Applications of AI Planning: Story Telling

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1 Introduction

The classic types of problems dealt with in the field of artificial intelligence planning are problem-solving tasks where the length of plans and the time for finding them are to be minimized. This is referred to as "classical planning". AI planning in this traditional sense is already applicable to various practical tasks, such as route planning or logistics. Additional areas of application can be found where the task at hand can be modeled in a way that is structurally similar to classical planning problems. One such area is *story telling*, where AI planning has been applied for well over a decade and currently is the dominant technology in use[1].

For a first intuition of how "story telling by means of planning" can look like, one can consider a story as being modeled as a sequence of actions performed by story characters. Given an initial world state, a goal and a set of characters with certain actions they can perform, a planner can create a coherent story leading from its beginning to the end. This is, of course, just a very basic notion. The inherent differences between classic problem-solving tasks and stories lead to significant deviations from techniques in classical planning and interesting challenges when more sophisticated approaches to narrative generation are considered.

The remainder of this document is a general introduction to story telling as an application area of AI planning. It is structured as follows:

- Section 2, "Differences to classical planning", describes what differences arise when dealing with stories instead of classic problem-solving tasks as a basis for planning.
- Section 3, "Story world modeling", discusses ways of translating a story into a planning problem.
- Section 4, "Concrete approaches", showcases two approaches of using planning for story telling.
- Section 5, "Conclusion", sums up the subject matter with a short discussion.

2 Differences to classical planning

Although the process of generating a story can be modeled as a planning task, the underlying nature of a classic planning problem and a narrative is very different. As a consequence there are similarities at a coarse level and differences once more complex properties are taken into account. An essential similarity on a very simple level: both the solution to a planning problem and a narrative are a sequence of successive steps, leading from a beginning to an end. In contrast, a key difference: a desired quality of a classic planning problem solution is shortness. Qualities sought in narratives, however, are less easily quantifiable, aesthetic properties such as "interestingness" and "originality". While there is no obvious solution as to how such properties can be encoded in a planning problem and optimised for, it is easily recognizable that shortness is not an optimum. A basic approach towards generating interesting stories is introducing variation. For a given, rough outline of a story, variation in character actions (within reasonable bounds of the story world) or changes in perspective can make for an interesting narrative.

Depending on what properties of a narrative are taken into account, further requirements or constraints have to be considered. These can sometimes be incorporated into the modeling of the story world — such that the resulting planning problem can be solved by an off-the-shelf solver — some efforts, however, make use of custom a solver. An example for such a solver, tailored for narrative planning, is IPOCL[2], which takes causality and character intentionality into account.

Since a common use case for narrative planning is interactive story telling, there is a need for systems capable of replanning in response to changes to the story world introduced by a human element. This is less of a difference between classical and narrative planning in and of themselves but a special requirement for certain narrative planning systems due to forementioned characteristic use case.

3 Story world modeling

The notion of a story as a sequence of character actions is easy to understand. However, the actual modeling of a story world as a planning problem can — depending on the level of sophistication of the modeling — be quite involved.

As a baisc example, consider the following story:

> "In a fictional world with a continent named Westeros, the high-born refugee Viserys sold his younger sister Daenerys to a warlord in exchange for the warlord's army. He used the army to conquer Westeros and become its king."

In order to create a planing problem from this textual representation one has to decide on how to identify predicates and operators. From there, initial and goal states can be defined. Actions can, for example, be acts carried out by characters and predicates the character's circumstances. For above example this would yield the predicates $A = \{V\text{-}has\text{-}army, V\text{-}king, D\text{-}sold\}$ and operators $O = \{V\text{-}sell\text{-}D, V\text{-}conquer\text{-}W\}$ where:
$V\text{-}sell\text{-}D = \langle \neg V\text{-}has\text{-}army \wedge \neg D\text{-}sold\ , V\text{-}has\text{-}army \wedge D\text{-}sold \rangle$
$V\text{-}conquer\text{-}W = \langle V\text{-}has\text{-}army \wedge \neg V\text{-}king\ , V\text{-}king \rangle$
Building upon the identified predicates:
$I = \neg V\text{-}has\text{-}army \wedge \neg V\text{-}king \wedge \neg D\text{-}sold$ (initial state)
$\gamma = V\text{-}king$ (goal formula)
$\Pi = \langle A, I, O, \gamma \rangle$ (planning task)

Above example shows how a very minimal story can be modeled as a planning task but it doesn't really make it clear why this would be useful. The problem is, that it is a mere one-to-one "translation" and solving the planning task results in nothing more than the story which was used a as starting point. Narrative generation becomes useful once its result is something *new*. This is the case, for example, when things like story variations or interactivity are introduced or when planning story structures based on fundamental world rules and a set of characters. This is also when the modeling process becomes more involved. Chapters 4.2, "Planning a fabula", and 4.3, "Planning a discourse", will describe two instances of such modeling approaches in more detail.

4 Concrete approaches

4.1 Narratology excursion

The following two subsections (4.2 and 4.3) will showcase two concrete cases of story telling by application of AI planning. Because they approach the

subject matter on different levels a distiction is required. It will be necessary to distinguish between *fabula* (or *story*) on the one hand, and *discourse* (or *plot*) on the other hand.
Chatman writes in [3] (furthermore cited in [4]):

> "In simple terms, the story is the *what* in a narrative that is depicted, discourse is the *how*."
>
> (Note: Since *story* and *plot* are more commonly used in everyday language and might lead to confusion or wrong assumptions the remainder of this document will refer to the two concepts as *fabula* and *discourse*.)

To illustrate the difference with an example: viewers of a movie might be presented with a character A, talking about what a character B has done (assume A's report to be truthful and B's action to be relevant for the movie). On the level of the fabula (the narrative structure), we have B doing something. On the level of the discourse (how this is conveyed to the recipient) we have A talking about it. When watching a movie or reading a book one is presented with a discourse and automatically constructs a fabula in their head.

4.2 Planning a fabula

In [5] Haslum shows how a specific model of story generation proposed for the IPOCL planner[6] can be compiled into a classic planning problem. The model in question is designed to create fabulae and incorporates the notion of character intetions. The following subsection will describe the story world modeling in general. After that aforementioned compilation will be adressed.

4.2.1 Story world modeling

The central building blocks in this apporach are story characters for which certain abilities are defined. For illustration purposes a story world which is loosely based on the tale of Aladdin is used. Characters are humans (Aladdin, Jasmine, king Jafar) and monsters (a genie, a dragon). The characters' abilities are actions which can be divided into intentional actions and happenings.

The former are deliberate interactions with the story world or other characters (such as traveling between locations or slaying a monster) while the latter are unintentional effects (e.g. a monster scaring a human because of its appearance or a human falling in love with another).

In order to create coherent, believable fabulae the modeling lays its focus on intentionality. Apart from the desired story outcome (the goal of the overall planning problem) characters can have their own goals which can arise and change through influence by the story world. Intentionality can also be caused by delegation — i.e. a character A evokes a character goal in another character B (for example through a command or persuasion). Most importantly character goals allow for *intentional plans* which characters can pursue. When a character has a goal and carries out an action in order to reach it, the action is said to be performed in a *frame of commitment*. Formally these terms are defined as follows:

> "**Definition 1** An intentional plan is one in which every occurrence of an intentional action is part of some frame of commitment. A frame of commitment is a subset S' of steps (i.e., action occurrences) in the plan, associated with a modal literal (*intends* A g), satisfying four requirements: (1) Character A is an actor of every step in S'. (2) There is a final step $s_{fin} \in S'$ that makes g true. (3) There is a motivating step s_m in the plan, which adds (*intends* A g) and which precedes all steps in S'. We'll say there is a motivational link from s_m to every step in the frame of commitment, S'. Note that s_m is not part of S'. (4) From each step in S' other than s_{fin} there is a path of causal or motivational links to s_{fin}. A complete (fabula) plan is one that is both intentional and valid in the classical sense." [5]

To visually aid the formal definition consider figure 1 on page 6. Arrows are to represent actions and dashed lines an arbitrary sequence of actions not shown. If all blue arrows are actions carried out by character A then the frame of commitment is $S' = \{s_i, s_{i+1}, s_{i+x}, s_{fin}\}$. Note that s_m does not necessarily have to be an action of A since intention can be delegated and that the intentional plan which includes S' may contain an arbitrary number of happenings unrelated to S' or g.

Ensuring that character goals are pursued by means of intentional plans is referred to as *explicit justification tracking*. In [6] this is performed by the

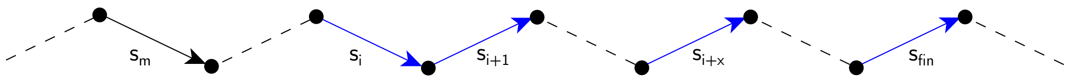

Figure 1: Visual example of a frame of commitment.

IPOCL planner but in [5] it is incorporated into the planning problem. This is accomplished by the main compilation described in [5] and will be briefly discussed in the following subsection.

4.2.2 Compilation

The original story generation model includes modal literals in the form of (*intends A g*) in order to handle intentionality. For the compilation into a classic planning problem predicates are introduced for intention, delegation and justification. Intention literals are used as preconditions for intentional actions, which allows the modeling of frames of commitment — e.g. (*intends-dead Aladdin Dragon*) as a precondition for every action in Aladdins frame of commitment to slay the dragon including the s_{fin} of him achieving his goal. Delegation and justification literals, on the other hand, are used for justification tracking. They are true in the initial state, required to be true at the goal, made false by certain intentional actions and then set up in a way such that only if motivational link as described in Definition 1 are adhered to will they become true again.

Description and discussion of this compilation's precise nature take up most of [5] and can therefore not be covered here. To get an intuition of a possible output consider below example of a monster slaying action in PPDL-like syntax.

```
1  (:action slay-1-because-intends-dead
2      :parameters (?knight - knight ?monster - monster ?where - place)
3      :precondition (and (alive ?knight) (at ?knight ?where)
4                         (alive ?monster) (at ?monster ?where)
5                         (intends ?knight (dead ?monster))
6                    (not (exists (?c) (and (not (= ?c ?knight))
7                                       (delegated ?c (dead ?monster))))))
8      :effect (and (not (alive ?monster)) (dead ?monster)
9          (justified (at ?knight ?where) (intends ?knight (dead ?monster)))
10         (justified (at ?monster ?where) (intends ?knight (dead ?monster)))
11         (not (delegated ?knight (dead ?monster)))))
```

A notable restriction of the compilation is that a delegated goal can only be achieved by the character it has been delegated to. In case of above monster slaying example this can be seen in lines 6 and 7. The monster may only be slain if there exists no other knight to whom the death of the monster has already been delegated.

4.2.3 Result

As already mentioned the story generation model at hand is designed to create fabulae. The result a planner produces therefore is a story *structure*. (TODO: Fig. 1 from Haslum paper in appendix or just mention?)

4.3 Planning a discourse

In [1] Porteous, Cavazza, and Charles present an approach to narrative generation on the level of discourse. The main focus of the proposed system is generating variation and being suitable for *interactive* story telling. Both aspects are realized through the way the story world is modeled and therefore will be part of the following subsection.

4.3.1 Story world modeling

For illustration purposes [1] employs the *pound of flesh* sub-plot of Shakespeare's *The Merchant of Venice*, which revolves around a loan agreement between Antonio, a wealthy Christian merchant and Shylock, a Jewish moneylender. Primary aspects of the story world modeling are the concepts of narrative control knowlege and decomposition — to allow interactivity and generated variation (deviation introduced by a non deterministic element) whilst adhering to a predefined baseline plot — and the usage of character PoV (point of view) — to generate variation. The modeling process that implements these constructs is illustrated in figure 2 on page 8 and will be explained in the following.

Narrative control knowlege makes it possible to control the shape of a narrative. It's concrete use in the modeling approach at hand is to guide the narrative along a predetermined baseline plot. This is done by identifying key components of the plot structure and formulating state trajectory constraints, which are based on story world predicates. An example for the *pound of flesh* sub-plot would be the predicate (*sealed-bond-over-load shylock antonio*).

These constraints are then implemented by PDDL3.0's modal operators *sometime-before* and *sometime*. Interesting to note is, that for a given generated story not all identified constraints are used. Only choosing a subset for each generation process is a way to introduce variation.

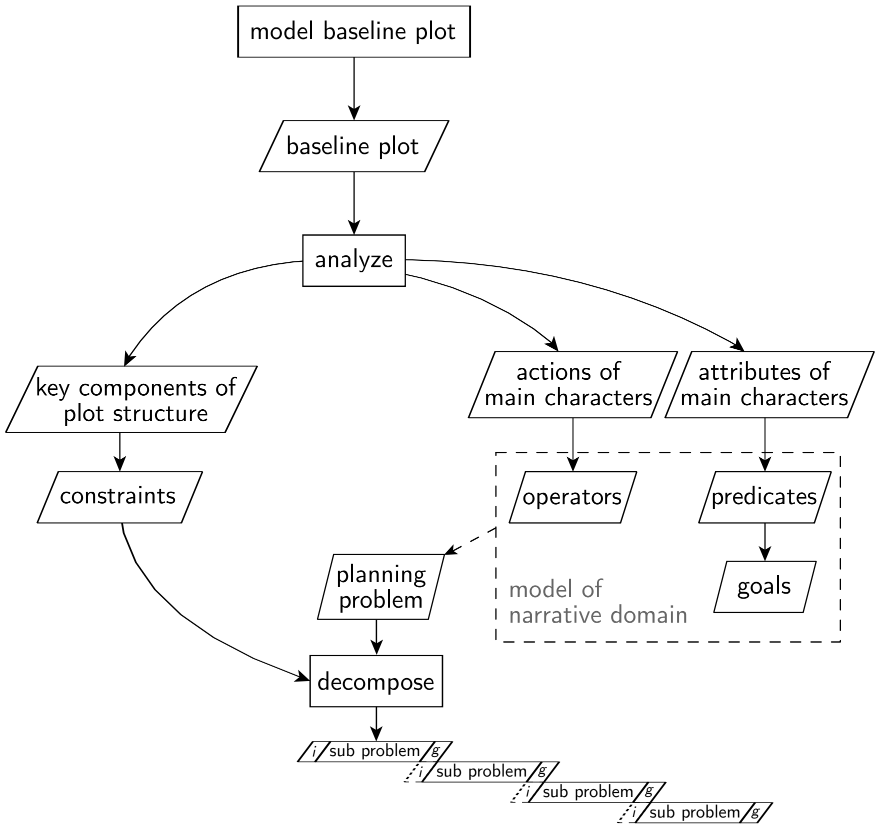

Figure 2: Visualization of the modeling process.

Similar to the story world modeling in section 4.2 attributes and actions of characters are translated into predicates and operators. Together with the goal built upon predicates this forms the model of narrative domain which leads to the initial planning problem. The chosen subset of constraints is then used to decompose the planning problem into several sub problems where the goal of a problem n is the initial state of the problem $n + 1$. This practice of decomposition accomplishes two things. First, since the constraints used are always different it leads to variation in the output; second, it allows for quick replanning which is necessary in the event of intervention — i.e. when the system is used for interactive story planning.

The key aspect that is not visible in 2 is PoV.

4.3.2 Result

5 Conclusion

References

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