Comparing Formal Frameworks of Narrative Structure

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Abstract

Aiming at a formal representation of narratives that captures the intuitive notion of *being the same story*, we discuss the comparison of two different formal frameworks.

1 Introduction

We aim at capturing the informal human notion of *equivalence of stories* in a formal system in such a way that two stories are perceived as equivalent when their formal representations are isomorphic (cf. (Löwe, Pacuit, and Saraf 2009, §§1.1 & 5.2)). There is no unique "human notion of equivalence of stories" as the research on analogical reasoning shows (Rattermann and Gentner 1987; Lam 2008); whether two stories are perceived as *versions of the same plot* by human audiences is a matter of context and emphasis. Yet we believe that with a reasonably fixed context, humans will be able to meaningfully compare the structure of stories and make informed decisions about structural equivalence.

In (Löwe and Pacuit 2008; Löwe, Pacuit, and Saraf 2009), the authors propose a formalism based on a language for preferences and iterated beliefs for narratives which could be called the *Doxastic Preference Framework* (DPF). In contrast to many other formal models of narrative, DPF uses a very sparse language, essentially reducing the entire narrative to questions about temporal order, preferences and (iterated) beliefs. This implies that DPF will give narratives the same formal structure that would be given different formal structures in more expressive frameworks: for instance, two stories that are the same all aspects expressible in terms of preferences and iterated beliefs will necessarily get the same formal representation in DPF.

We believe that formal systems adequate for capturing the informal notion of *equivalence of stories* are likely to be closer to such coarse frameworks than to the very elaborate models based on first or even fragments of higher order logic that are being used (with great success) in the automated *Story Understanding* community. Systems of a similar granularity as DPF (but quite different in approach) are Lehnert's *Plot Units* (Lehnert 1981) or Rumelhart's *Story Grammars* (Rumelhart 1980), and naturally, one would like to compare the adequacy of these approaches (in relation to the task at hand, i.e., capturing the notion of being the same story) to each other.

In this note, we give a general discussion of what it entails to compare two formal frameworks. We give semi-formal definitions in § 2 and then give a few examples (without any formal details) in § 3.

2 Formal Frameworks

Comparing the adequacy of frameworks is not a formal task, but deals with the degree of representation of the informal notions in the formal setting. It depends on ambiguities of the informal data, or—even worse—on the process of transforming the informal data into the formal model.

Our *narratives* are typically given in natural language or in some format of natural language with additional extralinguistic information (e.g., as movies or as an actual narrative act). On the other hand, a *formal framework* is a mathematical or logical entity, given by a *syntax* and a corresponding *semantics*. The syntax determines a formal language which in turn determines a type of mathematical model for the formal language together with a notion of *satisfaction* in the usual sense of mathematical logic. There is a natural notion of *isomorphism* between models of the right type for the given formal language (denoted by $\simeq$): as usual, bijections preserving all of the relevant structure; it is a purely mathematical notion and whether two models in the same formal framework are isomorphic or not cannot be a matter of debate.

After fixing a formal framework Σ, a *formalization* is a process assigning to each narrative one or multiple models of the right type for the formal system Σ. It can consist of multiple models if the formal framework requires modelling decisions for which the narrative provides no answer. For instance, suppose that the formal framework has a predicate P standing for "has a wart on his nose", but the text only provides the truth value of P for agent a, and not for agent b. Then there would be two models, one with $P(b)$ and one with $\neg P(b)$ representing the narrative equally well.

The formalization is performed by a human *formaliser* who understands the narrative and then produces the model based on his or her understanding of the narrative. A for-

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malization (despite its name) is necessarily a semi-formal process: it links the narratives—informal objects—to mathematical objects. There is no unique way of transforming a narrative to a formal object. The exact formal object assigned to a narrative will, e.g., depend on the intended granularity of the formalization.

Even if we try to fix the level of granularity by objective rules, it is possible to run into situations where the final formal representation of a part of a narrative depends on the interpretation of the formalizer. One such example is given in (Löwe, Pacuit, and Saraf 2009, § 3.3). However, in concrete cases, we feel that a sufficient level of objectivity can be reached that allows for individual assessments.

This dependency on the human formaliser relates our problem to issues in several other fields linking the humanities to the formal sciences. To name but one example (another would be musical corpora), in linguistics, corpora (i.e., natural language) are being annotated (Leech 2005) to be represented in formal grammatical structures. The rules of the annotation are typically given by a list of examples in annotation guidelines. Neither human error nor disagreement of annotators is excluded, but probably much less drastic than what can happen in the formalization of narratives.

In the following discussion, we shall ignore these problems and assume that with a sufficient amount of specification of the formalisation process, we can define a precise semi-formal operation $F : N \mapsto F(N)$ from narratives to sets of mathematical objects. Under this assumption, each formal system Σ together with a formalisation F generates a relation $\equiv_{\Sigma,F}$ between narratives by

$$N \equiv_{\Sigma,F} N^* :\Leftrightarrow \forall M \in F(N) \exists M^* \in F(N^*)(M \simeq M^*).$$

3 Comparison

We compare two formal frameworks by studying the granularity of the relation $\equiv_{\Sigma,F}$. Fixing two different formal frameworks Σ and Σ^* and corresponding formalisations F and F^*, there are three cases:

Case 1 (Σ, F) is a refinement of (Σ^*, F^*). This means that for any two narratives N and N^*, if $N \equiv_{\Sigma^*,F^*} N^*$, then $N \equiv_{\Sigma,F} N^*$.

Case 2 (Σ^*, F^*) is a refinement of (Σ, F). This means that for any two narratives N and N^*, if $N \equiv_{\Sigma,F} N^*$, then $N \equiv_{\Sigma^*,F^*} N^*$.

Case 3 The frameworks are incomparable. This means that there are narratives N_0, N_1, N_2, and N_4 such that $N_0 \equiv_{\Sigma,F} N_1$, $N_0 \not\equiv_{\Sigma^*,F^*} N_1$. $N_2 \equiv_{\Sigma^*,F^*} N_3$, and $N_2 \not\equiv_{\Sigma,F} N_3$.

Case 3 is the interesting case and contains the potential for deeper understanding of the strengths and weaknesses of our formal frameworks: in such a situation, we can compare the two semi-formal relations $\equiv_{\Sigma,F}$ and $\equiv_{\Sigma^*,F^*}$ to our intuition of whether the narratives are *versions of the same plot*. Do our intuitions conform with one of the two relations? We can also use Case 3 for the development of new formal frameworks: if our intuitions disagreed with $\equiv_{\Sigma,F}$ due to a lack of sensitivity to distinctive features, these feature should be added in an improved system.

Future work should focus on comparing different formal frameworks, in particular frameworks that have been studied over the decades. In this direction, some preliminary steps have been taken. However, here we would like to close with an example from the analysis of stories from the TV series *CSI: Crime Scene Investigation*™ with the DPF. The underlying structure of the DPF is a game tree on which the agents play a *game of changing and mistaken beliefs*. The game played is a perfect information game (i.e., all agents are aware of all played moves; cf. (Löwe, Pacuit, and Saraf 2009, § 3.2) for a discussion of the issues related to this) and it requires a strict chronological order, i.e., an explicit representation of temporal structure.

Suppose that in a given episode N, the chronological order of two actions a_0 and a_1 cannot be determined from the video material. The order does not matter for the story, so both possible models (the model M_0 that first lists a_0, then a_1, and the model M_1 that first lists a_1, then a_0) are formal representations of the same story. Minute variations of the video (for instance, creating an alternative narrative N^* by adding a visible clock in both scenes) will result in a change of formalisation: if the video fixes that a_0 happened before a_1, then M_1 is not an adequate formalization anymore, so $M_1 \notin F(N^*)$, and hence $N \not\equiv_{\Sigma,F} N^*$. This formal result seems to contradict our intuition that adding the clocks did not matter for the structure of the story, and could in turn be taken as an argument for formal frameworks without explicit representation of temporal structure (but rather a representation of the information structure).

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