

# A Study on the Use of Stemming for Monolingual Ad-Hoc Portuguese Information Retrieval

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**Abstract.** For UFRGS's first participation in CLEF our goal was to compare the performance of heavier and lighter stemming strategies using the Portuguese data collections for monolingual Ad-hoc retrieval. The results show that the safest strategy was to use the lighter alternative (reducing plural forms only). On a query-by-query analysis, full stemming achieved the highest improvement but also the biggest decrease in performance when compared to no stemming. In addition, statistical tests showed that the only significant improvement in terms of mean average precision, precision at ten and number of relevant retrieved was achieved by our lighter stemmer.

## 1 Introduction

This paper reports on monolingual information retrieval experiments that we have performed for CLEF2006. We took part in the ad-hoc monolingual track, focusing on the Portuguese test collections.

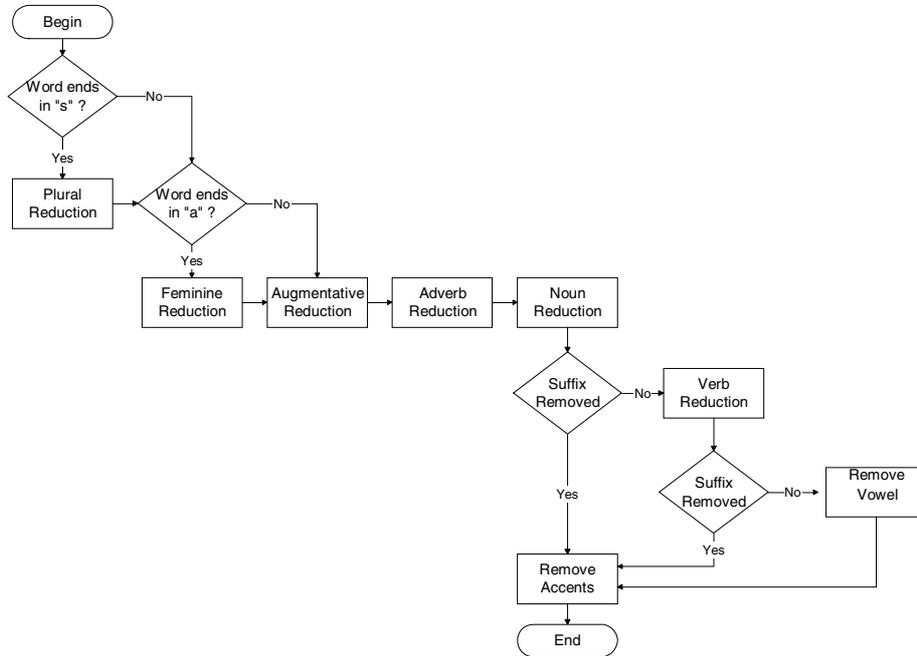
Our aim was to compare the performance of lighter and heavier stemming alternatives. We compared two different algorithms: a Portuguese version of the Porter stemmer and the “Removedor de Sufixos da Língua Portuguesa” (RSLP) [4]. Moreover, a simpler version of the RSLP stemmer that reduces plural forms only was also tested. We compared the results of the three stemming alternatives with results of no stemming.

The remainder of this paper is organised as follows: Section 2 presents the RSLP stemmer; Section 3 discusses the experiments and results; and Section 4 presents the conclusions.

## 2 The Stemming Algorithm

We have used the RSLP algorithm, proposed in our earlier work [4]. It was implemented in C and is freely available from <http://www.inf.ufrgs.br/~vmorengo/rs1p>.

This section introduces the algorithm. RSLP is based solely on a set of rules (not using any dictionaries) and is composed by 8 steps that need to be executed in a certain order. Figure 1 shows the sequence those steps must follow:



**Fig. 1.** Sequence of Steps for the RSLP Algorithm

Each step has a set of rules, the rules in the steps are examined in sequence and only one rule in a step can apply. However, the same word might be stemmed by more than one step. For example *francesinhas* (little French girls), would first go through the plural reduction step and become *francesinha*. Next, it would be stemmed by the feminine step, becoming *francesinho*. Finally, the augmentative/diminutive step would produce *frances*.

The longest possible suffix is always removed first because of the ordering of the rules within a step, e.g. the plural suffix *-es* should be tested before the suffix *-s*. At the moment, the Portuguese Stemmer contains 253 rules. please refer to web page for the complete list.

Each rule states:

- The *suffix* to be removed;
- The *minimum length* of the stem: this is to avoid removing a suffix when the stem is too short. This measure varies for each suffix, and the values were set by observing lists of words ending in the given suffix. Although there is no linguistic support for this procedure it reduces overstemming errors. Overstemming is the removal of a sequence of characters that is part of the stem and not a suffix.
- A *replacement suffix* to be appended to the stem, if applicable;

- A *list of exceptions*: for nearly all rules we defined, there were exceptions, so we added exception lists for each rule. Such lists were constructed with the aid of a vocabulary of 32,000 Portuguese words freely available from [6]. Tests with the stemmer have shown that exceptions list reduce overstemming errors by 5%.

An example of a rule is:

```
"inho", 3, "", {"caminho", "carinho", "cominho", "golfinho",
"padrinho", "sobrinho", "vizinho"}
```

Where *inho* is a suffix that denotes diminutive, 3 is the minimum size for the stem, which prevents words like *linho* (linen) from being stemmed and the words between brackets are the exceptions for this rule, that is, they end in the suffix but they are not diminutives. All other words that end in *-inho* and that are longer than 6 characters will be stemmed. There is no replacement suffix in this rule. Below we explain the eight steps involved in our stemming procedure.

#### Step 1: Plural Reduction

With rare exceptions, the plural forms in Portuguese end in *-s*. However, not all words ending in *-s* denote plural, e.g. *lápiz* (pencil). This step consists basically in removing the final *s* of the words that are not listed as exceptions. Yet sometimes a few extra modifications are needed e.g. words ending in *-ns* should have that suffix replaced by *m* like in *bons* → *bom*. There are 11 stemming rules in this step.

#### Step 2: Feminine Reduction

All nouns and adjectives in Portuguese have a gender. This step consists in transforming feminine forms to their corresponding masculine. Only words ending in *-a* are tested in this step but not all of them are converted, just the ones ending in the most common suffixes, e.g. *chinesa* → *chinês*. This step is composed by 15 rules.

#### Step 3: Adverb Reduction

This is the shortest step of all, as there is just one suffix that denotes adverbs *-mente*. Again not all words with that ending are adverbs so an exception list is needed.

#### Step 4: Augmentative/Diminutive Reduction

Portuguese nouns and adjectives present far more variant forms than their English counterparts. Words have augmentative, diminutive and superlative forms e.g. "small house" = *casinha*, where *-inha* is the suffix that indicates a diminutive. Those cases are treated by this step. According to Cunha & Lindley-Cintra [1], there are 38 of these suffixes. However, some of them are obsolete therefore, in order to avoid overstemming, our algorithm uses only the most common ones that are still in usage. This step comprises 23 rules.

#### Step 5: Noun Suffix Reduction

This step tests words against 84 noun (and adjective) endings. If a suffix is removed here, steps 6 and 7 are not executed.

**Step 6: Verb Suffix Reduction**

Portuguese is a very rich language in terms of verbal forms, while the regular verbs in English have just 4 variations (e.g. talk, talks, talked, talking), the Portuguese regular verbs have over 50 different forms [3]. Each one has its specific suffix. The verbs can vary according to tense, person, number and mode. The structure of the verbal forms can be represented as: root + thematic vowel + tense + person, e.g. *and + a + ra + m* (they walked). Verbal forms are reduced to their root, by 101 stemming rules.

**Step 7: Vowel Removal**

This task consists in removing the last vowel (“a”, “e” or “o”) of the words which have not been stemmed by steps 5 and 6, e.g. the word *menino* (boy) would not suffer any modifications by the previous steps, therefore this step will remove its final -o, so that it can be conflated with other variant forms such as *menina*, *meninice*, *meninão*, *menininho*, which will also be converted to the stem *menin*.

**Step 8: Accents Removal**

Removing accents is necessary because there are cases in which some variant forms of the word are accented and some are not, like in *psicólogo* (psychologist) and *psicologia* (psychology), after this step both forms would be conflated to *psicolog*. It is important that this step is done at this point and not right at the beginning of the algorithm because the presence of accents is significant for some rules e.g. *is* → *ol* transforming *sóis* (suns) to *sol* (sun). If the rule was *ois* → *ol* instead, it would make mistakes like stemming *dois* (two) to *dol*. There are 11 rules in this step.

It is possible that a single input word needs to go through all stemming steps. In terms of time complexity this represents the worst case possible.

The Portuguese version of the Porter Stemmer and the RSLP are based solely on rules that need to be applied in a certain order. However, there are some differences between the two stemmers:

- The number of rules - RSLP has many more rules than the Portuguese Porter because it was designed specifically for Portuguese. There are some morphological changes such as augmentatives and feminine forms that are not treated by the Portuguese Porter Stemmer.
- The use of exceptions lists - RSLP includes a list of exceptions for each rule as they help reducing overstemming errors.
- The steps composing the two algorithms are different.

### 3 Experiments

This section describes our experiments submitted to the CLEF 2006 campaign. Section 3.1 details the resources used, Section 3.2 presents the results and Section 3.3 shows the statistics of the stemming process.

### 3.1 Description of Runs and Resources

The Portuguese data collections were indexed using SMART [5]. We used the title and description fields of the query topics. Query terms were automatically extracted from the topics. Stop words were removed from both documents and topics. In addition, terms such as “find documents” were removed from the topics.

The processing time was less than 4 minutes for all runs in a Sunfire V240 with 6 GB of main memory and 2 ultra sparc IIIi processors of 1Ghz, under SunOS 5.9. This includes indexing the 210,734 documents and running all 50 queries.

Four runs were tested:

- **NoStem** - No stemming was applied, this run was used as the baseline
- **Porter** - Full stemming using the Portuguese version of the Porter stemmer
- **RSLP** - Full stemming using the RSLP stemmer
- **RSLP-S** - applying only the first step of RSLP to deal with plural reduction only

### 3.2 Results

Table 1 shows the number of terms indexed in each run. Full stemming with RSLP achieved the highest reduction on the number of entries, followed by the Portuguese version of the Porter stemmer. The lighter stemming strategy reduced the number of entries by 15%.

**Table 1.** Number of Terms in the Dictionary for all runs. The percentages indicate the reduction attained by each stemming procedure in relation to the baseline.

Run	Number of Terms
NoStem	425996
Porter	248121 (-41.75%)
RSLP	225356 (-47.10%)
RSLP-S	358299 (-15.89%)

The results show that the best performance, in terms of mean average precision (MAP), was achieved by RSLP-S. Both runs in which full stemming was performed achieved identical results in terms of MAP. However, the RSLP outperformed the Portuguese version of the Porter stemmer in terms of Pr@10, but the difference was only marginal. In terms of relevant documents retrieved, a *T-test* has shown that both Porter and RSLP-S have a significantly retrieved a larger number of relevant documents.

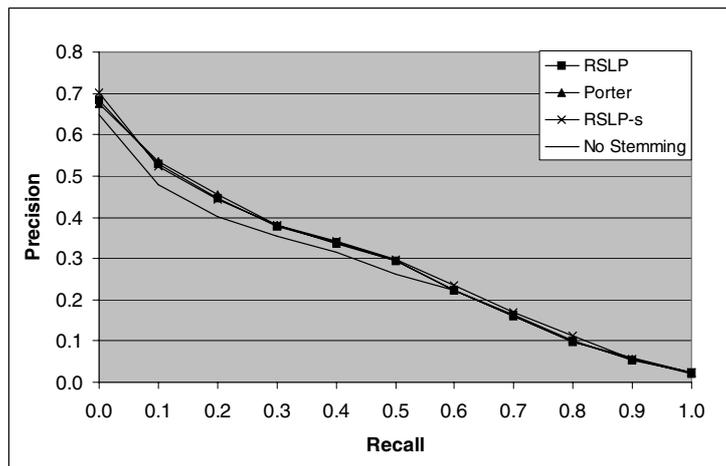
In order to see whether the performance improvements shown in Table 1 are statistically significant, a paired *T-test* was performed. Although our data is not

**Table 2.** Results in terms of MAP, Pr@10 and average number of relevant documents retrieved. The asterisk denotes a statistically significant improvement in relation to the baseline.

Run	Mean Average Precision	Precision at 10	Avg of Rel Ret
NoStem	0.2590	0.3880	38.70
Porter	0.2790 (+7.72%)	0,4260 (+9.79%)	43.12*
RSLP	0.2790 (+7.72%)	0,4320 (+11.34%)	42.18
RSLP-S	0.2821 (+8.91%)*	0,4300 (+10.82%)*	42.48*

perfectly normally distributed, Hull [2] argues that the *T-test* performs well even in such cases. The standard threshold for statistical significance ( $\alpha$ ) of 0.05 was used. When the calculated  $p$  value is less than  $\alpha$ , there is a significant difference between the two experimental runs. The results of the statistical tests show that full stemming does not produce a statistically significant improvement (in terms of both MAP and Pr@10) for either algorithm ( $p$  values of 0.25 for RSLP and 0.22 for Porter considering MAP and  $p$  values of 0.14 for RSLP and 0.18 for Porter when analysing Pr@10). Porter has achieved a significant improvement in terms of number of relevant documents retrieved ( $p$  value = 0.04). RSLP-S, however, has achieved a statistically significant improvement compared to baseline for MAP, Pr@10 and number of relevant documents retrieved ( $p$  values of 0.003, 0.01 and 0.04 respectively). Figure 2 shows recall-precision curves for all runs.

A query-by-query analysis, shown in Table 3, demonstrates that for 12 topics no stemming was the best alternative. Some form of stemming helped 38 out of 50 topics. Confirming the results in terms of MAP and Pr@10, the best per-



**Fig. 2.** Recall-precision curves for all runs

formance was achieved by the lighter stemming alternative RSLP-S. Full stemming with RSLP achieved the biggest performance improvement (topic 340 AvP 0.0003  $\rightarrow$  0.3039), but also the biggest drop (topic 343 AVP 0.4276  $\rightarrow$  0.1243). Stemming also helped finding 221 relevant documents that were not retrieved by the NoStem run.

**Table 3.** Runs and the number of topics in which they achieved the best average precision

<b>Run</b>	<b>Number of Topics</b>
NoStem	12
Porter	10
RSLP	12
RSLP-S	16
Total	50

It seemed plausible that queries with few relevant documents would benefit more from stemming, resulting in a negative correlation between the number of relevant documents for the topic and the change in performance achieved with stemming. However, a weak positive correlation of 0.15 was found. We would like to be able to predict the types of queries that would be benefited from stemming, but that needs further analysis with a larger number of topics.

**Table 4.** Percentage of Rule Applications by step

<b>Step</b>	<b>% of Applications</b>
Plural	17.55%
Feminine	5.08%
Adverb	0.82%
Augmentative	5.17%
Noun	21.01%
Verb	15.78%
Vowel	34.59%

### 3.3 RSLP Statistics

In this section we report on the statistics generated by the processing of the RSLP stemmer. The stemmer has processed a total of 53,047,190 words. The step with the largest number of applications is Vowel Removal (step 7), followed by Noun (step 5) and Verb (step 6). The least applied step was Adverb (step 3). The rules for Noun, Verb, Plural and Vowel account for approximately 90% of all reductions. Table 4 shows the percentage of rule applications by step. We have noticed that 11 rules (4.5%) of the rules were never applied. Those rules correspond to rare suffixes that were not present in the text.

## 4 Conclusions

This paper reported on monolingual ad-hoc IR experiments using Portuguese test collections. We evaluated the validity of stemming comparing the Portuguese version of the Porter stemmer and two versions of the RSLP stemmer, one that applies full stemming and one that only reduces plural forms. Below we summarise our conclusions:

- The lighter version of the RSLP stemmer yields statistically significant performance improvements in terms of MAP, Pr@10 and number of relevant retrieved.
- Full stemming, both with Porter and RSLP, has improved the results in terms of MAP, Pr@10 and Relevant Retrieved. However the difference was not statistically significant.
- On a query-by-query analysis we found that stemming helped 38 out of 50 topics and that it enabled the retrieval of 221 further relevant documents that were missed by the run in which no stemming was used.

We can conclude that lighter stemming is the most beneficial strategy for monolingual ah-hoc Portuguese retrieval. This is due to the fact that heavy stemming might introduce noise in the retrieval process and thus harm the performance for some query topics.

## Acknowledgements

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