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# Extending Digital Libraries with Digital Narratives

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#### **Outline of the Presentation**

- 1. Introduction & Motivation
- 2. The approach
- **3**. The ontology for narratives
- 4. The tool for bulding and visualising narratives
- 5. A qualitative evaluation: the Mingei project
- 6. Conclusions and future work

# **The Problem**

 Traditional libraries collect and make accessible narratives, as we all know from our very early days



 And so do Digital Libraries (DLs). Every object in a DL tells or participates in some story, regardless of the medium, the genre, or the type of the object.



# **The Problem**

- Narratives in DLs are expressed, if at all, in natural languages and are not *recognized* as such. There is no track of narratives in the conceptualization of today's DLs--they offer no service on narratives.
- In essence, DLs ignore a substantial aspect of their contents.
- Yet, narratives are a central notion to the activity of scholars, who investigate many aspects of a narrative, and relate narratives to each other and to the cultural context in which they are born.
- Narratives are also important to knowledge curators, who document the many ways knowledge is produced, distributed, organized, disseminated.
- The goal of our research is to make narratives emerge in DLs as first-class citizens, known to the DL and at the center of a rich set of services offered to the DL users.

# **The Approach**

- At present, software agents (SAs) can perform many important tasks on narratives, thanks to the dramatic improvements in the automatic analysis of the content of the digital objects that contain narratives.
- However, *understanding* the story told by, *e.g.*, a text or an audiovisual object, is definitely out of reach for SAs, at the moment.
- Until SAs grow to this task, we can help DLs getting smarter by creating the information space where narratives leave.
- SAs can help populating this space and, by so doing, maybe *learn* what a story is, and how it is built.
- In short, we want to define an ontology of *formal* narratives.

#### **The Proposal**

- To be apt to our goal, formal narratives should not *replace* traditional narratives.
- Rather, they should *enhance* them, by adding a formal dimension to the informal one.
- This formal dimension should capture what SAs cannot capture: the *story* that the narrative tells, as a series of events, situated in space and time, with a beginning, a development and an end.
- This network of events would then form the *conceptual glue* that holds together the DL objects and links them into meaningful wholes that is fundamental in contextualizing the objects themselves.

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#### Risultati: 8,898

Mozart, Wolfgang Amadeus;

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# ... and in Wikipedia

2.7 Mozart massone
2.8 Malattia e morte (1791)
3 La carriera di Mozart come libero artista
4 Lista parziale delle composizioni per genere
5 Lista di tutte le composizioni per numero di catalogo
6 Lo stile mozartiano
7 Mozart e i compositori contemporanei
7 1 Franz Joseph Havdn
8 Aneddotica
8 1 La leggenda su Mozart e Salieri
8.2. Prostiti da altri autori
0. Mezert pelle lettereture
10 Onorificenze
11 Filmografia
12 Lavori teatrali
13 Filatelia
14 Note
15 Bibliografia
15.1 Testi di Mozart e testi da lui musicati
15.2 Biografie e letteratura critica
16 Voci correlate
17 Altri progetti
18 Collegamenti esterni
18.1 Partiture e testi

#### Background

- Artificial Intelligence
  - Robotics
  - Storytelling systems
- Narratology
  - Aristotle
  - Russian formalists
  - Computational narratology

Abstract model of a narrative, as derived from the narratology and AI literature.

A narrative consists of three main elements:

- the *fabula*, the network of the events that compose the story
- the narration, the natural language messages that narrate the fabula
- the *reference function,* connecting the narration to the fabula

The fabula is built on top of events, including actions and activities. Events are situated in time and space, are connected to the people and the objects that participate in them, and are connected between each other by:

- A *mereological* relation, relating events to their parts, *e.g.*, the birth of Dante Alighieri is part of the life of Dante
- A *causal dependency* relation, relating events to their causes, *e.g.*, the eruption of the Vesuvius caused the destruction of Pompeii

### **The reference function**

The reference function connects fragments of narrations to the narrated events and by extension to constituents of events: time intervals, places, people, objects.

The reference function establishes the link between the informal and the formal level by providing the *interpretation* of the informal narratives. We can say that understanding a story means to compute the reference function: what humans can (almost always) do and SAs can (almost always) NOT do.

In addition, it allows deriving the plot of the narrative. 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.

#### A specification of the conceptualization

We have developed a first-order logic specification of the conceptualization relying on three existing ontologies:

- the CIDOC CRM for the specification of events and their constituents
- FRBRoo for the specification of narrations
- OWL Time for the specification of time

We have implemented the resulting ontology using RDF as a notation and OWL 2 DL as language (but mostly its rule-based extension SWRL which allows specifying inference rules on time intervals).

#### An example: the life of Dante Alighieri



#### **Representing the fabula**



#### **Representing the Narration**

![](_page_15_Figure_1.jpeg)

#### **Provenance**

![](_page_16_Figure_1.jpeg)

![](_page_16_Figure_2.jpeg)

#### **Creating and Visualizing Narratives**

On top of the ontology, we created a **semi-automatic tool** for building narratives, since we found no suitable tool to the needs of our research

![](_page_17_Picture_2.jpeg)

# **Creating Narratives**

- The tool retrieves and assigns URIs to the instances of the classes using Wikidata as resource
- The user can introduce new entities not present in Wikidata
- The instances are automatically classified in the classes of our ontology thanks to a mapping from Wikidata to our ontology

#### ALL SAVE Dante Alighieri Abel-François Vi... Aeneid **Event Title** PEOPLE CLEAR Aesop's Fables Albert I of Germ... Albertanus of Br., ORGS EXPORT Alfonso X of Cas... Albertus Magnus Alboino I della .. OBJECTS RELATIONS CONCEPTS Alfred, Lord Ten... Alighieri Alighiero di Bel... PLACES Drop entities here! Amore e 'l cor g... Anathema Andrea da Grosse.. WORKS Andrea del Casta.. Antonia Alighier... Antonio Nuvolone... SEARCH NEW Arezzo Aristotle Arnaldo D'Addari... Marriage of Bella and Marriage of Alighiero and Birth of Dante Baptism of Dante Death of Bella Elementa Alighiero 26-03-1266 1265 1270 Lapa 1255 1270 1272-( Alighiero di Bel.. Dante Alighieri Dante Alighieri Bella degli Abat.. Alighiero di Bel.. Dan Bella degli Abat .. Bella degli Abat .. Florence Baptist., Florence Lapa Cialuffi

Florence

Florence

Florence

#### Biography of Dante Alighieri

IT

Florence

Aes

![](_page_19_Figure_0.jpeg)

## **Evaluation: the Mingei project**

After an initial evaluation on the life of Dante, we are doing a more probing evaluation of the ontology and of the tool in a European project on *Representing and Preserving Craft Heritage*.

#### <u>mingei-project.eu</u>

Mingei addresses three crafts:

- Silk waving (Krefeld, Germany)
- Glass blowing (CERFAV, France)

![](_page_20_Picture_6.jpeg)

• Mastic cultivation and processing (Chios, Greece)

It uses co-creation to elicit craft knowledge from craftsmen and craftswomen and to build apps and museum installations to disseminate that knowledge to scholars and to the public.

It also addresses the preservation of craft knowledge using Digital Preservation methods, based on the OAIS Reference Model.

### **Narratives in Mingei**

Narratives play a central role in Mingei. A craft process is modelled as a narrative, whose fabula is linked to the media objects that document the various steps of the craft, each seen as an event.

These media objects include datasets containing the tracking of the movements of craft masters.

Narratives are also used to contextualize craft from the historical, social and cultural point of view.

In the silk weaving craft, we have collected the following narratives:

- Processes Exercised by the Krefeld Weaving Community
- History of Haus der Seidenkultur
- History of Krefeld
- Chronicle of the Casaretto Family
- Hubert Gotzes Weaving Workshop
- Story of the Jacquard Invention
- Story of the Cloth in the Shrine of Charlemagne and Its Motif

#### **Narratives in Mingei**

We have three narratives for glass blowing and four narratives for mastic cultivation and processing.

Thanks to Mingei we realized the importance of modelling process *schemes,* descriptions of the activities needed to make that craft, and of the order in which these activities must be done.

To add schemes to our ontology we followed the conceptualization of processes of UML activity diagrams:

- the basic ingredients are human activities (as opposed to computing operations)
- the primitives for establishing the order of the activity, that is, which activities need to be done before, or after, or in parallel to which activity, are those of Activity Diagrams

#### **Process scheme for mastic cultivation**

![](_page_23_Figure_1.jpeg)

#### **Conclusions**

- Digital narratives have in DLs the role that narratives have in traditional libraries: they are resources that the DL collects and makes available to their users, or employ in knowledge curation.
- To introduce automatic tools in the management of narratives in DLs, we have defined a formal ontology of narratives, based on few, simple notions recognized by narratology as the basic constituents of narratives: fabula, narration and reference function.
- The ontology structures the information space of a DL, so that many different ITs can be put at the service of the DL users.

#### **Conclusions**

- We have implemented a tool for the semi-automatic creation of narratives and for their visualization along several dimensions.
- The tool relies on an inference engine to properly manage the knowledge on narratives, including a rule-based engine to deduce temporal knowledge based on Allen's logic.
- The ontology and the tool are being employed in the Mingei project to represent and preserve craft heritage.
- At present, we are extending the narrative ontology with a richer representation of textual narrations, and experimenting with information extraction methods to give more support to the creation of narratives from texts.

# Thank You

<u>dlnarratives.eu</u> <u>mingei-project.eu</u>

![](_page_26_Picture_2.jpeg)

#### The Proposal

...the introduction of a **new search functionality** for DLs that does not return just a list of objects but a **narrative** 

#### Narrative

a semantic network of **events**, with a possibly associated **text**, that are linked to the **digital objects** of the existing digital libraries and are endowed with a set of **semantic relations** connecting them to each other

#### Narratology Background

- Aristotle
- Russian formalists

• Computational narratology studies narratives from a computational perspective and develops narratological models  $\rightarrow$  In the Artificial Intelligence field storytelling systems use narratives as interactive method. Ontologies are developed to give a formal computable representation of a narrative

#### Artificial Intelligence Background

Study of **Situation and Event Calculus theories** in order to:

- identify the **logical components of narratives** (e.g. events, actions, fluents, physical objects, agents)
- identify **types of events** (e.g. generalized events, processes, mental events)
- Logical definitions:
  - Event → Initiates(e, f, t) means that the occurrence of event e at time t causes fluent f to become true, while Terminates(w, f, t) means that f ceases to be true
  - Mental event  $\rightarrow$  *Believes*(Lois, x)

x represents *Flies*(Superman)

*Flies*(Superman) is a proposition that specifies a mental object: reification of the mental object that *Superman flies* 

#### **Evaluation of Ontology Learning Systems**

Ontology Learning (OL) is a method to create ontologies in an automatic or semi-automatic way from text analysis

Limits:

- language dependent
- style dependent
- the **quality** of the **ontologies** developed using semi-automatic methods is still **worse** than the quality of **ontologies developed by experts**

Our main goals:

- Reliability of collected data
- Ontology **independent from population techniques** (automatic, semiautomatic, manual)

#### Methodology

The creation of a **formal ontology** in order to **COLLECT** and **VISUALIZE** knowledge about **narratives** 

![](_page_31_Figure_2.jpeg)

#### Narration

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

We focus on the only aspect that is functional to our model of narrative, namely **textual content** that is the language expression that constitutes the content of a piece of text

# Mapping Between Classes of Wikidata and Our Ontology

• Mapping between classes of our ontology and those of Wikidata

Wikidata	Our ontology
Q5 human	E21 Person
Q16334295 group of humans	E74 Group
Q7184903 abstract object	E89 Propositional Object
Q223557 physical object	E19 Physical Object
Q17334923 location	E53 Place
Q234460 text	
Q478798 image	E73 Information Object
Q340169 media	
Q186081 time interval	E52 Time-Span
Q1190554 event	E5 Event

#### **Event Creation and Timeline**

			Biography of	Dante Alighi	<u>eri</u>		11				
	Dante Alighieri	Abel-François VI	. Aeneid	Event Title			SAVE		Event Title		
	Aesop's Fables	Albert I of Germ	Albertanus of Br	START DATE	EN	D DATE	CLEAR				
	Albertus Magnus	Alboino I della	Alfonso X of Cas	EVENT TYPE			RELATIONS	ST	TART DATE	END DATE	
5	Alfred, Lord Ten	Alighieri	Alighiero di Bel	ENTITIES				EV	/ENT TYPE		
	Amore e 1 cor g	Anathema	Andrea da Grosse		Drop entitie	s here!					
	Andrea del Casta	Antonia Alighier	Artoria Algine Artorio Navolone NOTES								
	Arezzo	Aristotle	Amaido D'Addari								
arriage of Bella and Alighiero 1255		Birth of Dante 1265 Baptism of Dante 26-03-1266		Dante Death of Bella Marriage of Alighiero and Elev 1270 Lapa 1270			d Elementa		Drop	entities here!	
Alighiero di Bel Bella degli Abat Florence		Dante Alighieri	Dante Aligh	ieri	Bella degli Abat	Alighiero di Bel	Da	NC	OTES		
		Bella degli Abat Flor Florence		egli Abat Florence Baptist		Florence Lapa Cialuffi Florence					
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		Marria	age of Bell Alighiero	a and		Birth of Danta 1265	e	Baptism of Dante 26-03-1266	GITAL OBJECT Death of Bella 1270	Marriage of Alighiero and Lapa	
		Marria	age of Bell Alighiero 1255	a and		Birth of Dante 1265	Ð	Baptism of Dante 26-03-1266	GITAL OBJECT Death of Bella 1270	Marriage of Alighiero and Lapa 1270	
		Marria	age of Bell Alighiero 1255 lighiero di Bel	a and		Birth of Danta 1265 Dante Alighieri	e	Baptism of Dante 26-03-1266 Dante Alighieri	GITAL OBJECT Death of Bella 1270 Bella degli Abat	Marriage of Alighiero and Lapa 1270 Alighiero di Bel	
		Marria	age of Bell Alighiero 1255 lighiero di Bel	a and 		Birth of Dante 1265 Dante Alighieri Bella degli Abat.	8	Baptism of Dante 26-03-1266 Dante Alighieri Florence Baptist	GITAL OBJECT Death of Bella 1270 Bella degli Abat Florence	Marriage of Alighiero and Lapa 1270 Alighiero di Bel Lapa Cialuffi	

#### **Causal and Mereological Relations**

![](_page_35_Figure_1.jpeg)

#### The SW Architecture

![](_page_36_Figure_1.jpeg)

# Visualization: graphs

![](_page_37_Figure_1.jpeg)

![](_page_37_Figure_2.jpeg)

#### **Visualization: Tables**

Event	Date	Primary Source	Author	Text Fragment	Reference Fragment		
Birth of Dante	1265	Inferno	Dante Alighieri	"io fui nato e cresciuto sovra 'l bel fiume d'Arno, alla gran villa"	XXIII 94-95		
Baptism of Dante	1266-03-26	Inferno	Dante Alighieri	'il mio bel San Giovanni'	XIX 17	Event	Date
Baptism of Dante	1266-03-26	Paradiso	Dante Alighieri	"in sul fonte del mio battesmo"	XXV 8-9		
Marriage of Dante and Gemma	1277-02-09	Instrumentum Dotis	strumentum Dotis Uguccione di Baldovino	aldovino "Domine Gemme vidue, uxori olim Dantis Allagherii et filie condam domini Manetti domini Donati, pro iure sue dotis librarum CC florenorum parvorum ut de instrumento dotis constat manu ser Ranaldi filii condam Oberti Baldovini de Florentia notarii, ex inbreviaturis ser Uguiccionis Baldovini notarii, facto in anno Domini M° CCLXXVI, indictione VJ, die VIIIJ° mensis februarii"	Capitani di Parte Guelfa, Numeri Rossi, 42, c. 3r	Baptism of Dante	1266-03-26
						Death of Bella	1270
						Marriage of Alighiero and Lapa	1270
Dante's First Travel to Bologna	1286-1287	Trattatello in laude di Dante	rattatello in laude di Giovanni Boccaccio "Egli li primi inizii, sì come di sopra è dichiarato, prese nella propia patria, e di quella, sì come a luogo più fertile di tal cibo, n'andò a Bologna"		Elementary Education of Dante	1272-1277	
				quella, si come a luogo più fertile di tal cibo, n'andò a Bologna"		Death of Alighiero	1276
						Marriage of Dante and Gemma	1277-02-09

## Evaluation 1/3

Questionnaire to a historian who is an expert of Dante Alighieri's life. We asked him about:

#### 1. The representational adequacy of the ontology

- The historian explored the narrative on the timeline and looked at the contextualization of the individual events of the fabula
- The use of external resources to enrich the narrative
- The representation of the provenance
- Different narratives of the same topic, created by different scholars
   **Result**: The historian gave *positive* evaluation on the points above (4.3/5)

#### 2. The effectiveness of a tool to build narratives

#### **Results**:

- It is possible to formalize a significant narrative from 40 pages (104,013 characters) of text in a matter of a few hours (80 events/7 hours)
- 70% of the entities used in the narration of the life of Dante are those defined in Wikidata

#### Evaluation 2/3

3. The satisfaction of the historian's requirements, defined at the beginning of the study  $\rightarrow$  SPARQL queries and visualisation of the knowledge

#### - Extracted knowledge

• Events happened in a certain given range of time

• Events involving certain given entities (e.g. place, person)

 $\odot$  Events inter-linked by certain given relations (e.g. causal or mereological)

#### - Knowledge visualisation

- Visualising the fabula of a narrative on a timeline
- $\odot$  Visualising events along with their primary sources in table format, exportable in CSV format

• Primary sources in table format, exportable in CSV format

Using network graphs to visualise an event and its related entities
 Using network graphs to visualise a certain given entity and its related events

#### Evaluation 3/3

In order to validate the ontology on **different domains**, representing **different types of narratives**, the narrative building tool and the underlying ontology are currently being used by:

- 1. A Computer Science professor at the University of Pisa to represent the **history of Informatics**, focussing on the Turing Award
- 2. A researcher in Computational Biology at the Italian National Research Council (CNR) to narrate the discoveries related to the **giant squid**
- 3. A Digital Humanities researcher at the CNR to create the narrative of the life and works of the Austrian painter **Gustav Klimt** and of the Italian poet **Dante Alighieri**