Key Issues for Generative Narrative Cognition in a Cognitive System: Association and Blending of Stories

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Abstract

Generative narrative cognition is a foundation of the human mind and a necessary element for human-like artificial agents. In this position paper, the author discusses key issues for generative narrative cognition in a cognitive system. It is claimed that stories are mental representations of an agent's subjective world. Interacting with an external environment by generating stories is the essence of an autonomous intelligence. Based on this standpoint, two key points are presented. The first one is to seek fundamental principles for associating mental stories in a cognitive system based on their similarity or relevance. The second is to seek fundamental principles of story creativity in a cognitive system. The author considers that story creativity is based on a cyclic system of stories that generates new stories by (re)using previously generated stories. From this perspective, the issue of story blending is raised in order to create a general model of computational story creativity.

Introduction

The author's basic objective is to seek fundamental principles of generative narrative cognition from a computational perspective. Computational principles of narrative will be a foundation for an agent's higher-level cognition including a relationship with societies, or cultural aspects of a mind.

In the field of artificial intelligence, Schank et al. developed fundamental theories for computational modeling of narrative cognition, including the script theory (Schank and Abelson 1977) and the concept of a dynamic memory framework (Schank 1982). Winston (2012)'s strong story hypothesis also argues for the generality of story in the human mind. Recently, several researchers started to address fundamental studies on narrative-based knowledge, memory, communication, and goal reasoning in cognitive architectures or cognitive systems (e.g., León 2016; Samsonovich and Aha 2015; Szilas 2015). The author has tackled narrative- or story-centered approaches to an agent's cognitive system over the past few years (Akimoto 2018a, 2018b). However, computational modeling of narrative cognition constitutes an extremely complex problem and the above studies are still in an exploratory stage.

In this position paper, based on the author's recent studies, fundamental issues for computational modeling of generative narrative cognition are discussed. In previous studies (Akimoto 2018a, 2018b), the author developed theoretical foundations of a story-centered cognitive system from a big-picture perspective. The basic concept presented in these studies are overviewed in the second section of the present paper. The next step is to develop computational principles of generative narrative cognition. From this standpoint, the key issues for the next research stage are discussed in the third section.

Toward a Story-Centered Cognitive System

The author considers that generative narrative cognition is a foundation of the human mind and a necessary element for a human-like artificial agent. The basic idea of a story-centered cognitive system is summarized below:

- Stories are mental representations of an agent's subjective world, involving meaning and rich temporal extent including past, present, future, and fiction.
- The essence of an autonomous intelligence is to interact with external (social and physical) environments by dynamically generating mental stories.
- An agent's mental stories are socially and culturally developed through communicating narratives with others in their societies. In this sense, stories are intersubjective information.

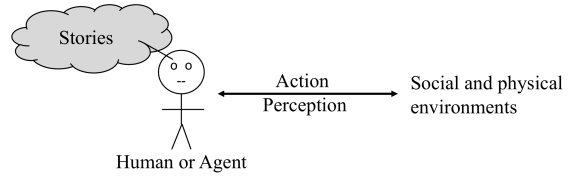
Stories Form an Agent's Subjective World

A narrative generally refers to an expression about events in a communicative context, by using language or other

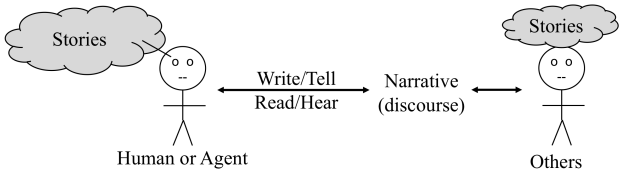
sign systems. However, a narrative can also be considered as the human way of mentally organizing world information including experiences, meaning of events and things, time, and self (e.g., Bruner 1990; León 2016; Noe 2005; Ricoeur 1983–1985; Scank 1982; Szilas 2015).

To distinguish these two (i.e., mental and expressive) aspects of a narrative from a cognitive system perspective, the author uses the terms "story" and "discourse" (Akimoto 2018a, 2018b). A story is positioned as a mental representation of an agent's subjective world in which events and the relevant mental objects (e.g., objects, non-verbal information, intent, and emotion) are organized chronologically and semantically. Given that events themselves do not exist in the external world, every story is a subjective information that is mentally composed.

Akimoto (2018b) described the structures and functions of mental stories from four structural perspectives: a) constructing the contextual structure of a present situation; b) associating past, future, and fiction with a present situation; c) imagining stories about others in a nested structure of stories; and d) distinguishing between facts and fictions based on a belief as a meta-story information. For example, a story about a present situation will function as the basis of an agent's higher-level action-perception system (Figure 1-a). The central character of this story is basically the agent itself and this story integrates a temporal world across past (experiences and results) and future (expectations and plans). Moreover, mentally constructing and associating stories in a communicative situation is a foundation of communicating the world information via narrative discourses (Figure 1-b).



a) *Story-based interaction with environments*



b) *Story-based communication with others*

Figure 1. Story as a foundation of autonomous intelligence.

Developmental Story Creativity is a Foundation of an Autonomous Intelligence

In a cognitive system, story creativity or potential to generate novel stories is a foundation of a true autonomous intelligence from the following two perspectives:

- Adaptation to new (unfamiliar) environments by creating stories.
- Making changes of environments by creating stories and communicating these stories with others via narrative discourses.

The author considers that the fundamental principle of story creation is to generate a new story by (re)using previously generated and accumulated stories, i.e., story-based story generation. This concept is inspired by various theories including Schank's dynamic memory framework (Schank 1982), analogy (Gentner 1983; Holyoak and Thagard 1995), case-based reasoning (Riesbeck and Schank 1989), combinational creativity (Boden 2009), conceptual blending (Fauconnier and Turner 2002), and intertextuality in literary theory (Kristeva 1980). In addition, similarity between creativity and cognitive development is also described by Aguilar and Pérez y Pérez (2015).

Advantage of the Story-centered Approach to Cognitive System/Architecture

A major problem in studies on cognitive systems or architectures (Laird, Lebiere, and Rosenbloom, 2017; Langley, Laird, and Rogers, 2009; Samsonovich, 2012) is obtaining computational accounts of the integrative and complex workings of the mind. Hence, it is important to develop common theories, principles, models, and frameworks for diverse cognitive functions or phenomena.

From this perspective, the key aspect of the story-centered approach is the notion that a story involves the *form* of the mental representation, as opposed to the *function* or *content*. This presents a new perspective on the mind, which is different from the traditional psychological-view. In particular, a story is considered as a uniform mental representation involving episodic memory, autobiographical memory, the current situation, prospective memory, planned or imagined future, imagined mental state of another individual, and fictional or hypothetical story. These include long-term, short-term, and working memories. Hence, the generative cognition of a story constitutes a common basis for a cognitive system or integrative autonomous artificial intelligence.

Key Issues for Computational Modeling of Generative Narrative Cognition

This section discusses fundamental issues for computational modeling of generative narrative cognition based on the

concept of a story-centered cognitive system. The author poses two key issues, i.e., computational principles for 1) associating stories and 2) generating stories by using previously generated stories.

Structural modeling or knowledge representation of a mental story is also a crucial problem, whereas the above two issues focus on the dynamic and generative aspect of stories. There is interdependence between the static/structural and the dynamic/generative aspects of stories.

Story Association

The cognitive mechanism of associating stories based on their similarity or relevance is a common foundation of the following cognitive activities:

- Remembering stories that are relevant to the story of a situation or context which the agent is facing.
- Gathering knowledge or materials (i.e., previously generated stories) to generate a new story.
- Constructing a subjective meaning of an object, e.g. the self and another person, based on the relationship with stories. For example, a household agent views each family member as a special person by connecting past episodic stories relevant to each of them.

As a background, the first two activities are related to cognitive and computational models of analogy (Gentner 1983; Holyoak and Thagard 1995) and memory retrieval based on various types of similarities (Forbus, Gentner, and Law 1994; Schank 1982; Thagard et al. 1990).

The basic form of story association is as follows. When a story is activated in a cognitive system (e.g., when acting in a situation, reading a narrative text, remembering a past story, or imagining a future or fictive story), one or more other stories are associatively activated. Here, the notion of "activation" is rooted in the spreading-activation theory of memory (Anderson 1983; Collins and Loftus 1975).

The central issue of story association is how stories are organized in a cognitive system. The author considers that each story itself is a unique informational unit and there are no direct connections between stories. However, stories are mutually associated via the organization of general representational elements that are shared among stories. Figure 2 illustrates this concept. Conceivable general representational elements are listed below:

- Concepts of general words: A general concept is a primitive element forming a meaning of a word (e.g., "mother," "dog," and "eat"). Various theories of semantic models of words have been proposed, e.g., semantic network, thesaurus, and distributional semantic models. The semantic organization of words can be positioned as a principle of story association based on semantic similarity or relatedness.

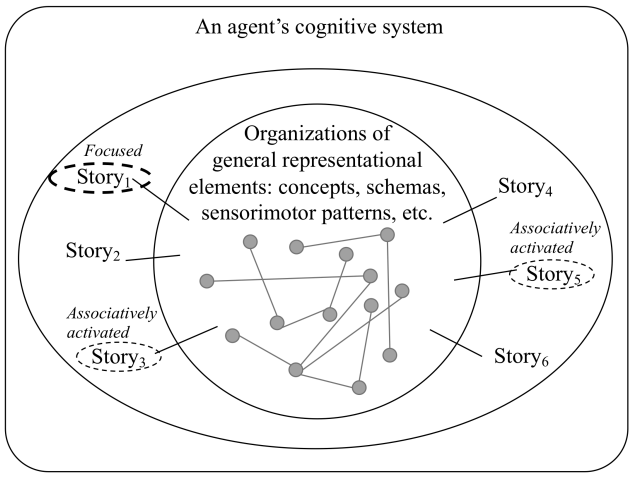


Figure 2. Story association based on the organization of general representational elements.

- Schemas: A schema is a general structure constructed via the generalization of events or things appearing in stories. Schemas underpin story association based on structural similarity.
- Concepts of individual objects: An individual concept corresponds to an identical entity, time, or place appearing in stories. For a person or an agent, a specific person (self, a family member, a friend, etc.), time (yesterday, one's own childhood, 1999s, etc.), and a place (Tokyo, hometown, etc.) are accompanied by relevant stories. From the perspective of story association, these mental objects can be positioned as organizational elements that mediate association between stories based on instance-level relatedness.
- Sensorimotor patterns: Stories may contain non-verbal information such as memories of visual images, sounds, smells, and physical movement. Sensorimotor patterns produce non-verbal similarities between stories.

The author considers that associations between stories emerge through composite actions of the above multiple representational elements. To seek computational principles of story association based on each of the above representational elements, under the integrated perspective, is a major future issue for the foundation of generative narrative cognition.

Story Blending

As previously described, the story creativity in a cognitive system must be modeled as a cyclic system of stories that generates new stories by (re)using previously generated stories. From this perspective, the author focuses on conceptual blending theory (Fauconnier and Turner 2002) that characterizes the fundamental mechanism of human crea-

tive thinking as the production of a novel concept by combining different familiar concepts. Although it is a cognitive theory, several researchers have proposed computational models of conceptual blending (e.g., Confalonieri 2018; Eppe 2018; Goguen and Harrell 2010). Computational conceptual blending is basically aimed at generating not a story's content-level structure but a general concept. However, the fundamental ideas of cognitive and computational conceptual blending are informative for computational modeling of story creativity.

To illustrate the notion of story blending, Figure 3 shows an example of story (narrative) blending by a non-expert human. A blended story was created by combining two given stories. This simple example contains various blending forms, such as merging temporal–spatial setting, replacing characters and their roles, and reconnecting the reason for a character's action. Furthermore, these operations are conducted in an integrated manner. Determining computational principles of this complex phenomenon is a challenging issue.

By adapting the conceptual blending theory, the basic framework of story blending can be formulated as shown in Figure 4.[1] The basic idea behind story blending is to create a new story S_b from the combination of two input stories S_l and S_r. In this process, a shared structure between input stories, based on the cross-space mapping and counterpart connections, is captured into a generic structure G. This shared structure is assumed as a basis for managing the consistent combinations between elements of the input stories. Moreover, a blended story may contain an emergent structure that is not directly projected from the input stories.

Story blending is considered to have a huge solution space (i.e., set of possible combinations). Hence, what directs story blending is also a crucial issue. Because the value of a story is highly dependent on the environmental context in which the story is used, defining absolute measures for identifying "good" stories seems inadequate when dealing with a general model of story creativity. Hence, this study considers this issue from a relativistic perspective. In particular, the basic requirements of story blending are as follows:

- A generated story has both *difference* and *similarity* from/to the two input stories. This is a basic condition for producing novel stories.
- A generated story has a structural *unity*. This is a basic condition for the structure of a story or a narrative.

[1] The main aim of this study is to develop a general model of computational story creativity. Although it is not intended for a specific application, a general model of story creativity has various potential applications including entertainment, human-computer interaction, and creativity support.

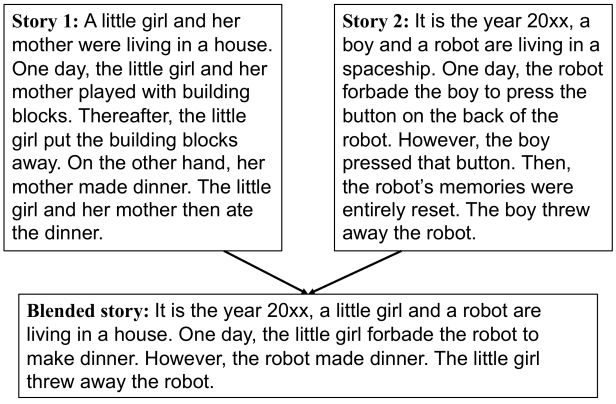


Figure 3. An example of a human created story (narrative).

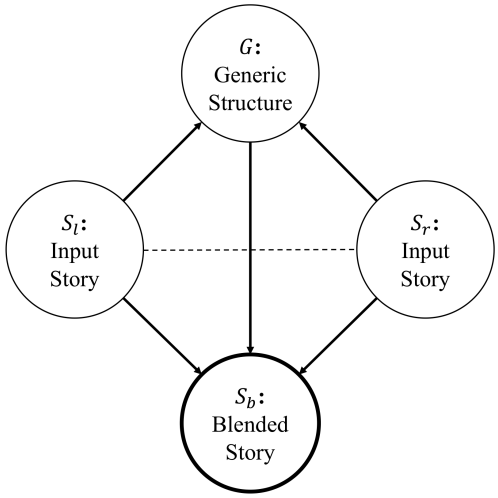


Figure 4. Basic framework of story blending.

Integrative View

Story blending and story association will work together in an integrated cognitive system. On the one hand, story blending is positioned as an internal process of generating stories from previously generated stories or memories. It will be a key principle of a developmental and creative aspect of a cognitive system. On the other hand, story association produces a connection between two stories to be blended from many stories. In other words, story association is positioned as a principle for generating constraints in potential connections between stories. In addition, the general representational elements of organizing stories and mediating story association are positioned as general or commonsense knowledge underpinning the process of story blending.

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