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RIZNICA: THE CROATIAN LANGUAGE CORPUS

SŁOWA KLUCZOWE: Korpus Języka Chorwackiego, anotacja, kompatybilność, przetwarzanie danych, standaryzacja

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1. Introduction

The Croatian Language Corpus (CLC) is currently a spin-off product of sub-projects of the research program *Riznica* (Croatian Language Repository). Originally, the Ministry of Science, Education and Sports (MZOŠ) of the Republic of Croatia granted funds for the creation of the necessary infrastructure for the CLC. The goal of this particular grant was to organize the initial infrastructure for online language data and resources related to the Croatian standard language and dialects.

As an extension of some of the basic ideas from the initial project phase, in 2007 the research program the *Croatian Language Repository* (CLR) was granted by the MZOŠ (Brozović Rončević, Ćavar 2008). Being a research program (PI, Dunja Brozović Rončević) with numerous subsumed independent research projects that make use of the CLC, the corpus was chiefly developed as a by-product of those research projects within the CLR, and in particular of the research activities conducted in the project *Semantic Nets and Computational Lexicology* (PI, Damir Ćavar). For the purpose of the Semantic Nets research project, various technologies, automatic annotation tools and language processing components have been developed in cooperation with the Linguistics Department at the University of Zadar and funded by other independent research projects.

2. Previous work

Given the large number of corpus (development) projects in the world, mentioning all or even some of the main ones would exceed the scope of the current article. When focusing on Croatian corpus projects only, there are several projects worth mentioning. Of particular interest, when comparing goals and methods with the CLC, are the "One million token corpus" and the Croatian National Corpus (see Tadić 2002).

The "One million token corpus" of Croatian literary language was compiled by Milan Moguš at the Institute of Linguistics at the University of Zagreb.[1] It encompasses texts from 1937 to 1978, and contains five sub-corpora with 200,000 tokens each that cover the genres: prose, poetry, drama, secondary school textbooks, and newspapers. Derived analysis results include an alphabetic dictionary and frequency dictionary of types and lemmas, as well as concordance / KWIC overviews based on tokens and lemmas.

The Croatian National Corpus (HNK) is a corpus of mostly contemporary Croatian texts with approx. 101 million tokens. It is available via additional software tools, see http://www.hnk.ffzg.hr/. As with the "One million token corpus", the HNK provides word-class information and lemmatized tokens for search and analysis. The HNK, on the other hand, contains mainly newspapers and journals, as well as texts available online from the late 20th century, thus, from a linguistic point of view, it does not contain relevant texts which are representative for changes and language development overviews.

The CLC provides, on the one hand, similar information as the two mentioned corpora, i.e. word-class tags and lemmas. On the other hand, the CLC aims at extending the annotation using other linguistic levels, e.g. including text sources that go beyond those found in the other corpora. Additionally, the CLC contains texts from the 19th century to the present day, as well as older texts that have been adapted to modern Croatian. Moreover, one of the technical goals of the CLC was to use exclusively standardized text and document encoding schemata (XML and TEI) and a uniformed common text-character encoding standard (e.g. UTF8). In addition to the goal to maintain common format compatibilities, the linguistic annotation is designed to maximize interoperability and compatibility with other tools and corpora, and in particular with linguistic annotation standards. The morpho-syntactic features and annotation symbols are taken from the General Ontology for Linguistic Description (GOLD) (Farrar, Langendoen 2003), wherever possible. We have worked on mappings of the GOLD annotation schema to other annotation labels, e.g. MULTEXT(-EAST) (Véronis, Khouri

[1] See for more details the URL http://www.ffzg.hr/zzl/zzl-home.htm.

1995; Erjavec 2010) in order to maximize the compatibility and interoperability with other corpora and corpus processing tools.

3. Development of the CLC

The initial goals of the CLC were to serve the lexicographical projects at the IHJJ[2], as well as other linguistic and language technology projects. For the purposes of the lexicographical project, it was desirable to include texts from all kinds of genres into the CLC, however, there was never an intention to balance it in any way. The notion of a balanced corpus seemed rather irrelevant for the respective research goals. Instead of presenting one fixed balanced corpus, our goal was to create an annotated text corpus, as large as possible, that could be dynamically mapped onto individual sub-corpora for specific research and development interests.

Currently the corpus contains more then 100 million tokens. The document collection that enters the CLC is extended on a daily basis. Depending on the complexity of the original text sources, the growth of the corpus is approx. 1.5 million tokens a day. Some resources, in particular journals available online that are added to corpus, can be converted automatically to the required file format for manual checkup.

The current content of the literature sub-corpus of the CLC is shown in table 1:

	Fiction	**Specialized**
Proportion	28%	72%

Table 1. *Content type proportions in the CLC*

The number of books in the fiction portion of the corpus can be divided into sub-domains as shown in table 2:

Type	**Number**
Poetry	35
(Lyric)	(16)
(Epic)	(19)

[2] Some of the projects are the development of a Standard Croatian One-Volume Dictionary, a Croatian Verb Valency Dictionary, a Croatian Terminology Dictionary and Online Repository (STRUNA), a Dictionary of Croatian Place Names, a Dictionary of Anthroponyms, and various bilingual dictionaries.

Type	Number
Prose	184
(Novel)	(101)
(Short Stories)	(83)
Drama	13
Total	**232**

Table 2: *Number of books in the fiction portion of the CLC*

The number of books in the specialized text proportion of the literature sub-section of the CLC is shown in table 3:

Type	Number
Non-fiction Prose	60
(Studies, Polemics)	(36)
(Essays, Memoirs, Letters)	(24)
Scientific Literature and Popular Science	35
(Textbooks)	(27)
(Manuals, Instructions)	(8)
Total	**95**

Table 3: *Number of books in the specialized text portion of the CLC*

From the scientific literature and popular sciences categories we have so far included textbooks from the domains of natural and technical sciences (63%) which are textbooks in medicine, biology, geography, informatics, chemistry and physics. Many of these texts are relevant for the STRUNA project which is developing terminological dictionaries and their online interfaces. The remaining 37% of sources include texts in science and humanities. The majority of manuals come from the area of law.

Besides this literature component, the CLC also contains a large number of articles from various newspapers and journals, among others *Glas Koncila*, *Vjesnik*, and *Zarez*. The amount of tokens in the CLC from these resources represents the largest proportion.

The CLC is a text corpus, annotated in XML (Bray et al. 2008). It uses the Text Encoding Initiative (TEI) P5 standard (Sperberg-McQueen 1994) for XML, as described in Vanhoutte (2004) or Burnard and Bauman (2007).

The CLC is created with the use of various text sources, among others:

- online newspapers, books, articles;
- printed and published books and other printed hard copies;
- digital files of printed books made available by publishers,[3]
- transcriptions of collected data and recordings.

Various resources with documents available online, newspapers, article and books are integrated into the corpus using digital archives provided to us by the publishers, or directly via the mirroring of the web resources. These documents are mainly based on HTML and other more or less systematically structured file formats that can be converted into the digital target format via manual conversion methods or automatic tools.

As far as books are concerned, some of them were made available to us in a digital format. However, many of the books in the CLC, in particular the older ones, were retrieved from hard-copy originals. Those books are scanned to TIFF images and the resulting images are converted to text via OCR software.

Since some OCR tools identify font formats and other textual properties, an intermediate format that is also used in the corpus creation process is Rich Text Format (RTF), which in this case does not contain annotations or meta-information.

The different digital file sources for the CLC come in various formats, e.g. InDesign, Pagemaker, Quark, Word, and PDF. These digital formats are either converted to Unicode text or directly to the basic TEI P5 XML format. For all standard document types that can be opened with OpenOffice, we use the TEI P5 XML export plugin (see XYZ) to export the files directly to the target XML format, minimizing additional manual annotation. For many other formats, the export had to be to an initial UTF8 encoded raw text format, which is manually annotated with the use of TEI P5 XML standards and tags. In the most difficult case which is image-based file formats, e.g. image-based PDF files, the file content has to be converted to raw text via Optical Character Recognition (OCR) tools.

In an initial text-to-XML conversion the meta-information is added with the use of the TEI (Text Encoding Initative) P5 XML standard. The text chapters, sections and paragraphs are annotated automatically or manually, depending on the underlying conversion pipeline. Subsequently, formats of fonts, markup of section titles, page--breaks and page-numbers, footnotes and other document properties are performed.

All resulting XML files, annotations, and markups are manually checked, corrected, and all changes and corrections are recorded. The resulting XML files are stored together with the underlying digital format and intermediate

[3] The Institute of Croatian Language and Linguistics has contracts with some of the prominent Croatian publishers, including Školska knjiga, and the Croatian Academy of Arts and Sciences. These publishers provide the IHJJ with digital copies of their books for the purposes of the CLC. At the same time, the IHJJ is also a publisher, and includes its own books in the corpus.

conversion formats in a file and document repository. File management allows for the annotation of files which were ready for inclusion in the final corpus and indexing for the interactive web interface.

We make use of various tools for corpus analysis and processing. For the web-based front-end for the CLC we decided to use PhiloLogic™ with various manipulations and adaptations. PhiloLogic™ was developed at the University of Chicago. It "is the primary full-text search, retrieval and analysis tool developed by the ARTFL Project and the Digital Library Development Center (DLDC)".[4] Its 2006 version is able to generate an index and an interface for a TEI XML-based corpus. Currently, it is being extended and further developed as an open source project, and version 3.2 is available at the URL http://sites.google.com/site/philologic3/. The installation requirements for PhiloLogic™ were minimal, including a running Apache web server, and basic interpreters like Perl and compilers like GCC. Besides the localization to Croatian of the front-end web interface, we have added for our purposes necessary additional functionalities to the 3.0 version of Philologic in our online interface.

The following diagram summarizes the corpus creation process as it is defined for the CLC:

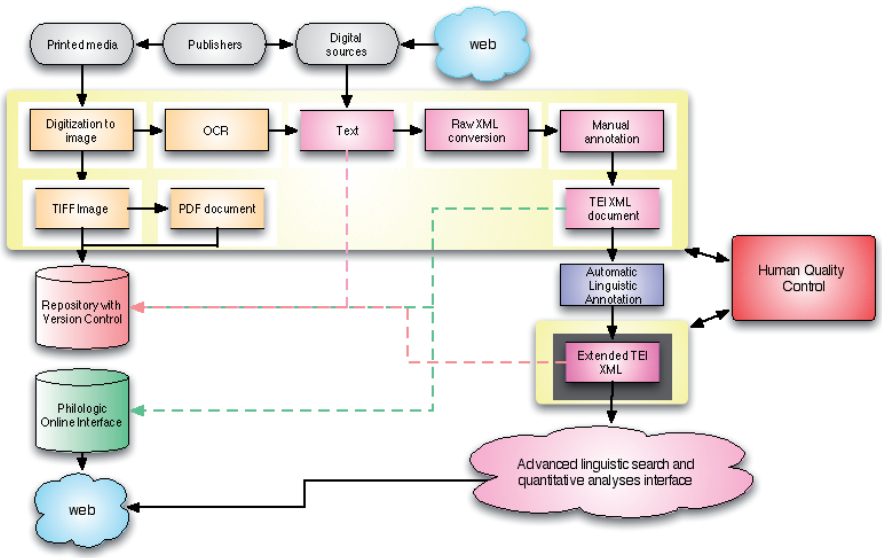


Figure 1. *The CLC creation process.*

[4] See http://philologic.uchicago.edu/.

Currently the search functionality includes token search with limited regular expression capabilities and a resulting visualization of text passages. It also allows for a keyword-in-context view on the hits, as well as left and right contexts with statistics and variable window sizes, and various further sub-specifications and limitations of the query.

One of the extensions includes the virtualization of the corpus database and the resulting index, and front-end handling of multiple corpora on the same installation. This means that in our version of Philologic it is possible to generate indexes and a web front-end for an individually specified corpus. A sample set of four individually specified corpora can be accessed at the CLC URL: http://riznica.ihjj.hr/.

In its current version, the corpus annotation is aimed at including not just lemmatization and part-of-speech annotation, but also multi-level linguistic annotation that includes phonemic transcriptions, syllable structures, morpheme segmentations of tokens and specific morpheme annotations, as well as syntactic phrasing and parse tree markup. While most of these annotations can easily be integrated in one XML TEI file in a classical way, for the syntactic annotation a stand--off markup (Bański, Przepiórkowski 2009) of phrase structures and trees is necessary for the final version, although currently various problems exist (Bański 2010), in particular since to our knowledge indexing and retrieval across links to target URIs is not supported. Thus, for indexing, we need to have inline markup within one XML file. This limitation might be irrelevant with future indexing engines.

The stand-off annotation makes particular sense, if different theoretical frameworks for syntactic tree annotations are taken into account, as is the case for the CLC. A concrete tree annotation, however, does not yet exist for the CLC, although the respective framework and approach is defined, annotation formats have been defined, and basic parsers and shallow grammars have been developed.

4. Automatic Linguistic Annotation

Different research foci require different annotation levels. A particular goal for the CLC was to provide multi-level annotation, which includes phonological, morphological, lexical, and syntactic information. The fundamental annotation of the CLC should include at least:

- lemmatization;
- part of speech information;
- named entity information;
- shallow syntactic structures and phrases.

In addition to these common corpus annotation levels, the extended annotation should also include phonological and morphological levels, including at least the following:

- phonemic transcription;
- syllable structure;
- morphological segments or morphemes and their features.

In general, qualitative and quantitative data of morphotactics, phonotactics, and related distributional linguistic information from corpora is sparse for any language, and for Croatian in particular. For various reasons, such distributional models are highly desirable for CLC-related research projects. Thus, activity focuses on the corpus annotation along these levels.

Manual annotation at various linguistic levels would be to costly and most likely very error-prone. An automatic annotation might also be error-prone, however, it is more likely that the errors would be systematic, and could be eliminated with additional rules, constraints and data in the grammars or language models of the particular NLP tools used in the markup process. Thus, one of the basic goals and concepts in the CLC development process was to also develop and use language-processing components to automatically annotate the corpus, and avoid direct manual annotation of the corpus at the linguistic level completely. The following graphic shows the concept of the linguistic processing pipeline in the CLC annotation process:

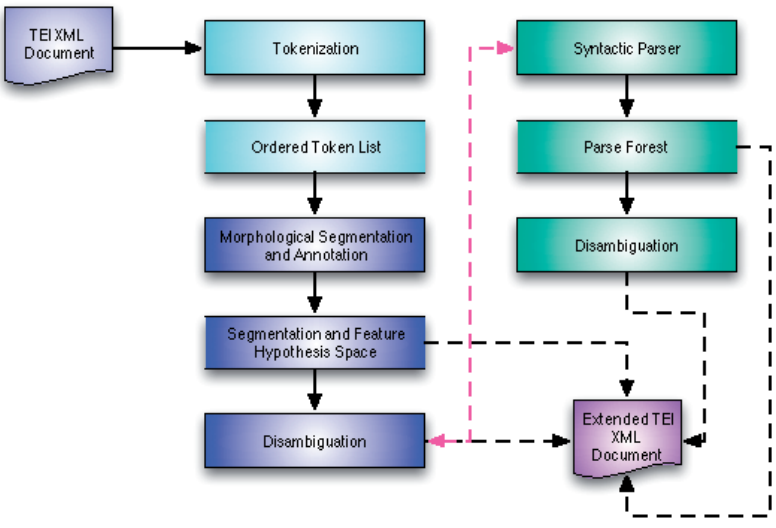


Figure 2. *CLC annotation process.*

Numerous language and text processing tools have been made available for the specific XML annotation used in the CLC.

We have developed an extended tokenizer for Croatian, using a finite state transducer approach. The tokenizer annotates not only tokens and orthographic symbols, but also basic tokens types and named entities, as well as sentence boundaries. The tokenizer consumes raw text, and its output is wrapped token annotations and sentence markup using TEI P5 XML. Clause type markup is possible to some limited extent, as shown in the following example:

```
<s>
     <cl type="matrix">
          <w>Petar</w>
          <w>je</w>
          <w>vozio</w>
          <w>mračnom</w>
          <w>ulicom</w>
          <pc>,</pc>
          <cl type="subordinate">
                <w>ali</w>
                <w>nije</w>
                <w>bio</w>
                <w>upalio</w>
                <w>svjetla</w>
                <pc>.</pc>
          </cl>
     </cl>
</s>
```

A morphological segmentation application for the annotation at the sub--word level has been developed. It is based on a morpheme dictionary that was generated from databases developed for lexicographic purposes at the IHJJ, and a set of morphological rules that are compiled into a binary finite state transducer (Ćavar et al. 2009) for morphological segmentation of complex words and feature annotation of single morphemes. The same transducer is also used for rule-based lemmatization and morpho-syntactic feature annotation (without disambiguation). Example input and output structures can be seen in the following sample:

Input: *pročitamo*

Output:

```
<w type="verb" lemma="pročitamo">
     <w type="verb">
          <m type="prefix" baseForm="pro">pro</m>
          <m type="root">čita</m>
     </w>
     <m type="suffix">mo</m>
</w>
```

An automatic transcription tool for the conversion of Croatian text to the International Phonetic Alphabet (IPA) is made available online (Ćavar D., Ćavar M. 2010). An extension of this component is used to enrich the corpus text with IPA transcription. A syllabification algorithm is also being tested for Croatian, that consumes the phonemic transcription and morphological segmentation of each word.

While for the XML coding a more elegant technological solution would be to link specific tokens via URIs to external dictionary entries where phonemic transcriptions and other information are stored, as for example syllable or morpho--syntactic feature structure, due to limitations of current indexing engines, we have chosen the inline approach to annotate at least phonemic transcriptions and syllable structures, as shown in the following sample:[5]

```
<seg type="w">
     <w type="verb" lemma="pozvati">
          <w type="verb">
               <m type="prefix" baseForm="po">po</m>
               <m type="root">zove</m>
          </w>
          <m type="suffix">mo</m>
     </w>
     <fs type="phonology">
          <f name="pron">pɔ̀zɔ̀vɛmɔ̀</f>
          <f name="syll">po-zo-ve-mo</f>
     </fs>
</seg>
```

The above mentioned tools have been developed as standalone tools, and partially they are being integrated in the SNLK[6] (Ćavar et al. 2011), together also

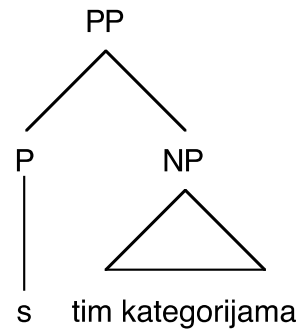
[5] Thanks to Piotr Bański (p.c.) for annotation suggestions wrt. inline solutions for our indexing problem.

[6] See www.snltk.org for more details.

with a shallow parsing component for elementary phrasing that makes simple noun phrase annotation possible, but also more complex phrase structure markup. On the one hand, we make use of the PARC XLE parser (Kaplan, Maxwell 1993; Crouch et al. 2008) using Lexical Functional Grammar (LFG) (Bresnan 2001), aiming at the development of LFG grammar segments for standard Croatian, and eventually a complete grammar for it. On the other hand, currently we also implemented our own algorithms that are based on variants of agenda-based chart parsing (Earley 1970) for context-free grammars (CFGs), using feature augmentation extensions on symbols and unification over CFG rules (Shieber 1986).

The primary goal of the syntactic annotation in the CLC is to be able to encode phrase structure trees, possibly with functional annotations (e.g. in the sense of LFG), for the purpose of visualization and computational processing (e.g. extraction of probabilistic grammars and other types of language models). The TEI P5 specification provides various possibilities to encode tree structures. The *tree* and the *eTree* tags, as described in chapter 19 of the TEI P5 guidelines, are ideal for graph oriented encoding and subsequent visualization of the corresponding phrase structure trees. Here is an example of such tree encoding for visualization purposes:

```
<eTree n="2451">
   <label>PP</label>
   <eTree>
      <label>P</label>
      <eLeaf>
         <label>s</label>
      </eLeaf>
   </eTree>
   <triangle>
      <label>NP</label>
      <eLeaf>
         <label>tim kategorijama</label>
      </eLeaf>
   </triangle>
</eTree>
```



Alternatively, the tree encoding can be undertaken using a strategy as suggested for the National Corpus of Polish (cf. Przepiórkowski 2009). Since our goal is limited to the task of wrapping a parser output in the appropriate XML markup, allowing for visualization and search over tree structures primarily, we initially restrict ourselves to the graph-oriented eTree encoding model of the

TEI P5 standard, but remain open to other annotation formats that allow the mapping of our parser output on TEI P5 compatible XML code.

The following graphic shows the different NLP components and the corresponding XML wrapping for the CLC:

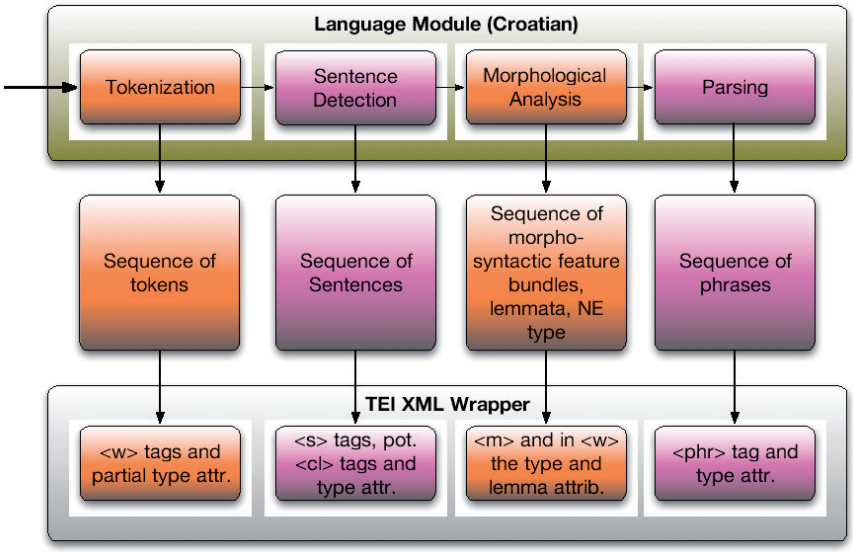


Figure 3. *NLP components and the corresponding XML wrapping for the CLC.*

In general, the approach we have chosen for the CLC linguistic annotation is to generate the complete markup via NLP annotation tools, rather than human or expert annotation. Thus, corrections and changes of annotation mistakes have to be corrected in the corresponding NLP tools, and not manually in the corpus. This approach has the positive side-effect of improving a mainly rule-based NLP tool-chain, and generating a qualitatively annotated corpus for the improvement of quantitative NLP models.

5. Conclusion

The Croatian Language Corpus is not a final result or product, it is rather a project, being developed and extended continuously. Not only is the amount of text in it growing continuously, but also the annotation depth and quality is extended over time, based on the needs and goals of related research projects.

Nevertheless, the CLC has been made available online in all its phases and stages of size and annotation for the purposes of a broader linguistic community. We are continuously working on ways and new technologies to improve open access to the corpus via online interfaces and other technologies.

Compared to other corpus projects, a particular challenge for the CLC is to include texts from a period covering at least 150 years, and thus involving a great deal of manual digitization effort. The same standards, tools and methodology that were developed for the CLC are also implemented and used for the development of language corpora of earlier phases of the Croatian language, which are being currently prepared at the IHJJ within the Riznica research program. These corpora will be made available online in the near future.

Additionally, the CLC is a corpus that aims at qualitative multi-level linguistic annotation that allows for analyses of linguistic properties, correlations and changes across linguistic domains, i.e. phonology, morphology and syntax. The necessary annotation technologies and language processing tools had to be created and adapted for this goal, and tools for the analysis and use of the encoded information had to be adapted, or even drafted and developed from scratch.

The CLC is not designed as a standalone general corpus for all kinds of potential purposes that are unknown to its creators. It is rather the result of specific research goals, embedded in concrete ongoing research projects. Its properties, annotation formats, and encoding technologies are not oriented towards general compatibility or even international standards, whether those exist, or not. They are however kept in a format that allows for conversion and adaptation towards other common formats and linguistic annotation standards, being closely linked for example to the GOLD linguistic annotation approach, or using the TEI P5 compatible encoding.

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Riznica – Korpus Języka Chorwackiego

S t r e s z c z e n i e

Artykuł przedstawia projekt Riznica, którego częścią jest m.in. stworzenie nowego korpusu współczesnego języka chorwackiego (teksty mające nie więcej niż 150 lat). Zostały w nim szczegółowo przedstawione techniczne metody tworzenia korpusu, takie jak sposoby kodowania, anotacja syntaktyczna i morfologiczna oraz sposoby pozyskiwania tekstów.

Korpus Języka Chorwackiego stworzony w ramach projektu umożliwi użytkownikowi analizę języka na wielu poziomach jednocześnie, docelowo łączyć ma bowiem tak różne obszary jak choćby fonologia i składnia. Dlatego bardzo ważnym zadaniem dla twórców jest użycie odpowiednich narzędzi informatycznych do przetwarzania danych językowych i adaptowania informacji pochodzących z różnych źródeł.

Autorzy kładą nacisk na techniczne procesy standaryzowania materiału i dostosowania tekstów do międzynarodowych standardów tak, aby efekt końcowy był kompatybilny ze światowymi korpusami.