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Boot-strapping a WordNet using multiple existing WordNets

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Abstract
In this paper we describe the construction of an illustrated Japanese WordNet. We bootstrap the WordNet using existing multiple existing wordnets in order to deal with the ambiguity inherent in translation. We illustrate it with pictures from the Open Clip Art Library.

1. Introduction

It is rare for languages to have many freely available lexical semantic resources. In particular, few languages have as many as English. This lack of resources slows down both theoretical and applied research into language meaning across languages.

Consider the case for Japanese. There are at least two excellent thesauruses available: the Japanese Synonym Dictionary (Hamanishi and Ono, 1990) and Goi-Taikei, a Japanese Lexicon (Ikehara et al., 1997). Unfortunately, although they were both used extensively in machine translation research, the published resources focus almost entirely on Japanese. Further, the thesauruses are proprietary, which makes it extremely hard to share and build on the results of research using them.

To alleviate this problem, we are investigating methods to quickly and efficiently build a Japanese version of WordNet (Fellbaum and Vossen, 2007). This wordnet is based on the structure of the English wordnet — Japanese near synonyms are added to the existing English synsets. For example, the English synset consisting of seal #n#9 "any of numerous marine mammals that come on shore to breed; chiefly of cold regions"1 has the following Japanese words associated with it: アザラシ azarashi "seal" and 海豹 gaiguntokushubutai "Navy Seal".

The WordNet project at Princeton has been a resounding success, creating a resource that is widely used in research (Fellbaum, 1998) and emulated in many languages (Vossen, 1998). In order for a lexical resource to be widely adopted it must be both accessible and usable. The Princeton WordNet is accessible due to its being released under a non-restrictive license; and usable because it has not just precise information but also reasonable coverage, especially of common words.

Because of this success, there have been many projects to build wordnets for other languages. One of the first was the EuroWordNet project, which built wordnets for several European languages (Vossen, 1998). Unfortunately, most of the wordnets are neither as accessible as the Princeton WordNet, due to more restrictive licenses, nor as usable due to more limited cover. Recently, the Global WordNet grid has tried to add even more languages, making the data as accessible as possible (Fellbaum and Vossen, 2007).

There have been several initiatives to create a Japanese wordnet, but none of them have yet produced something that is both accessible and usable. Hayashi (1999) created a translation of the entire noun part of the Princeton WordNet, including both synsets and glosses. This produced a very usable resource, but it was unfortunately not at all accessible. Koide et al. (2006) looked at combining EDR (EDR, 1990) with Princeton WordNet, but did not get beyond converting them both to RDF representations. Kaji and Watanabe (2006) presented a method of translating synsets from English to Japanese using corpus based contexts to improve accuracy, but only tested this on a few words. More recently, Cook (2008) produced a Multi-Lingual Semantic Network by translating monosemous parts of the Princeton WordNet into Japanese, Chinese and German. He also made an interface for browsing and amending the network. This data is accessible, as it is released under an open license, but loses a little on usability as most monosemous entries are for less frequent words.

The amount of previous work shows the great interest and value of producing a Japanese WordNet. We therefore decided to construct one as follows: First, automatically translate the Princeton WordNet into Japanese. Second, manually check the most frequent 20,000 synsets. Third, link the synsets to a corpus. Fourth, release the data under an open license. As we said earlier, this WordNet is based on the structure of the English wordnet: Japanese near synonyms are added to the existing English synsets. Adapting it more fully to Japanese is left to future research. More details of the overall project are given in Isahara et al. (2008).

The obvious way to do add Japanese to the English WordNet is by translating the entries using an English-Japanese dictionary. The problem with this is that bilingual dictionaries are not marked with WordNet senses, if we look up seal we get over 30 entries, including 判子 seal “stamp” and 海軍特殊部隊 gaiguntokushubutai “Navy Seal”. We need to associate these candidates with the appropriate WordNet senses.

Our method takes advantage of the existence of wordnets in multiple languages, and uses them to sense disambiguate the translations. We were able to build it quickly and efficiently using the results of existing work on building wordnets and lexicons, and we intend to make it freely available so that other people can build on it.

2. Lexical Resources

In this section we describe the resources we have used. Most of them are open resources.

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1All examples are from WordNet 3.0.
### 2.1. Wordnets

We use four wordnets, summarized in Table 1. The largest is the English Wordnet v3.0 (Fellbaum, 1998) with 117,659 entries. The EuroWordnets are considerably smaller, ranging from 15,132 for German up to 22,745 for French (Vossen, 1998), consisting mainly of nouns with some verbs. All of them share the same structure — a collection of synsets joined to make a semantic network. Because Wordnet keeps growing, both in size and complexity synsets can split up or even potentially merge across versions. The data for German was based on 1.5 and French and Spanish on 1.6. We mapped them into 3.0 using the mappings from Daude et al. (2003). When a synset mapped to more than one synset, we simply linked it to the most highly weighted one.

### 2.2. Lexicons

We use JMDict, the Japanese→Multilingual dictionary created by Jim Breen (Breen, 2004) for Japanese-English/French/German. We did not use its proper name dictionary, as wordnet does not have a lot of names. JMDict is widely used, and is increasing in size at the rate of almost 1,000 entries a month (Bond and Breen, 2007). To supplement this we also used the EDR Japanese-English lexicon (http://www2.nict.go.jp/r/r312/EDR/index.html) and the last downloadable version of the Japanese-English Life Science Dictionary Project (v4) (http://lsd.pharm.kyoto-u.ac.jp/r/r312/EDR/index.html). For Japanese-Spanish, we used a small dictionary downloaded from http://aulex.ohui.net/ (Goihata) and licensed under the GPL. The sizes of these lexicons are listed in Table 2. The lexical resources, are, as always, not evenly distributed amongst the world’s languages — Japanese-English has the most resources, followed by German, then French and then Spanish.

### 3. Creating the Japanese Wordnet

The approach we are taking to build the Japanese Wordnet is the standard expand approach: “translate WordNet synsets to another language and take over the structure” (Vossen, 2005). We did this both to keep a compatible structure with WordNet, and because we had access to a variety of resources to make the task easier. Our main innovation is that we are using WordNets in multiple languages to disambiguate the Japanese translations, thus providing more reliable estimates.

Consider the following two synsets for *bat*, with their translation shown in Figure 1:

| Part of Speech | Number of Synsets |
|----------------|-------------------|
| Speech         | English | French | Spanish | German |
| Noun           | 82,115  | 17,826 | 7,902   | 9,951  |
| Verb           | 13,767  | 4,919  | 3,775   | 5,166  |
| Adjective      | 18,156  | 0      | 3,879   | 15     |
| Adverb         | 3,621   | 0      | 0       | 0      |
| Total          | 117,659 | 22,745 | 15,556  | 15,132 |

Table 1: Sizes of the Wordnets used

| Part of Speech | Number of Synsets |
|----------------|-------------------|
| Speech         | s > 10 | s > 1 | All |
| Noun           | 9,243  | 36,432 | 42,725 |
| Verb           | 2,991  | 9717   | 10,321 |
| Adjective      | 629    | 6,283  | 8,915  |
| Adverb         | 9      | 1,317  | 1,726  |
| Total          | 12,872 | 53,749 | 63,687 |

Table 3: Japanese Synsets by score

The actual algorithm we used was as follows:

- For each synset in WordNet 3.0
  - Find equivalents in WN- {Fr,Es,De}
  - Look up translations for all equivalents \(\{J_{Fr}\}, \{J_{Es}\}, \{J_{De}\}\)
  - Rank Japanese equivalents
    - score \(s = |\text{links}| + 10\) for links in two languages

The result is a wordnet with multiple Japanese candidates for most synsets, with a confidence score \(s\) equal to the number of bilingual links plus a ten-point bonus for being linked in multiple languages.

### 4. Results and Evaluation

In this section we report on how many synsets we could translate into Japanese, and with what confidence. The results are summarized in Table 3. We have found some kind of translation for 63,687 out of the possible 117,007 synsets in Wordnet 3.0 (54.4%). Of these, the EuroWordnet data played a role in over 15,000 synsets. 12,872
Table 2: Size and Distribution of the various Lexicons

| Part of Speech | Number of Word-Pairs |
|----------------|----------------------|
|                | ja-en | ja-de | ja-fr | ja-es |
| Noun           | JMDict | EDR | Lifsci | JMDict | JMDict | Goihata |
| Verbs          | JMDict | EDR | Lifsci | JMDict | JMDict | Goihata |
| Adjective      | JMDict | EDR | Lifsci | JMDict | JMDict | Goihata |
| Unknown        | JMDict | EDR | Lifsci | JMDict | JMDict | Goihata |

Figure 1: Linking with Multiple Wordnets

Table 4: Base Japanese Synsets by Score (s) for the Base Synsets

| Part of Speech | Number of Synsets |
|----------------|-------------------|
|                | s > 10 | s > 1 | All |
| Noun           | 2,429  | 3,264 | 3,279 |
| Verb           | 656    | 988   | 993  |
| Adjective      | 153    | 586   | 653  |
| Total          | 3,238  | 4,838 | 4,925 |

Table 5: Base Noun Candidate Precision

| Appropriate Translation Candidates |
|------------------------------------|
| s > 10 | 10 > s > 1 | s = 1 | All |
| Base   | 55.30%   | 39.64% | 21.25% | 26.56% |

5. Illustrating WordNet

In order to make the sense distinctions more visible we also semi-automatically link synsets to illustrations from the Open Clip Art Library (OCAL; Phillips (2005)). This adds a new modality to the knowledge linked in the semantic net. Illustrations of concepts are useful for a variety of tasks. One is pedagogical — it is useful to have pictures in learners’ dictionaries. Another is in cross-cultural communication - for example in Pangea, where children use pictons (small concept representing pictures) to write messages (Takasaki and Mori, 2007).
We use the collection of OCAL images distributed as SVG (scalable vector graphic) images in the Ubuntu Fiesty distribution based on the OCAL release of October 2005 (v 0.18). It contains 8,107 images (with some duplicates), organized in a shallow file hierarchy. Currently, some 4,000 new images have been added to the OCAL, but we have not yet processed them.

Each image is associated with a collection of explicit metadata, including a title, description and a set of tags, all of which are recommended rather than obligatory. SVG images are written in XML, the metadata is embedded within using the Creative Commons’ metadata standard.

We take advantage of the metadata associated with each image to associate the image to a specific synset. The basic idea is to look for metadata associated with a word and its hypernym: if we can find a match of this combination in Wordnet, then we consider it a valid illustration for that synset. For example, for bat_orlando_karam_svg, its title is bat and it is tagged as mammal. We look in wordnet for hypernym synsets of bat that include mammal and find the following: bat#n#1 ⊂ placental#n#1 ⊂ mammal#n#1. Therefore, this picture illustrates bat#n#1 rather than the other synsets associated with the word bat.

There are several sources of metadata. We first use explicit metadata such as TITLE for the root word and TAGS for the hypernyms. If there is no explicit metadata (which is true for around a third of the images) or we couldn’t find a match, then we look for implicit metadata. We take the basename bat_orlando_karam and delete any numbers from the end. We also add directory names to the tag list (animals/mammals/bat_orlando_karam_.svg): in this case “mammal” and “animal”. Finally, we match the tags against each other.\footnote{We do some normalization when we look words up in wordnet: if we can’t find a word as is, we then look it up downcased, without spaces, and in singular form: paint brushes $\rightarrow$ \{paintbrushes, paint brush, paintbrush\}.}

Using the tags allows us to largely solve the problem of Image Sense Disambiguation for those pictures we identify. However, it does not solve all of the problems raised in (Alm et al., 2006), in particular the problems of depiction (is a sign with a train on it an example of train?) and partial display (is a picture of a dog’s head a good illustration for dog or head or neither or both?).

There are 956 illustrations which match, illustrating 758 synsets. All the successful links were of nouns. Most matches are of concrete objects, and generally of the base synsets. The synset with the most matches is smiley#n#1 “an emoticon of a smiling face” which has 33 illustrations.

We have only linked a small subset of illustrations (936 out of 8,107 images) and an even smaller proportion of wordnet (758 out of 82,115 noun synsets). However, these figures are better than they seem — many of the illustrations were not suitable in the first place. And any illustrated synset also (in theory) illustrates its hypernyms, so we have indirectly illustrated far more than 758 synsets.

6. Discussion

In this paper we presented a method of automatically producing a Japanese WordNet of reasonable quantity by cross checking senses across different languages.

In future work we will manually check the most frequent synsets, sense annotate a small corpus and release the data. We hope it will then be used along with other projects such as the Global Wordnet Grid (Fellbaum and Vossen, 2007) and the Multi-lingual Semantic Network (Cook, 2008) to produce an even more useful resource.

Our results confirm one of the advantages of the global wordnet grid: available high quality existing resources makes it easier to build more. Now we need to make these resources as easily available as possible to enable even further progress. Of course, not all languages have as many available resources as Japanese. However, bilingual lexicons are much more common than wordnets, so it makes sense to use the more common lexical resources to bootstrap the rarer one.

An example of the complete results for the synset tree#n#1 “a tall perennial woody plant . . . ” is given in Figure 2. Each synset is given a name consisting of the highest scoring Japanese match with the first English entry for that synset, in this case “ツリ/ツリー”. This is the format we use for browsing the results of our matching.

The Japanese matches are shown in three sets: $s > 10$ (◎); $10 > s > 1$ (○); $s = 1$ (●). In this case 2/3 of the top set (◎) are good matches; the third ツリ/ツリー “tree” is mainly used for Christmas trees. The middle set (○) consists solely of 木本 mokuhon “woody plant”, which is the immediate hypernym of tree#n#1. The second member of the last set is also good, the rest are irrelevant. The matches for the hyponyms (hypo) are mainly good: the lower down the hierarchy the less likely words are to be ambiguous.

We have also made a first step towards illustrating wordnet. We expect the number of linked illustrations to grow due to the following factors (a) more images (and better tags) being added to the OCAL; (b) more words being added to wordnet and (c) improvements in the matching algorithm.

In the long term, we would like to integrate the wordnet linking into the Open Clip Art Language workflow, so that new images can be tagged as they are added to the library. We hope that the link to definitions, examples and multilingual equivalents will provide even more motivation to artists to add accurate and detailed meta-tags.

From the point of view of the open clip art project, tagging illustrations with wordnet synsets will allow people to search for pictures more effectively. In particular, they can associate the image with its synonyms and hypernyms — someone looking for pinniped or aquatic mammal could find the image associated with seal. In addition, thanks to the global wordnet grid, we can do this in multiple languages: bat#n#1 is linked to chauve-souris “bat” in the French wordnet, Fledermaus “bat” in the German wordnet, 蝙蝠 koumori “bat” in the Japanese wordnet and so on.

7. Further Work

In the immediate future we plan to hand correct more entries, and sense tag a small corpus. We plan to release
the manually checked subset of WordNet sometime in June 2008. Rather than have a single maintainer and major releases, we hope to maintain the WordNet as a community resource, along the lines suggested by Charoenporn et al. (2008). Here a wiki-like tool is used to allow people to extend and amend the WordNet, with final changes checked by moderators. In this release, we also intend to add high confidence automatic entries (unambiguous translations of monosemous words) as suggested by Cook (2008) and explicit linking of orthographic variants: color/colour or 布団/ケット "bed". In other major extensions we are hoping to do the following:

- Link the wordnet to other ontologies, such as concepts in EDR (EDR, 1990), GoToKàkei (Ikehara et al., 1997) and CoreNet (Choi and Bae, 2003).
- Sense tag a variety of corpora.
- Use the WordNet data as a module for Japanese in the METEOR Automatic Machine Translation Evaluation System (Lavie and Agarwa, 2007).

8. Conclusions
In this paper we described the construction of the illustrated Japanese Wordnet. We bootstrapped the Wordnet using existing wordnets and bilingual lexicons. We were able to produce Japanese translations for 98% of the core classes, over half of them with high confidence.

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