Compiling and Processing Historical and Contemporary Portuguese Corpora

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Abstract
This technical report describes the framework used for processing three large Portuguese corpora. Two corpora contain texts from newspapers, one published in Brazil and the other published in Portugal. The third corpus is Colonia, a historical Portuguese collection containing texts written between the 16th and the early 20th century. The report presents pre-processing methods, segmentation, and annotation of the corpora as well as indexing and querying methods. Finally, it presents published research papers using the corpora.

Keywords: Portuguese; corpus compilation; annotation; CQP; historical corpora

1 Introduction

Corpora are great resources for the study of human language. They contain samples of real language use that can be analyzed using text processing software. Corpora provide valuable help for researchers to formulate, confirm or reject hypotheses when studying different aspects of language such as phonetics, syntax or semantics.

According to several scholars in corpus linguistics [1, 2, 3], one of the main advantages of the use of corpora over native speaker’s institution is reproducibility. Findings of corpus-based studies can be replicated much more easily than those obtained relying on human judgments and as a consequence the results obtained are open to objective verification. Leech (1992) [4], for example, argues that a corpus-based methodology conforms to the scientific method.

The first well-known corpora were compiled for English. Most notable examples include the Brown corpus [5] and the British National Corpus (BNC) [6]. English is still by far the most resource-rich language, but in the last decades several corpora and other language resources have been compiled for other languages as well.

For Portuguese, Linguateca[1] by Santos et al. (2004) [7] has been the most well-known repository of Portuguese corpora. Through the AC/DC project[2] [8] a number of Portuguese corpora of various kinds have been made available to the research community. Colonia, one of the corpora described in this technical report, is also available at Linguateca.

In this report I describe the framework used to compile and annotate three large Portuguese corpora that have been processed at the University of Cologne and released in September 2013. The list of corpora is presented next.

[1]http://www.linguateca.pt/
[2]http://www.linguateca.pt/ACDC/
- **DN-PT**: a journalistic corpus containing texts from the Portuguese newspaper Diário de Notícias published in 2007 and 2008.
- **FSP-BR**: a journalistic corpus containing texts from the Brazilian newspaper Folha de São Paulo published in 2004.
- **Colonia**: a diachronic corpus containing full novels published between 16th to the early 20th in Brazil and Portugal [9].

For comparability, the three corpora have been annotated using the same methodology (including tagset) which is described in this report. Copyright restrictions apply to the first two corpora as texts published in these newspapers belong to their respective copyright owners, thus they cannot be freely distributed. Colonia is the only corpus that could be made available to the research community and for this reason it has been used by a number of researchers, as evidenced in this report (see Section 4 for a list of studies using Colonia).

## 2 Data

Compiling and processing corpora is not a trivial task. Best practices include observing several aspects such as balance, sample, and representativeness when collecting data. A corpus is considered to be representative if it takes into account the variability of the population it aims to represent and if the findings obtained based on its content can be generalized to the whole population.

For Colonia[3], the compilation of the material was based on on open repositories such as Domínio Publico[4] and on existing historical Portuguese corpora, namely the one by Grupo de Morfologia Histórica do Português (GMHP)[5] from the University of Sao Paulo and Tycho Brahe [10]. A total of 100 texts written and/or published between 1500 and 1948 were collected from these sources and processed using the framework described in this report.

The DN-PT corpus contains all editions published in 2007 and 2008 by the Lisbon-based newspaper Diário de Notícias were collected whereas FSP-BR contains all texts published by Folha de São Paulo in 2004. It should be noted that in the case of these two corpora, even though sampling techniques have been applied, the corpora are not necessarily representative of the whole journalistic genre. For this purpose, samples from multiple newspapers should be collected to account for the variability present in journalistic texts. An example of a journalistic language variety corpus which includes Portuguese and is compiled from multiple newspapers is the DSL Corpus Collection (DSLCC) (Tan et al., 2014) [11].

The total number of tokens in each corpora is presented in Table 1.

| Corpus   | Tokens        |
|----------|---------------|
| DN-PT    | 60,845,721    |
| FSP-BR   | 42,258,153    |
| Colonia  | 5,157,982     |

Table 1 DN-PT and FSP-BR: Number of Tokens per Corpus.

[3]http://corporavm.uni-koeln.de/colonia/
[4]http://www.dominiopublico.gov.br/
[5]http://www.usp.br/gmhp/Corp.html
Colonia is publicly available. It can be used through a web-based graphical user interface (GUI) and downloaded in two versions: one containing raw texts and one containing texts with POS annotation. Colonia has been divided into five sub-corpora by century. The number of texts range from 13 texts published in the 16th century and 37 texts published in the 19th century. Table 2 presents the number of texts and tokens in each sub-corpus.

| Century     | Texts | Tokens       |
|-------------|-------|--------------|
| 16th Century| 13    | 399,245      |
| 17th Century| 18    | 709,646      |
| 18th Century| 14    | 425,624      |
| 19th Century| 38    | 2,490,771    |
| 20th Century| 17    | 1,132,696    |
| Total       | 100   | 5,157,982    |

Table 2 Colonia: Number of Texts and Tokens per Century.

3 Methods

The work described in this report uses the tools developed at the Institute for Computational Linguistics of the University of Stuttgart and by Andrew Hardie from the University of Lancaster. For annotation, TreeTagger [12] was used for POS tagging and lemmatization. The Corpus Workbench (CWB) [13] was used for encoding the corpus in a format to be processed by the Corpus Query Processor (CQP) [14]. On top of this architecture CQPWeb v3.0.9 [15] was installed in an Apache web server and it is responsible for providing a graphical user interface to CQP queries.

3.1 Pre-processing, Segmentation, and Annotation

The files compiled for the three corpora described in this report, most notably those comprising the two journalistic corpora, contained HTML and XML markup tags. This usually indicates that the data is structured and therefore easier to be parsed but in this case tags were used inconsistently (e.g. opening and not closing, missing attributes, etc.) which made processing these files more challenging. Correcting inconsistent tagging and removing unnecessary tags before segmenting the files (e.g. including sentence and text boundaries) was therefore necessary. For restructuring the files and cleaning tags I tested several HTML and XML parsers available for Python and an XML editor called Stylus Studio.[6] Some of these parsers did not work at all as they are developed to work on well-formed XML structure. ElementTree[7], however, helped me parsing the files to a certain extent. Even so it was necessary to manually check large parts of the files for inconsistencies. This manual step made processing these files very time consuming, but helped to avoid several inconsistencies that could have caused a number of problems in other steps of the processing chain.

For segmentation, I used Python scripts, regular expressions, and functions available in the Natural Language Toolkit (NLTK) [16]. I also performed some high-level

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[6] http://www.stylusstudio.com/
[7] https://docs.python.org/2/library/xml.etree.elementtree.html
normalization on tags and spelling. For Colonia, however, spelling normalization has not been carried out as many texts collected from Tycho Brahe already contained some form of normalized orthography. A post-processing step was carried out on Colonia texts to correct incorrect lemmas after annotation.

3.2 Annotation

For comparability, the three corpora described in this report have been annotated using the same annotation methods. I used TreeTagger [12], a probabilistic POS tagger, for annotation. Schmid (1994) reports performance of 96.36% accuracy on annotating the Penn-Treebank. I used the parameter files for Portuguese made available by Pablo Gamallo[8] and evaluated in Gamallo and Garcia (2013) [17]. Gamallo and Garcia (2013) report 96.03% accuracy on using TreeTagger to annotate a small European Portuguese dataset containing 600 tokens manually annotated for the purpose of evaluation.

The tagset available at Gamallo’s Portuguese parameter file contains the following tags:

- Adjective: ADJ
- Adverb: ADV
- Determinant: DET
- Cardinal or Ordinal: CARD
- Noun: NOM
- Pronoun: P
- Preposition: PREP
- Verb: V
- Interjection: I
- Punctuation marks: VIRG, SENT

The tagset is coarse-grained and morphosyntactic information is not available. Nevertheless, the tagset addresses frequent contractions (prepositions + determiners) and clitics in Portuguese using a few combinations of tags such as:

- Preposition + Determiner: PREP+DET
- Verb + Preposition: V+P

The aforementioned parameter file by Gamallo was trained on standard contemporary Portuguese. For DN-PT and FSP-BR, I relied solely on the TreeTagger annotation. Lemmatization of the historical texts included in Colonia, however, is more challenging and a few incorrectly attributed lemmas have been correcting in a post-processed step. No systematic correction of POS tags and lemmas has been carried out in any of the three corpora.

Once installed and trained, TreeTagger is fairly easy to use requiring the path to the input file (raw text), the path to the output file (annotated text), the path to the parameter file, and several optional attributes such as \(-prob\) to print tag probabilities and \(-lemma\) to print lemmas. A sample TreeTagger tagging command is presented next.

[8]https://gramatica.usc.es/ gamallo/tagger_intro.htm
TreeTagger's output presents one token per line. To be compatible with the input expected by CWB encoding, I used a three-column format which includes the word, POS, and lemma. Segmentation was represented by XML tags and some of them include meta-information as attributes. One example is presented next:

```xml
<text id="textid">
  <s>
    Word1 POS1 Lemma1  
    Word2 POS2 Lemma2  
    Word3 POS3 Lemma3  
  </s>
</text>
```

After annotation, the corpus was indexed using the Corpus Workbench (CWB) and then inputted in a CQP installation in a Linux server. This process is described in detail in the next section.

### 3.3 Encoding, Indexing, and Querying

To be able to perform queries in the corpora, CQP requires the corpus to be encoded in a particular format. The encoding step is carried out by CWB provided that the input text is formatted in the aforementioned one token per line format, also called verticalized text (extension `.vrt`). In the last Section, I showed that TreeTagger produced the correct input required by CWB and no intermediate steps between Treetagger and CWB were necessary.

To encode the text using CWB it was necessary to follow three steps:

1. Create a directory to store the binary CWB files (represented by `-d`).
2. Choose directory to register all encoded corpora (represented by `-R`).
3. Encode the corpus using the `cwb-encode` choosing positional attributes (represented by `-P`) and structural attributes (represented by `-S`).

Positional attributes in this case are POS tags and lemmas whereas structural attributes correspond to XML tags which are used to represent, for example, sentence boundaries `<s>`. An example of the `cwb-encode` command on a file `corpus.vrt` using POS and lemma as positional attributes and sentence boundaries as structural attribute is presented next.

```bash
$ cwb-encode -d path corpus.vrt -R path -P pos -P lemma -S s
```

The last steps carried out before the corpora could be used in CQP is indexing and compressing. For that I used the CWB/PERL interface that made indexing and compressing straightforward and quick using `cwb-make` and the name of the corpus.

Following this procedure the corpora were ready to be used by CQP. The first thing to do to start working with the corpora is to load the corpus on CQP:

```
[no corpus]> COLONIA;
```
After that, queries such as the one presented below can be carried out using the command line.

\texttt{COLONIA> "isso";}

The previous query will display all occurrences of the word \textit{isso} in the Colonia corpus. Several options can be changed for better visualization such as the context size. These options are explained in detail in the CQP Tutorial \cite{18} along with many other examples of queries.

After the corpus is loaded, queries can be performed by typing commands through the command line. However, this is not exactly a user-friendly interface. Moreover, this architecture requires users to have access to the server where CQP is installed making it very difficult to release corpora that can be used from outside a particular computer network and/or institution. To improve usability CQPWeb has been developed providing a web-based interface for CQP queries. CQPWeb is designed to be used on top of the architecture presented so far.

### 3.4 Interface

Installing the interface was among the most difficult and time consuming procedures described in this report. At the time of the installation, no comprehensive documentation was available for CQPWeb whereas now fortunately a document containing nearly 100 pages is available at the project’s website. CQPWeb developers acknowledge that installing the tool is not easy and now they provide a virtual machine with CQPWeb installed called CQPwebInABox\cite{9}. I installed and configured CQPWeb in an Ubuntu Linux virtual machine turned into a web server running Apache, MySQL, and the necessary software required to make CQPWeb work. A dedicated virtual machine has been allocated specially for this corpus compilation project so it was necessary to install all software (including operating systems) from scratch.

Once the installation and configuration was complete CQPWeb provides a very user-friendly and easy to use interface for CQP queries. In Figure 1 a screenshot of the standard query interface to the Colonia corpus is presented.

![Figure 1](http://cwb.sourceforge.net/cqpweb.php)

\textbf{Figure 1} A Screenshot of the Standard Query Window of CQPWeb with the Colonia Corpus.
On the left hand side the user finds the ‘Corpus queries’ menu with links to calculate frequency lists and keywords. The user is able to change settings and create/edit sub-corpora directly at CQPWeb using the links in the ‘User controls’ menu. By clicking the link ‘User settings’ in the ‘User controls’ menu the user is able to customize several as displayed in Figure 2.

![Figure 2 A Screenshot of the User Settings in CQPWeb.](image)

4 Applications

To the best of my knowledge,[10] the corpora presented in this report have been used for a variety of purposes ranging from studies in various topics in linguistics to NLP research. Colonia has been used extensively because it is an open resource that can be used through the CQPWeb interface or downloaded in two versions: raw text or annotated with POS information. After its compilation Colonia has been made available at Corpus Eye[11] and Linguateca[12] with different annotation methods.

A summary of the studies published using the corpora is presented next.

- **DN-PT and FSP-BR**
  - Language variety identification: There was no standard language variety identification dataset available until the compilation of the DSL Corpus Collection (DSLCC) [11]. Samples from these two corpora were used to train computational methods to discriminate between Brazilian and European Portuguese texts [19, 20, 21] as well as to train VarClass [22], an open source language identification tool.

- **Colonia**
  - Semantics: The study by Santos and Mota (2015) [23] investigate emotions using the framework by Maia (1994) [24]. The corpora available at the AC/DC project by Linguateca (including Colonia) have been used for this purpose.

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[10]: This section has been last updated in April 2017.
[11]: http://corp.hum.sdu.dk/cqp.pt.html
[12]: http://www.linguateca.pt/acesso/corpus.php?corpus=COLONIA
– Dictionary building: Historical dictionaries have been compiled for Portuguese [25, 26] using other corpora. Taking advantage of the annotation carried out using the parser Palavras [27], the study by Bick and Zampieri (2016) [28] presents a diachronic dictionary of Portuguese compiled based on the data available in Colonia.

– Diachronic morphology: A few studies on the diachronic development of Portuguese have used the Colonia corpus [29, 30].

– Temporal text classification: A number of studies on temporal text classification have used Colonia to train systems to predict the publication date of Portuguese texts. Published studies focused on quantifying stylistic changes across centuries using readability metrics [31], on dating documents using a ranking method [32], and on investigating language change across centuries and in intervals of 50 years [33].

5 Conclusion and Future Work

Processing large corpora is time consuming but a rewarding endeavor. Colonia has been used in several research projects, listed in Section 4, which compensates the time invested in its compilation. Unfortunately, due to copyright restrictions the two contemporary journalistic corpora, DN-PT and FSP-BR, cannot be used outside of the University of Cologne.

A few directions that the work presented in this report may take in the next few years are:

• Compiling comparable journalistic corpora for other varieties of Portuguese. These corpora could be annotated and made available using the same framework described in this report resulting a comprehensive account of Portuguese varieties similar to what the Varitext platform offers for French [34]. A step in this direction is version 2.1 of the DSLCC which contains texts from Portuguese Newspapers publisher in Macau. [13]

• Evaluating the performance of TreeTagger on these corpora using manually annotated gold standard data. This is particularly interesting in the case of Colonia as it is well-known that diachronic language variation, spelling in particular, influences the performance of annotation tools and parsers. Methods described in Hendrickx and Marquilhas (2011) [36] could be applied to normalize spelling in Colonia.

• Including fine-grained annotation for verbs and other grammatical categories. The TreeTagger parameter file provided by Pablo Gamallo is trained on a coarse-grained tagset presented in the Section 3 of this report. A version of Colonia available at Corpus Eye, for example, contains morphosyntactic information along with POS tags. A similar annotation could be carried out for the two journalistic corpora as well.

[13] See [35] for a computational analysis of the language used in Portuguese newspapers from Macau.
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