APPLICATION FOR THE ME PHD QUALIFYING EXAM

(please fill out the form and submit it to PhD Qualifying Exam Coordinator via email)

Student's name: Dane Sabo 7-digit ID: 4368326

PhD Advisor's name: Dr. Daniel G. Cole

Start date in the PhD program: August 23, 2023

Is this your first attempt at the PhD Qualifying Exam? **Yes** No

Qualifying Exam Track: Dynamic Systems and Control

Proposed Research Title: *Diffusion Generative Models for Unstructured Uncertainty Perturbations*

Technical Abstract: (*250 words maximum*)

The goal of this research is to use a generative diffusion model to create unstructured perturbations of a nominal plant. If this research is successful, this diffusion model will accomplish three main tasks. It will approximate a set of controllable plants by generating a large number of perturbed examples, perturb a nominal plant in an unstructured manner with a controllable amount of uncertainty, and generate time and frequency domain responses based on training data of example systems.

The diffusion generative model has shown great promise in creating novel and realistic samples from training data. This research will train a generative model to create Bode plots of transfer functions. This model will be given a nominal plant as an input and then generate a perturbed plant. Once created, this perturbed plant can be evaluated if it belongs to the set of controllable plants for a desired controller. This process will be repeated several times to generate enough plants to approximate the set of controllable plants.

These generated plants can be used to verify robustness of controller implementations. A model of a controller can use robust control theory to establish the set of controllable plants, but an actual implementation of a controller can not be verified as robust in the same way. Instead, it must be verified experimentally using elements of the set. Extracting elements of the set is not a trivial task, but if this research is successful, a generative model can reduce the effort required to create perturbed plants.

See next page

Please describe your current PhD thesis work and how different it is from your proposed research topic for this exam (300 words maximum):

My current PhD research focuses on hardware-in-the-loop (HiL) simulation and the cybersecurity of control systems. Over the past year, I have dedicated considerable time to establishing a HiL environment in the Instrumentation and Controls laboratory at Pitt. I plan to integrate formal methods and emerging secure-by-design technologies to develop secure controllers.

Robust control and diffusion models are not part of my future research, nor is the topic I'm proposing for this exam related to cybersecurity or formal methods. The only link between the two areas is HiL simulation. If this proposed topic proves successful, the simplest and perhaps only way to validate a controller with a perturbed plant would be through an HiL simulation of that plant. While HiL has influenced this research proposal, the field is so broad that it does not directly connect my current thesis work with this robust control generative model proposal.

List current and past graduate didactic courses taken to date since joining the PhD program

Number	Course Title	Grade
ME 2045	*Linear Control Systems*	*A*
ME 2646	*Linear System Theory*	*A-*
ME 2020	*Mechanical Vibrations*	*A*
ME 2027	*Advanced Dynamics*	*A*
ME 2811	*Innovating for Public Impact*	*A*
NUCE 2103	*Integration of Nuclear Plant Systems with the Reactor Core*	*A*
NUCE 2100	*Fundamentals of Nuclear Engineering*	*TBD*
ME 2016	*Nonlinear Dynamical Systems 1*	*TBD*

Both the student and the PhD advisor have to agree and sign the following statement:

The proposed research topic is original and not directly related to student's PhD dissertation research or their prior master's thesis

DocuSigned by:
691775384E3049F...
Student's signature

DocuSigned by:
Daniel Cole
180F5BDE411B4F4...
PhD Advisor's signature