Analyzing the Imagistic Foundation of Framality via Prepositions

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Abstract. Natural language understanding is a vibrant research area in Artificial Intelligence that requires linguistic and commonsense knowledge. To unite both types of knowledge, FrameNet associates words with semantic frames, conceptual structures that describe a type of object, event or situation. Frames are interrelated and feature some image schematic foundations. However, the resource's usefulness is limited by non-standard semantics. Framester, lying on a solid formal frame semantics, reengineers and links FrameNet to lexical and ontological resources to create one joint, powerful knowledge base. In this paper, we use Framester of FrameNet and of the Preposition Project (TPP) to systematically analyze the image-schematic foundation of frames via preposition senses. Framal knowledge is extracted from TPP, which contains senses for each English preposition, and frame interrelations are analyzed for the imagistic foundation of framality via preposition senses.

Keywords. frame semantics, prepositions, image schemas, ontology alignment, Linguistic Linked Data, knowledge graphs

1. Introduction

Automatically understanding natural language has been one of the most central challenges in Artificial Intelligence over the past centuries. In Natural Language Processing (NLP) research on extracting commonsense knowledge from text mainly follows two strands: action and situational knowledge, or structured relational knowledge. A third stream is provided by FrameNet [1], which uses frame semantics [8] to map word meaning to semantic frames, also establishing semantic roles and inter-frame relations. For instance, the `Spatial_contact` frame typically involves roles such as `figure` (an entity or event located with contact to a ground), `ground` (the basis for describing the location of the figure), `temporal profile`, `direction`, etc. Those roles are often evoked by prepositions: *on*, *against*, *on top of*, *upon*, *off*, by verbs: *contact*, *touch*, by adjectives: *tangent*, or by nouns, e.g. *contact*.

FrameNet has an analytic approach to base framality in imagism. Imagism denotes that our experiences derive from sensory experiences with the external world [7], and

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in this paper it refers to the theories of image schemas, which are generally described as spatio-temporal relationships that indicate a sense of motion, and are abstract patterns of sensori-motor experiences [13,14]. The inventory of image schemas in this paper is taken from [13,14]. The previous example frame is associated with the frame `Contact_image_schema`, which by definition relates to the CONTACT image schema [13], and is one of five subframes of the `Image_schema` frame. A multitude of frames relate by definition, lexical unit, and naming to image schemas, however, no explicit relation to the abstract, non-lexical `Image_schema` frame is established. The complexity of uncovering embodied schemas in the structure of FrameNet has been analyzed before [2,6], however, without the utilization of formal means.

Since FrameNet lacks a formal semantics, and it is hardly comparable to other lexical and factual resources, Framester [9] provides a formal representation, while simultaneously establishing relations to other linguistic linked data, factual resources, and ontology schemas. Framester can be used to jointly query all the resources aligned to its formal frame ontology.

In this paper, we extract framal knowledge from preposition senses, and analyze their image-schematic grounding. The proposed method, using the Framester SPARQL endpoint, retrieves frames associated with preposition senses and their lexical units, as well as relations to other frames, and analyzes the resulting frame sets in order to reconstruct their image-schematic grounding.

Prepositions represent an important vehicle for semantic roles in natural language. Evidence from cognitive linguistics research has theoretically [15,23] and practically [5, 16] proven their importance in defining spatio-temporal relationships in natural language. For instance, the expression *the cat is on the mat* experiences a drastic alteration of spatio-temporal relationships when replacing the preposition *on* with *above*, *below* or *all over*. Due to the multiplicity of meanings a single preposition potentially expresses, the image-schematic analysis of this word class has fascinated researchers for decades [4,5,12] and across languages [11].

Starting with preposition senses from The Preposition Project (TPP) [16], we analyze all explicit or implicit image-schematic foundations in FrameNet. By "explicit" we refer to frames related to the `Image_schema` frame, or stating "image schema" in their definition, while "implicit" refers to frames that feature a substantial definitional overlap with image schemas, but have no direct explicit association. Our contributions are as follows:

- three methods to detect image-schematic frames based on preposition senses annotated with frames:
  - extracting all frames explicitly linked to image-schematic frames by inter-frame relation utilizing the Framester SPARQL endpoint and frames relating to "image schema" in their definition
  - extracting all frames used to annotate preposition senses and manually analyzing their definitions for their image-schematic content
  - extracting all frames related to the lexical units of prepositions and manually analyzing their definitions for their image-schematic quality
- a repository of frames with image-schematic grounding in order to in the future obtain a complete image-schematic grounding of FrameNet

Given such a repository, annotating natural language also other than prepositions with image-schemas will be facilitated. To the best of our knowledge no such comprehensive analysis of image-schematic structures in FrameNet has been conducted so far.

The structure of our paper is as follows. In Sect. 2, we first provide preliminary definitions of the resources utilized in this study and their relation to image schemas. In Sect. 3, we detail approaches analyzing image-schematic grounding of prepositions or image-schematic representations in FrameNet, a combination of which has, to the best of our knowledge, not yet been conducted. Subsequently (Sect. 4), we detail the three aspects of our analysis method and their results (Sect. 5). After a discussion of our findings, the paper ends with concluding remarks.

2. Preliminaries

Ontological modeling of FrameNet in Framester is associated with image-schematic representations by way of prepositional meaning. Three resources are used in this work, which are briefly described here. Both FrameNet and the Preposition Project (TPP) have been used in their RDF/OWL representation (the FrameNet reengineering procedure is detailed in [17]) currently existing in the Framester distribution (accessible via SPARQL endpoint or as a dump).[2]

2.1. FrameNet

FrameNet [1] tackles a long-standing research challenge to represent natural language in machine- and human-readable way with a theoretical foundation in frame semantics [8]. In this theory, word meaning is best understood as *evoking* a situation type, with its participants, and props, which is called a *frame*, where frame elements (FE) are participant roles. A word or phrase may have one or more lexical units (LU) that is linked to a frame, and marked with a disambiguating part-of-speech (POS) tag, e.g. “near.a” for an adjectives and “near.prep” denoting a preposition. Associations of lemmas with frames were accomplished in a manual annotation process[3].

Frames are interrelated through inheritance, subframe, using, and perspectival relations [21]. *Inheritance* denotes a subsumption relation, e.g. `Fluidic_motion` is subsumed by `Motion`. *Subframe* denotes an (intensional) part of a frame, e.g. `Halt` is a subframe of `Motion`. *Using* denotes a presupposition or entailment, e.g. `Bringing` presupposes `Motion`. `Perspective` means that there are at least two point of view for a same situation, e.g. `Giving` is a perspective on `Transfer`.

Semantic types are used as selectional constraints over frame elements, e.g. the `Sentient` type constrains the `Agent` role in the `Activity` frame.

Finally, some frames are marked as *non-lexical* when they are not supposed to bear a direct lexicalisation. Examples include all frames subsumed by the `Image_schema` frame, and a few others, e.g. `Source_path_goal`.

[2]`https://github.com/framester/Framester`
[3]Frames can be explored from the online platform `https://framenet.icsi.berkeley.edu/fndrupal/`

2.1.1. Image Schemas in FrameNet

A top-level frame called `Image_schema` is semantically typed as non-lexical frame and defined as "A Profiled_region is picked out relative to a Ground"[4]. It is equipped with two FEs, `Ground` and `Profiled_region`, and subsumes five more specific frames as summarised in Table 1. The `Alignment_image_schema` could be interpreted as VERTICALITY, `Bounded_region` clearly relates to CONTAINMENT, and the `Contact_image_schema` is reminiscent of CONTACT. The `Proximity_image_schema` could potentially relate to NEAR-FAR but is too vaguely defined by differentiating it from two other vaguely defined schemas, which makes it difficult to interpret. The most difficult to map to image schemas is the `Collocation_image_schema`, which could potentially be argued as representing COVERING [4,5]. Further specifications are provided by frames inheriting from those image-schematic frames, such as differentiating *gradable* and *non-gradable* proximity.

Image Schema Frame	**Definition**
`Alignment_image_schema`	An `Alignment_match` region has the same orientation as the relatively linear Ground. The Alignment_mismatch region is oriented perpendicularly to the Ground.
`Bounded_region`	An Exterior, Surface, Boundary, and Interior are picked out relative to the Ground. This Ground may either occupy only the Boundary (in which case the Interior is negative space) or the Ground may fill the Interior.
`Collocation_image_schema`	A Profiled_region is specified as entirely or largely coinciding with that of a Ground.
`Contact_image_schema`	A Profiled_region occupies the space in contact with the Ground.
`Proximity_image_schema`	A Profiled_region is picked out which is near to the Ground to a certain Degree. [...] The Profiled_region cannot contact or overlap the location of the Ground, as contact, in English, is a categorically different situation–see `Contact_image_schema` and `Collocation_image_schema`.

Table 1. Explicitly image-schematic frames in FrameNet

As evident from Table 1, the set of image schema frames in FrameNet is vague and incomplete. An image-schema savvy reader will immediately notice a substantial omission of crucial image schemas, such as SOURCE_PATH_GOAL, SURFACE, SUPPORT, and CENTER-PERIPHERY. Some partially or fully corresponding frames exist without a direct relation or association to their potentially image-schematic basis. For instance, the frame `Path_traveled` is defined as "A Path, a series of connected locations, is traversed by a Theme, moving under its own power or under the influence of a physical force. The Path may be described in various terms depending on whether it is bounded or not. If it is bounded, the Path may be identified by its Endpoints, which may be presented separately as Source and Goal"[5]. This definition aligns well with the definition of the SOURCE_PATH_GOAL image schema.

FrameNet also explicitly represents metaphoric use of expressions, by providing sentence-level tags such as "Metaphor" [21]. However, a sentence-level mapping pro-

[4]Source `https://framenet2.icsi.berkeley.edu/fnReports/data/frameIndex.xml?frame=Image\_schema`

[5]Source `https://framenet2.icsi.berkeley.edu/fnReports/data/frameIndex.xml?frame=Path_traveled`

vides little usage for the annotation of prepositions. In fact, this mapping is explicitly described as vague in FrameNet documentation [21].

This incomplete and partly vague representation of imagism in framality has motivated the approach in this paper to analyze the image-schematic grounding of a particular word category, prepositions, in order to identify a more complete set of image-schematic frames beyond the explicit modeling in FrameNet.

2.2. The Preposition Project

The Preposition Project (TPP) [16] aims at providing a gold standard resource of semantic roles for each English preposition. In addition to semantic roles, the project characterizes preposition behaviour in terms of complement and attachment points to their syntactic behavior, which results in a rich semantic resource for prepositions. Prepositions are grouped into senses grouped into WordNet-like synsets. 847 preposition senses for 373 prepositions, including phrasal prepositions, are associated with FrameNet frames and frame elements. This explicit framal modeling, and the semantic function of a preposition in language to be a spatial indicator, render this resource an ideal component of our analysis.

2.3. Framester

Framester [9] provides a formal semantics for frames, reengineered and curated linked data versions of linguistic resources (WordNet, VerbNet, BabelNet, etc.), factual knowledge bases (DBpedia, YAGO, etc.), and ontology schemas (e.g. DOLCE-Zero), 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[6]) all the resources aligned to its formal frame ontology[7]. Framester has been used [10,3] to formalise the MetaNet resource of conceptual metaphors based on FrameNet frames as metaphor sources and targets, as well as 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 FrameNet imagistic foundation

3. Related Work

Two main strands of research are related to our analysis: approaches that analyze the image-schematic grounding of prepositions, and work on analyzing image schemas in FrameNet. To the best of our knowledge, no combination of both has been proposed. In the former category, Deane [5] analyzes the semantic variability of the preposition *over* arguing for the necessity of an image-schematic basis in the process and building on earlier work on polysemy in prepositions (e.g. [4]). In addition, a similar approach is applied to interpretations of *on*, *across*, and *above*. In a more indirect way, Velasco et al. [19] annotates the medical concept of *pain* in natural language with image schemas, thereby implicitly annotating prepositions in use with their image-schematic grounding.

[6] `http://etna.istc.cnr.it/framester2/sparql`

[7] The Framester Schema can be visualized from: `http://wit.istc.cnr.it/arco/lode/extract?url=http://etna.istc.cnr.it/framester/framester.owl`

For instance, most examples of CONTAINMENT provide typical prepositions associated with this image schema, that is, *into*, *out into*, *through*, *out*.

Sullivan [22] conducts a frame-based analysis of conceptual metaphors using English adjectives. She concludes that there seems to be a logic in the lexical choice of conceptual metaphors, which we believe can potentially be modeled with an image-schematic grounding of frames. Reed and Pease [20] construct a general cognition ontology building on WorNet, FrameNet, and Suggested Upper Merged Ontology (SUMO), but they do not deal with image-schemas, and focus on making psychological concepts converge into a formal taxonomy. Petruck and Ellsworth [18] analyze spatial relations in FrameNet, and conclude that the resource provides a solid foundation for modeling such relations in natural language.

Bicknell and Dodge [2] analyze force-dynamics in FrameNet utilizing Embodied Construction Grammar (ECG), and propose a set of rules to represent image schemas in FrameNet. Later Dodge et al. [6] conduct a more detailed analysis of embodied cognition in FrameNet with a view to leveraging it for ECG. In their analysis, similarly as in Framester, they found a necessity to restructure information available in FrameNet to make it more accessible and convert them to schemas in their grammar. In line with our work presented here, there is a large correspondence between embodied schemas in their grammar and frames in FrameNet, the mapping of which, however, is substantially challenged by inconsistent interrelation of frames.

4. Method

A combination of explicit and implicit methods is utilized to uncover image-schematic frames related to prepositions. In terms of explicit, benefiting from the formal linkages in Framester, we use SPARQL queries on the FrameNet graph to extract frames associated directly with image schema frames or mentioning the string "image schema" in thheir definition. This method relies on hierarchal relations of frames annotating prepositions.

A second query-based approach extracts all frames related to preposition senses utilizing four relations of FrameNet, that is, `inheritsFrom`, `perspectiveOn`, `uses`, and `subframeOf`. As a more refined method, it searches for all frames of a preposition sense. Most preposition senses are associated with one or more frame elements. For instance, the preposition sense `prepsense_000020094_2` is defined as "a place; physical space that can be crossed"; with the lexical unit *through* has frame elements such as `Path.body_movement`, `Goal.self_motion`, and `Path.travel`. In the domain of these frame elements, more frames, such as `Motion` or `Traversing`, can be retrieved. The latter is defined as "A Theme changes location with respect to a salient location, which can be expressed by a Source, Path, Goal, Area, Direction, Path_shape, or Distance". This definition clearly indicates SOURCE_PATH_GOAL, which is not explicitly marked as image schema in the dataset, neither by relation nor in the definition. We follow the entire hierarchy in the FrameNet graph of each central frame relation, that is, `inheritsFrom`, `perspectiveOn`, `uses`, and `subframeOf`, starting from the ones obtained based on the frame elements associated with preposition senses. Definitions of returned frames are analyzed for their explicit overlap with image schema definitions and spatial primitives.

In terms of implicit methods, we retrieve frames associated with the lexical units of prepositions. For instance, the lexical unit `through` is directly annotated with the frame

Locative_relation and has a uses relation to Path_shape. Our database query of the previously annotated data [12] confirms this general notion of identifying this sense as associated with the SOURCE_PATH_GOAL schema. Example data of the mentioned database are provided in Table 2.

verb	*prep*	*noun*	*prepsense*	*image schema*
going	through	motions	Location	SOURCE_PATH_GOAL
get	through	crisis	Location	SOURCE_PATH_GOAL
see	through	end	Location	SOURCE_PATH_GOAL

Table 2. Example of additional annotated data to confirm image-schematic grounding of FrameNet

To check on resulting image schema relations, we utilize an image schema dataset [12] where English prepositions from the Europarl corpus[8] have been automatically role-labelled along with their verbs and nouns, clustered, and manually annotated with image schemas. An example of such data is provided in Table 2.

The data additionally contains senses for associated verbs and nouns, so that the meaning of the prepositions can be mapped to the required verbs and nouns in TPP. For instance, "travel by air" was role-labeled in that previous work: verb: verb of movement, preposition: Journey, noun: physical object like water or atmosphere. This aligns well to TPP's prepsense_000121466_2, focused on locative and spatial expressions. This can be differentiated from "granted by commission", which is labeled with the "Assign" verb, with "Instrument" as preposition sense, and nouns like "Council, Department", which correspond to prepsense_000211938_15 on action expressions, and an agent in the ground position after the preposition. This dataset helps to determine whether frames associated with lexical units or preposition senses could indeed be considered image-schematic.

5. Results

We first report on results of traversing the hierarchy of basic frame relations. Table 3 reports on relations to frames that explicitly mention "image schema" in their definition and have an (indirect) relation to the preposition sense (prepsense) by way of the inheritsFrom subsumption relation. All of them are not explicitly associated in any way with the core frame Image_schema. The difference between Containment_relation_IS and Containment is that the former perspectivizes the latter, but both definitions relate to CONTAINMENT. Neither the Goal nor the Source_path_goal image schemas relate to preposition senses or any of the frames that directly relate to prepositions senses (see findings below). This corroborates the need for a more consistent and analytic modeling of image-schematic foundations in FrameNet.

Some prepositions associated with image-schematic frames in Table 3 might not intuitively be mapped to those frames. However, when checking the definition of the preposition senses, the association is supported. For instance, *about* is hard to associate with CONTAINMENT, however, in the sense of *around* as in *hills about/around the city*, the relation becomes more likely.

[8] https://www.statmt.org/europarl/

frame	prepsense count	preposition examples
Trajector-Landmark	55	around, round, through, behind, because_of, from, on
Containment	11	around, round, alongside, up, down, with, on the part of, about, in, for, below, underneath, out of
Containment_relation_IS	14	around, round, alongside, up, down, with, on the part of, inside, by, about, in, for, below, underneath, out of
Goal	0	-
SourcePathGoal	0	-

Table 3. Frames with explicit mentions of image schema in their definitions

In a second query-based approach, we extract all frames related by any of the four relations inheritsFrom, perspectiveOn, uses, and subframeOf in any number of hops in the graph (along their combined closure). All resulting candidate frames for a potential image-schematic grounding are presented in Table 4. Candidates without an explicit sense of motion were excluded, such as Locative_relation that defines the location of a figure with respect to a ground. Candidates are identified based on their motion and spatio-temporal elements in their definition. For instance, Motion_noise refers to "verbs take largely the same Source, Path and Goal expressions as other types of Motion verbs". Some are more specific, such as Change_of_state_scenario relates to movement towards the direction of an end state. Due to the multiplicity of retrieved candidate frames per image schema, in Table 4 we group the frames, rather than ranking them by frequency in preposition senses.

As with the previous query, some of these preposition examples might not intuitively be related with the corresponding image schema. However, the joint analysis of preposition sense, frame, and image schema definition shows a clear relation, even of "alongside" with PART-WHOLE.

In a third step, we analyzed the frames related either directly, or in one or two hops to the lexical units in order to check on the above listing, and to potentially find further image-schematic frames. Additionally, we compared the results thereof with the previously annotated data to back the image-schematic foundation. Based on this analysis we found the same and also further frames with image-schematic grounding in their definitions represented in Table 5. Furthermore, we uncovered some direct links to the main frame Image_schema in the form of Bounded_region, classified as image schema itself, Spatial_contact related to the Contact_image_schema, and Non-gradable_proximity that is in turn linked to the Proximity_image_schema. One explicit image-schematic frame is that of Goal in the SOURCE_PATH_GOAL mapping, where no relations where found to prepositions senses but only to lexical units. However, it has to be remembered here that this frame is only explicit in the sense of mentioning the word "image schema" in the definition. For each preposition sense, all associated lexical units are queried, and the predominant frame related to the correct sense of the prepositions is analyzed, also in terms of its relations to other frames.

In all analysis methods but the last, SOURCE_PATH_GOAL is quantitatively dominant. When querying lexical units, CONTAINMENT frames are found to be more frequent. By utilizing these different methods, we can see that those two image schemas are the most common ones in annotating preposition senses. This tells us that these two

image schema	frames	preposition
SOURCE_PATH_GOAL	Traversing, Motion_scenario, Motion_noise, Motion_directional, Moving_in_place , Change_of_state_scenario, Body_movement, Change_posture, Placing_scenario, Use_vehicle, Self_motion, Operate_vehicle, Ride_vehicle, Cause_fluidic_motion, Fluidic_motion, Mass_motion, Travel, Cause_to_start, Cause_to_end,Cause_to_resume, Cause_to_continue, Cause_to_move_in_place, Removing, Departing, Arriving, Removing_scenario, Sound_movement, Light_movement, Emanating	around, through, behind, on top of, for, by, till, up to, off, toward, past
PART-WHOLE	Being_included, Inclusion_scenario, Wholes_and_parts, Part_whole, Part_piece, Shaped_part, Grinding, Cause_to_fragment	through, under, alongside, within, via
CONTAINMENT	Containers, Containing, Container_focused_removing, Abounding_with, In, Ingest_substance, Bounded_entity, Containment_relation_IS, Container_focused_removing, Container_focused_placing	on, next to, inside, above, atop, about, underneath
BLOCKAGE	Hindering, Impact, Cause_impact, Thwarting	on the part of, with, over, against
CONTACT	Attaching, Inchoative_attaching, Being_attached	within, into, in
SOURCE_PATH_GOAL, SCALING	Change_position_on_a_scale, Cause_change_of_position_on_a_scale	pursuant to, in accordance with

Table 4. Candidate frames related to preposition senses

might be most commonly underlying semantics of prepositions, however, further studies are in order to confirm this assumption. One very interesting result of this last analysis is that preposition senses related to a certain semantic type are never associated with any image-schematic frame. The following list shows those types, an example, and one example preposition sense as identified in Framester.

- Manner (*handle with care*, prepsense_000564045_3)
- Topic (*about image schemas*, prepsense_000342956_18)
- Cause (*because of her smile*, prepsense_000193438_11)
- Temporal (*during this hour*, prepsense_000193438_11)
- verbal nouns and object relation (*payment of his debts*, prepsense_000342956_0)
- Beneficiary (*a present for you*, prepsense_000193438_0)
- Possession (*decision of the Council*, prepsense_000342956_2)
- Agents (*done by my cousin*, prepsense_000143452_16)
- Material (*made of wood*, prepsense_000342956_14)

image schema	frames	preposition examples
SOURCE_PATH_GOAL	`Goal`, `Distributed_position`, `Adjacency`	towards, to, onto, off, over
PART-WHOLE	`Partitive`, `Be_subset_of`	of, in, among, alongside
CONTAINMENT	`Interior_profile_relation`, `ContainmentScenario`, `Containers`, `Bounded_region`, `Surrounding`	about, around, outside of, in, into, within
FORCE	`Level_of_force_resistance`	with, over, against, around
CONTACT	`Spatial_contact`	onto, into, between, upon, up against
VERTICALITY	`Directional_locative_relation`	over, above, on top of, up, down, beneath

Table 5. Candidate frames related to the lexical units of prepositions

From the previous list, it seems that some types share a *lack of motion*. Since image schemas are defined as spatio-temporal relations requiring a sense of motion, which makes them dynamic, this is an intuitive result. However, to allow for a full annotation of natural language with image-schematic grounding, it might be worth defining a *static* type of schema that accounts for these semantic types.

6. Discussion

Our results clearly show that a more structured mapping of the imagistic foundation of frames is in order. The multitude of frames that clearly define spatio-temporal relationships but have no explicit connection to any such frame shows a high potential for a revised top-level modeling of image schemas in FrameNet. It, at the same time, confirms previous studies (e.g. [5,23]) regarding the identified complexity of preposition senses and the number of different image schemas one single preposition can potentially express. For instance, *on* can denote SUPPORT (*be on the mat*), SOURCE_PATH_GOAL (*travel on foot*), VERTICALITY (*on top of the house*), and many more.

In terms of analysis method, we remark that little overlap exists between the results from the three methods employed. This means that joint reasoning across heterogeneous datasets with multiple graph traversing patterns, and possibly with additional measures is most promising for retrieving frames with a grounding in image-schematic structures.

One major advantage of these bottom-up methods is that they bring to light prepositions that – with a top-down approach – would unlikely be associated with a particular image-schematic pattern, as in the case of *about* for CONTAINMENT.

A major challenge is the treatment of borderline cases. Frames such as `Contacting`, in the sense of establishing a communication channel, could potentially be likened to the physical CONTACT. Also frames related to `Perceive` might have more image-schematic grounding than identified in this experiment. Thus, to accomplish a more complete analysis and annotation of frames with image schemas, we intend a full annotation of frames with several annotators to improve on the treatment of borderline cases. This is also useful to find all image schemas that might relate to one specific frame, since image schema collocations, that is, more than one image schema applying to a specific natural language unit or statement, are common phenomena.

For now we limited the selection of frames to the ones explicitly referring to the lexical manifestation of image-schematic structures in their definitions, including spatial primitives such as GOAL or CONTACT. We also included frames that might not have such explicit mentions but a definition that clearly resonates with the definition of a particular image schema. For instance, the `Impact` frame is defined as "While in motion, an Impactor makes sudden, forcible contact with the Impactee", which very closely relates to the BLOCKAGE image schema. As part of future endeavors, a differentiation between single image-schematic structures and their combinations would be interesting, such as CONTAINMENT and SOURCE_PATH_GOAL in `Container_focused_removing`.

One additional interesting finding of this repository of image-schematic frames is that several standard image schemas, such as VERTICALITY or SURFACE are strongly underrepresented. This might be due to our analysis methods or choice of word class, while other approaches might bring a higher diversity of image schemas to light. It might also be due to some gaps in FrameNet that can be uncovered with this alignment of frames with high-level cognitive building blocks. This is one important analysis in future work, where a consistent mapping of all frames to high-level concepts is envisioned.

7. Conclusion

Prepositions turned out to uncover a large number of frames that have a clear image-schematic grounding without any explicit relation in the FrameNet graph. As such, this preliminary study provided an important analysis of the current state, which paves the way to perform a complete grounding of FrameNet frames in Framester with image-schematic structures.

We have applied three distinct methods in this study: analyzing FrameNet definitions that mention image schemas, analyzing frames resulting from graph traversals in Framester, and analyzing frames associated with lexical units in the Preposition project. The study has exploited the semantic homogeneity provided by the Framester schema for all resources examined.

All three methods returned different sets of candidate image-schematic frames, with a limited overlap. This finding points towards ensemble methods for further investigation into the consistency of imagistic foundations of framality. Nevertheless, the multitude of image-schematic frames discovered indicates that an analysis of such foundation is reasonable and fosters an explicit image schema modeling in FrameNet. For this, further analysis including generalised grammatical feature rather than prepositions, and the employment of multiple annotators are foreseen. In the long run, such textual analytics and the proposed methods shall serve to uncover a full mapping between image schemas and frames in Framester and a formal representation of image-schematic grounding of frames.

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