Transformer-based Part-of-Speech Tagging and Lemmatization for Latin

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Abstract

The paper presents a submission to the EvaLatin 2022 shared task. Our system places first for lemmatization, part-of-speech and morphological tagging in both closed and open modalities. The results for cross-genre and cross-time sub-tasks show that the system handles the diachronic and diastatic variation of Latin. The architecture employs state-of-the-art transformer models. For part-of-speech and morphological tagging, we use XLM-RoBERTa large, while for lemmatization a ByT5 small model was employed. The paper features a thorough discussion of part-of-speech and lemmatization errors which shows how the system performance may be improved for Classical, Medieval and Neo-Latin texts.

Keywords: part-of-speech tagging, lemmatization, morphosyntactic tagging, Latin, transformers

1. Introduction

The performance of lemmatization and part-of-speech tagging tools is essential for Latin as it is for all historical languages. Due to relative scarcity of annotated data, newly developed tools may be expected to be effective or at least adaptable to handle Classical, Medieval, and Neo-Latin, despite the fact that their use spans over more than 15 centuries. The recent advancements in NLP technology along with increasing availability of large language models have opened new venues for computational Latin linguistics.

| Corpus   | Tokens | Sentences | Avg |
|----------|--------|-----------|-----|
| **EVALATIN 2022** | | | |
| **TRAIN** | Classical | 320,355 | 15,785 | 20.29 |
| **TEST** | Cross-genre | 22,086 | 1,329 | 16.62 |
| **TEST** | Cross-time | 9,174 | 246 | 37.29 |
| **EVALATIN 2020** | | | |
| **TEST** | Cross-genre | 13,290 | 597 | 22.26 |
| **TEST** | Cross-time | 11,556 | 883 | 13.09 |
| **UD LATIN** | | 977,722 | 58,405 | 16.74 |
| **LASLA** | | 1,728,933 | 92,170 | 18.76 |

Table 1: Corpora used in the study

In this paper, we present our submission to the EvaLatin 2022 shared task (Sprugnoli et al., 2022). First, we briefly characterize the task, focusing on specific challenges the texts included in the test dataset posed. Next, we provide a detailed description of our system and describe its two modalities. Additionally, we show what data were used to enhance the performance of the open variant of the model and provide a thorough analysis of lemmatization and part-of-speech errors. We believe that the present system may be further adapted to address challenges of linguistic annotation of the Medieval and Neo-Latin texts.

2. Training and Test Data

The training dataset of the EvaLatin 2022 shared task contains prosaic texts of five authors composed between the 1st century BC and the beginning of the 2nd century AD. The test dataset includes works which represent various genres and periods of the Latin literature history. The Classical sub-task consists of the VIIIth book of Livy’s ‘Ab urbe condita’, a work which is arguably closest to the training data. Two texts in the Cross-Genre sub-task differ from the training data in their literary form and subject domain. The VIIIth and IXth books of the Ovid’s epic poem contain narratives of Greek mythology. Pliny the Elder’s Naturalis Historia, on the other hand, is an encyclopedic work in prose whose XXXVIIth book discusses properties of gemstones. Both texts contain a significant number of words of Greek origin: person and place names in case of Metamorphoses and rare terms regarding mineralogy in case of Pliny. The only text included in the Cross-Time sub-task dataset is the De Latinae Linguae Reparatione, a Renaissance dialogue on history by Marcus Antonius Coccius Sabellicus (†1504). The major challenge seems to be its non-Classical orthography and a number of post-Classical proper names.

3. System Description

Our architecture is based on transformer models, as they are state-of-the-art in part-of-speech tagging and lemmatization. It builds on a morphosyntactic tagger KFTT (Wróbel, 2020) which won the PolEval 2020 task 1 competition (Morphosyntactic tagging of Middle, New and Modern Polish) and uses a transformer model contrary to its RNN-based predecessor KRNNT (Wróbel, 2017).
Table 2: Corpora used in the open modality system

| Task      | Phase | UD Latin | LASLA | EvaLatin '22 Train | EvaLatin '20 X-Genre | EvaLatin '20 X-Time |
|-----------|-------|----------|-------|--------------------|----------------------|---------------------|
| POS       | 1     | +        | +     | +                  | +                    | +                   |
|           | 2     |          |       |                    |                      |                     |
| Feats     | 1     | +        | -     | +                  | +                    | +                   |
|           | 2     |          |       |                    |                      |                     |
| Lemmatization | 1   | +        | +     | +                  | +                    | +                   |
|           | 2     |          |       |                    |                      |                     |

Part-of-speech and morphologic tagging are addressed with a transformer encoder model with a token classification head on top. The transformer, first, returns contextual embeddings of each token; next, a linear layer with softmax activation returns normalized scores for each tag seen in training.

In the lemmatization task, the system uses information about predicted parts of speech, but it does not use context of a word. It is solved with sequence to sequence model with input constructed as a word form and predicted part of speech.

In the open modality variant of the system, in which external resources can be employed (see Table 2), our models are first trained on a set of corpora that were annotated following different guidelines than the ones adopted in the present competition. In the next phase, the models are re-trained on the EvaLatin 2022 training dataset. Detailed information on each corpus can be consulted in the Table 1. The performance of the system in each task was evaluated using micro-averaged accuracy. 5% of the EvaLatin 2022 training data were used for validation.

For the POS and Feats tasks we used XLM-RoBERTa large (Conneau et al., 2020) – a multilingual encoder. Model training parameters were:

- batch size: 12
- epochs: 10,
- learning rate: 2e-5,
- sequence length: 256.

Lemmatization was performed with ByT5 small model (Xue et al., 2022) whose input are separate bytes of text. Initial experiments with subword models (e.g. mT5 (Xue et al., 2021)) showed worse accuracy. Model training parameters were the following:

- batch size: 128,
- epochs: 5,
- input sequence length: 48,
- output sequence length: 24,
- learning rate: 0.001.

In the open modality for the PoS and Feats tasks first training is performed for 2 epochs without early stopping.

All models here described are publicly available

https://huggingface.co/enelpol/

4. Results

Our system performed best in every task in the competition. In the closed modality variant, it was ahead of the second best architecture by 0.9%-4.5% in the PoS task, by 25.5%-31.9% in the Feats task, and by 4.4%-11.0% in the Lemmatization task (Table 3).

Since the system is expected to be employed in Medieval and Neo-Latin corpus projects, it was essential to examine its performance in qualitative terms as well (Nowak et al., 2016). Therefore, we carefully analyzed tagging errors (1) to assess the impact of additional training data on the performance in the open modality and (2) to get insight into major challenges that language variation poses to the system. Due to space limitations, however, we only briefly discuss the results of the Lemmatization and PoS task.

4.1. Part-of-Speech Tagging

All texts combined, the PoS tagging errors affect in particular nominal categories, with ADJs misclassified as NOUNs or PROPNs, NOUNs as ADJs, and VERBs as ADJs (see Figure 1). The error distribution varies slightly between sub-tasks and modalities.

![Figure 1: PoS Tagging: Confusion Matrix (closed and open modalities)](https://huggingface.co/enelpol/)
annotated resources leads to better discrimination between homonymous forms of nouns and adjectives, such as *iuuenis* ‘young’: *a young person*, *securus*.ADJ ‘safe’: *securis*.NOUN ‘an axe’ or *sacer*.ADJ ‘sacred’: *sacrum*.NOUN ‘a holy thing’. In the open modality, correct lemmas are assigned, for instance, to Greek-origin terms such as †*synechitus*.ADJ → *synechitis*.NOUN ‘a kind of gemstone’ or †*iaspidus*.ADJ → *iaspidis*.NOUN ‘jasper’.

The improvement is noticeable the other way around, too. Part-of-speech labels are amended for words which were assigned either correct (†*edax*.NOUN → *edax*.ADJ ‘edacious’) or incorrect lemmas (†*femineum*.NOUN → *femineus*.ADJ ‘feminine’) in the closed modality.

**PROPN ↔ ADJ** Additional training data in the open variant of our system improves considerably the distinction between homonymous PROPN and ADJ in all but the CROSS-TIME sub-tasks. The improvement concerns both frequent lexical units, such as Romanus.PROPN: Romanus.ADJ ‘Roman’, and less frequent words, such as Phlaegreus.PROPN → Phlaegreus.ADJ ‘of Phlegra’. Likewise, ethnonyms are usually better distinguished from homonymous adjectives: Persius.ADJ ‘Persian’ → Persiae.PROPN ‘Persians’ or Campanus.ADJ ‘of Campania’ → Campani.PROPN ‘Campanians’.

**VERB ↔ NOUN, ADJ** The open variant of the system reduces considerably the number of incorrect idiosyncratic annotations, such as supero.VERB ‘suffer’ instead of *superi*.NOUN for superi ‘the gods’, †*uitro*.VERB instead of *uitrum* ‘glass’.NOUN for *uitri*,
or †sideo.VERB instead of siderita.NOUN ‘a kind of gemstone’ for sideritis. It also leads to improved annotation of deverbal nouns, such as secuta ‘a cut’, partus ‘a birth’, which in the closed version were misclassified as VERB forms of resp. seco ‘to cut’ and pario ‘to bring forth.’.

For Livy’s and Ovid’s works, the open variant performs better in labelling participles as VERBS rather than NOUNS. It also improves recognition of verb forms in the Metamorphoses: sileo.VERB ‘to keep silence’ for sileam or auguror.VERB ‘to augur’ for auguror. In the closed modality, these first-person forms, untypical of prosaic discourse, are misclassified as †auguror.NOUN and †sileo.NOUN.

4.2. Lemmatization

It comes of no surprise that the open variant of our system improves lemmatization results, as both lemmatization and part-of-speech tagging are closely related sub-tasks, on the other hand, the open variant of the system assigns correct lemmas to words of Greek origin related to mythology (Ovid: heros, nympha, thalamaus) and mineralogy (Pliny: smaragdus, crystallass, sardonyx), as well as to proper names (Ovid: Alcmene, Iphis, Byblis, Dryope).

Correct lemmas are also reached for a number of words which occur frequently in the test data, but (1) are rare or absent from the training dataset (Ovid: liliun or Pliny: gutta); (2) present phonetic assimilation unseen in the training dataset (tralucoe; translaucoe); or (3) have alternative spellings (etiun nunc; etiamnunc).

In the CROSS-TIME sub-task, the open variant of our system improves significantly the lemmatization of words which display post-classical or non-standard orthography that is not accounted for in the training dataset. Correct lemmas are assigned to word forms such as:

- qu-lc-: quum → cum
- -nl-m-: tanquam → tanquam
- -ae-/-e-: pene → paene

Likewise, a number of proper nouns, both attested and not attested in Classical texts, are correctly lemmatized in the open modality (for instance Laurentius, Lactantius, Strabo, Plato etc.).

Despite using supplementary annotated data in the open modality, a number of lemmatization errors persist. They include among others:

- sui ‘their etc. (sc. friends, followers)’ is frequently misclassified as suus.DET;
- ethnonyms, which are either assigned lemmas in singular rather than plural (e.g. uolscus instead of uolscii) or are confused with adjectives of Greek origin related to mythology (Ovid: heros, nympha, thalamaus) and mineralogy (Pliny: smaragdus, crystallass, sardonyx), as well as to proper names (Ovid: Alcmene, Iphis, Byblis, Dryope).

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- ethnonyms, which are either assigned lemmas in singular rather than plural (e.g. uolscus instead of uolscii) or are confused with adjectives

| Classical | Cross-genre | Cross-time |
|-----------|-------------|------------|
| quis       | quis       | indicus    | maior      |
| sui        | aer        | indi       | minus      |
| priuernates| amans      | quis       | minus      |
| pedum      | refero     | crystallus | fama       |
| uolsci     | quo        | sarda      | latinus    |
| latini     | carus      | sestertius | melior     |
| triarius   | lotos      | margarita  | adsum      |
| apuli      | ora        | uisus      | maxime     |
| philo      | ausum      | carchedonius| epistula  |
| comitia    | superus    | quod       | aliqui     |

Table 4: 10 most confused lemmas for each task

(e.g. carchedonii.PROPN instead of carchedonius.ADJ);

- homonymous forms of low-frequency words, such as pedum.VERB ‘a town in Latium’ (incorrectly lemmatized as pes.NOUN ‘a foot’) or almost full homonym pairs, such as aer ‘the air’:aes ‘(any) base metal’.

Some lemmatization choices may also be considered arbitrary and thus should not be expected to be correctly predicted by the tagger. This is the case, for instance, of hyacinthos instead of hyacinthus or myrrha instead of murra.

Finally, the last group of tagging errors results from the non-classical orthography employed in Sabellicus’ work. However, poor results of the system in the closed modality might have been expected, since the training dataset does not account for spelling variation of Medieval or Neo-Latin texts:

- -o/-u-: epistola → epistula
- -ph/-f-: phama → fama
- -ci/-ti-: oium → otium
- -oe/-e-: foelix → felix

5. Conclusions

The system presented in this paper outperforms competing architecture in lemmatization, part-of-speech and morphological tagging of Latin texts. It handles well the diachronic and diastratic variation of the language whose range of uses and coverage may be compared only to contemporary English. The open variant of the architecture improves significantly the results of both lemmatization and PoS tagging, leaving only small group of specific issues to persist in the resulting data.

Future work can focus on training language models on unlabeled Latin texts instead of using multilingual models, using context for lemmatization, and combining models into one for all tasks. The error analysis shows that careful selection of training data should help in addressing most if not all problems related to
spelling variation, unseen proper names and domain-specific terminology. The use of curated lexical resources should permit to reach preferred lemma labels for the convenience of the linguistic community. The system may be, then, hoped to perform well in a large-scale annotation of Medieval and Neo-Latin texts (Nowak, 2022).

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