unseen test text was determined through cross validation on all available text data. As a desirable baseline, word accuracy was also tested on a closed-vocabulary scenario yielding a performance of 66.9%.

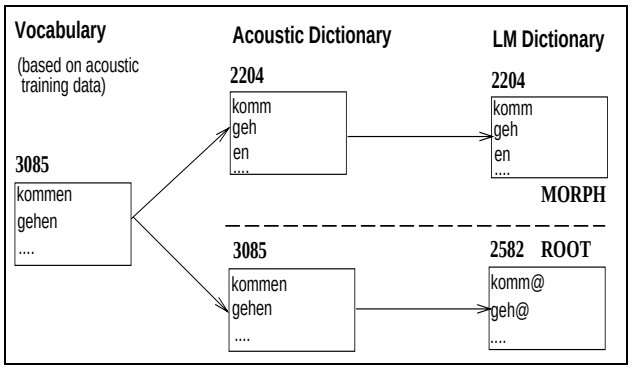


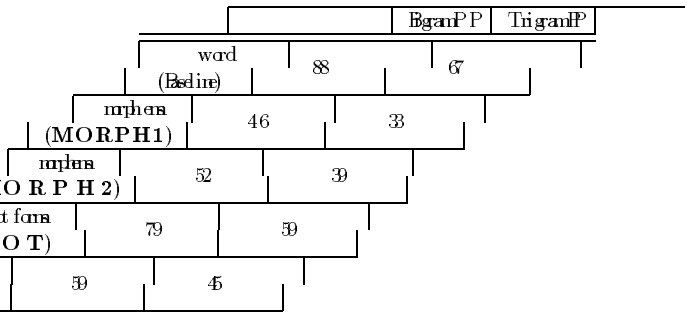
Figure 4. Mapping of Acoustic and Language Modeling Dictionaries during Recognition Process

5.1. Morphem-based Decomposition

Pure morphem-based recognition (as described in MORPH2) measured on word basis slightly outperforms the result achieved with word bigram models by 0.7% (table 6). As the vocabulary size of the acoustic dictionary used within the recognition process is much smaller than on word basis, recognition speed is accelerated by one third.

5.2. Root Form Decomposition

Using root forms only reduces the original language model dictionary from 3821 words to 3205 root forms. This means a 16% reduction in the vocabulary used as basis for language modeling. The relatively small decrease results 10% perplexity improvement and thus a slightly gram language model. However, root fo as acoustic dictionary for the re all inflections also ha ing the rec th



and Morphem Perplexity

Utterances

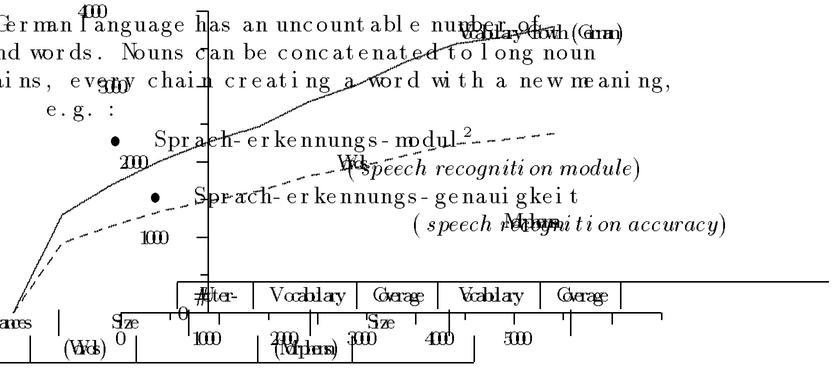
n the
morphems in-
y, as it can be seen
rage of morphems almost ap-
rage found in the English language
man word coverage of 88% by 3% based on
ning data.
ng the number of tokens in table 4, we see that
the average one word becomes 1.25 tokens within the
morphem-based framework. All available 225 training dia-
logues were used for building two overall language models:
One based on words, the other on their morphem decom-
positions. Smoothing was done by absolute discounting [2]
in both cases.
As to be expected the reduction in vocabulary growth
leads to a significant perplexity reduction when comparing
morphem-based language models with word models. Tak-
ing into account that only every fourth word has been de-
composed the perplexity results are surprising: Morphem
bigram perplexity is 48% lower than word bigram, for tri-
grams there is a 51% reduction (see table 5).

4.1. Morphem-based Decomposition

Even though perplexity reduction (and also the restric-
tion of dictionary growth) is highest when using a s
linguistic-based decomposition of words,
(see table 6) are degrading c
recognition process. W
from a very small

Also the German language has an uncountable number of compound words. Nouns can be concatenated to long noun chains, every chain creating a word with a new meaning, e.g. :

- Sprach-erkennungs-modul[2] (*speech recognition module*)
- Sprach-erkennungs-genauigkeit (*speech recognition accuracy*)



# Utterances	Vocabulary Size (Words)	Coverage	Vocabulary Size (Morphems)	Coverage
500	1301	65%	925	72%
1000	1696	70%	1151	76%
	2015	73%	1341	82%
		78%	1485	84%
			1612	85%
			2000	87%

Figure 1. Vocabulary Growth of Words and Morphems in German

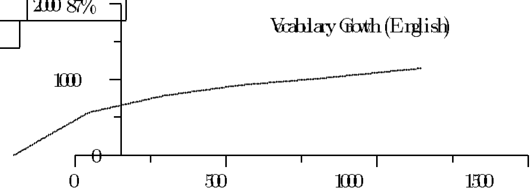


Figure 2. Vocabulary Growth in English

MORPHEM BASED LANGUAGE MODELS

w more robust probabil-
ning databases and also limit the
growth with increasing training material.
different ways of decompositions can be performed:

1. strictly morphem-based decomposition, e.g. :
   - weggehen → weg-geh-en[2] (*to go away*)
   - Spracherkennung → Sprach-er-kenn-ung (*speech recognition*)
2. decomposition in root forms:
   - weggehen → weggeh@ (*to go away*)
   - Dialoge → Dialog@ (*dialogues*)
3. combination of strictly morphem-based decomposition and root forms

steadily
rds that might ap-
can be foreseen. Tables 2
ary coverage of the German test
ish test text. The smaller English vo-
already covers 92% of English words in the test
alogues whereas the fourfold amount of training data in German only covers 88%. As a logical consequence it is desirable to work on smaller base recognition units than words to be able to compose new unseen words out of several parts already known to the dictionary.

For the German Spontaneous Scheduling Task (GSST) the decomposition of training texts in strictly linguistically based morphems (MORPH) results in a reduction of vocabulary size by 37% (see figure 1). Whereas the word dictionary contains 3821 words, the corresponding morphem dictionary consists of only 2391 entries (see table 4). This reduction will certainly get bigger the more data will b

	Words	Morphems
# tokens	117489	145990
vocabulary size	3821	2391

Table 4. Comparing Word and Morphem Vocabulary

[2] Hyphens are used for clarification purposes as decomposition markers only and do not appear in the actual German spelling.

USING MORPHOLOGY TOWARDS BETTER LARGE-VOCABULARY SPEECH RECOGNITION SYSTEMS

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ABSTRACT

To guarantee unrestricted natural language processing, state-of-the-art speech recognition systems require huge dictionaries that increase search space and result in performance degradations. This is especially true for languages where there do exist a large number of inflections and compound words such as German, Spanish, etc. One way to keep up decent recognition results with increasing lary is the use of other base units than si paper different decomposition me morphological decomposi be compared. Not vocabulary g data,