Ontology Oriented Computation of English Verbs Metaphorical Trait

Zili Chen, Jonathan J. Webster, Ian I. Chow and Tianyong Hao

Department of Chinese, Translation and Linguistics, City University of Hong Kong,
81 Tat Chee Avenue, Kowloon Tong, KLN, Hong Kong

Abstract. Research on metaphor has generally focused on exploring its context-dependent behavior and function. This current study aims to testify the postulate of English verb's innate trait of Metaphor Making potential. This paper intends 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 assessment of an English verb's metaphor making potential, a refined algorithm has been developed, and a program made to realize the computation. At last, it is 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 categories. As a preliminary context-free experiment with metaphor, this research foresees the possibility of providing an annotation schema for critical discourse analysis and a new parameter for scaling the difficulty level of reading comprehension of English texts.

Keywords: ontological computation, English verbs, MMP

1 Introduction and Previous Work

Metaphorical computation continues to remain a significant challenge to NLP. Recent researches of it mainly fall into two categories: rule-based approaches and statistical-based approaches. Up to now, some achievements have been attained, among which knowledge representation based methods are predominant [1]. These methods mainly employ knowledge representation based ontologies, such as The Suggested Upper Merged Ontology (SUMO), as their working mechanism. However, those researches are all limited to the study of metaphor's behavior and function in different contexts.

In line with Lakoff's view [2], "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", 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. Whereas Ahrens & Huang's research with SUMO and metaphor has focused on specific domain metaphors [3, 4], thus failing to make full use of SUMO's overall domain coverage.

Now that verb maintains the core for language processing, as believed by some

© A. Gelbukh (Ed.)
Advances in Computational Linguistics.
Research in Computing Science 41, 2009, pp. 135-142

Received 28/11/08
Accepted 11/12/08
Final version 04/02/09

linguists and philosophers, and previous work on metaphorical computation was focusing on noun metaphors, or verb's collocations, now the question is, would it be possible to look into the verb itself for its metaphorical property?

Lakoff also 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 [5]. But illustration and validation of this phenomenon depends on linguists' introspection and inference. We thus should expect the most efficient and objective way to investigate the Interactional Property and its underlying internal cross-domain alignment of prototypes is to examine how they are projected by the category-oriented SUMO hierarchy. Investigating this phenomenon using SUMO's hierarchy will provide a de facto computable ground for understanding verbs' self-contained metaphorical nature.

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 is carried out with a small sample size of 50 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 [2] 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 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 verbs' metaphorical property. As a pilot context-free study with metaphor, this research foresees the possibility of providing an annotation schema for critical discourse analysis and a new parameter for scaling the difficulty level of reading comprehension of English texts.

1.1 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 [2] 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 SUMO hierarchy.

Recent researches in metaphorical computation mainly fall into two categories: rule-based approaches and statistical-based approaches. The former stems from conventional theories of metaphor in linguistics, philosophy and psychology, including specifically metaphor semantics, possible worlds semantics, and knowledge representation. And the latter dwells 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 [1].

2 Research Justification and Design

In terms of the above consideration, the intended experiment will look 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 [5]. But illustration and validation of this phenomenon depends 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 [6].

SUMO has more than 1000 terms, 4000 axioms and 750 rules. A verb in WordNet has various senses all of which are located in different levels of concepts under Entity in SUMO. Verbs differ from each other in that each verb's senses' depth to the root differs from that of other verbs [7, 8, 9]. 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 [10], Leacock-Chodorow [11], Wu and Palmer [12], Jiang-Conrath [13], Lin [12], and Gloss Vector (pairwise) [13]. They assign different weights on words' width, depth, information content, etc., thus output different semantic distances. All those measures calculate the semantic distance by computing the shortest edges or IC between two words. Our tentative measurement varies from the above in that instead of directly measuring the shortest paths between two words, this method determines a verb's metaphorical width by adding up its senses' overall relative distance, which by turns is calculated by tracing and measuring each closest concept pair's Lowest Common Consumer's location in SUMO hierarchy back to its root. Comparing with methods of information content, the major difference is that it measures the information content above the LCCs, not below the LCCs.

3 Research Methodology

3.1 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 are consulted for English verbs' general purpose frequency ranking. We filtered and finalized a list of 50 most frequent verbs for our pilot study.

Adam Peace et al have already mapped a word's WordNet senses to its SUMO corresponding concepts [16].

3.2 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 Relative Width (ORWD). A verb's MMP is calculated and partly normalized by the formula below,

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

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 the maximum depth of a sense in SUMO hierarchical concept, *ORWD(Verb)* is the verb's WordNet senses' overall relative 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,

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

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 Relative Width in SUMO Ontology. The Overall Relative 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 static and fixed methods for measuring semantic distance such as Hirst-St-Onge etc., this notion of metaphorical width is a dynamic and relative one. Following Lakoff [2], "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 metaphorical property. A shift from a concept to another generates 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 to spot the shortest one. 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 $\{C_1, Ci, Cj \ldots C_k\}$ ($k \leq n$). A verb's metaphorical width is defined as the minimum overall relative distance in SUMO from C_1 through C_i, C_j to C_k. A verb's overall relative width (*ORWD(Verb)*) can be obtained by formulas below,

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

$$RWD(C_i, C_j) = \frac{1}{Min(len_n(Paths_{LCS(C_i, C_j)}))}$$

where *Cj* is the closest concept to any concept *Ci* of *C* in SUMO, RWD(*Ci, Cj*) is the relative width between *Ci* and *Cj*, *LCS*(*Ci, Cj*) is the Lowest Common Subsumer of *Ci* and *Cj*, and Len_n is the number of nodes count from *LCS*(*Ci, Cj*) to Entity. Note that we start from any concept *Ci*, to its closest concept *Cj*, then move on to *Cj*'s closest concept excluding *Ci*, 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 forms the last interrelated pair which generates relative width.

4 Results and Discussion

Before the experiment, what has been anticipated is that the higher frequent verbs would possess the more metaphorical potential, which is based on the belief that a more utilized verb is involved in more interactions, thus tends to incur more metaphorical usages [5]. Result of this preliminary study shows that the hypothesis is generally true as shown by the trend line in Figure 1.

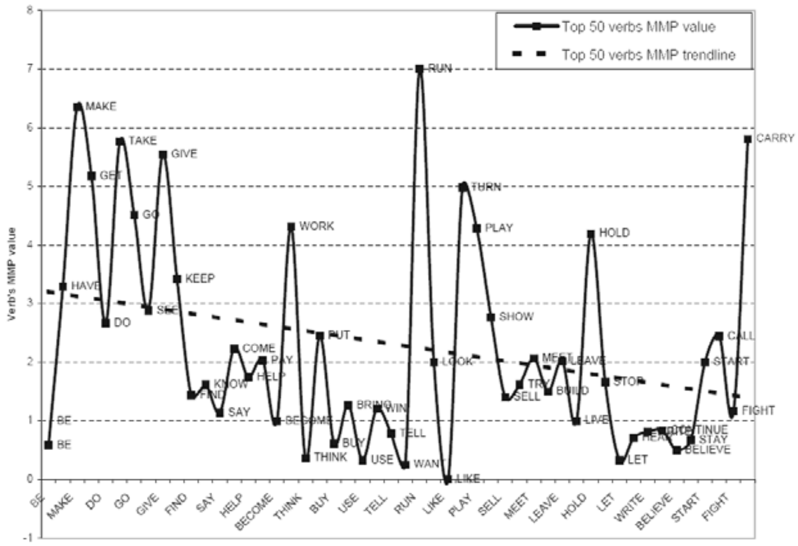

Fig. 1. Top most frequent verbs MMP distribution

Mann-Kendall method [17] 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(Verb50)) 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 50 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 50 verb's MMP.

Moreover, we also observed some interesting phenomenon. Verbs like *give, take, make, get, run, turn, hold, carry, etc.,* which are positioned in the middle or bottom based on frequency ranking are at the top in terms of their MMP value; while verbs *be, do, say, think, want, etc.,* which are ranked at the top or middle based on their 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, Production and Motion; while those ranking lower in metaphorical potential (with the exception of *say*) all fall into the verb category of General Dynamic and Cognition [18]. This finding suggests that verbs' MMP trait is closely linked to verbs' functional categories.

The small size of the 50 words samples analyzed however precludes the possibility of hastily drawing any generalizations. Instead, we anticipate that such should be possible after conducting a future study into verbs' metaphorical traits based on a large sample size analyzed using SUMO.

5 Summary and Future Work

The metaphor making potential in language is another breakthrough finding of a word's build-in universal trait in terms of metaphor. On the one hand, it depends on a word's ability to cross-domain attribute, while on the other hand it makes it feasible to understand and experience one kind of thing in terms of another. Expanding the definition of a concept and broadening its range of applicability is possible because every word has its metaphor making potential which renders the open-endedness of concept. Related to that, SUMO illustrates a full blown hierarchy of terms chosen to cover all general domain concepts needed to represent world knowledge. Thus SUMO ontology is used to project a verb's MMP.

This study is both theory- and application-oriented. A refined method is proposed to assess a word's intrinsic metaphorical property. And SUMO as an ontology benchmark is validated as well. We have 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. As a preliminary context-free experiment with metaphor, this research foresees the possibility of providing an annotation schema for critical discourse analysis and a new parameter for scaling the difficulty level of reading comprehension of English texts.

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. We also hope that its application to discourse analysis and textual annotation will also be explored.

References

1. Zhou, C.L., Yang Y., Huang X.X.: 2007. Computational Mechanisms for Metaphor in Languages: A Survey. Journal of Computer Science and Technology. 22(2), 308-319 (2007)
2. Lakoff, G., Johnson, M.: Metaphors We Live by. The University of Chicago Press, Chicago (1980)
3. Ahrens, k.: When Love Is Not Digested: Underlying Reasons for Source to Target Domain Pairing in the Contemporary Theory of Metaphor. In: Proc. 1st Cognitive Linguistics Conference, pp. 273-302. Taipei (2002)
4. Ahrens, K., Huang, C.R., Chung, S.F.: Conceptual Metaphors: Ontology-Based Representation and Corpora Driven Mapping Principles. In: Proc. ACL Workshop on Lexicon and Figurative Language, pp. 35-41. Sapporo, Japan (2003)
5. Lakoff, G.: The Contemporary Theory of Metaphor. In: Ortony A. (ed.) Metaphor and Thought, 2nd Edition, pp. 202--251. Cambridge University Press, Cambridge (1993)
6. Viberg, A.: Crosslinguistic Perspectives on Lexical Organization and Lexical Progression. In Hyltenstam, K., Viberg, A. (eds.) Progression & Regression in Language: Sociocultural,

Neuropsychological, & Linguistic Perspectives, pp. 340-385. Cambridge University Press, Cambridge (1993)
7. Niles, I., Pease, A.; Towards a Standard Upper Ontology. In: Welty C., Smith B. (eds.) Proceedings of the 2nd International Conference on Formal Ontology in Information Systems (FOIS-2001). October 17-19, Ogunquit, Maine (2001)
8. Pease, A., Niles, I., Li, J.: The Suggested Upper Merged Ontology: A Large Ontology for the Semantic Web and its Applications. In: Working Notes of the AAAI-2002 Workshop on Ontologies and the Semantic Web, July 28-August 1, Edmonton, Canada (2002)
9. Chow, I.C., Webster, J.J.: Mapping FrameNet and SUMO with WordNet Verb: Statistical Distribution of Lexical-Ontological Realization. In: Fifth Mexican International Conference on Artificial Intelligence (MICAI'06), pp. 262-268. (2006)
10. Hirst, G., St-Onge, D.: Lexical Chains as Representations of Context for the Detection and Correction of Malapropisms. In: Fellbaum, C. (ed.) WordNet: An Electronic Lexical Database, pp. 305–332. MIT Press, Cambridge MA (1998)
11. Leacock, C., Chodorow, M.: Combining Local Context and WordNet Similarity for Word Sense Identification. In: Fellbaum, C. (ed.) WordNet: An Electronic Lexical Database, pp. 265–283. MIT Press, Cambridge MA (1998)
12. Wu, Z., Palmer, M.: Verb Semantics and Lexical Selection. In: 32nd Annual Meeting of the Association for Computational Linguistics, pp. 133–138. Las Cruces, New Mexico (1994)
13. Jiang, J., Conrath, D.: Semantic Similarity Based on Corpus Statistics and Lexical Taxonomy. In: Proceedings on International Conference on Research in Computational Linguistics, pp. 19–33. Taiwan (1997)
14. Lin, D.: An Information-Theoretic definition of Similarity. In: Proceedings of the International Conference on Machine Learning. Madison (1998)
15. Patwardhan, S., Banerjee, S., Pedersen, T.: Using Measures of Semantic Relatedness for Word Sense Disambiguation. In: Proceedings of the Fourth International Conference on Intelligent Text Processing and Computational Linguistics, pp. 241–257. February, Mexico City (2003)
16. WordNet & SUMO mapping. http://sigmakee.cvs.sourceforge.net/viewvc/sigmakee/KBs/WordNetMappings/
17. Kendall, M.G.: Rank Correlation Methods, 3rd edition. Hafner, New York (1962)
18. Levin, B.: English Verb Class and Alternations: A Preliminary Investigation. University of Chicago Press, Chicago (1993)