Diffusion Generative Models For Unstructured Uncertainty Perturbations

Real world control systems operate on physical plants that can have different dynamics than a nominal model. This discrepancy is called a perturbation, and can affect controller performance. The field of robust control creates a way to establish a set of allowable ~~perturbations~~ for a given plant, controller, and design requirements. We can make guarantees that a controller meets performance or safety criterion when the real plant does not perfectly match the nominal model.

A model controller can be proven to control a set of plants, but a real controller can only control one plant at a time. Validating robustness for a real controller requires extracted elements of the perturbed set, which can be deceptively difficult to create. Perturbed plants are commonly generated by using a structured uncertainty, where an engineer creates distributed ranges for system parameters. These distributions are then sampled and used to create a perturbed plant. This is an knowledge intensive and time consuming process.

We suggest using generative artificial intelligence to efficiently create perturbed plants. The diffusion generative model has shown great promise in creating novel and realistic samples from training data. This model can be used to remove the laborious effort of creating perturbed plants. We suggest training a generative model to create Bode plots of transfer functions. This trained model will then be given a warm start with the nominal plant as an input, with which it will then be able to generate a limitless number of unique perturbed plants for controller validation.

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