Contrastive Polysemy in Concept Space: Implications for Multilingual Semantic Lexicons

Somsukla Banerjee
Centre for Applied Linguistics and Translation Studies
University of Hyderabad
somsukla2005@gmail.com

Achla Raina
Humanities and Social Sciences
Indian Institute of Technology Kanpur
achla@iitk.ac.in

Harish Karnick
Department of Computer Science & Engineering
Technology Kanpur
hk@iitk.ac.in

Abstract

We propose a model of polysemy within a larger framework *Concept Space* accounting for the organization and generation of concepts in the human cognitive architecture. The predictions of the model about the bilingual user's resolution of contrastive polysemy are worked out taking a subset of verbal polysemies from English and Hindi and crosslinguistic interrelationships in a semantically rich lexicon are modeled along the lines of the *Concept Space* framework. Computational implications of the present work are outlined.

1 Introduction

The phenomenon of polysemy has, in the recent years, emerged as the focus of attention of lexical semanticists primarily for the implications it has for cognitive and computational modeling of natural language. Polysemy refers to multiple senses for a given word. However, polysemous words often show interesting crosslinguistic distributional parallels and contrasts with synonym sets in another language. The word *walk* in English, for example, is polysemous between self-motion and cause-motion senses (e.g., `John walked` as against `John walked the dog`). In Hindi, these two distinct but related word senses are expressed through different, though morphologically related verbs, *chal* and *chalaa*. On the other hand, the verb `see` in English is polysemous between perceive-through-sight and perceive-mentally, and its synonym in Hindi, *dekh*, parallels these word senses. These crosslinguistic parallels and contrasts in lexical polysemy have significant implications for bilingual processing of natural language, some of which are being explored in the present study. When we consider a pair of languages, we often come across words which have more than one senses in one language but these different senses are realized as separate lexical units in the other. This is an instance of contrastive polysemy (CP) across languages: polysemous words in L-1 map into different words into L-2 and vice versa (Boas, 2001). Like many other issues in lexical semantics, contrastive polysemy is of interest from the twin perspectives of computational and cognitive modeling of natural language. In the domain of computational modeling, the study of CP could be useful in domains like computational lexicography and natural language understanding and generation systems. In the domain of cognitive modeling on the other hand, CP emerges as an important issue in crosslinguistic lexical processing in the bilingual mind.

In this paper, we begin with an outline of the preliminaries of the *Concept Space* model which accounts for generation and organization of concepts in the human mind and their subsequent mappings to linguistic expressions. Thereafter we present a description of how polysemy and contrastive polysemy is handled in the *Concept Space* considering instances of contrastive polysemy English and Hindi with their mappings in the other language. We also look into a set of polysemous verbs from Hindi, and their English equivalents. The contrasts are examined in terms of the various operations such as *addition, removal, widening narrowing*, *abstraction* and *projection* of attributes and *addition* and *removal* of functions apply on concepts to derive concepts corresponding to polysemous words in question. We conclude the paper with some observations regarding the implications of the present work for multilingual machine readable lexical databases.

2 Concept Space

Concepts in the proposed model are autonomous and prelinguistic. The *Concept*

Space CS consists of the pair (C, O) where C denotes a set of concepts and O is a finite set of operations on concepts. The set of attributes and functions present in a concept form its *representational structure.* An attribute is a three tuple <name, type, value. An attribute is a static feature whereas a function is dynamic in nature consisting of the three tuple <argument, process, returned value>. A function has typed formal arguments. When the values are passed for these arguments, an operation is undertaken and a value, which can be a reference to another concept, is optionally returned after the completion of the operation. A function can change the values of its arguments or of attributes in the concept.

The *Concept Space* is endowed with the potential to generate infinitely many concepts using a finite set of operations. With these operations, the human cognitive processor is able to perform a variety of tasks in *the Concept Space* which includes *addition* or *removal* of attributes, *projection* of attributes to form a new concept, *widening* or *narrowing* of attribute types and invocation of functions that may lead to the formation of new concepts.

Apart from other attributes such as physical extension, countability etc., we introduce the attribute *derivation_account* which captures the derivational history associated with a particular concept. Assuming that it is possible to derive new concepts from the existing ones by the use of a set of operations, the *derivation_account* includes details about the specific operation/s through which the concept has been derived. The *derivation_account* is a generalization of the traditional hierarchical structure.

We consider words and other visual signs as a part of the conceptual system. We refer to these as w*ord concepts*. A w*ord concept* has an attribute called the *conceptual_referent* and this attribute acts as a reference to the conceptual entity that a word stands for. Similarly, a concept has an attribute known as the *linguistic_referent* which is a pointer to the *word concept* which is its linguistic representation. Knowing the meaning of a word involves establishing the link between the relevant *word concept* and its corresponding concept through the *conceptual_referent*.

In C*oncept Space*, there are concepts that have only attributes. We refer to these concepts as *entity_concepts* and these can be distinguished on the basis of attributes such as *physical_extension*, *countability* etc. There are concepts which include both attributes and functions in their *representational structure.* We refer to these concepts as *event_concepts.* A concept such as GIVE may be viewed in terms of an operation involving an act of TRANSFER of an object from one entity to another. It is not possible to conceptualize the event GIVE without the entities that take part in it. We refer to such entities as *participating entities* of an *event_concept* and they are present as attributes in the *representational structure* of the concept. An *event_concept* is always instantiated in a particular context. The function takes the context as an argument and creates a new concept which is derivationally related to the earlier concept.

The instantiation of an *event_concept* invokes the embedded function. The *event_concept* is always instantiated in a particular context and the function takes the context as its argument(s) and creates a new concept. The tense and aspectual properties of events are derived procedurally by the function when an *event_concept* is instantiated.

We propose the following operations in the *Concept Space:*

1. ***add_attribute*** (*a*) adds attribute *a* in concept *C.*
2. ***remove_attribute****(a)* eliminates an attribute *a* from concept *C.*
3. ***add_function****(f)* inserta function *f* in concept *C.*
4. ***remove_ function***(*f*) eliminates function f from concept *C*. The function *f* includes the signature so there is no ambiguity regarding the function in question.
5. ***widen_attribute*** *(a, t*) widens the type of attribute *a* to *t* in concept *C.*
6. ***narrow_attribute****(a ,t*) narrows the type of attribute *a* to *t* in concept *C.*
7. ***project_attribute***(S_a, S_f) projects a set of attributes S_a and /or functions S_f from concept *C* to form a new concept.
8. ***reify***(*C*) applies all the derivations in concept *C* to produce a fully specified concept with an empty derivation**.**

9. ***abstract***(<C_1, C_2, …, C_n>) produces an abstract concept with only the common attributes in the sequence of concepts of C_1, C_2, …, C_n.

The list of operations is indicative and not exhaustive. The derivational history of a concept is stored in the attribute *derivation_account*. Clearly, a derivation can model a hierarchy, so we do not explicitly organize concepts in a hierarchy.

3 Word Concepts and Polysemy

Words as well as visuo-motor signs which stand for concepts are concepts in their own right in the *Concept Space*. The *linguistic_referent* of a concept may contain more than a single value pointing to multiple *word concepts*, as is the case with synonyms. Conversely, the *conceptual_referent* of a particular *word concept* may be linked to multiple concepts, thus yielding polysemies.

We would now consider derivations of a few *event_concepts* as our discussion here concentrate on verbal polysemies in Hindi and English. By now we know that *event_concepts* have an embedded function which takes the context as argument and derives a new concept . Let us consider the derivational mechanisms for a set of verbal polysemies. The representational structures of the concepts corresponding to the polysemous *word concept* ‘*walk*’ as illustrated in (1a-b):

(1) a. Ram **walked** in the park
b. Ram **walked** the dog in the park.

(1) $WALK_1$

1. <participating_entity1, Human, ram >
2. <participating_entity3, Place, park>
3. < event type, Processive_event, process_instance>

function(walk)

4. <derivation_account, Derivation, null >
5. <linguistic_ referent, Word concept, *walk*>

--Tense(procedure_time) : past
--Aspect (procedure_aspect) :activity

(2) $WALK_2$

1. <participating_entity1, Human, Ram>
2. <participating _entity 2, Animate, dog >
3. <participating_ entity3, Place, park>
4. < event type, Processive_event, process_instance>

function(walk)

5. <derivation_account, Derivation, *add_attribute* < participating_entity, Animate, dog>
6. <linguistic_referent, Word concept, *walk*>

--Tense(procedure_time) : past
--Aspect (procedure_aspect):activity

One can derive $WALK_2$ from $WALK_1$ by the operation *add_attribute* which inserts an additional *participating_entity* in the representation of $WALK_1$. Both are *event_concepts* where $WALK_1$ involves a *participating_entity* undertaking the process and $WALK_2$, where one of the *participating_entities* causes another to undertake this process. Similarly it is possible to derive $WALK_1$ from $WALK_2$ by the operation *remove_attribute*.

4 Contrastive Polysemy

We have mentioned in the introduction about the existence of contrastive polysemy across languages. We now consider set of verbs in English and Hindi that demonstrate contrastive polysemy. The data in (2-3) illustrate a range of senses expressed by the English verbs ‘*run’*, and *‘raise’*

(2) a. Maya **ran** on the road.
b. Maya **ran** the dog off the road.

The verb ‘*run*’ in both (2a) and (2b) corresponds to *processive_events*. If we look at the Hindi equivalent of (2), as given in (3), we find that Hindi uses distinct *word concepts* to express the different meanings of each of these events. In Hindi the corresponding *event_concepts* are bhag and bhagaa respectively.

We now present examples of Hindi polysemous verbs which are realized as distinct word concepts in English. The Hindi verb mil is polysemous and it has two distinct *conceptual_ reference* links, FIND and MEET.

This will be clear from the examples from Hindi given below.

```
(3) a. use ek kitaab milii.
       He-dat one book find-past-png
       (He found a book.)

    b. vaha tumse milaa thaa.
       he you-acc meet be-past-png
       (He met you.)
```

The polysemous *word concept* `mil` corresponding to the *stative_event* concepts FIND and MEET can be derived by the operations *widen* or *narrow_attribute*. The *participating_entities* of MEET are HUMAN and from this concept one can derive FIND by the operation *widen_attribute* which expands the type of *participating_entities* that can be passed as the argument of the function.

So far we have seen that the various concepts that correspond to the multiple senses of the polysemous *word_concepts* can be derived from one another by the use of the various operations that exist in *Concept Space*. In the next section we discuss the implications of the present approach for bilingual machine readable lexicons.

5 Computational Implications

The framework of *Concept Space* through which we have dealt with the issue of contrastive polysemy that we have presented so far is of particular relevance to WordNet and other such databases that aim to store cross linguistic lexical semantic information. Conceptual and lexical representation is two essential elements of language processing. Multilingual representation of lexical knowledge which links a concept to its linguistic mappings in different languages will enable language processing in multiple languages. Though a large amount of work has been done in word sense disambiguation for the purposes of machine translation, the need for semantically rich bilingual lexicons still remains. If some of the principles *Concept Space* framework is employed for organizing large bilingual databases, significant crosslinguistic lexical information can be captured in an economical and efficient way. A semantically rich bilingual lexicon will have applications in various domains of natural language like semantics-driven translation, multilingual natural language understanding systems and other semantic analysis tools. Recently there has been a move towards constructing bilingual concept MRDs. However it is reasonably difficult to build such a lexicon for as one has to consider two ontologies and also the fact that the evolution of such a lexicon is quite challenging. The issue of contrastive polysemy is very crucial in multilingual lexical resources where one has to list the multiple senses of a word and link it to the appropriate mappings in the other language. Describing a polysmous word concept in terms of its various attributes and functions and participating entities in case of event and property concepts will enable a productive description.

In the last decade, there has been considerable emphasis on research related to bilingual cognitive processing. A question that is often posed in this context concerns the relationship between the conceptual and linguistic structures, or more specifically, whether conceptual representations in the bilingual are unitary or language specific.

6 Conclusion

In this paper we have outlined the *Concept Space* model and described how this framework handles the issue of polysemy in general and contrastive polysemy in particular. We have analyzed a fragment of Hindi English contrastive polysemies drawing upon a concept space based representation of these units. We have further suggested that some of these Concept Space based structures are crucial to bilingual processing of language and should be incorporated in the construction of a bilingual MRD.

References:

Hans C. Boas, .2001. Frame-semantics as a Framework for Describing Polysemy and Syntactic Structures of English and German Motion Verbs in Contrastive Computational Lexicography, P. Rayson, et al., (eds.), *Proceedings of the Corpus Linguistics 2001, Technical Papers*,13, University Centre for Computer Corpus Research on Language.

Somsukla Banerjee. 2008. *Modelling Concept Space: An Investigation into Bilingual Language*

Processing, Unpublished PhD Dissertation, IIT Kanpur.

Yael Ravin and Claudia Leacock (eds.),2000. *Polysemy: Theoretical and Computational Approaches*, Oxford University Press, USA.