Causality with Deep Learning

Proposal
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1 Introduction

Traditionally, to determine the causal relationship, one must perform the randomized test to determine the causality of the variables. However, alternatively, one can create a causal model to determine the causal relationship. Both of which can be exploited with deep learning. However, the hypothesis testing exploitation will be explored

1.1 Hypothesis testing exploitation

As the process of hypothesis testing involves evaluating the test statistics and using that to find the critical region under the distribution. However, that can be simplified, hopefully, into the classification problem that can be exploited with the machine learning model. The transformation of the data into its representation form, i.e., embedding might reveal the underlying causal relation. The use of a machine learning model in substitution for hypothesis testing for causal inference will be explored, along with the analysis of the power of testing using a classification model.

2 Dataset

ASSISTments dataset[1] will be explored in various aspects.

3 Proposed Method (Roughly)

3.1 Hypothesis testing exploitation

1. Explore the hypothesis testing and analyze the classification problem as the statistical test to show the feasibility of the method and analyze the tradeoff of this method.
2. Comparing the traditional method of determining the causal relationship with the deep learning model mainly aims to classify whether to reject the null hypothesis (whether A has an effect on B) or not.

4 Goal

To apply the exploited homogenity test to test whether the result from the treatment group and outcome group are homogenious or not. If the result is not homogenious, then the treatment group has an effect on the outcome group.

5 Literature Review

5.1 Explotation on f-divergence

Definition 1. *Let $p(x)$ and $q(x)$ be two probability distributions such that $q(x) > 0$ for all x and let f be a function that is convex and satisfies $f(0) = 0$. Then, f-divergence is defined as*

$$D_f(p||q) = \int p(x) f\left(\frac{p(x)}{q(x)}\right) dx \tag{1}$$

One can see that f-divergence family would include the KL divergence, Jensen-Shannon divergence, etc. With this, one can exploit the f-divergence in order for semiparametric homogenity test.

5.2 Homogenity test

6 Approach

6.1 Prove that the transformation of embedding is sufficient for test statistic

6.2 Prove that the model itself have the same classification power as the hypothesis testing

In this path, one can easily show empirically that the type II error rate is the same as the power of the test. However, the problem arise when the prove is needed to be done analytically, which is the main goal of this project.

References

[1] Wang, Y., Heffernan, N. T., and Heffernan, C. Towards better affect detectors: Effect of missing skills, class features and common wrong answers. In *Proceedings of the Fifth International Conference on Learning Analytics And Knowledge* (New York, NY, USA, 2015), LAK '15, Association for Computing Machinery, p. 31–35.