Ontological Representations of Narratives: a Case Study on Stories and Actions*

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Abstract

In this paper, we describe the narrative ontological model encompassed in the Labyrinth system. The aim of the system is to allow users to explore a digital archive by following the narrative relations among the resources contained in it. Targeted at cultural heritage applications, the Labyrinth project relies on the notion of "cultural archetype", i.e., a core representation encompassing archetypical stories and characters, exploited as a conceptual framework for the access to archives of heterogeneous media objects.

In particular, we describe how the system leverages various types of ontological reasoning to let narrative relations emerge between artworks, and exemplify how these relations are exploited by the system to provide the user with a narrative conceptual framework she or he is familiar with in the exploration of the archive.

1998 ACM Subject Classification H.5.4 Hypertext/Hypermedia

Keywords and phrases Story ontology, Cultural Heritage, Semantic Applications

Digital Object Identifier 10.4230/OASIcs.CMN.2013.76

1 Introduction and Motivations

In recent years, the advent of digital media has enabled the publication on the Web of a huge quantity of resources, i.e., images, audiovisual objects, text documents and their combination. However, as the number of online digital contents increases, the way they are described is far from meeting the requirements of content-based access required by the general public: neither their description in terms of editorial metadata nor the tags added by users seem adequate to describe the content of media resources, and fall short of providing an effective access to digital media. The classification of resources in terms of stylistic features (layouts, patterns, colour profiles, etc.) is inadequate as well to the users' needs.

In the field of cultural heritage, in particular, a content based description of artworks is required. As shown by the media studies, when users tag artworks, they tend to describe the content of the artworks [33]. For visual arts, stories can provide an effective way to mediate between the users and the description of the artwork by using a conceptual model users are familiar with [4]. In many cases, the content of visual artworks can be described

* This work was partially supported by Regione Piemonte, Polo di Innovazione per la Creatività Digitale e la Multimedialità, 2012-2014, POR-FESR 2008-2013.

Workshop on Computational Models of Narrative 2013.
Editors: Mark A. Finlayson, Bernhard Fisseni, Benedikt Löwe, and Jan Christoph Meister; pp. 76–93

OpenAccess Series in Informatics
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

in terms of some narrative situation, i.e., a basic framework where a character is caught in the act of doing something, using some instrument, possibly with the participation of other characters. The role of stories in the description of artworks is explicitly acknowledged by iconology. For example, consider a painting representing a mythological subject, such as Ariadne: the character of Ariadne is sometimes represented in the act of giving to Theseus a ball of thread (that he will employ to escape from labyrinth of Minos); or, she is depicted as abandoned by Theseus in the island of Naxos; or else, following a different myth, she is represented with Bacchus. In the Iconclass system for iconological classification[1], the first subject corresponds to the *id* 94M34 ("Ariadne gives Theseus a ball of thread"), the second one to the *id* 95B(ARIADNE)61 ("Ariadne left behind on the island of Naxos"), where Bacchus will find her later on (*id* 92L1211, "Bacchus finds Ariadne on Naxos") [17].

Thanks to the practice of imitation [19], in Western culture, the same subject is represented multiple times across authors and ages: in the neoclassical painting by Pelagio Pelagi ("Arianna dona il gomitolo a Teseo", 1814), in the painting by Jean–Baptiste Regnault ("Ariane et Thésée", 1827), etc. Moreover, the same stories are the subject of many other artworks, conveyed through different media: for example, consider "Ariadne auf Naxos" (1916), an opera by Richard Strauss, or the peplum film "Teseo contro il Minotauro" (Italy, 1960). In the digital age, remediation [3] contributes to keeping this practice alive, with narrative contents being adapted from texts, to films and comics and so on, meeting the expectations of different audience types and the distribution requirements posed by different devices. Finally, narrative situations are linked to each other to form larger stories, which provide further, more indirect connections between artworks: consider, for example, the "story of Ariadne" (encoded in Iconclass as "95B(ARIADNE) (story of) Ariadne"), which, as a more general class, encompasses the single stories mentioned above.

This paper describes an ontology-based approach to the description of the narrative content of artworks, implemented in the Labyrinth system. The aim of the Labyrinth system is to test the feasibility of using narrative concepts for the exploration of media archives, in the field of cultural heritage. Artworks, in fact, often have a narrative content, but span only single episodes of larger stories; moreover, they often do it through audio visual languages that are not available for text processing. The use of an ontological model, where narrative situations are described and grouped into stories, allows implicit relations to emerge among artworks through reasoning: for example, starting from their narrative features (represented characters, action, location, etc.), different artworks can be inferred as displaying the same episode, or different episodes of the same story. Narrative relations, then, are exploited to create navigation paths among the artworks, or to generate recommendations of similar contents.

Targeted at cultural heritage dissemination and digital publishing, the Labyrinth project relies on the notion of "cultural archetype", i.e., a core representation encompassing archetypal stories and characters, proposed as a conceptual framework for the access to archives of heterogeneous media objects. In the Archetype ontology, stories are represented as containing a set of actions, enacted by characters in a given location and time, and described according to a role–based schema. A story can encompass other simpler stories, which in turn are composed of increasingly simpler actions. The ontology has been designed with the goal of supporting reasoning on the relations among characters, actions and stories, while abstracting from different genres and media types. In this paper, we illustrate the Archetype Ontology and show, by resorting to examples, how the ontology supports narrative reasoning on the

[1] `http://www.iconclass.org`

relations between stories, actions and character. Finally, we illustrate how the narrative relations obtained through the reasoning process are employed in the system to support the navigation in the archive.

The paper is organised as follows: after surveying the related work (Section 2), in Section 3 we briefly describe the system within which the proposed model of story is being developed and tested. In Section 4, the conceptual model of the archetype ontology is described. Section 5 shows how the connections among artefacts and stories (or actions) is obtained. Section 6 illustrates how the inferences generated by the reasoner on the narrative model are employed to support the narrative based navigation among the artworks. Conclusions and future work end the paper.

2 Related Work

In the last decade, the access to cultural heritage and the distribution of media objects have moved toward a digital convergence [22]. In cultural heritage, this process has taken the form of digital platforms, such as online museums, cultural websites, etc. aimed at encouraging the access to the cultural heritage by the general public (consider, for example, the Europeana web portal).[2] In parallel, the advent of new media has pushed forward re-mediation practices [3]: according to the paradigm of re-mediation, the contents of one medium are re-focused onto another medium (like for example, the transposition of a novel into a film or the reuse of movie contents in videogame design). Despite the scenario described above, the convergent culture has not been effective in creating tools for organizing and accessing contents in the field of cultural heritage. In today's web, searching media objects, in fact, is still largely based on keywords and/or tags: the search outputs a list of objects (books, pictures, videos, etc.) but does not contain an explicit representation of the narrative relations they entertain with the input keywords.

The use of ontologies for the exploration of media archives has been explored by several research projects. A pioneering contribution in the use of ontologies to provide online access to cultural heritage is given by the CultureSampo project [20]. This project encompasses a set of domain ontologies, which provide the background against which cultural objects, encoded in different media formats, can be explored, tracking the connections among them [21] in terms of geographical and chronological relations, authorships, production processes, etc. The folkloric saga called Kalevala, also encoded in an ontological form, is employed to describe and connect the episodes referred to by artworks.

The DECHO system [1] relies on a conceptual model of the archeological domain to support the exploration of cultural heritage objects. Targeted at the integration of different data sources, the ontology has been developed on top of the CIDOC Conceptual Reference Model (CIDOC-CRM) [12]. In particular, the system encompasses digital images, 3D models of objects and environment, and narratives, using the ontology to establish connections among them. Mainly oriented toward the interaction with 3D virtual environment and objects, the DECHO system integrates in a unifying semantic framework an advanced 3D visualisation tool and a corpus of textual documentation about the displayed objects, including narratives.

Narrative is the focus of the Bletchley Park Text system [28], a semantic system designed with the goal of supporting the users in the exploration of online museum collections. Designed with the notion of the "guided visit" in mind, the system relies on an ontology of story, taken from the Story Fountain project [29]. The stories represented in the system are exploited to

[2] http://www.europeana.org

create relations between the entities contained in the online collections, allowing the user to query the system for a semantic path between entities. Similarly to [28], the Labyrinth project mainly relies on narrative concepts for the users' conceptualisation of resources [28]. However, the Labyrinth project is not targeted at the fruition of a specific (virtual or physical) collection: rather, it aims at exploiting narrative concepts to create an open system that leverages the reasoning capabilities of the Semantic Web technologies to let meaningful connections emerge within heterogeneous resources.

Concerning the use of ontologies to model narrative concepts, story ontologies have been proposed with two main goals, namely the purpose of classifying story types and the purpose of providing an underlying model for narrative annotation. A well known example of the first type of systems is the work by [15]. In this work, inspired by the work of Propp [32], an ontology of fairy tales, encoded in OWL, is exploited to model different plot types. The system uses the ontology to perform case-based reasoning: given a story plan, the system searches a similar plot in the ontology, measuring the semantic similarity of the given plot with the plot types encoded in the ontology. A natural language module, then, generates a textual version of the obtained plot, adapted to the input parameters (characters, situations, etc.) given by the user. In the same line, the work by [18] used automatic classification techniques to classify plot types. However, with the notable exception of the Opiate system [13], structuralist models not have received much attention in recent years, following the criticism that they do not provide the flexibility needed to face the challenges of new media.

Overcoming the differences among different media types and genres is a main challenge faced by the research in media annotation. In this field, story ontologies have been proposed as a way to provide a shared and interoperable model for annotation scenarios which are characterised by the presence of different types of narrative contents and rely on the paradigm of crowd–sourcing. A media-independent model is provided by the OntoMedia ontology, exploited across different projects (such as the Contextus Project [23, 24]) to annotate the narrative content of different media objects, ranging from written literature to comics and TV fiction. The OntoMedia ontology contains a very detailed model, tailored on story annotation, and mainly focused on the representation of events and the order in which they are exposed. In [24], it is employed to annotate common elements and plot across the different episodes of the Dr. Who sci-fi TV series. OntoMedia lends itself to the comparison of cross-media versions of the same story (for example, a novel and its filmic adaptation), while it does not cover in a detailed way the description of characters' behavior (intentions, roles, etc.).

The Cadmos project [25, 8] shares with these approaches the basic assumption that a media object can be segmented into meaningful narrative units and that, given some kind of formal or semi-formal annotation, these units can be accessed and navigated. In the Drammar ontology, the basic unit of the annotation is the "drama unit": based on the Aristotelean notion of unity of action, the unit contains one or more incidents, which can be either naturally occurring events, or intentional actions performed by the story characters in order to achieve some goals. A main innovation attained by the Drammar is the mapping of the annotation schema to linguistic resources (namely, FrameNet [2] and WordNet [27]), and the design of a meaning negotiation process [8] to let users select the appropriate concept for describing events in large common sense ontologies (such as YAGOSUMO [11]).

The SUMO ontology, although not specifically tailored on story modelling, has been employed for the task of story annotation and story generation. In [10], the axiomatic definition of processes, in SUMO, is exploited to reason on stories and to generate plots. This approach, although not directly relevant for story models, reveals the relevance of an accurate representation of actions (processes, in SUMO terminology) for story description.

The ontology encompassed by the Labyrinth system (Archetype ontology) incorporates some of the main tenets of the Drammar of ontology, such as the commitment towards a core story model, neutral with respect to different narrative theories and genres; differently from Drammar, which provides a character–based account of narrative concepts, it assumes that a library of basic stories, relevant to the cultural archetypes of Western culture, is edited by hand and exploited to link different media resources. Inspired by the approach proposed by [20], where a single folkloric saga has been employed as a red thread for the presentation of artworks, in the Labyrinth projects, the story model serves as a framework for the users' conceptualisation of artworks, in a domain (cultural heritage) where narrative is, across media and ages, a powerful metaphor for content description.

With respect to the story models encoded in [15, 23], which are oriented, respectively, to story classification and annotation, the narrative model of the Labyrinth system is oriented to the description of basic narrative situations, represented in terms of characters and objects participating to a narrative situation, and their organisation into larger stories according to a modular perspective. In this sense, it abstracts from the notions of plot types and genre, accounting for the distinction between entities and processes acknowledged by top level ontologies such as Dolce [26]. Being targeted at representing the narrative properties of artworks, the Archetype ontology has been designed with the goal of interoperability with the standard ontologies for media description, such as Media Ontology[3] and FRBR [30].

Finally, differently from other approaches issued by industrial and academic research (see, for example, Knowledge Graph project[4]), Labyrinth does not aim at creating a general infrastructure for representing semantic relations among media items, but limits its scope to a set of few relevant archetypes (the labyrinth, the hero, journey, etc.) which are pervasive in Western culture. The underlying assumption of this approach is that these archetypes (and their related stories) are limited in number and shared by the audience along geographical and temporal coordinates, providing a valid affordance to content access for the general public of new media.

3 Overview of the Labyrinth system

The Labyrinth system allows the user to explore a repository of media resources through the conceptual mediation of an "archetype". The user can see how the resources in the repository relate with the various element which compose the archetype model (places, stories, characters, objects, etc., described in Section 4), and how they are connected to each other through the links with the archetype they share (for example, resources displaying the same character or symbol, related to a certain archetype).

The interaction design of the system integrates a top-down, hypertextual exploration of the repository with a 3D environment (still under development). In the hypertextual mode, the system filters the contents according to their links to the reference archetype and shows how they are related with each archetype element (stories, characters, objects, locations, etc.). When a single artwork is reached, the user starts navigating the repository resource by resource, following the semantic relations between the artworks, in a way that resembles the walk through a maze. Semantic browsing and navigation are not limited to the explicit representation contained in the ontology, but leverage the inferences made by the ontology server.

[3] http://dev.w3.org/2008/video/mediaann/mediaont-1.0/mediaont-1.0.html
[4] http://www.google.com/insidesearch/features/search/knowledge.html

The Labyrinth system encompasses four main modules:

- The Ontology server maintains the ontology describing the archetypes, maps the media resources and their relations onto the ontological model, and provides the reasoning services.[5]
- The Media repository stores the resources and is managed through a relational database (DB).
- The Labyrinth Web application, written in Java, provides search and navigation functionalities by querying the ontology.
- The client side applications, i.e., the web site and the 3D plugin, support the interaction with the user.

Since the Labyrinth system merges the perspective of digital archives with the paradigm of new media, adding a new repository to the the system requires a two-step process, which includes data integration and editing: the data integration phase is accomplished through an internalization procedure, which translates the description of the resources to be incorporated (encoded in their metadata) into the ontological model of the system; in some case, the model must be edited to accommodate the new data.

The content creation pipeline, then, is the following: a domain expert examines the contents of the repository to be incorporated and suggests a list of archetypes which are relevant to the resources in the repository. Then, the ontology engineer edits the ontology to create the required archetypes (unless they are already present in the ontology). Adding new archetypes to the ontology, however, does not affect the archetype model, leaving the top-level classes of the ontology unmodified. Finally, the resources in the repository are mapped onto the archetypes contained in the system (and their audiovisual documentation is copied in the Media repository), through a set of mapping rules.

By using the online interface, the users can search and explore the resources contained in the repository based on the relations they have with the archetypes described in the ontology. The assumption is that "emergent" meaning relations, inferred by the semantic engine on the ontological model, can generate thematic (perhaps serendipitous) paths through the repository.

4 The archetype ontology

The Archetype Ontology (AO), designed for the Labyrinth system, relies on and incorporates, in a unifying model, multiple ontologies already available in the literature and representing different relevant aspects of the narrative of media objects. More precisely, the ontologies incorporated in AO are the following: the Ontology for Media Resource[6], a formal framework for describing media objects (e.g., images, videos etc.) according to their format (e.g., jpeg, avi etc.); the FRBR (Functional Requirements for Bibliographical Records) ontology[7], a framework for describing resources according to an abstract model; finally, part of the Drammar ontology [9], a core ontology for the representation of characters and actions in narrative units. Following a tradition dating back to Aristotle in drama studies and narratology [5, 31], the Drammar ontology acknowledges the primary role of character in

[5] Currently, the ontology server is provided by the Owlim RDF database management systems (`http://www.ontotext.com/owlim`).
[6] `http://dev.w3.org/2008/video/mediaann/mediaont-1.0/mediaont-1.0.html`
[7] `http://www.ifla.org/publications/functional-requirements-for-bibliographic-records`

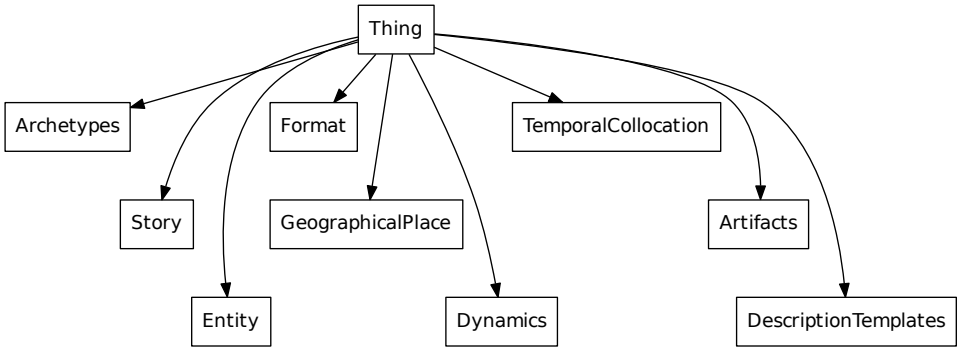

Figure 1 The top level of the Archetype ontology.

story, intended as the intentional agent of a sequence of causally related story incidents. The role of characters has emerged also in contemporary aesthetics, where it is considered the medium of audience involvement, thanks to the process of identification with characters [16, 7]

AO serves the explicit goal of representing the peculiar narrative aspects related to the definition of 'cultural archetypes'. Archetypes, in turn, serve the scope of describing the semantic relations occurring among a set of cultural and artistic artifacts. Therefore, for its own nature, the Archetype Ontology is not intended to cover the foundational aspects of narratives, but only the ones intrinsically connected with the concept of Archetype, intended as a core representation encompassing archetypical stories and characters. The ontology has been designed with the goal of supporting reasoning on these typ of narrative relations, that the Labyrinth system exploits to guide the user exploration of media archives.

The top level classes of AO are the represented in Figure 1. The **Archetypes** class contains the thematic archetypes to which a story can be referred; the **Artifact** class contains the media objects, organized according to the FRBR model; the **Dynamics** class (from Drammar) represents actions, processes and state of affairs involving the narrative entities; **Entity** contains the characters and objects represented in an artefact or involved in a story; **Story** represents a collection of stories; **Description Templates** (from the Drammar ontology) contains the role schema (**SituationSchema**) that can be filled by narrative entities (characters and objects) in a dynamics (i.e., a process or state), inspired by the "Situation Description" ontology pattern [14]; the **Format** class encodes the format and type of media resources; **Geographical Place** and **Temporal Collocation**, finally, represent the classes where it is possible to encode, respectively, the spatial and temporal information related to artefacts, stories and archetypes.

The above mentioned ontologies have been inserted in our model as follows: FRBR ontology has been used in order to describe the individuals belonging to the **Artifact** class. The four abstract levels for the resource description of the FRBR model [30] are: *work*, representing a certain intellectual or artistic creation (e.g., the *Faust*); *expression*, representing the different intellectual or artistic realization of a work (e.g., book, video etc.); *manifestation*, representing the physical embodiment of an expression (e.g., the Italian translation of the book of *Faust*) and *item*, the specific exemplar of a certain manifestation (e.g., the book number 32 of the Italian translation of the book of *Faust*). The incorporation

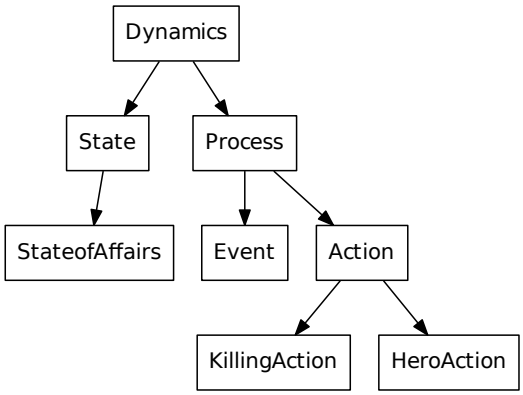

Figure 2 The Dynamics class.

of this model allowed us to represent the status (in terms of ideation and production) of the media objects according to the commitments expressed in FRBR (however, in the Archetype Ontology, the "item" category was not used since this concepts is implicit in the membership of the class **Manifestation**). Furthermore, the Media Object ontology has been inserted at the level of **Format** class in our general model. Finally, the imported components of the Drammar ontology have been used to express the relations between the **Dynamics**, **Entity** and **Description Template** classes.

The "narrative branches" of the ontology are obtained by the following classes: **Archetype**, **Artifact**, **Story**, **Dynamics** and **Entity**. The **Archetypes** class currently contains two directed subclasses, namely **Hero** and **Labyrinth**, representing the two narrative myths ("Hero" and "Labyrinth" respectively) already encoded in the model. These classes have been specialized into other subclasses described with a set of necessary and sufficient conditions. For example: the class **MythologicalHero** has been defined as a subclass of **Hero** where the participating characters (or agents in Labyrinth terms) are restricted to the members of the **MythologicalEntity** class. Other properties (mainly corresponding to binary relations in first order logic) allow providing informative connections with other narrative classes. For example: the *isEvokedIn* property allows connecting archetypes and artefacts (e.g., with this property it is possible to state that the "Cnossos Labyrinth" archetype is evoked by a certain artefact, e.g., namely an artefact representing the characters of Ariadne and Theseus), the property *isRecalledIn* connects the archetypes with the stories (e.g., "Cnossos Labyrinth" can be connected to the story named "Ariadne gives Theseus a ball of thread").

The class **Artifact**, specialized, as mentioned above, according to the FRBR model, is connected with the other narrative classes by the following properties: *evokes*, inverse property of the above mentioned *isEvokedIn*, which connects **Archetypes** and **Artifact**; *displays*, connecting **Artifact** and **Entity** (e.g., this property allows asserting that a certain artefact, let suppose the painting "Arianna e Teseo", displays as characters the entities Ariadne and Theseus); *describeAction*, connecting Artifact and Dynamics (e.g., this property allows stating that the artefact "Theseus kills the Minotaur" describes the action of "killing"). In our model, the *describeAction* property has been defined as a sub-property of the more general property *hasPart*. This modeling solution has an impact on both the intended meaning of

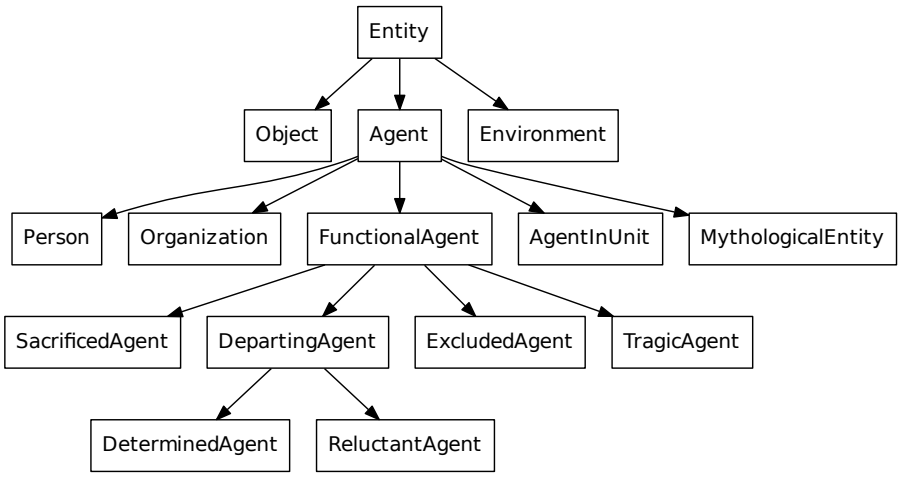

Figure 3 The Entity class.

describeAction (e.g., this property is intended as expressing a sense of "membership") and, therefore, on the reasoning processes coming up from the model. In fact, the statement that the painting "Theseus kills the Minotaur" describes the action of "killing" implies that this action is inferred as belonging to (via the part-of property) that artefact.

The class **Dynamics** has been imported from the Drammar ontology, where it represents the structure of the story incidents. It has been specialized as shown in Figure 2: its direct subclasses are **State** and **Process**, identifying different types of narrative situations. **Process** types have been divided in **Action** and **Event** and some actions, e.g., **Killing Action**, **Hero Actions** etc. have been constrained with necessary and sufficient conditions. For example: the class **Hero Action** is defined as the class of the Action instances having, as characters, some agent referred to the archetype of the Hero. The main properties connecting **Dynamics** with the other narrative classes in the ontology are: *hasCharacter*, connecting the **Dynamics** with the characters (**Entity**) participating in it, and *isDynamicsOf* (a transitive property connecting the **Dynamics**, e.g., actions or states, with the class **Story**). Even this property, as the *describeAction* property shown above, has been encoded as sub-property of *hasPart*. Therefore, it can be inferred that an action or a process are dynamics (intended as "part of") a certain story. Moreover, the stories are intended as composed by several dynamics.

The class **Story** is connected with the classes **Dynamics** (as illustrated before), **Entity** and **Archetype**. The connection with the class **Entity** is given by the already mentioned property *hasCharacter*, while the connection with the **Archetype** class is given by the property *recall* (e.g., it is possible to assert that a certain story "recalls" a certain archetype). At the current stage of development, the **Story** class is specialized with some subclasses defined according to necessary and sufficient conditions. The defined subclasses are **MythologicalStory** (or myths, defined as stories having as character some mythological entity), **KillingStory** (stories including a killing act), **CnossosStory** (stories of the Hellenic period recalling the Cnossos Labyrinth) and **StoryOfAriadne** (stories having as character Ariadne).

```
1  <owl:NamedIndividual rdf:about="&www;labyrinth#AriadneAndTheThread">
2   <rdf:type rdf:resource="&www;labyrinth#Story"/>
3      <hasCharacter rdf:resource="&www;labyrinth#Ariadne"/>
4      <hasCharacter rdf:resource="&www;labyrinth#Theseus"/>
5      <hasAction rdf:resource="&www;labyrinth#giving_the_thread"/>
6      <isPartOf rdf:resource="&www;labyrinth#MinotaurStory"/>
7      <recalls rdf:resource="&www;labyrinth#CnossosLabyrinth"/>
8      <recalls rdf:resource="&www;labyrinth#Theseus_Hero"/>
9      <hasTimePeriod rdf:resource="&www;labyrinth#Year2000BC"/>
10   </owl:NamedIndividual>
```

Figure 4 RDF description of the story "AriadneAndTheThread" ("Ariadne and the ball of thread") in the AO ontology.

Finally, the class **Entity** describes the agents (and objects or places) that have some narrative role within actions, stories and archetypes, and that are represented in some **Artefact**. It has been specialized according to the following hierarchy: **Agent**, **Object** and **Environments** are the direct subclasses of the root. **Agent** further specializes into the following subclasses: **Person**, **Organization**, **Mythological Entity** and **FunctionalAgent**. This latter class has as subclasses a set of different classes inspired by Propp's theory of functional roles in tales [32] (merged with some elements from [6]), such as **TragicAgent**, **DepartingAgent**, etc. These specific agent types are obtained by posing necessary and sufficient conditions on the type of actions they perform, by exploiting the relation between the **Agent** class and the **Dynamics** class. Figure 3 shows an overview of the Entity taxonomy.

5 Applying Narrative Properties to Artwork Representation

The representation of stories and actions in the ontology is functional to the description of the narrative elements of the artefacts incorporated in the system. In this paragraph, we show how stories and actions are represented in the ontology and how this information is applied to the description of the artefacts through a three-step process.

Let us consider, for the sake of simplicity, the example of the story "Ariadne and the thread", illustrated in Figure 4. It is characterised by the performance of an action (here, the action of giving a ball of thread) and by a set of characters (Ariadne and Theseus). In the ontology, this story corresponds to an individual ("AriadneAndTheThread") belonging to the **Story** class (line 2), and is described as follows:

- the *hasCharacter* property connects the story with its charactes, Ariadne and Theseus (lines 3–4)
- the *hasAction* property (line 5) connects the story with the actions composing it, i.e., "giving_the_thread" (see below the description of this action) ;
- the *partOf* property describes the story as a subpart of another story, "MinotaurStory" (line 6);
- *recalls* relates this story with the archetype of the labyrinth ("CnossosLabyrinth", instance of the **Labyrinth** class, line 7) and with the archetype of the hero (Thesues_Hero, instance of the **Hero** class, line 8); both **Hero** and **CnossosLabyrinth** are subclasses of the **Archetype** class;
- *hasTimePeriod* locates the narrated time into a time period ("Year2000BC", line 9).

```
1 <!-- http://www.di.unito.it/labyrinth#giving_the_thread -->
2
3 <owl:NamedIndividual rdf:about="&www;labyrinth#giving_the_thread">
4   <rdf:type rdf:resource="&www;labyrinth#Action"/>
5 </owl:NamedIndividual>
6
7 <!-- http://www.di.unito.it/labyrinth#GivingProcessSchema -->
8
9 <owl:NamedIndividual rdf:about="&www;labyrinth#GivingProcessSchema">
10  <rdf:type rdf:resource="&www;labyrinth#ProcessSchema"/>
11   <Frame rdf:datatype="&xsd;string">Giving</Frame>
12   <predicate rdf:datatype="&xsd;string">Giving</predicate>
13   <hasRole rdf:resource="&www;labyrinth#Donor"/>
14   <hasRole rdf:resource="&www;labyrinth#Recipient"/>
15   <hasRole rdf:resource="&www;labyrinth#Theme"/>
16 </owl:NamedIndividual>
```

Figure 5 RDF description of the action of giving (a ball of thread) in the AO ontology.

Notice that value of the *hasAction* property of the story description corresponds to the URI "giving_the_thread" , an instance of the **Action** class (see Figure 5, lines 3–5). This action is described by an instance of the class **ProcessSchema** (subclass of the **SituationSchema** class), part of a design pattern [14] which represents an action as a process having a set of roles attached to it, filled by the characters involved in the process. The **ProcessSchema** class relates the action to a Framenet frame (here, "giving", line 11) and to its roles (here, "Donor", "Recipient" and "Theme", lines 13–15). The roles are filled by the agents and objects which play these roles in the action: "Ariadne" as the "Donor", "Theseus" as the "Recipient", and the "ball of thread" as the "Theme" (for the sake of brevity, role fillers not shown in the Figure). The DescriptionTemplate class has been taken from the Drammar ontology as well as the pattern of which it is part (further details are contained in [8]).

While the representation of stories and actions is assumed to be encoded top down in the ontological model, the representation of the artefacts is obtained through a three step process. First, an internalization phase (*internalization*) imports the encoded metadata information about an artefact into the ontology. Then, the connection (*mapping*) of the imported artefact with the ontological model is performed. Finally, narrative connections are established. All phases are accomplished via rules encoded in SWRL format, in order to guarantee the portability of the system. The internalization process is as follows: when a new resource is added to the system, the ontological base is updated: a new individual is created to represent the artwork, and a set of assertions describing it are added to the ontological base. The system assumes that the resources given as input are described according to the Dublin Core (DC) metadata schema, encoded in RDF/XML.

As an example of the internalization phase, consider the "creator" DC element, which usually contains the reference to the artist who created a given artwork. The internalization procedure searches the ontological base for an author having the same name as the one contained in the creator element. If an instance representing the author of the artwork is not found, a new instance is created, with the *name* data property set to the value of the creator descriptor. Then, the artwork is connected to its author through the appropriate property (*hasCreator*). Similar rules are applied to all description elements. The internalization mechanism has a strategic importance, since it extends the task of populating the ontology to non–experts, by allowing them to annotate the information about the artefact in the Dublin Core format, and leaving to the system the task of encoding it into the ontology.

```
1  <!-- http://www.di.unito.it/labyrinth#
              Arianna_dona_il_gomitolo_di_filo_a_Teseo -->
2
3  <owl:NamedIndividual
     rdf:about="&www;labyrinth#Arianna_dona_il_gomitolo_di_filo_a_Teseo">
4    <rdf:type rdf:resource="&www;labyrinth#Manifestation"/>
5    <hasResourceType rdf:resource="&www;labyrinth#Image"/>
6    <evokes rdf:resource="&www;labyrinth#CnossosLabyrinth"/>
7    <evokes rdf:resource="&www;labyrinth#Theseus_Hero"/>
8    <displays rdf:resource="&www;labyrinth#Ariadne/>
9    <displays rdf:resource="&www;labyrinth#Theseus"/>
10   <hasGeographicalLocation rdf:resource="&www;labyrinth#Italy"/>
11   <describesAction rdf:resource="&www;labyrinth#giving_the_thread"/>
12   <ma-ont:hasCreator rdf:resource="&www;labyrinth#Pelagio_Palagi"/>
13   <ma-ont:hasPublisher
       rdf:resource="&www;labyrinth#Pinacoteca_Nazionale_di_Bologna"/>
14 </owl:NamedIndividual>
```

Figure 6 Description of an artwork "Arianna dona il gomitolo a Teseo" ("Ariadne gives Theseus a ball of thread") in the ontology after the internalization and mapping phase.

In the mapping phase, the metadata of the internalized resource are searched for keywords associated with the components of each archetype. For example, the title of the resource is searched for characters' names, which often occur in the title of artworks. Temporal and geographic information is sought for in "date" and "coverage". As an example of these rules, consider the rule that examines the keywords contained in the elements of type "subject" (which have already been internalized in the previous step) in order to find a connection with the archetype of the labyrinth: if the "labyrinth" or "maze" keywords are found in the subject descriptors of the artwork, the rule is applied and the artwork will be connected with the archetype of the labyrinth via the *evokes* property.

The internalization and mapping phases output a description of the artefact where the metadata have been internalized (such as creator, subject, etc.) and the connection with archetypes has been established. For example, consider the artwork represented as in Figure 6. In this case, the representation of the Italian painting "Arianna dona il gomitolo a Teseo" ("Ariadne gives Theseus a ball of thread"), by Pelagio Pelagi (1814) describes the artwork as an image, whose author is the painter Pelagio Pelagi, and whose subject displays two characters, Adriadne and Theseus. The painting is represented in the ontology as an instance of the **Manifestation** class (Figure 6, lines 3–4). This instance has several properties that relate it with other individuals in the ontology:

- *hasResourceType* describes the media type (image) in line 5;
- *evokes* connects the painting with the archetypes of the Labyrinth and of the Hero, lines 6–7;
- *displays* connects the painting with each entity which appears in it, i.e., Ariadne and Theseus (lines 8–9);
- *hasGeographicalLocation* relates the painting to the place where it is located ("Italy", line 10);
- *describesAction* relates the painting with the action type it represents ("giving_the_thread", line 11);

```
1  <!-- http://www.di.unito.it/labyrinth#
              Arianna_dona_il_gomitolo_di_filo_a_Teseo -->
2
3  <owl:NamedIndividual
     rdf:about="&www;labyrinth#Arianna_dona_il_gomitolo_di_filo_a_Teseo">
4    <rdf:type rdf:resource="&www;labyrinth#Manifestation"/>
5    <rdf:type rdf:resource="&www;labyrinth#artefact"/
6    <hasResourceType rdf:resource="&www;labyrinth#Image"/>
7    <evokes rdf:resource="&www;labyrinth#CnossosLabyrinth"/>
8    <evokes rdf:resource="&www;labyrinth#Theseus_Hero"/>
9    <displays rdf:resource="&www;labyrinth#Ariadne/>
10   <displays rdf:resource="&www;labyrinth#Theseus"/>
11   <hasGeographicalLocation rdf:resource="&www;labyrinth#Italy"/>
12   <describesAction rdf:resource="&www;labyrinth#giving_the_thread"/>
13   <describesAction rdf:resource="&www;labyrinth#Killing_the_Minotaur"/>
14   <describesAction rdf:resource="&www;labyrinth#Fighting"/>
15   <ma-ont:hasCreator rdf:resource="&www;labyrinth#Pelagio_Palagi"/>
16   <ma-ont:hasPublisher
      rdf:resource="&www;labyrinth#Pinacoteca_Nazionale_di_Bologna"/>
17   <hasPart rdf:resource="&www;labyrinth#AriadneAndTheThread"/>
18   <hasPart rdf:resource="&www;labyrinth#MinotaurStory"/>
19 </owl:NamedIndividual>
```

Figure 7 Description of the artwork "Arianna dona il gomitolo a Teseo" ("Ariadne gives Theseus a ball of thread") in the AO ontology, with properties added by the reasoner.

- *ma-ont:hasCreator*, taken from the Media Ontology, connects the painting with its author, Pelagio Pelagi (line 12);

- *ma-ont:hasPublisher* connects the painting with the institution by which it has been put online (line 13);

Upon the internalized and mapped representation of the artwork, a set of narrative rules in then applied. These rules consider the stories associated with the archetypes and check if their characters and actions are referred to by the artefact. By doing so, narrative associations are inferred only after the archetype association is performed, as in a classical cascade model.

For example, let us consider now the story "AriadneAndTheThread" represented in Figure 4: this story has Theseus, Ariadne, and the Minotaur as characters, and includes the action of giving the thread to Theseus by Ariadne. Since the artefact "Arianna da' il gomitolo a Teseo" ("Ariadne gives Theseus a ball of thread") shares with the "AriadneAndTheThread" story both the characters and the action, then the latter story is recognized to be a narrative "part of" the artwork (see Figure 7, line 17). The larger story, "MinotaurStory" (of which the "AriadneAndTheThread" story is a part), is also recognised as a part of the artwork (line 18). Therefore an "augmented" representation of the artefact with a narrative information is obtained (as shown in the Figure 7), which includes, via narrative rules, also the connection to the actions contained in the related stories (lines 12 and 13): "giving_the_thread" (from "AriadneAndTheThread") and "Killing_the_Minotaur" (from the "MinotaurStory").

6 Using narrative inferences in navigation

After the phases of internalization and mapping, "AriadneAndTheThread" and the application of narrative rules, the system performs several inferences on the artefacts represented in the ontology base. These inferences are exploited by the Labyrinth system for two main goals: on the one side, allowing the user to navigate among the artworks by following the semantic relations encoded in the ontology, even when they are not explicitly stated but inferred; on the other side, to classify the artefacts (and the other entities referred by it) with respect to the model encoded in the ontology, so that possible, alternative perspectives emerge on the artwork and can be proposed to the user's conceptualisation.

As an example of the first type of inference, consider the story termed "Ariadne and the ball of thread", described in Section 5 (Figure 4). The description of the artwork used as example (i.e., the painting "Arianna dona il gomitolo di filo a Teseo", Figure 7) states that the painting refers to this story. However, the painting also refers to the more general "Story of Ariadne" (**StoryOfAriadne**), encoded in the ontology as the class of stories having Ariadne as character (in OWL terms, the necessary and sufficient condition attached to the class is: *Story and (hasCharacter value Arianna)*): the fact that the painting also refers to the "Story of Ariadne", although not stated in the description, is automatically inferred by the system given the description of the story "Ariadne and the ball of thread". So, when the user is presented with the painting, the accompanying information is augmented with the inferred relations with more general stories: beside the "Story of Ariadne", for example, the system encompasses other similar classes, for example "Mythological Story", etc.

By the same reasoning type, other stories having Ariadne as character will be recognised as belonging to the **StoryOfAriadne** class: for example, the story termed "Bacchus and Ariadne" is also classified as belonging to this class, since it features Ariadne as character. The system uses this information for generating links between the artworks and for generating recommendations of similar contents (a painting which represents Bacchus and Ariadne, for example, or the libretto of the work "Ariadne auf Naxos" by Richard Strauss).

Useful inferences for the conceptualisation of stories also concern the relation between story and actions. In our model, stories can be subpart of other stories and are related to the actions they contain via a specialisation of the hasPart property (as described in Section 4). So, for example, the story "Ariadne and the ball of thread" is not only a specific type of story ("story of Ariadne") but also a subpart of the "story of the Minotaur". This mereological relations are supposed to hold also among the dynamics (e.g., actions, processes etc.) occurring in a story as well as among stories. In this way, it is possible to model the fact that some actions are part of other, more general, actions; that some actions are part of certain stories; that stories can be part of other stories. As a consequence of this modeling solution, higher-level stories (e.g., the "story of the Minotaur") are automatically connected with the actions which appear in the sub stories which are part of it. So, for example, the "story of the Minotaur" will be inferred as containing all the actions which appear in its sub stories. Therefore, from the description of "Ariadne and the ball of thread", it will be inferred as containing the action of giving, where Ariadne gives the ball of thread to Theseus; from the description of the story "Theseus and the Minotaur", it will acquire the action of killing, where Theseus kills the Minotaur and so on.

Thanks to these inferences, by gathering smaller stories (or episodes) in larger stories, actions are gathered as well, without the need, for the encoder, to explicitly track the relation between the actions in the episodes and the actions in the larger story. The navigation among the different artefacts through inferred actions and stories represents one of the innovative

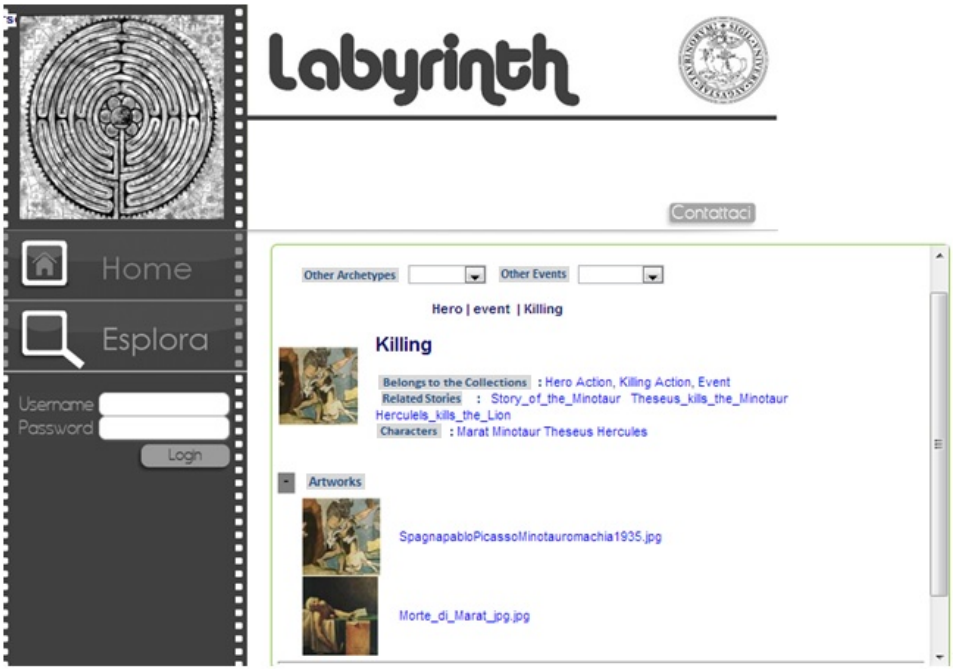

Figure 8 Example of the narrative based semantic exploration.

aspects of our proposal. In cultural heritage, this is a benefit for user access, because users may not know how the single episodes are linked to each other as part of the larger story: by exploring the repository, they become aware of the relation between the episodes through the artworks.

An example of this narrative, semantic driven, navigation among the artifacts is given in Figure 8. In this case, we hypothesize that the user is exploring the Actions related to the archetype of the Hero. For the action "Killing", a set of narrative information is recovered from the ontological model, using both the explicit and the inferred relations. Namely: information about the possible classifications of the selected actions ("Hero Action", "KillingAction" or, more in general, "Event"), about the stories related to that action (e.g., the "Minotaur Story", the story of "Theseus killing the Minotaur" – subpart of the previous one – and the story of "Hercules and the Lion") and about some characters involved, with different roles, in that action (e.g., Marat, Minotaur, Hercules and Theseus). Finally some artefacts are also obtained, which represent directly, as in the case of the painting called "Death of Marat", or indirecty, as in the painting "Minotauromachia" by Picasso, the action of killing: by doing so, the system enhances the semantic grouping and retrieval of information in a way that is not possible with classical relational databases.

7 Conclusions and Future Work

Formal ontologies can be a powerful tool for intelligent information systems aimed at improving the narrative navigation of digital artefacts. Beside the narrative model explicitly encoded in the ontology, automatic reasoning processes provide useful insights on the relations connecting different media resources having, by and large, narrative content. In cultural heritage, this amounts to providing the users with a conceptual framework – stories – they are familiar with, open to heterogenous contents over media and ages.

In this paper, we presented Labyrinth, an ontology based system designed for the enhancement of the semantic exploration of digital media archives. Given the information encoded in the ontology, the user can explore a repository based on the relations that link the repository contents (i.e., a set of media resources) with a given archetype, which has a prominently narrative nature. Thanks to the representation of the complex interplay of the concepts of story, characters and actions in the ontology, the use of reasoning tools lets a set of relations emerge among the resources in the archive, thus contributing to the user involvement in the exploration experience.

The system is currently being developed and was tested on a small corpus of resources of different type and format, in order to asses the functioning and feasibility of the approach.

As future work, we envisage the validation of the ontology on a larger set of media resources, and the testing of the proposed representation and inferences on real users, according to the paradigm of user studies.

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