Approaches to Story Planning using Causal Links, Agents and Commonsense Ontology

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ABSTRACT

Story generation systems have been around for decades with the intent of making machines learn to generate human understandable stories. In this paper, we present a comparative analysis of the approaches employed by Picture Books 2 (PB2) and its variants, PB2 Planning Agents and PB2 ConceptNet, to produce children's stories of the fable form. The comparison is aimed at determining whether the enhancement of the storytelling knowledge and the use of agents that can reason over this knowledge during story planning would lead to the generation of stories that contain more cohesive story events. Specifically, two forms of enhancement were made; first, by using pre- and post-conditions as additional criteria in the selection of candidate events; and second, by using existing language resources to supply the necessary commonsense knowledge needed by story generation.

Comparative evaluation of the three systems using the criteria on *coherence and cohesion*, *story elements* and *content* showed that PB2 Planning Agents received the highest overall average score of 4.25 out of 5, followed by Picture Books 2 garnering an average score of 3.81, and PB2 ConceptNet garnering the lowest average score of 3.29. The use of three agents (character, plot and world agents) in PB2 Planning Agents led to the generation of better story plans containing character actions that are more consistent and directed to the selected theme. The use of existing resources in PB2 ConceptNet, though appropriate and relevant to the identified story themes, is found to be insufficient to support the storytelling knowledge requirements of the planner.

Keywords

Story Generation, Story Planning, Agents, Commonsense Knowledge

1. INTRODUCTION

The past few years have seen the continuous efforts at the Center for Language Technologies to develop Picture Books, with each variant generating its own "kind" of stories, particularly fables, for children age 4 to 8 years old, and utilizing various algorithms to address the planning issues in automated story generation. All of these efforts have one goal, which is to teach the children the important values such as honesty and friendship, using a common story pattern wherein the main child character violates the lesson, suffers from the consequences of his/her action/s, and eventually learns the intended lesson.

The first system in the series, Picture Books 1 [1], is targeted for children age 4 to 6 years old. A Picture Editor facility lets the user choose a background and place character and object stickers to the selected background to form a picture that will serve as the input to the story planner. Then, the system generates a story text based from this input picture.

Even though Picture Books 1 has a surprisingly positive results based from the experts' evaluations and shows a lot of potential in the story generation field, there are problems with the stories being generated. Since the system limits its users by only allowing single-scene inputs, the generated stories may not necessarily match the original intent of the user as he/she selects the story's background and its characters and objects.

Picture Books 2 [2], the second system in the Picture Books series, tries to address this issue. Targeted for children age 6 to 8 years old, its Story Editor facility allows its users to define multiple scenes having the same background as input to the system. By doing so, children can visually specify character and object movement and appearance/disappearance across two adjacent scenes while enabling the system to output more complex stories with more interesting plot.

Picture Books 2 (PB2) is also set on more adventurous places such as the *camp* and the *street* to help the older children learn to explore the world on their own. Furthermore, the story characters have been given three positive traits and three negative traits to help children relate to these characters better. These traits are then used as a factor in planning the story to be generated.

This paper focuses on Picture Books 2 and its variants – the PB2 Planning Agents [3] and the PB2 ConceptNet [4]. The next section begins by providing the motivation for pursing the PB2 Planning Agents and the PB2 ConceptNet projects. This is followed by a detailed discussion of the approaches in story planning employed by each of these systems. Section 3 presents a comparative analysis of the results from evaluating the three systems. The paper ends with a summary of our findings and recommendations for further work to enhance the quality of the generated stories.

2. STORY PLANNING IN PB2

The development of Picture Books 2 [2] was motivated by three main factors - i) to allow the child to specify his/her input picture containing a sequence of at least three scenes depicting appearance/disappearance and movement of characters or objects; ii) to support character believability by giving traits to each of the story characters; and iii) to explore the use of causal event planning instead of the predefined author goals that dictate the various subplots of a story which was implemented in the first Picture Books system [1]. However, without a reasoning engine with rules for checking the logical consistencies of story events, instances of stories that make no sense in terms of character actions and responses to events were generated.

PB2 Planning Agents [3] provided three solutions to address this limitation. First, an enhanced representation of events that include pre-condition and post-condition criteria was implemented. Second, a model representing the current state of the story world is also included to track the physical and emotional states of story characters, as well as the states of the different objects that these characters manipulate or use for interaction as the story progresses. This model is one of the five levels of story knowledge representation defined by Oinonen and his colleagues [5]. The last approach is the utilization of three agents in planning the story, which was adopted from the multi-agent framework of the Virtual Storyteller [6].

At the onset of the Picture Books research, it has been recognized that a collection of knowledge is a necessary pre-requisite for computers to generate stories. The basic design of this knowledge base adapted the binary conceptual relations of ConceptNet [7], a semantic network of commonsense concepts classified into thematic categories such as events, causal and affective, which fit with some of the characteristics inherent in stories. It was argued that ConceptNet may not contain the necessary concepts that reflect the daily activities of children, such as *playing*, *going to school*, and *staying safe and healthy*. Thus, each of the Picture Books system has its own commonsense semantic ontology that has been manually populated with concepts relevant to the set of themes supported by a specific story generation system [8]. *But can ConceptNet provide the necessary knowledge needed by computer story generators?* This was the primary research question that motivated the development of PB2 ConceptNet [4].

The next three sections provide a detailed discussion of the planning algorithms employed by each of the three PB2 systems.

2.1. Causal Event Story Planning

Picture Books 2 employs a theme-based cause-effect planning [2] algorithm to generate a story for a given multi-scene input picture. This story planner has three subcomponents, as shown in Figure 1, namely Theme Formulator, Setting Formulator, and Event Generator.

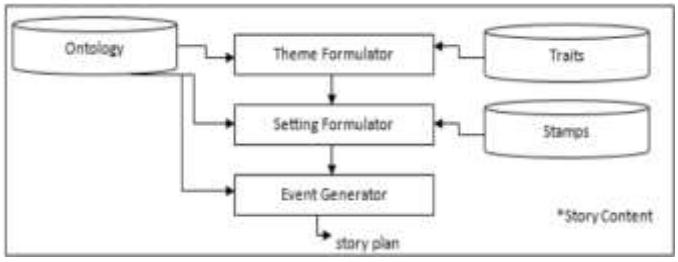

Figure 1. Story Planner of Picture Books 2 [9]

Given an abstract story representation of the input picture from the Story Editor, the Theme Formulator uses the *CausesConflictOf* relations in the semantic ontology to identify the conflict of the story that will be the basis for the theme. For example, if a story character is not brave, the conflict may revolve around story events highlighting his/her being afraid or scared of something, as shown in Table 1. The story theme will then be about *learning to be brave* (or to overcome one's fear).

The Setting Formulator then uses the theme and the selected background to determine the time when the story takes place. Using the *learning to be brave* theme and a *camp* background, the time can be set to *evening*.

Table 1. *CausesConflictOf* relations between non-Character traits and *Conflict* concepts

Concept 1	Relation	Concept2
Brave	CausesConflictOf	Scared
Responsible	CausesConflictOf	Lose
Obedient	CausesConflictOf	Disobey

The Event Generator takes the adjective used to describe the background as a starting point to find a path in the semantic ontology that will lead to the identified conflict. For example, the *camp* can be described with the adjectives *far* and *crowded.* From one of these adjectives as the starting node, the planner follows a chain of *EffectOf* relations to reach the target node containing the conflict concept. Figure 2 illustrates a sample path, represented in the semantic ontology as *EffectOf* relations, depicting the cause-effect link between "story events" concepts, starting from the background adjective *crowded*, leading to feeling *dizzy*, necessitating a *sleep* action, until finally the target node containing the conflict concept, e.g., *scared*, is reached.

To increase the length of the story, the Event Generator also checks for candidate sub-events, depicted in Figure 2 as orange-colored nodes (e.g., to go to *sleep*, the character may need to *take a bath*, *brush* his/her teeth, *comb* his/her hair, or *pray*).

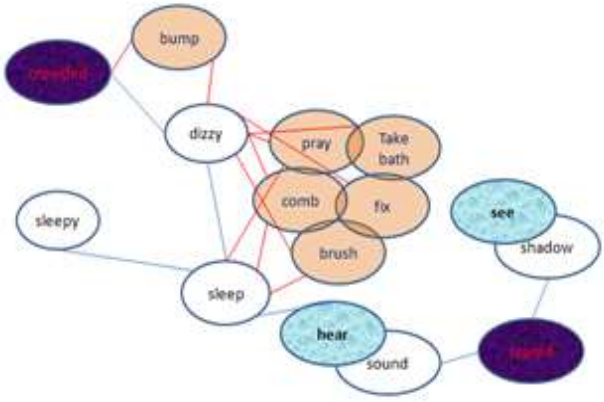

Figure 2. Story Planner of Picture Books 2 [2]

The process is repeated in order to find a path from the conflict, i.e., *scared*, to a possible resolution, e.g., the character should *search* for the cause (*what is making the scary sound in the night?*). The *HasResolution* relations in the semantic ontology, shown in Table 2, are used by the Events Generator.

Table 2. *HasResolution* relations between *Conflict* concepts and *Resolution* concepts

Concept 1	Relation	Concept2
Scared	HasResolution	Search
Lose	HasResolution	Admit
Disobey	HasResolution	Apologize

Variances in the generated story (for a given background, character trait, and objects) are achieved by populating the semantic ontology with sufficient conceptual relations to allow the planner to randomly select a candidate node to pursue.

2.2. Agents in Story Planning

Picture Books 2 selects a path among several candidate chain of events on a random basis, thus, resulting in stories that are illogical or unbelievable at times. PB2 Planning Agents (PA) [3] tries to address this problem by improving on the reasoning engine of the Story Planner. Instead of using only the *EffectOf* relations, pre-conditions and post-conditions were added as criteria for the selection of candidate events.

The world state is also represented to model the changing physical and emotional states of characters and objects as a result of executing events or performing character actions. The model has been derived from the Virtual Storyteller [6] that modified Trabasso's original General Transition Network (GTN) [10] to comprise story elements and causal relationships for use in story generation. A more detailed discussion of the world state model of PB2-PA can be found in [3].

Three agents were also utilized, namely the character agents, the world agent and the plot agent, as shown in Figure 3. The Character Agent takes care of generating the candidate actions of a character given his/her goal. It ensures that the character's action is justified by his/her predefined trait, belief and desire in order to achieve character believability as described in [11]. A character frame is maintained for this purpose and contains predefined information such as name, gender, traits, roles and desires; and dynamic attributes such as bodily needs, physical state, emotion and perception. These dynamic attributes change based on the post-condition of the action that the character has performed as the story progresses.

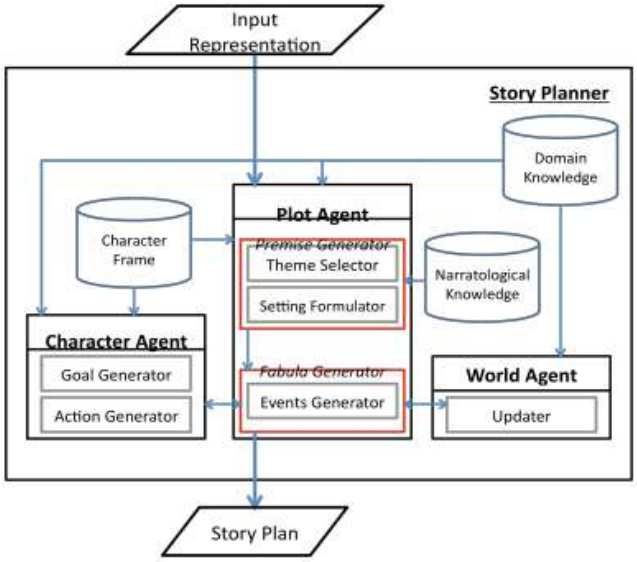

Figure 3. PB 2 Planning Agents Architecture [3]

Because a character may have multiple goals, it is also the task of the Character Agent to prioritize these goals based on their intensity, with goals triggered by emotions being given the highest priority, followed by goals toward the satisfaction of a bodily need, and finally by the desires. The Character Agent evaluates its goal after ever execution of an event by checking the world state.

Given a goal, the Character Agent generates the plan of action for the character to accomplish its goal. This plan of action is a causal chain of events that is retrieved from the knowledge base. A goal is considered "accomplished if the post-conditions defined for that goal have been satisfied.

The World Agent manages the world state and knows what has happened in the story world. It can also determine if an action can occur by checking whether or not the current world state has satisfied the pre-conditions of an action or event. After the execution of an event or action, the world state is updated again by applying the post-conditions.

The Plot Agent acts as the director and makes sure that the selected story path will lead to the identified theme by approving or disapproving character actions. The best-fit theme is selected based on the negative traits of the main character, and by the presence and positioning of the characters and objects in the input picture. Every condition that is satisfied by the input picture is given a score (a single point) and the candidate theme with the highest score is chosen.

The Plot Agent uses a collection of narratological knowledge (described in detail in [3]) comprising of themes and author goals to drive the story flow. The author goals, first introduced in Picture Books 1 [1], were modified to work with the agent-based planner. It contains the three essential parts of a story, which are the character and his/her environment, the conflict (and its counter action) and the conclusion or the final state of the world.

Whereas PB2 relies on the Events Generator to derive the chain of events, the Plot Agent of PB2-PA works with its Character Agent to verify if the action proposed by the latter could lead the story character to the conflict, then to experience its consequences and finally to the resolution of the conflict. In cases of deviations, the Plot Agent formulates possible events to force the character to change his/her goal, thus triggering a change in his/her plan of actions towards the achievement of the story theme. This may include, among others, the performance of an action that necessitates the explicit use of objects and the possible introduction of new characters into the story. If no story can be generated, the Plot Agent selects the next highest scoring theme and performs the same process again.

Listing 1 shows a sample story with the theme learning to be responsible with the premise "*lose-search-find*".

Listing 1. Sample story from PB2-Planning Agents

Title: Peter learns to be responsible

One evening, Peter wanted to play in the camp. Peter loves his sister, Peggy. Peter borrowed Peggy's water jug from Peggy. Peter went to the camp. Peter played in the camp. Peter lost Peggy's water jug in the camp.

Peter felt tired. Peter felt thirsty thus Peter wanted to drink water from the water jug. Peter realized that he lost Peggy's water jug in the camp. Peter felt scared.

Peter searched Peggy's water jug in the camp because Peter wanted to find Peggy's water jug. Peter found Peggy's water jug in the camp. From then on, Peter learned to be responsible.

2.3. ConceptNet in Story Planning

The task of making computer systems generate logical stories is difficult because of their lack of a sufficient collection of commonsense knowledge that humans inherently possess in order to understand and create stories. Previous systems made use of knowledge bases that have been manually populated with concepts specifically for a particular domain dictated by the set of story themes to be generated; thus, they will not work for inputs that are not expected by these systems. PB2 ConceptNet (PB2-CN) [4] tries to address this contraint on the knowledge base by

exploring the use of existing large commonsense knowledge and linguistic repositories, specifically ConceptNet [7], VerbNet [12] and WordNet [13].

Because the available resources, despite their volume, are still insufficient to support the tasks of the planner, PB2-CN used a two-layer ontology that was adapted from Swartjes [14] to represent storytelling knowledge. The Upper Story World Ontology (SWO) contains information pooled from the three existing commonsense resources stated above, with the knowledge representation following the binary semantic relations of ConceptNet. The Domain Specific SWO contains knowledge needed to be able to generate a story such as characters, roles, traits, author goals and vocabulary.

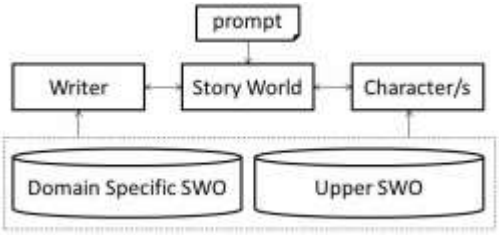

Figure 4. Picture Books 2 ConceptNet Architecture [4]

Story planning begins with a Prompt (shown in Figure 4) that asks the user to select story elements such as the background, characters and objects to be included in the story. The characters should be chosen from a pre-defined set of available story characters while the objects and background can be anything the user wants.

The Writer component then randomly selects at least one main character from the user provided Prompt. Since the story follows a pattern where the main character performs a behavior that is associated with his/her negative trait and progresses until he/she learns the lesson, the Writer has to check the Story World at every timepoint to see if the story theme has been achieved.

The main characters formulate their own goals by querying Desires(?role, goal) from the upper story world ontology. For each role of a main character, there is a corresponding set of candidate goals that is retrieved from the ontology based on the character's desires. Each desire is given a score that signifies how valid or acceptable the candidate assertion is. Only desires which have a score of at least 2.0 can be used by the planner. Furthermore, the higher the score, the higher are its chances of being selected. The type of the goal depends on the character's desire. It can be a goal with a desire to *possess an object* or a goal *to achieve some event or action such as learn and play*.

The main characters should also devise a set of actions that they should do in order to achieve their respective goals. These candidate actions are again queried from either the domain-specific ontology or the upper story world ontology. For an action coming from the domain-specific ontology to be selected, its pre-conditions must be satisfied by previous events that have already taken place in the story world, and its post-condition should be equivalent with the goal. On the other hand, a story graph is created by expanding every unexplored node if the character queries from the upper story world ontology using the following:

MotivatedByGoal(?event, goal),
HasPrerequisite(goal, ?event),
Causes(?event, goal),
UsedFor(?event, goal).

From the resulting story graph, the character searches for candidate paths that have a length of three (or three nodes away from the goal node). This optimal value for the path length was derived from an empirical test conducted which suggests that paths with length 4 or higher produces unreliable story events.

The Writer's responsibility is to ensure that the path gathered by the characters adhere to the intended plot structure and if the user input satisfies these actions. The Writer will only retain paths that contain an action related to the negative trait of the character, lead to a consequence and eventually reach the goal. This is necessary to achieve character believability, where character actions are dictated by their traits. The story elements such as characters, objects and locations needed by the events in the candidate paths are also checked if they are present in the Prompt. The Writer then forwards the partial story plan containing the validated paths to the Story World.

Both the Writer and the Characters execute the partial story plan by interacting with the Story World. The Story World consists of all the story events that have already occurred along with their respective timepoints. In order to progress in the story, the Writer and the Characters interact through querying from the storytelling knowledge and passing the results to the Story World. The Writer is given a full access to all the information in the two-level ontology while the Characters can only access certain information.

For each event in the story plan, if the Character is the agent of the action, he/she executes the action by passing the event to the Story World. Otherwise, if he/she is at least involved in the event, he/she reacts accordingly. The task of the Writer is to give a description that contains the role of the agent who asserted the goal.

A sample story plan is shown in Listing 2. The events in the story have been formatted in English for easier reading, though the system does not produce any surface form of the story text.

Listing 2. Sample story plan from PB2-ConceptNet

Input: Danny (lazy)

[1] Danny is a student. Danny wants good grade.
[2] Danny is lazy. Danny not take note using pocket size notebook. Danny sleep.
[3] Danny cannot pass course.
[4] Danny does not good grade.
[5] Dante realizes mistake of not take note because of lazy.

3. TEST RESULTS AND FINDINGS

From the sets of all stories that the three variants of the PB2 systems are able to produce, a subset of the stories were randomly chosen for evaluation purposes. There were 10 stories each for the evaluation of PB2 and PB2-PA while there were 15 stories for PB2-CN.

Experts in the field of linguistics, child education and story writing were asked to evaluate the generated stories of the three systems with PB2-PA and PB2-CN having the same set of evaluators. The criteria used for evaluation are *coherence and cohesion*, *story elements*, and *content*. The coherence and cohesion criterion evaluates the transition between the events and the flow of the story to determine if the generated story makes sense and can be easily understood by the target users. On the other hand, the story elements criterion checks the appropriateness of the character, objects and backgrounds used in the stories.

Lastly, the content criterion deals with the appropriateness of the story to the target age group, the sufficiency of the details provided, and the believability of the story events (or the actions performed by the characters). A language criterion, which measures the correctness of the sentence structure and the appropriateness of the vocabulary, is not included in the evaluation because PB2-CN did not produce a surface form of the story text as the study focused primarily on the sufficiency of existing linguistic resources in aiding the story planning process. Each criterion is rated by the experts with scores ranging from 1 to 5, with 5 being the highest.

For Picture Books 2, two sets of stories were evaluated. After conducting the first evaluation, revisions were made to the planner to address some of the issues mentioned by the experts. The stories produced after this revision are the ones compared with the output of PB2-PA and PB2-CN. Table 3 shows a comparative summary of the evaluations on these three systems.

Table 3. Evaluation Results for the 3 PB2 Systems

Criteria	PB2	PB2-PA	PB2-CN
Coherence and Cohesion	3.66	4.25	3.33
Elements	4.02	4.30	3.26
Content	3.76	4.20	3.28
Average	**3.81**	**4.25**	**3.29**

All criteria have received an average score of 3.0 and above, which means that the systems performed generally well. The results suggest that the overall flow of events in the stories generated is generally correct and acceptable. It also means that character believability has been achieved. Furthermore, story elements such as objects and locations are usually used in their proper context and are consistent with the user input.

Because there is no consistency in the individual scores of the stories generated by these systems, it cannot be generalized that the stories are good or not. In some cases, the systems can produce stories that receive high average scores in all criteria but in other cases, low scores were gathered. High-scoring stories have smooth flow and appropriate transitions of events whereas low-scoring stories provide unbelievable flow of events and sentences that consist of incorrect structure or grammar and cannot be comprehended.

PB2-CN garnered the lowest average scores in all criteria because its storytelling knowledge has been minimized to test the sufficiency and effectiveness of the contents of ConceptNet in supporting the knowledge requiresments of the story generator. Thus, even though results showed that ConceptNet is suitable, it cannot be the only source of knowledge for generating stories because there will be cases where information needed by the system is missing and must be gathered from other knowledge base. Because of this, more information has to be added to the upper story world ontology and domain-specific ontology to be able to produce better stories.

On the other hand, PB2-PA garnered the highest average scores in every criterion among the three systems because the planning algorithm gives priority to story plans that adhere to the selected theme. Furthermore, the use of a Plot Agent assures the actions of the characters are consistent and directed to the selected theme. Overall, the use of the three agents (character agent, plot agent and the world agent) has been proven to be helpful in its story planning tasks.

4. CONCLUSION

In this paper, we have compared the planning processes of Picture Books 2 and its extensions, PB2-PA that uses three agents in the planning process, and PB2-CN that uses available resources to provide the planner with the knowledge it needs to do its task. The extensions were meant to address the limitations of Picture Books 2 in two aspects – 1) in planning, by delegating the task of planning the actions to the individual characters to promote character believability while maintaining a plot agent or a writer to ensure overall adherence of the story events to the identified theme and story plot structure; and 2) in sufficiency of the knowledge base, by reducing the reliance on manually populated knowledge bases by turning to readily available linguistic resources, namely ConceptNet, WordNet and VerbNet.

Since creating an automatic story generation system that is capable of producing stories that vary greatly from one another is mainly due to how diverse and large its commonsense knowledge and storytelling ontology is, investing in these knowledge bases will be beneficial. One can explore projects like Never-Ending Language Learning (NELL) [15] that crawls over millions of web pages to learn new knowledge to append knowledge to the story generator. However, just as PB2-CN had to use a threshold on the assertions that the planner can use in generating story events, additional works to filter NELL's knowledge base should be done in order to extract only those knowledge that is appropriate for the target age group and the target domain and/or genre of the stories to be generated. Furthermore, to facilitate learning, the scope of the knowledge and the filtering mechanism can be made dynamic such that it adjusts to the cognitive level of the child as he grows older. This way, NELL provides the story generator with age-appropriate knowledge suitable to the child and will continue to support his/her reading due to the variances and increasing complexity and scope of the stories being generated.

Another possible future work is to track the world state of the stories so that the problems of generating illogical, unnatural and unbelievable stories can be addressed. The story world state can be used to track the sequences of events that have already taken place, therefore, allowing the system to take these into considerations before proceeding to generate the next story events or situations. It can, for example, help prevent the planners from doing sudden shift in the story location without putting a closure on the previous events.

Lastly, support for multiple characters and multiple locations can be integrated into the current systems to give the target users a wider range of options on the scope and complexity of the story he/she wishes the system to generate. Having multiple characters and multiple locations will require planners to take into account story events that will ensure characters are interacting with each other to attain their goals, and to identify points in the story when location changes can be effected.

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