Context-Sensitive Spelling Correction and Rich Morphology

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Abstract

Context-sensitive spelling correction is the task of correcting spelling errors which result in valid words. We present work in progress where we adapt established methods from English to a morphologically rich language and conclude that the rich morphology negatively affects performance. However, our system is still good enough to be useful in regular word processing.

1 Introduction

Context-sensitive spelling correction is the task of correcting spelling errors which result in valid words. For example, in the sentence I want a peace of cake, peace is a valid word in isolation but an error in this context (should be piece). Most spelling correction systems check one word at a time and do not correct such errors. Context-sensitive errors account for 25% to 50% of observed errors (in English data) (Kukich, 1992) and thus it is important to address this problem. A variety of methods have given good results for English but little attention has been paid to how well such methods perform on languages with very rich morphology. No earlier attempts at this task exist for the language of our study, Icelandic.

In this paper, we aim to shed light on the issue of morphological richness and ambiguity in context-sensitive spelling correction by presenting a system (a work in progress) for Icelandic, whose morphology is both rich and highly ambiguous. We adapt methods used in previous work on English to be used on Icelandic and evaluate the performance of the system.

The paper is organized as follows. In Sect. 2 we review some of the previous work carried out on the subject. Sect. 3 describes our method and its evaluation which estimates the accuracy of the system to be 87.2%. We conclude in Sect. 4.

2 Context-Sensitive Spelling Correction

In the literature, the problem of context-sensitive spelling correction is commonly formulated as a disambiguation task (Roth, 1998) where the ambiguity among words is modeled by confusion sets. A confusion set $C = \{W_1, ..., W_n\}$ means that each word $W_i$ in the set is ambiguous with each other word in the set. Thus, if $C = \{piece, peace\}$ and either piece or peace is encountered in a text, the task is to decide which one was intended.

Such errors can be categorized in various ways (Kukich, 1992). One distinction is whether the contrast between the contexts of the members of the confusion set is semantic, grammatical or both. (1) Semantic contrast (piece/peace): Different words with different meaning but they belong to the same distributional class (in this case they are both nouns) and behave identically with respect to the syntactic context. (2) Grammatical contrast (he/him): Different forms of one word which behave differently with respect to the syntactic context. (3) Semantic and grammatical contrast (cite/site): Different words with different meanings and different syntactic properties (verb vs. noun). We evaluate the performance of a data-driven approach against all the above types of errors.

2.1 Related Work

Our focus is on data-driven systems which are able to handle disambiguation between members of confusion sets without relying entirely on syntactic structure. We can divide these into two categories based on whether they can be trained using only a corpus or whether they require external semantic databases like WordNet (Fellbaum, 1998).

Solutions which do not rely on external semantic databases extract semantic and grammatical features from the contexts of members of confusion sets using corpora and take advantage
of general purpose classifiers. Successful methods used for this purpose include Bayesian classifiers (Golding, 1995) and Winnow-based classifiers (Golding and Roth, 1999).

Solutions which do rely on external semantic databases take advantage of the fact that semantic relations within the lexicon of a given language provide useful evidence for semantic disambiguation. If we have a confusion set \( C = \{a, b\} \) and many words in the context are semantically related to \( a \) but few are semantically related to \( b \), then this is evidence that the intended form is \( a \). A few such methods are compared in Budanitsky and Hirst (2006). It is a feasible option to take advantage of knowledge-rich resources in context-sensitive spelling correction but the problem is the cost of developing such resources. For example, there exists no WordNet-like resource for Icelandic suitable for this purpose.

### 2.2 Morphological Richness

We take Icelandic as our test-case for a morphologically rich language. Icelandic has rich inflection and morphosyntactic categories are encoded using affixes which are often quite ambiguous. This is reflected in the tagset normally used when PoS-tagging the language which has about 700 different PoS-tags (originally developed by Find et al. (1991)). This leads to data sparseness when collecting evidence from a corpus. The sparseness of the features used for disambiguation can furthermore make it more difficult to effectively prune the number of features without losing important evidence, thus making scalability a more serious problem. To counter the data sparseness problem it is possible to normalize the data in the corpus. For normalization we used the Lemmald lemmatizer (Ingason et al., 2008). Lemmald is a data-driven system but it still employs some linguistic knowledge about Icelandic grammar. Note that the problems caused by the morphological richness also apply to the lemmatization itself. The lemmatizer achieves an accuracy of 98.54%.

The rich morphology and the corresponding large tagset also affect the accuracy of the PoS-tagging. Various taggers and combinations of taggers have been tried out for Icelandic PoS-tagging (Helgadóttir, 2005; Loftsson, 2006; Loftsson, 2008; Dredze and Wallenberg, 2008). The highest reported tagging accuracy for a data-driven solution is 92.06% (Dredze and Wallenberg, 2008) but the rule-based IceTagger achieves 91.54% accuracy (Loftsson, 2008) and runs considerably faster (2,700 tokens/sec vs. 179 tokens/sec). We used IceTagger in our experiments. Note that, while performance is low compared to the over 97% reported performance for state-of-the-art English taggers (Shen et al., 2007; Giménez and Márquez, 2004), the tagging of only the word class actually has a similar accuracy as the state-of-the-art taggers for English – most mistakes are made in tagging other features such as case.

### 3 Machine Learning Approach

#### 3.1 Feature Extraction

The choice of features is the result of experiments with different combinations of features intended to bring out important evidence of context. More work is needed to evaluate the actual contribution of specific types of features. We extracted three types of features from the corpus in our experiments. (1) Context Words: Word forms occurring at a distance of \( \leq 5 \) from the confusion word; (2) Context Lemmas: Lemmas (base forms of words) occurring at a distance of \( \leq 5 \) from the confusion word; (3) Collocations with words and tags combined (all such possible tri-grams including the confusion word). The Context Word and Context Lemma feature extractors simply collect all words and base forms of words which occur within a window of 5 tokens on either side of the confusion word. The Collocation feature extractor combines word forms and PoS-tags and every such possible tri-gram is a potential feature.

(1) **Listamaður frá Reykjavík hefur ákveðið að**
*Artist from Reykjavik has decided to*

**sýna verk sín á listahátíð.**
*show work his at art festival*

‘An artist from Reykjavik has decided to show his work at an art festival.’

Sentence (1) contains the word *sýna* ‘show’ which is sometimes confused with *sína* ‘his/her/its’ because in Modern Icelandic there is no phonetic difference between ‘í’ and ‘ý’ (and spelling mistakes are common in many words in which those letters occur). The window we use for our Collocation feature extractor is shown in (2) where the second line displays the PoS-tags for the corresponding tokens. The confusion word is represented as ‘_’.

(2) **ákveðið að _ verk sín**

**ssg cn _ nhfo fehfo**

*decided to _ work his*
We then generate all possible tri-gram combinations of word forms and tags from the window. Those are shown in (3).

(3) ákveðið að_; ssg að_; ákveðið cn_; ssg cn_; cn_ verk ; að_ nhðo ; verk sin ; nhðo sin ; verk feðo ; nh ð o feð o ; að_ verk ; cn_ nhðo

For evaluation purposes we extracted features for 11 confusion sets from a selected part of the SÁ corpus\(^1\) according to the methods described above. Table 1 shows the 11 confusion sets and their frequency in the corpus.

To reduce the number of features we remove all features which occur less than 4 times in the training data. Table 2 shows the number of features extracted for each confusion set, first the total number of features, then the features that occur in the context of both members of the confusion set, then the features which belong only to the former member and finally the features which belong only to the latter member.

As Table 2 shows, the amount of evidence varies quite a lot between confusion sets. For some of the confusion sets there are many features which belong exclusively to one of the two members but for others, such as lýst ‘appetite’, there is a serious data sparseness problem.

### 3.2 Evaluation

The features extracted according to the description in the previous section were fed to data-driven classification algorithms implemented in the Weka algorithm collection (Witten and Frank, 2005).

1\(^{\text{Textasafn Orðabókar Háskólab. [SÁ Corpus.] www.lexis.hi.is/corpus/leit.pl}}\)

We tried two methods that have performed well for English: Naive Bayes and Winnow. We also compared the result with a baseline classifier which always chooses the more common member of the confusion set. All tests were performed using a 10-fold cross validation on all sentences which contained the confusion set in question. The results of these tests are displayed in Table 3.

The results show lower accuracy than what has been reported for English (Golding, 1995; Golding and Roth, 1999) but the performance is still close to 90% which is probably enough for a real world application to be useful. It is unexpected that the Naive Bayes method outperforms Winnow which has been more successful for English (cf. the references above) and we do not have an ex-

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**Table 1: Frequencies of confusion words in training corpus**

| Confusion set | $F_{\text{Total}}$ | $F_1$ | $F_2$ |
|---------------|-----------------|------|------|
| sína 'his', sýna 'show' | 951 | 521 | 430 |
| list 'at', lýst 'appetite' | 177 | 150 | 27 |
| kvatt 'said bye', hvatt 'encouraged' | 170 | 100 | 70 |
| mg 't-ace', mér 't-dat' | 895 | 558 | 337 |
| vil 'want-1.p.', vili 'want-3.p.' | 803 | 480 | 322 |
| fín 'fine-masc', fin 'fine-fem' | 203 | 110 | 93 |
| leiti 'search,hill', leyti 'respect' | 606 | 439 | 167 |
| himinn 'sky-nom', himin 'sky-acc' | 192 | 101 | 91 |
| deyi 'die', dégi 'day' | 462 | 420 | 42 |
| líkur 'similar', lýkur 'finishes' | 807 | 414 | 393 |
| honum 'he-dat', hann 'he-nom' | 2829 | 2068 | 761 |

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**Table 2: Number of features extracted for each confusion set**

| Confusion set | $F_{\text{T}}$ | $F_{\text{S}}$ | $F_{\text{1}}$ | $F_{\text{2}}$ |
|---------------|----------------|--------------|-------------|-------------|
| sína, sýna    | 871            | 419          | 229         | 223         |
| list, lýst    | 176            | 88           | 86          | 2           |
| kvatt, hvatt  | 168            | 113          | 33          | 22          |
| mg, mér       | 821            | 547          | 217         | 57          |
| vil, vili     | 720            | 349          | 252         | 119         |
| líkur, lýkur  | 315            | 292          | 194         |             |
| honum, hann   | 264            | 138          | 27          | 20          |

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**Table 3: Evaluation of the performance of two classification algorithms from the Weka algorithm collection when given the task of disambiguating the members of each confusion set.**

| Confusion set | Baseline | NaiveBayes | Winnow |
|---------------|----------|------------|--------|
| sína, sýna    | 95.0%    | 96.0%      | 92.0%  |
| list, lýst    | 85.0%    | 87.0%      | 71.8%  |
| kvatt, hvatt  | 58.0%    | 77.6%      | 61.1%  |
| mg, mér       | 62.0%    | 81.2%      | 77.8%  |
| vil, vili     | 60.0%    | 95.3%      | 94.9%  |
| líkur, lýkur  | 54.0%    | 80.8%      | 72.9%  |
| honum, hann   | 73.0%    | 87.5%      | 80.2%  |

**Average**  64.9%   87.2%   80.9%
It is not unexpected that the results are worse for a morphologically rich language like Icelandic than for morphologically simple English. Data sparseness and errors in PoS-tagging and normalization are the most likely reasons for this. Even if we include all the features described in the previous section, context-sensitive spell checking for Icelandic lags behind comparable systems for English.

4 Conclusion and Future Work

As expected, morphological complexity negatively affects performance. However, our system is still a viable option for everyday word processing. We have begun integrating our system into the LanguageTool platform (Naber, 2003) which provides easy integration into OpenOffice.org. Our system must still be viewed as work in progress and some issues require further study. We hope to gain a better understanding of why a Winnow-based classification method does not perform well for Icelandic. We also hope to construct semantic resources for Icelandic to complement the method we use for semantic disambiguation.

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