

# Augmented Narratives: A Data-Driven Platform for Interactive Storytelling Based on Artificial Intelligence and Knowledge Representation Techniques

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## Abstract

This paper introduces "StoryHub", an innovative platform for interactive storytelling based on the integration of semantic technologies, Large Language Models (LLMs) and immersive environments in augmented and virtual reality. The platform enables the transformation of narrative, historical or literary content into digital experiences that can be explored through semantic graphs, conversational avatars and three-dimensional scenes. The process is based on the automatic extraction of knowledge from texts, its validation by experts, and its modelling in structured ontologies, in accordance with the principles of interoperability, traceability and reuse of data. The user can interact with virtual historical characters in a natural and personalised way, exploring the narrative from different perspectives. The paper describes the architecture of the platform, the functional modules and the technologies adopted, and finally discusses the application potential of the system in the fields of cultural heritage, education and immersive communication.

## Keywords

Large Language Models, Semantic, Virtual Reality, Augmented Reality, Knowledge Graph

## 1. Introduction and Motivations

In recent years, the joint evolution of technologies related to generative artificial intelligence, augmented and virtual reality and semantic representation of knowledge has opened up new opportunities for the creation and enjoyment of interactive digital content [1]. In particular, the structured extraction of knowledge from textual sources and its subsequent integration into virtual environments are redefining the way information is made accessible, navigable and understandable by end users [2]. This is the backdrop for the "StoryHub" project, a prototype platform developed within the RASTA (Augmented Reality and Automated StoryTelling) project, which aims to transform narrative texts (literary, historical or educational) into enriched digital experiences based on knowledge graphs, augmented and virtual reality, and large-scale language models (LLM). Starting from textual content, the system automatically builds a semantic network of characters, events and relationships, which can be explored through a visual interface or enjoyed in conversational form via a 3D avatar in augmented or virtual reality. Thus, by means of special graphic interfaces, the user has the possibility of graphically exploring the narrative structure, favouring the analysis of the connections between the protagonists, the understanding of the context and the consultation of automatically generated narrative profiles. The project aims to combine the expressive power of narrative with the potential of data science technologies, proposing a new way of accessing knowledge through transparent, interoperable and reusable data structures. The dialogic component, fed by LLM and guided by a knowledge base automatically generated from the text,

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then validated by human experts, opens the way to new forms of interaction with the content, while raising relevant questions about ethics, traceability of sources and reliability of automatic answers. The dialogue component based on semantic retrieval (Semantic-RAG) allows for personalised and verifiable interaction, which is a step forward compared to generalist generative models not based on controlled knowledge bases. The entire process is driven by a focus on data governance: the generated graphs are persistent, versionable, interoperable and reusable in other application contexts (museums, publishing, education), consistent with the principles of data spaces and data reusability. Furthermore, the system is designed to be explainable, allowing the provenance of information (data lineage) to be traced and the output generated by LLM to be supervised, in line with the requirements of reliability, transparency and ethics in the use of Big Data [3].

This platform represents a concrete example of Big Data and Data Science Application, in which textual knowledge is transformed into structured data and then reused in advanced computational environments, serving human-computer interaction and cultural fruition. Furthermore, the use of LLM for the generation of personalised and dialogic content raises important considerations about the control and verification of automatic information, which the paper discusses with reference to the principles of the Ethics of Big Data and Trustworthy AI. Through the analysis of this use case, the paper intends to offer an interdisciplinary reflection on the methods and practices for the representation, governance and ethical use of narrative data in augmented environments, proposing "StoryHub" as an adaptable framework for applications in education, culture and industry, with a particular focus on cultural heritage enhancement and immersive communication.

The paper is structured as follows: Section 2 analyses the main related works, with a focus on automated storytelling technologies, semantic representation and immersive applications. Section 3 describes in detail the methodology adopted to build the "StoryHub" platform, highlighting the roles involved and the process of transforming narrative content into structured knowledge. Section 4 delves into the implementation aspects, illustrating the technologies used and the ontology developed for the historical domain. Section 5 provides an overview of the usability modes made available by the platform, including graph visualisation, interactive storytelling, and augmented and virtual Web reality scenarios. Finally, Section 6 presents the conclusions of the work and proposes directions for future developments.

## 2. Related Works

Recent studies have focused on the integration of big data, knowledge graphs and immersive technologies to develop new forms of automatic, interactive and personalized storytelling. In [4], the authors propose an innovative framework for Cultural Heritage based on a Multimedia Knowledge Graph (MKG). The system exploits deep learning techniques and Linked Open Data to segment images and identify relevant elements in multimedia contents automatically collected from the web. The goal is to generate coherent and semantically rich stories that guide the user through a dynamic and intuitive interface. In a complementary manner, the Open Story Model (OSM) introduced in [5] addresses the challenge of understanding heterogeneous big data through a pipeline that transforms them into structured knowledge graphs, from which personalized narratives are then derived. The generated stories are not only descriptive, but take the form of interactive data products, which allow stakeholders to explore and analyze in real time information relevant to their interests. Another relevant contribution comes from the work of Gatt and Reiter [6], which explores the transition from structured data and knowledge graphs to natural language texts. An in-depth overview of Natural Language Generation (NLG) techniques is provided, highlighting the challenges in generating cohesive narratives from non-linguistic data. The tutorial discusses both traditional approaches and modern solutions based on neural architectures, with an emphasis on adaptability and scalability in domains without parallelized corpora. An interesting perspective on the use of knowledge graphs in narrative generation is presented in [7], where sophisticated semantic relations, such as intentional or enabling causalities, are proposed beyond the classic "who, what, where, when" relations. The adoption of such semantic structures enriches the

generated narratives, improving their grammatical coherence and semantic precision. The work [8] explores the use of virtual reality in immersive storytelling as a form of affective ethnography. Through the case of *Traveling While Black*, they show how VR can facilitate an empathetic and non-intrusive experience, creating a sensory and reflective relationship between viewer and narrated subject. In [9] it is analyzed immersive storytelling in mixed reality (VR/AR) environments, investigating how emerging technologies can shape future identities, especially in spatial contexts. Through installations, interactive books and performances with humans, robots and avatars, the project combines art and science to create sensory experiences that stimulate reflections on technology, the body and society. The approach is interdisciplinary and oriented towards experimentation with young audiences. On the immersive visualization of big data, the work [10] highlights the limits of traditional techniques in representing high-dimensional data, proposing instead the use of AR/VR technologies to improve the perception of information structures. Interaction in augmented reality environments allows for greater immediacy in understanding and cognitive retention of the relationships between data. Similarly, [11] proposes virtual reality platforms for collaborative data visualization. Such immersive environments offer tangible benefits in terms of geometric perception and intuitive understanding of datascares, also favoring shared exploration between users in a common visual space. Finally, the article [12] analyzes the impact of virtual reality on digital media in the era of big data and artificial intelligence. The integration of VR in areas such as tourism, audiovisual production and urban planning shows how technology can improve the communicative effectiveness of content and facilitate a more direct and engaging transmission of information. In summary, a convergence between big data, knowledge graphs and immersive technologies emerges, which makes the development of interactive, multimodal and personalized narratives possible. The use of conversational avatars and augmented reality opens up promising scenarios for a participatory fruition of knowledge, capable of connecting complex data with rich, intuitive and engaging user experiences.

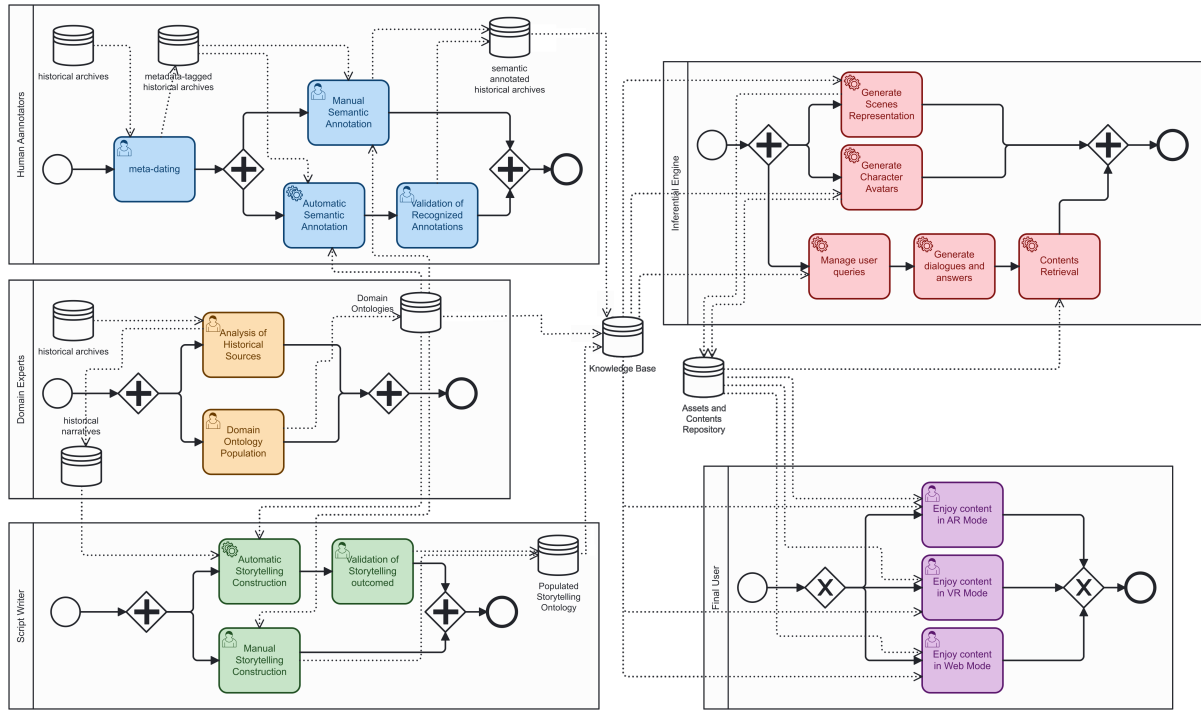
Although the literature reviewed outlines an increasing convergence between, generative AI, immersive reality and semantic web technologies, “StoryHub” stands out for its systemic approach that integrates these fields into a single operational workflow, replicable and validated on a specific cultural-historical domain. While some works deal with individual components, the platform proposed in this article coherently unifies semantic modelling, dialogic generation based on a structured knowledge base, and immersive content fruition with end users.

### 3. Methodology

Figure 1 shows the methodology behind the “StoryHub” tool, represented with the BPMN notation (Business Process Model and Notation).

As can be seen from Figure 1, the methodology involves the interaction of 5 different actors

- **Domain Experts:** have the initial task of analysing historical sources (archives, books, letters, etc.) and reporting the knowledge in a “*historical narratives*” database, containing natural language storytelling processing. In addition, all the main storytelling elements inherent to the narrative domain (locations, scene objects, events and actors) are to be reported in a domain ontology.
- **Script Writers:** have the task of modelling the storytelling using a special story composition tool, or using Natural Language Processing and/or generative techniques to automatically extract storytelling elements from the natural language text. To ensure storytelling consistency, in the second case it is necessary for human domain experts to validate the automatically extracted content using the same story composition tool to support validation. In both cases, the produced storytelling is automatically converted into a semantic representation, for details of which see Article [13]. Thus, the script writers’ task ends with the populating of the semantic database “*Populated Storytelling Ontology*”.
- **Human Annotators:** have the task of semantically annotating historical archive sources (texts or digital scans) with the storytelling elements defined in the domain ontologies. As the same



**Figure 1:** "StoryHub" Methodology

domain ontologies are used for both storytelling modelling and semantic annotation, an indirect semantic link is created between the storytelling and archive sources. Thus, greater historical coherence is provided to the narratives. The tool used is a semantic annotator of texts and images, for details of which see articles [14] and [15]. The annotations produced with the tool are stored in OWL (Ontology Web Language) format in the ontology "*Semantic Annotated Historical Archives*". The merge of the three semantic databases "*historical narratives*", "*Populated Storytelling Ontology*" and "*Semantic Annotated Historical Archives*" builds the knowledge base of "StoryHub".

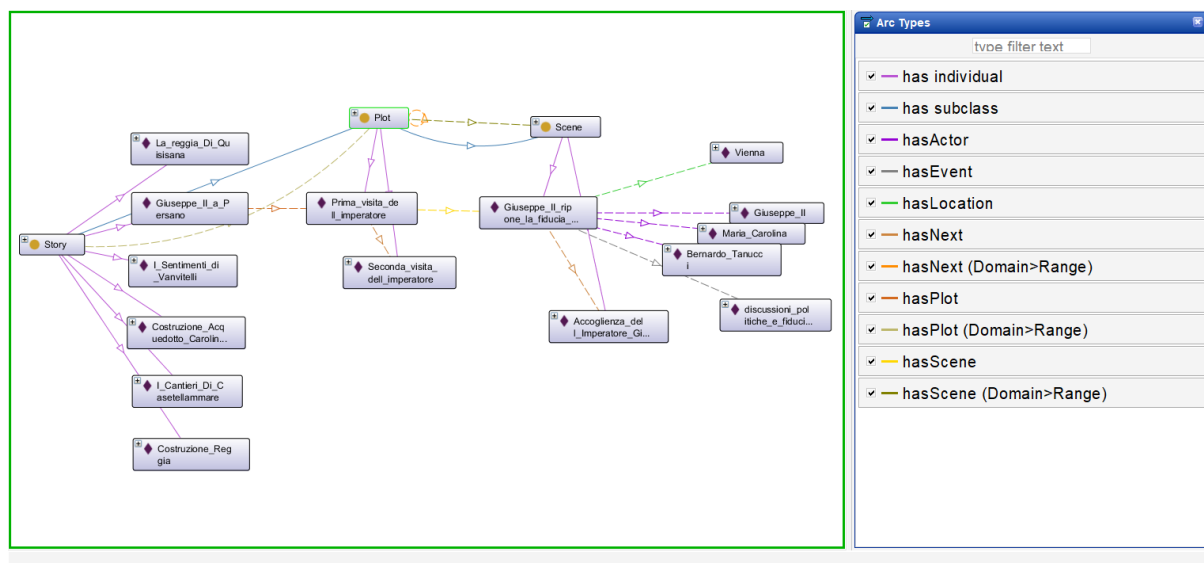
- **Inference Engine:** is the processing heart of the system. It uses the structured knowledge contained in the knowledge base to create the assets to be used for enjoyment, including 3D avatars and scene representations. In particular, the task of this module is to automatically construct prompts consistent with the structured knowledge validated by experts for the generation of assets through generative models. Another task of this module consists in the generation of answers to user queries posed to characters of stories or dialogues between characters: thanks to the semantic structuring of knowledge, in order to be able to answer a user query, the LLM performs a semantic retrieval of content within the knowledge base, in order to guarantee answers consistent with historical content and avoiding fake news.
- **Final User:** can take advantage of the functionalities provided by "StoryHub" through special user scenarios. The assets generated by the inference engine are used to provide the user with an immersive user experience consistent with the narrated facts. In particular, "StoryHub" provides three different fruition scenarios: augmented reality, virtual reality and virtual web reality. In addition, the tool offers the possibility to enjoy storytelling through three points of view: Navigable Characters Knowledge Graph View, Storytelling View and Interactive Conversational Avatars View.



## 4. Implementation

In this Section, some details concerning the implementation of the methodology presented in Section 3 are presented.

Semantic technologies were used for storytelling modelling. In particular, both storytelling and domain ontologies used for the composition of stories are realised in **OWL** (Ontology Web Language). For the RASTA project, **HistoricO** [16] was created, an ad-hoc ontology inherent to the cultural-historical domain in Italy in the 1700s, containing knowledge inherent to the social-political-cultural classes of the time, characters from the noble hierarchy (kings, queens, princes, etc.), politics (ministers, councillors, etc.) and civil (merchants, professionals), historical events, historical artefacts (documents, books and letters inherent to the historical period), locations, etc. An example of storytelling modelled in OWL is illustrated in Figure 2.



**Figure 2: Example of Modelled Storytelling in OWL**

Figure 2 shows the semantic modelling of a portion of the story “Joseph II at Persano”: the story recounts Emperor Joseph II of Habsburg-Lorraine’s journey to Naples to meet his sister Maria Carolina and King Ferdinand of Bourbon, describing his negative impressions of the latter.

Each story is structured into several plots, each of which is structured into several scenes. For each scene, the sequence of actions that implement it, the props used, the characters actively participating in it and the location are modelled. In particular, the story "Joseph II in Persano" consists of two plots; the first plot has as its first scene "*Giuseppe II puts his trust in Tanucci*", to which the following have been associated: i) the actors Joseph II of Habsburg, Maria Carolina of Habsburg and Bernardo Tanucci, through a "*hasActor*" type relationship (purple strings); ii) the location "Vienna" by means of a relation of type "*hasLocation*" (green arches); iii) the "Political Discussions" event by means of a relationship of type "*hasEvent*" (yellow arcs). By means of a "*hasNext*" relationship (orange arcs), the temporal/causal consequentiality between the various scenes of a story is semantically modeled.

To realise the utilisation system, various technologies were used: Web Virtual Reality utilisation was implemented in **JavaScript**, with the use of libraries such as **Three.JS** and **Graph Force 3D**; for Augmented and Virtual Reality fruition scenarios, technologies such as **AR.js** and **Unity** were used. The backend side was implemented entirely in **Python**, while the inference engine employs a **Gemini** LLM deployed via the **Dify** cloud platform. More details are provided in Article [17]. The avatar was realised with the **MeshAI**<sup>1</sup> tool in GLB format.

<sup>1</sup><https://www.meshy.ai>

## 5. "StoryHub" Overview

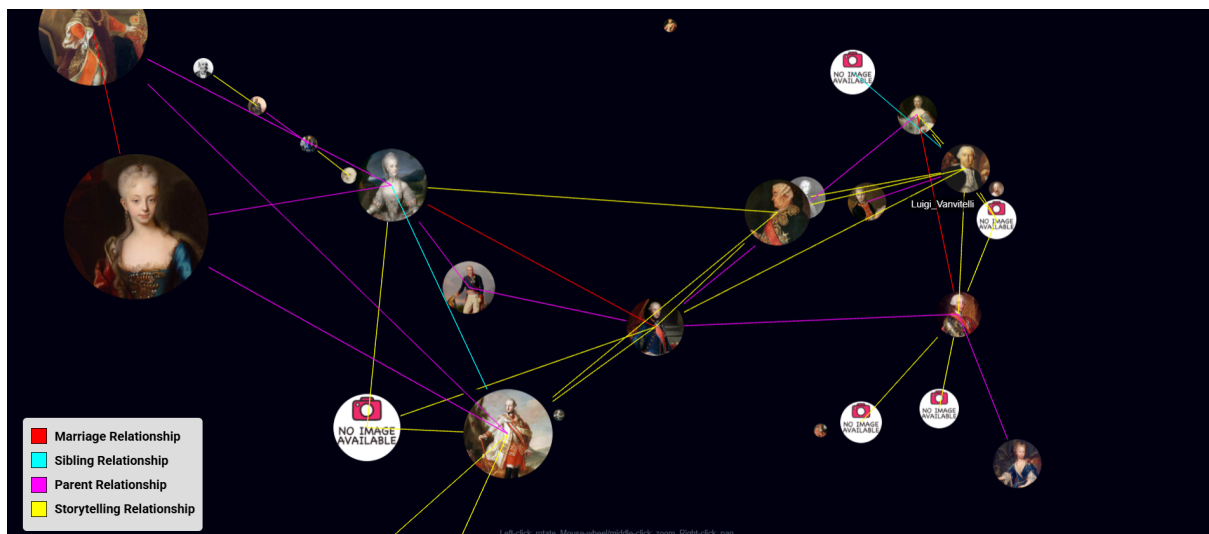
The storytelling ontology populated with the stories modelled by script writers was used as the knowledge base for the "StoryHub" utilisation tool, described in Deliverable. The tool provides three modes of fruition:

- **Navigable Characters Knowledge Graph View:** it is possible to navigate a knowledge graph whose nodes represent all the characters present in the semantic knowledge base. Various filters can be applied to the graph and all the information associated with each character can be displayed. In addition, a conversational agent can be activated to dialogue with each of the characters in the graph.
- **Storytelling View:** the structure of one or more stories modelled in the knowledge base is displayed. A story is displayed as a sequence of scenes, each of which is graphically represented with a cube. It is possible to view all the information in each scene, displaying all the props used, the actions taken in the scene and the characters participating in each action. In addition, it is also possible to 'bring the scene to life' by activating a conversational agent that generates dialogues between two or more characters involved in the scene.
- **Interactive Conversational Avatars View:** through this view, each scene can be visualised in 3D through avatars that can converse in real time with each other and with an external user about the context of the scene in question.

More details on the use of the tool are provided in the following subsections.

### 5.1. Navigable Characters Knowledge Graph View

Figure 3 shows the knowledge graph of the characters modelled in the storytelling ontology.



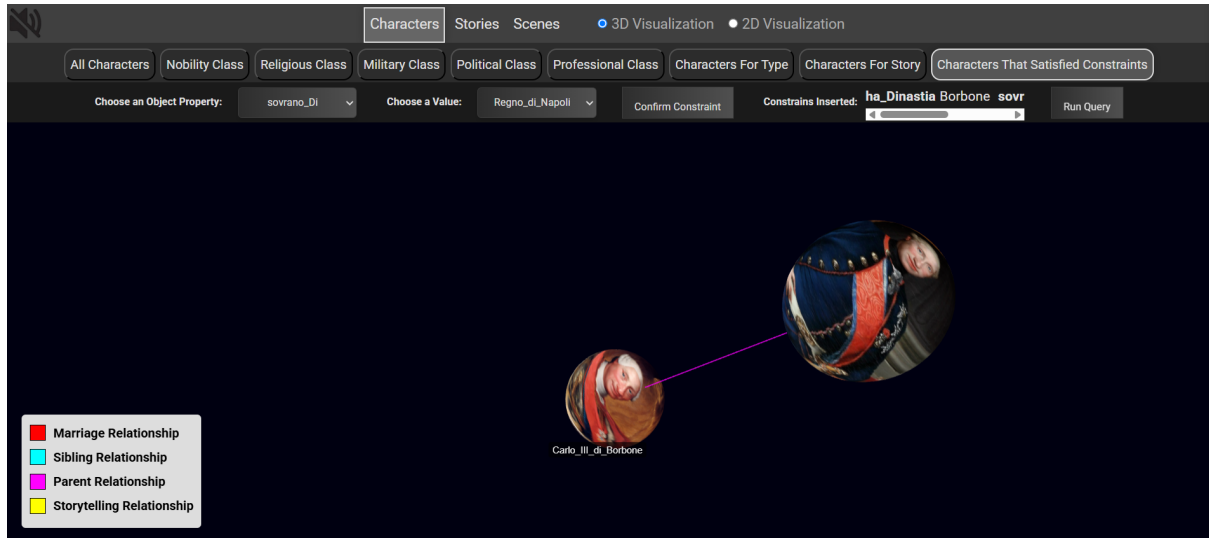
**Figure 3:** Knowledge graph of the characters modelled in the Storytelling Ontology

As can be seen from Figure 3, each node in the graph represents a character modelled in the knowledge base, while the edges represent one of the possible relationships between the characters. Four relationships are used:

- **Marriage Relationship:** corresponds to one of the possible marriage relationships in the domain ontology.
- **Sibling Relationship:** corresponds to one of the possible family relationships indicating that a character is the brother or sister of another character.

- **Parent Relationship:** corresponds to a father-son relationship.
- **Storytelling Relationship:** corresponds to a collaboration between two characters in at least one action of a story. This relationship testifies that the two characters know each other and have interacted at least once in their lives.

Various filters can be applied to the graph; for example, the filter “Characters that satisfy constraints” is available, which allows one to select all and only those domain instances that satisfy one or more restrictions on the object properties of the semantic knowledge base by means of an automatically generated SPARQL query based on the parameters selected graphically by the user. An example is shown in Figure 4, where the graph has been restricted to all and only those individuals who were sovereigns of the “Kingdom of Naples” and whose dynasty is “Bourbon”.



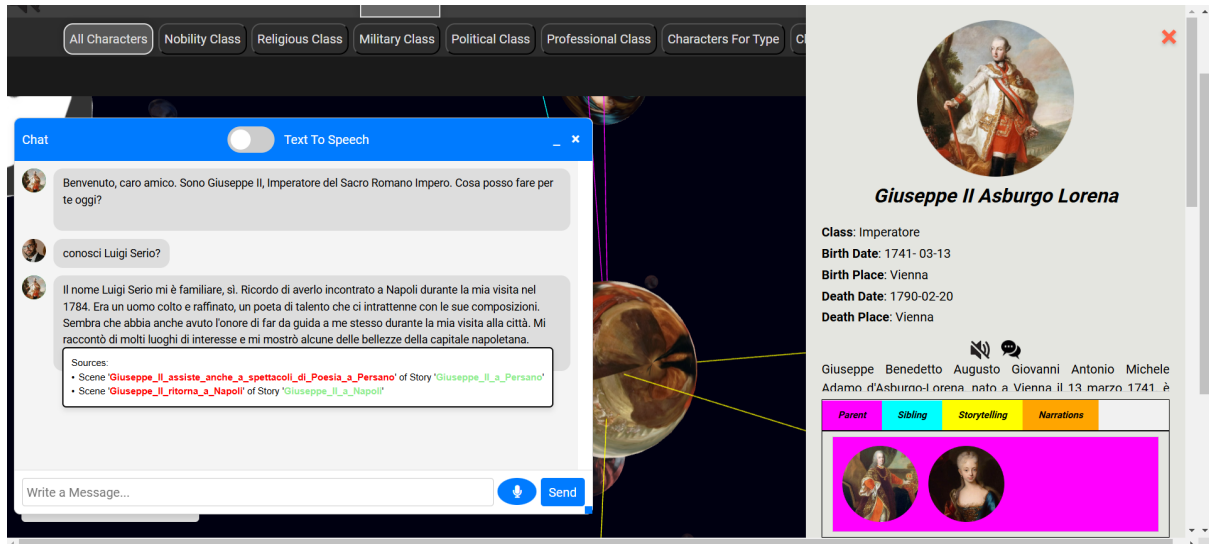
**Figure 4:** Graph Restriction Example

Clicking on a ‘character’ node displays an information sheet containing all the information related to that character, which is extracted from the semantic knowledge base by means of a series of SPARQL queries. Information such as the date and place of birth and death, the class or classes to which the domain instance belongs, the description, any relationships with other characters and the list of stories in which the character appears are shown. It is also possible to activate a conversational agent to converse with the character via a special button on the information sheet. It is possible to converse with a character either by means of a special chat or verbally through a text to speech and speech to text module. Figure 5 shows an example of a conversation with the character “Giuseppe II Asburgo Lorena”.

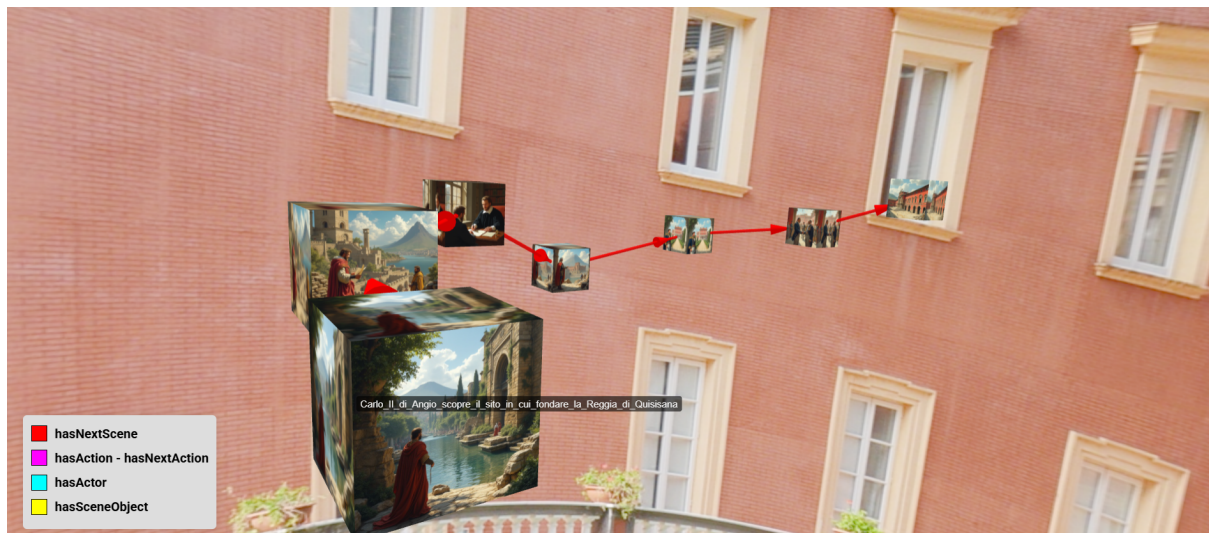
As can be seen from Figure 5, Emperor Giuseppe II of Habsburg was asked via chat if he knew the character “Luigi Serio”. The conversational agent, in order to provide the answers, uses an LLM on which a semantic RAG was performed. Thus, the knowledge used to provide the answers is acquired from the stories modelled in the semantic base, in such a way as to avoid the generation of fake news and historical inconsistencies. Indeed, through the chat, for each answer generated by the LLM, it is possible to visualise which sources were used; in the example shown in Figure 5, knowledge was acquired from two scenes from the story “Giuseppe II at Persano”.

## 5.2. Story View

The Story View allows the visualisation of the storytelling modelled in the semantic knowledge base. Figure 6 shows an example from story 6, which tells of the evolution of the Royal Palace of Quisisana, in Castellammare (Italy), from its foundation under “Carlo II di Angio” its modern restoration.



**Figure 5:** Example of a Conversation with the Character “Giuseppe II Asburgo Lorena”



**Figure 6:** Story View - Quisisana Storytelling

As can be seen from Figure 6, scenes are modelled with cubes placed in sequence between them. Once a scene has been chosen, it is also possible to display the actions performed in it, the characters involved and the scene objects used. With a click on a given node, an information panel can be opened with all the information available in the knowledge base; Figure 7 shows an example of a document-type prop representation, namely a letter from Vanvitelli to his brother Urbano in 1751.

Thanks to the semantic annotation work carried out earlier, a semantic layer was added to relate the props modelled in the stories to the historical sources. This step ensures a higher level of consistency in the generation of dialogues with the characters in the stories. By clicking on a node of type ‘Scene’, it is possible to display all the information related to it, and it is also possible to activate a conversational agent to ‘execute’ the scene, using an LLM to generate dialogues between two or more characters involved in the scene, again using semantic RAG techniques to avoid fake news. Figure 8 shows an example of dialogues generated between the characters “Luigi Vanvitelli”, “Carlo III di Borbone” and “Maria Amalia di Sassonia”, during the second presentation of the designs of the royal palace of Caserta, held at the Palace of Portici, at the time the residence of the sovereigns.



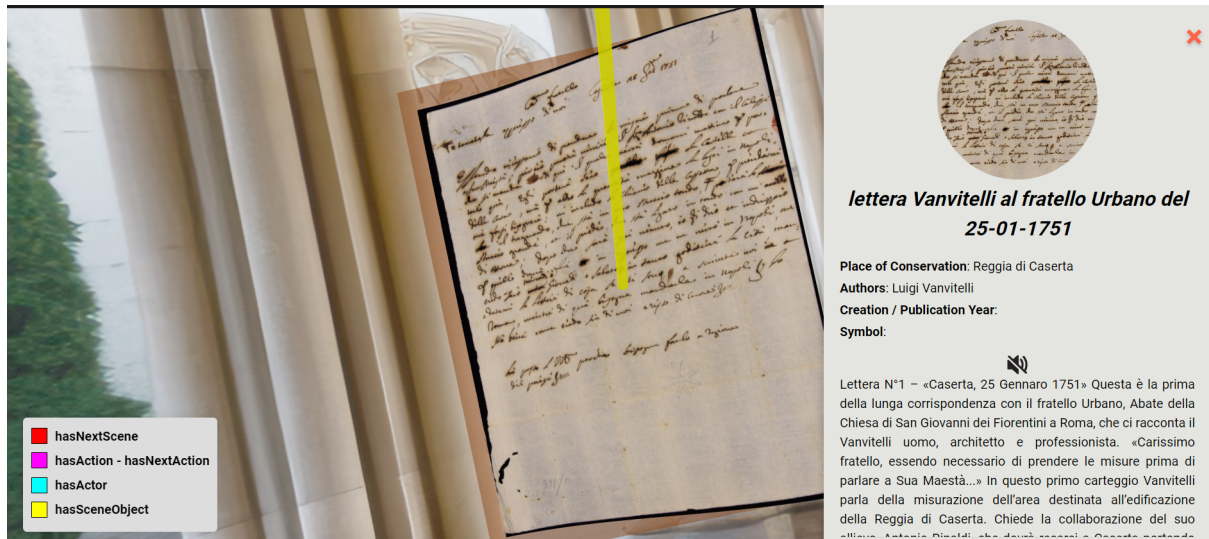


Figure 7: Story View - Example of Scene Object

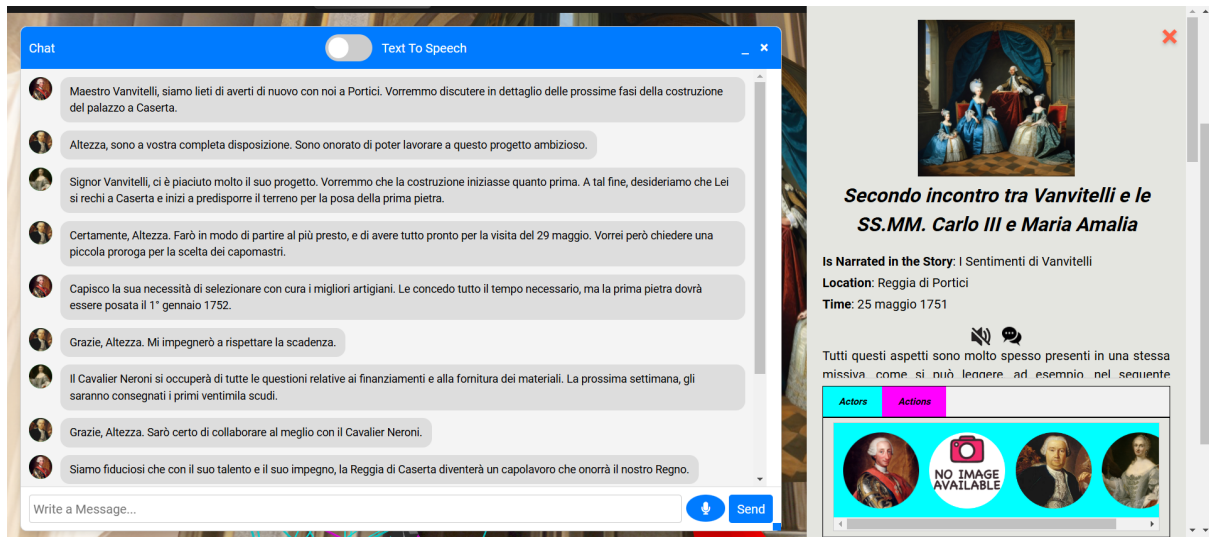


Figure 8: Example of dialogues generated between the characters “Luigi Vanvitelli”, “Carlo III di Borbone” and “Maria Amalia di Sassonia”

In addition, the tool provides the user with the possibility to intrude at any point in the conversation in real time, in such a way as to actively participate in the narrative, asking questions or even making suggestions to the characters.

### 5.3. Interactive Conversational Avatars View

From each specific scene of the Story View it is possible to activate this visualisation, which consists of a Virtual 3D Mode reproduction of the scene: the scene comes to life, showing all the characters involved in it within the location. The characters interact with each other through dialogues generated by the LLM, but the user can also here at any time insert himself into the conversation by asking general remarks or a specific question to one or more characters in the scene. The conversation that is generated is not a static asset but is a dynamic conversation generated in real time by combining the linguistic generative capacity of LLMs used to convey coherent and reliable content derived from the knowledge base containing context, scene and storytelling elements. An example of a reproduction of



the "Presentation of the designs of the royal palace of Caserta" scene is shown in Figure 9.



**Figure 9:** Interactive Conversational Avatars View

#### 5.4. Augmented Reality Scenario

The functionality offered by "StoryHub" can also be used through an Augmented Reality scenario. By framing the surrounding area with the camera of their person device (smartphone, tablet, etc.) the user will see the 3D avatar of the historical character appear. The user has the possibility of manipulating the avatar by means of gestures: for example, he can resize it, rotate it, turn it upside down and even attach it to a flat surface such as a table or the floor. Once the character has been arranged, the user has the possibility of initiating a conversation with it: by clicking three times consecutively on the avatar, audio acquisition is activated, and another three clicks stop the acquisition. The acquired audio is encoded into text by a "Speech to Text" module, and the text is used as the input prompt of an LLM (Large Language Model), in whose instructions it is specified to respond by simulating the character's historical knowledge and dialectical ability. LLM Gemini version 1.5 was used. The response returned by the LLM is encoded in audio via a special "Text to Speech" module. Figure 10 shows the historical character Pliny the Elder, with whom one can interact.

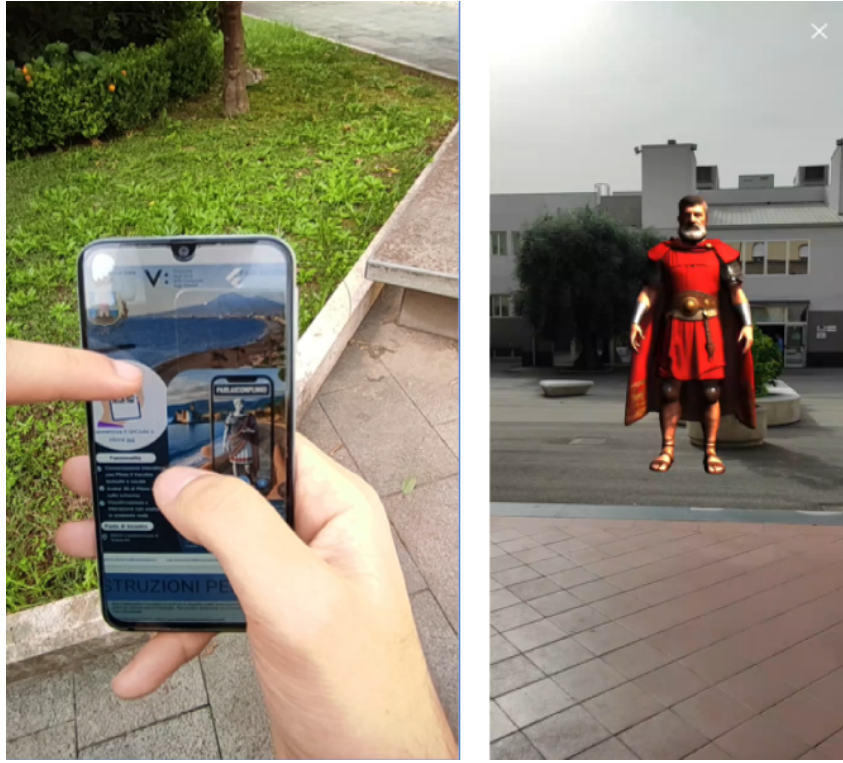
#### 5.5. Preliminary evaluation

For a preliminary evaluation, a pilot experimental protocol was set up to collect measurable metrics and structured feedback. Table 1 shows the indicators that were considered for an initial quantitative evaluation. During the exploratory pilot, 15 non-expert users (high school and university students) and 10 experts (historians) were involved.

In addition, qualitative insights were gathered through semi-structured interviews, which revealed:

- **Perceived educational value:** users and historians identified consistency of sources as a distinguishing feature.
- **Graph navigation:** intuitive for both experts and general users.
- **Immersion:** AR/VR mode was perceived as immersive (average presence score 5.8 out of 7), with positive feedback on realism and clarity of interactions.

These preliminary results indicate a good balance between usability, consistency and immersion. In the next phases we plan to plan a study with a larger sample ( $\geq 50$  users) with a group variance analysis



**Figure 10:** Augmented Reality View Example

**Table 1**

Preliminary Evaluation Metrics for the StoryHub Platform

Indicator	Description	Value / Scale
Story Graph Usability (SUS)	Average usability score for navigating and interacting with the semantic graph, based on the System Usability Scale.	75 / 100
Avatar Response Coherence	Degree of consistency and factual accuracy of avatar responses as judged by domain experts.	4.2 / 5
Average Response Time	Mean latency in avatar dialogue response generation using LLM with semantic grounding.	350 ms
User Interaction Frequency	Average number of user-initiated interactions (questions or inputs) per session.	6 interactions / session
Source Traceability Rate	Percentage of avatar responses that include explicit citation or traceable source data.	80% / 100%
Immersion Level (AR/VR)	Self-reported user perception of immersion during AR/VR experiences (Likert scale).	5.8 / 7

and we will perform quantitative analysis with metrics such as task completion rate, retention/return rate (AR/VR) and clickstream analysis.

## 6. Conclusions and Future Works

StoryHub demonstrated how advanced generative artificial intelligence technologies, semantic knowledge representation and augmented/virtual reality can be integrated to transform narrative content into interactive and immersive digital experiences. The proposed approach creates a bridge between historical fiction and new forms of digital enjoyment, allowing users not only to explore stories and characters through semantic graphs and conversational avatars, but also to interact with them in real time, in a coherent and historically grounded context. The system is based on principles of transparency,

interoperability and reusability of data, proposing a model that can also be replicated in other application areas, such as museums, publishing, education and cultural tourism. The synergy between automatic extraction, human validation and conversational generation makes it possible to maintain a balance between automation and content accuracy, while respecting the criteria of reliability and traceability inherent to the ethos of Big Data and reliable Artificial Intelligence. Future developments of the project will focus on several directions. First, it is planned to extend the HistoricO ontology to other cultural and temporal contexts, in order to enrich the knowledge base and increase the variety of accessible narratives. Secondly, customisation techniques of the narrative experience based on the user profile will be explored to make the interaction even more engaging and adaptive. Finally, the explainability and auditing capabilities of LLM responses will be enhanced by integrating feedback and verification modules that actively involve the user in the information validation process. It is important to emphasise that the modular and data-driven structure of the platform was conceived in order to be able to evolve towards contexts in which the narrative and interaction do not only concern historical content, but also relevant phenomena in the technical-scientific field. It would be interesting to experiment in the future with the methodology underlying the proposed platform by applying it to contexts other than the enhancement of the historical-cultural heritage, such as purely technical fields such as the monitoring and detection of cloud patterns.

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## Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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