# ImageSchemaNet: Formalizing Embodied Commonsense Knowledge Providing an Image-Schematic Layer to Framester.

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**Abstract.**
Commonsense knowledge is a broad and challenging area of research which investigates our understanding of the world as well as human assumptions about reality. Deriving directly from the subjective perception of the external world it is intrinsically intertwined with embodied cognition. Commonsense reasoning in particular is linked to human sense-making, pattern recognition and knowledge framing abilities. This work proposes a new resource that formalizes the cognitive theory of image schemas. Image schemas are described as dynamic conceptual building blocks originating from our sensorimotor interactions with the physical world, and enable our sense-making cognitive activity to assign coherence and structure to entities, events and situations we experience everyday. ImageSchemaNet is an ontology that aligns pre-existing resources, such as FrameNet, VerbNet, WordNet and MetaNet from the Framester hub, to image schema theory. This article provides an empirical application of ImageSchemaNet combined with semantic parsers on the task of annotating natural language sentences with image schemas.

Keywords: Image Schemas, Cognitive Semantics, Frame Semantics, Commonsense Reasoning

## 1. Introduction

Extracting and representing commonsense knowledge is a broad and challenging area of research, in order to solve reasoning problems related to everyday situations. Commonsense knowledge we deal with everyday includes topicalized knowledge about socio-cultural dynamics e.g. “water is sold in bottles”, jointly with its general patterns, also known as semantic frames, scripts, scenarios, etc. [1], e.g. the `CommercialTransaction` frame, which involves some buyer, some seller, a possible storing place (e.g., a fridge), a way of payment, etc. The approach of utilizing frames to represent a type of object, event or situation builds upon Fillmore’s frame semantics [2], the foundation for FrameNet [3], later formalised in various resources, notably the Framester hub [4] that integrates multimodal knowledge under a formal hat.

Furthermore, everyday commonsense is bound to inferential naive physical patterns in order to operate in open world environments [5], e.g. “water is in the fridge” usually implies that “water is in a bottle, which is in the fridge”

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[6]. Given the dynamic and flexible character of natural language, automatically understanding those implications for concrete, physical situations is very challenging. However, automated understanding is further aggravated when the situation is in abstract language, typically through metaphors. For instance, “bottle up”, meaning *to keep emotions inside*, relates to the conceptual metaphors FEELINGS ARE LIQUIDS and BODY IS A CONTAINER, as proposed by cognitive semantics [7] . The state-of-the-art approach to motivate and describe metaphorical projection from the physical realm, e.g. the “bottle”, to the non-physical, abstract world, e.g. “bottle up”, is the image schema theory by Johnson [8] and Lakoff [9].

Image schemas have been proposed within the tradition of embodied cognition as conceptual structures that capture sensorimotor experiences and shape abstract cognition, including commonsense reasoning and semantic structures of natural language (see e.g. [10, 11]). Image schemas are internally structured gestalts, that is, composed by spatial primitives that make up more complex image schemas as unified wholes [10, 12, 13]. For instance, the “bottle” is a CONTAINER with an inside, an outside, and a border containing liquids in the physical world. By way of metaphorical projection these characteristics are captured by the image schema CONTAINMENT that is transferred to the abstract realm of emotions inside a body and linguistically expressed, e.g. to “bottle up”. While their existence in natural language has been studied by means of corpus-based (e.g. [14, 15]) and machine learning methods (e.g. [16–18]), few approaches to formalize image schemas (e.g. Image Schema Logic [19]) and connect them to existing resources to capture semantics exist.

In this article, we present a formal representation of image schemas as a new layer of the Framester hub, called ImageSchemaNet. Since a major flaw in current image schema theory is the lack of agreement about image schemas lexical coverage, we introduce an image-schematic layer linked to FrameNet [20] WordNet [21], VerbNet [22], etc., thereby creating a formal, lexicalized integration of cognitive semantics, enactive theories, and frame semantics. The main contributions of this approach are as follows:

- An image-schematic layer in the Framester hub called ImageSchemaNet that is easy to access by means of a SPARQL endpoint, linking image schemas to existing resources
- A formal and re-usable representation of image schemas as Semantic Web technology in form of an ontological layer
- An explicit representation of the interplay of existing (lexical) semantic and formal resources to interlink commonsense knowledge represented as image schemas to natural language and vice versa
- An empirically evaluated method for semi-automatically identifying image schemas in natural language sequences

The paper is organized as follows: in Section 2 we summarise embodied cognitive semantics theories, with a focus on image schemas (IS), spatial primitives (SP), and their operationalization; in Section 3 we introduce the basics about IS literature and Frame Semantics; in Section 4 we describe ImageSchemaNet and its vocabulary; in Section 5 we explain the SPARQL queries pipeline used to populate ImageSchemaNet; in Section 6 we provide an evaluation setting; in Section 7 we discuss the results of annotating natural language sentences with image schemas using ImageSchemaNet and semantic parsers; finally in Section 8 we draw some conclusion and future developments.

## 2. Related Work

Previous work on image schemas and ontologies focuses on formalizing specific IS, e.g., CONTAINMENT [23], or a specific perspective, e.g., IS as families of micro-theories [13], where authors exemplify their perspective or theory based on (possible combinations of) specific image schemas.

In terms of dynamic aspects, [24] and [25] investigate affordances in relation to image schemas. Affordances as defined by Gibson [26] concern commonsense about the opportunities for action offered by real world objects, environments and roles. Schorlemmer et al. [27] investigate the characterisation of creative processes in conceptual blending by means of diagrams of image schemas. A diagram has to be understood here within the context of category theory, and a means to model the internal structure of a categorical object. Such framing of image-schematic diagrams within a category-theoretic model of creative processes seeks to provide a mathematically rigorous and computationally feasible model of image-schematic structures.

The work by Kuhn [28] is relevant in using WordNet to extract the image schematic structure from expressions and concepts, followed by formally representing the extracted image schemas using the Haskell programming language. Walton and Worboys [29] advance on this work by aiming to express how image schemas are not only connected to one another, but can be combined to form complex conceptualisations.

Several approaches have used image schemas to model events and scenarios (e.g. [30, 31]) starting from compositionality of IS, like OBJECT, PATH and CONTACT to obtain more complex ones like BLOCKAGE, BOUNCING and BLOCKED_MOVEMENT, introducing temporal dimension.

Other formal work includes how to structure IS as families or clusters of similar concepts (e.g. [13, 32]). Bennett and Cialone [33] take up this idea of clustering and analyze occurrences of CONTAINMENT in biological textbooks in order to propose a sense cluster-based method for semi-automatically constructing a spatial ontology from natural language. It focuses on senses as contextualized interpretations, and expresses them within RCC-8 [34] to formally represent different spatial configurations of spatial primitives within the context of CONTAINMENT.

Image Schema Logic $\mathsf{ISL}^M$ [19] provides a more complete formalization of image schema theory. It brings together RCC-8 [34], Qualitative Trajectory Calculus [35], cardinal direction, and linear temporal logic [36, 37]. $\mathsf{ISL}^M$ was exemplified with the formalization of SUPPORT and CONTACT, and later applied to CONTAINMENT [23] as well.

In this work, we perform an experimental evaluation of ImageSchemaNet by automatically annotating natural language sentences with image schemas. Related work in this direction mostly focused on identifying image schemas in natural language by means of clustering verb-preposition pairs with noun vectors [17], also in a multilingual setting [16]. An extension of this traditional machine learning approach to include word embeddings has been proposed by Wachowiak [38]. One approach that relies on the Image Schema Repository [39], also used in the experimental setting of this article, is a fully automated method of classifying natural language expressions into image schema categories by fine-tuning a pre-trained neural language model [18]. While the results, especially of transferring the learned knowledge to other languages, are promising, there is still room for improvement. One short-coming of the approach is that it can only predict one image schema per natural language expression because of the nature of the dataset, while multiple image schemas frequently co-occur in a given natural language sequence.

Our work departs from previous research in linking to Framester, since it operationalizes image schemas as a new layer on top of frame-based knowledge extracted from text. We include testing on a small evaluation dataset, using full-fledged Semantic Web techniques to design ImageSchemaNet.

In contrast to clustering and neural approaches, the method for annotating natural language sequences with image schemas is fully explainable, since we identify lexical units, their related frames, and the links between frames and formalized image schemas. Furthermore, we can identify more than one image schema per sequence when applicable.

## 3. Preliminaries

Two important theoretical pillars for ImageSchemaNet are image schemas and frames. Prior to detailing our approach, we first define image schemas and their relation to spatial primitives. Secondly, we specify frames and their representation in the Framester hub.

### *3.1. Defining Image Schemas*

According to Johnson's famous definition, "an image schema is a recurring, dynamic pattern of our perceptual interactions and motor programs that gives coherence and structure to our experience" [8]. For instance, playing with shape puzzles[1] as an infant, represents early experiences of spatial boundedness and CONTAINMENT. They are directly meaningful experiential gestalts, that is, they are internally structured compositions of parts to form coherent, uniform wholes. These repeatedly experienced structures are considered to shape higher-level abstract cognition, such as language and commonsense reasoning. For instance, *He just sails through life* depicts life as

[1] A game where objects of specific shapes have to be inserted into openings of the same shape.

a CONTAINER, *through* which we travel on our PATH. By way of metaphorical projection, structures of physical source domains can be mapped onto abstract target domains, e.g. the inside (being alive), outside (not being alive), and boundary (birth, death). Johnson [8] and Lakoff [9, 40] provided numerous linguistic and sensorimotor examples as well as related high-level entailments without, however, fully formalizing their theory. ImageSchemaNet currently provides a formalization of the following frequently discussed and utilized image schemas, here as defined in natural language by image schema literature:

- CONTAINMENT: an experience of boundedness, entailing an interior, exterior and a boundary [8].
- CENTER_PERIPHERY: the experience of objects or events as central, while others are peripheral or even outside [41]. The periphery depends on the center but not vice versa [9].
- SOURCE_PATH_GOAL: a source or starting point, goal or endpoint, a series of contiguous locations connecting those two, and movement [8].
- PART_WHOLE: wholes consisting of parts and a configuration of parts [9].
- SUPPORT: CONTACT between two objects in the vertical dimension [42]; CONTACT has also been considered as image schema in its own right and has been added accordingly to ImageSchemaNet.
- BLOCKAGE: obstacles that block or resist our force; a force vector encountering a barrier and then taking any number of directions [8].

To provide a more formal account, Hedblom et al. [13] propose a utilization of DOL to represent shared gestalt structures of seemingly unrelated image schemas as a family, that is, a set of interlinked theories. Such a gestalt grouping of experiential structures implies a distinction between primitive and complex types. To this end, the perspective of Mandler and Pagán Cánovas [43] rooted in developmental psychology was adopted to distinguish spatial primitives, image schemas, and conceptual integrations. Spatial primitives are the very first preverbal building blocks infants form that quickly compose to more complex structures, the parts that compose to coherent unified wholes. These wholes or spatial events built from spatial primitives are image schemas. Finally, conceptual integration refers to the inclusion of non-spatial elements, such as emotions. Hedblom et al. [13] take up this initial definition and depict spatial primitives as roles participating in the frame image schema. Thereby, image schematic-structures, primitive or not, can be grouped based on experiential gestalt family resemblances. This initial formalisation is later extended as Image Schema Logic ($\mathsf{ISL}^M$) [19].

### 3.2. Frame Semantics and Framester

To connect our ontologies with linguistic examples of image schemas, we rely on representations and formalizations of frames from FrameNet [44] and MetaNet [45] in Framester. Frames in a most general notion are (cognitive) representations of typical features of a situation. Fillmore's frame semantics [2] has been most influential as a combination of linguistic descriptions and characterisation of related knowledge structures to describe cognitive phenomena. Words or phrases are associated with frames based on the common scene they evoke. In FrameNet, frames are also explained as *situation types*. In Framester semantics [1] observed/anticipated/imagined situations are consequently occurrences of frames.

Fillmore explicitly compares frames to other notions, such as experiential gestalt [7], stating that frames can refer to a unified framework of knowledge or a coherent schematization of experience. Thus, widely acknowledged frames provide a theoretically well founded and practically validated basis for commonsense knowledge patterns.

Framester [4][1] provides a formal semantics for frames in a reengineered and curated linked data versions of linguistic resources (e.g., WordNet [21], VerbNet [46], BabelNet [47], etc.), factual knowledge bases (e.g., DBpedia [48], YAGO [49], etc.), and ontology schemas (e.g., DOLCE-Zero [50]), with formal links between them, resulting in a strongly connected RDF/OWL knowledge graph. Framester can be used to jointly query (via a SPARQL endpoint[2]) all the resources aligned to its formal frame ontology[3]. Framester has been used [45] to formalize the MetaNet resource of conceptual metaphors[4], based on FrameNet frames as metaphor sources and targets, as well as

[2]http://etna.istc.cnr.it/framester2/sparql
[3]The Framester Schema is available at: https://w3id.org/framester/schema/
[4]The MetaNet schema in Framester's OWL is at https://w3id.org/framester/metanet/schema/.

to uncover semantic puzzles emerging from a logical treatment of frame-based metaphors. Yet, an image-schematic analysis of MetaNet is lacking, and can be enabled by a refinement of the FrameNet imagistic foundation, which has only been sketched with respect to Framester's prepositional knowledge [51].

## 4. ImageSchemaNet Structure

ImageShemaNet relies on ISAAC, the Image Schema Analysis And Comparison ontology[5], which models both formal and semi- or unstructured state-of-the-art IS theories, and proposes an integrated theory combining Johnson's definition [8] of image schemas as gestalt structures, Mandler and Pagán Cánovas spatial primitives conception [10] as "first conceptual building blocks", and Hedblom's IS compositionality [31]. ISAAC uses Framester (and derivatively Fillmore's) Frame Semantics to deliver a reified representation of situations evoked in natural language as occurrences of frames and their foundational IS.

ImageSchemaNet reuses the `:bibRef` property from Exuviae - a formal "exoskeleton" for representing epistemological choices when comparing ontologies [52] - which is meant to keep precise reference of the bibliographical and theoretical provenance of each entity and property with the original definition and formal dependencies. In particular ImageSchemaNet focuses on the `:ImageSchema`, `:SpatialPrimitive` and `:IS_Profile` classes from the ISAAC ontology, and introduces the `:activates` property in order to declare assertions about the activation (i.e., a bodily-schematic evocation) of some image schema or spatial primitive from any entity in the Framester resource.

The ImageSchemaNet ontology is available and can be queried from the Framester endpoint [6]. A detailed documentation about the structure, querying, and evaluation is provided in the following sections and in the Appendix, as well as on the ImageSchemaNet GitHub repository[7]. Albeit importing ISAAC ontology, ImageSchemaNet specifically focuses on providing lexical coverage to the Image Schema Theory, via `:activation` assertions, which currently cover the following image schemas: CONTAINMENT, CENTER_PERIPHERY, SOURCE_PATH_GOAL, PART_WHOLE, BLOCKAGE, and SUPPORT.

### 4.1. ImageSchemaNet Classes

*`:ImageSchema`* The `:ImageSchema` class represents the general concept of Image Schema, it is defined using the `:bibRef` property, quoting literature definitions, and it takes as instances image schemas whose activation is covered in the ImageSchemaNet ontology. Each IS is axiomatized as a gestalt structure, composed by at least 2 spatial primitives, and it is modeled as a kind of conceptual frame.

*`:SpatialPrimitive`* The `:SpatialPrimitive` class takes as instances the "first conceptual building blocks formed in infancy" as in [43], and represents them as semantic roles. The labels used respectively for IS and SP refers to well established and documented names used in literature, as for the SUPPORT IS, quoting their definition and provenance. When specific "official" names were not already given to entities, which existence was nonetheless implicitly or explicitly stated, we used labels extracted from empirical use case. E.g., in the aforementioned SUPPORT case, while literature is often mentioning examples involving its spatial primitives, no official name was available, and for this reason the SUPPORTER and SUPPORTED SP were introduced from anew.

*`:IS_Profile`* The `:IS_Profile` class is used as in [53] and [54] to describe the collection of IS which are activated by some entity, sentence, situation or event. One of the relevant future developments stemming from our work is the automatic extraction of the image schema profile and the investigation of the conceptual nature of relations among IS in such a collection. The prominence of one particular IS in a set generated from, for example, a text string, refers to a form of frame compositionality as in [1], which could be determined by syntax as well as discourse structure, depending on term, sentence and text compositionality. The `:IS_Profile` class is particularly relevant here since it's the class used for our evaluation system as described in Section 6.

[5] Available on arXiv as *ISAAC: an Image Schema Analysis And Comparison Ontology from Diverging Degrees of Formality Theories*
[6] http://etna.istc.cnr.it/framester2/sparql
[7] https://github.com/StenDoipanni/ISAAC/tree/main/ImageSchemaNet

### *4.2. ImageSchemaNet Properties*

All the activation declarations in ImageSchemaNet are realized via the `:activates` object property or its subproperties, which specify details about the way, layer, resource and type of activation. The meaning of `:activates` refers to some element that *activates* the cognitive substratum that is associated with an image schema. For instance, the verb *to contain*, the noun *container*, the frame `Containment`, and the frame element `Container` all activate the image schema CONTAINMENT.

For this reasons, the following sub-properties were introduced in the graph:

- `:activates` : declares the activation from a Framester or Framenet frame to an IS. It is the super-property to all the following properties
- `:closeMatchActivation` : used for the activation of some IS from entities which have a `skos:closeMatch` (close alignment declarations from Framester) to a FrameNet frame that activates an IS
- `:coreSPActivation`, `:peripheralSPActivation`, `:extraThematicSPActivation` : used for the activation of spatial primitives from FrameNet frame elements, which are distinguished into core (necessary), peripheral (optional), and extra-thematic (not frame-specific)
- `:lexicalSenseActivation` : used for lexical entities directly evoking spatial primitives or image schemas. This property represents activation based on: 1) very accurate manually verified alignments; 2) alignments inferred from logical rules. For example, the IS activation from WordNet synsets and Framester frames is realized by the query proposed in Appendix A, paragraph "Lexical Entity Activation", which encodes the following rule: if a synset *s* evokes a frame *f* that activates an IS *i*, then *s* activates *i*
- `:semTypeActivation` : used for semantic types used e.g. in FrameNet or VerbNet as selectional restrictions, which activate image schemas or spatial primitives
- `:semanticRoleActivation` : used for VerbNet arguments, FrameNet frame elements and PropBank roles activating spatial primitives
- `:gestaltActivation` : activation of an image schema through its spatial primitives

In Section 7 we provide examples of cases from Section 6, in which the assertion of some synset as activator could be acceptable or debatable, and some others in which a specific type of activation has been crucial for detecting the correct IS.

Some useful queries to explore the resource using the aforementioned properties can be found in Appendix B.

In the following section we describe the SPARQL queries used to retrieve Framester entities activating an image schema or a spatial primitive.

## 5. ImageSchemaNet Grounding Pipeline

There is no repository that aligns entities from different semantic layers (lexical units, semantic roles, framal structures, factual entities, etc.), to image schemas and spatial primitives. Moreover, albeit a few references could be found in FrameNet, no lexical grounding has been provided for image schemas.

In order to operationalise ImageSchemaNet, we have created a lexical and factual grounding with a *heuristic abstraction* method. The Framester hub is appropriate to heuristic abstraction, since it implements a formal frame semantics in OWL2, creating interoperability across lexical and factual resources that have been reengineered as knowledge graphs (or directly reused), and aligned to frames and foundational ontologies. The overall architecture of Framester provides then inheritance and unification within the resources integrated in the hub.

Since ImageSchemaNet is an extension of Framester, and image schemas are represented as a special kind of frames activated by other Framester elements, that grounding is straightforwardly performed according to the heuristic abstraction method presented in the following. We firstly provide a simple example of how ImageSchemaNet can be used after being grounded, in order to make the process more intuitive to the reader.

Given the sentence *The Obama administration had entered into an agreement with Iran*, we can: (a) tokenize the sentence into its main elements (*Obama administration*, *enter into agreement with*, *Iran*), (b) collect their senses and (c) disambiguate the contextually valid ones (e.g. Obama_Presidency from DBpedia entity linking, Enter_51010000 from VerbNet disambiguation, Joint Comprehensive Plan of Action from DBpedia, Iran state from DBpedia), (d) retrieve the frames evoked by the senses (Organization, Path_shape, Be_in_agreement_on_action, Political_locales, all from FrameNet), and finally (e) retrieve the image schema activated by an entity, a sense, or a frame (nil,SOURCE_PATH_GOAL,nil,nil).[8] .

In practice, the heuristic abstraction method reveals that the main image schema activated by the sentence is SOURCE_PATH_GOAL. The inferential structure of SOURCE_PATH_GOAL can further lead us to infer the roles played by an organization, an observed situation, and a political locale.

The exemplified heuristic abstraction can be performed with automated tools, which are evaluated in Section 6.

Let's move now to present the hybrid grounding procedure used to populate ImageSchemaNet on top of Framester. We have used both the queries listed in Appendix A, and manual revision. The queries can be reproduced on the Framester endpoint by substituting (manually or programmatically) the `insert_variable` element with the corresponding entity, as specified in the query description, and by providing the correct prefix as stated in Appendix A.

### 5.1. Frame-driven Activation

We have started looking for the frames activating some IS. The first search uses a non-disambiguated lexical unit (e.g. *contain* for the CONTAINMENT IS) to retrieve all the senses and frames evoked by a lexical unit in isolation. For example, for *contain*, the searching process can collect all its senses, and their evoked frames. Based on sense inheritance hierarchies (as available in OWL versions of WordNet and other lexical resources), the search is extended to more specific or more generic senses of e.g. *contain*, so extending the set of evoked frames, and potentially activated IS. This kind of query is exemplified on Framester and can be found in Appendix A at the "Frames Activation Query" paragraph and in the OWL file as annotation of the `:activates` object property using the `:operationalizedVia` annotation property.
However, the amount of senses and related frames can be large, and we need *contextual disambiguation* in order to make it more precise. After performing the query, the selection of frames activating an IS is done manually, and after the iteration of the query for all synonyms and hyponyms, the first phase of frames activation search is declared closed, and we move to the frame element activation search.

### 5.2. Frame Element-driven Activation

Frame element activation concerns the activation of a spatial primitive (SP), and can be performed similarly as with frames. This kind of query is exemplified by focusing on retrieving FrameNet frame elements of type "Core", "Extra-Thematic" and "Peripheral". After performing the query, the selection of frame elements is done manually, using as pivotal the set of frames selected in the step before, possibly enriching the set with further frames, not retrieved by the query in the first step. The query is available in Appendix A, in the "Frame Elements Activation Query" paragraph.

### 5.3. Lexical Unit-driven Activation

Activation from lexical material is a substantial part of the heuristic abstraction, and it is generated by automatically querying Framester knowledge base, asking for all the elements (typically WordNet synsets or VerbNet verb senses) that evoke a frame. The query is performed for all the frames retrieved and selected as activators by the Frame Activation query. The heuristic rule here is: if an entity evokes a frame, which activates an IS, than that entity should have some form of activation for the IS. The amount of elements retrieved may be considerable (for some IS, thousands of WordNet synsets). As a consequence, the synsets in the knowledge base are the most useful but potentially debatable part of the populated ImageSchemaNet knowledge graph, since they are retrieved making an inference from previous existing alignments, which may have different levels of confidence on their turn. For example, both the "vase" and "absolutism" terms end up activating the CONTAINER image schema, because some synsets for

[8] The "nil" values could be further populated by looking for possible activated spatial primitives

theoretical concepts of philosophical doctrines or behavioural attitudes (e.g., "absolutism") are aligned in Framester with a `skos:closeMatch` to the FrameNet frame `Containing` (possibly with a lower alignment confidence). In practice, "absolutism as a container" could be considered valid only when conceptual metaphors, e.g., IDEAS ARE OBJECTS, THINKING IS OBJECT MANIPULATION or CATEGORIES ARE BOUNDED REGIONS, are taken into account. A part of Section 7 discusses this and other debatable examples. This query could be found in Appendix A at paragraph "Lexical Elements Activation Query".

### *5.4. Semantic Role-driven Activation*

Activation assertions to FrameNet frame elements is extended through the multiple sources of semantic roles present in Framester (VerbNet arguments, PropBank roles, WordNet tropes, etc.). Semantic roles in Framester are organized as a complex taxonomy with a small top level that helps integrating them, and getting to the activated IS. The activation of spatial primitives (SP), modelled as semantic roles, is materialised via the `:semantiRoleActivation` property. Roles are retrieved with two queries, starting from top nodes of different graphs, in order to declare the activation of both general and specific roles. The queries are available in Appendix A in the "General Semantic Roles Activation" and "Specific Semantic Roles Activation" sections.

### *5.5. Semantic Type-driven Activation*

A final important aspect of populating the image schematic activation graph is constituted by the inner semantics of entity types. For example, a FrameNet semantic type like `Lateral`, `Leftish`, and `Motion_based_orientation` activates CENTER_PERIPHERY, while the frame element `Goal` in frames like `Attaching`, `Body_movement` or `Bringing` has the FrameNet semantic type `Goal`, and activates the GOAL spatial primitive. Further examples are provided in Section 7. The queries used for semantic type activation assertions include an initial query listing all existing semantic types, followed by a manual exploration of their differences and coverage, resulting in a selection of semantic types activating some IS or SP. Consequently, a second query is performed, looking for entities filtered by the aforementioned iteration of non-disambiguated lexical units from synsets and their hyponyms, also extracting their semantic type, ending in a final manual check of coherence between the entities retrieved, their semantic type, and their semantic type activation of an IS or SP. The queries are available at Appendix A, in paragraph "Semantic Type Activation Query".

## 6. Evaluation

Devising an evaluation method for ImageSchemaNet is not an easy task, since there is no previously available formal resource featuring IS activation, and no automatic tool able to detect and extract automatically IS from text. Consequently, no baseline is proposed. However, starting from a corpus of manually annotated sentences, we have performed an evaluation of ImageSchemaNet by using it as an extension to existing automated methods: the end-to-end OpenSesame frame parser, and the hybrid FRED frame-based machine reader. In practice, we have taken the entities extracted by those tools as annotations of the sentences in a manually-annotated corpus, and we have inferred their IS activation, eventually measuring the resulting accuracy with respect to the manual annotation.

### *6.1. Evaluation Setting*

The evaluation setting uses an excerpt of the ISCAT dataset[9], and state-of-the-art tools for frame detection from natural language.

The ISCAT excerpt has been taken from a cleaned version[10] of the ISCAT online resource. ISCAT is a repository of image schema sentences taken from a large variety of original sources, mainly from literature (e.g. [8, 41]), but

[9] Image Schema Database procured by Jörn Hurtienne, http://zope.psyergo.uni-wuerzburg.de/iscat
[10] https://github.com/dgromann/ImageSchemaRepository

also from some online sources (e.g. MetaNet, newspaper articles), which are listed in the cleaned repository. The sentences from the excerpt were manually annotated with one IS per sentence.

In this evaluation run, we selected 99 out of 2,478 sample sentences from the cleaned ISCAT excerpt. The reason for this extreme reduction of the evaluation set is due to the fact that the original dataset only annotates one image schema per sentence. The gold standard is limited to this unique annotation, but image schemas often co-occur in a single sentence or even phrase, and we were interested in whether the image schemas resulting from the evaluation pipeline would at all be possible for the sentence at hand. For that reason, we had to manually analyze all results, so providing a customised manual evaluation in addition to the automated standard evaluation.

Further criteria for selecting the set of sample sentences from the larger cleaned repository were (1) variety of original sources, (2) distribution of image schemas, (3) only image schemas already covered in ImageSchemaNet, (4) mixture of concrete and abstract examples, and (5) English language only. In terms of variety of sources, we wanted to ensure that not all samples are derived from the same authors, addressing similar ideas or scenarios.

The evaluation setting uses two frame parsers with totally different architectures, in order to get a finer assessment of the effect of ImageSchemaNet in the process. The parsers include OpenSesame [55] and FRED [56].

OpenSesame is an end-to-end system focused on frame (and semantic role) detection. Its trained model is based on softmax-margin segmental recurrent neural nets. As with most NLP tools, OpenSesame labels extracted textual segments rather then trying to abstract them as entities and their relations in a knowledge graph.

FRED is a hybrid knowledge extraction system with a pipeline including both statistical and rule-based components, aimed at producing RDF and OWL knowledge graphs, with embedded entity linking, word-sense disambiguation, and frame/semantic role detection.

The big differences between the two parsers are supposed to make evaluation nuances emerge across parsing paradigms (string-centric vs. entity-centric, informal vs. logical representation).

In order to evaluate ImageSchemaNet, we automatically parse natural language sentences in order to annotate them with frames from FrameNet, and we use these frames to get the activated image schemas as encoded in ImageSchemaNet. We then compare the automated annotations to the manual ones, in order to estimate the accuracy of the process, so providing the first results for explainable image-schema detection in natural language texts. Explainability is granted by the heuristic abstraction applied in ImageSchemaNet and in its usage with the parsers.

| **Image Schema** | **Count** |
|---|---|
| CONTAINMENT | 33 |
| CENTER_PERIPHERY | 19 |
| SOURCE_PATH_GOAL | 17 |
| PART_WHOLE | 14 |
| BLOCKAGE | 10 |
| SUPPORT | 6 |
| **Total** | 99 |

Table 1

Distribution of sentences per image schema

The image schemas covered in Framester and their frequency in the evaluation dataset are represented in Table 1, where we can notice that considerably more examples for CONTAINMENT were included than for the other image schemas. This distribution was selected to reflect the image schema frequency in the original dataset, with by far fewest examples for SUPPORT. Finally, both concrete, i.e., directly relating to a physical or real scenario, and non-physical, i.e., transferring physical aspects to a more abstract scenario, such as MIND AS A CONTAINER, sentences should be represented. The evaluation corpus is available in Appendix C as well as on the ImageSchemaNet GitHub.

### 6.2. Evaluation Procedure

In order to measure the coverage of ImageSchemaNet, an initial trigger in form of frames is required, which allows us to evaluate whether these frames lead to the correct image schema profile. To this end, we used natural

Table 2

Comparison of retrieved Image Schemas and Franes by OpenSesame and FRED

| Parser | Frame types | Frame tokens | IS Types | IS tokens | IS-Annnotated Sentences |
|---|---|---|---|---|---|
| OpenSesame | 15 | 57 | 6 | 78 | 75 / 99 |
| FRED | 39 | 127 | 6 | 126 | 53 / 99 |

Table 3

Comparison of weighted F1 scores by parser

| Parser | Precision | Recall | Weighted F1 | Processed Sentences |
|---|---|---|---|---|
| OpenSesame | 33.95 | 24.24 | 26.89 | 86 / 99 |
| FRED | 78.90 | 39.80 | 46.06 | 98 / 99 |

language sentences as initial frame triggers, and implemented a two-step pipeline. First, we parse natural language sentences with OpenSesame [57] and FRED [56], which return frames for each sentence. Second, frames are in turn used to query ImageSchemaNet, and identify potentially activated image schema profiles.

To evaluate the final result set from this approach, we first performed automated evaluation (against the original manual IS annotation) utilizing standard information extraction measures of precision, recall, and weighted F1 score. Each natural language sentence in the evaluation set is annotated with exactly one image schema. However, as discussed in Section 7, and shown in Table 2, in practice image schemas are commonly co-located in individual sentences or even phrases, and ImageSchemaNet enables the detection of more than one image schema per input sentence. For that reason, we have performed a second manual evaluation process to identify whether the returned image schema(s) is plausible for a given sentence.

### *6.3. Evaluation Results*

The dataset described in Section 6.1 and listed in Appendix C was used to test our pipeline approach for correct linking between frames detected in natural language and underlying image schema. In Table 2 we present data about frame detection from the selected corpus, noting a better performance from FRED except for the IS type, which were limited by default by the current ImageSchemaNet coverage of six image schemas. In Table 3 we present weighted F1 scores for each frame parser as well as for their confusion matrix.

Table 3 compares the final results of the two parsers on the evaluation set of 99 sentences, where the last column represents the number of sentences which were actually processed, due probably to syntactic parsing failure. For several sentences both parsers lead to a collocation of image schemas, which we counted as correct if the set contained the correct image schema. Please be reminded that several image schemas might be correct for a single sentence, however, each sentence in this dataset is manually annotated with only one. The result set of multiple image schemas contained the correct image schema for 11 result sets when using OpenSesame and for 15 with FRED. The overall results of FRED are significantly higher than those of OpenSesame, due to the fact that the former identifies more frames and synsets activating a correct image schema. This is also reflected by the absolute counts of sentences for which frames activating some IS (at least one) were detected, which were 75 for FRED and only 53 for OpenSesame, as shown in last column of Table 2.

To provide a more detailed analysis of the type of confusion that results from each parser, Fig. 1 provides the true labels on the vertical axis and the predicted labels on the horizontal axis for OpenSesame. A total of 94 examples are represented in this confusion matrix, since 5 sentences lead to a result set of more than one image schema that did not contain the true label. *NO_IS* means that no image schemas was returned from the pipeline, which are exactly the 46 sentences for which no frames could be detected. The most confusing image schema apparently was CONTAINMENT, where for 11 sentences frames linking to CENTER_PERIPHERY were returned, e.g. `Locative_relation` for the sentence *There was passion in her eyes* and many others. Overall, a tendency to confuse other image schemas with CENTER_PERIPHERY can be observed.

When using FRED to detect frames and their interlinking to image schemas, the highest number of correct results could be obtained for SOURCE_PATH_GOAL as depicted in Fig. 2. However, there was considerable confusion for

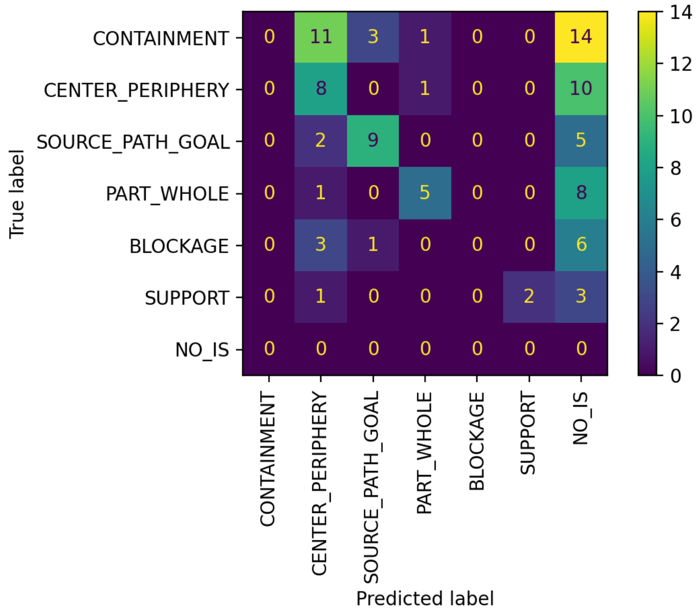


Fig. 1. Results of frame and image schema detection using OpenSesame

this image schema with CONTAINMENT where frames, such as `Motion` were returned for the sentence *The whole situation spiraled out of control*. This and other similar examples could benefit from a stronger preposition sense detection component both in FRED and Framester, which we plan to provide as stated in Section 8. Out of 99, only 91 samples are represented in this confusion matrix, because the remaining 8 sentences lead to a result set of more than one image schema that did not contain the true label.

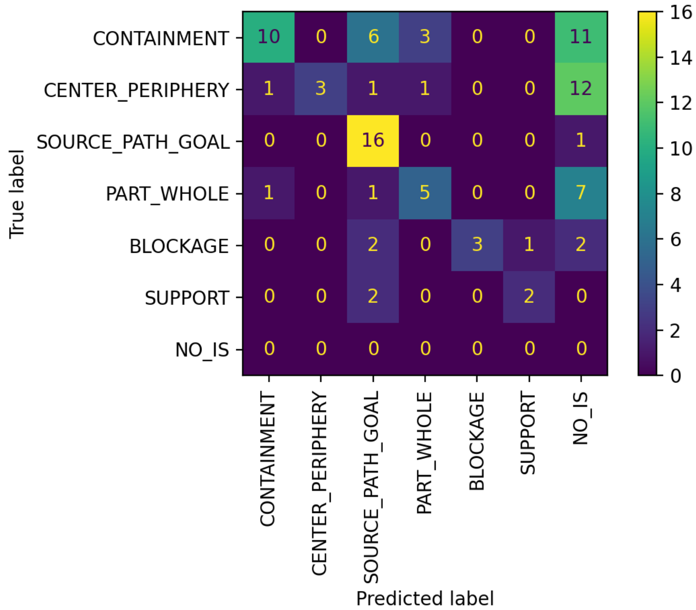


Fig. 2. Results of frame and image schema detection using FRED

Even though there is room for improvement, these results show that this idea of interlinking frames with an image-schematic layer in Framester is promising. The main bottleneck at the moment is the frame parser. For instance, a strong preposition to frame detection component in FRED could drastically improve these results, since prepositions are currently not considered in the tool, however, they provide a very strong indicator for spatial language and type of image schema (see also [51]).

The evaluation dataset is available in Appendix C, while the OpenSesame parsing file, FRED knowledge graphs generated from text, and manual IS and SP detection files can be found at the ImageSchemaNet GitHub.

We have manually inspected the returned image schemas with respect to whether (a) the returned image schema that does not correspond to the original gold standard label could be correct, and (b) whether several returned image schemas actually apply to the sentence at hand. For instance for (a), the expression *We are approaching the end of the year* is labeled with CENTER_PERIPHERY, however, clearly shows a collocation with SOURCE_PATH_GOAL. And for (b), for instance, *My symptoms went away* is labeled as CENTER_PERIPHERY. FRED parser, as shown in Figure 3, detects three frames: `Motion`, `Travel` and `Departing`. All of them activate SOURCE_PATH_GOAL but `Departing` also activates CENTER_PERIPHERY, which is the label from the ISCAT repository. OpenSesame, on the contrary, as shown in Figure 4, detects only `Motion` from the verb *go*, but recognizes the `Motion` frame element `Distance`, which has a `:coreSPActivation` towards PATH and PERIPHERY. Consequently, the `:IS_Profile` according both to FRED and OpenSesame shows a co-activation of SOURCE_PATH_GOAL and CENTER_PERIPHERY.

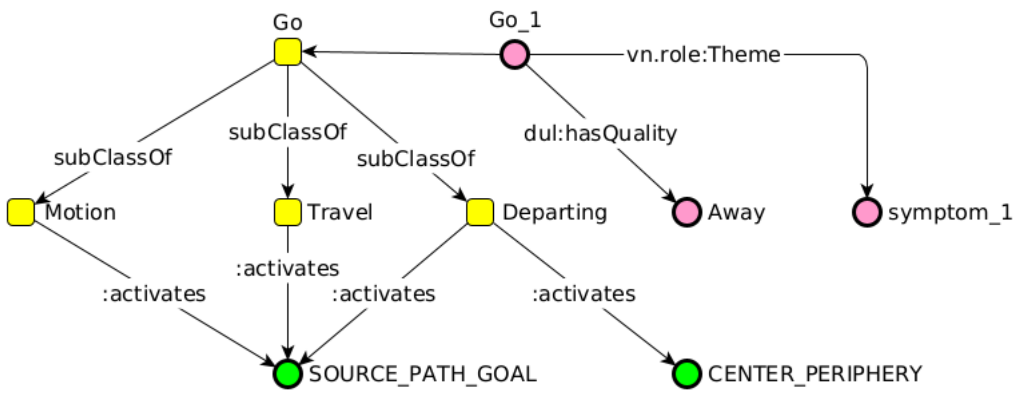


Fig. 3. FRED graph with image schemas activation for *my symptoms went away*

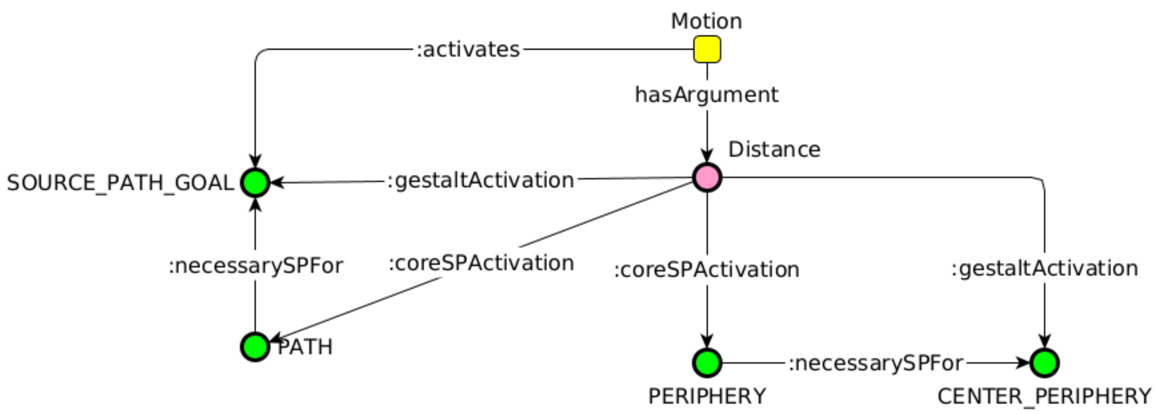


Fig. 4. OpenSesame graph with image schemas activation for *my symptoms went away*

The method based on OpenSesame showed a preference for CENTER_PERIPHERY irrespective of the gold standard label. In 40 of 53 annotated sequences the method returned one image schema, of which 13 were correct and 16 returned reasonable image schemas even though not corresponding to the gold standard label. The remaining 13 sequences of 53 were annotated with more than one image schema, out of which 10 contained the gold standard label, and 9 out of the 13 represented correct image schema collocations.

The method based on FRED frequently returned SOURCE_PATH_GOAL when the label is CONTAINMENT, where in all of these six cases a collocation of both could be observed, e.g. *Try to get out of those commitments*. Interestingly, slight lexical variation would result in the same set of image schemas, e.g. *He took the problem apart piece by piece* and *He tore the problem apart looking for its solution* would both be annotated with BLOCKAGE, SOURCE_PATH_GOAL, and PART_WHOLE, whereas the gold label only considered PART_WHOLE. For FRED, 44 natural language sequences out of 65 annotated only resulted in one image schema, of which 24 corresponded to the gold label and 13 where image schemas that can be considered also correct. In 21 cases the method relying on FRED returned more than one label, of which 14 contained the gold standard label and 11 provided reasonable collocations of up to three image schemas.

## 7. Discussion

Evaluation results open a discussion on many aspects, about different layers of analysis and empirical evidence, from which some preliminary observation can be sketched.

Some IS, in fact, at least from their lexical base, seems to have a more intelligible nature than others, like PART_WHOLE, which is the one actually used to define the very core of image schemas as gestalt structures, in some curious form of meta-circularity. Moreover, PART_WHOLE is declared to be activated by some conceptual frame like `PartWhole`, but the decision becomes more problematic when facing frames, such as `BodyParts`. This activation would in fact allow the whole lexical base of `BodyParts` evocators to be also activators of PART_WHOLE, as described in Section 5, but this does not seem the most efficient decision, since it would result in cases like e.g. "liver" activating PART_WHOLE. For sure from a certain point of view this is acceptable, being the liver part of the human body, but the risk is to introduce too much noise. One strategy we put into practice is, depending on the case, to declare as activators both the frame and its lexical base, or the frame only, or even selected synsets only, and this was possible thanks to the ImageSchemaNet object property diversification.

Similar to the aforementioned case is CONTAINMENT. From exploring the resource it seems that some abstract concepts and doctrines, e.g. humanism, evoke the `Containing` frame, and, for this reason, they are activators of CONTAINMENT in ImageSchemaNet. Being a work in progress we respected the rationale in FrameNet, since it is probable that such abstract concepts might be used as in specific contexts. This hypothesis could be tested on a larger lexical corpus, including also longer texts, and lexical data can be analyzed in their different aspects, crossing them and considering also, for example, their semantic type.
Referring again to the initial example of "water is sold in bottles", an autonomous agent operating in uncertain conditions being able to make inferences starting from the semantic type of an entity could be able to make, starting from the lexical unit, the inference that, if the synset `water-noun-1` has a `:semTypeActivation` of SUBSTANCE, then, in order to be moved on purpose and in its integrity, it is necessarily contained in some CONTAINER. In this specific case, the `waterbottle-noun-1` which has a `:lexicalSenseActivation` of CONTAINER.

Finally, some activations are intrinsic to the commonsense semantics of a frame or lexical unit. It is the case of the `Storing` and `Ingestion` Framester frames, which in three occasions are the sole elements which correctly allows the detection of CONTAINMENT. Instead in the sentence *He tore the problem apart looking for its solution* we face a false positive, since the correct activation of PART_WHOLE is not due to "tear" or "apart" or a combination of both, but stems from a wrong disambiguation of "solution" onto the chemistry-related sense, as a compound of particles.

## 8. Conclusions and Future Work

We presented ImageSchemaNet, a resource of more than 40,000 triples, which formalizes image schemas with a Framester semantics, so providing an image-schematic layer to FrameNet, MetaNet, WordNet, VerbNet, and other resources in the Framester hub. ImageSchemaNet has been built starting from image schema definitions and examples in literature, and provides lexical coverage as image schema or spatial primitive activators retrieved via SPARQL queries from Framester. ImageSchemaNet allows non trivial image schema profile extraction from various semantic layers, including disambiguated natural language units from multiple semantic resources, semantic roles, frames, semantic types, and individual entities. This extraction has been exemplified in an empirical evaluation of annotating natural language sentences with frame parsers and ImageSchemaNet.

As future work, we plan to extend the coverage of ImageSchemaNet to all image schemas in literature, e.g., Verticality, Scale, etc. As a direct consequence, other than a quantitative improvement of the resource, this extension would enable further investigation on relations among image schemas in order to clarify possible taxonomic, lexical, functional, mereological and usage relations between IS, bringing greater clarity on frame compositionality and the related underlying commonsense reasoning.

From an operational perspective, we plan to realize a fine tuning of the FRED tool, with a focus on image schema detection and image schema profile extraction from natural language. One such improvement would be the consideration of prepositions in the parsing process, which is currently not the case. We also envisage to integrate recently proposed BERT-based frame detection algorithms (e.g., [58]). Second, we intend to provide a tool that directly proposes image schemas for natural language sequences without a two-step pipeline process as done in our empirical evaluation. This would allow non-trivial spatial commonsense inferences starting from image schematic reasoning, with application in the robOntics field (robotics with ontological based reasoning systems).

## Appendix A. Building The Resource

The following queries can be performed at Framester endpoint: http://etna.istc.cnr.it/framester2/sparql using the uri: <http://www.ontologydesignpatterns.org/ont/is/isnet.owl#>

### *Frames Activation Query*

```
 SELECT DISTINCT ?frame
WHERE {
?frame rdf:type fschema:ConceptualFrame , owl:Class ;
rdfs:subClassOf fschema:FrameOccurrence ;
owl:sameAs ?fnframe .
?fnframe skos:closeMatch ?syn ; a fn15schema:Frame .
?syn wn30schema:senseLabel "insert_variable"@en-us
}
```

### *Frame Elements Activation Query*

```
 SELECT DISTINCT ?corefe ?etfe ?perife
WHERE {
{ ?frame1 fn15schema:hasFrameElement ?corefe .
?corefe
<https://w3id.org/framester/framenet/tbox/FE_coreType> "Core" ^^xsd:string
.
FILTER(regex(?corefe, "insert_variable", "i")) }
UNION
{ ?frame2 fn15schema:hasFrameElement ?etfe .
?etfe <https://w3id.org/framester/framenet/tbox/FE_coreType>
```

```
"Extra-Thematic"^^xsd:string .
FILTER(regex(?etfe, "insert_variable", "i")) }
UNION
{ ?frame3 fn15schema:hasFrameElement ?perife .
?perife <https://w3id.org/framester/framenet/tbox/FE_coreType>
"Peripheral"^^xsd:string .
FILTER(regex(?perife, "insert_variable", "i")) }
}
```

*Lexical Elements Activation Query*

```
 SELECT DISTINCT ?framestersyn ?wnsyn
WHERE { <insert_frame_uri>
<https://w3id.org/framester/schema/subsumes> ?framestersyn .
?framestersyn a <https://w3id.org/framester/schema/WnSynsetFrame> ;
<https://w3id.org/framester/schema/unaryProjection> ?wnsyn .
}
```

*General Semantic Roles Activation Query*

```
 SELECT DISTINCT ?argument ?fe ?gfe ?genRole ?genArg ?tropeRole ?semRole
{ GRAPH ?g {
{ ?argument a <https://w3id.org/framester/vn/schema/Argument>.
FILTER(regex(?argument, "insert_variable", "i")) }
UNION
{ ?fe a <https://w3id.org/framester/framenet/tbox/FrameElement> .
FILTER(regex(?fe, "insert_variable", "i")) }
UNION
{ ?gfe a <https://w3id.org/framester/framenet/tbox/GenericFE> .
FILTER(regex(?gfe, "insert_variable", "i")) }
UNION
{?genRole a <https://w3id.org/framester/schema/GenericRole> .
FILTER(regex(?genRole, "insert_variable", "i")) }
UNION
{ ?genArg a <https://w3id.org/framester/vn/schema/GenericArgument> .
FILTER(regex(?genArg, "insert_variable", "i")) }
UNION
{ ?tropeRole a
<https://w3id.org/framester/wn/wn30/wordnet-verbnountropes/TropeRole> .
FILTER(regex(?tropeRole, "insert_variable", "i")) }
UNION
{ ?semRole a <https://w3id.org/framester/schema/semanticRole> .
FILTER(regex(?semRole, "insert_variable", "i")) }
} }
```

*Specific Semantic Roles Activation Query*

```
 SELECT DISTINCT ?x ?coreRole ?y ?arg ?z ?fe ?k ?role ?s ?necRole ?q ?optRole
?r ?vnRole
{ GRAPH ?g {
{ ?x <https://w3id.org/framester/schema/coreRole> ?coreRole .
FILTER(regex(?coreRole, "insert_variable", "i")) }
UNION
{ ?y <https://w3id.org/framester/vn/schema/hasArgument> ?arg .
```

```
FILTER(regex(?arg, "insert_variable", "i")) }
UNION
{ ?z <https://w3id.org/framester/framenet/tbox/hasFrameElement> ?fe .
FILTER(regex(?fe, "insert_variable", "i")) }
UNION
{ ?k <https://w3id.org/framester/pb/pbschema/hasRole> ?role .
FILTER(regex(?role, "insert_variable", "i")) }
UNION
{ ?s <https://w3id.org/framester/schema/necessaryRole> ?necRole .
FILTER(regex(?necRole, "insert_variable", "i")) }
UNION
{ ?q <https://w3id.org/framester/schema/optionalRole> ?optRole .
FILTER(regex(?optRole, "insert_variable", "i")) }
UNION
{ ?r <https://w3id.org/framester/schema/vnRole> ?vnRole .
FILTER(regex(?vnRole, "insert_variable", "i")) }
} }
```

***Semantic Type Query***

```
 SELECT DISTINCT ?entity ?semanticType
WHERE {
?entity
<https://w3id.org/framester/framenet/tbox/hasSemType> ?semanticType .
FILTER(regex(?entity, "insert_variable", "i"))
}
```

## Appendix B. Exploring The Resource

Some useful queries which show how the resource can be explored. A desired prefix can be substituted to "isnet:" declaring the uri: <http://www.ontologydesignpatterns.org/ont/is/isnet.owl#> on the Framester enpoint.

***ASK***

Query to ask if some entity is a lexical activator of some spatial primitive which is necessary to the image schema CONTAINMENT.

```
ASK
?entity isnet:lexicalSenseActivation ?sp .
?sp ^isnet:necessarySP isnet:CONTAINMENT .
```

***SELECT***

Query to retrieve all the entities, image schemas and spatial primitives for which some entity is a lexical activator of some SP which is a necessary SP to some IS.

```
SELECT DISTINCT ?entity ?is ?sp
WHERE {
?entity isnet:lexicalSenseActivation ?sp .
?sp ^isnet:necessarySP ?is .
FILTER(regex(?entity, "insert_variable", "i")) }
```

***CONSTRUCT***

Query to simulate the image-schema-profile extraction starting from a single non disambiguated lexical unit. The query can be executed by replacing each "insert_variable" with the same lexical unit.

```
CONSTRUCT { [] isnet:ISProfile ?isLex , ?coresp , ?perisp , ?etsp , ?semis
, ?rolesp . }
WHERE {
{ ?x1 isnet:lexicalSenseActivation ?isLex .
FILTER(regex(?x1, "insert_variable", "i")) }
UNION
{ ?x2 isnet:coreSPActivation ?coresp .
FILTER(regex(?x2, "insert_variable", "i")) }
UNION
{ ?x3 isnet:peripheralSPActivation ?perisp .
FILTER(regex(?x3, "insert_variable", "i")) }
UNION
{ ?x4 isnet:extraThematicSPActivation ?etsp .
FILTER(regex(?x4, "insert_variable", "i")) }
UNION
{ ?x5 isnet:semTypeActivation ?semis .
FILTER(regex(?x5, "insert_variable", "i")) }
UNION
{ ?x6 isnet:semanticRoleActivation ?rolesp .
FILTER(regex(?x6, "insert_variable", "i")) }
}
```

## Appendix C. Evaluation Materials

Fig. 5. Evaluation Corpus

| 1 | IMAGE_SCHEMA_ANNOTATION | LinguisticExamples | [SOURCE] |
|---|---|---|---|
| 2 | CENTER-PERIPHERY | That's just a peripheral issue. | [Lakoff et al., 1991:13] |
| 3 | CENTER-PERIPHERY | This is the core of the matter. | [Lakoff et al., 1991:13] |
| 4 | CENTER-PERIPHERY | Put aside for a moment the fact that the man has been in prison. | [Jäkel:158-159] |
| 5 | CENTER-PERIPHERY | In the midst of the nation's grief. | [Verbytska 2017] |
| 6 | CENTER-PERIPHERY | The chairman has managed to weave together quite a coalition | [Grady 1998] |
| 7 | CENTER-PERIPHERY | I can't tell them apart. | [Lakoff et al., 1991:60] |
| 8 | CENTER-PERIPHERY | These ideas are closely related. | MetaNet |
| 9 | CENTER-PERIPHERY | France has close ties to former colony Tunisia | www.allvoices.com/.../78525367-france-has-close-ties-to-former-col... |
| 10 | CENTER-PERIPHERY | Far be it for me to try and teach you your job, but… | [BNC, 2007] |
| 11 | CENTER-PERIPHERY | That's a far-fetched idea. | [Tolaas, 1991:216] |
| 12 | CENTER-PERIPHERY | I feel close to him. | [Lakoff et al., 1991:155] |
| 13 | CENTER-PERIPHERY | He distances himself. | [Lakoff et al., 1991:155] |
| 14 | CENTER-PERIPHERY | People who are dear to us should be near us. | [Krzeszowski, 1997:118] |
| 15 | CENTER-PERIPHERY | Who's with me? | MetaNet |
| 16 | CENTER-PERIPHERY | We are approaching the end of the year. | [Núñez & Sweetser 2006:438] |
| 17 | CENTER-PERIPHERY | It is close on midnight. | [Hurtienne & Meschke, 2016] |
| 18 | CENTER-PERIPHERY | He was close to tears. | [Hurtienne & Meschke, 2016] |
| 19 | CENTER-PERIPHERY | My symptoms went away. | MetaNet |
| 20 | CENTER-PERIPHERY | Canada is by far the closest of all our neighbors. | http://www.historians.org/projects/GIRoundtable/Canada/Canada_Intro.htm |
| 21 | CONTAINMENT | What obligations have you gotten yourself into? | [Lakoff et al., 1991:33,207] |
| 22 | CONTAINMENT | Try to get out of those committments, don't let your boss box you in. | [Lakoff et al., 1991:33,207] |
| 23 | CONTAINMENT | Have they entered into an agreement yet? | [Lakoff et al., 1991:33] |
| 24 | CONTAINMENT | My morning has been very full. | [Grady 1998] |
| 25 | CONTAINMENT | Who put that idea in your head? | [Jäkel:156-157] |
| 26 | CONTAINMENT | Keep it in the back of your mind | MetaNet |
| 27 | CONTAINMENT | Open your mind to some new thoughts. | [Jäkel:158] |
| 28 | CONTAINMENT | I've kept this in my memory for years. | [Jäkel, 2003:168] |
| 29 | CONTAINMENT | There was passion in her eyes. | [Lakoff & Johnson, 1980:50] |
| 30 | CONTAINMENT | The ship is coming into view. | [Lakoff & Johnson, 1980:30] |
| 31 | CONTAINMENT | He's out of sight now. | [Lakoff & Johnson, 1980:30] |
| 32 | CONTAINMENT | He's a young man trapped in an old man's body. | [Lakoff et al., 1991:209] |
| 33 | CONTAINMENT | He's a beautiful person inside. | [Lakoff et al., 1991:209] |
| 34 | CONTAINMENT | She was filled with hatred. | [Raymond:43] |
| 35 | CONTAINMENT | The truth had to be dragged out of him. | [Lingua] |
| 36 | CONTAINMENT | We're in a mess. | [Lakoff et al., 1991:75] |
| 37 | CONTAINMENT | We're in a lot of trouble now. | [Lakoff et al., 1991:75] |
| 38 | CONTAINMENT | The solution finally was brought to light. | [Jäkel:164] |
| 39 | CONTAINMENT | We fished out a number of unpleasant facts. | [Jäkel:164] |
| 40 | CONTAINMENT | I put a lot of energy into washing the windows. | [Lakoff & Johnson, 1980:31] |
| 41 | CONTAINMENT | He's in love. | [Lakoff & Johnson, 1980:32] |
| 42 | CONTAINMENT | I'm slowly getting into shape. | [Lakoff & Johnson, 1980:32] |
| 43 | CONTAINMENT | The limit must be drawn somewhere. | [Tolaas, 1991:216] |
| 44 | CONTAINMENT | This goes beyond all bounds. | [Tolaas, 1991:216] |
| 45 | CONTAINMENT | The whole situation spiraled out of control. | Ellen |
| 46 | CONTAINMENT | There are twenty members in this group. | MetaNet |
| 47 | CONTAINMENT | He kept a lid on anger | [Stefanowitsch:19] |
| 48 | CONTAINMENT | He's bursting with excitement. | MetaNet |
| 49 | CONTAINMENT | There is both cotton and polyester in that shirt. | [Grady 1998:121] |
| 50 | CONTAINMENT | let the cat out of the bag | [Clausner & Croft, 1997:265] |
| 51 | CONTAINMENT | The wind bellied out the sails. | [Lingua] |
| 52 | CONTAINMENT | You're getting off the subject. | [Lakoff & Johnson, 1980:91] |
| 53 | CONTAINMENT | They had a falling out. | MetaNet |
| 54 | PART-WHOLE | They pieced a theory together. | [Lakoff et al., 1991:114] |
| 55 | PART-WHOLE | I'm going to pieces. | [Lakoff & Johnson, 1980:28] |
| 56 | PART-WHOLE | He took the problem apart piece by piece. | [Lakoff et al., 1991:200] |
| 57 | PART-WHOLE | He tore the problem apart looking for its solution. | [Lakoff et al., 1991:200] |
| 58 | PART-WHOLE | Something is missing in that argument. | [Lakoff et al., 1991:138] |
| 59 | PART-WHOLE | His thoughts are scattered. | [Lakoff et al., 1991:138] |
| 60 | PART-WHOLE | I'm missing a piece of the puzzle. | [Lakoff et al., 1991:138] |
| 61 | PART-WHOLE | We are one. | [Lakoff et al., 1991:154] |
| 62 | PART-WHOLE | She is my other half. | [Lakoff et al., 1991:154] |
| 63 | PART-WHOLE | Five is made up of two plus three. | [Lakoff & Nunez, 2000:65] |
| 64 | PART-WHOLE | The Milky Way belongs to a cluster of galaxies. | MetaNet |
| 65 | PART-WHOLE | Our galaxy has at least 100 billion planets. | MetaNet |
| 66 | PART-WHOLE | The eye possesses several parts. | MetaNet |
| 67 | PART-WHOLE | Which car part belongs to which car? | MetaNet |
| 68 | SOURCE_PATH_GOAL | Let's meet the future head-on. | [Lakoff & Johnson, 1980:43] |
| 69 | SOURCE_PATH_GOAL | The deadline is approaching. | [Lakoff & Johnson, 1999:143] |
| 70 | SOURCE_PATH_GOAL | There's going to be trouble along the road. | [Kövecses, 2002:34, Lakoff et al.:146] |
| 71 | SOURCE_PATH_GOAL | Things are going my way. | [Lakoff & Johnson, 1999:192] |
| 72 | SOURCE_PATH_GOAL | Let's keep moving forward. | [Lakoff, 1990:60] |
| 73 | SOURCE_PATH_GOAL | You are falling behind on your studies. | [Macaranas et al. 2012] |
| 74 | SOURCE_PATH_GOAL | He went over the edge. | [Lakoff et al., 1991:148] |
| 75 | SOURCE_PATH_GOAL | He finally reached his goals. | [Kövecses, 2002:135] |
| 76 | SOURCE_PATH_GOAL | It took him hours to reach a state of perfect concentration. | [Lakoff et al., 1991:8] |
| 77 | SOURCE_PATH_GOAL | As we travel down life's path. . . | [Lakoff et al., 1991:36] |
| 78 | SOURCE_PATH_GOAL | His life has taken a good course. | [Grady 1998:113] |
| 79 | SOURCE_PATH_GOAL | I go where my path leads me. | [Grady 1998:113] |
| 80 | SOURCE_PATH_GOAL | As I've traveled through life, I've made a lot of friends along the way. | [Grady 1998:113] |
| 81 | SOURCE_PATH_GOAL | He has changed his direction in life, and taken a more spiritual path. | [Grady 1998:113] |
| 82 | SOURCE_PATH_GOAL | He started going down a bad life path. | MetaNet |
| 83 | SOURCE_PATH_GOAL | He's no longer with us. | MetaNet |
| 84 | SOURCE_PATH_GOAL | They stopped me from leaving. | [Lakoff & Johnson, 1999:204] |
| 85 | SUPPORT | Our conservation program needs your support. | [Grady 1998] |
| 86 | SUPPORT | I've really been leaning on my friends the past few months. | [Grady 1998] |
| 87 | SUPPORT | The poor in our country need a boost up. | MetaNet |
| 88 | SUPPORT | In times of need, the impoverished should be able to lean on our government for support. | MetaNet |
| 89 | SUPPORT | Our conservation program needs your support. | [Grady 1998] |
| 90 | SUPPORT | I've really been leaning on my friends the past few months. | [Grady 1998] |
| 91 | FORCE | Let's try to get around this problem. | [Kövecses, 2002:74] |
| 92 | FORCE | We ran into a brick wall. | [Lakoff & Johnson, 1999:189] |
| 93 | FORCE | We hit a roadblock. | [Lakoff 1990:58] |
| 94 | FORCE | Our project has hit a roadblock. | MetaNet |
| 95 | FORCE | We have a lot of hurdles to get over in our relationship. | MetaNet |
| 96 | FORCE | Recently enacted policies provide cover for companies engaged in illicit activities. | MetaNet |
| 97 | FORCE | My life is going nowhere - I'm just spinning my wheels. | MetaNet |
| 98 | FORCE | Break out of your daily routine. | [Lakoff & Johnson, 1999:188] |
| 99 | FORCE | Workers of the world throw off your chains! | [Lakoff & Johnson, 1999:188] |
| 100 | FORCE | All these rules and regulations are obstacles to innovation. | MetaNet |

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