Modelling and control of flexible robots subject to large loads

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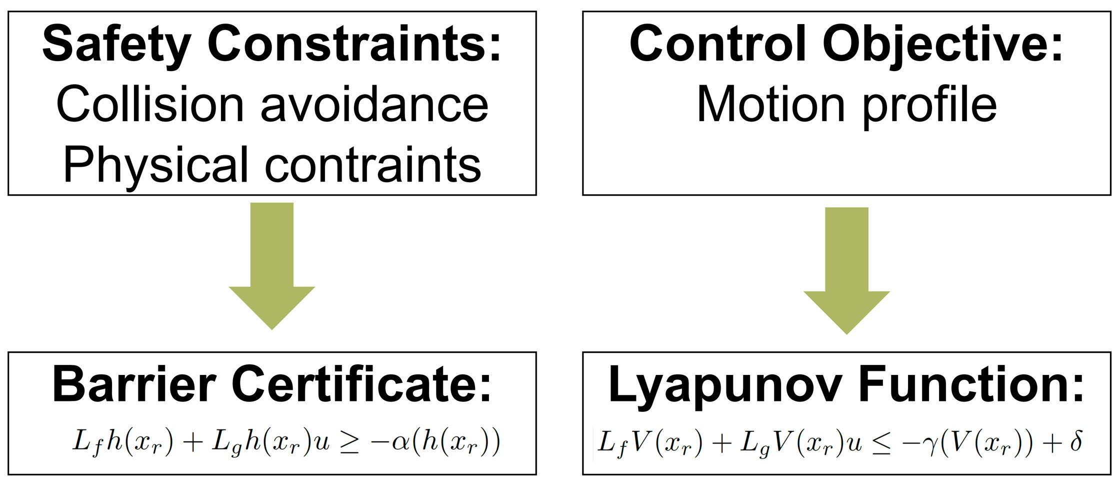
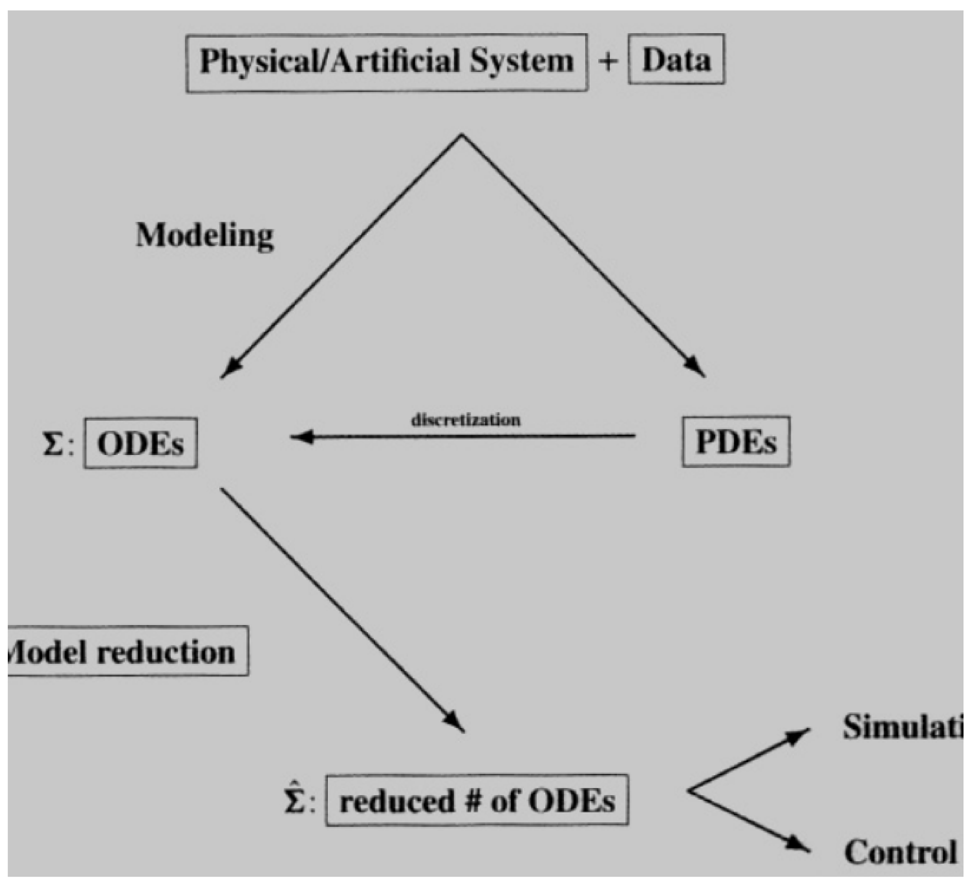
Background

The study presents a methodology and thereafter implementation for modeling and control of flexible robots subject to large loads. The design of guaranteeing controllers for safety critical systems has gained increasing interest in the last decades, as such methodology is necessary for applications such as self-driving cars and medical robots. Conducted studies adapted methodology of governing ordinary differential equation (ODE). But fewer studies adapted governing partial differential equation (PDE). The DEMOnstration power plant (DEMO) is part of EUROfusion roadmap and aims to show that fusion power plants can be used for commercial electricity production. A necessary condition for the operation of a fusion reactor is a robust and safe control system for maintenance, since one of the toplevel requirements of DEMO is reliability, maintainability, availability, and inspectability abbreviated by RAMI. Due to radiation within a fusion reactor, the remote maintenance is expected to be conducted autonomously. One maintenance task is the replacement of breeder blankets that are 12 m tall and have a mass of roughly 80 tonnes - this removal task is addressed in this paper.



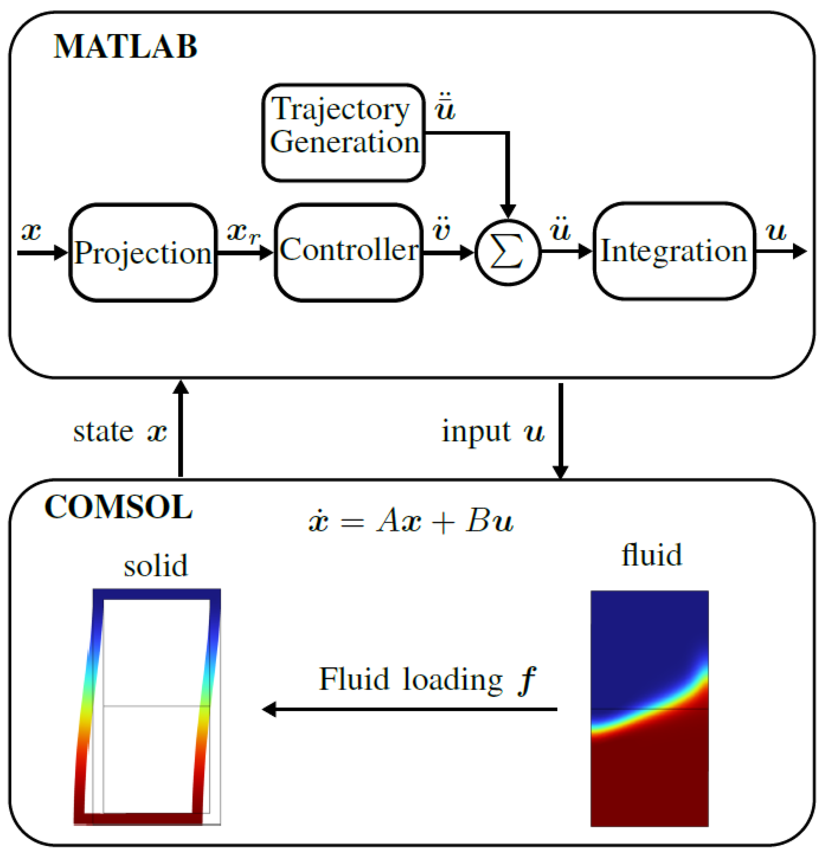
Optimal control with constraint

The controller that implements barrier certificates for guaranteeing safety of nonlinear control systems has gained increasing interest



Handling of PDE

This research will traverse various method for handling PDE. Typical method converting PDE to ODE is finite element method (FEM). The second method is energy-based modeling.



Framework

Through amalgamation of optimal control and handling PDE, the contoroller will ensure safety of deformable structure

Research Area

- Modelling and control of flexible robots subject to large loads
- Adaptive control uses barrier certificates
- Simulation of flexible objects
- Implementation of developed research into reliable software applications

DEMO

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Objectives

The major aim of the research is to develop the controller that guarantee safety based on partial differential governing equation and given information of adversary noise or the environment. The methodology comes from optimal control theory that ensure control Lyapunov function and control barrier function.

Safety

Value function for safety control

•Set invariance on the safe set

•Safe set $\mathcal{C}$ defined by value function $h(x) \geq 0$

$$\mathcal{C} = \{x \in \mathbb{R}^n : \ h(x) \geq 0\}$$

•Control barrier function

$$\forall x \in \mathbb{R}^n$$

$$\sup_{u \in U} [L_f h(x) + L_g h(x) u + \alpha(h(x)) \geq 0]$$

$$\Updownarrow$$

$\mathcal{C}$ is safe

Methodology/methods

a) Optimal control with safety certificates

The controller that implements barrier certificates for guaranteeing safety of nonlinear control systems has gained increasing interest. The safety verification framework has subsequently been extended to stochastic and robust control.

b) PDE handling

Typical method converting PDE to ODE is finite element method (FEM). The second method is energy-based modeling. Alternative naming for energy-based modeling is port-Hamiltonian system.

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