Smart Access to Historical Archives based on Rich Semantic Metadata

Smart Access to Historical Archives based on Rich Semantic Metadata *

Matteo Caserio, Anna Goy and Diego Magro
Dipartimento di Informatica, Università di Torino, C. Svizzera 185, Torino, Italy
mat_cas@libero.it, {goy, magro}@di.unito.it

Keywords: Digital Archives, User Interface, Semantic Metadata, Ontologies, Web Application.

Abstract: Documentary heritage about social and political history of the 20th Century could be an important support for citizens awareness, provided that it is not endangered by the lack of effective access and management tools. In this paper we present a work that is part of the Harlock'900 project and aims at showing how a rich semantic representation, based on ontologies and Semantic Web standards, can enable an innovative and user-friendly access to resources stored in historical archives. In particular, we present a web application enabling users to explore events, places and people mentioned in archival resources. The application relies on a semantic layer – including a computational ontology and a RDF triplestore, and provides a User Interface that supports the navigation through highly interconnected data, offering different possible exploration paths. We also report the encouraging feedback obtained by a preliminary evaluation based on a domain expert walkthrough the app.

1 INTRODUCTION

Documentary heritage about social and political history of the 20th century has a high potential for creating and supporting the awareness of citizens about the changes occurred in society in the last century. This awareness, in turn, is the key to a more self-aware social and economical development of countries, with positive effects on national and trans-national integration.

Highly relevant for scholars, social and political scientists or historians, this heritage is valuable also for the general audience, due to its capability of narrating social changes through documents and testimonies where places, people and events are brought to life by pictures, newspaper articles, audiovisual clips, interviews, etc.

However, this potential is endangered by the lack of effective, user friendly access and management tools, to orientate the audience in the extremely rich and varied universe of documents and resources.

The main objective of the work presented in this paper is to show how a rich semantic representation, based on ontologies and Semantic Web standards, can support metadata enrichment, which in turn enables an innovative and effective access to resources from historical archives, offering users new paths through the history of the 20th Century.

Such an innovative and effective access is demonstrated by the User Interface of the web-based application resulting from our approach, and it can benefit a heterogeneous and large audience, including humanities researchers, journalists, policy makers, designers, movie/multimedia makers, and simply interested people, as well as travel agencies and tourist promotion organizations, educational institutions, creative writing schools, trade unions and other civil society actors.

One of the most innovative aspects of the approach is that relationships between events, people, organizations, places, and documents need not to be hard-coded in the system, but dynamically computed/discovered by automatically exploring and querying the system semantic knowledge about the content of resources.

This work is part of the on-going Harlock'900 project (started in 2016) involving the University of Torino (Computer Science Department) and the Fondazione Istituto Piemontese A. Gramsci, a non-profit institution for research on contemporary history, that is part of the Polo del '900 cultural initiative (www.polodel900.it). The project's main goal is that of providing an online user-friendly

*POSTPRINT VERSION. Cite as: Caserio, M., Goy, A., and Magro, D.. Smart Access to Historical Archives based on Rich Semantic Metadata. In Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2015) - Volume 3: KMIS, pages 93-99 - ISBN: 978-989-758-273-8.

access to a set of documents from the institute's archives, based on a rich semantic representation of their content. The overall approach is summarized in (Goy et al., 2015). The project is partially funded by Compagnia di San Paolo and University of Torino, within the PRiSMHA project (started in May 2017).

In the following we will summarize the relevant related work (Section 2), then we will briefly present the semantic layer, including the HERO ontology and the RDF representation of resources content (Section 3). In Section 4 we will describe the User Interface enabling users to explore events, places and people mentioned in archival resources, together with some implementation details. We will conclude the paper by reporting the result of a preliminary evaluation (Section 5) and by sketching the future directions (Section 6).

2 RELATED WORK

In recent years there has been a remarkable interest in the application of Semantic Web technologies to history research, as documented by the survey reported in (Meroño-Peñuela et al., 2015), which surveyed 21 scientific papers, 21 research projects and 36 tools. Many results considered in this survey show the effectiveness of semantic approaches (including ontologies and Linked Data best practices) in publishing and connecting historical datasets and in enhancing search and retrieval. This holds, in particular, also for archives and cultural heritage resources, a domain where semantic technologies and the LOD (Linked Open Data) principles are receiving more and more attention (Oomen and Belice, 2012) and have already proved their maturity.

A lot of projects could be mentioned, but a full survey is out of the scope of this paper. Europeana (www.europeana.eu) – the European Union digital library providing access to cultural heritage digitized contents of hundreds of European galleries, libraries, archives – is one of the most prominent examples of usage of Semantic Web technologies in the cultural heritage domain. A considerable portion of Europeana metadata are already available on the LOD cloud – see, for instance, the Europeana LOD Pilot (Haslhofe and Isaac, 2011) – based on EDM: Europeana Data Model (Isaac, 2013), the metadata model adopted within Europeana. Another important semantic model in the cultural heritage domain is the CIDOC Conceptual Reference Model (www.cidoc-crm.org), which is an ISO standard and has been successfully adopted in several EU-funded projects, like PAPYRUS (www.ict-papyrus.eu) – an EU project aimed at enabling users to query digital libraries in order to discover cross-domain relationships between concepts.

In the historical domain, the notion of *event* is a key concept; as a consequence, as described in Section 3, it plays a major role in our system, in line with other projects with a similar focus on recent history; see, for example, Agora (van den Akker et al, 2010) and DIVE (de Boer et al., 2015) a project that builds on the results of Agora and aims at supporting researchers, professional users, and general public in event-centric browsing of cultural heritage objects from multiple heterogeneous collections.

EDM, CIDOC-CRM, and other models – e.g. the Event Ontology (purl.org/NET/c4dm/event.owl), LODE (Shaw et al, 2009), SEM (Hage et al., 2011) – provide a basic notion of event, enable the representation of "who does what when and where", but fail to offer tools for a richer semantic representation that is the main goal of our project (see Section 3).

Partially within the Europeana ecosystem, some projects can provide valuable hints for the promotion of innovative and creative usage of digital (data on) cultural resources; see, for instance: Europeana Space (www.europeana-space.eu); Europeana Creative (www.europeanacreative.eu); AXES (www.axes-project.eu), that provides advanced multimodal search and access to audiovisual digital resources (search for spoken words in audio, for images within video sequences, for images depicting specific kinds of objects or similar to other images); the recently started I-Media-Cities (imediacities.eu); HOPE (www.peoplesheritage.eu), that aims at providing an access point to digital collections – in particular, smaller, independent and usually not maintained by official state archives – relevant to the social history and to the history of the labor movement.

An important aspect of the application presented in this paper is the experience supported by the User Interface. As demonstrated by projects like the Atlas of Nazi and Fascist massacres (www.straginazifasciste.it/?lang=en), or Memorie di Guerra (War Memories: www.memoriediguerra.it), a key aspect in projects aimed at supporting an enhanced access to historical documents is the availability of advanced and user-friendly interfaces, supporting multi-dimensional access to archival resources (Boschetti et al., 2014). In the project described by Boschetti and colleagues, advanced search functionalities are offered to explore World

Wars textual documents. The same focus on advanced search tools based on content automatically extracted from historical documents characterizes the ALCIDE project (Moretti et al., 2016). The platform User Interface enables users to select the time span to search for and display keywords and entities mentioned in the retrieved documents. In the work about the Betrothed Lovers book, described in (Bolioli et al., 2013), interactive graphs are used to display the social network of the story characters, while in the RAMBLE ON project (Menini et al., 2017) the focus is on the movements of famous historical figures and thus the User Interface is based on interactive maps.

In other works, narrative formats – based on an underlying semantic representation of the contents of a cultural heritage collection – have been exploited to present meaningful patterns. For example, in the Storyspace (Wolff et al., 2012) and Storyscope (Mulholland et al., 2015) systems the User Interface displays an underlying *narrative*, i.e. a composition of events and related objects, possibly tailored to different audiences, while the Labyrinth project (Lieto and Damiano, 2013) offers an application for exploring digital media repositories with the guidance of a set of *cultural archetypes*, enabling user interaction through maps, timelines and 3D navigation.

3 SEMANTIC LAYER

We think that one of the main reasons why "European digital content [...] used to be inaccessible, buried among huge amounts of data and not sufficiently tagged with adequate metadata" (*EU Programmes 2014-2020, call H2020-CULT-COOP-09-2017*: ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/cult-coop-09-2017.html) is the very low expressive power of currently available semantic representations. In fact, although simple semantic models have the clear advantage of facilitate processing, interoperability and sharing, they often fail to provide actually useful data. In other words, some semantic complexity is needed, in order to express interesting information (characterizations and relations).

To this purpose, we designed and implemented a *semantic layer* that takes archive metadata as input and enrich them with a semantic representation of resources content, linked to an ontology that represents a shared conceptualization.

Figure 1 depicts the overall architecture underlying our application. The Metadata Management Platform, relying on basic metadata from archives catalogs, is endowed with a layer hosting the semantic model (the ontology and the semantic knowledge base, described in the following).

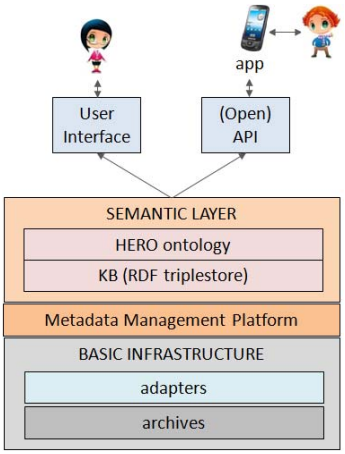

Figure 1: Overall architecture of the application.

The semantic layer can be seen as a "semantic lens" on archive resources, enabling users to "see" their content. In particular, the semantic representation should enable the system to discover relations between events, people, places, organizations, and archival resources themselves. For instance, the system could identify relevant relationships between E. Valabrega, his niece M. Diena, the city of Torino, the Valabrega company, the historical period called 'Resistenza', the deportation of Jews, linking them to the pictures, texts, letters and historical documents talking about them.

The semantic model is represented by a *computational ontology* of historical events (HERO: Historical Event Representation Ontology), that relies on the well-known and cognitive-grounded foundational ontology DOLCE (Masolo et al., 2003). An exhaustive description of the HERO ontology – and its dependencies on existing models – is out of the scope of this paper. In the following, we will sketch its main structure, in order to provide the reader with an overall picture of the kind of knowledge available in the semantic layer.

HERO is written in OWL and is composed by different modules; the most important are the following:

- HERO-TOP: it includes the top layer, i.e. the most general concepts, directly linked to DOLCE classes (e.g. the *hero:Object* class,

defined as a subclass of *dolce:Endurant*; the *hero:Perdurant* class, defined as a subclass of *dolce:Perdurant*).

- HERO-EVENT: it includes classes and properties related to the representation of events; for example, it includes a class hierarchy, a small part of which is depicted in Figure 2. Moreover, it contains the relations: *hero:hasParticipant*, useful to connect events to their participants; *hero:hasLocation*, to connect events to the places they occurred; *hero:hasTimeSpan*, to connect events to the time intervals within which they took place.
- HERO-PLACE: it includes classes and properties modeling geographic features, i.e., entities that can be georeferenced on a map (e.g., cities, rivers, countries, but also buildings and streets).
- HERO-TIME: it includes classes and properties modeling time intervals, following Allen's Interval Algebra (Allen, 1983).
- HERO-ROCS: it includes classes and properties for the representation of "containers", i.e. entities that contain other entities as their members; in particular, it defines the semantics of *sets* and *collections*, taking into account the analysis in (Bottazzi et al., 2006). This module also models the notion of *organization*, partially based on the discussion in (Bottazzi et al., 2009).

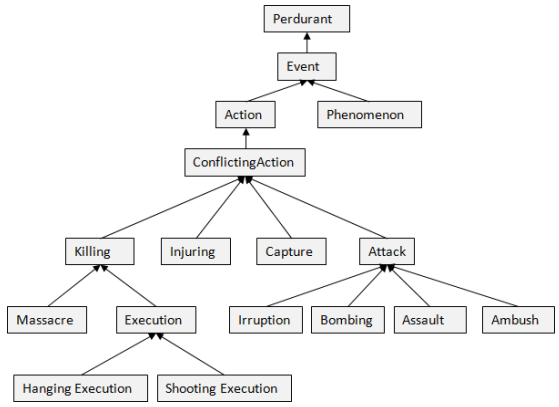

Figure 2: A fragment of the HERO taxonomy of classes representing event types.

On the basis of HERO, the content of archival resources can be formally represented in a machine-readable format. In particular, within the Harlock'900 project, we annotated 200 text fragments, extracted from biographies and testimonies talking about events occurred in Piemonte (North-West of Italy) in the period 1943-1945, and often related to the "Resistenza" (the local partisans struggle against the Fascist regime and the Nazi occupation). In each text fragment, a small team of annotators identified the mentioned *events* and, for each event, they identified a *typology* (as defined by classes in HERO-EVENT), as well as – when available – the *time period*, the *place* it occurred and its *participants*.

The result of the annotation process is a set of RDF triples, stored in a triplestore (see below for implementation details). A small text fragment, together with its partial semantic representation, is shown in Figure 3.

Fragment #15:

Ernesto Valabrega, fratello di mia madre, dirigeva, come aveva fatto il nonno, la fabbrica di mobili; [...] il 24 marzo 1944, fu catturato dai fascisti proprio nello stabilimento. [...].
(Ernesto Valabrega, my mother's brother, ran, as my grandfather had done, the furniture factory; [...] on March 24 1944 he was captured by the Fascists right inside the factory. [...]).

(Partial) semantic representation:

```
<https://w3id.org/dataset_resistenza/resource/event/16,
   http://www.w3.org/1999/02/22-rdf-syntax-ns#type,
   https://w3id.org/hero/HERO-EVENT#Capture>
<https://w3id.org/dataset_resistenza/resource/event/16,
   http://www.w3.org/2000/01/rdf-schema#label, 'Cattura di E.
   Valabrega'>
<https://w3id.org/dataset_resistenza/resource/event/16,
   https://w3id.org/hero/HERO-EVENT#hasParticipant,
   https://w3id.org/dataset_resistenza/resource/object/24>
<https://w3id.org/dataset_resistenza/resource/object/24,
   http://www.w3.org/1999/02/22-rdf-syntax-ns#type,
   https://w3id.org/hero/HERO-ROCS#Collective>
<https://w3id.org/dataset_resistenza/resource/object/24,
   http://www.w3.org/2000/01/rdf-schema#label, 'fascisti'>
<https://w3id.org/dataset_resistenza/resource/event/16,
   https://w3id.org/hero/HERO-EVENT#hasParticipant,
   https://w3id.org/dataset_resistenza/resource/object/39>
<https://w3id.org/dataset_resistenza/resource/object/39,
   http://www.w3.org/1999/02/22-rdf-syntax-ns#type,
   https://w3id.org/hero/HERO-TOP#Person>
<https://w3id.org/dataset_resistenza/resource/object/39,
   https://w3id.org/hero/HERO-EVENT#hasName, 'E. Valabrega'>
<https://w3id.org/dataset_resistenza/resource/event/16,
   https://w3id.org/hero/HERO-EVENT#hasTimespan,
   https://w3id.org/dataset_resistenza/resource/time/44>
<https://w3id.org/dataset_resistenza/resource/time/44,
   http://www.w3.org/1999/02/22-rdf-syntax-ns#type,
   https://w3id.org/hero/HERO-TIME#Day>
<https://w3id.org/dataset_resistenza/resource/time/44,
   http://www.w3.org/2000/01/rdf-schema#label, '24/03/44'>
```

Figure 3: A text fragment with its (partial) semantic representation.

4 WEB APPLICATION AND USER INTERFACE

The data in the semantic layer can be accessed in two ways, namely through:

- RESTful API, that enable third party applications to use them.
- A User Interface, that allow users to access archival resources by navigating their content.

In the following, we will describe the web application offering the User Interface (UI); the full definition and implementation of RESTful API to access data in the semantic layer is a work in progress.

The major role of the UI is to support the navigation through highly interconnected data, and therefore it offers many different possible exploration paths: for example, a user may be interested in retrieving all event occurred in a given place, and from them to discover involved people, thus finding further interesting places where other events took place, and so on. Figure 4 shows the web app home page.

Figure 4: Home page.

On the left-hand side, users can select an area (*provincia*) within the Piemonte region by clicking on it: the app provides an interactive map, populated with all places in that area where events occurred (see Figure 5).

Figure 5: The map showing places in Provincia di Cuneo (left-hand side) and access to events occurred in Barge (right-hand side).

By clicking on the pop-up referring to a single place (the village of Barge in the right-hand side of Figure 5), the events that occurred there can be seen and explored. The page listing the events occurred in a specific place is analogous to the page listing all events in the knowledge base, accessible from the home page (Figure 4, first button on the right-hand side), and depicted in Figure 6. From the right-hand side of the home page, the user can also search for a specific person, group or organization, select a single place, or access text fragments (see Figure 4).

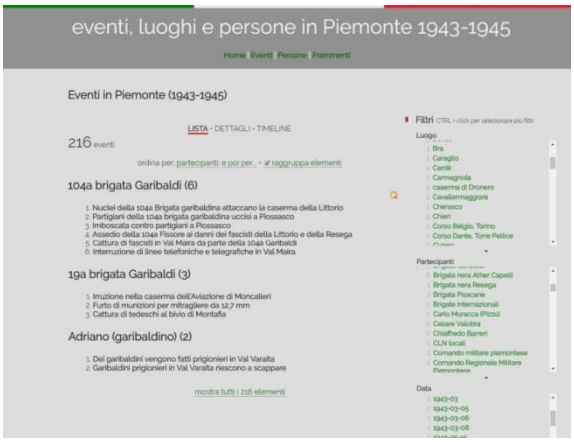

Figure 6: Events (list).

On the right-hand side of the page listing events (Figure 6) there are filters: depending on the activated ones, the listed events can refer to a specific (set of) place(s) or participants, or time (date). Moreover, the default visualization is a list, that can be ordered by combining different criteria (in Figure 6, for example, it is ordered by participants, and further orderings can be added – e.g., by time), but the user can switch to a table view, providing more details (Figure 7, upper-side) or to a timeline view (Figure 7, lower-side).

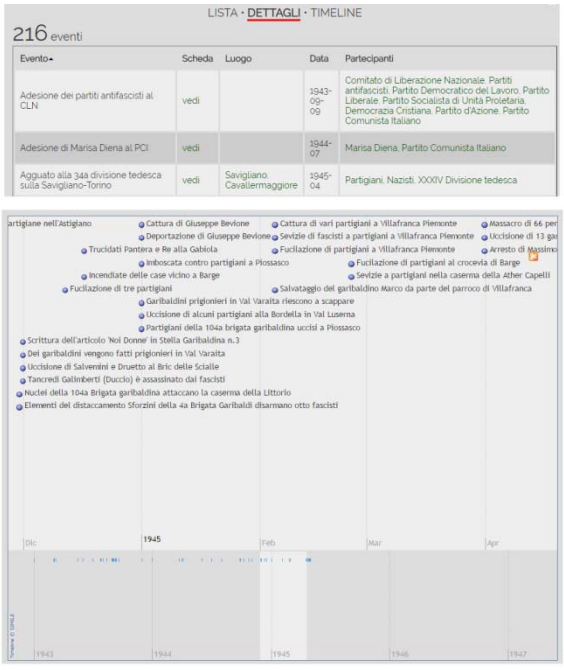

Figure 7: Events: table view with details (upper-side) and timeline view (lower-side).

By clicking on a single entity (person, group, organization, place, event), wherever in the User Interface, its profile with detailed information is provided (Figure 8). For instance, if a person is selected, the corresponding profile shows: the events that person had been involved in; other people linked to that person (because they participated in a same event); an interactive map with markers on the locations where the events took place; the text fragments where that person is mentioned. Moreover, on the right-hand side, references to original archival resources related to that person (e.g., original documents, letters, pictures) are shown.

The web app has been implemented using standard web languages and technologies (such as Java, JSTL, Javascript, jQuery, HTML5, and CSS3); it exploits several libraries, namely: Leaflet (leafletjs.com), Exhibit (www.simile-widgets.org/exhibit), D3 (Data Driven Documents: d3js.org), TopoJSON (github.com/topojson/topojson), and Bootstrap (getbootstrap.com).

The triplestore for metadata is implemented with Apache Jena Fuseki (http://jena.apache.org/documentation/fuseki2/index.html).

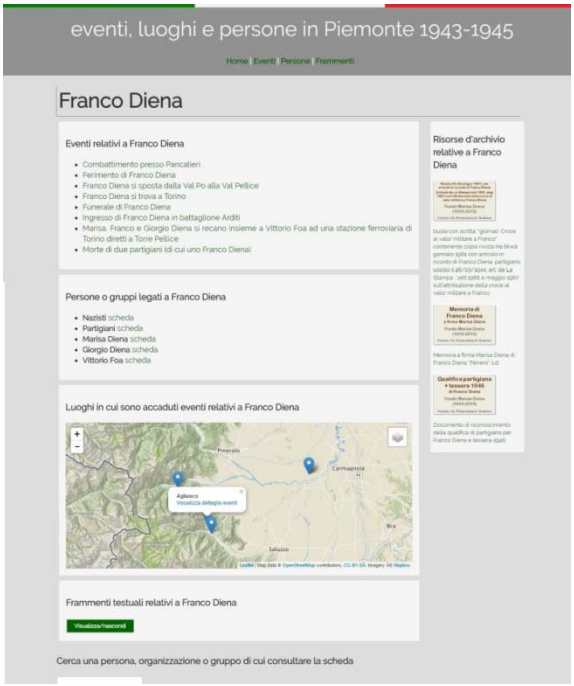

Figure 8: Profile of Franco Diena.

5 EVALUATION OF THE APPROACH

The UI described in Section 4 represents an important proof-of-concept for our project, since it demonstrates that a rich semantic representation of resources content enables user to navigate a very rich graph of relations between events, people, places, and resources themselves. However, being a proof-of-concept, it is currently based on a relatively small set of data, that is not enough for an evaluation with real users.

We are working in two directions, in order to set up tools for feeding large amounts of new data describing resources content to the knowledge base (RDF triplestore). In particular, we are investigating: (a) strategies for automatic event extraction from texts (Rovera, 2016), and (b) crowdsourcing systems (within the already mentioned PRiSMHA project). With a larger knowledge base, covering a significant number of archival resources and historical events, we will be able to test the web application in real world scenarios, with end users. For the moment, in order to assess the current User Interface, we performed a preliminary evaluation by asking two domain experts (historians, in our case) to perform a walkthrough, acting as users of the web application. Instead of focusing on usability issues (as in standard cognitive walkthrough evaluations (Polson et al., 1992; Gena and Weibelzahl, 2007)), we asked experts to assess the potential usefulness of our app. To this purpose, we provided them with the following usage scenario:

> *You are a researcher in history of the 20th Century, and you have just been assigned the task of creating a multimedia narrative to be linked to a "pietra d'inciampo" (small brass plates fixed on sidewalk tiles; each plate shows the name of a victim of the Nazi-Fascist deportation and it is placed close to the victim's home), namely the one mentioning the Valabrega family. In order to build the narrative, you have to discover the story of the most important members of the Valabrega family, the (historical) events they took parts, the relevant places they lived. Moreover, we suggest to include, within the narrative, references to archival resources available in Torino, such as pictures, videos, manuscripts, books, etc.*

We encouraged the experts, playing the role of users of our prototype, to express free comments about their experience, and recorded them.

We obtained some specific suggestions about possible improvements of the UI (e.g., they asked for a "pictorial" representation of the relations among people, organizations and groups), but the overall feedback was definitely positive: in summary they said that – with respect to traditional access tools for online archives they are used to – the application provides a much richer, more flexible, and more interesting way to discover: (a) relationships between people, events and places; (b) relevant historical resources, otherwise hidden in the archive shelves.

6 CONCLUSIONS

In this paper we presented a web-based prototype enabling user to navigate through historical events, people and places linked to archival resources. The richness of the navigation experience is based on the semantic representation of the resources content, grounded in the HERO ontology and stored in a RDF triplestore.

As already mentioned (Section 5), we are working towards two enhancements supporting input to the semantic knowledge base, i.e., automatic event extraction from texts (Rovera, 2016), and crowdsourcing approaches. Moreover, as mentioned in Section 4, we are implementing a set of RESTful API that will enable third party applications (e.g., in the educational and touristic fields) to reuse our semantically enriched metadata.

A further enhancement of the semantic knowledge base is the possibility of linking our metadata to open dataset such as GeoNames (www.geonames.org) and DBpedia (wiki.dbpedia.org). However, in this respect, it is worth noting that, given the very specific domain and the relatively fine-grained representation of events, a lot of entities in our triplestore (events themselves, but also places and people) are not present, even in huge datasets like GeoNames and DBpedia; so, the linking is interesting but limited.

Finally, the UI itself could be enhanced by exploiting more advanced Information Visualizations tools and techniques. In particular, we are exploring the possibility of using interactive graphs to graphically show the relations among people, providing users with a picture of the social network of the players.

REFERENCES

van den Akker, C., Aroyo, L., Cybulska, A., van Erp, M., Gorgels, P., Hollink, L., Jager, C., Legêne, S., van der Meij, L., Oomen, J., van Ossenbruggen, J., Schreiber, G., Segers, R., Vossen, P., Wielinga, B., 2010. Historical Event-based Access to Museum Collections. *Applied Artificial Intelligence*, 25.

Allen, J.F., 1983. Maintaining Knowledge about Temporal Intervals. *Communications of the ACM*, 26(11), 832-843.

Bolioli, A., Casu, M., Lana, M., Roda, R., 2013. Exploring the Betrothed Lovers. In M. Finlayson, B. Fisseni, B. Lowe, J. C. Meister (Eds.), *Workshop on Computational Models of Narrative*, vol. 32, OASIC.

Boschetti, F., Cimino, A., Dell'Orletta, F., Lebani, G. E., Passaro, L., Picchi, P., Venturi, G., Montemagni, S., Lenci, A. 2014. Computational Analysis of Historical Documents: An Application to Italian War Bulletins in World War I and II. In *LREC 2014 Workshop on Language resources and technologies for processing and linking historical documents and archives – Deploying Linked Open Data in Cultural Heritage.*

Bottazzi, E., Catenacci, C., Gangemi, A., Castelfranchi, C., 2006. From Collective Intentionality to Intentional Collectives: An Ontological Perspective. *Cognitive System Research*, 7(2-3), 192-208.

Bottazzi, E., Ferrario, R., 2009. Preliminaries to a DOLCE Ontology of Organisations. *Int. J. Business Process Integration and Management*, 4(4), 225-238.

de Boer, V. Oomen, J., Inel, O., Aroyo, L., van Staveren, E., Helmich, W., de Beurs, D. 2015. DIVE into the Event-Based Browsing of Linked Historical Media. *Journal of Web Semantics*, 35(3), 152-158.

Isaac A. (Ed.), 2013. *Europeana Data Model Primer*. http://pro.europeana.eu/files/Europeana_Professional/Share_your_data/Technical_requirements/EDM_Documentation/EDM_Primer_130714.pdf.

Gena, C., Weibelzahl, S., 2007. Usability engineering for the adaptive web. In P. Brusilovsky, A. Kobsa, W. Nejdl (Eds.), *The Adaptive Web. Methods and Strategies of Web Personalization*, Springer, Berlin, 720-762.

Goy, A., Magro, D., Rovera, M., 2015. Ontologies and historical archives: A way to tell new stories. *Applied Ontology*, 10(3-4), 331-338.

van Hage, W.R., Malaisé, V., Segers, R., Hollink, L., Schreiber, G., 2011. Desing and use of the Simple Event Model (SEM). *Journal of Web Semantics*, 9(2), 128-136.

Haslhofe, B., Isaac, A. 2011. data.europeana.eu – The Europeana Linked Open Data Pilot. In *International Conference on Dublin Core and Metadata Applications.*

Lieto, A. Damiano, R. 2013. Building Narrative Connections among Media Objects in Cultural Heritage Repositories. In *International Conference on Interactive Storytelling*, 257-260.

Masolo, C., Borgo, S., Gangemi, A., Guarino, N., Oltramari, A., 2003. *WonderWeb Deliverable D18*. Technical Report, CNR.

Menini, S., Sprugnoli, R., Moretti, G., Bignotti, E., Tonelli, S., Lepri, B., 2017. RAMBLE ON: Tracing Movements of Popular Historical Figures. *Conference of the European Chapter of the Association for Computational Linguistic*, to appear.

Meroño-Peñuela, A. Ashkpour, A., van Erp, M., Mandemakers, K., Breure, L., Scharnhorst, A., Schlobach, S., van Harmelen, F., 2015. Semantic Technologies for Historical Research: A Survey. *Semantic Web Journal*, 6(6), 539-564.

Moretti, G., Sprugnoli, R., Menini, S., Tonelli, S., 2016. ALCIDE: Extracting and visualising content from large document collections to support humanities studies. *Knowledge-Based Systems*, 111, 100-112.

Mulholland P., Wolff A., Kilfeather E., 2015. Storyscope: Supporting the authoring and reading of museum stories using online data sources. In *WebSci 2015*, ACM Press.

Oomen, J., Belice, L., 2012. Sharing cultural heritage the linked open data way: why you should sign up. In *Museums and the Web Conference*.

Polson P.G., Lewis C., Rieman J., Wharton C., 1992. Cognitive Walkthroughs: A Method for Theory-Based Evaluation of User Interfaces. *International Journal of Man-Machine Studies*, 36, 741-773.

Rovera, M., 2016. A Knowledge-Based Framework for Events Representation and Reuse from Historical Archives. In H. Sack, E. Blomqvist, M. d'Aquin, C. Ghidini, S. P. Ponzetto, C. Lange (Eds.). *The Semantic Web – Proc. ESWC 2016*. LNCS 9678, Springer, Heidelberg, 845-852.

Shaw, R., Troncy, R., Hardman, L., 2009. LODE: Linking Open Descriptions of Events. *4th Asian Conference on The Semantic Web*, 153-167.

Wolff, A., Mulholland, P., Collins, T., Storyspace: a story-driven approach for creating museum narratives. In *23rd ACM conference on Hypertext and social media*, ACM Press, 89-98.