A State-Event Transformation Mechanism for Generating Micro Structures of Story in an Integrated Narrative Generation System

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Abstract

This paper describes the current version of state-event transformation system to transform story lines and story worlds each other using a knowledge base and a conceptual dictionary. Moreover, we extend the basic framework to a circulative generation mechanism with a simple mutation function. Through the preliminary performance checks, we confirmed that the transformation of story worlds and story lines is approximately logically adequate and the circular process produces the diversity of stories. The proposed system is a module in an integrated narrative generation system and the pilot version is already implemented. In the context of the narrative generation system, the proposed system plays roles for expanding the variation of discourse to be generated and limiting possible narrative elements at any given time in a narraive generation process.

Keywords: Narrative generation system; story generation; state; action; conceptual dictionary.

Introduction

In the context of natural language processing in the wide sense, the research of narrative generation system which aims at automatic generation of narrative texts by computer has been developing from 1960s. Meehan (1977) shows a classical approach and Bringsjord and Ferrucci (2000) is an example of the comparatively new result. Along with traditional literary genres, narrative and story will play important roles for digital entertainment genres such as computer game. The mechanism we propose in this paper is a part in an integrated narrative generation system we have studied as a project. The applicable goal is creating novel contents such as automatic generation game, which has not a fixed story, and narrative generation based narrative or literature, which is a form of novel containing narrative generation mechanisms. Moreover, narrative is the strongest method for organizing and structuring fragmentary information and a kind of collective knowledge in human being. The narrative generation system is also associated with a variety of issues such as the organic formation of fragmentary information, the diverse interpretation of an event or events, and so on (Ogata & Kanai, 2010).

In this paper, we deal with a part of mechanism for generating a story, which is a sequence of events to be narrated, in the narrative generation process. In concrete terms, we propose a system to make a correlation between state and event (action) which are main elements to construct stories using a conceptual dictionary for noun/verb concepts and transformation rules. We analyze and classify the relationship between an action and the states in front and behind for 689 verb concepts to develop a mechanism that mutually transforms from an action to states or from states to an action and cyclically repeats the process. The action means an event in which a verb concept for an action is included as the central element. A temporal sequence of events is corresponding to a story. On the other hand, a collection of states means a static narrative knowledge supporting events.

Narrative Generation and Proposed Mechanism

Three main modules of our narrative generation system are story generation mechanism, discourse mechanism, and surface expression mechanism. Story means a sequence of events to be narrated and discourse means the narrated structure of events, and both are described with conceptual representation. Expression contains surface representations including natural language, animated movie, music, and so on. The system has a conceptual dictionary and various narrative knowledge bases used mainly in story and discourse parts. Although our previous works was to develop the comparatively independent modules, we are currently starting to complete an integrated narrative generation system in which a variety of mechanisms are synthesized by standardizing data structure for event representation and constructing a conceptual dictionary to be used in a lot of modules commonly (Akimoto & Ogata, 2011). Figure 1 shows the overall structure of a pilot version of the system. The proposed system in this paper is correnponding to both "SL (story line)→SW (story world)" and "SW→SL" in the "Structual operation module". As mentioned later in detaile, a story line is a sequence of events and a story world is a collection of states.

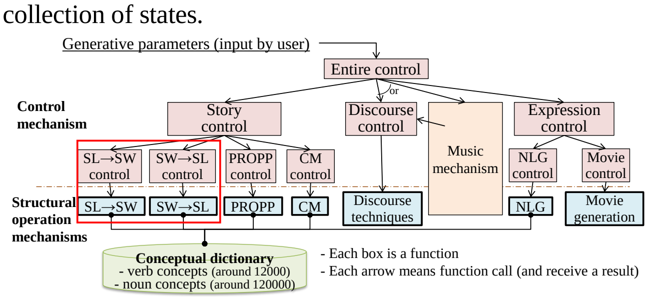


Figure 1: The overall structure of an integrated narrative generation system

A story is represented as a tree structure as shown in Figure 2. Three types of components in a story tree are relation, event, and state. An event forms a case frame with some elements such as agent, object, location, and so on. A relation semantically binds some events or the following part. The generation mechanism in this level is described in Ogata, Hori and Ohsuga (1994). The lowest layer of the tree is formed by states. A state means the precondition and the result of an event. Each state is represented with some kinds of frames describing the values of case frames in the corresponding event, namely it actually is a set of semantic data. We call the layer of states "story world" and the layer of events "story line". An event produces two states and two states are corresponding to an event. This paper describes the detailed structures and proposes the mechanism of mutual transformation processing by refining and expanding previous studies (Nakashima & Ogata 2008; Onodera, Oishi & Ogata, 2011). In the context of narrative generation system, the primary roles of this mechanism are providing a function for generating narrative representations such as descriptions and explanations besides events sequences and a construction for limiting possible elements (like agent, object, and place) at any given time in a narraive generation process, using the detailed and explicit definition of states.

Research Background

In the research of "the history of narrave" by philosophers (Noe, 2005), history is a kind of story to transform a chronicle as chronologically arranged events into a sequence of events sorted through the narrator's filter. As described above, we devide a narrative gneration process into the information to be narrated (story) and the narration itself (discourse and surface expression). It may be thought that the part of state and event in this paper is corresponding to the chlonicle. One of the characteristics in our narrative generation system research is an interdisciplinary approach of the humanities such as narratology & literary theories and computer science such as AI. The materialization as a program of the conceptual idea and theory contributes to give the new tools of thought to such area. From thie point of view, the problem is that what kinds of knowledge and techniques are used for executing the transformation from states as a chronicle to events as a story. Although we propose only the micro level's technique in this paper, we are aiming at building the narraitve generation sytem on such conceptual and philosophycal foundation.

In AI, this paper is related to the function of planning that an agent automatically executes a goal through a goal oriented process. Planning technique, which is a strong foundation in many story or narrative generation systems (Mueller, 1990; Okada & Endo, 1992), generates stories or

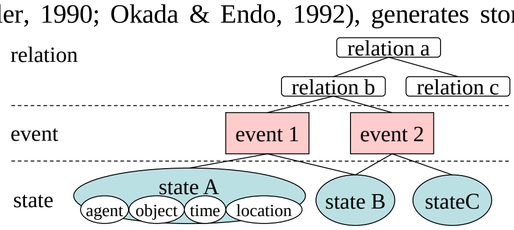


Figure 2: The structure of a story

plot lines to reach a goal through the recursive division of the goal. Although the planning is a comparatively macro framework for story generation, in this paper, we pay attention to the part of micro transformation process between states and events without a specific goal. Therefore, it is not planning in a strict sense. As our narrative generation system adopts a kind of modular approach in which a variety of elements are organically integrated, the aspect of goal-based planning can be incorporated into the system as a different module.

Next, conceptual dependency theory by Schank (1975) is a classical study regarding to the semantic categorization of concepts and categorizes verb concepts into 11 types of fundamental concepts. It is difficult to faithfully categorize real diverse concepts in accordance with the theoretical framework. However, we will able to partially apply it or the idea as a reference, regarding to the part of especially abstract actions. A verb thesaurus by Takeuchi (2011) also shows a detailed system of semantic classification of verbs. It classifies verbs into basic events (states and activities) and complicated events (verbs for state change). Verbs for transitioning among states in this thesaurus are corresponding to verb concepts for changing states in this paper. Although our research shows more detailed classification about the caterogies of moving of agent and object, we may be able to refer to this thesausus's classification about other categories, namely, human relationships, body information such as personal appearance and physial condition, psychological information such as emotion, change of hardness and shape of object, etc. In addition, FrameNet (Fillmore & Baker, 2010) and Japanese FrameNet (Ohara, 2008) define the semantics of a word by a semantic frame, which means the structured knowledge about a typical scene, constructed with the frame elements. And, VerbNet (Kipper-Schuler, Dang, & Palmer, 2000; Kipper-Schuler, 2005) is a hierarchical verb lexicon in which each class is described by semantic predicates, thematic roles, and basic syntactic frames. Because this research's purpose is not building a conceptual lexicon itself and the implementation from the viewpoint of the narrative generation system, we do not aim at the direct use or the direct revision of above resources currently. However, for revising the knowledge base mentioned later, the more direct reference will be needed in the future.

Moreover, the proposed system uses a conceptual dictionary to transform between states and events. As an example of story generation systems by the use of conceptual knowledge base, McIntyre and Lapata (2009) proposed a system which generates stories by using a knowledge base of compositions of an event sentence and chains of events. Stories are generated by a kind of tree search of possible stories. The system has several scoring criteria for pruning low scored branches. Although this is a completed story generation system, the proposed system is a mechanism in a big framework of narrative generation system to be able to add various other mechanisms such as a selection function based on some specific criteria on the foundation of a simple basic mechanism.

An Overview of the Mechanism

Figure 3 draws an image of the state-event transformation mechanism. The state of A (a place in this case) changes or does not change based on an event. A state includes some kinds of information such as a place, an agent's features, and object or objects, and so on. These elements in a state are described by each frame. For example, an agent's frame contains name, location, time, possession, and so on. The each element is really corresponding to an instance as the substantiation of each element in a conceptual dictionary. On the other hand, an event is described by a conceptual representation form shown in Figure 4. When the system recognizes a change in the states of agent, object, place, and time, it infers an event using "state-event transformation knowledge base". In contrast, the system can also infer two states from an event using the same knowledge base. We call a set of states "story world" and a sequence of events "story line". In summary, in a story line, each event is represented with a case frame including agent, object, location, time, and so on. In a story world, each state is represented with a set of four types of frames of agent, object, location, and time corresponding to above cases. And, each frame is constructed with slots and the values. A state means static knowledge and an event means dynamic one generated by the change of two states. The system can also repeat a circulative transformation process between states and events. The objective is to add various changes to the flows of stories through the cyclical process. However, as the state change and events are the relationship of one-to-many, in the case of simple circulation, the change of story worlds remains small compared with the comparatively large change of story lines. To add a larger change to story worlds, a kind of simple mutational function is introduced. This system is implemented by Common Lisp as with other main parts in the narrative generation system.

The conceptual dictionary is a hierarchical system for verb and noun concepts developed referring to "Goi-Taikei: a Japanese lexicon" (Ikehara et al., 1999) and "Japanese WordNet" (Bond et al., 2009) mainly. It contains about 12000 verb concepts and about 120000 noun concepts. In the current version in this paper, we limitedly treat only verb concepts relevant to the "physical transfer" and "possessive transfer". The each verb concept is described as a case frame form

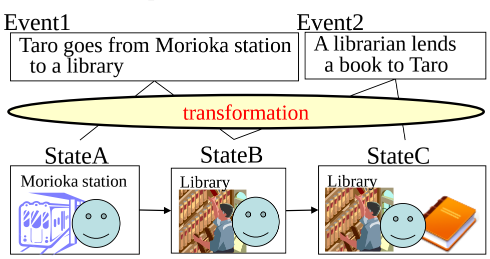
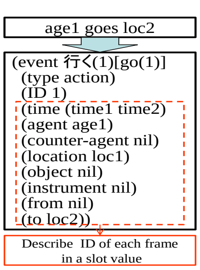


Figure 3: An image of the proposed mechanism



Case	Function of case
type	Kind of event (action or happening) (Prince, 1987)
ID	Identification of an event
time	A pair of starting time and ending time of event
agent	Agent of the action
counter-agent	Object of the action (living thing)
location	Occurrence of the event
object	Object of the action (no living thing)
instrument	Instrument or tool used by the action
from	Starting position of the action
to	Ending position of the action

Figure 4: The conceptual representation form of an event

shown in Figure 4. Oishi and Ogata (2011, 2012) propose the detailed explanation.

State-Event Transformation Knowledge Base

This stores rules for transforming two states and an event mutually. As shown in Figure 5, a transformation rule consists of following three elements: (1) The pattern of the change of states, (2) a set of preconditions for the change, and (3) A set of verb concepts associated with the change. This example means "change of the place where a character exits". Above (2) is the condition to apply a transformation rule and this example means "an agent exits at a place, and the place and another place exists". In above (3), a group of verb concepts produce a same type of state change in common. In the current step of implementation, 138 "transformation rules" and 689 verb concepts are contained.

The transformation rules are hierarchically classified. The highest layer is divided into "the change of location, address, possession, health, durability, and posture" and "generation and disappearance" according to the changing element in each slot in agent, object, and place. Second layer shows the concrete way of changing in a slot and is classifies into 27 kinds. For example, in the movement of place, there are the movement among different places, the vertical movement, and the high/low movement in a same place. And, one or more rules according to each movement can be defined. For example, in the movement among different places, an event satisfies both slots of "from" and "to" in common and another event satisfies only "from" or "to". Table 1 lists defined categories of state change. For example, the change of location slot in an agent frame or an object frame is corresponded to 11 types of categories. In this table, "large classification" means it is based on what (or which slot) is changed in a state and "small classification" means it is based on how it changes. For about 4200 kinds of "physical actions that an agent becomes the subject", about 2000 kinds of "other physical actions", and about 4100 kinds of "psychological actions", we are currently proceeding this expansion and revision by focus on what is changed in a state (we need to expand frame as necessary), how a state changes, and what kind of cases a verb concept has.

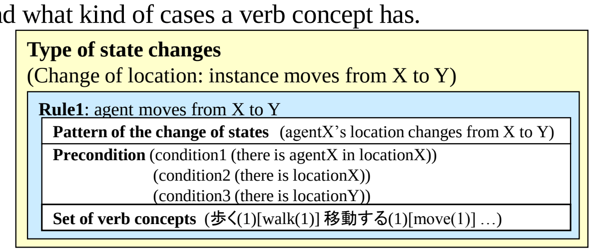


Figure 5: A state-event transformation rule

Table 1: The classification of transformation rules (the details are omitted)

Large classification	Small classification
Change of location	Move, Move[up], Move[down], Move[out], Move[in], Move[near], Move[far], Carry, Go together, Near, Leave.
Change of posture	Stand, Sit, Lie.
Change of possession	Have, Relinquish, Give, Trade, Throw.
Change of health/durability	Death, Break, Damage, Heat.
Change of address	Migrate
Generation disappear	Generation, Disappear, Ingest

Two Processes of Generation

The flows of transformation are from a story line to a story world ("story world generation") and from a story world to a story line ("story line generation"). In addition, these transformations can be also repeated continuously or cyclically.

Story World Generation Process

The process of story world generation is as follows (Figure 6): (1) The user specifies a story line and each value of agents, objects, and places in the story line. (2) The system searches a rule in a state-event transformation knowledge base according to a verb concept from first event in the story line. (3) The system selects a rule which has the verb concept in the group of verb concepts. (4) The system sets a state before the event which is the precondition in the selected rule. If a state already exists, the system simply overwrites by the new state. (5) The system refers the pattern of the change of states in the rule and makes a state after the event by changing the previous state set in above (4). (6) The system refers next event. If it exists, the process returns to above (2). If it does not exist, the process finishes.

Story Line Generation Process

The flow of story line generation is as follows (Figure 7): (1) The user specifies two or more states in a story world according to the numerical order of ID. (2) The system compares the changed frame(s) and slot(s) in the first two states. (3) In the state-event transformation knowledge base, the system searches a transformation rule in which the first state & the precondition and the change in the second state & the content of change respectively match. (4) The system checks the constraints for each verb concept stored in the rule.

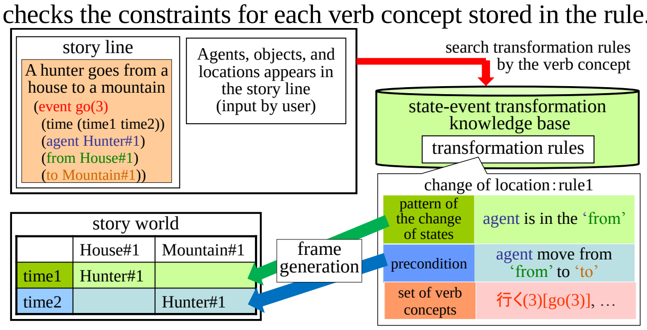


Figure 6: The flow of story world generation

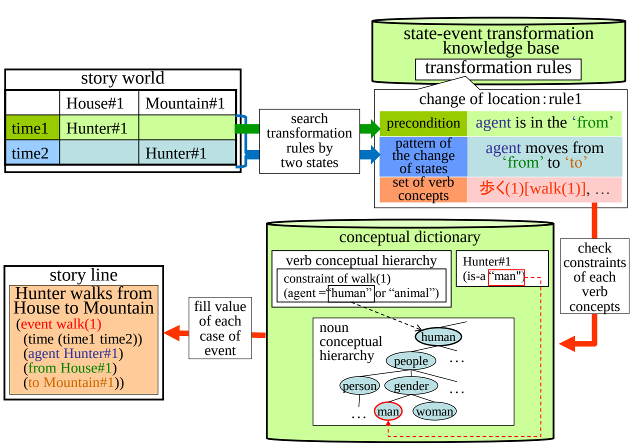


Figure 7: The flow of story line generation process

Specifically, the system checks whether the agents and objects are within the range of each constraint. And, the system allocates agents, objects, and places to the case frame for a verb concept that satisfies all constraints to generate an event. (5) If one or more events remain, the process returns to (2). And if no event, the process finishes.

Circulative Generation Process

The system can repeat the transformation among story worlds and story lines. For example, an event such as "Taro goes to the park from the house" can be transformed into two states, "Taro is in the house" and "Taro is in the park". Next, these states can be transformed into an event that is different from the former such as "Taro comes to the park from the house". The system enables "circulative generation" in which two types of transformations are repeated each other. A verb concept in an event in a story line changes within a given range through such circulative process. However, a story world does not change from the initial story world because it is knowledge to prescribe the story content. Story world and story line have one-to-many relationship in the ordinary mechanism.

Moreover, we introduce a mechanism to produce larger changes in both story line and story world through the circulative generation process. Although we can imagine various methods to actualize it, we implemented a function using a simple mutation mechanism. In story world generation, the function randomly changes a state and the value of an agent or an object in a frame after the generation process. On the other hand, in story line generation, it randomly changes an event and a case's value in an event concept after the generation process.

Execution Examples

First, as the input information, we prepare the summary of a part of Mishima's "The sailor who fell from grace with the sea" (1963) (Figure 8). Table 2 shows a generated story world. In addition, Figure 9 shows the result of a story line based on the story world. In these figures, we show the result by a simple sentence generation program. Figure 8 is a scene that Ryuji, Noboru, and a "don" move from a hill to a dry dock in Yokohama. In Figure 9, some changes occur. For example, Ryuji and Noboru move together in one event and the don moves as if he comes after Noboru.

Second, circulative generation was attempted based on a tale in Yanagita's "The legends of Tono" (1955) (a story that a hunter forces a big priest to eat burned stones to punish the big priest who ate the hunter's rice cakes without the permission).

E1: *Ryuji#1* takes *Sailor cap#1* in *Ryuji#1*'s hand
E2: *Ryuji#1* goes from *Store#1* to *Hill#1*
E3: *Don#1* goes to *Hill#1*
E4: *Noboru#1* goes to *Hill#1*
E5: *Ryuji#1* supplies *Sailor cap#1* to *Don#1*
E6: *Noboru#1* buys *Sailor cap#1*
E7: *Noboru#1* delivers *Sailor cap#1* to *Ryuji#1*
E8: *Ryuji#1* leaves *Hill#1* for *Sugita#1*
E9: *Noboru#1* leaves *Hill#1* for *Sugita#1*
E10: *Don#1* leaves *Hill#1* for *Sugita#1*
E11: *Ryuji#1* goes around *Slope#1*
E12: *Noboru#1* goes around *Slope#1*
E13: *Don#1* goes around *Slope#1*
E14: *Ryuji#1* gets to *Tunnel#1*
E15: *Noboru#1* gets to *Tunnel#1*
E16: *Don#1* gets to *Tunnel#1*
E17: *Ryuji#1* heads to *Hill#2*
E18: *Noboru#1* heads to *Hill#2*
E19: *Don#1* heads to *Hill#2*
E20: *Ryuji#1* arrives at *Dry dock#1* from *Hill#2*
E21: *Noboru#1* arrives at *Dry dock#1* from *Hill#2*
E22: *Don#1* arrives at *Dry dock#1* from *Hill#2*
E23: *Ryuji#1* sits down in *Dry dock#1*
E24: *Noboru#1* sits down in *Dry dock#1*
E25: *Don#1* sits down in *Dry dock#1*
E26: *Ryuji#1* supplies *Sailor cap#1* to *Noboru#1*
E27: *Noboru#1* parts with *Sailor cap#1*
E28: *Noboru#1* takes *Tea#1* in *Noboru#1*'s hand
E29: *Noboru#1* supplies *Tea#1* to *Ryuji#1*
E30: *Ryuji#1* drinks *Tea#1*

Figure 8: Input information

Table 2: A part of generated story world

	Store#1	Hill#1	Dry dock#1	…
t1	Ryuji#1, Sailor cap#1		Noboru#1,Don#1, Tea#1	
t2	Ryuji#1(have: Sailor cap#1), Sailor cap#1		Noboru#1,Don#1, Tea#1	
t3		Ryuji#1(have: Sailor cap#1), Sailor cap#1	Noboru#1,Don#1, Tea#1	
t4		Ryuji#1(have: Sailor cap#1), Noboru#1, Don#1, Sailor cap#1	Tea#1	
t5		Ryuji#1, Noboru#1, Don#1 (have: Sailor cap#1), Sailor cap#1	Tea#1	
t6		Ryuji#1, Noboru#1(have: Sailor cap#1), Don#1, Sailor cap#1	Tea#1	
t7		Ryuji#1(have: Sailor cap#1), Noboru#1,Don#1, Sailor cap#1	Tea#1	
…				

E1: *Ryuji#1* gets *Sailor cap#1*
E2: *Ryuji#1* escorts *Sailor cap#1* to *Hill#1*
E3: *Noboru#1* follows *Don#1* from *Dry dock#1* to *Hill#1*
E4: *Don#1* buys *Sailor cap#1*
E5: *Noboru#1* buys *Sailor cap#1*
E6: *Ryuji#1* buys *Sailor cap#1*
E7: *Ryuji#1* escorts *Noboru#1* to *Sugita#1*
E8: *Don#1* strolls around *Sugita#1*
E9: *Ryuji#1* escorts *Noboru#1* to *Slope#1*
E10: *Don#1* advances to *Slope#1*
E11: *Ryuji#1* moves *Noboru#1* from *Slope#1* to *Tunnel#1*
E12: *Noboru#1* posts *Don#1* at *Tunnel#1*
E13: *Ryuji#1* carries *Noboru#1* from *Tunnel#1* to *Hill#2*
E14: *Don#1* leaves *Tunnel#1*
E15: *Ryuji#1* follows *Noboru#1* from *Hill#2* to *Dry dock#1*
E16: *Don#1* chases *Ryuji#1*
E17: *Ryuji#1* sits down in *Dry dock#1*
E18: *Noboru#1* sits down in *Dry dock#1*
E19: *Don#1* sits down in *Dry dock#1*
E20: *Ryuji#1* supplies *Sailor cap#1* to *Noboru#1*
E21: *Noboru#1* parts with *Sailor cap#1*
E22: *Noboru#1* wins *Tea#1* in "lottery"
E23: *Noboru#1* supplies *Tea#1* to *Ryuji#1*
E24: *Ryuji#1* drinks *Tea#1*

Figure 9: A generated story line

In this circulative generation, we implemented a simple mutation function. It randomly changes the generated values for frames of agents and objects or values for case frames of event concepts to other values for agents, objects, and places in the story. In this time, we attempted the mutation probability, 0.1. Figure 10 shows an input story line and two story lines of 4 times and 40 times. As a result, in 4th generation, a scene in which the hunter and the priest bite each other is inserted and various events occur over the rice cakes. In 40th generation, objects in the story are only two rice cakes and a scene in which the big priest dies is omitted. The reason of outstanding reduction of the number of events and the simplification of generated stories are basically by that elements which are introduced in the simple mutation are only ones appeared in the generated stories already. We plan to attempt another circulative experiment by the arbitrary introducing of elements that do not exist in the already generated stories.

Performance Checks

We show some preliminary checks of the system's basic performance using the result of "The legends of Tono" as mentioned above. First, we analyzed 20 samples which were generated from a same story line to investigate the correctness and the diversity of generated states in the story world. Second, for the story line generation, we analyzed 20 samples which were generated from a same story world to confirm the possibility and the diversity of events. In both experiments, we did not consider the naturalness of context and adopted whether each event simply physically occur as the evaluation criterion. For example, a sample story has a scene in which a big priest eats a burned stone. In spite of actual unnaturalness, this scene is physically possible. In addition, in many stories, physically impossible events and fantastical events also occur. A basic policy of our narrative generation system is the generation of realistically possible events, and unrealistic and fantastical events are generated on the basis of the advanced rhetorical techniques such as the "defamiliarization" processing by the relaxation and adjustment of conceptual constraints using a conceptual dictionary (Zhang, Ono & Ogata, 2011, 2012). Therefore, the proposed system aims at a mechanism for generating realistic events and to the extent possible. As this preliminary check, we confirmed that the system could generate comparatively adequate and diverse results in both generation mechanisms except that few impossible events are generated in the story line processing. To decrease the impossible events, the elaboration of the conceptual dictionary is required.

Next, for circulative generation, we executed 15 cycles from a story line to analyze the degree of change in the generated story lines. As a result, we observed several types of changes such as the appearance of new event(s) and the disappearance of event(s). Table 3 shows the result of comparison between the 5th story line and the 15th one.

At last, we investigated the naturalness of story lines. The naturalness simply means that a story has not any realistic contradiction. We analyzed 10 story lines by a circulative generation process. As a result, we discovered some types of

Input story line

E1: *Hunter#1* burns *Rice cake#1*
E2: *Hunter#1* burns *Rice cake#2*
E3: *Hunter#1* burns *Rice cake#3*
E4: *Hunter#1* gets *Rice cake#1* from *Patrol*
E5: *Big priest#1* advances to *House#1*
E6: *Big priest#1* gets *Rice cake#1* from *Omitted letter*
E7: *Big priest#1* eats *Rice cake#2*
E8: *Hunter#1* acquires *Rice cake#3*
E9: *Big priest#1* buys *Rice cake#3*
E10: *Hunter#1* bites *Big priest#1*
E11: *Big priest#1* runs in *Mountain#1*
E12: *Hunter#1* burns *Rice cake#4*
E13: *Hunter#1* burns *Stone#1*
E14: *Hunter#1* acquires *Stone#1*
E15: *Hunter#1* abandons *Stone#1*
E16: *Big priest#1* chases *Hunter#1*
E17: *Big priest#1* gets *Rice cake#4*
E18: *Big priest#1* eats *Rice cake#4*
E19: *Big priest#1* acquires *Stone#1*
E20: *Big priest#1* gnaws on *Kiln#1*
E21: *Big priest#1* parts with *Stone#1*
E22: *Big priest#1* slips away from *House#1*
E23: *Big priest#1* loses *Big priest#1's* life

⋮

4th generation

E1: *Hunter#1* burns *Rice cake#1*
E2: *Hunter#1* burns *Rice cake#2*
E3: *Hunter#1* burns *Rice cake#3*
E4: *Hunter#1* wins *Rice cake#1* in award
E5: *Big priest#1* gets to *House#1*
E6: *Big priest#1* collects *Rice cake#2*
E7: *Big priest#1* chews *Hunter#1*
E8: *Hunter#1* abandons *Rice cake#1*
E9: *Hunter#1* buys *Rice cake#3*
E10: *Big priest#1* confiscates *Rice cake#3*
E11: *Hunter#1* chews *Big priest#1*
E12: *Hunter#1* burns <u>*Rice cake#4*</u>
E13: *Hunter#1* abandons *Rice cake#3*
E14: *Hunter#1* burns *Stone#1*
E15: *Hunter#1* acquires *Stone#1*
E16: *Big priest#1* abandons <u>*Rice cake#4*</u>
E17: *Big priest#1* brings <u>*Rice cake#4*</u> into *Mountain#1*
E18: *Big priest#1* confiscates <u>*Rice cake#4*</u>
E19: *Hunter#1* transports <u>*Rice cake#4*</u> to *House#1* by dump truck
E20: *Big priest#1* abandons <u>*Rice cake#4*</u>
E21: *Big priest#1* collects <u>*Rice cake#4*</u>
E22: *Hunter#1* damages Klin#1
E23: *Big priest#1* parts with *Stone#1*
E24: *Hunter#1* takes *Big priest#1* out of *House#1*
E25: *Big priest#1* dies of road game

⋮

40th generation

E1: *Big priest#1* strolls around *House#1*
<u>E2: *Hunter#1* chews *Rice cake#1*</u>
E3: *Hunter#1* escapes from *House#1*
<u>E4: *Hunter#1* chews *Rice cake#2*</u>
E5: *Hunter#1* leaves *Mountain#1*
E6: *Hunter#1* escorts *Big priest#1* to *Mountain#1*
E7: *Big priest#1* travels around *House#1*
E8: *Hunter#1* drifts in *House#1*
E9: *Hunter#1* carries *Rice cake#1* to *Mountain#1*
E10: *Hunter#1* brings *Rice cake#1* in *House#1*
E11: *Big priest#1* escapes from *House#1*
E12: *Big priest#1* runs the whole *House#1*
E13: *Big priest#1* abandons *Rice cake#1*

Figure 10: An example of circular generation

Table 3: The change of story lines through circulation

	Input story line	**5th story line**	**15th story line**
Appearing agent	*Hunter* and *Big priest* are half-and-half	*Hunter* is two-thirds	*Hunter* is mostly
Appearing object	*Stone* and *kiln* appear once	*Stone* and *kiln* appear more than once	*Stone* is mostly
Location of agent (*Hunter*)	Stay in the *House* from beginning to end	Do a round trip to *House* and *Mountain* many times	Do a round trip to *House* and *Mountain* many times
Location of agent (*Big priest*)	Do a round trip to *House* and *Mountain* two times	Do a round trip to *House* and *Mountain* one times	Do a round trip to *House* and *Mountain* one times
Contradiction of the story	none	none	*Hunter* moves to the same location many times
Number of event	23	21	19

contradictions. In an example, an agent moved to the location X from location Y and again moves to a different place from the X. Such contradiction is brought from the random choice of a location by the mutation function. It is necessary to adjust the mutation function so that contradictions do not arise completely or if a contradiction occurs, a kind of complement mechanism rewrites state(s) and event(s) after the story line or the story world were made. We prepared two methods for such ex-post solution. First method is "the rewrite of information" and second one is "the complement of information". The former is a method that when a contradiction among some events occurs, the description of a state is changed to generate a new story. In the latter, when a contradiction arises, a new state is inserted into the existing states to generate a new story. In the former, an event's content changes but the story line's length does not change. On the other hand, in the latter, as a new state and a new event are inserted, the story line's length gets longer. As another contradiction, a dead agent acts. For such case, we partially alter the mechanism so that a dead man or a disappearing object is not chosen as an agent or an object by changing the category to which the noun concept is belonged. For example, in the event like "Taro (dead-man) walks", the constraint of agent in verb concept "walk" was originally the category of "human" except for "dead-man". Accordingly, the system can alter the category to which Taro belongs from "human" to "dead-man". Of course, for narratives and stories, such contradiction or unreality is certainly necessary and rather very important and essential element. Again, our policy is that we regard the knowledge and mechanism prepared based on the realism or physical possibility in a narrow sense as a standard and basic method, and introduce the processing of rhetorical knowledge and techniques to adjust the reference range in the conceptual dictionary.

Conclusions

This paper reported the current version of state-event transformation system to transform story lines and story worlds each other using a knowledge base and a conceptual dictionary. Moreover, we extended the basic framework to a circulative generation mechanism with a simple mutation function. Through the preliminary performance checks, we confirmed that the transformation of story worlds and story lines is approximately logically adequate and the circular process produces the diversity of stories. The proposed system is a module in an integrated narrative generation system and the pilot version is already implemented. In the context of the narrative generation system, the proposed system plays roles for expanding the variation of discourse to be generated and limiting possible narrative elements at any given time in a narraive generation process.

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