Steps Towards Accessing Digital Libraries Using Narratives

Carlo Meghini, Valentina Bartalesi, Daniele Metilli

ISTI "Alessandro Faedo" – CNR, Pisa, Italy
{carlo.meghini,valentina.bartalesi,daniele.metilli}@isti.cnr.it

Abstract. One of the main problems of the current Digital Libraries (DLs) is the limitation of the informative services offered to the users. Indeed, DLs provide simple search functionalities which return a list of the information objects contained in them. No semantic relation among the returned objects is usually reported which can help the user in obtaining a more complete knowledge on the subject of the search. The introduction of the Semantic Web has the potential of improving the search functionalities of DLs. Many cultural institutions have represented their metadata into *formal descriptions* encoded by means of formal languages such as RDF and OWL. In this context, the aim of our research is to introduce the narrative as a new search functionality which does not only return a list of objects but presents a narrative, composed of events that are linked to the objects of the library and endowed with a set of semantic relations connecting these events into a meaningful semantic network. The paper presents the first theoretical achievements on a model for representing narratives.

Keywords: Narratology, Digital Libraries, Semantic Web, Ontologies

1 Introduction

Digital libraries (DLs) are information systems that offer services over large sets of digital objects [23]. The traditional search functionalities of DLs, such as Europeana[1], consider that users express their information need through a natural language query, and the digital library returns a ranked list of digital objects. This approach works well on the web, where the objects of the search are rich text pages with images and links to other pages, but it performs poorly on most DLs. The reason is that the digital objects contained in them (e.g. representations of books, photographs) are not meant to be read and navigated on the fly like web pages. As a result, the response to a web-like query on a digital library is typically a ranked list of metadata descriptors. In our study, we aim at overcoming this limitation of current DLs by introducing a new first-class search functionality: the *narrative*. The vision is that a user searching for a cultural heritage item like the Baptistery of Florence in Europeana would obtain in response not the ranked

[1] `http://www.europeana.eu/portal/`

list of objects concerning the Baptistery but rather a *narrative* about it, made up of a list of events that compose its history, linked to the objects of the digital library that contextualize them. Our study aims to introduce this new search functionality using Semantic Web technologies, and developing a formal ontology for representing narratives. In order to reach this goal, we studied the narratology and computational narratology literature to identify the basic structure of a narrative. We also reviewed the Artificial Intelligence (AI) literature to identify the logical components of the narrative structure (e.g. events, fluents, agents), and give their logical definitions. Then, we developed a conceptualization of the narrative structure, as derived from the above background. Finally, in order to develop an ontology to represent narratives, we evaluated the CIDOC CRM[2] as reference ontology [11]. The evaluation was based on the mapping between the logic components of narratives and the terms included in the CRM.

The paper is structured as follows: Section 2 presents the narratology and computational narratology background and Section 3 an overview of the related works. In Section 4 an analysis of the AI literature in order to identify the formal components of narratives is reported. Section 5 presents a conceptualization of the narrative structure. In Section 6, a mapping between the formal components of narratives and the CRM is reported. Section 7 presents a brief discussion of the results of the mapping. Finally, Section 8 reports our conclusions.

2 Background

2.1 Narratology

In literary theory, narratology is a discipline that studies the narrative structure and the logic, principles, and practices of its representation [24]. The earliest antecedent to modern narratology can be found in the *Poetics* of Aristotle, who defines a narrative as the imitation of real actions that forms an argument whose fundamental units, or events, can be arranged in a plot [4]. However, the theoretical principles of narratology derive from linguistic-centered approaches to literature defined by Russian formalists in the early 20th century. Russian formalism defines narratology as based on the idea of a universal pattern of codes that operates within the content of a work. A narrative can thus be conveyed through several different means of communication, e.g. speech, writing, gestures, music. In particular, Vladimir Propp proposed a model to represent folktales as combinations of basic building blocks, including thirty-one narrative functions and seven roles of the characters [27]. Russian formalism distinguishes between a *fabula*, defined as a series of events in chronological order, and a *syuzhet*, which is the particular way the story is narrated by its author [27]. The theory of narratology was further developed by mid-20th Century European structuralism. Claude Lévi-Strauss outlined a grammar of mythology [17]; Tzvetan Todorov was the first to coin the term *narratologie* [29]. In the Cognitive Narratology [14] perspective, narratology is considered a psychological phenomenon, and narrative

[2] Conceptual Reference Model

aspects have to be studied from a cognitive perspective. Currently, there is no universally accepted definition of narrative structure. For instance, Crawford [9] claims that a narrative is a high-level structure based on causality, but not on spatio-temporal relations. In addition to the fabula and syuzhet, Bal [5] defines a third level that constitutes the concrete representation of the content that is conveyed to the audience.

2.2 Computational Narratology

Computational narratology studies narratives from a computational perspective, focusing on "the algorithmic processes involved in creating and interpreting narratives, modelling narrative structure in terms of formal computable representations" [19]. Computational narratology is based on engineering disciplines aiming at developing AI systems for reproducing human-like narrative behaviour and intelligent interfaces for interacting with narratives [20]. In AI this term refers to storytelling systems, i.e., software generating stories described in natural language, implementing linguistic formalisms [7]. Some of the early storytelling systems are TALE-SPIN [22] abd UNIVERSE [16]. These are hybrid systems that implement a computer model of creativity in writing. Recently, ontologies were used to generate narratives. For example, it happened in the MAKEBELIEVE [18] and ProtoPropp [13] projects. In our research context, these systems are interesting because they use formal models that provide a symbolic representation of a narrative.

3 Related Works

Narratives have been recently proposed to enhance the information contents and functionalities of DLs, with special emphasis on information discovery and exploration. For example, Bletchley Park Text [26] is a semantic application that allows users to explore collections of museums. The semantic description of the resources is used to organize a collection into a personalized web site based on the chosen topics. In the PATHS project [12] a system that acts as an interactive personalized tour guide through existing digital library collections was created. In this system the events are linked by inherence relations. Within the CULTURA project [1] a tool to enrich the cultural heritage collections with guided paths in the form of short lessons called *narratives* was developed.

4 Components of Narratives in Artificial Intelligence

We conducted a study of the AI literature in order to identify the formal components of narratives. In this Section we report the logic definitions of the components of narratives as defined in the Event Calculus (EC) theory [15], with a brief mention also to the Situation Calculus (SC) [21] as related background. The SC is a logic language for representing and reasoning about dynamical domains. In dynamical domains the scenarios change because of the actions performed by the agents. The basic elements of the calculus are:

- *Situations* represent a sequence of actions. The situation is a state resulting from these actions. Sequences of actions are represented using the function symbol *do*, so that *do(a, s)* represents the new situation after that the action a was performed in situation s.
- *Fluents* are functions and predicates that vary over situations (e.g. location of the agent). Fluents are situation-dependent components used to describe the effects of actions.
- *Actions* are changes performed by agents from a situation to another in a dynamic world.

SC works well when there is a single agent performing instantaneous, discrete actions. When actions have duration and can overlap with each other the alternative formalism is the EC, which is used for reasoning on actions and changes and it is based on points rather than on situations. EC allows reasoning over intervals of time and fluents are time-dependent rather than situation-dependent. EC axioms define a fluent true at a point in time if "the fluent was initiated by an event at some time in the past and was not terminated by an intervening event" [28]. Davidson [10] defines *actions* as a subclass of *events*. In Davidson's opinion, the distinct sign between general events and actions is the intentionality of actions. Like SC, Event Calculus has actions. However, Davidson's distinction between events and actions is not present. In the EC actions are events. In the following list we report the logical definitions of the components of narratives.

- *Generalized events*. In the context in which actions and objects are aspects of a physical universe with a spatial and temporal dimension, a generalized event is a space-time chunk. This abstraction allows thinking to generalize event concepts like actions, locations, times, fluents and physical objects.
- *Mental events and mental objects*. The relations between an agent and "mental objects" like *believes* and *knows*, are called propositional attitudes, because they identify attitudes that agents can have towards a proposition [28]. Using the reification method it is possible to turn a proposition into an object that could become an argument of a sentence (because only terms and not sentences can be arguments of predicates).
- *Narrative*. A narrative is a possibly incomplete specification of a set of actual event occurrences [25]. The EC is narrative-based, unlike the standard SC in which an exact sequence of hypothetical actions is represented.

5 A Conceptualization of the Narrative Structure

Following the narratology theory and the components of narratives as defined in the AI literature, we envisage a *narrative* as consisting of three main elements:

1. the *fabula*, representing the fabula as defined by the Russian formalism, i.e. the sequence of the events that composes the story in chronological order;
2. the *narrations*, one or more texts that narrate the fabula, and that correspond to Bal's definition of *presentation*;
3. a *reference* function that connects the narrations to the fabula and allows deriving the *syuzhet* (or plot) as defined by the Russian formalism.

Fabula. The fabula is built on top of events, an event being an action or occurrence taking place at a certain time at a specific location. In a fabula, events are connected to each other by three kinds of relations:

- a *mereological* relation, relating events to other events that include them as parts, e.g. the birth of Dante Alighieri, the major Italian poet of the late Middle Ages, is part of the life of Dante;
- a *temporal occurrence* relation, associating each event with a time interval during which the event occurs. An event occurs before (or during, or after) another if and only if the period of occurrence of the former event is before (or during, or after) the period of occurrence of the latter. We formalize these relations between events using Allen's temporal logic [3];
- a *causal dependency* relation, relating events that in normal discourse are predicated to have a *cause-effect* relation in the narrator's opinion, e.g. the eruption of the Vesuvius caused the destruction of Pompeii. We are not interested in modeling the mechanical causal relationships that connect events in a physical process. We are rather interested in a more generic notion of causality, whereby the connected events may be years apart in time and the causal connection may be indirect.

Narrations. Each narration of a fabula consists of one or more narrators and a text, which is *authored by* the narrator(s).

Reference. The reference function connects each portion of text that narrates an event to the narrated event. In order to model reference we need to identify textual units, which we call *narrative fragments* (or simply fragments), each of which narrates one or more events. Notice that the reference function allows deriving the plot of the narrative. Indeed, by visiting the text of the narration in its natural order, it is possible to access the *narrative fragments* and, via these, the events in the fabula, *in the order established by the narrator*.

We provided a specification of the above conceptualization in mathematical terms. This allows us to concentrate on the proper capturing of the notions highlighted above, postponing any language consideration to a later stage, once the mathematical specification will have brought forward the required machinery. A detailed description of the mathematical specification is reported in [6].

6 CRM Mapping of Narratives Components

In order to develop a semantic model to represent narratives, on top of which to develop the new search functionality for DLs, we used the CIDOC CRM (CRM for short) as reference ontology [11]. This choice was determined by the fact that the CRM is an ISO standard ontology and promotes a shared understanding of cultural heritage information through a semantic framework that any cultural heritage organization can use to map its cultural objects. Furthermore, the CRM terms allow mapping the most important logic components of narratives as reported below. The following definitions are extracted from the CRM official documentation[3].

[3] `http://www.cidoc-crm.org/docs/cidoc\_crm\_version\_6.2.pdf`

- *Event*. In the CRM, the class *E5 Event* corresponds to the definition of *event* in the EC theory. This class "comprises changes of states in cultural, social or physical systems, regardless of scale, brought about by a series or group of coherent physical, cultural, technological or legal phenomena".
- *Action*. Actions identified by Davidson correspond to the class *E7 Activity* in the CRM. "This class comprises actions intentionally carried out by an actor that result in changes of state in the cultural, social, or physical systems documented".

In order to refine our mapping, we analysed the single types of generalized events that are useful to represent the components of events and we mapped them with the classes of the CRM.

- *Agent*. The CRM uses the class *E39 Actor* to represent people, either individually or in groups, who have the potential to perform intentional actions of kinds for which someone may be held responsible.
- *Location*. This concept is represented in the CRM through the class *E53 Place*. "This class comprises extents in space, in particular on the surface of the earth [...] independent from temporal phenomena and matter".
- *Time*. CRM uses the class *E52 Time-Span* to represent this concept. "This class comprises abstract temporal extents, in the sense of Galilean physics, having a beginning, an end and a duration".
- *Physical Objects*. In the CRM the class *E18 Physical Thing* describes "all persistent physical items with a relatively stable form, man-made or natural".
- *Mental Objects*. In the CRM the class *E28 Conceptual Object* comprises "non-material products of our minds and other human produced data that have become objects of a discourse about their identity, circumstances of creation or historical implication".

The relations defined on the events (and actions) of the fabula, are expressed by the following CRM properties:

- The *mereological* relation is represented using the property *P9 consists of*, which associates an instance of *E4 Period* with another instance of *E4* that is defined by a subset of the phenomena that define the former. *E5 Event* is a subclass of *E4*, therefore *P9* can be used also as an event mereology.
- The *event occurrence* relation is represented by the CRM property *P4 has time-span*, which describes the temporal confinement of an instance of an *E2 Temporal Entity* and therefore of an event. Because the period of occurrence of an event may not be known, the CRM allows to directly relate events based on their occurrence time. To this end, it introduces seven properties (*P114-P120*) mirroring Allen's temporal logic [2].
- The *causality* relation is represented by introducing a new property of *causal dependency*. This is the only proposed extension to the CRM, whose only causal property *P17 was motivated by* cannot be used for narratives since it relates activities but not events. Indeed, CRMsci[4], an extension of CRM for science, defines a direct causality relation, via the property *O13 triggers*, which "associates an instance of *E5 Event* that triggers another instance of

[4] http://www.ics.forth.gr/isl/CRMext/CRMsci/docs/CRMsci1.2.2.pdf

E5 Event with the latter [...]; in that sense it is interpreted as the cause". However, this property is inadequate to the needs of narratives, whose events may be separated by possibly long periods of time.

7 Discussion

As result of the mapping, the logic components of narratives we identified can be defined using classes and properties of the CRM. Furthermore, the CRM provides several subclasses of *E5 Event* which identify types of event (e.g. *E63 Beginning of Existence, E65 Creation*). These subclasses are useful to establish a first categorization of events. Furthermore, another advantage of the use of the CRM is the existence of CRMinf[5], an extension of the CRM, which we are considering to describe the inference processes of the narrator. Indeed, in addition to the components of narratives, we considered to represent the inferential process of a narrator who reconstructs the events that compose a narrative starting from the study of the primary sources. Our model aims at describing the *knowledge provenance*, i.e. the process of tracing the origins of knowledge [8]. Reconstructing the inference process is important to evaluate the trustworthiness of the knowledge. A user can determine the quality of the knowledge based on its derivations. CRMinf aims at representing data attribution, scientific concepts of observation, inferences and beliefs. For these reasons, we have adopted the CRM as reference vocabulary to construct an ontology for representing narratives.

8 Conclusions and Future Work

In this paper we have presented the first theoretical achievements on a model for representing narratives. In particular, we have presented a review of the works on narratives and described our project relating it to developed models both in the cultural heritage and in the digital library fields. The final aim of our research is introducing narratives as as a new search functionality for DLs. As output of a query, this new search functionality should not return just a list of objects, as the current DLs report as output, but it should present a semantic network we called *narrative*, composed of the events of the narrated story. The events and their contextualizing components, e.g. digital objects, are connected by semantic relations meaningful to the user.

References

1. Agosti, M., Manfioletti, M., Orio, N., Ponchia, C.: Enhancing end user access to cultural heritage systems: Tailored narratives and human-centered computing. In: New Trends in Image Analysis and Processing 2013, pp. 278–287. Springer (2013)
2. Allen, J.F.: Maintaining knowledge about temporal intervals. Communications of the ACM 26(11), 832–843 (1983)

[5] `http://www.ics.forth.gr/isl/CRMext/CRMinf/docs/CRMinf-0.7.pdf`

3. Allen, J.F.: Towards a general theory of action and time. Artificial intelligence 23(2), 123–154 (1984)
4. Aristotele: Poetica. Laterza (1998)
5. Bal, M.: Narratology: Introduction to the theory of narrative. University of Toronto Press (1997)
6. Bartalesi, V., Meghini, C., Metilli, D.: Steps towards a formal ontology of narratives based on narratology. In: CMN 2016 (2016)
7. Cavazza, M., Pizzi, D.: Narratology for interactive storytelling: A critical introduction. In: Technologies for Interactive Digital Storytelling and Entertainment, pp. 72–83. Springer (2006)
8. Committee, P.E., et al.: Premis data dictionary for preservation metadata, version 2.0. Retrieved May 22, 2010 (2008)
9. Crawford, C.: Chris Crawford on interactive storytelling. New Riders (2012)
10. Davidson, D.: Essays on actions and events: Philosophical essays, vol. 1. Oxford University Press (2001)
11. Doerr, M.: The cidoc conceptual reference module: an ontological approach to semantic interoperability of metadata. AI magazine 24(3), 75 (2003)
12. Fernie, K., Griffiths, J., Archer, P., Chandrinos, K., de Polo, A., Stevenson, M., Clough, P., Goodale, P., Hall, M., Agirre, E., et al.: Paths: Personalising access to cultural heritage spaces. In: Virtual Systems and Multimedia (VSMM), 2012 18th International Conference on. pp. 469–474. IEEE (2012)
13. Gervás, P., Díaz-Agudo, B., Peinado, F., Hervás, R.: Story plot generation based on cbr. Knowledge-Based Systems 18(4), 235–242 (2005)
14. Herman, D.: Narratology as a cognitive science. image and narrative 1(1) (2000)
15. Kowalski, R., Sergot, M.: A logic-based calculus of events. In: Foundations of knowledge base management, pp. 23–55. Springer (1989)
16. Lebowitz, M.: Story-telling as planning and learning. Poetics 14(6), 483–502 (1985)
17. Levi-Strauss, C.: Structural analysis in linguistics and in anthropology. Semiotics-An Introductory Anthology pp. 110–128 (1963)
18. Liu, H., Singh, P.: Makebelieve: Using commonsense knowledge to generate stories. In: AAAI/IAAI. pp. 957–958 (2002)
19. Mani, I.: Computational modeling of narrative. Synthesis Lectures on Human Language Technologies 5(3), 1–142 (2012)
20. Mani, I.: Computational narratology. Handbook of narratology pp. 84–92 (2014)
21. McCarthy, J.: A basis for a mathematical theory of computation. Computer programming and formal systems 354 (1963)
22. Meehan, J.R.: Tale-spin, an interactive program that writes stories. In: IJCAI. pp. 91–98 (1977)
23. Meghini, C., Spyratos, N., Sugibuchi, T., Yang, J.: A model for digital libraries and its translation to rdf. Journal on Data Semantics 3(2), 107–139 (2014)
24. Meister, J.C.: Narratology. (2012), synthesis. American Museum of Natural History. Available at http://ncep.amnh.org.
25. Miller, R., Shanahan, M.: Narratives in the situation calculus. Journal of Logic and Computation 4(5), 513–530 (1994)
26. Mulholland, P., Collins, T.: Using digital narratives to support the collaborative learning and exploration of cultural heritage. In: Database and Expert Systems Applications. pp. 527–531. IEEE (2002)
27. Propp, V.: Morphology of the Folktale, vol. 9. University of Texas Press (1973)
28. Russell, S.J., Norvig, P.: Artificial intelligence: a modern approach. Prentice Hall (1995)
29. Todorov, T.: Grammaire du décaméron. Mouton The Hague (1969)