ALIGHIERoo: Advanced Literary and Iconographic Graph for Hermeneutics of Interconnected Editions and Resources - Object Oriented⋆

Domenico Cantone, Marianna Nicolosi-Asmundo and Stefano Angelo Rizzo⋆⋆

Dept. of Mathematics and Computer Science, University of Catania, Italy

Abstract

This paper introduces **ALIGHIERoo** (Advanced Literary and Iconographic Graph for Hermeneutics of Interconnected Editions and Resources – object-oriented), an ontological framework currently under development within the *Naples Dante Project*. Drawing upon CIDOC CRM and LRMoo, ALIGHIERoo focuses on the representation of intricate textual and iconographic elements within Dante's *Commedia*, though it aims for a high level of scalability. By prioritizing semantic granularity and inferential reasoning, ALIGHIERoo is envisioned as a versatile and expandable framework for digital philology and heritage studies. The project constitutes a structured proposal for future refinement and collaborative validation.

Keywords

Dante, OWL ontology, Naples Dante Project, Philology

1. Introduction

The **Naples Dante Project (NDP)** [1] is a research initiative focused on developing an online aggregator of databases related to Dante Alighieri's *Commedia*, covering both manuscript and early printed editions, with particular attention to illustrated content. The project, directed by Gennaro Ferrante (University of Naples, Italy), is organized around two primary research domains: text and image.
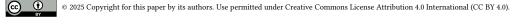
In literary scholarship, ontological models based on the **Web Ontology Language (OWL)** play a crucial role in formalizing complex relationships among entities. OWL supports semantic interoperability and richer data integration, which is especially important when addressing intricate textual traditions. In such contexts, diverse manuscript witnesses, editorial interventions, and iconographic programs interact across time and media, requiring a framework capable of expressing layered, cross-referential connections.

Within this ecosystem, the **CIDOC Conceptual Reference Model (CIDOC CRM)** provides a flexible and extensible framework for modeling cultural heritage data, capturing the interplay between text, image, manuscript, and print, while allowing nuanced scholarly distinctions.

A central component of our model is **LRMoo**, an extension that integrates the *IFLA Library Reference Model (LRM)* into CIDOC CRM. LRMoo succeeds and refines earlier standards like *FRBR* and *FRBRoo*, offering an updated framework for modeling bibliographic entities and their interrelations. In our proposal, LRMoo is embraced to fully represent the multiple textual layers of the *Commedia*.

The **ALIGHIERoo** ontology (short for *Advanced Literary* and *Iconographic Graph* for *Hermeneutics* of *Interconnected Editions* and *Resources - Object Oriented*), built on this foundation, serves to represent and analyze Dante's corpus and offers a reusable framework for illuminated works more broadly. It leverages OWL to encode semantic richness and employs the structural logic of CIDOC CRM and LRMoo to represent both textual and visual elements of the tradition. Still under development, ALIGHIERoo shows

✉ domenico.cantone@unict.it (D. Cantone); marianna.nicolosiasmundo@unict.it (M. Nicolosi-Asmundo); Stefano.Angelo.Rizzo@gmail.com (S. A. Rizzo)

🆔 0000-0002-1306-1166 (D. Cantone); 0000-0003-4456-5110 (M. Nicolosi-Asmundo); 0009-0005-7160-616X (S. A. Rizzo)

promise as an adaptable model, offering both domain-specific insights and generalizable strategies for digital humanities research.

The ontology not only incorporates the foundational distinctions of LRMoo—such as the layered segmentation into *Work*, *Expression*, *Manifestation*, and *Item*—but also extends them through domain-specific inferences.

2. Related Works

The fundamental inspirations for encoding the elements of ALIGHIERoo originate from ongoing and completed initiatives within the **Naples Dante Project (NDP)**, particularly the **Illuminated Dante Project (IDP)** [2, 3], from the OWL ontology **OntoComedySources** [4], describing literary and iconographic sources of the *Commedia*, and from persistent modeling efforts of experts. A crucial component of the NDP framework is **CADMUS** [5], developed by Daniele Fusi. It provides a modular architecture for building structured content editors for digital humanities projects; in particular, the *Cadmus-Codicology* module organizes manuscript information.

Regarding OWL-specific components, ALIGHIERoo utilizes previously established ontological frameworks. Among these, **MeMO (Medieval Manuscript Ontology)** [6] stands as a foundational model for manuscript encoding, representing a milestone in the application of ontologies to the study of medieval manuscripts. Originally designed in the context of FRBR/FRBRoo, MeMO has contributed significantly to the conceptualization of manuscript description through ontological structures. The later transition of FRBRoo-based models to LRMoo, exemplified by **IMAGO (Index Medii Aevi Geographiae Operum)** [7], has resulted in a higher level of ontological detail. This evolution is also embraced in ALIGHIERoo, which leverages these advancements while ensuring compatibility with previous models, thereby guaranteeing both continuity and enhancement in the depiction of manuscript and textual traditions.

ALIGHIERoo is conceived within this framework as an innovative tool for Dante studies. By merging the semantic capabilities of OWL with the structural coherence of CIDOC CRM, ALIGHIERoo aims to provide a comprehensive and interconnected representation of the *Commedia*'s textual and iconographic traditions. This approach enhances scholarly research on Dante and establishes a scalable model for the examination of other literary corpora, supporting the broader advancement of digital humanities research.

3. ALIGHIERoo Ontology: Structure and Innovations

The current version (1.3) includes 68 classes, 10 object properties, and 123 individuals, totaling 151 classes and 370 object properties when integrated with CIDOC's framework. Its design supports the structured classification of manuscripts, early printed editions, scholarly works, and the extensive iconographic apparatus surrounding them.

At its core, CIDOC CRM organizes knowledge around six primary branches deriving from the overarching class E1 CRM Entity: *Dimension*, *Persistent Item*, *Place*, *Spacetime Volume*, *Temporal Entity*, and *Time-Span*. These categories enable the modeling of physical, temporal, spatial, and conceptual relationships across cultural heritage domains. The framework is *event-centric*, structuring data around *events* connecting people and objects (*persistent items*), *places*, and *times*. This design facilitates the depiction of dynamic processes, including production, transmission, and interpretation, which are particularly significant in the analysis of intricate textual traditions.

ALIGHIERoo adapts and extends this structure to the specific needs of Dante studies. It introduces enhancements for domain-specific scenarios such as illuminated traditions, miscellaneous manuscripts, and fictive topographies. The result is a model that maintains interoperability with CIDOC-compliant ontologies while providing the specificity required for fine-grained reasoning.

3.1. Dimension

In E54 Dimension, a new dimension, header_length, represents the number of bytes used for the header of a packet or digital document. This may enable automated agents to detect scans falling below quality standards or to measure data loss over digital preservation processes. Tracking degradation is crucial for preserving the integrity of digitized materials, especially in long-term archival projects.

ALIGHIERoo adopts the same dimension-recording methodology as **EpiOnt** [8], ensuring model compatibility. A new class, Object_Length, incorporates the primary dimensions of three-dimensional objects: x (width/length), y (height), and z (thickness/depth). Additionally, two measurements have been devised for epigraphs and fragmented objects, suitable for manuscript fragments:

- MaxDimension defines the maximum value for a dimension when measurements are uncertain, corresponding to the smallest square filling the fragment or epigraph, including reconstructed parts.
- MinDimension defines the minimum value for a dimension under uncertainty, corresponding to the broadest square inscribed within the remaining parts of a fragment or epigraph.

These concepts enhance precision in representing fragmented textual materials, supporting a more flexible and rigorous approach to manuscript and epigraphic studies. The methodology aligns with CADMUS, strengthening its applicability within scholarly frameworks.

3.2. Person

We turn to the Persistent Items class. Within the Person subclass, ALIGHIERoo expands the range of recognized agents to trace the complex transmission and reception of textual works. These key actors, defined through projects such as the IDP and IMAGO, document the intellectual, material, and cultural transformations of manuscripts and printed works. The newly introduced agent classes are listed in Table 1.

Role	Description
Annotator	Adds explanatory or interpretative notes to a text, typically in the margins
Author	The original intellectual creator of a work
Commentator	Provides systematic interpretation or analysis of a text
Concepteur	Conceptual architect of a project or structure
Copyist	Manually transcribes texts, potentially introducing variations
Curator	Oversees preservation and scholarly interpretation of manuscripts or prints
Dedicatee	Recipient of the dedication of a work
Holder	Holds or held a manuscript or printed item
Illustrator	Creates visual elements that accompany a text
Patron	Commissions or supports the production of a work
Publisher	Responsible for reproduction and dissemination of a work
Restorer	Repairs or conserves textual artifacts
Scholar	Conducts critical and historical analysis of texts
Stationer	Supplies or sells writing materials and books
Translator	Renders a text into another language
Typographer	Designs and arranges printed type

Table 1: Agent roles introduced in ALIGHIERoo

These roles enable a more precise representation of the networks of intellectual, artistic, and material agents involved in the production, transmission, and reception of textual works. By distinguishing these figures, ALIGHIERoo refines the model to support scholarly inquiry in philology, book history, and manuscript studies.

3.3. Thing

The Person subclass refers to real individuals; fictional characters are not accommodated within this CIDOC category. ALIGHIERoo reintroduces a Character class to represent personas depicted in textual works, ensuring a structured representation of characters. Within the broader CIDOC CRM ecosystem, an equivalent class has been assigned to CRMsoc, the extension dedicated to modeling social constructs and interactions. While *CRMsoc* is still in development, integrating such a class in ALIGHIERoo guarantees future interoperability without relying on external modules.

Additionally, two types of CIDOC's E89 Propositional Objects are introduced: Iconographic_Action and Scene_Macro_Area. The former serves to describe highly specific, non-generic actions within a visual or textual context, while the latter, subdivided into Typical_Scene, enables the grouping and classification of visual elements such as miniatures or drawings: these items are defined with the CIDOC class E36 Visual Item. The individuals of Scene_Macro_Area have been arbitrarily determined by the *NDP* team, serving as broad conceptual categories into which multiple Typical_Scenes can be grouped. While the former provides a stable set of reference points, the number of Typical_Scenes remains theoretically infinite, reflecting the variability of artistic representation. Crucially, the combination of unique scene elements facilitates both inferential classification and content-based retrieval. Each miniature or picture can be seen as a Visual Item formed by a *background* (Fictional_Place), *protagonist characters* (Character), and *distinctive actions* (Iconographic_Action). Analyzing these components allows the reasoner to identify the subject of an illustration. For example, an image featuring Dante and the usurers likely refers to *Inferno, Canto XVII,* not merely due to Dante's constant presence, but to the distinct presence of the *usurers*.

However, iconographic references are rarely univocal. It is not uncommon to find illustrations that merge elements from different cantos, such as a depiction of the *Selva Oscura*, the dark forest before Hell's Gates, featuring Minos, the judge of Hell, found much later in the poem. Such variations arise from stylistic choices, illustrative constraints, established conventions, or artist misinterpretations. Leveraging SPARQL queries, the ontology determines whether illustrations adhere to canonical correspondences or incorporate references to other passages, enhancing interpretative scholarship and digital humanities methodologies. Such mix-ups justify focusing on unique elements rather than broader, omnipresent ones.

3.3.1. Work, Expression, Manifestation, Item

A core feature of LRMoo and its predecessors, FRBR and FRBRoo, is the structured division of *propositional* and *information objects* into four fundamental levels. Such hierarchical distinction allows for a precise representation of textual and non-textual heritage, ranging from abstract concepts to their physical instantiations:

- F1 Work - conceptual essence of a creation, independent of any realization; encapsulates intellectual or artistic content.
- F2 Expression - specific realization of an F1, capturing the multiple particular[1] textual forms that define an intellectual variant of the content.
- F3 Manifestation - a concretized form of one or more F2; it encompasses the medium with no reference to a tangible object. This level is crucial as it distinguishes between different editorial states.
- F5 Item - discrete material instantiation of an F3, reflecting unique physical characteristics and provenance.

Building on this structure, ALIGHIERoo introduces the following subclasses:
For Expression

---

[1]As CIDOC specifies, every variation due to errors in copying or more purposeful editorial choices constitutes a new instance of F2.

- Main Text - core intellectual production of the author, subdivided into:
  - Author Draft, preliminary writing stages, possibly including corrections, marginalia, or incomplete sections;
  - Author Final Draft, the ultimate version of a text completed or approved by the author.

  Such distinction arose from discussions within the NDP team comparing Dante and Petrarca: the *Commedia* lacks a surviving autograph, requiring reconstruction from multiple witnesses, while Petrarca documented multiple drafts. This differentiation provides a nuanced approach to textual stratification, reflecting both authorial intent and textual transmission.
- Paratext - includes supplementary textual materials that accompany, contextualize, or elucidate the main text, made by the author of the *main text* or by other agents. Rather than separating into distinct classes, the class groups textual elements such as *glosses*, *annotations*, *ownership notes*, *rubrics*, *introductions*, and *appendices*. These diverse components are viewed as interpretative or contextual layers, "ancillary texts" enhancing the comprehension, dissemination, or application of the main work. Future distinctions are possible, but the current version embraces a unified approach for clarity and adaptability.

For Manifestation

- Critical Edition - editions produced with scholarly intervention, combining a base text with paratexts (apparatus, commentary, annotations) synthesized from multiple witnesses;
- Manuscript Edition, hand-copied textual witnesses, varying in accuracy, scribal fidelity, or decoration;
- Hand Printed Book, early printed versions (before circa 1830), including incunabula and other typographic products retaining manuscript traits.

An additional subclass is presented as a peculiar instance of manuscripts: Miscellaneous_Manuscript. These manuscripts are repositories of multiple F1 Works and their corresponding F2 Expressions. This category is crucial for studying medieval and early modern textual transmission, offering insights into reading practices, intellectual networks, and the circulation of works.

3.3.2. Design or Procedure

In Design or Procedure, two key additions have been introduced: Book_Decor_Style and Book_Decor_Technique. These subclasses capture the stylistic and methodological aspects of decoration in manuscripts and printed editions. Avoiding rigid distinctions between manuscript and print traditions, the framework is able to describe even modern decorative elements that reference or revive historical styles and techniques.

The individuals populating the ontology reflect distinctions aligned with the classification criteria established in the *Illuminated Dante Project*, which are integral to the broader project and will be maintained or refined elsewhere. This ensures consistency across ontological components and supports detailed annotation of artistic and technical features across historical periods.

3.3.3. Type

The Type class in CIDOC CRM serves as the most general categorization mechanism across domains, as it strategically enables classification without rigid constraints, allowing flexible attribution of types to objects, events, and concepts alike.

Within ALIGHIERoo, the class Book_Decoration_Type encompasses various forms of book ornamentation, as presented in Table 2. Each subclass targets specific individuals representing decorative elements, ensuring a structured and expandable framework. Although established primarily for Dante-related case studies, Book_Decoration_Type remains open to refinements and additions.

Beyond book decoration, additional type-based classes have been introduced in Table 3.

These expansions ensure that ALIGHIERoo can accurately classify and differentiate textual and decorative elements, supporting a more precise analysis of historical manuscripts and printed materials.

Subcategory	Description
Cover Decor Type	Decorated book covers.
Diagram	Schematic and structured graphical elements.
Illustration	Independent pictorial compositions (printed or hand-made miniatures).
ImageDecor (W.I.P.)	Marginal mnemonic or paratextual cues (e.g., figurative catchwords).
InitialLetter	Decorated initials.
Ornamentation	Established types of decoration (e.g., Tabula Ansata, Coat of Arms), including the subclass *Frieze* for linear or border decorations.

Table 2: Subcategories of Book_Decoration_Type in ALIGHIERoo

Subclass	Description
Quire Type	Structural categorization of folios in manuscripts and early printed copies.
Metrical Form	Poetic meter of a text, crucial for analyzing verse structures.
Textual Section Type	Distinct textual components like colophons, dedications, and other defined segments.

Table 3: Further Subcategories of Type in ALIGHIERoo

3.4. Place

In ALIGHIERoo, the Place class follows *CIDOC CRM*'s distinction, representing only real-world locations. To accommodate fictional settings -essential for literary studies- a separate *Fictional_Place* class was introduced. For real places, ALIGHIERoo expands the ontology with three subclasses: City, Region, and Nation. A Nation can encompass Regions, and a Region can contain Cities, all linked through the standard relation P10_falls_within. This approach facilitates SPARQL queries retrieving historical and administrative data relevant to manuscript provenance and textual transmission, ensuring compatibility while supporting spatial analyses of physical and narrative geographies.

4. Relationships

Given the extensive relationships in CIDOC CRM, only a few new properties were introduced in ALIGHIERoo to enhance the modeling of narrative and visual content. These relationships align with the ontology's class structure and integrate literary, artistic, and material aspects of textual heritage.

- has_action (Typical_Scene → Iconographic_Action): connects a scene to a specific, non-generic action depicted within it.
- has_background (Typical_Scene → Fictional_Place): specifies the setting or location within which the scene takes place, distinguishing real and imaginary environments.
- has_character (Typical_Scene → F38_Character): links a scene to the characters it portrays. The inverse property, *participates*, associates a character with the scene in which they appear.
- has_dedicatee (Human-Made Thing → Actor): captures the act of dedication, such as in manuscripts, printed works, or artistic creations. The inverse, is_dedicated_to, expresses the recipient's role in this relationship.
- has_fictional_counterpart (Actor → F38_Character): due to CIDOC CRM's division between non- and real entities, this property models cases where a historical figure also exists as a fictional character, such as *Dante the Author* versus *Dante the Character*. More broadly, it applies to real figures appearing in literary works with altered or symbolic identities, as in *The Divine Comedy*.

5. Reasoning capacities

5.1. Visual Items

The ALIGHIERoo ontology employs an inferential engine to analyze and classify scenes and textual elements in Dante's works. This approach aligns with methodologies like VideOWL [9], which models game environments by focusing on core features rather than predefined categories. Similarly,

ALIGHIERoo prioritizes the relationships that take place in *Visual Element*s throughout Commedia among fundamental elements: characters, actions, and settings. This enables a structured yet flexible framework, as *Visual Items* are linked to text portions and specific editions, consistent with CIDOC principles.

Our inferential system relies on specific classes to formalize this process. Typical_Scene serves as a container for visual and textual representations, linking them to their essential components. Each Typical_Scene may be characterized by one or more:

- Iconographic_Action, capturing distinct actions within the scene (e.g., "*Virgil gestures toward the city of Dis*" or "*Dante faints*");
- F38_Character, identifying key figures, distinguishing real from their fictional counterparts via has_fictional_counterpart;
- Fictional_Place, classifying the setting into *Earthly-*, *Infernal-*, *Purgatorial-* and *Heavenly_Place*;
- Scene_Macro_Area, grouping Typical_Scene instances into broad inferential categories for pattern recognition and high-level reasoning.

For instance, an illustration of Dante among the usurers in *Inferno XVII* is identified not just by the protagonist's presence (constant throughout the work) but by unique F38_Character instances (e.g., *Reginaldo Scrovegni*) and the distinct Infernal_Place (the *sandpit*).

The system also accommodates artistic and interpretative variations, as manuscript illuminations often combine elements from different cantos due to stylistic choices, constraints, or illustrator misunderstandings. For example, a depiction of the *Selva Oscura* (the dark forest of *Inferno I*) might include *Minos*, canonically appearing at the threshold of Hell later in *Canto V*. The Scene_Macro_Area classification mechanism detects such atypical combinations, enabling queries on adherence to the textual sequence or the introduction of other elements.

A crucial component of this system is the use of E41 Appellation to match text segments (F2 expressions with their corresponding E33 Linguistic Object) with their corresponding Canto. By associating each Canto with an Appellation instance, such as "*Inferno Canto V*", the ontology ensures that all textual entities are properly grouped according to CIDOC conventions. This parallels *VideOWL*, where stable appellations unify distinct but related elements in video game environments under a common reference.

Through these structured relationships, ALIGHIERoo offers a robust mechanism for analyzing Dante's works and more, demonstrating the power of ontological modeling in the humanities.

5.2. Granular Inference Rules

The high granularity of ALIGHIERoo enables multiple inference rules supporting classification, review processes, and reasoning across works and materials. By leveraging structured relationships and constraints, the ontology enables automated deductions, streamlining research and analysis.

A straightforward example involves the material properties of manuscript illuminations: if a miniature is colored gold, the corresponding manuscript[2] necessarily contains actual gold, as historically the color could not be replicated synthetically.

A more articulated inferential mechanism addresses the identification of miscellaneous manuscripts, allowing one to grasp a key distinction: a single-work manuscript contains a unified textual expression, whereas a miscellaneous manuscript compiles multiple independent works. When a Manuscript_Edition[3] embodies F2 Expressions distinct kinds of F1 Work, the new specialized property perpetuatesWork semantically links the manuscript to its associated multiple works. This is inferred through the property chain R4_embodies ∘ R3i_realises, able to bridge the F3/F2/F1 layers.

Applied at scale, these mechanisms enable more precise analysis of historical artifacts, assisting researchers in identifying and categorizing complex manuscripts and tracing text-image patterns. By embedding these reasoning capabilities into the ontology, ALIGHIERoo provides an advanced framework for studying medieval texts and their transmission.

---

[2]Linked via the relationship *has_decoration_type* to the class *Book_Decoration_Type*.
[3]As mentioned, a subclass of F3 Manifestation.

6. Conclusions and future work

Although it is still a work in progress, ALIGHIERoo shows considerable promise in organizing and enhancing the analysis of textual works, particularly manuscripts and early print traditions. By integrating CIDOC CRM and LRMoo, it ensures compatibility with established standards, while new classes and properties broaden its applicability to complex textual and visual phenomena. These additions are a key strength of the ontology's approach to such elements, heavily shaped by the contributions of the NDP. Consequently, ALIGHIERoo extends beyond being a simple augmentation of LRMoo, evolving into a valuable resource for the semantic analysis of manuscript illumination, decorative styles, and text-image connections.

As development continues, further refinements will strengthen the ontology's capacity to facilitate in-depth research in textual heritage. The foundational work provides a robust basis for future developments, offering a model adaptable to evolving scholarly demands in exploring historical texts and material culture.

Declaration on Generative AI

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

References

[1] G. Ferrante, F. Autiero, et al., *Naples Dante Project website*, https://www.dante.unina.it, 2023. Last accessed: 29-04-2025.

[2] G. Ferrante, *"Illuminated Dante Project". Per un archivio digitale delle più antiche illustrazioni della "Commedia". I. Un "case study" quattrocentesco (mss. Italien 74, Riccardiano 1004 e Guarneriano 200)*, in: M. Ciccuto, L. M. G. Livraghi (Eds.), Dante visualizzato. Carte ridenti, II. XV secolo. Prima parte, Cesati, Firenze, 2019, pp. 229–255.

[3] F. Autiero, G. Ferrante, S. Gorla, S. Picarelli, *Dante e Petrarca allo (stesso) scrittoio. Per lo sviluppo di un'ontologia di IDP a partire dall'istanza manoscritti di "Itinera"*, in: F. Ciracì, G. Miglietta, C. Gatto (Eds.), Proceedings from AIUCD 2022 - Culture digitali, Lecce, Italy, 2022, pp. 171–196.

[4] A. De Domenico, D. Cantone, M. Nicolosi-Asmundo, *An ontology for the iconographic sources of La Divina Commedia*, in: F. Calimeri, S. Perri, E. Zumpano (Eds.), Proceedings of the 35th Italian Conference on Computational Logic - CILC 2020, volume 2710, 2020, pp. 157–168.

[5] D. Fusi, *CADMUS Documentation*, https://vedph.github.io/cadmus-doc/, 2023. Last accessed: 29 April 2025.

[6] S. Barzaghi, M. Palmirani, S. Peroni, *Development of an ontology for modelling medieval manuscripts: the case of Progetto IRNERIO*, Umanistica Digitale 4 (2020) 117–140. URL: https://umanisticadigitale.unibo.it/article/view/11187. doi:10.6092/ISSN.2532-8816/11187.

[7] V. Bartalesi Lenzi, N. Pratelli, *The IMAGO project: towards a knowledge base of medieval and renaissance geographical works*, Proceedings of the International Joint Workshop on Semantic Web and Ontology Design for Cultural Heritage co-located with the Bolzano Summer of Knowledge 2021 (BOSK 2021) 2949 (2021).

[8] D. Cantone, S. Cristofaro, M. Nicolosi-Asmundo, F. Prado, D. F. Santamaria, D. Spampinato, *An EPIDOC ontological perspective: The epigraphs of the Castello Ursino Civic museum of Catania via CIDOC CRM*, Archeologia e Calcolatori 30 (2019) 139–157. doi:10.19282/ac.30.2019.10.

[9] S. De Martino, M. Nicolosi-Asmundo, S. A. Rizzo, D. F. Santamaria, *Modeling the Video Game Environment: the VideOWL Ontology*, in: R. Falcone, C. Castelfranchi, A. Sapienza, F. Cantucci (Eds.), Proceedings of the 24th Workshop From Objects to Agents (WOA 2023), volume 3579 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2023, pp. 191–205. URL: https://ceur-ws.org/Vol-3579/paper15.pdf.