Homework 3

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***Abstract*— 3 Scenarios as listed in the homework were performed in Google Collab and numerical results were recorded and plotted.**

I. SIMULATION 1

1. Simulation of the motion of the sphere of random mass *m* hanging under gravity. The mass is attached to two springs of stiffness *k*1 and *k*2 in the figure. Now you are going to construct a neural network to predict the mass of the sphere with random *k*1 and *k*2. How many input parameters do you need? What is the prediction error of your neural network model?

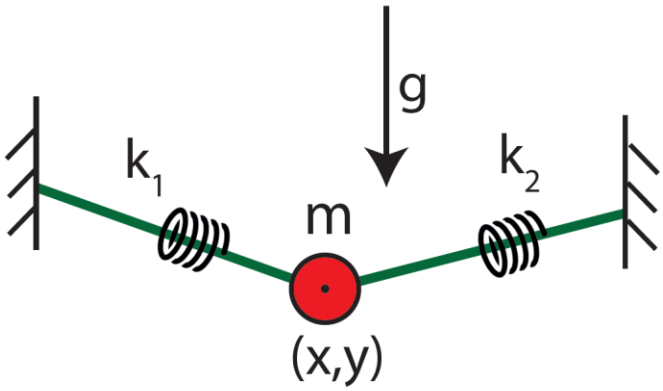

Fig. 1: Spring Mass System

B. Solution:

• The Neural Network Model to predict the mass given the stiffness of the two springs with stifness coefficients k1 and k2 and the final position of the mass is calculated in the Notebook provided by Dr. Ma and run in Google Collab.

In Totality 4 parameters are needed:

1) x-coordinate of the Final Position
2) y-coordinate of the Final Position
3) k1
4) k2

However, since we have it was advised to use k1 = k2, we get x = 0.5 as constant and the number of required parameters reduces to 2 (y-coordinate of the Final Position and k = k1 = k2) for the simplified system.

• RESULT: We get a prediction error of 0.09211 for this system from our trained Neural Network.

II. SIMULATION II

2. Simulation of the deformation of a two-edge beam hanging under gravity. Initially, the beam is straight in a horizontal line but with a certain value of initial velocity. Plot to compare the variation of bending angle over time *t* given certain initial velocity. Now you are going to construct a neural network / neural ODE to predict $\theta(t)$, given angle at previous time steps.

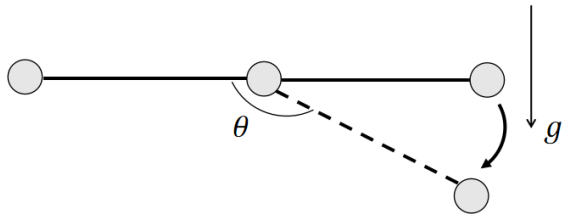

Fig. 2: Neural ODE System

2.1 Apply a fully-connected neural network. The output is the $\theta(t)$. The input is the bending angle θ at previous steps, e.g. $t\text{-}\Delta t$, $t\text{-}2\Delta t$, $t\text{-}3\Delta t$. What is the performance of the neural network model?

2.2 Apply a neural ode model to predict the evolution of $\theta(t)$ given the initial conditions of θ. What is the performance of the neural ode model?

The Neural ODE Model for this system is implemented in the IPython Notebook provided and running it on Google Collab.

1) **2.1: The Prediction Error of the Model is1.42e-5**. Also, the plot of the predicted values vs the actual values is shown in Figure 3 which further highlights that the model performed well.

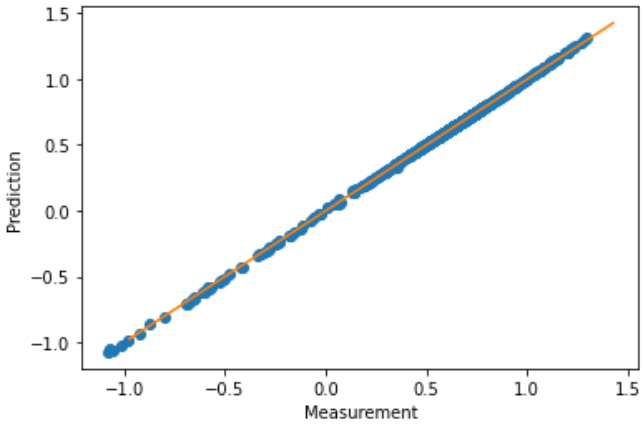

Fig. 3: Prediction vs Actual Values for 2.1

2) **2.2: The Prediction Error of the Model are 1.51098, 1.64718, and 1.819068 for the three different cases**.The plots of the trajectories are shown in Figure 4, 5 and 6,indicate the error is within an acceptable margin.

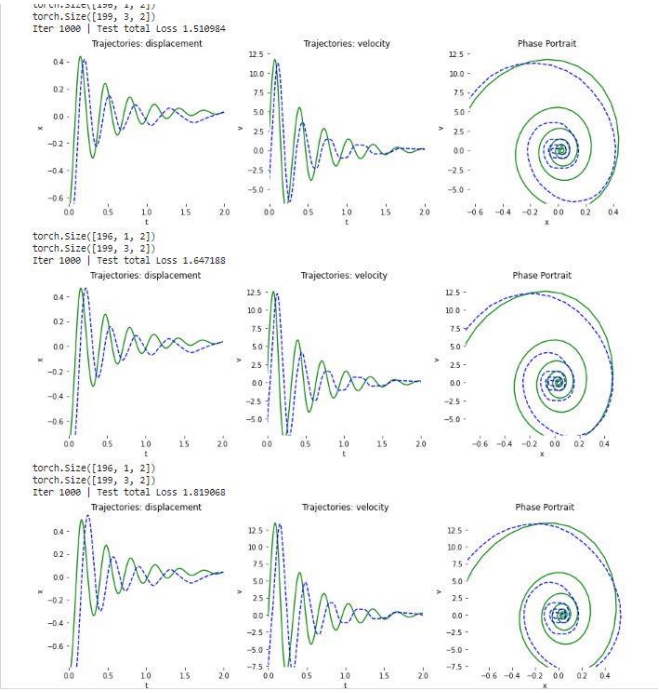

Fig. 4,5,6: Prediction vs Actual Values for 2.2

APPENDIX.

ACKNOWLEDGMENT

The homework makes use of many functions written by Dr. Leixin Ma, UCLA, Sameuli School of Engineering.

REFERENCES

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