Playing Story Creation Games With Logical Abduction

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Abstract. Story Creation Games, such as Rory's Story Cubes and the Tell Tale card game, require players to invent creative and coherent narratives from a set of unconnected elements assembled by random chance, e.g., the throw of a die or the draw of a card. We model this human ability as a process of logical abduction, where the reasoning task is to identify a set of assumptions about a fictional world that logically entail the elements depicted on the dice or on the cards. We demonstrate the feasibility of this approach by hand-authoring a knowledge base of axioms that is sufficient to generate eight creative narratives each related to three Tell Tale cards, depicting a baseball player, a heart, and a train.

Keywords: story creation games, commonsense knowledge, logical abduction

1 Introduction

Story Creation Games, such as Rory's Story Cubes and the Tell Tale card game, require players to invent creative and coherent narratives from a set of unconnected elements assembled by random chance, e.g., the throw of a die or the draw of a card. Often producing comical and entertaining storylines, these games also demonstrate the remarkable human capacity for sense-making, where one's knowledge and experience is used to explain the co-occurrence of novel combinations of observations.

We hypothesize that this sense-making capacity can be modeled algorithmically as a process of logical abduction. As first described by the philosopher Charles Pierce (1839-1914), logical abduction is a reasoning process, distinct from deduction or induction, that searches for assumptions that, if they were indeed true, would logically entail a set of observations given a knowledge base of logical axioms. Although abduction is not a sound reasoning mechanism, it is a natural fit for tasks where the goal is to find some set of unobserved states or events that would account for those that are observed, e.g., diagnostic tasks. In story creation games like Rory's Story Cubes and the Tell Tale card game, the dice and cards are the observations, and the proof structure of the entailing assumptions provides a narrative solution.

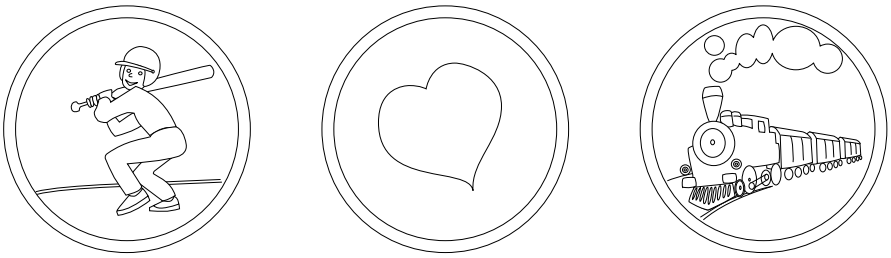

Fig. 1. Images of a baseball player, a heart, and a train, as depicted on Tell Tale cards

To explore the this approach to creative story generation, we attempted to use an existing abductive reasoning engine to output narratives that corresponded to those produced by human players of story creation games. We began by asking friends, family, and colleagues to produce fictional situations that included each of the elements depicted on three cards from the Tell Tale card game[1], as shown in Figure 1. We selected eight of these solutions as targets to reproduce via logical abduction:

1. Once there was a boy playing baseball, and when it was his turn at bat, his heart was beating like a train in anticipation of the pitch.
2. Once there was a boy playing baseball, and when it was his turn at bat, his heart was beating like a train from the physical activity of the sport.
3. A professional baseball player commutes to the practice field by train, and eventually falls in love with the conductor who he sees each time.
4. If you love sports, you must train.
5. I missed the baseball game because the train was late and this broke my heart.
6. The life story of this devotional local baseball club member is not complete without mentioning that his death was caused by a heart disease that he developed over many years while having to practice close to train tracks, where he was constantly exposed to diesel exhausts containing nitrogen dioxide.
7. Once there was a train who loved watching baseball. It was always late when passing fields on game days.
8. A boy had his birthday party on a train and hit a heart-shaped piñata with a bat.

As a software engine for logical abduction, we utilized `EtcAbductionPy`[2], an open-source implementation of Etcetera Abduction [5] for knowledge bases expressed as definite clauses in first-order logic. For each of the eight stories, we hand-authored a set of axioms (definite clauses) such that the top-ranked solution found using `EtcAbductionPy` mirrored our own conceptualization of its

[1] http://blueorangegames.com
[2] https://github.com/asgordon/EtcAbductionPy

narrative structure. Although other researchers have shown the natural language representations can be generated from solutions of this sort [1], we made no attempts to generate natural language in our current research.

2 Example: Heart Beating Like a Train

To generate an abductive solution that approximated the first interpretation in the list above, we devised a set of axioms (definite clauses) such that each of the three cards could be logically entailed by an overlapping set of narrative assumptions. In these axioms, the cards themselves were represented as distinct predicates without arguments, while the narrative entities that explained them were encoded as predicates with variables representing events and states, as in the following examples:

$$at\_bat'(e, b) \wedge etc1(0.1, e, b) \rightarrow card\_baseball \tag{1}$$

$$etc2(0.1, e, b) \rightarrow at\_bat'(e, b) \tag{2}$$

Here, the predicate at_bat' represents the event e of a baseball player b being the batter at a moment in a baseball game. In the second of these axioms, this event is itself explained by an etcetera literal, i.e., an assumption that reifies the prior probability of the event. Defeasibly, the batter might experience performance anxiety during such an event, which would defeasibly lead them to have a racing heart, which explains the observed heart card, encoded in the following three axioms:

$$at\_bat'(e1, b) \wedge etc3(0.1, e1, e, b) \rightarrow performance\_anxiety'(e, b) \tag{3}$$

$$performance\_anxiety'(e1, p) \wedge etc4(0.1, e1, p, e, h) \rightarrow racing\_heart'(e, h) \tag{4}$$

$$racing\_heart'(e1, h) \wedge etc5(0.1, e1, h) \rightarrow card\_heart \tag{5}$$

Defeasibly, the event of a racing heart might be metaphorically like a train, and this metaphor itself explains the observation of the train card, encoded as follows:

$$racing\_heart'(e1, p) \wedge etc6(0.1, e, e1, p) \rightarrow like\_a\_train'(e, e1) \tag{6}$$

$$like\_a\_train'(e1, e2) \wedge etc7(0.1, e1, e2) \rightarrow card\_train \tag{7}$$

Given these seven axioms, `etcAbductionPy` finds solutions by backward-chaining from the three observations (the three cards), unifying antecedent literals wherever possible, until all assumptions are expressed as etcetera literals. Variables remaining in these literals are replaced with Skolem constants that instantiate events, objects, states, and characters in the imagined narrative. When using `etcAbductionPy`, a proof of the observables can be obtained by forward-chaining from any set of identified assumptions. Here, forward-chaining from these Skolemized assumptions using these seven axioms deductively entails the three observed cards.

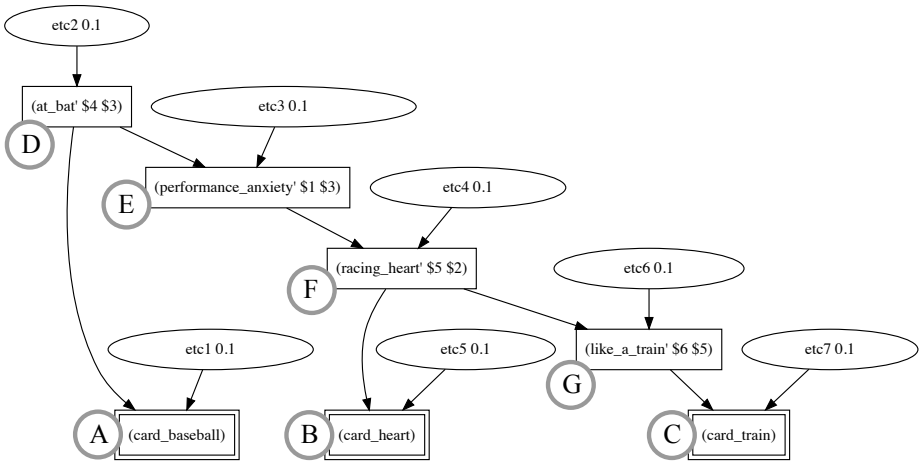

Fig. 2. Abductive proof representing the three cards (A,B,C), the inferred narrative (D,E,F,G), and seven assumptions (ovals) of prior and conditional probabilities.

Figure 2 is a graphical representation of this proof structure for our first story, as produced by `etcAbductionPy`. Here the heart and the train cards have a racing heart as a common factor, while the baseball player card and this racing heart have a common factor of a baseball player at bat.

In all, we authored 72 axioms (definite clauses) to reproduce the narrative structures in the eight stories of our analysis. The main finding of our analysis was that it was, indeed, possible for us to generate formal approximations of our own informal understandings of these eight stories using abductive reasoning. While the software itself was often cumbersome and the notation of axioms was prone to authoring errors, we found that the reasoning procedure of logical abduction was a natural fit for the algorithmic generation of creative storylines. Creative story generation can be modeled as a process of logical abduction, and in this respect shares much in common with the generation of causal explanations of observable evidence and in the interpretation of natural language discourse [7], and other interpretation tasks [6].

We contrast this approach with those proposed in related work on story generation [3, 8], particularly with recent work on narrative text generation using neural networks [10, 2, 9, 4]. Our analysis, where the three input cards generate extremely different yet coherent stories, highlights the combinatorial nature of the task as a search for coherent combination of associations among the input observations—and encourages future neural network approaches to incorporate analogous mechanisms in their architectures.

3 Acknowledgments

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