Causal Scene Generation

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Abstract

The project aims to procedurally generate 2D images from natural language where the causal model describes the relationship between the entities in the caption. By taking the vision- as – inverse graphics view of computer vision, we could think of captions as natural language representation of the data generating process that generated the accompanying image.

1 Introduction

A causal model aims to represent a data generating process. There have been numerous attempts to model text to an image and it predominantly involves usage of a Generative Adversarial Network or GAN. [1] shows an existing GAN model which attempts to display an image that describes the text, however ineffectively. It doesn't capture the necessary relation between all the entities in the image. This is where a causal model would be highly beneficial, to capture the relationship between the different entities. To give an example, we could have a caption "*A man is walking towards a door*". If we have a causal model and a procedural image generation scheme, we could ask a counterfactual question, "*Had it been a woman*", what would the image look like? This independent study is a humble attempt at figuring out the necessary pieces needed to solve scene generation from text by showing a proof of concept that works for a pre-defined universe with limited entities.

2 Background

The current work is an extension of a project titled "*Causal Object Oriented Programming*" where, a proof-of-concept was created to answer probabilistic queries for different entities that are related using Pyro [2] This work utilized Avi Pfeffer's concept of Bayesian Object Oriented Programming[3] which was originally created in a programming language named Figaro using Scala. This work allowed us to represent real world entities and their relationship with other entities, probabilistically with the familiarity of Object-Oriented Programming. In this work, we considered a toy example found in [3] and reproduced the results in pyro. The example and the corresponding code base for this work could be found here [4]

3 Methods

The different components required to generate a scene from caption are, a causal model that understands the relations between the entities, a procedural generation scheme to draw the 2D image given the necessary metadata about the image and a natural language parser to get all the required metadata from the captions.

3.1 Procedural Generation

A procedural generation is an automated way of creating data. Here, we are trying to automatically generate 2D images given some metadata about the image. In our example, we considered a universe of game characters (currently two characters Satyr and Golem) doing a limited set of actions like Attack, Taunt, Walk etc. Each set of character has different types where the armor, head color and the way they perform the actions varies. The procedural generation code creates different versions of the character which didn't exist in the original

set.

HEAD HAIR TORSO WEAPON GENERATED CHARACTER

The above is an example of how a 2D image can be generated from different metadata. With the help of the above rendering mechanism, we can generate a scene by giving some information about the scene. We basically use a look up table to get to the corresponding images and merge them all together. Each image is of the same height and width.

3.2 Causal Model

A causal model represents the data generating process. For scene generation, the interplay between the different entities in a scene can be captured by a causal model. To give an example, say, we have a caption "*A boy is walking on the road*". Here, the boy is an entity and the action that entity is doing is walking. The background environment where this scene takes place is the road. Suppose, if we ask a counterfactual question, "*Had it been a girl?* ", then we need to know about the data generating process and get the action and the background the girl (entity) has the high probability of occurring with. We use the pyro framework to create causal models.

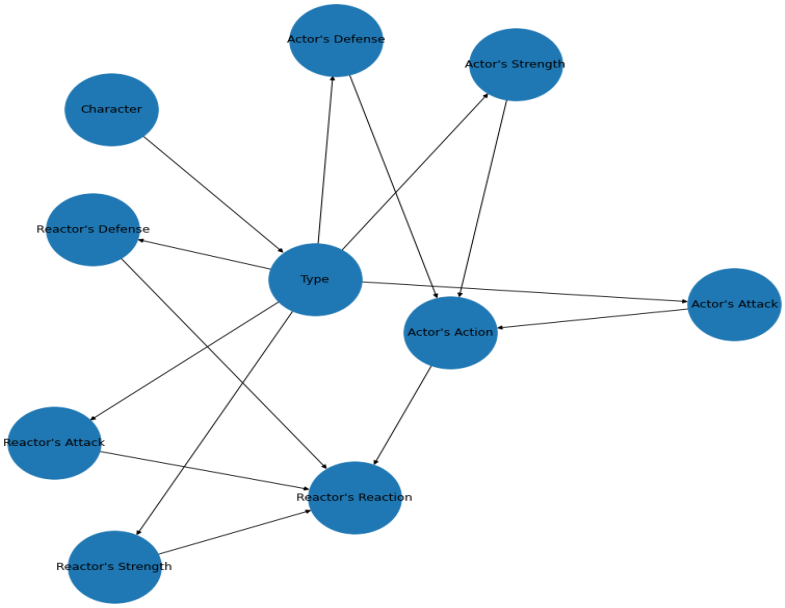
4 Implementation

To build a causal model, we decided to use the characters that appear in games. We chose two characters, Satyr and Golem and decided to give attributes like Strength, Defense and Attack that define their behavior. Each attribute can be either high or low.The causal model tries to represent what happens when these characters interact with each other. To model this, we first need the sample space of all the actions that they can do. The different activities that each character does are Walking, Taunting, Being Idle, Attacking, Getting Hurt if they're attacked and possibly die. Each Character has 3 different ways by which they can visually appear and they affect the character's attributes. All the different actions and the types that each character does correspond to a different image.

To make things simpler, each interaction has an actor, one who instigates or makes an action towards the other character based on his own attributes. The other character simply reacts to the action based on his own attributes. The probabilities in which each character is chosen and doing other actions are randomly assigned, for now, in the form of conditional probability tables and not learnt from data.

4.1 DAG

A Directed Acyclic Graph explains how the random variables in the process affect each other. In the following image, the character and its type affect the attributes, like strength, attack and defense. The actor's action in that scene depends on his strength, defense and attack. The reactor's reaction depends on his attributes and the actor's action.



4.2 Sample Image

When we just randomly sample the probabilistic model, we get an actor's action and reactor's action along with the respective character and type. Based on this metadata, we can draw an image of the scene.

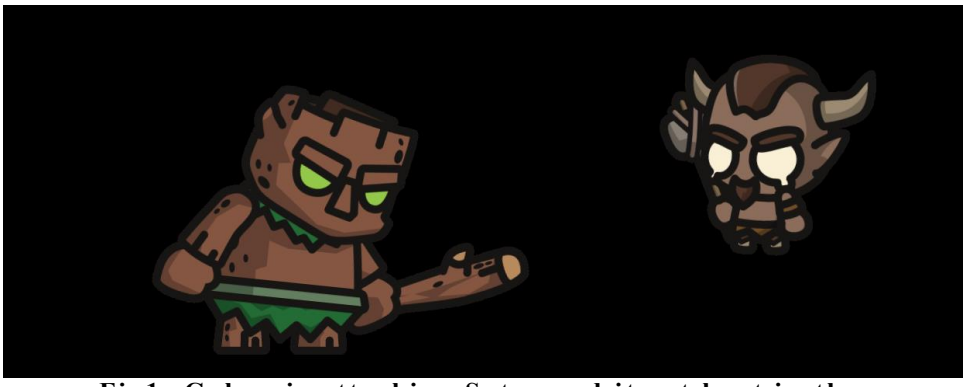


Fig1: Golem is attacking Satyr and it got hurt in the process.

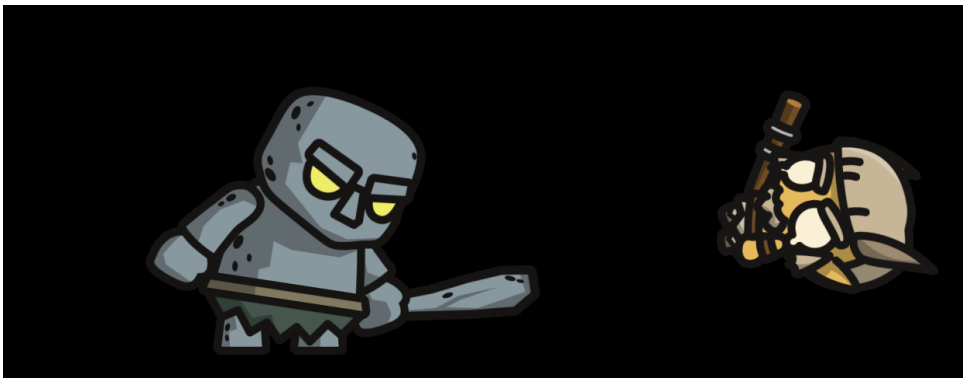


Fig2: Golem is attacking Satyr and it died in the process

5 Results

TODO

6 Discussion

TODO

References

[1] https://experiments.runwayml.com/generative_engine/

[2] http://pyro.ai/examples/intro_part_i.html

[3] https://www.manning.com/books/practical-probabilistic-programming

[4] https://github.com/robertness/causalML/tree/master/projects/causal%20OOP/causal_oop_social_media/ppp_replication