Dynamical System State Prediction based on Generative Adversarial Network

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1 Project Aim

The Generative adversarial network is famous for it can be used to process pictures, there is another interesting direction of the application of Generative adversarial network is that it may be used to predict the state of dynamicals system. This project attempts to use the generative adversarial network to predict the state of the dynamical system. According to the given dynamical system model, through the learning of the generative adversarial network, the random input from latent space is used to generate the output consistent with the model to achieve the prediction purpose. This is a good attempt to apply neural network to dynamical systems. This approach will provide a new idea for dealing with dynamical system problems and be more efficient.

This project can be categorised into AI & Robotics because the generative adversarial network is a form of generative model for unsupervised learning, also proven useful for semi-supervised learning, fully supervised learning and reinforcement learning. At present, Generative adversarial network has a very wide range of applications in the field of artificial intelligence.

2 Related work

In 2014, Ian Goodfellow first invented the Generative adversarial network (GAN), his idea is two neural networks contest with each other in a game[1]. A good overview published be Hong et al. discussed the the details of GANs and focus on how the GAN can be combined with an autoencoder framework[2]. Wu et al. wrote a paper about enforcing statistical constraints in GAN to solve the partial differential equations in simulating complex physical systems[7]. Zheng et al. used a generative adversarial network approach to generate phasor measurement unit (PMU) data[8]. Li et al. proposed the anomaly detection with GAN

for multivariate time series in large and complex cyber-physical systems[3], they also named a new type of GAN which is MAD-GAN[4]. Olof Mogren proposed a generative adversarial model working on continuous sequential data which is C-RNN-GAN[6]. There is also an analysis of nonautonomous adversarial systems wrote by Arash Mehrjou[5].

3 Project Objectives

A complete project can be divided into several small objectives, each objective has a relationship between the top and bottom, and the successful completion of the previous objective is the basis for the start of the next objective. At the very beginning of a project, the first thing to do is a literature review. Through the review, we can understand what other researchers have done relevant to the current project. By summing up, it can be known that in the current field what can be improved or innovated. After completing the literature review, understand the programming language and learning library required for the current project, learn and build the experimental environment required for the project to ensure the smooth development of the project. Next, first test the feasibility of the current project through a simple model. In the dynamical system, we can test it by a simple single pendulum model to see if the generative adversarial network can predict the state of the pendulum model well. Then increase the complexity of the model, for example, it can change the single pendulum model to a double pendulum model, or other more complex dynamical system models, like Foucault pendulum model. When generative adversarial network can complete the prediction of more complex dynamical system models, analyse the current results and consider more complex or more generalised models make the project more applicable. Finally, summarise all experimental data and results, make discussion, and finally complete the thesis writing.

Separate objectives are listed below.

1. Literature review
   A good literature review will be a part of the final thesis.

2. Experimental environment construction
   PyTorch platform will be constructed and be able to do the experiment.

3. Simple pendulum model build
   A good model will be able to describe the state of the pendulum.

4. Apply Generative adversarial network to predict simple pendulum model
   Generative adversarial network will be able to predict the state based on simple pendulum model.

5. Foucault pendulum model build
   Complicate single pendulum models, introduce more Foucault pendulum models, increase input parameters and dimensions.

6. Apply Generative adversarial network to predict Foucault pendulum model
   Generative adversarial network will be able to predict the state based on Foucault pendulum model.

7. Result analysis and discussion
   The analysis and discussion will be a part of the final thesis.

8. Final thesis
   The final thesis will be finished on time and fulfill requirements.

4 Methodology

The primary research methods of this project are literature review and dynamical system modelling. Through the literature review, it can be understand the basics of GAN and the application of Generative adversarial network in this field. Establish different dynamical system models, and apply Generative adversarial network to train them. To evaluate the performance of the gan network, quantitative analysis methods are used here to compare the model results and prediction results. Finally, through the results analysis and discussion, summarise and evaluate the applicability of Generative adversarial network in dynamical system state prediction.

5 Project plan

5.1 Feasibility

This project is the application of neural networks. I took the neural computation module in the master stage, and I have experience in training neural networks in the coursework of this module. I have experience using frameworks such as Tensonflow and Keras. In this project, I will train Generative adversarial network based on PyTorch. At the same time, I also have a certain physical foundation to build some complex dynamical systems.

5.2 Gantt Chart

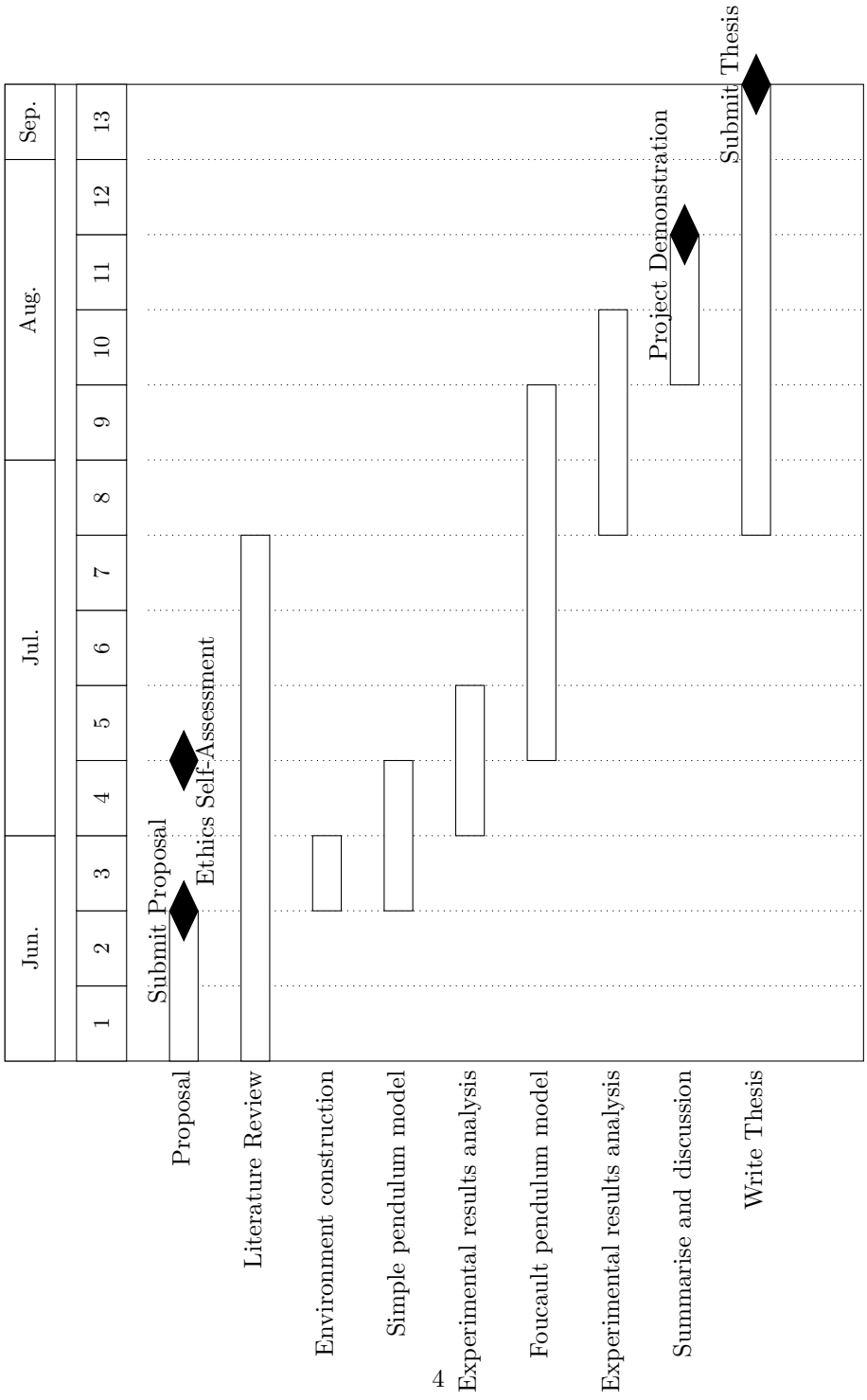

Figure 1: Gantt Chart for Project Plan

6 Risks and contingency plan

This project is a brand new field and a new attempt, and there is not much relevant work to refer to, which is a big challenge for the work. For me, the worry is whether the Generative Adversarial network can perform well in the prediction of dynamical system states, and the modelling of complex dynamical systems is difficult for me. If the project does not complete as expected, If the project does not complete as expected, or the Genertive adversarial network predictions on dynamical systems is not as good as expected. I can start with the experimental results, analyse the performance of the Genertive adversarial network and why it does not perform well in the dynamical system state prediction tasks.

References

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