A Framework for the Analysis of Host-Microbiome Interactions Using Experimental Data

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Microbiome communities represent dynamic and diverse ecosystems with considerable variation within and between hosts. Studies on host-microbiota interactions and pathogenicity using omics approaches to infer biotic interactions rely primarily on correlation analysis. As a consequence, taxon-taxon interactions are often not captured using these inference methods. There is a critical need to develop rules-based approaches that provide mechanistic and predictive insights into microbiome dynamics. Thus, we seek to develop a framework for developing robust rule-based understanding of host-microbiota interactions using machine learning and mathematical modeling approaches in combination with experimental data from model organisms with tractable microbiomes. Using these methods, we have developed an algorithm to estimate the parameters of complex ecological models and a likelihood-based framework for comparing the efficacy of proposed models in capturing the dynamics exhibited by experimental systems. This algorithm and framework have proven effective at reproducing system dynamics and identifying rules governing ecological interactions in simulated data. However, these tools have not yet been applied to experimental data. The methods developed in this study bring us closer to a better understanding of the complex interactions that govern host-microbiome dynamics by providing new tools to test proposed models of these interactions with experimental data.

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