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"Active Machine Learning for Multi-photon 3D Nano-printing"

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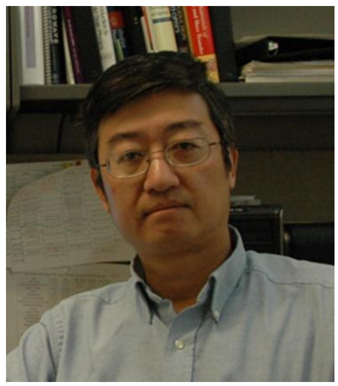

Bio: Xianfan Xu is James J. and Carol L. Shuttleworth Professor of Mechanical Engineering at Purdue University, with a courtesy appointment in Electrical and Computer Engineering. He obtained his M.S. (1991) and Ph.D. (1994) degrees in Mechanical Engineering from the University of California, Berkeley. His current research is focused on ultrafast and nanoscale optics and their applications in energy transfer/conversion and nano-manufacturing. He is the recipient of the ASME Heat Transfer Memorial Award, and a Fellow of the American Society of Mechanical Engineers, SPIE, and Optica. He currently serves as an Associate Editor for the International Journal of Heat and Mass Transfer and Scientific Reports.

Abstract: The rapidly developing frontiers of additive manufacturing, especially multi-photon lithography for 3D nanoscale printing, create the needs for optimization of processing parameters for various applications. Multi-photon lithography uses nonlinear absorption of two or more photons from a high intensity light source to induce highly confined polymerization to print 3D structures with submicron resolution. However, the typical serial, point-by-point scanning of the process has a low throughput for manufacturing. The recently developed projection multi-photon lithography has presented a new way to increase throughput by several orders of magnitude. Yet, like all additive manufacturing techniques, this process requires time-consuming experimentation and costly measurement techniques to determine optimal process parameters. We developed an active machine learning based framework for quickly and inexpensively determining optimal process parameters for projection 3D nano-printing. This 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 projection multi-photon lithography by predicting optimal processing parameters for achieving a target geometry. Various shapes at different scales are tested. In each case, the active learning framework significantly improves the geometric accuracy and reduces the geometric error to within the measurement accuracy in four or less iterations of the Bayesian optimization, with each case requiring the collection only a few hundred training data points. This machine learning frame work is also compared with commonly used Convolutional Neural Network (CNN) to demonstrate its advantages in rapid learning.