Roadmap for a multilingual BioPortal

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Abstract. Ontology indexes and repositories are important in the realization of the Semantic Web; however, the need has clearly moved to multilingual capabilities that are hard to offer when dealing with multiple ontologies, originally in different formats and contributed by an open community. In this paper, we present a roadmap for addressing the issues of dealing with multilingual or monolingual ontologies in BioPortal, the reference ontology repository in biomedicine, currently mostly English-oriented. We propose a set of representations to support multilingualism in the portal and to enable a complete use of the functionalities and services for any kind of ontologies and data. While encouraging the community to use the best available specifications to represent multilingual content e.g., Lemon; our objective is to handle multilingualism in a proper semantically rich and consistent manner in the ontology repository. We are currently deploying and implementing these representations in a local instance of BioPortal for French ontologies.

Keywords: ontology repository, ontology localization, biomedical ontologies, BioPortal, multilingual Semantic Web, multilingual alignment, ontology relation.

1 Introduction

A key aspect in addressing semantic interoperability for life sciences is the use of terminologies and ontologies as a common denominator to structure biomedical data and make them interoperable [4]. For instance, the community has turned toward ontologies to design semantic indexes of data that leverage the medical knowledge for better information mining and retrieval. However, ontologies and terminologies in biology and medicine are originally spread out over the Web and in different formats [9] making their use often cumbersome. One way to address this issue was by designing ontology indexes or buy building ontology repositories. For instances, indexes includes Watson [8], Swoogle [12], or the EBI Ontology Lookup Service [7]; repositories, in the biomedical domain, includes the NCBO BioPortal [23] or the HeTOP [17]; we may also cite the Open Ontology Repository [2] or the listing at: http://www.w3.org/wiki/Ontology_repositories.

However, scientific discoveries that could be made with help of ontologies to annotate, integrate, mine and search data, are often limited by the availability of ontology-based tools and services only for one natural language, usually English, for which there exist the most ontologies. Recently, ontology localization, i.e., “the process of adapting and an ontology to a concrete language and culture community” [6], has become very important in the ontology development lifecycle, but when efforts are made to properly represent lexical (e.g., using Lemon [20]) or multilingual information (e.g., using LexOMV [21] or Lemon translation module [16]) are made, then it is rarely leveraged by ontology indexes and portals. This situation is clearly a problem for international organizations where several languages are official e.g., European Union.

In the biomedical domain, the reference platform to host and find ontologies is *BioPortal* (http://bioportal.bioontology.org) developed by the National Center for Biomedical Ontology (NCBO) project. It is an open library of ontologies and terminologies in biology and medicine [23]. Using the portal, health professionals and biologists can browse, search, visualize and comment on ontologies both interactively, through a Web interface, and programmatically, via Web services. Within BioPortal, ontologies are used to develop a semantic annotation workflow [19] that can be used to index biomedical text data resources (in English) to provide semantic search features.

In the context of the *Semantic Indexing of French Biomedical Data Resources* (SIFR) project (http://www.lirmm.fr/sifr), we are investigating making BioPortal multilingual. We are currently building a local instance of BioPortal[1] to host ontologies and terminologies with French labels with the goal of designing a semantic annotation workflow capable of processing French text data. In this paper, we discuss our choices and propositions to internationalize BioPortal. We distinguish interface internationalization which consists of displaying static elements of the user interface (e.g., menu names, help, etc.) in different languages and enabling to switch from one language to another; from content internationalization which consists in displaying BioPortal content (e.g., ontology labels, mappings, etc.) in another language. In the following our interest goes beyond internationalization (which is mainly related to display) to provide a full model to support multilingualism in the portal i.e., to enable a complete use of the functionalities and services of the portal for any kind of multilingual/monolingual ontologies and data. Our main objective is to handle multilingualism in a proper semantically rich and consistent manner (i.e., using the appropriate Semantic Web mechanisms and vocabularies) enabling BioPortal users to use ontologies independently of the language and therefore enabling cross lingual search or annotation with ontologies and mining of data indexed with ontologies.

The rest of the paper is organized as follows: Section 2 presents the vocabulary and definitions we use in the paper. Section 4, presents a brief status of multilingualism in BioPortal as of today. Section 5 describes in each subsections the propositions to handle semantic representation of multilingual content as illustrated on an example in Fig. 3. Then, section 6 establishes the roadmap to implement a future multilingual BioPortal. And finally, section 7 concludes and presents the perspectives of this work.

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[1] NCBO technology is open source and available in part on https://github.com/ncbo or as a virtual appliance http://www.bioontology.org/wiki/index.php/Category:NCBO_Virtual_Appliance

2 Related work

Multilingualism became an important issue with the explosion of data being released and linked over the Web today. Even if today Web content is mainly in English, followed by Chinese and Spanish,[2] the vision of the Semantic Web is to be able to leverage and interoperate data whatever natural language these data are available into. Within the Semantic Web community research about multilingualism has gained a lot of interest in the last years [5]. Several approaches have been proposed to add lexical information to ontologies such as SKOS-XL, Lexvo [11], Lingvoj, resulting on the proposition of the Lemon standard [20]. For instance, instead of using rdfs:label or skos:*Label, one can use the SKOS-XL extension to define labels as classes with property skosxl:literalForm for the label itself. This reification of the label property allows defining further properties for labels e.g., acronym, short forms, translations. This solution offers a richer description of what a label is and support entailment to SKOS. The state-of-the-art for adding complex lexical information to an ontology is the Lemon (LExical Model for ONtologies) model done within the Monnet EU project, which is designed to represent lexical information about words and terms relative to an ontology. Lemon allows for instance, to add part-of-speech information to terms thanks to a clear separation of the lexicon and ontology layers in the model. Lemon perfectly defines how to represent translations within a multilingual ontology[3] and making BioPortal multilingual will for sure mean to be able to parse Lemon translation descriptions when an ontology is uploaded to the portal. A recent extension offers mechanisms to represent even more precisely multilingual content in ontologies [16] by reifying the translation relation into a class with specific attributes.

In the biomedical domain, the Unified Medical Language System (UMLS) Metathesaurus, a set of terminologies which are manually integrated and distributed by the United States National Library of Medicine [3], does contain terminologies in other languages than English. In addition, the HeTOP portal [17] also offers translated terms in multiple languages, especially French, and enables cross lingual search. In both cases, the underlying approach is one of a common meta-model for all the integrated ontologies which means that there exists a unique class for concepts (e.g., CUI) and additional label properties offer translations to multiple languages. This is different from the BioPortal approach which does not build a global thesaurus but keep each ontologies separated and use alignments to interconnect them. Another difference with BioPortal, is that neither UMLS nor HeTOP are built natively with Semantic Web technologies and thus do not offer semantic representation for ontologies with multilingual content.

We are also interested in the formalization and representation of multilingual ontology alignments [18, 15], however we do not focus on their creation or extraction [27]. In addition, a few work has been done about classifications of relations between ontologies

[2] Internet World Stats, 2013

[3] "A Translation is a special case of SenseVariation involving 2 lexical senses in different languages that stand in a translation relation in the sense that they can be exchanged for each other without any meaning implications."

(e.g., [1]), especially related to multilingual aspects, such as [18], where four types of proximities between the structure of knowledge organization systems are defined.

3 Vocabulary

In the following, we discuss only ontology (thus including the notion of terminology). We call *natural language*, the language (French, English, Spanish, etc.) used when defining the class labels in an ontology. This language property, has not to be confused with the *format language* used to describe the ontology (OWL, RDFS, RRF, etc.). We call a *multilingual ontology*, an ontology that provides labels or lexicalizations in different *natural languages* and uses the standard ways to differentiate them (e.g., rdfs:label et xmllang property with values in ISO-639-3) or a rich lexical representation (e.g., Lemon). For instance, Orphanet ontology [26], that was constructed with labels in 5 languages. We call a *language specific ontology*, or a *monolingual ontology*, an ontology that provides labels in a unique natural language that usually serves as the basis for conceptualization. These ontologies are either being originally developed in a given language or are the result of a translation of an ontology in another language. For instance MeSH-fr, which is the specific French version of MeSH translated by the French INSERM organization (http://mesh.inserm.fr). We call *partial multilingual ontology*, an ontology that contains labels in multiple language more or less systematically and miss some labels; which makes them more difficult to use [21]. This is for instance the case of the Foundational Model of Anatomy (http://fma.biostr.washington.edu).

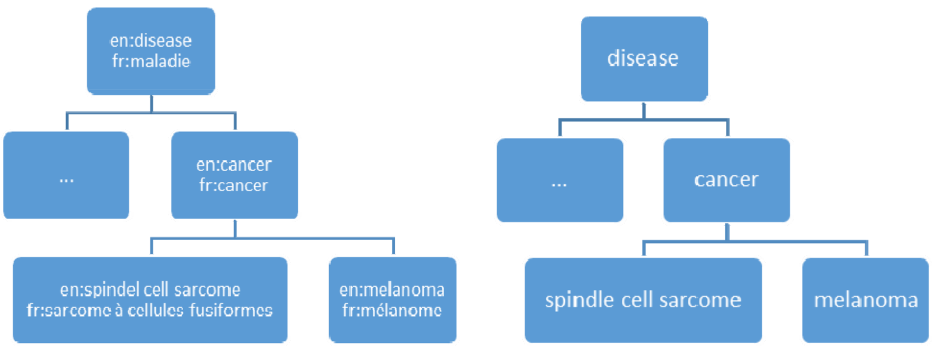

Fig. 1. Examples of multilingual and monolingual ontologies.

We call a *translation*, the relation between two monolingual or multilingual ontologies, in different languages, that represent mainly the same knowledge resource (domain, topics, classes, relations).[4] For instance, MeSH-fr is a translation of MeSH. Other

[4] We do not include in this definition of translation, the process of constructing a multilingual ontology by aggregating several existing monolingual ontologies into a new multilingual one.

relations between ontologies can also be used to be more specific. We call *multilingual mapping*, a one-to-one concept mapping (or alignment) between two language specific ontologies. We call a *multilingual translation mapping* when additionally the two concerned language specific ontologies are a translation of one another. A multilingual mapping states that the terms in the mapped ontologies are a translation of one another (between the natural languages of the ontologies). For instance, Mesh-fr/mélanome has a multilingual translation mapping to Mesh/melanoma but only a multilingual mapping to DOID/melanoma. With those definitions, the notion of translation stays at the ontology level, while keeping the classic method (mapping) to represent translations between classes. In the following, we will discuss the best Semantic Web to choose non exclusively.

4 Status of multilingualism in BioPortal

As of today, BioPortal is not multilingual and hosts mainly English ontologies. The portal does accept (and parse) both multilingual ontologies and language specific ontologies, but it is neither capable to leverage the multilingual structure and content of the first ones nor it is capable to reconcile and deal with the multilingual mappings necessary for the second ones. As of March 2015, there are 433 ontologies in BioPortal, mostly in English. A few ontologies (5) are French monolingual ontologies and 1 is in Spanish (cf. Table 1). Some ontologies are multilingual or partial multilingual, although the exact number can hardly be determined as they are not uploaded completely or parsed correctly by the portal.

Table 1. Examples of ontologies with multilingual content in the NCBO BioPortal

Ontology	Acronym	Type	Status
International Classification of Primary Care, French translation	ICPCFRE	French LSO	View of ICPC
Medical Dictionary for Regulatory Activities Terminology, French edition	MDRFRE	French LSO	View of MEDDRA
Thesaurus Biomedical Francais/Anglais [French translation of MeSH]s	MSHFRE	French LSO	View of MESH
Minimal Standard Terminology of Digestive Endoscopy, French	MSTDE-FRE	French LSO	Main ontology
Ontology of Alternative Medicine, French	ONTOMA	French LSO	Main ontology
SNOMED Terminos Clinicos	SCTSPA	Spanish LSO	View of SNOMEDCT
Ontology of Nuclear Toxicity	ONTOTOXNUC	MO	Main ontology
Foundational Model of Anatomy	FMA	PMO	Main ontology

BioPortal neither uses a proper mechanism to identify the language property(ies) of an ontology nor supports relationships between ontologies in different languages. However, often, but not systematically, non-English language specific ontologies are available as views[5] of the English version, and in this case the relation between the ontologies is formal, but not semantically described. The portal model does not semantically represent

[5] A view is a subset, a subpart or any other variation of a main ontology explicitly attached to this ontology.

the mapping between e.g., an English term and the French one available in the corresponding view. Thus, it is impossible to get the French term while browsing the English one and vice-versa. In addition, when multilingual content is available, the portal does not appropriately support inclusion/exclusion of labels in different languages in the use of the services the portal offers. For instance, the Annotator will mix languages when retrieving concepts from text making the results often incorrect. The historical choice made during BioPortal design was assuming English as the main and by default language and considering non English language specific ontologies as specific views of main English ontologies. However, what to do with language specific ontology not in English, with no existing translation to English available (or not yet in BioPortal). There would be no "main" ontology to attach the view. In addition, ontology views are not first class objects within BioPortal architecture. For instance, they cannot be part of groups, or are not included in the Annotator.
Finally, BioPortal does not support any interface internationalization. The whole user interface exists only in English.

5 Representation of multilingual content in BioPortal

5.1. Representation of natural language property for an ontology

We need a way to represent the natural language(s) of an ontology. We propose to use the property omv:naturalLanguage because OMV (http://omv2.sourceforge.net) [25] is already used within BioPortal Metadata ontology, which represents metadata about ontologies, projects, mappings, etc. [24].

```
omv: <http://omv.ontoware.org/2005/05/ontology#>
omv:naturalLanguage (with values in ISO-639-3)[6]
```

Note that this is not a functional property, therefore it can be used multiple times in the case of multilingual ontologies. In the case of partial multilingual ontologies we propose to assign values for each language possibly available in the ontology.

5.2. Representation of relations between ontologies

We need a way to represent the translation relation between ontologies and more generally any relationships between ontologies. We suggest to use and extend the DOOR ontology [1] which is the state-of-the-art about ontology relationships. We need to extend the DOOR ontology (Fig. 2) with a new relation to represent ontology translation i.e., a translated ontology is a specific *evolution* of the ontology with an *equivalent syntax* but in another language; this can also be done in BioPortal Metadata.

[6] Note that as of the latest version of OMV, omv:naturalLanguage is a data property which range is String. However, Lexvo does now provides URIs for ISO-639-3 values that would be better to use.

```
meta: <http://bioportal.bioontology.org/metadata/def/>
door: <http://kannel.open.ac.uk/ontology#>
meta:isTranslationOf
    subPropertyOf door:explanationEvolutionOf
    subPropertyOf door:syntacticallyEquivalentTo
```

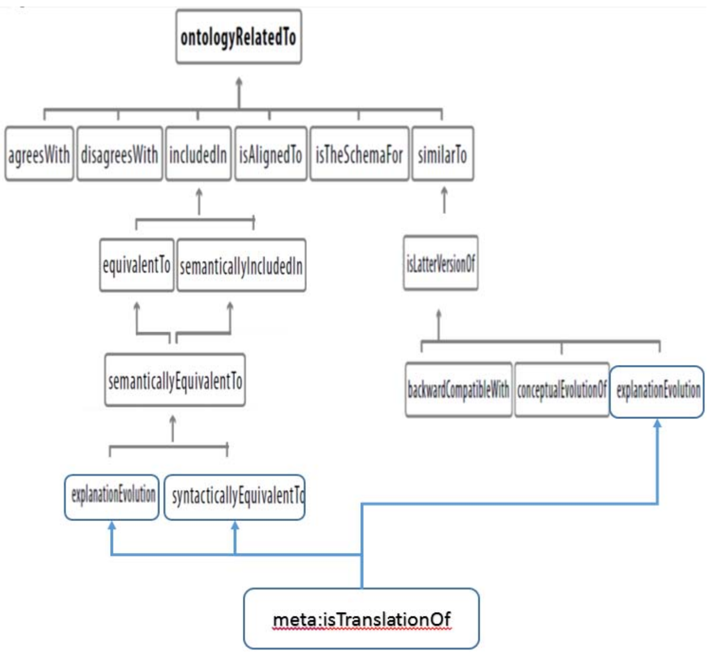

Fig. 2. Extension of DOOR ontology.

5.3. Representation of the distinction between ontologies with multilingual content

Optionally, we can also extend OMV within BioPortal Metadata to include and formalize the distinction between multilingual ontology and language specific ontology. Then create the following classes and relations.

```
meta:MultilingualOntology
    rdfs:subClassOf omv:Ontology
    omv:naturalLanguage some Literal
meta:LanguageSpecificOntology
    rdfs:subClassOf omv:Ontology
    omv:naturalLanguage exactly 1 literal
```

However, this solution does not allows to represent partial multilingual ontologies.

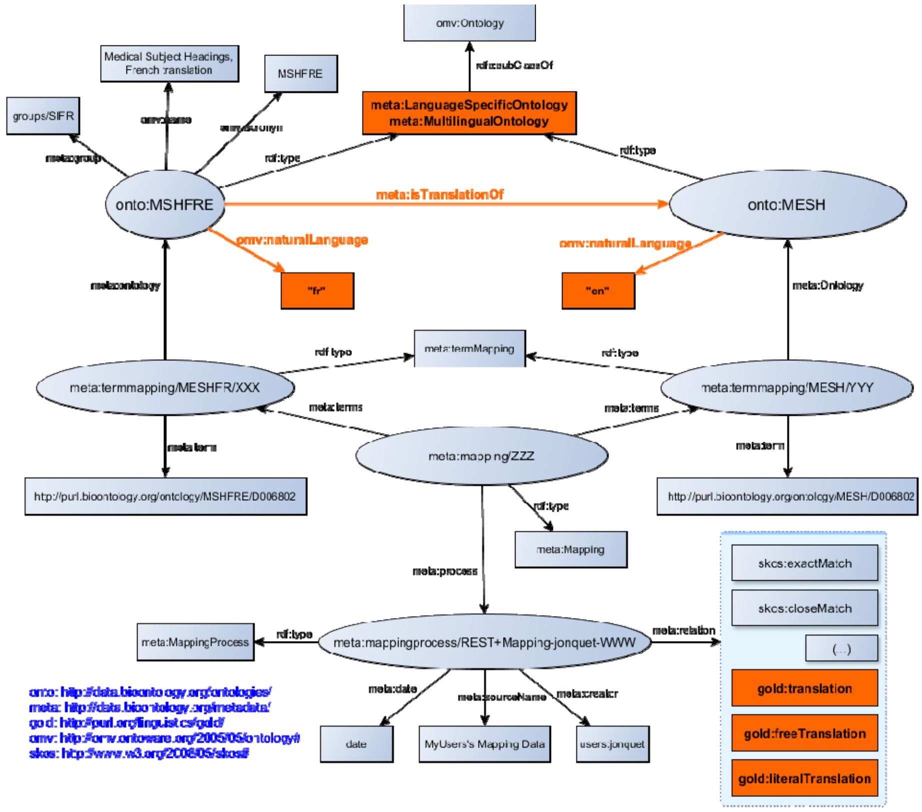

Fig. 3. Representations of multilingual content in BioPortal. New elements in orange.

5.4. Representation of multilingual mappings

We need a way to represent multilingual translation mappings between concepts (mostly from monolingual ontologies). Considering that multilingual mappings could be as complex to extract and represent than others mappings, we suggest to keep a single and simple model as the one BioPortal already provides to represent any mappings. Therefore, we propose to represent multilingual mappings (i.e., one-to-one mappings) between concepts from ontologies in different languages as any other BioPortal mapping, but with a specific relation. We currently suggest to represent translations with the GOLD ontology (http://linguistics-ontology.org/) [14] and the gold:translation property when mappings explicitly connect terms with a different 'orthographic expression'.

```
gold: <gold="http://purl.org/linguistics/gold/#>
gold:translation  //both expression have the same or roughly the same meaning
gold:freeTranslation  //both expressions have exactly the same meaning
        subPropertyOf gold:translation
gold:literalTranslation//translation word-by-word
        subPropertyOf gold:translation
```

Other vocabularies or classification may also be used, such as Chen & Chen's one [18]: equivalence (exact, inexact, partial) and non-equivalence (cultural or scope) assuming they are described in an available ontology or vocabulary. Depending on the types of translation to represent, GOLD might not be appropriate and we suggest to represent translations with other specifications such as the Lemon translation module [16].

```
trcat: <trcat="http://purl.org/net/translation/#>
trcat:Translation
        trcat:translationCategory trcat:directEquivalent // semantically equivalent
entities that refer to entities that exist in both cultures and languages
        trcat:translationCategory trcat:culturalEquivalent // entities that are not
semantically but pragmatically equivalent
        trcat:translationCategory trcat:lexicalEquivalent // point to the same entity,
but one of them verbalizes the original term by using target language words
```

This approach avoid to create specific relations per languages e.g., frenchToEnglishTranslationOf. Indeed, using omv:naturalLanguage property will provide the information about which language are concerned.[7] In addition, those representations are not exclusives: other mapping relations already used in BioPortal can also be used (owl:sameAs, skos:*Match). For instance, Mesh-fr/mélanome, and Mesh/melanoma, can be linked by two mappings skos:exactMatch and gold:freeTranslation.

6 Roadmap for making BioPortal multilingual

6.1. Reconciliation of multilingual mappings

Language specific ontologies that have been produced by translating another ontology will not always precisely describe a way to resolve translations between concepts. If the two ontologies do not use the same URIs, then a one-to-one multilingual mapping need to be reconcile between the ontologies. BioPortal does not extract or generate mappings when an ontology is uploaded and parsed by the portal. But it offers a batch or API[8] access to the mappings store enabling to add mappings connecting ontologies as a side

[7] Note that in the case of a translation multilingual mappings between multilingual ontologies (with multiple omv:naturalLanguage values) we assume the labels will themselves by tagged with their language (xmllang).
[8] http://data.bioontology.org/documentation#Mapping. Eventually, multilingual mapping extraction and reconciliation should happen automatically when an ontology is uploaded to BioPortal.

process after uploading the ontologies in the portal. Therefore, we need to implement several methods to extract multilingual translation mappings between translated ontologies and then reconcile them into BioPortal mapping repositories. We have identified several approaches (sorted hereafter from simplest to harder):

- Directly using the concept codes (or any other local class identifier) if they are the same in the translated ontologies. For instance, both Mesh/melanoma (http://purl.bioontology.org/ontology/MSH/D008545) and Mesh-fr/mélanome (http://purl.bioontology.org/ontology/MSHFRE/D008545) share the same code.
- Using a federated database such as the UMLS Metathesaurus [3] which offer a few terminologies in other languages than English and link terms to one another using CUI identifiers. Or using the CISMEF information system [10] and the HeTOP portal which is the biggest source of French-English alignments for biomedical terms.
- From other mappings existing between ontologies (eng-eng or fr-fr). Indeed, BioPortal include large number of mappings between the ontologies. However, one need to make sure that mappings (that are not multilingual) are not automatically transposed to multilingual mappings because it could lead to irrelevant results.
- From external multilingual dictionary or lexicalized semantic network publicly available such as BabelNet [22].
- From data resources available in multiple languages and that can be used for translation e.g., Health Canada (http://www.hc-sc.gc.ca).
- From adapting any complex alignment generation process to be multilingual [13, 27].

6.2. Internationalization of the portal

Once multilingual mappings are reconciled within BioPortal, and multilingual ontologies are properly handled, content internationalization of the portal becomes possible. One can switch from a user interface display to another using a contextual link (e.g., clicking on a language flag): in the case of a multilingual ontology a simple change of the label displayed is necessary whereas in the case of a monolingual ontology the concept being displayed has to change using the multilingual translation mapping if exists. Services, such as the Annotator can be use with a language parameter for the language of the given text data. In addition, we will have to translate the user interface (menu, help) and make sure the portal can switch from one language to the other (as any other web application).

7 Conclusion and future work

In this paper we have presented propositions to make BioPortal multilingual. We believe the challenge of managing multilingualism within biomedical ontologies repository is important and exceeds the linguistic aspects. Multilingual data sets integration will permit translational discoveries by merging not only data in other natural languages but data relating to different populations and/or culture. In biomedicine, considering the enormous results obtained in mining & analysis of clinical data one maybe motivated by the potential discoveries that would become possible by crossing large amount of clinical data about population of different ethnics and continental origins currently expressed and limited to a unique natural language. For instance, multilingual crossing of genotype-phenotype distinction studies will certainly help understanding better the role of the environment on the expression of genes.

We have seen that even if some mechanisms exist to semantically describe lexical or multilingual content within an ontology, it has to be completed with solutions for an open platform like BioPortal that do not edit the ontologies uploaded directly by their developers. In the future, this will be interesting to make the portal fully compliant with specifications like LexOMV or Lemon, in order to encourage ontology developers to adopt and uses those specifications to encode multilingual ontologies. In addition, we envision potential new applications for multilingual content in BioPortal such as automated translation of free text, or automatic query expansion for multilingual search.

The SIFR project currently works on implementing the propositions in a local instance of BioPortal. In the future, we will push those modifications back into the main BioPortal, while taking into account that multiple instances may have to be interoperable.

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