Referential Structure - A Mechanism for Giving Word-Definition in Ordinary Lexicons

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ABSTRACT

Superficially an ordinary lexicon is merely a compiled list of the word-definitions. And usually people use ordinary lexicons just by finding an entry-word and reading the corresponding description. But in spite of the superficial simplicity, the actual word definition mechanism of ordinary lexicons is fairy complicated.

This paper tries to formulate this mechanism based on the concept of referential structure. The referential structure naturally derives the referential network composed of word-reference-path, which can be regarded as a fundamental word-definition mechanism of ordinary lexicons. Tha t is, human extracts his wanting word-knowledge from this referential network using the support of [implicit] commonsense.

This paper also gives the method of how to extract the word-knowledge from the referential network. This method is based on the network traversing and pattern-matching which is currently designed in rather simple and naive way, and thus, is to be easily implemented.

As for the word-knowledge to be extracted, currently I suppose those which go along with the conceptual relations, such as, is-a, have-a, is-a-member-of, is-composed-of, is-an-example-of, etc. I believe that my proposed mechanism will make a good theoretical base for constructing various natural language understanding applications.

1. INTRODUCTION

For almost all the people, the way to use an ordinary lexicon is standardized in three steps as follows:

find the location(page and line) of the entry word,
read the corresponding definition or explanation,
do the job based on the understanding.

It is quite natural to think: if we can extend this rather routine work of the ordinary lexicon usage in terms of the computational formulation, we can get the powerful function to extract the useful knowledge from ordinary

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lexicons. In this paper we will realize this extension based on the concept of referential structure which is the essential knowledge structure [Nitta 86] & [Nitta 88].

In order to get the notion of referential structure, it is enough for us to see the way that an ordinary lexicon presents the meaning of an entry-word:

x →a b c,

which designates that the word x refers three words a, b, and c, namely, the definition or explanation of the word x is given by three words a, b and c. Let us see an example taken from [SHORTER 82]:

society →a group of persons joined together for a common purpose or by a common interest,

where articles, prepositions, linking-verbs (such as be-verbs) morphological affixes and some class of words are to be removed to other place to receive the special treatment. We will call this removing-function a linguistic filter. Applying this linguistic filter to the above example, the word \`society´ turns to refer six words: \`group´, \`person´, \`join´, \`common´, \`purpose´ and \`interest´. Each of them again refers other words:

••••••

common→ belonging equally to all,

purpose →an aim or intention,

intention→ purpose or design,

design→ a drawing, plan or sketch, from which a thing may be made,

interest → the condition of wanting to know or learn about something,

know →perceive as a fact or truth; have information about; be acquainted with by sight, experience, or the like; be versed in; be skilled in; be able to distinguish (one from another),

learn→ acquire knowledge of (a subject) or skill in (an art, etc.) by study, instruction, etc.; become informed of or acquainted with.

As is easily understood, if we conjoin referential structure repeatedly, we will get the referential network which is spanning its paths with the entry-word as its center (in the above example, the center is x or \`society´. The reason why we adopt the term \`network´ instead of \`tree´ is that we allow the possibility of the self-reference and the recursive-reference:

x →a b x c, a→ l m n, •••• l→ p q x r, ••••.

My principle to formulate the knowledge structure of ordinary lexicons is, in short, highlighting the traversing process on the referential network. This traversing process is divided into two types according to its direction: one is top-down type traversing by which some kinds of the inheritance information are being passed to frontier words, the other is bottom-up type traversing by which some kinds of the constraint information are being posed on their center word.

Gathering the passed or posed information along the traversed paths, is the remarkable advantage of my formulation that enables us to utilize ordinary lexicons as a powerful knowledge base. Some of the global knowledge to be extracted by my formulation are possibly be far beyond the original intentions of the compilers of ordinary lexicons.

2. KNOWLEDGE REPRESENTATION FORM OF ORDINARY LEXICONS

First of all, let us examine briefly the knowledge representation form of O.L.(which is the abbreviation for ˋordinary lexiconˊ hereafter). Usually O.L. gives grammatical knowledge such as grammatical categories, part-of-speeches, collocations [for more precise discussion, see [Sinclair 87] for example]; pragmatic knowledge such as written forms, pronunciations, accents, and word usage examples; and general knowledge such as etymologies, idioms and a short note of grammar; in a compact and elaborate form. But clearly the essential knowledge given by O.L. is the collection of the pair:

entry-word + D.E.,

which is the main concerns of this paper. Here D.E. is the abbreviation for ˋdefinition or explanation ˊ in O.L.

It is very difficult to give the decisively proper D.E. to each word, where by ˋproper D.E. ˊ we mean the sentences to define word meaning in a precise style enough to cope with the theoretical treatment. Nevertheless the most common idea for composing D.E., which has at least been supported by the majority of the traditional lexicographers, may be:

> The D.E. is to define or explain: 1)the object(s), event(s) and/or relation(s) which are specified by the entry-word, or 2)the effect or action to be caused when the entry word is used in a real situation. And the D.E. can be <u>recursive</u>. By ˋrecursive ˊwe mean that the word(s) that compose(s) D.E. can again be entry-word(s) in other places.

But the technique of the recursive use of entry-words for composing D.E. may not be the original intention of the traditional lexicographers. This technique is only the convention for reducing the total volume of lexicons. Their original idea [for the detailed discussion, see [Moon 87]] may be as follows:

> The meaning of the word is proper and unique to the word, and thus which should be independent from the meaning(s) of other word(s). That is to say, the meaning should have the function to separate the word from other words by characterizing it uniquely.

The above mentioned idea seems to have been deeply connected with the fact that ordinary lexicons are traditionally compiled as the collection of word-by-word description segments. But unfortunately this traditional idea of lexicographers is not entirely correct. Because in the real world the meaning of words can not be independent from others. They are deeply dependent on others, and their mutual dependent relation forms the macro-structure of the word meaning supported by the actual world's situation. This macro-structure is the very key mechanism for defining or explaining the meaning of each word. Thus the word meaning is `something ´ that exists crossing over the boundary of each word-by-word segments. This new idea of mine will be formalized, to some extent, in terms of the notion of referential structure in the next section. The mechanism for defining the word meaning by using other words already defined elsewhere, is the very essential function of D.E.

Notwithstanding the incorrectness of their original idea, the traditional lexicographer's method for treating the word meanings as a collection of word-by-word segments is adequate in the sense that it provides the representation form for the word meanings at its highest efficiency. This traditional representation form has been very stable and reliable and seems to have almost no room for improvement. In fact we have no means [i.e. representation forms] for describing all the meanings of words with their actual word-usage-environments such as in conversations, communications, letters, reports, etc. If we could describe all the actual meanings of words with their environments, then we should have the mean to represent the almost infinite number of word-usage-environments corresponding to infinitely many varieties of situations of this world.

Thus each entry-word, even though being in solitude, must take a role of describing a certain part of this world that is composed of infinitely many objects and relations; and hence the meaning of each entry word is not unique (or unitary) but many sorted. Here we should note that the meaning of each word which is just being used in a certain actual situation is absolutely unique, never multiple, though there is some small possibility of misunderstanding. This is due to the work of selective restriction or filtering invoked by the context or the situation.

Let us assume we are to give the meaning of a word being completely isolated from its context and situation. This assumption corresponds to the attitude of treating the word meaning as a dead and fixed object. [Moon 87] said that this attitude was something like observing a dead fly fixed in amber instead of a vivid flying fly in a natural environment. But indeed the actual ordinary lexicons are obliged to treat the word meaning as if it is fixed in amber, because a living word in an actual context has infinitely many varieties which are impossible to accommodate with the space allowed.

Some common devices to add the living and dynamic [contextual] information to the fixed words are as follows:

1)to list the description of different/separable meanings of the entry word:
bank 1. the land along the side of a river, canal, lake, etc.
2. an institution for keeping, lending, exchanging and issuing money.

2)to give the hint of context by giving some words which are able to connect with the entry-word.
page 1. [of books] one side of a sheet of paper.
2. [of persons] a youth who attends(=takes care of)a persons of rank.

3)to give the hint of context by giving examples of phrase or sentence using the entry-word.

<u>leak</u> 1. a hole or crack through which liquid, gas, electric current, etc. passes in or out. %% a leak in a roof.

2. the water, steam, etc. that passes through leak-1. %% a lot of leak from this pipe.

4) to explain the effect of the entry-word used in an actual situation, so as to give the hint of context[Hanks 87].

<u>listen</u> 1. If you <u>listen to someone</u> who is talking or <u>to a sound</u> that you can hear, you give your attention to them or to it. [COBUILD 87]

2. If you <u>listen for something</u> that you are expecting to hear or •••

We may regard that all the above devices are the elaboration to admit the pragmatic meaning that is uniquely defined by its context of word usage. And clearly no device can attain complete (i.e. 100%) coverage of all the varieties of contextual meanings. And further, lexicons should have the mission to give the <u>standard meaning</u>, i.e. the <u>sense</u> of a word which is, to some extent, to be independent of context and situation [Moon 87].

3. REFERENTIAL STRUCTURE

In the previous section we have seen the traditional view of D.E. (= definition or explanation) in O.L.(= ordinary lexicon) which has a strong tendency to regard each D.E. as the isolated and/or separated one from others. Along with this traditional idea, each `entry-word and D.E.´ should be independent and self-closed description. But unfortunately this traditional idea is not so valid when we should view an ordinary lexicon in its totality, i.e. an expert knowledge-base; even though the traditional view has been providing a sound guiding principle for lexicographers.

The recursive nature of D.E. i.e. `the property that each word is defined by other words already defined elsewhere´ is the essential character of D.E. In order to clarify this new view of mine, I will introduce a new concept named <u>referential structure</u> [Nitta 88]. This recursive nature seems also to go well with the human's word-meaning understanding ability. If we follow this recursive nature without considering the logically detailed matters, we will easily reach the idea of referential structure. Let us follow the paths:

FIND: the location of entry-word → READ & UNDERSTAND: its D.E. → SELECT: unknown words which are contained in D.E. → FIND: the location(s) of new entry-word(s) which used to be the unknown word(s) → READ & UNDERSTAND: its(or their) D.E.(s) → SELECT: ••• → FIND: ••• READ & UNDERSTAND: ••• → •••

More symbolically, <u>referential paths</u> are written as:

$x \rightarrow f(y_1, y_2, y_3, \cdots),$

$\quad y_i \rightarrow g(z_1, z_2, z_3, \cdots),$

$\quad\quad z_j \rightarrow h(w_1, w_2, w_3, \cdots),$

where x, y_i and z_j stand for entry-words and f(•• y ••) stands for D.E. which contains a word y which again may become yet another entry-word. As for g( ) and h( ), they have almost same roles as f( ). Note that it is possible for

$y_k = x$ or $z_k = x$ or $w_k = x$ (for some k)

to occur, which forms a referential loop, i.e. self-reference or recursive reference.

If we are to traverse the referential paths from a certain entry-word x, then we will traverse branched paths in parallel or sometimes will make a loop along the paths; thus our traversed paths will eventually form some network N(x, D). I will call this N(x, D) a referential network [spanned by a lexicon D with an entry-word x]. N(x, D) has many interesting properties from a computational viewpoint. But here I will only show one cognitive interpretation of N(x, D).

It may be natural to regard the human H as having reached the understanding of the meaning of a word x with a help of lexicon D, when all the `words located at the frontier of the referential-network N(x, D)´ belong to the vocabulary V(H) of human H. In order to have a little bit more precise discussion on the above interpretation, I have to begin with the somewhat careful definition of the referential network N(x, D) w.r.t. an entry-word x and a lexicon D.

In this paper I will not give explicitly the whole vocabulary and the D.E.s of the lexicon D, but the D is a specially tailored one that I have made by consulting various ordinary lexicons published so far, inclusive of [ALDCE 74], [COBUILD 87], [LDOCE 78] and [SHORTER 82].

I denote the referential structure of the word x w.r.t. the lexicon D as R(x, D) or simply R(x). R(x, D) is defined as the set of words which are referred in D.E.(=definition or explanation) of x. Let us see an simple example, where the lexicon D gives a definition that:

genius = `a person having very great natural power of mind´,

then,

R(genius,D)= {a, person, having, very, great, natural, power, of, mind} ,

or simply,

genius→ a, person, having, very, great, natural, power, of, mind.

For the purpose of linguistically meaningful discussion, we need some linguistic filter to remove some class of words such as prepositions, conjugations, articles, some common verbs, etc. from a referential structure. In this paper, I will use this filter without giving further comments whenever I am to describe a referential structure. Thus,

R(genius, D) = {person, natural, power, mind} ,

or

genius→ person, natural, power, mind.

I may also call the arrow `→´ a path. Thus the referential structure

R(demon, D) is equivalent to four paths:

genius→ person, genius→ natural, genius→ power, genius →mind,

or more graphically:

```
                ┌→ person
genius    →  ┤ → natural
                │ → power
                └ → mind
```

As is easily imagined, the above graph is a part of the referential network N(genius, D) whose entire graph may be fairly complicated with lots of paths. Repeatedly referring the lexicon D, we get:

person → a man, woman or child,
natural → of nature; produced by nature; having to with nature,
    nature → that which is the source of life; the forces that create,
power → strength; force; a particular ability of the body or mind,
mind → the part of a person that thinks, feels and wishes.

In the above examples, for the sake of an easy understanding, each referential structure is presented as being not yet processed by the linguistic filter. Such a repeating process will eventually form a referential network N(genius, D).

In order to avoid generating an infinite referential network, we have to put some constraint on the above repeating process:

1) If $y \in V(H)$ then y has no more paths and thus $y \in$ frontier-of-N(x, D),
2) If y is already in N(x, D) then add only a return-path to N(x, D),
3) If the path-length from x to y reaches a certain limit then same as 1),
where x is an entry-word, y is a currently referred word, V(H) is the vocabulary of some fixed person H, D is a certain fixed reference lexicon and N(x, D) is the referential-network as is already defined.

Note that clearly some notions of the referential structure are isomorphic to those of graph theory [see [Wilson 85] for example]. So some terminologies can be replaced by those of graph theory. But in this paper I have stuck to my own terminologies taking the advantage of linguistically richer images.

Now being based upon the definitions given so far, I can give a cognitive interpretation of N(x, D):

Interpretation: A person H can understand the meaning of the word x by consulting the lexicon D, if and only if there exists N(x, D) such that all of the frontier words of N(x, D) belong to the H's vocabulary V(H).

So far we have seen a simplified version of the referential structure that is equipped with only a word-filter. Though this version has been effective to explain the cognitive aspect of human's word meaning understanding process, it is not yet enough to develop a formal and/or computational function of language understanding. In order to facilitate this function, we have adopted a slightly modified version of FOL(= first order logic) and theorem proving [or more generally, unification] mechanism. Because of the space limitation of this paper, I only give a part of examples of a logical version of the referential structure consulting [SHORTER 82] as D:

liquid→ substance that is neither a solid nor gas and flows freely like water,

$$liquid(x) \rightarrow substance(x) \wedge \neg solid(x) \wedge \neg gas(x) \wedge ff(x) \wedge \{water(y) \Rightarrow like[ff(x), ff(y)]\},$$

where:

$$ff(\cdot) \equiv freely(\ flow(\cdot)\ ), \qquad \neg\Psi \equiv \text{negation of } \Psi,$$

and I omit the universal quantifiers and the lambda notations. Applying the unification process over N(liquid, D), we will get:

$$liquid(x) \rightarrow \exists y\ \text{be made of}(y, x) \wedge like[fsm(x),\ fsm(w_1)],$$

where:

$$fsm(x) \equiv \neg fixed\ \{\ smoothly[\ move(x)\ ]\ \},$$

and w_1 is the Skolem-constant for $\exists w{:}water(w)$. The above example suggests:

$$\text{be-made-of}(\ \cdot,\ \cdot) \in V(H) \text{ and } like(\cdot,\ \cdot) \in V(H).$$

4. PATH LABELING

The process of a human's word-meaning-understanding can be interpreted by the referential-network-traversing process as is shown in the previous section, However this interpretation is still superficial, not enough for providing a computational method(s) for computer program(s). The actual human's word-meaning-understanding process is more sophisticated. Especially each path of referential network is not of homogeneous, which should be distinguished by various path labeling. Human's word-meaning-understanding process also seems to to be guided by the tacit difference in the path labeling. In the previous section I only show the labeling of non-significant word, and the process of filtering them away for the sake of simplicity.

In this section I will show several kinds of path labelling in order to contribute to both the more reasonable interpretation of cognitive (= human's word-meaning-understanding) process and the more tractable computational process.

Let us return to the previous example.

```
          ┌→ person
genius →  │→ natural
          │→ power
          └→ mind
```

First, we can classify referential-paths into two categories: <u>direct-referential-path</u> and <u>indirect-referential-path</u>, where the first designates that the entry-word and the referred-word has some direct relation, whereas the latter does not. The latter suggests that the refferred-word has yet another [direct-]referential-path to another refferred-word. Let us explain this claim by the example.

```
genius→ ┌→(is-a)→ person
        └→(have-a)→  power → ┌→(modified-by) → natural
                             └→(owned-by)    → mind
```

The above referential network designates that: `genius→ person´ and `genius→ power´ are direct-referential-paths, whereas `genius→ natural´ and `genius→ mind´ are indirect-referential-paths. The referential-path labeled by `owend-by´ is just the inverse-referential-path labeled by `have-a´, thus we can also write as:

mind → (have-a) → power ← ・・・.

From more careful observation we may be able to get the network below instead of the above:

genius→(is-a)→ person →(have-a)→ power →・・・

where `genius→ power´ is a indirect referential path. This discussion has something to do with `property-inheritance´ problem and is interesting one, but here I will not go into further because of the space allowed. I only note that in our referential network let us utilize `property-inheritance´ as much as possible. This means that:

If $x \to (label_i) \to y \to (label_j) \to z$
and $(label_j):z$ is inheritable to x.
Then, instead of the above, let us adopt

```
x→ ┌→(label i )→y
   └→(label j )→z.
```

I call this principle MIP(maximum inheritance principle).

The definition of the path-label (or referential relation) `modified-by´ may also be controversial. But here I simply define this as the restrictive relation mainly invoked by adjectival or adverbial word(s). Let us see another previous example:

society →a group of persons joined together for a common purpose or by a common interest.

```
society →(is-a)→group →(composed-of) →persons →*
     * →(whose-goal-is) → ┌→interest→(modified-by) →common
                          └→purpose →(modified-by) →common
```

Again by virtue of MIP, from the referential network above, we get:

```
society → ┌→(is-a)→group
          │→(composed-of) →persons
          └→(whose-goal-is) → ┌→interest→(modified-by) →common
                              └→purpose →(modified-by) →common
```

As is easily understood, the aim of MIP is for maximizing the amount of knowledge extractable from the direct-referential-paths.

As for the kinds and number of path-labels, I have not yet reached the final and satisfactory conclusion. On this point I will report in the forthcoming paper based on the result of a large-scale experiment.

5. IMPLEMENTATION ASPECT

In this section I will comment very briefly, how to utiliz the idea of referential structure to implement a useful program on the base of ordinary lexicons. As I have shown in the the previous chapter, the principal methodology is in the referential-network-traversing. The referential network N(x, D) is a set of the one-word-to-many-words correspondences:

$$\{ (x \rightarrow x_1, x_2, x_3, \cdots, x_n \} ,$$

where n depends on the entry word x. Thus the traversing is actually performed by following these one-to-many-correspondences consecutively. In order to accelerate this traversing, it is essential to use an index file technique[such as the B-tree file technique]. This is mathematically equivalent to:

1)devising a high speed function I to give the unique index i for each entry word x, i.e. $I: x \rightarrow i$ or $I(x) = i$,
2)devising also a high speed inverse-function I^{-1} i.e. $I^{-1}(i) = x$,
3)devising an efficient data file, i.e. $F = \{ D(i) \}$ and $D(i) = (i_1, i_2, \cdots i_n)$, where $I^{-1}(i) = x$, $I^{-1}(i_1) = x_1$, $I^{-1}(i_2) = x_2$, $\cdots$, $I^{-1}(i_n) = x_n$; thus in short this file F contains the set of referred words in terms of their indexes,
4)devising an efficient inverted-data-file: $F^{-1} = \{ D^{-1}(i_j) \}$ and $D^{-1}(i_j) = i$ (for $j = 1, 2, \cdots, n$), where n depends on i.

In this paper I will omit to discuss: the linguistic filter L for putting constraint on referred-words, and the unification algorithm U for extracting the information from a logical version of the referential network N(x, D).

The translation algorithm T for making FOL(=first order logic) forms from D.E.s, is currently done in a semi-automatic manner i.e. coding FOL by hands with the help of an analyzing program. This translation algorithm, however, is very tough and contains lots of unsolved problems. One interesting attempt to perform this translation is given by [Colmerauer 82].

One more important practical remark is that the both file F and F^{-1} are to be extended to F^* ($\supset F$) and (F^*) $^{-1}$ ($\supset F^{-1}$) by applying the linguistic filter L to the actual traversing process. This extension can be taken as a compensatory treatment for the disunity in the description of actual ordinary lexicons. It is over these extended files F^* and $(F^*)^{-1}$ that the traversing algorithm can play a role of the engine of a global-lexical-knowledge-extracting-program.

Yet another remark: as for the referential-network-traversing, there are two directional types. One is top-down type traversing: from x to (x_1, x_2, ••• x_n), and the other is bottom-up type traversing: from (x_1, x_2, ••• x_n) to x. As is easily understood, the bottom-up type traversing is far more difficult than the other type, which requires lots of time and space for performing complicated computation through the inverse function I^{-1} and the inverted file (F^*) $^{-1}$. The bottom-up type traversing is very essential to make various kinds of inference on D.E.s, which will eventually contribute to conduct the exact word from D.E.s.

As for the kind of knowledge that is expected to be extracted from O.L. through the referential structure, I give only a brief list of examples without comments:

- restating a word-meaning in more basic (or elementary) words,
- making a taxonomic hierarchy [see [Tsurumaru et al. 87] for example],
- analyzing facets (or attributes) of conceptual words [Nitta et al. 80],
- inverting the retrieval process on a lexicon, i.e. finding the entry-word from its definition or explanation,
- selecting the pertinent one word from among many candidates.

5. CONCLUSION

Though ordinary lexicons have plenty of room for further improvements in their printing layout, they seem to have reached their completion as far as their fundamental knowledge structure and their [hand] usage style.

This paper has revealed that the essence of the structural completion is in the referential-structure, which naturally derives the concept of referential-network. Also this paper has shown that the fundamental method to extract the various useful knowledge from ordinary lexicons is to traverse the referential-structure, or more precisely, to traverse the referential-network, while applying a linguistic-filter and a logical-translator.

This paper could not spend an enough space to present the matter of program implementation. Our current experimental programs are based on FOL(= first order logic) and UA(= unification algorithm); which are to be presented in the forthcoming paper(s).

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REFERENCES

[ALDCE 74] Hornby, A. S. with A. P. Cowie(eds.): Advanced Learners' Dictionary of Current English, 3rd edition, Oxford University Press, Oxford (1974)

[COBUILD 87] Sinclair, J. (ed. in chief): Collins Cobuild English Language Dictionary, Collins Publishers and The University of Birmingham, London and Glasgow (1987)

[Colmerauer 82] Colmerauer, A.: An Interesting Subset of Natural Language, in: Clark, K. L. and S.-A. Tarnlund (eds.): Logic Programming, Academic Press, London, New York, Tokyo, pp.45-66 (1982)

[Hanks 87] Hanks, P.: Definitions and Explanations, in: [Sinclair (ed.) 87], Chap.6, pp.116-136 (1987)

[Hobbs et al. 87] Hobbs, J. R., W. Croft and T. Davis: Commonsense Metaphysics and Lexical Semantics, Computational Linguistics, Vol.13, No.3-4, pp.241-250(1987)

[LDOCE 78] Procter, P. et al. (eds.): Longman Dictionary of Contemporary English, Longman, London (1978)

[Moon 87] Moon, R.: The Analysis of Meaning, in: [Sinclair (ed.) 87], Chap.4, pp.86-103 (1987)

[Nitta et al. 80] Nitta, Y., K. Nukada, K. Mori and M. Ohkawa: Information Retrieval for Design Review Support, Proc. of ARMS'80 (The 1980 Annual Reliability and Maintainability Symposium), San Francisco, pp.152-157 (1980)

[Nitta 86] Nitta, Y.: Natural Language Understanding Viewed as Human Interface, Proc. of the 2nd Symp. on Human Interface, SICE, Tokyo, pp.527-534 (1986)

[Nitta 88] Nitta, Y.: The Role of Lexical Knowledge in Human Interface, Proc. of the 3rd Symp. on Human Interface, SICE, Tokyo, pp.311-320 (1988)

[SHORTER 82] Suganuma, T. and J. B. Harris (eds.): Obunsha's Shorter English Dictionary, Obunsha, Tokyo, Japan (1982)

[Sinclair (ed.) 87] Sinclair, J. M. (ed.): Looking Up---- An Account of the COBUILD Project in Lexical Computing, Collins ELT, London and Glasgow (1987)

[Sinclair 87] Sinclair, J.: Grammar in the Dictionary, in: [Sinclair(ed.) 87], Chap.5, pp.104-115 (1987)

[Tsurumaru et al. 87] Tsurumaru, H. et al.: Extracting Word Hierarchies from Definitions Given in a Dictionary (in Japanese), IPSJ Research Report on Natural Language Processing 64 2, IPSJ, Tokyo (1987)

[Wilson 85] Wilson, R. J.: Introduction to Graph Theory, 3rd edition, Longman, England (1985)