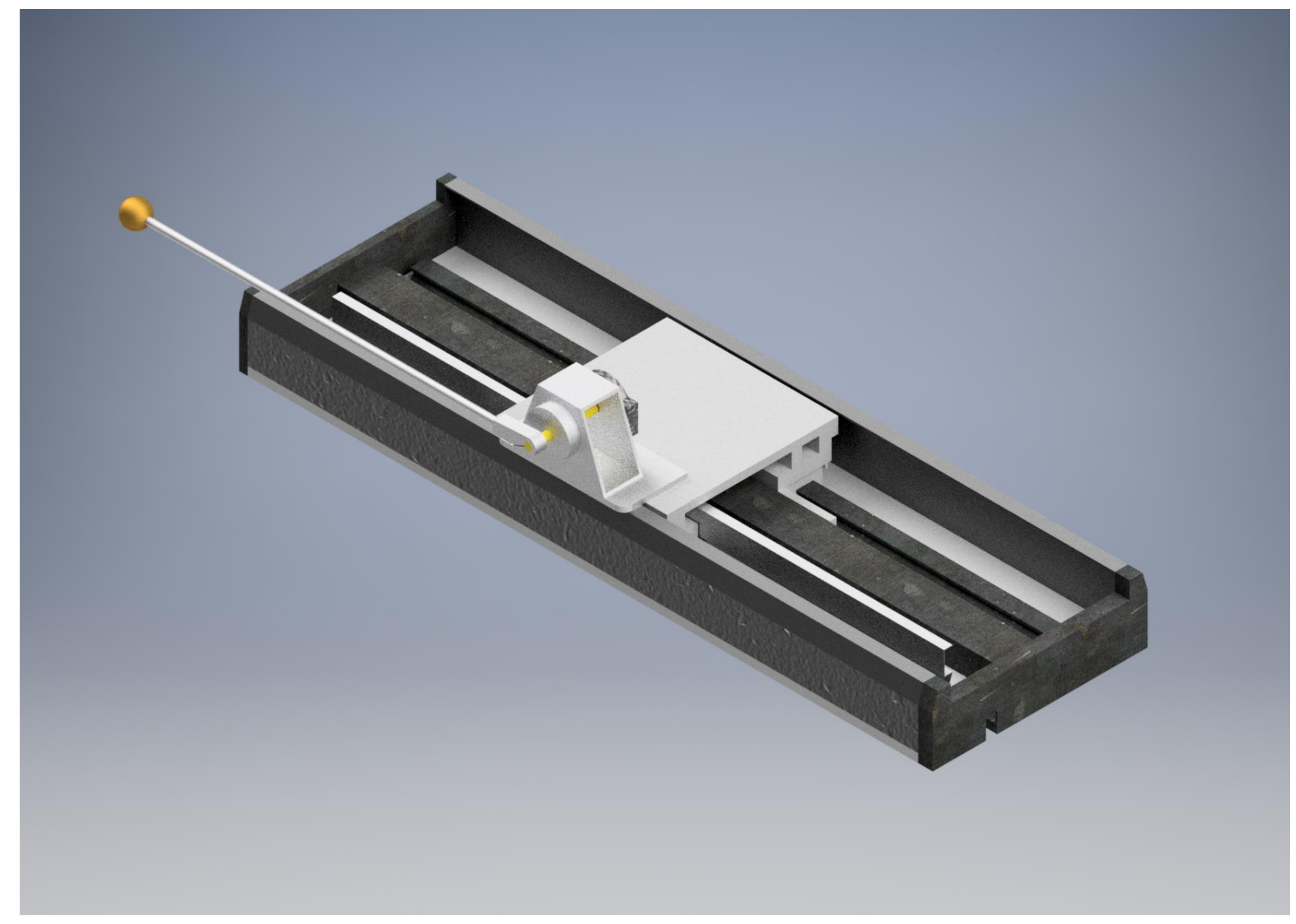
Inverted Pendulum

Integrated Tool Suite Test Bed

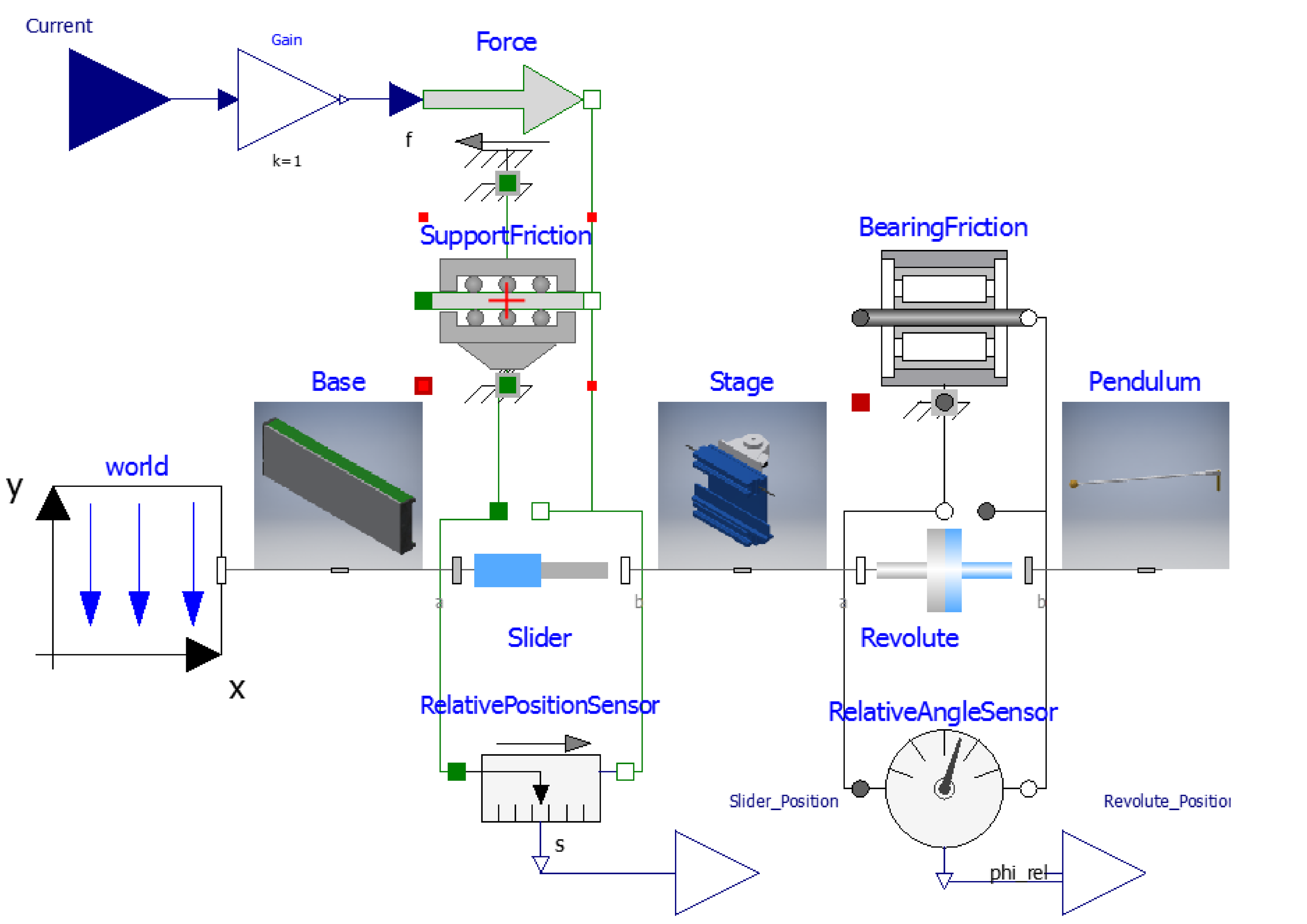


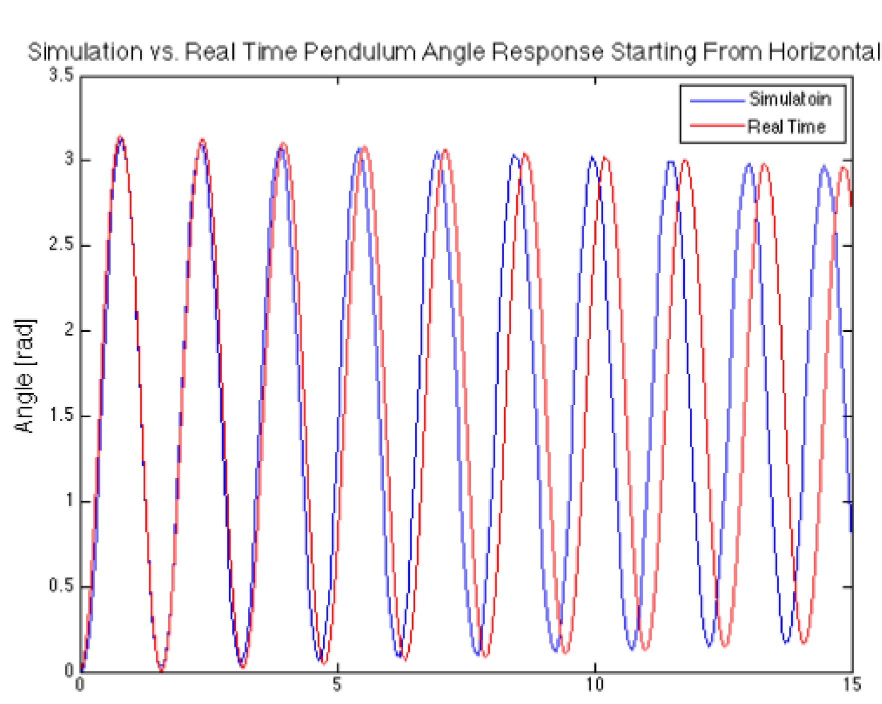
Introduction

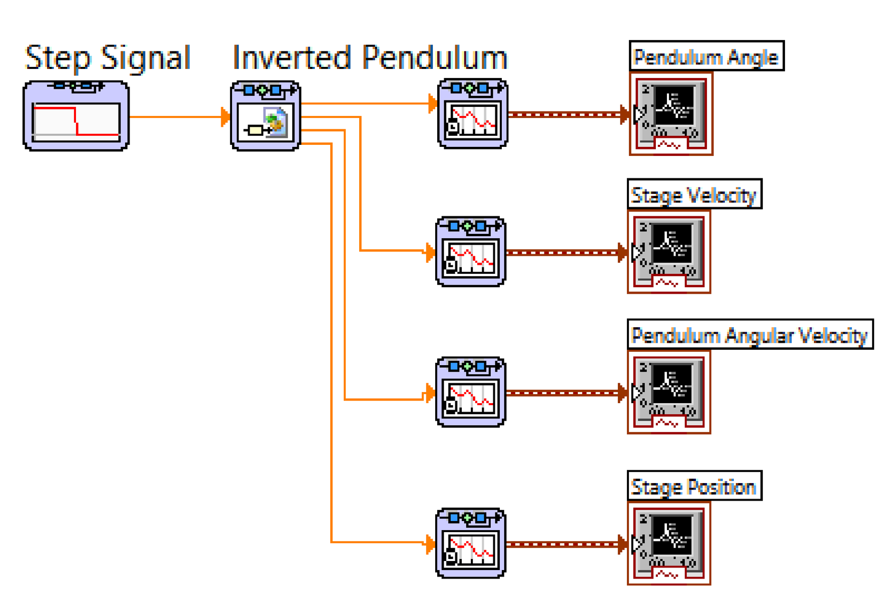
This poster will explore the end-to-end process of our prospective automated work flow for the design and control of an inverted pendulum. The inverted pendulum is an inherently unstable system and a classic problem in dynamics and control theory.

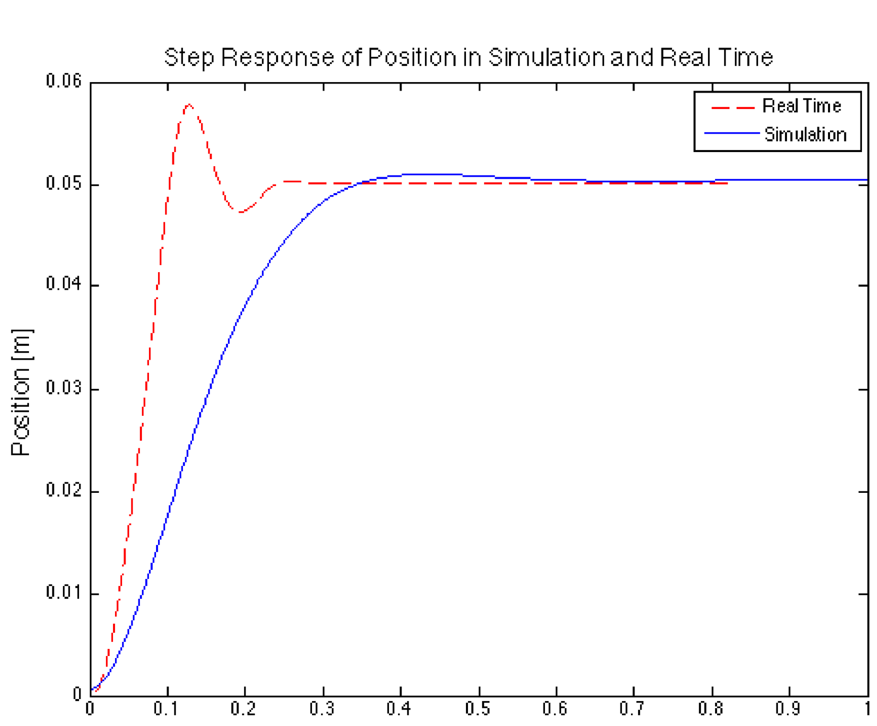
Workflow Overview

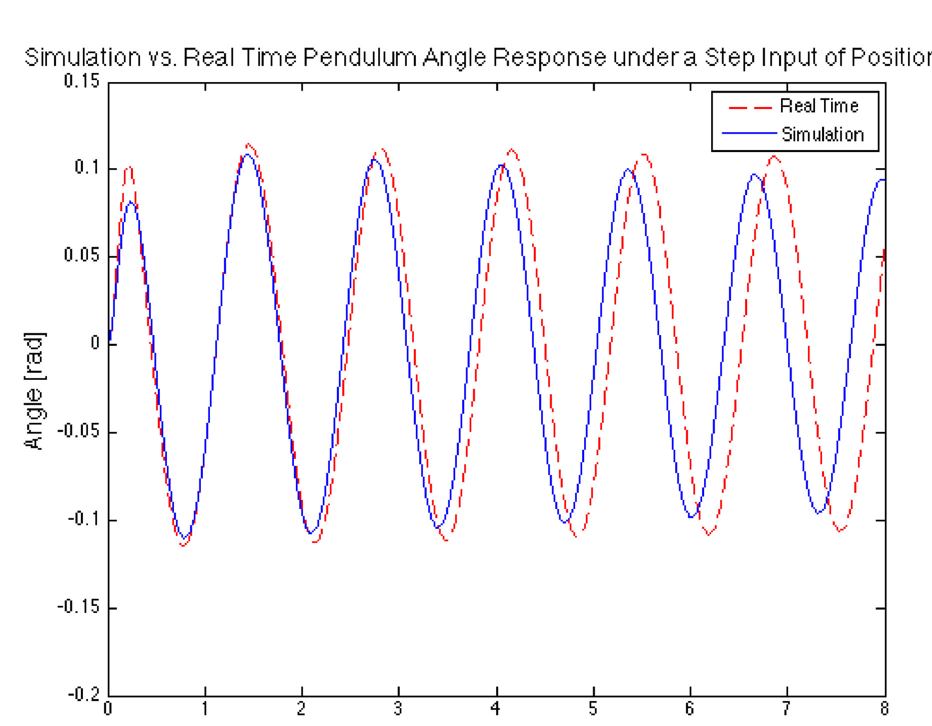
We start with a physical model of the inverted pendulum system, reverse engineer the process of designing it using Inventor, and export details of the system to LabVIEW. Then we compare results of simulations of the system in LabVIEW with the results of connecting the same control schema to the physical system.

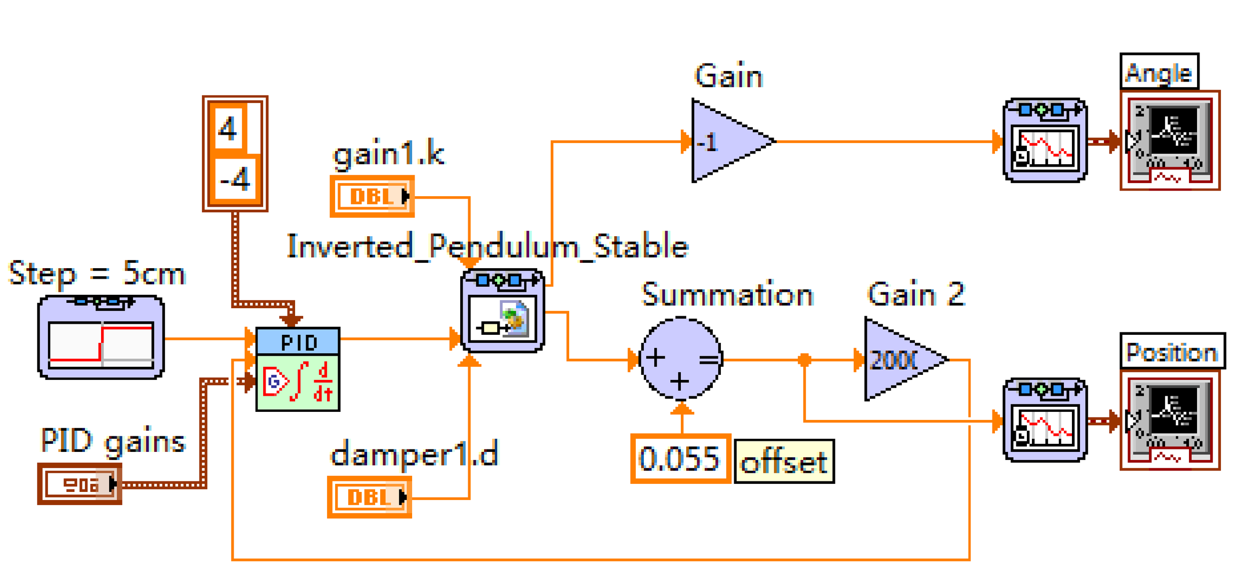












Step 1: Computer Aided Design

A model of the inverted pendulum is created in Inventor using dimensions from the fixture. The inverted pendulum system consists of three main parts: the pendulum, the stage, and the base. The stage slides along the base and the pendulum rotates about a point on the stage.

Step 2: Modelica-to-Inventor Translator

A Modelica model of the inverted pendulum is created using the Inventor-to-Modelica translation software. The translator is able to convert the constraints from the CAD model correctly but did not include multimedia elements needed in our model for simulation.

Step 3: Adding Multimedia Components

We can add the multimedia elements and relationships not captured by the translator by taking advantage of the Modelica Standard Library. For the inverted pendulum, we add components such as friction blocks, sensor blocks, and input/output terminals.

Step 4: Functional Mock-up Interface (FMI)

To convert our inverted pendulum model from Modelica to LabVIEW, we use JModelica and the Functional Mock-up Interface, a tool independent standard that supports model exchange and co-simulation.

Step 5: Tuning Model Specifications

In LabVIEW, we calibrate our model specifications by performing experiments comparing the simulation and the real time system to get accurate models of each component. For the inverted pendulum system, we tune the linear motor gains and friction coefficients.

Step 6: Control System Design

We implement a simple PD control system for the position of the stage in simulation and compare the results from the simulation with the results from the real time system using the same control system. In this example, we approximate friction with damping since the Modelica static friction blocks had trouble exporting to LabVIEW.

Step 7: Dynamic Visualization

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 the Dynamic Simulation tools available.

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