CAS 741: Problem Statement

Dynamical Systems: Multi-Pendulum

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Table 1: Revision History

Date	Developer(s)	Change
September 17, 2018	Karol Serkis	First revision of document
September 14, 2018	Karol Serkis	Problem Idea proposed & discussed with Dr. Spencer Smith

Problem

A simple gravity pendulum has very easy to system to model and consists of a weight suspended from a pivot and the weight is given enough space to swing freely. To simplify the model we assume no air resistance with a frictionless pivot [1]. The model and calculations for the simple gravity pendulum are well defined and only require simple derivations and differential solvers [2].

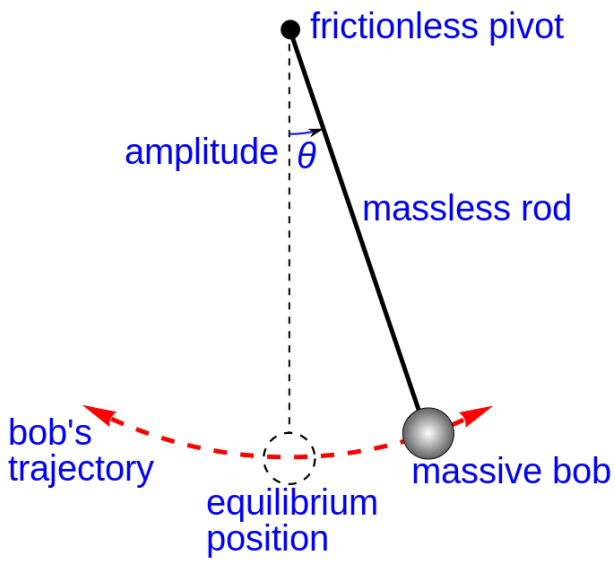

Figure 1: A simple gravity pendulum where the model assumes no friction or air resistance [1]

However, once you attach a pendulum to the bottom of another pendulum in the case of a double pendulum you have a new system that is dynamic and chaotic and requires a set of coupled ordinary differential equation solvers [3]. Once you introduce multiple pendula the system becomes chaotic and interesting to model and simulate.

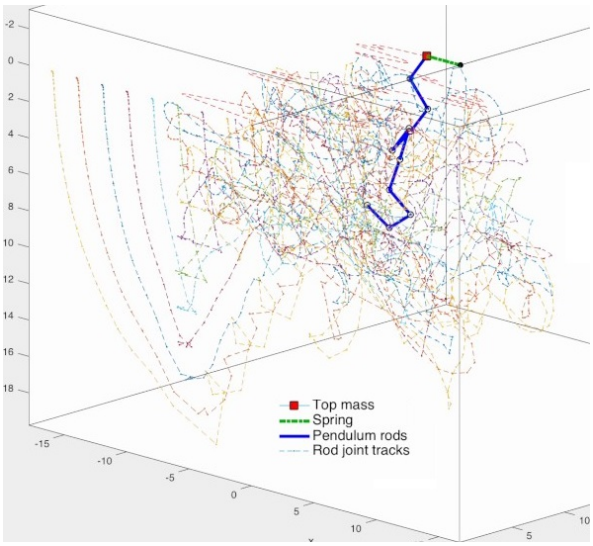

Figure 2: An example of dynamical and chaoitc system with Spring-Mass-Multi-Pendulum [5]

Proposed Solution

A proposed software solution will produce a simulation of a multi-pendulum system. Inspiration for this problem came from Dr. Ned Nedialkov's Multi-body Lagrangian Simulations using DAETS (Differential-Algebraic Equations by Taylor Series). DAETS is a C++ package for solving initial value problems for DAE systems [4].

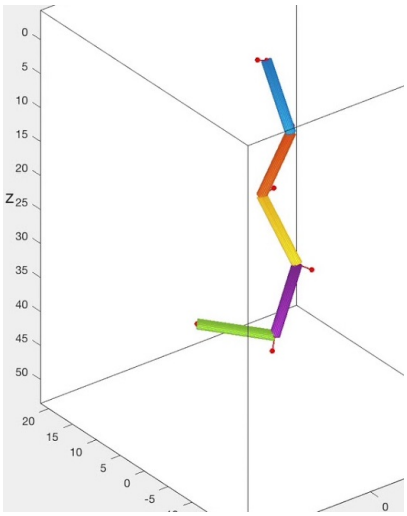

Figure 3: Simulation of Multi-Pendulum system using DAETS [5]

The proposed software is to develop a multi-platform equivalent solution that only focuses on multi-pendulum simulations and tracking the chaotic motion of the system. It will allow users to generate diagrams and plot trajectories over time using two different ODE/DAE initial value problem solvers [4]. If time allows, multiple solvers can be compared for performance and accuracy.

Context

Environment

The simulation software will be created with multi-platform support in mind and be compatible with Windows 10, Mac OS, Linux, etc. In order to achieve this, Python and/or MATLAB will be used for development of the software.

Stakeholders

Specific stakeholders include:

- Karol Serkis
- Dr. Spencer Smith
- Dr. Ned Nedialov
- Students of CAS 741
- Individuals studying or working in fields related to physics

References

- [1] Pendulum
  `https://en.wikipedia.org/wiki/Pendulum`
- [2] Pendulum (mathematics)
  `https://en.wikipedia.org/wiki/Pendulum_(mathematics)`
- [3] Double Pendulum
  `https://en.wikipedia.org/wiki/Double_pendulum`
- [4] Differential-Algebraic Equations by Taylor Series
  `http://www.cas.mcmaster.ca/~nedialk/daets/`
- [5] Multi-body Lagrangian Simulations
  `https://www.youtube.com/channel/UCCuLchOxOWOyoNE9KOCYlVQ`