Integrated Tool Suite

Simulation as a Tool for Design

Introduction

The goal of this project is to introduce simulation earlier in the design process by automating the workflow associated with the design and control of complex mechanical systems.

Workflow Overview

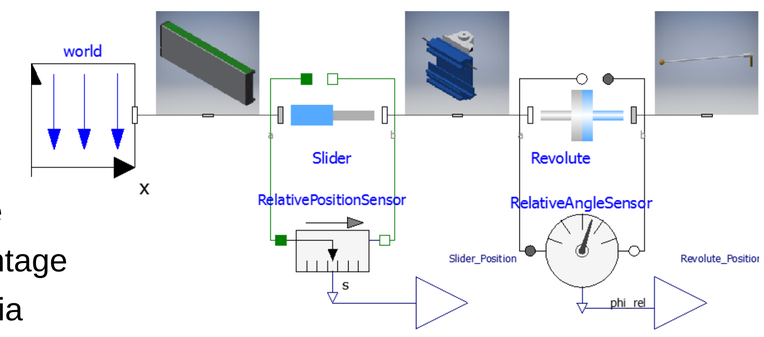
In the workflow, we start with a CAD model of our complex system then transfer the model into a simulation environment, where control software can be designed to control both the model in a simulation and the physical system. We can repeat this process until we get satisfactory behavior from our system before manufacturing the physical system.

Step 1: Computer Aided Design – Autodesk Inventor

We model our mechanical system in Autodesk Inventor. The CAD environment allows us to add constraints and specify material and mass properties. This information is crucial for modeling the dynamics of a mechanical system.

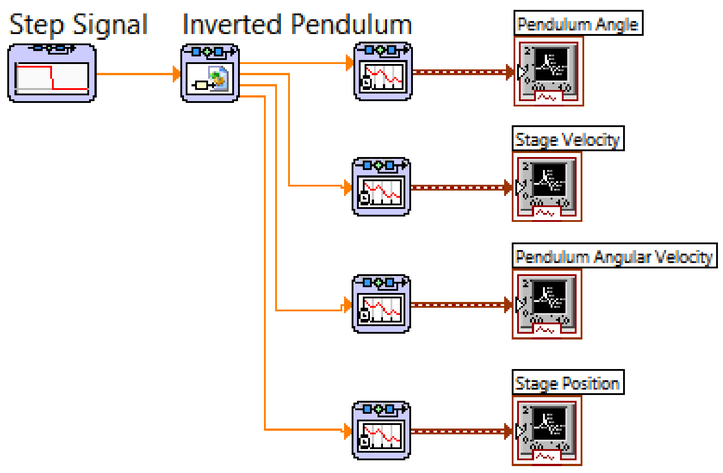
Step 2: System Modeling – Modelica

We use the Modelica modeling language as an intermediate step to convert the Inventor model into a LabVIEW block for control and simulation. We take advantage of the Modelica Standard Library for ready-to-use components to add multimedia components: motors, sensors, input and output blocks, and more.



Step 3: Simulation and Control System Design – LabVIEW

LabVIEW is a convenient tool for simulating dynamic systems, testing controller designs, and deploying control systems to real-time hardware in an integrated environment. Given a complex mechanical system as a FMU from Modelica, we convert the system into a plant model, tune system parameters, and design multilayer control systems for the mechanical system.



Step 4: Dynamic Visualization – Autodesk Inventor

LabVIEW simulation provides useful data about the position, velocity, and acceleration of all components using the original Modelica model. This information is used to visualize the dynamic behavior of the complex system by exporting the data to Inventor and using Inventor Dynamic Simulation.

Test Bed Overview

The following test beds illustrate a variety of properties found in real mechanical systems. Aside from the slider crank, we reverse engineer these physical systems to avoid bias from designing mechanisms that would adhere to the workflow.

1. DC Motor Test Stand

2. Inverted Pendulum

3. Five Axis Robotic Arm

4. Go Cart Drivetrain

5. Go Cart Steering

6. Slider Crank

For each test bed, we run through our prospective workflow and document challenges unique to each system.