Representing Dutch Morphology in a Machine Translation System

EDWARD A. KOOL

In order to create an efficient machine translation system for Dutch, it is necessary, first of all, to solve the following tasks:

• create an efficient morphological analyzer for Dutch, which will be able to recognize the word forms in the source text, when translating from Dutch into another language;
• create an equally efficient morphological synthesizer for generating correct Dutch word forms in the target text when translating into Dutch.

Dutch is one of the languages of the Germanic group, and, although it is mainly analytical, unlike Slavic languages, it, as our experience shows, poses a lot of challenges that make its formalized representation a task far from trivial.

The PARS family of MT systems embraces the following languages:

• Slavic: Polish, Russian, Ukrainian [1]; Bulgarian is under way;
• Germanic: English, German [2], Dutch.

As for any language in the PARS family, we begin with the set of parts of speech. For Dutch, we have introduced the following part of speech (POS) classes:

- Noun
- Verb
- Adjective
- Adverb
- Preposition
- Participle
- Part of a composite word
Conjunction except “en/of”
Conjunction “en/of”
Article
Particle te
wat
welke
Particle niet

As we can see, some of the classes have one word only, such as ‘Particle te’. The reason of introducing such classes are purely practical: easier homography and homonymy resolution.

Each POS has its own set of subclass features. Below are descriptions of subclass features for two POS classes: nouns and verbs.

I. NOUN FEATURES

Animate: no, yes.

Gender/Number:
- Masculine
- Plural
- Feminine
- Neuter
- Pronoun “ik”
- Pronoun “wij”
- Pronoun “jij”
- Pronoun “jullie”

Semantics:
- none
- Geography
- Time
- Quantity
- Nationality
- Name

There is a number of noun declension. Below are some examples:

Plural ending:
- bedelaar bedelaars beggar
- gemeente gemeenten municipality
Genitive ending: none, -s.

One of the most serious challenges is alterations, which are very typical of Dutch nouns as well as verbs (see below). We have systematized the Singular-Plural alterations, and here are a few examples:

Singular-Plural Alterations:

<table>
<thead>
<tr>
<th>Singular</th>
<th>Plural</th>
</tr>
</thead>
<tbody>
<tr>
<td>f-v</td>
<td>dief</td>
</tr>
<tr>
<td>s-z</td>
<td>huis</td>
</tr>
<tr>
<td>ook-oke</td>
<td>strook</td>
</tr>
<tr>
<td>aag-age</td>
<td>aanvraag</td>
</tr>
</tbody>
</table>

2. VERB FEATURES

Conjugation: Regular or Irregular

Used with auxiliary verb: hebben, zijn.

Special type:

modal verb
auxiliary verb “hebben”
 auxiliary verb “zijn”
 auxiliary verb “worden”
 other auxiliary

Transitivity: intransitive, transitive.

Reflexive: yes/no.

Conjugation:

Infinitive ending: -en, -n, -an, -none.
Ending in the 2nd and 3rd persons, singular, Present Tense: -t, none.
Ending in the singular, Past Tense: -nd, -de, -te, -t, -d, none.
Ending in the plural, Past Tense: -ten, -den, -nden, -en, none.
Ending in Partizip II (Participle II): -t, -d, -en, -an, none.
Partizip II is formed with prefix ge-: yes/no.
We have compiled a list of Dutch separable and inseparable prefixes, which we consider complete or at least close to complete. Here are just a few examples:

Separable: aan, af, beeld, beet,..., steen, stijf, stil, stop...
Inseparable: be, ge...

Verb alterations are by far the greatest challenge among the Dutch morphological features. There are many dozens of alteration types for vowels and consonants, including single/double vowel alterations, depending on the verb form:

- Infinitive
- Present 1<sup>st</sup> Singular
- Present 2<sup>nd</sup> and 3<sup>rd</sup> Singular
- Past Singular
- Past Plural
- Participle II.

We have managed to systematized them and come with the Verb Alteration Table, which is one of the most sophisticated tools underlying the Dutch morphological analyzer and synthesizer in the PARS family of MT systems.

Here is a portion of the Table:

<table>
<thead>
<tr>
<th>Infinitive</th>
<th>Present 1&lt;sup&gt;st&lt;/sup&gt;, Singular</th>
<th>Present 2&lt;sup&gt;nd&lt;/sup&gt; &amp; 3&lt;sup&gt;rd&lt;/sup&gt; Sg.</th>
<th>Past Singular</th>
<th>Past Plural</th>
<th>Participle II</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>a</td>
<td>a</td>
<td>i</td>
<td>i</td>
<td>a</td>
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<tr>
<td>a</td>
<td>a</td>
<td>aa</td>
<td>o</td>
<td>o</td>
<td>a</td>
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<tr>
<td>a</td>
<td>aa</td>
<td>aa</td>
<td>oe</td>
<td>oe</td>
<td>a</td>
</tr>
<tr>
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<td>aa</td>
<td>oe</td>
<td>oe</td>
<td>aa</td>
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<td>st</td>
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<td>t</td>
</tr>
</tbody>
</table>

Due to the alterations, the Dutch verbs have rather a sophisticated set of conjugation paradigms. Here are some of the complete verb conjugation paradigms recognized and synthesized by the PARS morphological engine:
<table>
<thead>
<tr>
<th>Present Present</th>
<th>Past</th>
<th>Past</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>2nd &amp; 3rd</td>
<td>1st, 2nd &amp; 3rd</td>
</tr>
<tr>
<td>Singular</td>
<td>Singular</td>
<td>Plural</td>
</tr>
<tr>
<td>1st, 2nd, 3rd</td>
<td>1st, 2nd, 3rd</td>
<td>Auxiliary</td>
</tr>
</tbody>
</table>

**Regular**

<table>
<thead>
<tr>
<th>werken</th>
<th>werk</th>
<th>werk-te</th>
<th>werk-ten</th>
<th>werk-end</th>
<th>ge-werk-t</th>
<th>hebben</th>
</tr>
</thead>
<tbody>
<tr>
<td>fietsen</td>
<td>fiets</td>
<td>fiets-te</td>
<td>fiets-ten</td>
<td>fiets-end</td>
<td>ge-fiets-t</td>
<td>hebben</td>
</tr>
</tbody>
</table>

**Irregular**

<table>
<thead>
<tr>
<th>antwoorden</th>
<th>antwoord</th>
<th>antwoord</th>
<th>antwoord</th>
<th>ge-</th>
<th>hebben</th>
</tr>
</thead>
<tbody>
<tr>
<td>-t</td>
<td>-de</td>
<td>-den</td>
<td>-end</td>
<td>antwoord</td>
<td></td>
</tr>
</tbody>
</table>

**PARS/H Dictionary Editor**

The above features are used for tagging the Dutch words entered into the English⇒Dutch dictionaries in the PARS/H English⇒Dutch MT system. The dictionary editor is user friendly: in particular, it lets the lexicographer have a Dutch verb semi-automatically tagged. For example, after the Dutch verb *aandringen* has been entered into the dictionary, and the POS = Verb selected, the dictionary editor prompts that *aan* is a separable prefix, and the conjugation type is Regular.
When tagging Dutch nouns, the lexicographer selects the relevant values for the corresponding noun features, such as Gender, endings, and alteration type:
A typical dictionary in the PARS/Dutch system consists of two halves: English-Dutch and Dutch-English. Each half consists of 3 files:

- master file: main file comprising dictionary entries (.DIC);
- main index: (.NDI) used for translation and dictionary updating;
- alphabetic index: used for dictionary updating ('editing').NDX).
The first 1-5 characters of the dictionary filenames are the same for all the files of this dictionary and are called ‘the name of the dictionary’. Names of the files of the English-Dutch part end in _EH, while those of the Dutch-English part have _HE. For example:

- GEN_HE.DIC is the Dutch-English master-file of the general dictionary
- GEN_EH.NDX is the English-Dutch alphabetic index of that dictionary

A dictionary used for unidirectional translation may only consist of the corresponding half. A dictionary that is not used for updating may have no alphabetic index.

The PARS/H morphological analyzer and synthesizer make use of the English↔Dutch dictionaries based on the above-mentioned Dutch grammar features. This makes it possible for the analyzer to recognize any Dutch word-form in the source Dutch text, and synthesize the correct Dutch word-form in the target Dutch text. Besides, a special set of rules is aimed at decomposing the Dutch composite nouns.

This Dutch analysis and synthesis apparatus can and will be laid in the foundation of a family of Dutch MT systems, such as Dutch↔German, Dutch↔French (both under way), and others.

**GRAMMAR RULES**

In addition to the above-mentioned morphological analyzer for translating to and from the Dutch language, two grammar books are used to specify and test the PARS English ↔ Dutch MT program:

i. *Nederlandse grammatica voor anderstaligen*  
(Dutch grammar for non-native speakers). *ISBN 90 5517 014 3*

This grammar book describes more than 800 rules. We are developing a translation program that would translate between English and Dutch according to those rules. The rules cover the issues ranging from spelling to irregular verbs.

ii. *English Grammar in Use*  
*Cambridge University Press. ISBN 0 521 43680 X*

This grammar book describes more than 450 rules. Again, the translation program is supposed to translate between English and Dutch according to those rules. The rules pertain to subjects ranging from Present and Past to Phrasal Verbs.
Representing Dutch Morphology in a MT System

Sequence: 0

Rule explanation:

Bij samenstelling woorden schijvt men eerst de delen van de samenstelling:

- Bij
- Staat:
- Word
- Bestanddeel
- Part

Note: See 56, 122

Bee composite words separates one list the deal of the synthesis.

- Bee
- Translated as bee, the
- Insect

One is 3p separate should be separates.

Record: 14 of 10 (Filtered)
Jan heeft in deze vakantie al veel brieven geschreven.

Jan has written in this holiday though much letters.

Thought: already, as used as adverb not conjunction.
Veel brieven: plural should be many not much.

The location of the direct objects in relation until other part of a sentence.

Records: 14 | 137 | 118 of 817
Present continuous (I am doing)

Study this example situation:

This means: she is driving now, at the time of speaking. The action is not finished.

Am/is/are + -ing is the present continuous:

I am (I'm) driving
he/she/it is (= he's etc.) working
we/you/they are (= we're etc.) doing etc.

I am doing something = I'm in the middle of doing something; I've started doing it and I haven't finished yet.

Often the action is happening at the time of speaking:

1. Please don't make so much noise. I'm working.
2. 'Where's Margaret?' 'She's having a bath.' (not 'she has a bath')
3. Let's go out now, it isn't raining any more. (not 'it doesn't rain')
4. Hello, Jane. Are you enjoying the party? (not 'do you enjoy')
5. Jim's tired. I'm going to bed now. Goodnight!

But the action is not necessarily happening at the time of speaking.

For example:

6. Tom and Ann are talking in a café. Tom says
   I'm reading an interesting book at the moment.
7. I lend it to you when I have finished it.
REFERENCES


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EDWARD A. KOOL
LINGVISTICA B.V.
P.O.Box 311, 5100
AH DONGEN
THE NETHERLANDS
www.ling98.com www.lingvistica.nl