



Research article

Stories as mental representations of an agent's subjective world: A structural overview



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ABSTRACT

Narrative is a universal form of human information and communication. The generative cognition of narrative will be a core element of a human-like and human-friendly autonomous agent. In the field of artificial intelligence (AI), the knowledge aspect of narrative, including script knowledge and episodic memory, has been studied from a functional perspective. However, this knowledge aspect is rooted in the close relationship between a narrative and how the human mind organizes subjective experiences into a mental representation. We use the term “story” to refer to the uniform mental representation of a piece of a subjective world containing individual meaning and a rich temporal extent. For example, stories include the following types of mental object: an episodic memory, an autobiographical memory, the contextual structure of a current situation, a prospective memory, a planned or imagined future, and a fictional or virtual story. Although narrative cognition is a very complex problem for AI, a cognitive mechanism for dynamically generating mental stories through interacting with external environments is necessary for the ultimate autonomous agent. Considering this long-term goal, in this paper, we provide a structural overview of a subjective world formed by stories as experiences of an agent. In particular, the following structural aspects of mental stories are described: a story-based context of a current situation, association of past, future, and fictional stories, association of others' mental stories, and the distinction between factual and fictitious stories.

Introduction

The generative cognition of narrative will be a core element of a human-like and human-friendly autonomous agent. From the early years of artificial intelligence (AI), the cognitive mechanism of narrative and memory has been researched by Schank and his colleagues (Schank & Abelson, 1977; Schank, 1982). Mateas and Sengers (2003) provided interdisciplinary perspectives on the relationship between narrative and intelligence. In cognitive architecture studies, a narrative or story is studied in terms of episodic and procedural memories (Anderson, 2015; León, 2016a; León, 2016b; Szilas, 2015). On the other hand, from psychological and philosophical perspectives, a narrative is treated as a human method of making sense of the world, including self, identity, personality, others, experience, and time (Bruner, 1990; McAdams, 1993; Ricoeur, 1983-1985).

In this study, we assume that a “story” can be used as a uniform mental representation that forms a piece of the subjectively constructed world inside an agent's mind. This subjective world contains individual meaning and a rich temporal extent, based on the linguistic or narrative-based composition of the information. In this study, the term “story” is used as the unifying concept involving an episodic memory,

an autobiographical memory, the contextual structure of a current situation, a prospective memory, a planned or imagined future, and a fictional or virtual story. The cognitive mechanism for dynamically constructing mental stories will be a foundation for the intelligence of an autonomous agent. Considering this long-term goal, in this paper, we provide a structural overview of a subjective world formed by stories as experiences of an agent.

Background: Narrative as memory and knowledge

In the AI field, narrative is researched mainly in terms of creativity, natural language understanding or analysis, and knowledge representation. As background information for this study, this section overviews previous AI studies relevant to narrative's knowledge aspect.

From the early AI years, the relationship between intelligence and a narrative or story has been explored by Schank and his colleagues. They proposed several AI theories of narrative-based knowledge representation models, including script theory and a dynamic memory framework (Schank & Abelson, 1977; Schank, 1982). Script (Schank & Abelson, 1977) is a well-known knowledge representation corresponding to the pattern of the normal flow of events in a specific cultural situation, e.g.,

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“eating in a restaurant”. They subsequently expanded the script theory to a dynamic memory framework (Schank, 1982) for the dynamic organization of episodic stories.

A key concept in this framework is the memory organization packet (MOP). A MOP is a type of schematic representation of a high-level structure that associates analogous stories. Based on this framework, Schank discussed the cognitive mechanism of the flexible remembering, construction, and generalization of stories in various situations. In addition, the concept of a dynamic memory is applied to the formulation of case-based reasoning (Riesbeck & Schank, 1989) as a model for solving a new problem using a previous similar episode (a case and its solution).

In several recent studies on cognitive architecture, the psychological concept of episodic memory (Tulving, 1983), which refers to the memory of one’s past experiences, has been adopted in cognitive architectures. In particular, the Soar cognitive architecture (Laird, 2012; Nuxoll & Laird, 2007) includes episodic memory as one of the knowledge elements. Although the Soar episodic memory is only a snapshot of the virtual environment at each time step, the knowledge representation of an episodic memory is discussed in terms of a narrative or story (Anderson, 2015; León, 2016a; Szilas, 2015). León (2016a) proposed a graph-based knowledge representation of a narrative-form memory, including episodic and procedural memories. In addition, he modeled the production of an episodic narrative as a type of narrative discourse generation based on an episodic memory. In addition to concrete episodic knowledge, generalized schematic knowledge is an important element for human-like AI. For example, León (2016b) addresses the computational modeling of script construction.

Although autobiographical memory (memory of past information relevant to the self) and prospective memory (memory of future actions to be done) are well-known concepts in psychological studies on human memory, there are few or no studies which introduce these concepts into cognitive architectures.

Stories and script knowledge are also considered as knowledge elements in common-sense knowledge resources. For example, Chambers and Jurafsky (2010) proposed a resource of script-like knowledge based on automatic learning from narrative texts. Singh, Barry, and Liu (2004) proposed the concept of an integration framework for ConceptNet, LifeNet, and StoryNet. ConceptNet is a large-scale semantic network of concepts. A concept corresponds to a word or a phrase, and its semantic knowledge is represented based on its relation to other concepts. StoryNet corresponds to a database of small stories. A story is stored as simple sentences representing a sequence of events. In the integration framework, ConceptNet and StoryNet are connected in a type of complementary relationship. A story in StoryNet forms concretely contextualized knowledge of events. Concepts in ConceptNet are linked to stories that provide abstract or general semantic knowledge.

Story as the representational aspect of narrative: From a narrative-communication perspective

As described above, the knowledge aspect of narrative has been studied from a functional perspective. However, this knowledge aspect is rooted in the close relationship between the narrative and the method of organizing experiences into a mental representation. In this section, based on our previous formulation (Akimoto, 2018), we introduce the notion of “story” to refer to the representational aspect of a narrative.

Story as representation and discourse as expression

To clearly distinguish the representational aspect from an expressed narrative, we apply the notions of “story” and “discourse” in narratological¹ terminology (Genette, 1980; Prince, 2003). According to

¹ Narratology refers to the discipline of theoretical studies on narrative, inspired by structuralism and semiology.

Prince’s “a dictionary of narratology” (Prince, 2003), a narrative refers to an expression of events in a real or fictional world based on a language or other sign system. In narratology, the terms story and discourse are generally used to distinguish between the content and expression planes of a narrative. Namely, a story refers to the content plane of a narrative and a discourse refers to the expression plane of a narrative.² In other words, a discourse is the narrative text itself and a story corresponds to the content, i.e., the chronological organization of events recounted in the text. However, because a story is immaterial, the notion of story is slightly unclear.

From a narrative-communication perspective, the relationship between the content and expression planes of a narrative can be re-interpreted as the relationship between mental representations and the surface expression, as illustrated in Fig. 1. Stories between the sender (author or teller) and the receiver (reader or hearer) are not the same objects. On the sender side, a story corresponds to the source information of the expressed discourse, which is remembered or generated inside one’s mind. On the receiver side, a story is also mentally constructed through interpreting or understanding the discourse expressed by the sender. For example, when a sender tells a receiver of his/her past experience, the sender’s story corresponds to an episodic memory, and the receiver’s story is made by interpreting the expressed discourse.

Basic story structure

In general terms, a story refers to chronologically organized events. This study assumes that a story represents a piece of a subjective world dominated by the temporal dimension, which is formed as a course of events. The entities’ dimension, i.e., story world, is subordinated within the temporal dimension. Namely, a story contains a story world. We explain this using a simple example structure in Fig. 2. This story assumes a type of episodic memory of a boy named Taro. The story forms a course of events based on temporal and causal relations. The story world contained in the story forms the relational structure of the entities (characters, objects, and places) relevant to these events.

Although this example story shows a very simplified structure, a story is essentially a complex collection of information integrating events, entities, relationships, abstract concepts, intents, goals, emotions, and non-verbal information (e.g., memories of visual images). This type of multiplicity has been discussed from computational perspectives (e.g. Akimoto, 2018; Gervás & León, 2014; León, 2016a; Mani, 2013; Schank & Abelson, 1977). However, the computational modeling of a story structure with rich representational power remains a huge problem.

Subjective structures in stories

As we described in the previous section, a story is a mental object composed within the mind of an individual person or agent. The story itself does not exist in the external world. In this sense, every story is a subjective and individual object. For example, when several people watch a boxing match in a stadium, they will retain more or less different episodic memories (stories) based on their own experiences.³ Although people cannot directly view stories inside other persons, their different stories are expressed in their discourses.

In this section, we address the conceptualization of how subjective

² Genette (1980) presented a general narratological theory of narrative discourse structure. From a computational perspective, Mani (2013) provides an outline of narratological concepts of narrative structure, including Genette’s theory.

³ However, background knowledge and the way of story making are partially shared with others through the cultural narrative experiences in their societies. In this sense, a story is essentially an intersubjective object.

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