A Morphological Analyzer for Japanese Nouns, Verbs and Adjectives

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Abstract

We present an open source morphological analyzer for Japanese nouns, verbs and adjectives. The system builds upon the morphological analyzing capabilities of MeCab [Matsumoto et al., 1999] to incorporate finer details of classification such as politeness, tense, mood and voice attributes. We implemented our analyzer in the form of a finite state transducer using the open source finite state compiler FOMA toolkit [Hulden, 2009].

1 Basic Information about Japanese

The Japanese language is spoken by more than 100 million speakers (mostly in Japan). It is an agglutinative language with a SOV word order. The Japanese writing system makes extensive use of Chinese characters, also known as kanji, along with scripts, hiragana and katakana, which are syllabic.

There are 3 main lexical classes in Japanese that exhibit morphology, they are the nouns, verbs and adjectives. In Japanese, adverbs are often adjectives suffixed with a special morpheme. As such, it is often not considered a separate class of words. In §4 we will discuss the phenomenon for each of these word classes.

2 Past Work on the Japanese morphology

In traditional Japanese morphological analysis, a lexicon is assumed. The lexicon is a list of pairs of a word and its corresponding part-of-speech. As Japanese is an unsegmented language, past work on Japanese language morphology analyzers require the use of a segmenter. Often, the segmentation step is conducted jointly with the morphological analysis step in a rule based [Matsumoto et al., 1991] or machine learning framework [Kudo et al., 2004, Matsumoto et al., 1999].

The current state of the art Japanese language part of speech and morphological analyzer is MeCab [Matsumoto et al., 1999], which is an extended from ChaSei [Matsumoto et al., 1991], but using CRFs [Lafferty et al., 2001] instead of HMMs to model the morpheme sequences.

*This morphological analyzer is done as part of the project requirements for the Spring 2013 NLP Lab (11-712) at Carnegie Mellon University (http://www.cs.cmu.edu/~protect/unbox/voidb8x/penalty/\penalty\0nasmith/NLPLab/).

1 The source code and tool is available at https://bitbucket.org/skylander/yc-nlplab/. http://mecab.googlecode.com/svn/trunk/mecab/doc/index.html
http://chasen-legacy.sourceforge.jp/
MeCab segments words and provides annotations for 69 different part of speech categories. These categories, although comprehensive, do not cover the certain morphological phenomena in detail, such as the differences between honorifics used with Japanese nouns, and the finer grammatical attributes of verbal and adjectival conjugations. In this lab, we will seek to improve upon current morphological analysis tools by filling in these missing gaps.

3 Available Resources

We will be using MeCab as a preprocessing tool for word segmentation and POS tagging. MeCab achieved $F_\beta$ scores of above 0.96 on standard Japanese text corpora that has been segmented and annotated with POS tags.

We gathered the following text corpora:

(i) Tanaka corpus [Tanaka, 2001] contains 149,909 English-Japanese sentence pairs from various sources such as books, songs, bible, etc. These sentences are word segmented and contain kana readings for ambiguous Kanji characters. However, they do not contain morphological annotations.

(ii) Japanese-Multilingual Dictionary [Breen, 2004] is a multilingual lexical database with Japanese as the pivot language. It is updated almost everyday and contains numerous information about lexical items, such as kanji/kana/romaji readings, part of speech, conjugation group and sense tags. We used the dictionary for our verbs and adjective lexicon.

Table 1 shows the distribution of different lexical types in the above two corpora.

| Lexical type      | Tanaka corpus | Japanese-Multilingual dictionary |
|-------------------|---------------|----------------------------------|
|                   | Tokens  | Types  | Types  |
| Nouns             | 331,577 | 15,769 | -      |
| Verbs             | 247,544 | 4,588  | 40,507 |
| Adjectival verbs  | 29,869  | 584    | 4,032  |
| Adjectival nouns  | 22,138  | 1113   | 10,242 |

Table 1: Statistics of lexical items in Tanaka corpus and Japanese-Multilingual dictionary.

4 Survey of Phenomena in Japanese

4.1 Nouns

Nouns are usually not inflected. However, the Japanese language do have an extensive honorific system, and nouns often take politeness prefixes and suffixes (for animate objects), a small group of suffixes are also used to refer to collective nouns.

Honorific prefixes The prefixes *o- (お-)* and *go- (ご-)* are prefixes applied to nouns (and sometimes verbs) to convey a respectful or polite tone of speech. Native Japanese words are preceded by *o-* while Sino-Japanese words are usually preceded by *go-*, although there are exceptions to both cases.

http://mecab.googlecode.com/svn/trunk/mecab/doc/posid.html
Honorific suffixes
Honorific suffixes are almost always attached to person names and occasionally other non-human objects (such as animals, inanimate objects, etc). These suffixes depend on the formality of the dialogue, the speaker’s familiarity and status difference with the referred person, as well as the gender/age of the referred person.

Collective suffixes
Collective suffixes are appended to nouns to signify a collective group of the noun. These suffixes are often used with singular pronouns to refer to its plural counterpart. Common collective suffixes are -tachi and -ra. Occasionally, these suffixes may be used with proper animate nouns to signify a group including the mentioned noun (collective, not pluralizing). For instance, Tanaka-tachi maybe translated as ‘Tanaka and his friends’ or ‘Tanaka and his family’ but not ‘some people named Tanaka’. We take this distinction into account when collective suffixes are used in the context of pronouns.

Pronouns
Japanese is a pro-drop language, and hence are used less frequently than in English. Hence, pronouns are usually treated morphologically like nouns and plural pronouns are formed with collective suffixes. In addition, pronouns are considered an open lexical class (since it behaves just like a noun), which means that new pronouns are being “created” to be used in specialized contexts (age, familiarity, different levels of formality, etc). As such, we will only consider pronouns that are found in our corpus.

4.2 Verbs
Verbs in the Japanese language are conjugated extensively depending on their grammatical categories. Due to the agglutinative nature of the language, the suffixes are fairly productive and in casual speech, many contractions are used. Generally, verbs can be conjugated for aspect, polarity, politeness, mood, voice, tense. Details about verb conjugations will be described in §7.1.
4.3 Adjectives

Japanese do not have adjectives in a syntactic sense. Unlike western languages where adjectives are usually inflected similar to noun declensions, Japanese adjectives are conjugated like a verb. This is because words that behave semantically as adjectives are technically considered as specialized verbs (i-adjectives) or nominals (na-adjectives). There are several other classes of adjectives, which are more commonly used in Classical Japanese, and in Modern Japanese are limited to a select few special cases. There are two main classes of adjectives: adjectival verbs and adjectival nouns.

5 System Design

5.1 High level overview

Our morphological analyzer will focus on the task of analyzing the morphology of individual tokens. Hence, we will design our analyzer to take input from the processed output of MeCab, a high quality state of the art Japanese part of speech tagger and morphological analyzer. MeCab is a CRF classifier that segments and tags each token with a part of speech category. It has a hierarchical tag set (of up to 4 levels), starting with 8 coarse categories and 68 fine categories in total. In the case of nouns, it provides a coarse morphological analysis by segmenting the morphemes for honorifics and collectivism and classifying it as suffixes or prefixes belonging to persons, locations, quantifiers, etc. Hence, our contribution would be to incorporate finer details of classification such as politeness and gender attributes. Details of our implementation for nouns would be described in §5.3.

For verbs, adjectives and adverbs, the morphemes are not segmented as the surface forms undergo various morphophonological changes. Thus, the analysis by MeCab is limited to the forms of the verbs and its lemma. Our analyzer will therefore focus on extracting the morphological attributes such as tense, mood, voice, etc. The details of our implementation for verbs will be discussed in §7.

Figure 4 shows the high level view of our morphological analyzer pipeline.

Figure 4: Raw sentences will be fed to MeCab for segmentation and POS tagging. After which, the individual tokens, along with the POS and lemma information will be fed to our FST-based morphological analyzer for analysis.

5.2 Morphological analyzer system details

We implement our analyzer by building finite state transducers to process and generate finer analyses. We will use Foma\(^5\), which is a popular open source tool compiler, programming language, and C library for constructing finite-state automata and transducers for NLP applications.

Our morphological analyzer will consist of two independent FSTs, for handling (i) nouns, and (ii) verbs/adjectives, which we will describe in the sequel.

\(^5\)https://code.google.com/p/foma/
5.3 FSTs for analyzing nouns

Japanese nouns have fairly regular conjugations, as such, we will design our FST as a transducer that takes MeCab’s part of speech information as input, and translate it into its analysis.

From MeCab’s output, we will have a post-processing script that parses MeCab’s output and convert it into a format suitable for our analyzers. We will do this using a Python script and the input to the FST would be

\[ \text{N#<token1>/<pos_id1> <token2>/<pos_id2> ...} \]

For some nouns, the prefixes and suffixes have been segmented into separate tokens. Thus, an input may consist of several tokens with different part of speech IDs.

Noun morphology phenomena The following noun morphology are handled by our analyzer:

1. Honorific prefixes: お-, ご- (common) and 御- (usually only found in literary writings). Output will be marked with a +POLITE attribute.

2. Formal/informal honorific suffixes for animate objects: ちゃん, さん, 君 and 様. For ちゃん and 君, the output will be marked with +INFORMAL, while 様 will be marked with +FORMAL. The very common さん suffix is not tagged formal/informal because the use of it is standard in Japanese (as a default polite form) and hence its use do not convey much politeness information beyond that of typical social scenarios. However, all objects with honorific suffixes mentioned above will have an +ANIMATE attribute.

3. Collective suffixes: 達, 等, 方, たち, ら and かた. Output will be marked with a +COLLECTIVE attribute.

4. Table 2 presents a list of pronouns that are handled by our analyzer and their morphological attributes. Furthermore, consecutive sequences of pronouns-collectives are handled as a single entity even if MeCab segments them into separate tokens (i.e +PLURAL instead of +COLLECTIVE).

5. Noun possessive marker no (の). Noun phrases ending with a no token are replaced with a +POSSESSIVE attribute.

6 First System Analysis (Nouns)

We extracted all the types that were tagged as nouns in Tanaka corpus. Table 1 show statistics about nouns in the corpus. We randomly selected 1,000 types to manually evaluate and analyze for mistakes.

Table 3 shows some statistics about the nouns evaluation set. In general, most nouns in the corpus does not exhibit any morphology. For those that do contain morphological elements, our analyzer was able to identify them with high accuracy. However, our analyzer made a few mistakes (10 on the evaluation set to be exact), which can all be attributed to segmentation/tagging errors returned by MeCab, which was unable to segment the sentences correctly.

6.1 Examples

Table 4 shows example analyses produced by our noun FST.

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6 MeCab tags such tokens as 名詞,非自立, 一般, with a POS ID of 63.
7 FSTs for analyzing verbs and adjectives

Japanese verbs and adjectives are handled very similarly. In fact, most adjectives can be considered a form of specialized verbs, and feature very similar conjugation rules. As such, we shall use a single FST to handle these two categories of words.

7.1 Verb morphology phenomena

Lexically, almost every verb in Japanese is belongs to one of four conjugation groups:

(i) Ichidan verb (一段動詞),
(ii) Godan verb (五段動詞),
(iii) Sa row irregular conjugations (サ行変格活用), and
(iv) Ka row irregular conjugations (カ行変格活用)

A verb in Japanese is made up two parts, a stem form and a series of morphemes. The stem form is usually written in kanji along with a kana character that denote one of the 6 verb forms in
Table 4: Example analyses produced by noun FST.

| Input to FST     | Analysis                                |
|------------------|-----------------------------------------|
| お医者/30         | 医者+FORMAL+ANIMATE+POLITE ‘doctor’     |
| 38 様/55$        |                                         |
| 少年/38 達/51$    | 少年+COLLECTIVE ‘youth’                 |
| 51$              |                                         |
| 彼女/59 達/51$    | PRN+3PER+FEMALE+PL+INFORMAL ‘the gals’  |

Japanese. The morphemes suffixes are usually written in kana. We refer the user to a comprehensive grammar guidebook for more information about the stem forms. Here, we will briefly describe the morpheme suffixes that are handled by our analyzer. We will now describe the suffixes that are analyzed by our system:

1. Dictionary forms: The root form of a Japanese verb is known as the dictionary form. When used in its dictionary form, it denotes an imperfective aspect and informal tone. The dictionary form is returned by our analyzer as a verb’s lemma.

2. Perfective aspects (+PFV) are usually denoted by -ta (-た) or -da (-だ) suffix, but various phonetic changes are made depending on a verb’s last syllable.

3. Negation (+NEG) are usually denoted by -nai (-ない) suffix. However, in casual and colloquial Japanese, many different suffixes for negation are encountered. Some examples that we found in our corpus are -な, -ぬ, -ん, -ず, -ずな, -なきゃ, -せぬ, -ざる.

4. Passive form (+PASV) have a -reru (-れる) suffix which can be treated as an ichidan verb and conjugated.

5. Te-forms (+TE), also known as conjunctive forms, allow multiple verbs to be used together. Example (9) and (10) shows some te-form verbs being used. The verbs that conjoin with the te-form stems can be considered a form of helper auxiliary verb, of which there are many in Japanese. Also, the newly conjoined verb is usually conjugated as an ichidan verb. Since there are to many possible auxiliaries for us to consider, we only consider the auxiliary -iru (-いる) when used with te-forms, which denotes the progressive aspect (+PROG). Other auxiliaries would be analyzed independently, and it would be up to the downstream application to take into account the presence of a preceding +TE form token. It would be easy to extend the FST to handle other helper auxiliary verbs.

(9) 眠て いる
nete iru
sleep+TE to be
‘to be sleeping’

(10) 食て おく
tabete oku
eat+TE put/place
‘to eat in advance’

Figure 5: Examples of te-form conjunctive verbs.

In addition, there are also many auxiliaries that compound with non te-form stems.

6. Conditional moods (+COND) are used in conditionals and denoted (usually) by the -ba (-ば) and -ra (-ら) suffixes.
7. Volitional form (+vol) expresses intention and are used with the -u (－う) suffix.

8. Imperative form (+imp) are characterized by verbs conjugating to have an e phonetic ending.

9. Causative forms (+caus) generally have a -seru (－せる) / -sar (－さる) suffix.

10. Potential forms (+pot) are used to express that one has the ability to do something.

11. Like nouns, verbs have a polite form (+pol) that is usually characterized by a -masu (－ます) suffix.

7.2 Phonological rules

Like most languages, there are several phonological rules that apply to the conjugated verbs and adjectives. One such common and regular rule is phonological change when ending with a [t] consonant. For example te-form verb endings -ite, -chite, -rite change to a double consonant, -tte, endings in -bite, -mite, -nite change to -nde (voicing of the te syllable), endings in -kite change to -ite, and endings in -gite change to -ide (voicing of the te syllable). The above double consonants and voicing patterns also applies when dealing with perfective aspect endings -ta.

There are also numerous contractions that are used in colloquial conversations. For instance, the progressive marker -teiru becomes -teru and -teshimau becomes -chau.

7.3 FST as a generator

Due to the agglutinative nature of the language, the morphemes suffixes can be added in many different arbitrary order. Hence, we have designed the FST as a generator, meaning the output of the FST is the surface form of a conjugated verb and the input is its lemma and morphological feature. The FST inherently has no knowledge of valid or invalid orderings of these suffixes and thus tend to over generate surface forms for a particular input.

When the FST is being used, it is trivial to reverse the direction of the FST, and return the underlying form of the verb token. However, it is very possible for a verb token to have multiple analysis and it is up to the downstream application to decide between possible analyses.

7.4 Adjective morphology phenomena

As described in §4.3, there are two main classes of adjectives, and we describe how our analyzer handle them here.

Adjectival verbs (i-adjectives) end with -i (－い) and can be conjugated with almost all the suffixes for verbs. These adjectives are also often found in predicate positions, denoting their verb-like nature. For instance, when a verb takes on a -nai negation suffix, it can be treated morphologically like an i-adjective, and likewise, when an i-adjective is conjugated for te-form, it behaves just like any other te-form verb.

Adjectival nouns (na-adjectives) always occur with a form of the copula -da (－だ). Because adjectival nouns are usually formed from nouns, it has led many linguists to consider them a type of nominal. The copula (considered an irregular ichidan verb) can conjugated just like any other verb. It is thus treated as such by our analyzers.
Other adjective classes have limited use in modern Japanese. In our analyzer, we have chosen to ignore these adjectives and not analyze them.

8 Second System Analysis (verbs and adjectives)

We extracted all the tokens that were tagged as verbs or adjectives in the Tanaka corpus. Table 1 shows statistics about the verbal and adjectival lexical items in the corpus. From all the tokens, we extracted 2,000 verb and 1,000 adjective tokens for manual evaluation. Since for each token, the FST produces multiple analyses (there can also be multiple valid analyses absent context), we measure the precision/recall performance of our analyzer. Precision is computed by

\[
\frac{1}{|\text{evaluation set}|} \sum_{i \in \text{evaluation set}} \frac{\# \text{ of correct analyses}}{\# \text{ of analyses}}
\]

and recall is computed by

\[
\frac{1}{|\text{evaluation set}|} \sum_{i \in \text{evaluation set}} I(\# \text{ of correct analyses} > 0)
\]

Table 5 presents the results of our evaluation. Since our FST overgenerates (see Table 6 and Table 7 for such examples), we were able to obtain reasonably good recall. However, we missed many items due to a lack of coverage in our lexicon. The Japanese-Multilingual dictionary, though comprehensive, does not provide coverage of all the lexical items that appeared in the Tanaka corpus. This problem is more pronounced in verbs due to verbs being a much larger and more productive lexical class.

The precision for our verb analysis were quite low, which we attribute to the agglutinative nature of the language. The morpheme suffixes are a productive class, and the Tanaka corpus contain a significant amount of conversational text and colloquial language. On the other hand, adjectives tend to exhibit far lesser conjugations and hence we are able to achieve better precision. In fact, 77.4% of the surface forms in the adjective evaluation set were found to be in dictionary form (i.e., were not conjugated). Adjectives are usually conjugated when they are used in the predicate position.

| Lexical type | Precision | Recall |
|--------------|-----------|--------|
| Verbs        | 0.776     | 0.892  |
| Adjectives   | 0.892     | 0.990  |

Table 5: Evaluation results for verbs and adjectives.

8.1 Examples

See Table 6 and Table 7 for verb and adjective example analyses respectively.

9 Final Revisions

Many of the erroneous analyses produced can be eliminated by means of simple heuristics. We built a post-processing recognizer (instead of an FST) that takes as input: (i) the dictionary forms (lemmas) returned by MeCab, and (ii) each of the various analyses returned by our; and decide whether the analysis
Table 6: Example verbal analyses produced by verbs/adjectives FST.

| Input to FST  | Analysis                                           |
|--------------|---------------------------------------------------|
| 言った        | 言う+V+PFV ‘said’                                  |
| 助かりでした  | 助かる+V+POL+PFV ‘saved’                           |
| 信じられている | 信じる+V+PASV+TE+PROG (less common) ‘had been believing’ |
| 見られない  | 見る+V+POT+NEG ‘not able to see’ or ‘was not seen’  |

Table 7: Example adjectival analyses produced by verbs/adjectives FST.

| Input to FST  | Analysis                                           |
|--------------|---------------------------------------------------|
| 容易な        | 容易+ADJ+ADV ‘easily’                              |
| 悪くない      | 悪い+ADJ+NEG ‘not bad’                             |
| 奇麗だった   | 奇麗+ADJ+PFV ‘was pretty’                           |
| 好きです      | 好き+V+POL ‘like’ (verb) or ‘is lovely’ (adjective) |
| 美しかった    | 美しい+ADJ+PFV ‘was beautiful’                      |

(i) contained invalid orderings of morphemes, or

(ii) matches MeCab’s dictionary forms.

We believe this will help reduce the number of analyses generated per input, thus improving precision without hurting recall.

10 Future Work

For future work, we propose the following improvements

(i) increasing coverage of verbal and adjectival lexical items,

(ii) extending coverage of analyzer to handle te-form conjunctive verbs,

(iii) extending coverage of adjective analyzer to handle rare adjectives and verb classes, and

(iv) possibly more heuristics in the post-processing to reduce over-generation.
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