A New Method for Measuring English Verb's Metaphor Making Potential

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Abstract

A general practice in the research of metaphor has been to investigate its behavior and function in different contexts. This current study aims to investigate the notion that verbs possess a metaphor-making potential, this being an initiatory context-free experiment with metaphor. The goal of this paper is to carry out an in-depth case study of a group of English core verbs using WordNet and SUMO ontology. In order to operationalize the measurement of an English verb's metaphor making potential, a new algorithm has been developed, and a program made to realize the computation. At last, it has been observed that higher frequency verbs generally possess greater metaphor making potential; while a verb's metaphor making potential on the other hand is also strongly influenced by its functional category.

Introduction

Metaphor computation continues to pose a significant challenge to NLP. Up to now, some achievements have been attained in machine understanding of metaphors generally through rule-based and statistical-based approaches. Among them, knowledge representation based methods are predominant (Zhou, Yang and Huang, 2007). These methods mainly employ as their working mechanism knowledge representation based ontologies, such as The Suggested Upper Merged Ontology (SUMO), which has been exploited by Ahrens, Huang, et al in their doing metaphorical computation.

SUMO, an effort of the IEEE Standard Upper Ontology Working Group with the support of Teknowledge, contains terms chosen to cover all general domain concepts needed to represent world knowledge. Ahrens & Huang's research with SUMO and metaphor has focused on specific domain metaphors (Ahrens, 2002; Ahrens, Huang and Chung, 2003), thus failing to make full use of SUMO's overall domain coverage.

Since the verb is the core for language processing, as believed by some linguists and philosophers, and previous work on metaphorical computation focused on noun metaphors, or verb's collocations, now the question is whether it be possible to look into the verb itself for its metaphorical properties? Since Metaphor Making Potential (MMP) in language depends on a word's ability to cross domain attributes, SUMO, with its well developed hierarchy of domain concepts, has attracted our interest.

This paper conducts an in-depth case study of a selected group of English core verbs in the framework of WordNet and SUMO. In seeking ways to operationalize the assessment of English verbs' property of MMP, an algorithm is proposed based on the WordNet lexical representation and SUMO ontology. A pilot experiment has been carried out with a small sample size of 20 most frequent English non-modal verbs of both imperfective and perfective obtained from BNC, TIME Magazine, CCAE (previously ANC) and Brown Corpus. A hypothesis based on Lakoff view (Lakoff and Johnson, 1980) that metaphor is the result of "our constant interaction with our physical and cultural environments" has been set up as well to test whether higher frequency verbs show greater MMP. As a study which is both theory and application-oriented, this paper also shows that an ontology-based approach is more objective than an intuition-based approach in generating insights into a verb's metaphorical properties.

Metaphor, Conceptual Metaphor and Metaphorical Computation

Metaphor study has gone through three major stages from Aristotle's Comparison and Substitute View, through Richard and Black's Interaction View to finally the current Conceptual View. Meanwhile, Chinese linguists have for the most part limited their investigation of metaphor to its rhetorical and psychological properties.

G. Lakoff and M. Johnson (Lakoff and Johnson, 1980) set out to develop a new theory called Conceptual Metaphor (CM), in which they argue that human thought processes and conceptual system are metaphorically defined and structured; and "the essence of metaphor is understanding and experiencing one kind of thing in terms of another." Differing from the objectivist's view of inherent property, CM's conceptual system is the product of how we interact with our physical and cultural environments. Furthering the definition of a concept and changing its range of applicability is possible because metaphor-driven categorization and recategorization render the open-endedness of concept. Thus we should expect the most efficient way to investigate those Interactional Properties and their underlying internal cross-domain alignment of prototypes is to examine how they are projected by the category-oriented ontologies, such as the SUMO hierarchy.

Recent research in metaphorical computation mainly falls into two categories: rule-based approaches and statistical-based approaches. The former ones stem from conventional theories of metaphor in linguistics, philosophy and psychology, including specifically metaphor semantics, possible worlds semantics, and knowledge representation. And the latter dwell on corpus linguistics and employs statistical based techniques. Those papers are all limited to the study of metaphor's behavior and function in different contexts (Zhou, Yang and Huang, 2007).

Research Justification and Design

In line with the above consideration, we plan to carry out an in-depth investigation into a selected group of English core verb's self-contained metaphorical traits through mapping their senses in WordNet to SUMO's domain-aligned hierarchy.

Lakoff argues that verbs, as well as words of other classes, develop their new metaphorical meanings and usages from their root meanings through interaction with their surroundings (Lakoff, 1993). But illustration and validation of this phenomenon depend on linguists' introspection and inference. Investigating this phenomenon using SUMO's hierarchy will provide a de facto computable ground for understanding verbs' self-contained metaphorical nature. Moreover, the centrality of verbs for language progression and processing has often been emphasized (Viberg, 1993).

SUMO has more than 1000 terms, 4000 axioms and 750 rules. A verb in SUMO hierarchy has different senses located in different levels of concepts under Entity. Verbs differ from each other in that each verb's senses' depth to the root differs from that of other verbs (Niles and Pease, 2001; Niles, Pease and Li, 2002; Chow and Webster, 2006). Calculation of these differences resembles computation of words' semantic distance, semantic similarity and semantic relatedness. There are currently dozens of calculators to measure words' semantic distance/similarity/relatedness, most of which rest on WordNet. Representative measures are Hirst-St-Onge(Hirst and St-Onge, 1998), Leacock-Chodorow (Leacock and Chodorow, 1998), Wu and Palmer (Wu and Palmer, 1994), Jiang-Conrath(Jiang and Conrath, 1997), Lin (Lin, 1998), and Gloss Vector (pairwise) (Patwardhan, Banerjee and Pedersen, 2003). They assign different weights on words' width, depth, information content, etc., thus output different semantic distances. Our tentative measurement varies from the above mainly in that it determines a verb's MMP by both its metaphorical depth and overall width; and the second part by turns is calculated by tracing and measuring each closest concept pair's Lowest Common Consumer's location in SUMO hierarchy.

Research Methodology

Identification of the Selected List of English Core Verbs and Mapping their WordNet Senses to SUMO Concepts

A simple method shown to be very useful to delimit a group of core verbs is frequency ranking (e.g. the normal practice is the 10, 20, 50, or 100 most frequent verbs) within a particular word class; frequency ranking of general purpose corpus will be considered for trimming the list of core verbs. Specifically, the British National Corpus (BNC), TIME Magazine, Corpus of Contemporary American English and the book "Frequency Analysis of English Usage" based on the earlier Brown Corpus were consulted for English verbs' general purpose frequency ranking. We filtered and finalized a list of 20 most frequent verbs for our pilot study.

Adam Peace et al have already mapped a word's WordNet senses to its SUMO corresponding concepts (http://www.ontologyportal.org/).

Algorithmic Consideration

Calculate a Verb's MMP Value. A verb's metaphor making potential (MMP) is measured in terms of the verb's WordNet Senses' locations in the SUMO ontology, which are mapped onto SUMO's hierarchical concepts. The verb's MMP in the SUMO hierarchy is further determined by its' senses' respective Depths and Overall Width (OWD). A verb's MMP is calculated and normalized by the formula below,

$$MMP(Verb) = \sum_{i=1}^{n} \frac{DP(S_i)}{Max_{DP(S)}} \cdot OWD(Verb)$$

Where n is a verb's total number of WordNet senses mapped to SUMO's hierarchical concept, $DP(S_i)$ is the depth of i-th sense in SUMO hierarchy, $Max_{DP(S)}$ is a sense's maximum depth in SUMO hierarchical concept, $OWD(Verb)$ is the verb's WordNet senses' overall width in SUMO hierarchy.

Calculate the Depth of a Sense in SUMO Ontology. The depth of a verb's WordNet sense is defined as the minimum edge count of paths in SUMO from the root to the sense, i.e. from the Entity to the concept that the sense subsumes or equates, including the sense when subsuming or not including the sense when equating.

We define the depth of the sense i as $DP(S_i)$ in SUMO ontology,

$$DP(S_i) = Min(Len_e(Path_l) \mid 1 \leq l < TotalPaths)$$

where $TotalPaths$ is the total number of paths from this sense to the Entity, $Len_e(Path_l)$ is the edge count of $Path_l$ of this sense i, including the sense edge when it subsumes the SUMO concept or not including the sense edge when it equates the SUMO concept.

Calculate a verb's Overall Width in SUMO Ontology. The Overall Width of a verb's senses is a new term coined in this paper to describe another inherent metaphorical property of a verb—Metaphorical Width, namely, the horizontal reciprocal distance of all concepts that a verb's senses subsume or equate. Unlike the more isolated and fixed methods of measuring semantic distance, this notion of metaphorical width is a generic and dynamic one.

Following Lakoff (Lakoff, 1980), "Metaphor allows us to understand one domain of experience in terms of another. This suggests that understanding takes place in terms of entire domains of experience and not in terms of isolated concepts", this research postulates that a verb's metaphorical width must be assessed by viewing all concerned SUMO concepts simultaneously; any isolated treatment of concepts is theoretically and operationally partial and will fail to obtain the overall assessment. Moreover, since metaphorization is primarily about migration of a concept to any successive potential concept, the metaphorical width calculation shall consider the de facto displacement both between two interrelated concepts and among all interrelated concepts. In other words, this paper posits that it is the shifting between those interrelated concepts, instead of the static concepts themselves that works to delineate a word's metaphor making potential. A shift from a concept to another produces a certain quantity of metaphorical potential. So what we do is to find a way to quantify how much metaphorical potential those shifts generate.

The approach for counting a verb's metaphorical width sets off to compute all possible paths of the verb's all senses. Suppose a verb has a sense set S, which contains $\{S_1 \ldots S_n\}$. Each sense is mapped to corresponding SUMO concept in the verb's senses' SUMO concept set C, which contains $\{C_1, C_i, C_j \ldots C_k\}$ ($k \leq n$). A verb's metaphorical width is defined as the minimum overall distance in SUMO from C_1 through C_i, C_j to C_k. A verb's overall width ($OWD(Verb)$) can be obtained by formulas below,

$$OWD(Verb) = \sum_{i=1}^{k} WD(C_i, C_j)$$

$$WD(C_i, C_j) = Min(Len_e(C_i, C_{lcs})) + Min(Len_e(C_{lcs}, C_j))$$

where C_j is the closest concept to any concept C_i of C in SUMO, $WD(C_i, C_j)$ is the relative width between C_i and C_j, C_{lcs} is the Lowest Common Subsumer of C_i and C_j, and Len_e is the number of edge counts. Note that we start from any concept C_i, to its closest concept C_j, then move on to C_j's closest concept excluding C_i and C_j, and the like, till the last concept C_k; and since the whole metaphorical shifting process stops at C_k, C_k and its closest preceding concept thus form the last interrelated pair which generate relative width.

Results and Discussion

Before the experiment, the hypothesis is that the more frequent verbs possess greater metaphorical potential,

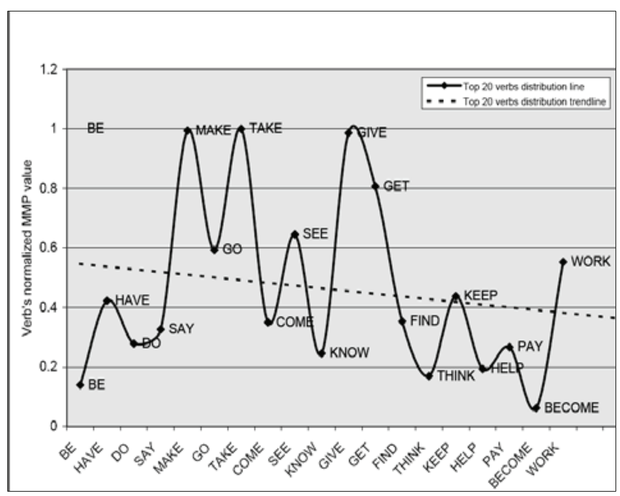

Figure 1 Top20 most frequent verbs MMP distribution

which is based on the belief that a more utilized verb is involved in more interactions, thus tends to incur more metaphorical usages (Lakoff, 1993). Result of this preliminary study shows that the hypothesis is generally true as shown by the trend line in Figure 1.

Mann-Kendall method (Kendall, 1962) is used to further test whether verbs' MMP has a significant downward trend in correlation with verbs' frequency ranking. Kendall test is a nonparametric test rule and insensitive to extreme value and thus fits the feature of the experimental data (MMP(Verb1), ... MMP(Verb20)) as a sample of independent and non-normally distributed random variables. Its null hypothesis H_0 is that there is no trend in the top 20 verbs' Metaphor Making Potential *MMP(Verb)*. The Kendall test rejected the H_0 by showing that there is a significant downward trend at the 0.05 level for the top 20 verb's MMP.

Moreover, we also observed some interesting phenomenon. Verbs like *give, take, make, get* which are positioned in the middle based on frequency ranking are at the top in terms of their MMP value; while verbs *be, do, say* which are ranked at the top based on frequency ranking now at the bottom in terms of their MMP ranking. Further investigation reveals that those verbs ranking higher in terms of metaphorical potential fall into the verb categories of Possession and Production; while those ranking lower in metaphorical potential (with the exception of *say*) all fall into the verb category of General Dynamic (Beth, 1993). This finding suggests that verbs' MMP trait is closely linked to verbs' functional categories.

The small size of the samples analyzed however precludes the possibility of hastily drawing any generalizations. Instead, we anticipate that such should be possible after conducting further study into verbs' metaphorical traits based on a large sample size analyzed using SUMO.

Summary

This study is both theory- and application-oriented. A new method is proposed to study a word's intrinsic metaphorical property. We have as well observed that higher frequency verbs generally possess greater metaphor making potential; while the verb's MMP on the other hand is also strongly influenced by its functional category.

One of the future tasks is to expand the sample size of core English verbs to produce a stronger validation; another is to apply this method to other classes of words to generate the contour of a word's trait of metaphor making potential.

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