The POSTDATA network of Ontologies for European Poetry.

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Abstract.

One of the lines of work in Digital Humanities is concerned with standardization processes to describe traditional concepts using computer-readable languages. In regard to Literary studies, poetry is a particularly complex domain due to, among other aspects, the special use of language that it implies. This paper presents a network of ontologies for capturing the poetry domain knowledge. The most significative ontologies are presented. These ontologies are related to the poetic work, and its structural and prosodic components. A date ontology that represents the especial needs of literary works is presented as well. This work is part of the results of the POSTDATA ERC (Poetry Standardization and Linked Open Data) project, which aims to provide a means for poetry researchers to publish their semantically enriched data as Linked Open Data (LOD), in the context of European poetry.

Keywords: European Poetry, Standardization, Network of Ontologies, Interoperability, Linked Open Data

1. Introduction

The need for standardization has increased significantly in different research fields as a standard way of understanding and exchanging information. Many scientific disciplines have established formal protocols and languages, which have been quickly adopted and adapted to their particular problems. Some humanities and cultural disciplines have followed, however, an independent path in which creativity and tradition play an essential role. Literature, and especially poetry, is a clear reflection of this idiosyncrasy.

From the philological point of view, there is no uniform academic approach to analyze, classify or study the different poetic manifestations, and the divergence of theories is even bigger when comparing poetry schools from different languages and periods. One of the most significant conceptual and terminological problems is that, even when a set of poetic works is formalized under a repertoire, each repertoire belongs to its poetical tradition, and each tradition has independently developed its analytical terminology, for centuries, in some cases [1]. The result of this uncoordinated evolution is a great variety of terminologies to explain similar metrical phenomena through the different poetic systems whose correspondences have been hardly studied. For example, the same quatrain of dodecasyllables can be encoded in different ways depending on the philological tradition:

(i.e. 12A12A12A12A or 4x(7pp+7p) or 4aaaa)

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or even named with a different meaning: "alexandrine" means a 14-syllable line in Spanish but only 12-syllables in French [2].

As a result, if a researcher were to look for quatrains of dodecasyllables in different traditions, it would be necessary to visit each database independently and then carry out different searches adapting the query to the conventions of the resources.

There is one additional drawback: research in this field is usually conducted in an individual and isolated manner, and there is a certain lack of communication with other areas of knowledge.

There are also significant technical issues, as these repertoires were created in different periods, and stand-alone collected databases drive most of them [3–8]. Interoperability among all these collections would be useful to perform comparative studies and to move a step forward beyond the modern philological state-of-the-art, to explain phenomena like the origins of vernacular poetry or the evolution from accentual to syllabic rhythmical patterns.

Although the current technical infrastructures are prepared to harvest such collections and provide access to them by a search engine, it is necessary to standardize metadata and vocabularies at a philological level to be able to climb up the semantic layer and link data between different traditions [9–11]

In this context, the use of technologies applied to poetry is ground-breaking, as this way of representing distributed literary collections as machine-readable repositories will open the door to pose new research questions and to perform comparative philological analysis between heterogeneous poetic corpora with different formats.

All these difficulties and problems of access to poetic resources and, in short, to the impossibility of having ways of processing this information in a completely and efficiently have been the origin and incentive for the conception of a poetry ontology network , [9,12].

For this purpose, we have extracted from a set of repertoires of different poetic traditions and periods, [13,14], the concepts and relationships necessary to achieve the representation of a universal and complete poetry domain. From this study, we have identified areas of knowledge that are complementary to the central core of poetry knowledge. We have modeled each of these areas as complementary ontologies. The result of the whole process has led us to the development of a network of ontologies for European poetry.

This paper presents the methodology carried out to build a network of ontologies for covering the poetry domain knowledge and the most significant ontologies of this domain. This work is part of the results of the POSTDATA ERC (Poetry Standardization and Linked Open Data) project, which aims to provide a means for poetry researchers to publish their semantically enriched data as Linked Open Data (LOD), in the context of European poetry.

The document is structured as follows. In section §2, we present some previous results related to ontologies in literature, especially in the domain of poetry. Section §3 presents a description of the methodology used for the ontological development. Section §4 presents a detailed description of the most relevant ontologies developed. Finally, §5 outlines the conclusions and future work.

2. Related works

The progressive transformation of Humanities into "Digital Humanities," is accompanied by the creation of new standards, such as the Text Encoding Initiative TEI-XML[1], Dublin Core[2] or CIDOC-CRM[3], among others, to describe traditional concepts with computer-readable languages. These systems are developing fast in several areas, such as digital text editions, libraries, or archives, and it exits a significant number of projects working with them as TexGrid[4], OpenEdition[5] or Scholar Digital Editions (SDE)[6].

Although semantic web technologies have had great success in archives, libraries and museums (group known as LODLAM[7]), however, the application of these technologies to poetry is still limited, [15,16], and there is not a conceptual model of ontology referred to metrics and poetry yet.

The first attempt to build a poetry ontology can be found in the ReMetca project [5] that defined a conceptual model for poetry and participated in the definition of TEI-Verse module. However, it is necessary to expand and complete it to reflect the different possibilities of poetic properties and relationships. The

[1] https://tei-c.org/

[2] https://www.dublincore.org/specifications/dublin-core/

[3] http://www.cidoc-crm.org/

[4] https://textgrid.de/

[5] https://www.openedition.org/

[6] http://www.sd-editions.com/

[7] http://lodlam.net/

next closest works related to this topic are probably CIDOC CRM, Conceptual Reference Model (CIDOC-CRM)[8], an ontology that formally describes the concepts and relationships used to document cultural heritage. This model is more focused on the representation of museums' heritage works, although it contains concepts to the representation of entities such as people and places associated with the works. Other related ontologies are Functional Requirements of Bibliographic Records (FRBR)[9] and FRBRoo[10]. FRBR offers a perspective on the structure and relationships of bibliographic and authority records [17]. The most significant entities are Work, Expression, Manifestation, and Item, which represent the different ways of conceiving a literary work as a text or physical resource. FRBRoo is an object-oriented version of FRBR combined with the CIDOC-CRM model, thus harmonizing information from museums, archives, and libraries as information relating to cultural heritage entities. These ontologies can cover the descriptive aspects of the works and their forms of expression and manifestation, but it does not cover structural aspects, nor literary analysis nor prosody.

Another ontology aligned with FRBR is FaBiO[11] (FRBR-aligned Bibliographic Ontology) that is conceived for the description of entities that are published or that are potentially publishable.

All these ontologies focus on bibliographic aspects of the works but do not model information that may come from the analysis of textual features.

Another form of semantic enrichment of literary and poetic texts is the semantic annotation by means of markup languages. In this way, the texts are presented semantically enriched. Among the most important initiatives is the Text Encoding Initiative (TEI),which in addition to having mark-up modules of general features, has a verse module [18] with the necessary elements to annotate forms and structures of poetic works and it also plays an important role due to its widespread implementation [19–21].

The relationship between ontological models and TEI has been taken into consideration very seriously in the last years [22–24].

In regard to the analytical aspect of the works, we can find other ontologies; for example, the Lexicon Model for Ontologies (Lemon)[12] designed for modeling machine-readable dictionaries and lexicons. Lemon covers aspects of lexical decomposition, sentence structure, syntax, variation, morphology, and mapping of lexical ontology. The Gold[13] ontology is a complete ontology for descriptive linguistics and formally describes the most basic categories and relationships used in the scientific description of human language. It tries to solve the problems of linguistic data tagging. One of the important features of this ontology is that it is applicable to all languages. The Rhetorical Annotation Ontology Project (RAOP)[14], a specific domain ontology, is built for the annotation of speech figures and the rhetorical aspects of written and oral texts. Thus, it can be mapped to represent the structures of a rhetorical system. This project is one of the possible approaches that have been taken into account for the digitization of speech figures through the use of technologies associated with linked data and the semantic web. RAOP covers rhetorical aspects that are considered in the model that has been built in the POSTDATA project.

Beyond this analysis of well-known ontologies in the areas of Digital Humanities, we have also made a general search for ontologies that be relevant in usual ontology repositories, such as Linked Open Vocabularies[15], Open Metadata Registry[16], Basel Register of Thesauri Ontologies & Classifications [17].

From this review, it is shown the convenience to tackle the development of a new poetry ontology that includes all the entities and properties related to poetic works, although some concepts and relationships of the ontologies mentioned are perfectly reusable in this new ontology. Even more, we have proposed specializations or refinements to express more clearly the unique semantic features of the poetic works and their expressions.

3. Ontology development

For the development of the ontology we have considered four scenarios of the Neon methodology [25]: scenario 2 for reusing and re-engineering non-

[8] http://www.cidoc-crm.org/cidoc-crm

[9] http://purl.org/vocab/frbr/core#

[10] http://www.cidoc-crm.org/frbroo/home-0

[11] https://sparontologies.github.io/fabio/current/fabio.html

[12] https://www.lemon-model.net/index.php

[13] http://purl.org/linguistics/gold/

[14] http://bakulf.github.io/raop/

[15] https://lov.linkeddata.es/dataset/lov/

[16] http://metadataregistry.org

[17] http://www.bartoc.org/

ontological resources, scenario 3 that contemplates the reuse of ontological resources, scenario 4 for the reengineering of ontological resources, and scenario 7 for the reuse of ontological design patterns.

The first step for tackling this work was to build a conceptual domain model of European poetry, trying to have a precise picture of the domain. For this purpose, we analyzed a set of twenty-five repertories described in [26], most of them available on the web . These repertories were selected because they represent different poetry traditions, languages, prosodic systems, and cultures [27]. They are implemented using different tools and format, for example MySQL dumps, XSD and XML files, Perl scripts, and spreadsheets. We used a reverse engineering approach. Most of these repertories are the result of research projects and therefore contain information gathered or generated by experts. This property improves the reliability and robustness of information, categories, and structures.

The obtained model covers both the descriptive and bibliographic aspects of poetic works, including details about textual transmission, as well as aspects related to prosody, literary and rhetorical analysis, the structures identified in the poems, significant elements for publications, and its relationships with music, Figure 1. The result is a European Poetry Domain Model (DM-EP) with 40 entities, 494 attributes, and 409 relationships.

Figure 1. Areas of knowledge in the domain model.

This domain model was the starting point for the development of the ontology. Due the complexity of the poetry domain, we decided to build a network of ontologies for the representation of information concerning European poetry [28]. The criteria used to build each of the ontologies present in the network were:

- The classes, relations and axioms of the ontology must be thematically related or complete the semantics of another ontology entity. In this case, the underlying semantics of each class is related to the area of knowledge.
- The weak coupled is guaranteed between ontological modules. Each of them must present autonomy sufficient: it is a self-contained ontological module that preserves the relationships with other ontologies. None of the ontologies created present subsumption relationships with classes of another ontology in the network.
- Each module or ontology has a strong cohesion. Each ontology contains all the object properties to model the relationships between its internal classes. Therefore, a high degree of cohesion is achieved, the ontology functionality is described and avoids coupling with other ontologies of the network.

The development process was carried out through an iterative-incremental model. Each ontology was built by the premise of reusing existing ontologies, aligning vocabularies and properties to facilitate its development, improving the semantic understanding of entities, and facilitating interoperability, Figure 2.

Moreover, we have placed particular emphasis on establishing both the domains and the ranges of the properties. It allows defining its semantics completely and reducing ambiguity.

After each iteration, the OWL specification of each ontology was obtained. Besides, a graphical representation was created using a diagram of classes, data properties, and object properties.

For the definition of some properties' ranges, we have identified a set of controlled vocabularies. They have been specified using the data model of the Simple Knowledge Organization System (SKOS)[18]. These controlled vocabularies allow establishing standard terminologies that are used by the scientific.

18 https://www.w3.org/2004/02/skos.

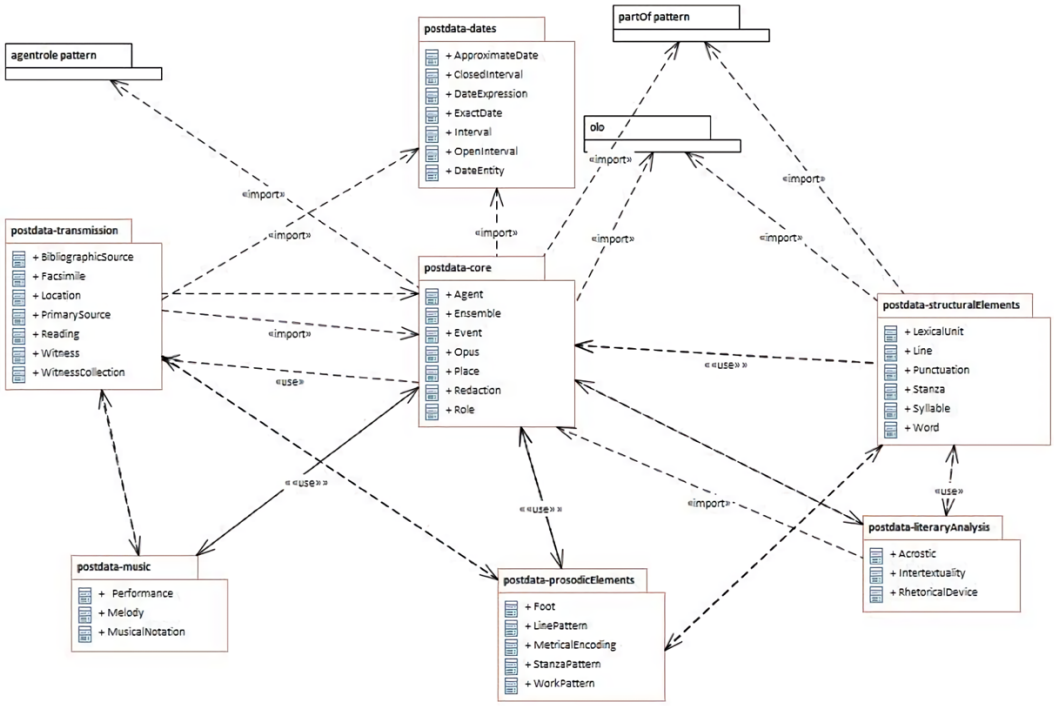

Figure 2 Network of ontologies

community. Likewise, the definition of cardinal, and universal and existential restrictions in classes have been undertaken to prevent inconsistencies and avoid semantic conflicts.

4. Ontologies description

This section describes the four ontologies that we have already developed at the time of writing: `postdata-core` ontology, `postdata-prosodicElements` ontology, `postdata-structuralElements` ontology, and `postdata-dates` ontology.

4.1. postdata-core ontology (pdcore)

This ontology is the main ontology for poetic representation. It provides information about poetic works and their manifestations. In the poetry domain, a poetic work, a poem, can be represented by different manifestations or versions. Of course, it is usual to find a set of poems grouped, for example, in a book. These situations are modeled in the ontology, as well. Figure 3.

The most significant classes of this ontology are `pdcore:PoeticWork`, `pdcore:Redaction`, *and* `pdcore:Ensemble`. These classes have been defined as the specialization of `Frbroo` classes.

- `PoeticWork` class models the abstract concept of artistic creation. These creations must be in verse (poem, play, song), and its properties represent the descriptive metadata of a poetic work like title, abstract, creator or author, and the creation date. This class is implemented as a subclass of `frbroo:F1_Work` class.
- `Redaction` class is a subclass of `frbroo:F22_Self-Contained_Expression` class and models representatives of a poetic work. Each version of poetic work is a redaction of it.
- `Ensemble` class *is a* subclass of `frbroo:F17_Aggregation_Work` class and allows to model an Ensemble as a collection of poetic works, organized by author, by book song or by collection of poems. We also define an Ensemble as a work mainly written in prose that contains more than one poetic piece.

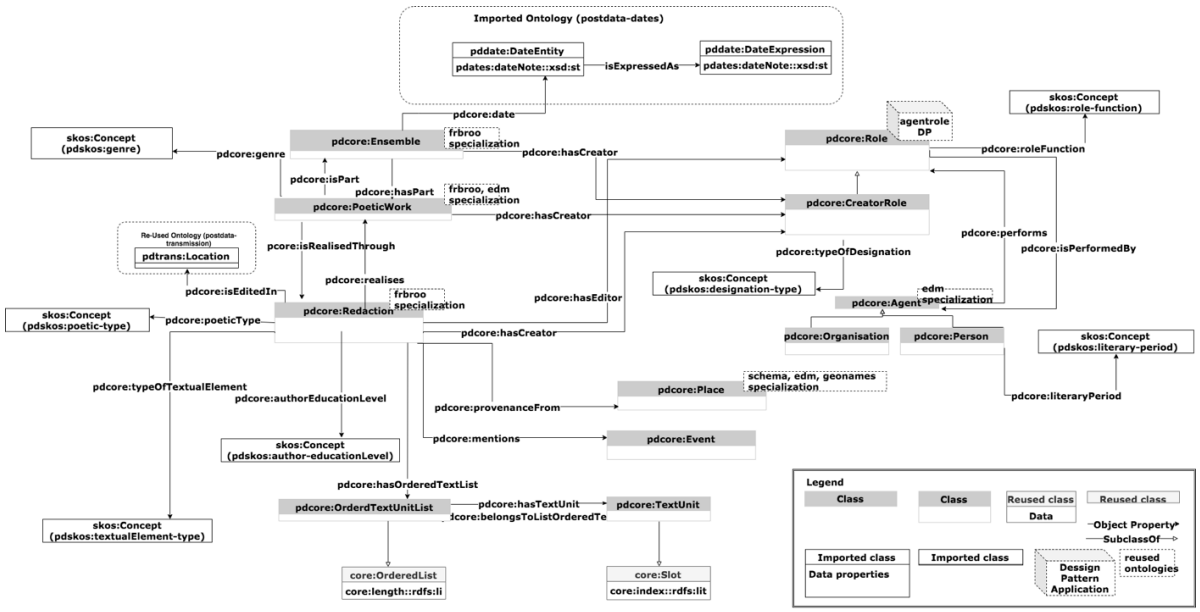

Figure 3. postdata-core ontology

Together with these main classes, we have considered to include classes that, although not specific to poetry, model a transversal knowledge of the poetic domain and complete the relevant information.

Some examples of this kind of classes are:

- `pdcore:Person` *and* `pdcore:Organisation`. To model the agents that participate in the poetic work and the redaction with different roles.
- `pdcore:Place` *and* `pdcore:Event`, to represent origin places and mentioned events and places.

A relevant aspect that must be treated in a literary work is the authorship and the roles that play the related agents, Figure 4. To model this knowledge, we have used the design pattern `agentRole`[19], and we have defined the class `pdcore:Role` and its subclass `pdcore:CreatorRole`. These classes have the necessary properties to establish the relationship between the different agents. The `pdcore:CreatorRole` class is useful in the treatment of authorship because it can support the representation of:

- Multiple authorships through the multiple cardinality assignation for the pdcore:hasCreator property.
- Anonymous author, using `pdcore:isAnonymous` property with a Boolean range.
- Wrong attributions, through the `pdcore:isWrongAttribution` property with a Boolean range.

This core ontology not only contains the necessary information about a poetic work but a set of common properties that have the same semantics in all the classes in which they are defined. Also, we have identified a set of controlled vocabularies used as ranges of the following properties in the classes.

- `PoeticWork` class:`genre`, `poeticType`, and `authorEducationLevel`.
- `Redaction` class: `typeOfTextualElement`.
- `Person` class: `gender`, `literaryPeriod`, `school`, `socialStatus` and `religiousAffiliation`.
- `Role` class:`roleFunction`, `typeOfCharacter`.
- `CreatorRole` class: `typeOfDesignation`.
- `Person`: `certainty`.

[19] http://www.ontologydesignpatterns.org/cp/owl/agentrole.owl

The complete ontology has 44 classes and 158 data and object properties. This ontology is published in [30]

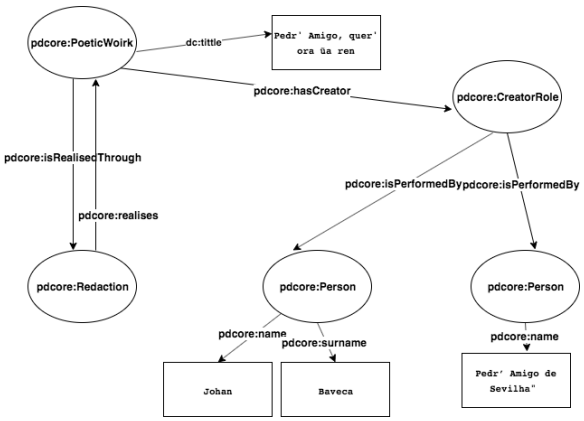

Figure 4 Example of authorship in a Poetic Work

4.2. Postdata-structuralElements ontology (pdstruct)

The `postdata-structuralElements` ontology contains all the information related to the structural element of a `Redaction`.

A Redaction of a poetic work is directly organized in lines or in stanzas. Therefore, in the `structuralElements` ontology to capture these possibilities is necessary to define two classes: `pdstruct:OrderedLineList` and a `pdstruct:OrderedStanzaList` class.

These classes are related to `pdcore:Redaction` class using `pdstruct:hasLineList` property or `psdtruct:hasStanzaList` property.

Since a stanza is a list of lines, a line is a list of words and punctuation marks and a word is composed of syllables, to complete the ontology, we have defined five more classes: `pdstruct:Line`, `pdstruct:Stanza`, `pdstruct:Word`, `pdstruct:Syllable`, and `pdstruct:Punctuation`.

- `Line` represents a unit of verse that usually ends in a visual or typographic break and generally characterized by its length and meter.
- `Stanza` represents a group of lines. Usually, this grouping forms the basic recurring metrical unit of a poem.
- `Word` represents words as list of syllables.
- `Punctuation` represents the punctuation symbols.
- `Syllable` represents a single unit of speech sound as written or spoken.

According to the semantics of the Ordered List ontology, these classes are subclasses of `olo:Slot` since all them are considered a slot of an ordered list. But also the three first are subclasses of `olo:OrderedList`, since they are considered a list of ordered elements, Figure 5.

In this ontology four controlled vocabularies have been identified. Also, we have identified a set of controlled vocabularies used as ranges of the following properties in the classes.

- `Stanza class: typeOfStanza` and `typeOfStanzaEdition`.
- `Word class: partOfSpeech`.
- `Syllable class: nucleusType`.

The complete ontology is built with 8 new classes, 21 data properties, and 50 object properties. This ontology is published in [31]

4.3. postdata-prosodicElements ontology (pdprosodic)

This ontology contains the necessary classes and properties to structure the information extracted in a prosodic analysis of poetic work.

The prosodic analysis of a poetic work contains information about the metrical patterns of a poem, **¡Error! No se encuentra el origen de la referencia.**. These metrical patterns are defined in three levels: poem, stanza, and line. This ontology imports the `postdatastructuralElements` ontology because the information it provides is related to the metric patterns of the line, the stanza, and the poem. According to this, we have defined three classes to represent these metrical patterns.

These classes are `pdprosodic:LinePattern`, `pdprosodic:StanzaPattern`, and

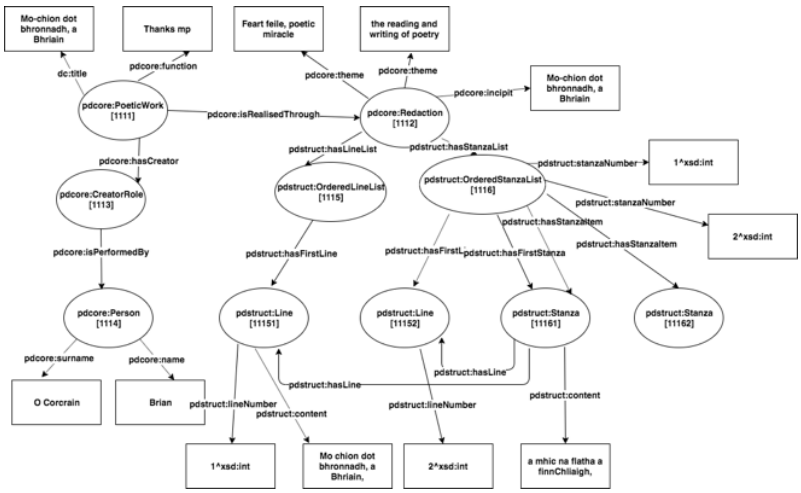

Figure 5 Example of list of lines and stanzas in structural ontology

`pdprosodic-WorkPattern`. The three classes belong to the hierarchy `pdprosodic:Pattern`.

- `LinePattern` models the metric pattern of the `Line`. Some important properties related to the line pattern are:
  - `pdprosodic:accentedVowels` to represent stressed vowels in the order in which they occur in the text.
  - `pdprosodic:countingMetricalScheme` for representing the metrical scheme according to the number of syllables.
  - `grammaticalStressPattern` is used to represent patterns based on the position of the expected stresses according to grammar rules including the distribution of weak and strong positions.
- `StanzaPattern` summarizes some specific properties of the stanza as `pdprosodic:rhymeScheme` property. It represents the rhyme scheme, the pattern of rhymes at the end of each line of the stanza. One of the most common conventions is to use letters to indicate which lines rhyme.
- `WorkPattern` shares some of the properties defined in `LinePattern` and `StanzaPattern` class but define more specific properties as `pdprosodic:presentRhymeMatching` that allows the categorization of the poetic work according to the degree in which the different rhyming sounds match (i.e., assonant, consonant). This property also applies to the `StanzaPattern` class.

These ontologies have been enriched with more classes used to store the prosodic analysis data. Some of these classes are:

- `pdprosodic:Rhyme` to represent the repetition of similar sounding words occurring at the end of lines in poems or songs .
- `pdprosodic:Foot` to represent the unit of poetic meter in most Indo-European poetic traditions, including the English syllabic verse and the quantitative compass of Greek and ancient Latin classical poetry.
- The `pdprosodic:metricalEncoding` class to define the notation employed to represent a metrical pattern, for example, the plus sign to encode the strong positions of syllables.

Finally, in poetry is common to find poetic licenses that affect the number of syllables, for example, dieresis, syneresis, synalepha, or hiatus. These figures consist of altering the writing or pronunciation of words without altering their meaning. The `pdprosodic:Metaplasm` class allows to know the type of prosodic figure, where it is allocated, and which words are involved in the phenomena.

In this ontology, the controlled vocabularies are of special interest because they represent the values of the prosodic properties in a normalized way. We have defined twelve controlled vocabularies used as ranges of the following properties in the classes.

- `Patterns` class: `clausulaSchemeType`, `metricalCategory`, `metricalComplexity`, `metricalContext`, `rhymeDispositionType`, `versificationType`.
- `Line` or `Stanza` class: `feetType` and `metricalType`.
- `Foot` and `FootDivision` class: `clausula`, `footType`, and `footUnitType`.
- `RhymeMatching` class: `typeOfRhymeMatching`.
- `Metaplasm` class: `typeOfMetaplasm`.

The complete ontology is made of 10 new classes, 52 data properties, and 40 object properties. This ontology is published in [32].

4.4. postdata-dates ontology

Depending on the composition period, it might be difficult to date with exactitude a poetic work or its manifestations, moreover, in ancient or anonymous publications, it is not always possible to find a particular date, and it may be necessary to establish ranges or make a suggestion on the likelihood of a date. This problem is present when the form of transmission or preservation does not facilitate the trace of a date of composition. For this reason, we have proposed an independent and reusable ontology in the literary domain or heritage domain that covers special dating needs. In this ontology, two classes are provided:

- `pddates:DateEntity` represents a temporal entity associated with poetic work, its manifestations, or event.
- `pdddates:DateExpression` is the base of a class hierarchy. This class and its subclasses provide several modes to represent a date related to the creation or whatever event associated with an entity.

The complete ontology is made of 7 new classes, 7 data properties, and 2 object properties, Figure 6. This ontology is published in [33].

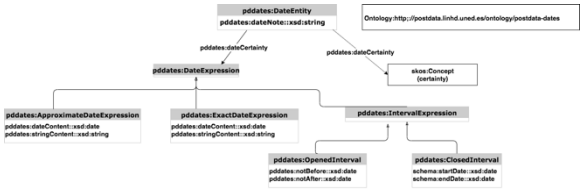

Figure 6 Postdata-dates Ontology.

5. Applications of the ontologies

In the context of the POSTDATA project, one of the main goals is the development of PoetryLab. PoetryLab is an extensible open-source toolkit for poetry analysis. At this moment it can perform the syllabification, the scansion (extraction of stress patterns), the enjambment detection (syntactical units split into two lines), the rhyme detection, and medieval named entity recognition for Spanish poetry. This toolkit achieves state of the art performance in the tasks for which reproducible alternatives exist. Moreover, it is designed to aggregate as many tools needed for poetry analysis. PoetryLab uses the network of ontologies as data model, so it uses its RDF triples as source for its application and generates new triples as results. So it is currently the data persistence and interoperability base of PoetryLab.

Another of the objectives of the POSTDATA project is to share poetry knowledge as linked data. Then we have started to populate the ontology. For this purpose, we are currently mapping some poetry databases or repertories: *MedDB Base de Datos da Lírica Profana Galego-Portuguesa* [7], B*ardic Poetry database* [34], *ReMetCa,* a medieval Spanish metrical repertory [21], *Musisque Deoque* repository [35], and *Pede Certo,* a digital Latin metre database [6].

6. Conclusions and future work

In this paper, we have presented the most significant ontologies from the network of ontologies for European Poetry developed in the framework of the POSTDATA ERC Project: `postdata-core` ontology, `postdata-prosodic` ontology, `postdata-structural` ontology, and `postdata-dates` ontology. This network of ontologies is composed of four more ontologies under construction: `postdata-literaryAnalysis` ontology,

`postdata-transmission` ontology, `postdata-music` ontology, and `postdata-aditionalContent` ontology.

To build this network, we have started from the development of a domain model for European poetry. This model was developed for three years, and we analyzed 25 repertories. This domain model is the most complete data model specific of poetry ever done.
The ontologies have been developed using state-of-the-art ontology engineering methodologies and published according to best practices and recommendations for Linked Data vocabulary publishing.
The ontologies described in this work are Postdata core ontology, prosodic ontology, structural ontology, and date ontology. The first three are related to the description of the poetic work and its essential properties such as the prosodic elements.
The fourth is an ontology for capturing the dating knowledge that in literature entails an especial complexity.
These ontologies are the semantic and data persistence base of PoetryLab, an extensible open-source toolkit for poetry analysis developed in the POSTDATA Project as well.
Finally, we are mapping different poetry databases and repertories to the ontologies with the main aim of populating the ontologies and sharing the information in an interoperable RDF format. This is a complex task because to build the knowledge graphs requires to build conceptual mappings and a RDF generation using RML mappings.
At this moment, we are working on the final definition of controlled vocabularies detected. Also, we are working on the review and publication of the rest of the ontologies that integrate the network.

7. Acknowledgements

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