a target geometry. Three primitive 2D shapes at three different scales are used as test cases for this framework. In each case, the active learning framework improves the geometric accuracy, reducing the geometric error to within measurement accuracy in just four iterations (five experiments) of the Bayesian optimization, with each case requiring the collection only a few hundred training data points.

Focus areas

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