Electronics and Computer Science
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An AI Approach to Chaotic Physical Systems:

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Abstract

Empirical laws are mathematical generalisations found through observing the physical world. It has taken us centuries of gathering data, keen research along with repeated experiments, and no doubt plenty of talented scientists to discover these laws. Leading us to understand everything from the mysteries that govern the collision of two objects to the shape of the path planets thread upon.

Recent advances in neural networks including increases in computational power permit us to train models, that replicate, fasten and automate our discovery of empirical laws. This extends to even noisy chaotic systems such as the double pendulum. Combined with white box models, symbolic regression and explanable A.I., we can peer into the ”mind,” of how such models, process data and conclude their observations. Human congition is inherently finite in its capacity for thought and observational ability, has been historically overcome through the development of new tools such as the microscope. Similarly, congitive biases can be mitigated, by utillising artificial intelligence, which is a rapidly emerging technology capable of expanding our perception and analysis.

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Abstract

I would like to thank my supervisors, Professor Adam Peugeot and Professor David Millard, for all the help and advise I received throughout this project.

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1 Introduction:

1.1 Motivation:

1.2 Previous Work:

2 Noise:

In this section, I aimed to explore how noise affects the model, and potential ways to mitigate it. Continuing onwards from the previous model, in the data generation step, noise was artificially added, and the results were observed.

2.1 How noise affects the model:

So in order to add noise to the generated data set, I imported in random, and used the randn.int function. In order to vary the inputs, another function was created that incrememntally passes in higher numbers as parameters to the random function, allowing each set of generated data to incrememntally become more and more noisy. Then the symbolic regression model is run on these new data sets, and the resulting equations levels of noise are then plotted in a graph. Furthermore using the Time library to measure the amount of time it takes to run the model as the amount of random error increases.

2.2 How to mitigate noise in data:

Ways to mitigate the noise and it's affects on the model were explored. Functions such as "denoise," in the symbolic regression library helped to some extent. However after a certain point, such methods do not seem to offer much assistance.

3 Predicting future states using initial conditions:

One of the use cases of such AI models, is to infact predict the future states and values of chaotic systems. This has been applied to find approximate solutions for various initial states for complex problems such as the 3 body problem(check this!). It will be applied here on the simplest chaotic system, which is a double pendulum. Using a neural network and training data, we will explore how the prediction works with varying levels of initial force and conditions.

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3.4 Prediction of future states:

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