

Dependency Annotation of Ottoman Turkish with Multilingual BERT

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Abstract

This study introduces a pretrained large language model-based annotation methodology for the first dependency treebank in Ottoman Turkish. Our experimental results show that, iteratively, i) pseudo-annotating data using a multilingual BERT-based parsing model, ii) manually correcting the pseudo-annotations, and iii) fine-tuning the parsing model with the corrected annotations, we speed up and simplify the challenging dependency annotation process. The resulting treebank, that will be a part of the Universal Dependencies (UD) project, will facilitate automated analysis of Ottoman Turkish documents, unlocking the linguistic richness embedded in this historical heritage.

1 Introduction

The Ottoman Turkish is one of the historical versions of Turkish. It was in use for nearly six centuries before it evolved into modern Turkish. During that period, it went through many changes in terms of lexicon and, to some extent, syntax.

There is an increasing trend in digitization campaigns that aim to preserve historical documents and facilitate user access to these resources. Numerous institutions publicly share images of their historical documents written in Ottoman Turkish. As these historical materials become more accessible in digital form, a crucial need for automated processing and retrieval of their content arises. However, unlike modern languages with well-established linguistic resources and corpora, Ottoman Turkish has quite a limited availability of annotated data, dictionaries, and linguistic references. That scarcity of resources hinders the development and training of robust NLP models for the Ottoman Turkish.

A possible solution for the problem of resource scarcity can be leveraging Turkish resources based on the fact that they are actually two versions of

the same language. However, the linguistic evolution from Ottoman Turkish to modern Turkish involves substantial changes over time. This transition impacts semantic nuances, vocabulary, and grammatical structures, making it challenging to apply contemporary Turkish NLP techniques directly to historical texts.

It is a common approach to prepare the necessary resources manually in the case of low-resource languages. However, manual tagging and annotation are both time-consuming and expensive. In the case of dependency annotation, there is also a need for experts specialized in the task at hand.

To simplify and speed up the manual annotation process for our objective of constructing an Ottoman Turkish dependency treebank, we propose to use pretrained Large Language Models (LLMs) as pseudo-annotators. LLMs have proven themselves as powerful tools widely used in various fields due to their adaptability. They excel in understanding natural language, making them valuable across diverse areas, from downstream tasks like machine translation (Yang et al., 2020) and sentiment analysis (Hoang et al., 2019) to data annotation (Tejani et al., 2022). We experiment with a multilingual BERT-based parsing model for dependency annotation in our treebank. Our proposed methodology suggests generating pseudo-annotations using the parsing model, then correcting them manually and fine-tuning the model with the corrections, and then using the updated model to pseudo-annotate new data in a repeated cycle.

In this study, we present our LLM-enhanced syntactic annotation methodology for the first Ottoman Turkish dependency treebank, which will be a part of the Universal Dependencies (UD) project (Nivre et al., 2016). We investigate the impact of enhancing the accuracy of pseudo-annotations by fine-tuning the parsing model with labeled Ottoman Turkish data. We show that utilizing a multilingual BERT-based parsing model in dependency anno-

tation leads to better pseudo-annotations, which eases the manual annotation of the Ottoman Turkish treebank job for human annotators. With the creation of this treebank, we aim at facilitating the automatic analysis and understanding of Ottoman Turkish documents, thereby facilitating a more comprehensive exploration of this linguistically rich heritage.

2 Background and Related work

We present some background on the Ottoman Turkish and discuss its differences from modern Turkish in this section. The section includes a summary of the related works from the literature as well.

2.1 The Ottoman Turkish

Ottoman Turkish is the historical form of the Turkish language used in the Ottoman Empire from the late 13th to the early 20th century. It has a writing system based on an extended version of the Arabic script where five additional characters are used to represent some Turkish sounds. Ottoman Turkish has a significant number of loanwords borrowed from Arabic and Persian. Furthermore, it contains some complex grammatical forms borrowed from these two languages, like long noun phrases with multiple words and particular word ordering. Finally, the number of words in a sentence can get quite large, especially in the texts written in the early periods of the Ottoman Empire.

The Arabic alphabet-based writing system was replaced with a Latin alphabet-based one in 1928. Also, the language reforms in the early 20th century led to significant modifications in the vocabulary, where many of the loanwords of Arabic and Persian origin were replaced with words borrowed from European languages or newly coined words. These language reforms have led to a substantial divergence between modern and Ottoman Turkish.

A comparison of modern Turkish and Ottoman Turkish in terms of the percentage of loanwords can be helpful in understanding the differences between the two versions. The well-known Ottoman dictionary "A Turkish and English Lexicon" by James W. Redhouse (Redhouse, 1884) contains 79,491 words, of which 57% are Arabic-origin and 12% are Persian-origin. In contrast, a study by (Moore and Uni, 2015) reports that approximately 25% of the selected 3,270 most frequently used Turkish words are Arabic-origin, and the percentage of Persian loanwords is only 6% in the selected vocabu-

lary. On the other hand, of the 104,481 words in the standard Turkish Dictionary by TDK (Turkish Language Institution), 6,463 (~6%) are Arabic-origin and 1,374 (~1%) are Persian-origin (TDK, 2005).

2.2 Related Work

The Universal Dependencies (UD) Project¹ is a collaborative effort that aims to develop cross-linguistically consistent treebank annotation for many languages. The project provides a standardized framework for annotating the grammatical structure of sentences, encompassing parts of speech, syntactic dependencies, and other linguistic features. Most of the treebanks in UD are dedicated to annotating modern languages. Efforts to include historical languages in the project have been limited. Ancient Greek is one of the lucky historical languages having three UD treebanks (Bamman and Crane, 2011). Ancient Hebrew (Swanson and Tyers, 2022), Classical Chinese (Lee and Kong, 2012), and Coptic (Zeldes and Abrams, 2018) treebanks are some other notable UD treebanks that contain annotated sentences from historical languages. Using trained models as pseudo-annotators is a common practice in data annotation (Haunss et al., 2020; Benato et al., 2021; He et al., 2022). In the context of dependency annotation, there are some studies that utilize automatic parsers to parse raw data as an initial step in order to provide human annotators with a starting point in the manual annotation process (e.g., the Belarusian HSE UD Treebank²). However, to the best of our knowledge, these studies use machine assistance as a one-time process only; none of them adopted an iterative approach as we do.

3 OTA-BOUN: A UD Treebank for Ottoman Turkish

As an initial endeavor towards enriching Ottoman Turkish Natural Language Processing (NLP) resources and enhancing the effectiveness of existing NLP tools on Ottoman Turkish texts, we have initiated the creation of the Ottoman Turkish UD Treebank. In Section 3.1, we provide information about the source and language of the treebank. Section 3.2 details our annotation process, and Section 3.3 states the challenges encountered in annotating Ottoman Turkish sentences, accompanied by

¹<https://universaldependencies.org/introduction.html>

²https://github.com/UniversalDependencies/UD_Belarusian-HSE

illustrative examples, and clarifies the approaches undertaken to overcome these challenges.

3.1 Data

The creation of an Ottoman Turkish dependency treebank is an ongoing project. The first version of the treebank³ is planned to contain 500 syntactically annotated Ottoman Turkish sentences. The annotated sentences exist in two writing styles in the treebank; 1) written with the Latin-based Turkish alphabet, and 2) written with the Perso-Arabic alphabet. (See Figure 3 for CoNLL-U representation⁴ of treebank items.)

The sentences are sampled from seven texts by four different writers. All of the texts are from literature published between 1900 and 1928. There are two articles, excerpts from two history texts, two stories, and one excerpt from a novel. Our ultimate goal is to include annotations for a total of 2,000 sentences, sourced from various origins, in the final version.

Figure 1 shows two example sentences from the dataset in Ottoman and modern Turkish. In the figure, some of the words that have been replaced by modern versions can be seen in red boxes. A group of defunct words can be replaced by a single word (ex. *ihraç ediliyor* → *çıkarılıyor* (*is being extracted*)) and vice versa (ex. *muvafakatiyle* → *uygun bulması ile* (*with the approval of*)). A noun phrase form that is mostly obsolete is replaced with its modern counterpart where the word order changes (ex. *mebde-i kelam* → *konuşma başlangıç(ı)* (*the beginning of the speech*)). Here, the words are also replaced with synonyms in the modern version.

In addition to changes in vocabulary, the syntactical features of an Ottoman Turkish sentence can be different from those of the modern version. Figure 2 shows the dependency trees of two versions of a sentence: the original one and its translation to modern Turkish. The difference in grammatical structure of both sentences is visible through their dependency trees. To give a concrete example, the way the subject of the sentence (*Damat İbrahim Paşa*), which is a person, is connected to the verb is different in the original sentence (via an *oblique* relation through one of its parent nodes) and in its translation (directly via *nominal subject* relation).

Another example of their differences is in the

way they indicate that *Muşkara*, a place name, is the subject's birthplace. This is done indirectly in the original sentence by connecting them at the *root* word. The connection is more straightforward in its translation to modern Turkish, which is done directly using a clausal modifier. Due to such differences in the grammar and vocabulary of Ottoman and modern Turkish, the annotation process is not straightforward.

3.2 The Annotation Scheme

For the annotation of the Ottoman Turkish treebank, we used a team of two annotators who are linguists and have comprehensive knowledge of Turkish grammar and general linguistics, as well as grammatical theories. Assisting the team of annotators in the process of manual annotation are two senior computer scientists with extensive expertise both in NLP and in Ottoman Turkish.

In the annotation process, we employ double annotation for a randomly chosen set of 50 sentences. We measure Cohen's kappa between the annotated dependency labels as 0.85 for determining the inter-annotator agreement. The unlabelled and labeled attachment scores between the annotations are found to be 82.20% and 76.91%, respectively. The rest of the annotation is held separately. After each annotator finishes their respective portions, the annotated sentences are examined, and any disagreement is resolved within the linguist team.

In most cases, we adhered to the conventions of Universal Dependencies but referred to the Suggested UD Guidelines for Turkish⁵ when necessary. At the current step, we do the manual annotation on the syntactic level. Following the UD scheme, the annotated data is stored in CoNLL-U format. Figure 3 depicts this format on an annotated sentence from our treebank. As mentioned, we preserve the original Arabic script version of the data, providing the text value both in Latin and Arabic letters. The tokens of the sentence in Latin script are found in the second column, while their Arabic counterparts are provided in the last column.

3.3 Challenges in the Syntactic Annotation

Deformation of Turkish Morphosyntax In the process of annotating Ottoman Turkish, a significant challenge encountered was that certain structures influenced by Arabic and Persian do not require Turkish inflectional suffixes, which distin-

³The treebank will be released with the next scheduled release of UD (v2.14).

⁴<https://universaldependencies.org/format.html>

⁵https://github.com/boun-tabi/UD_docs/blob/main/_tr/dep/Turkish_deprel_guidelines.pdf

1-

- a) Koyu mavi gözleri mütefekkirane, mahzunane bir halde, kırık ciheti eski bir paçavra ile örtülmüş olan pencereye matuf idi.
 b) Koyu mavi gözleri düşünürcesine, kederli bir halde, kırık tarafı eski bir paçavra ile örtülmüş olan pencereye çevriliydi.
 (her) dark blue eyes as if thinking sadly in a way broken side of old a rag with covered that is to the window turned
 c) Her dark blue eyes were turned sadly, as if thinking, towards the window, the broken side of which was covered with an old rag

2-

- a) Nihayet, mebd-i kelâm kabul ettiğimiz tarihten dört gün evvel, İtilâf Devletleri'nin muvâfakatiyle Yunan ordusu da İzmir'e ihraç ediliyor.
 b) Nihayet, konuşmamıza başlangıç olarak aldığımız tarihten dört gün önce, İtilâf Devletleri'nin uygun bulması ile Yunan ordusu da İzmir'e çıkartılıyor.
 Finally, to our conversation start that we take as from the date four days before of the Allied Powers with the approval Greek army too to Izmir is landed
 c) Finally, four days before the date we take as the date of starting to our conversation, the Greek army was landed in Izmir with the approval of the Allied Powers.

Figure 1: Two Ottoman Turkish sentences (in Latin script), their modernized versions and English translations.

guishes them from modern Turkish syntax and morphology. For example, *münasebet tabian* in Example 1 means *subject to relationship*. The word *tabian* is a verbal adverb derived from the Arabic word *tabi* (*subject to*) and the Arabic adverbial suffix *-An*. In modern Turkish, the phrase can be expressed as follows: *münasebete tabi olarak* (*by being subject to a relationship*). As seen, the noun *münasebet* is inflected with a dative case *-A*. In Ottoman Turkish, however, a dative case is not needed in some instances, making a difference from modern Turkish. The excessive exposure to Arabic led some suffixes to disappear without a narrowing in meaning, consequently causing difficulties in the annotation process.

- (1) güneş-in sema üzerin-de-ki
 sun-GEN.3SG sky above-LOC-ADJ
 seyr-i ile münasebet tabian
 journey-POSS.3SG COM relationship subject_to
 'with respect to the trajectory of the sun in the sky'

The application of Turkish suffixes to structures in Arabic and Persian poses difficulties for both the parser and our team. For instance, in the phrase *Harb-i Umumi'de* (*in the world war*) in Example 2, although *harb* is the head, the locative suffix is attached to the dependent, diverging from standard modern Turkish rules and leading to incorrect automatic annotations.

- (2) Memleket-i Harb-i Umumi-ye sevk
 country-ACC war-EZ general-DAT dispatch
 ed-en-ler
 make-REL-PL
 'Those who sent the country to the World War'

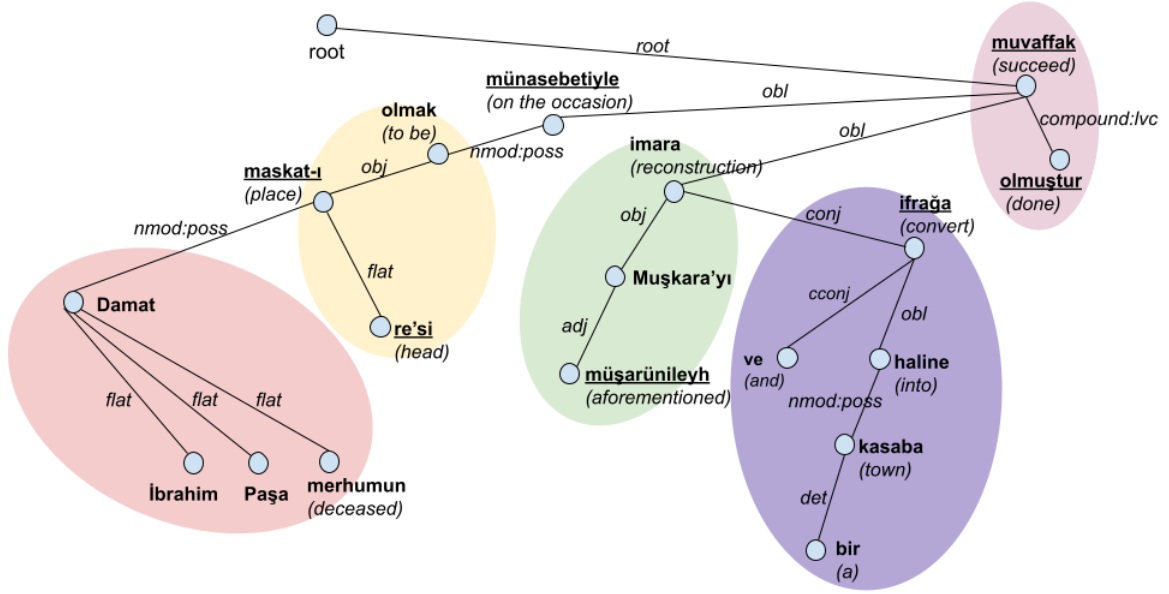
Foreign Compounds Another challenge was identifying compound verbs formed with foreign words not commonly used in modern Turkish, such as *mehcur bırakmak* (*to leave abandoned*). The

high frequency of uncommon phrasal verbs poses a challenge to the annotation process.

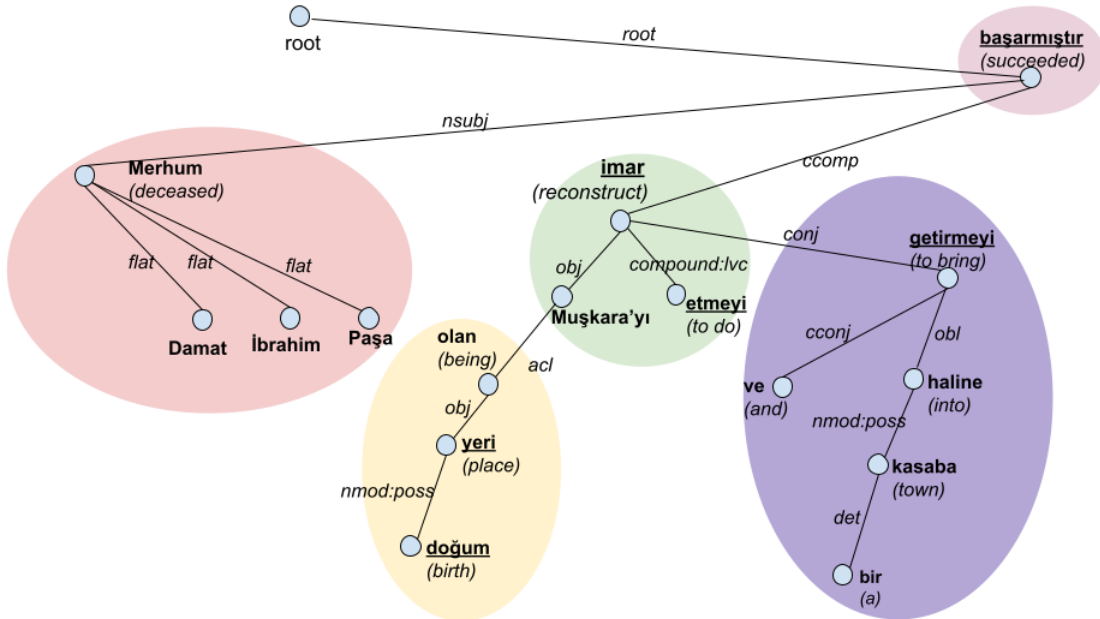
Abundance of Foreign Words It was additionally observed that the aforesaid cultural interactions influenced the lexicon of Ottoman Turkish. The influence led to confusion about determining the part-of-speech of certain words with two meanings without showing any structural difference. They make sense within the context in which they are used, making them challenging to annotate just by looking at their syntactic and morphological structures. In *sû-i muamelat* (*unpleasant behavior*) given in Example 3, *sû* is an adjective. However, in *sû-i tefehhüm* (*misunderstanding*), it acts as an adverb. At first glance, these phrases appear to have no difference, both syntactically and morphologically. This similarity poses a challenge, as it demands substantial lexical knowledge of Arabic.

- (3) yap-ıl-an su-i muâmel-ât-ta
 do-PASS-REL bad-EZ treatment-PL-LOC
 millet-in medhaldar
 nation-GEN.3SG responsible
 bul-un-ma-dığ-in-ı
 find-PASS-NEG-NMLZ-POSS.3SG-ACC
 'that the nation is not responsible for the mistreatment done'

There are foreign words in Ottoman Turkish that preserve morphological features gained in their original language. The challenge arises from the fact that the derivational morphemes remain productive, making it difficult to determine their syntactic relations. The primary reason for this challenge is the necessity of understanding the nature of the language from which the words originate. Consider the phrase *i'tâ-yı ma'lûmat* (*giving information*) in Example 4. The verbal noun *i'tâ*, derived from *aṭā* (*grant*), requires knowledge of Arabic grammar to identify it as a verbal noun.



Damat İbrahim Paşa merhumun maskat-ı re'si olmak münasebetiyle müşarünileyh Muşkara'yı imara ve bir kasaba haline ifrağa muvaffak olmuştur.



Merhum Damat İbrahim Paşa doğum yeri olan Muşkara'yı imar etmeyi ve bir kasaba haline getirmeyi başarmıştır.

Figure 2: Dependency tree representations of an Ottoman Turkish sentence (above) and its rephrased version using the modern Turkish (below). The highlighted portions enclosed in colored circles indicate corresponding segments in the sentences. English translations of words are provided in *italics* within parentheses. Words of a sentence that do not exist in the other sentence are underlined in the figure. **English translation of the sentence:** "The late Damat İbrahim Paşa succeeded in developing Muşkara, his birthplace, and turning it into a town."

Such examples are prevalent in Ottoman Turkish, posing difficulties in annotation.

itâ-yı malum-ât eyle-mek
give.NMLZ-EZ known-PL make-NMLZ

- (4) *Hedef-i siyasi-ler-i hakkında*
goal-EZ political-PL-POSS.3 about

'to give information about their political goals'

# sent_id = nutuk_51															
# text_latin = Binâenaleyh cemiyet, aynı esbâb ve vesâitle mücehhez olarak hukuk-ı milliye ve tarihiyeyi müdafaaya çalışıyor.															
# text_arabic = بناء عليه جمعية , عني اسباب و وسائله مجهز اوله رق حقوق مليه و تاريخيبي مدافعيه چالشيور .															
1	Binâenaleyh	Binâenaleyh	ADV	—	—	15	advmod	—	بناء عليه						
2	cemiyet	cemiyet	NOUN	—	Case=Nom Number=Sing Person=3	15	nsubj	—	جمعية	SpaceAfter=No					
3	,	,	PUNCT	Comma	—	15	punct	—	,						
4	aynı	aynı	ADJ	Adj	—	5	amod	—	عني						
5	esbâb	esbâb	NOUN	—	Case=Nom Number=Sing Person=3	8	obl	—	اسباب						
6	ve	ve	CCONJ	—	—	7	cc	—	و						
7	vesâitle	vesâit	NOUN	—	Case=Ins Number=Sing Person=3	5	conj	—	وسائله						
8	mücehhez	mücehhez	NOUN	—	Case=Nom Number=Sing Person=3	14	advcl	—	مجهز						
9	olarak	ol	VERB	Conv	Polarity=Pos VerbForm=Conv	8	compound:lvc	—	اوله رق						
10	hukuk-ı	hukuk-ı	NOUN	—	Case=Nom Number=Sing Person=3	14	obj	—	حقوق						
11	milliye	milli	NOUN	—	Case=Dat Number=Sing Person=3	10	amod	—	مليه						
12	ve	ve	CCONJ	—	—	13	cc	—	و						
13	tarihiyeyi	tarihiye	NOUN	—	Case=Acc Number=Sing Person=3	11	conj	—	تاريخيبي						
14	müdafaaya	müdafaa	NOUN	—	Case=Dat Number=Sing Person=3	15	ccomp	—	مدافعيه						
15	çalışıyor	çalış	VERB	—	Aspect=Imp Number=Sing Person=3	0	root	—	چالشيور	SpaceAfter=No					
16	.	.	PUNCT	Stop	—	15	punct	—	.						

Figure 3: CoNLL-U Representation of an example sentence from our Ottoman BOUN UD Treebank.

Annotation of Regular Structures Another issue is annotating phrases borrowed from foreign languages. According to UD, names with a regular syntactic structure should be annotated with regular syntactic relations rather than being annotated as *flat*. It is also noted that foreign language expressions should be annotated as *flat*. Despite these guidelines, due to their significant effects, we aimed to preserve frequently used grammar structures obtained from foreign languages as much as possible. For instance, in *Harb-i Umumi* (*World War*), *harb* is a noun meaning *war* and *umumi* is an adjective meaning *universal*. This phrase could have been created in Turkish grammar as *Umumi Harp*. Although the structure is foreign, we annotated *Harb-i Umumi* and similar phrases as regular structures.

4 Iterative Annotation with Multilingual BERT

Because dependency annotation is both cost- and time-intensive, and given the challenges outlined in the previous section, we recently contemplated whether we could ease our manual annotation phase by leveraging state-of-the-art Large Language Models (LLMs). To test this idea, we conducted an experiment where we utilized the multilingual BERT model⁶ (Devlin et al., 2019). The experiment is set up as follows:

- Initially, we fine-tuned a multilingual BERT-based parsing model (Grünwald et al., 2021) using the Turkish BOUN UD Treebank (Türk et al., 2022) containing only modern Turkish sentences.

- The fine-tuned model pseudo-annotated a subset of 50 sentences from the Ottoman Turkish corpus. This pseudo-annotated 50 sentences will be referred to as ‘First-Batch-Pseudo-Annotated’.
- Subsequently, our human annotators reviewed and corrected the ‘First-Batch-Pseudo-Annotated’, the result of which is ‘First-Batch-Gold’.
- We then further fine-tuned our parsing model with ‘First-Batch-Gold’.
- Using this updated model, we pseudo-annotated another set of 50 sentences, denoted as the ‘Second-Batch-Pseudo-Annotated’.
- Finally, our human annotators corrected ‘Second-Batch-Pseudo-Annotated’, resulting in the ‘Second-Batch-Gold’.

Figure 4 depicts this iterative annotation scheme for two iterations.

Thus, in this initial phase of annotation, we have 100 manually annotated Ottoman Turkish sentences in two iterative batches of 50 sentences each. We should note that, because of the difficulty in finding parallel Ottoman Turkish and modern Turkish data, the sentences in these two batches originated from different sources and different genres. This has led to variations in the annotation complexity of the two batches due to the diversity in their origins.

With the data obtained in this manner, we have the opportunity to address our research question: Has fine-tuning the multilingual BERT model with Ottoman Turkish data facilitated the manual annotation and correction phase? To answer this question,

⁶<https://huggingface.co/bert-base-multilingual-cased>

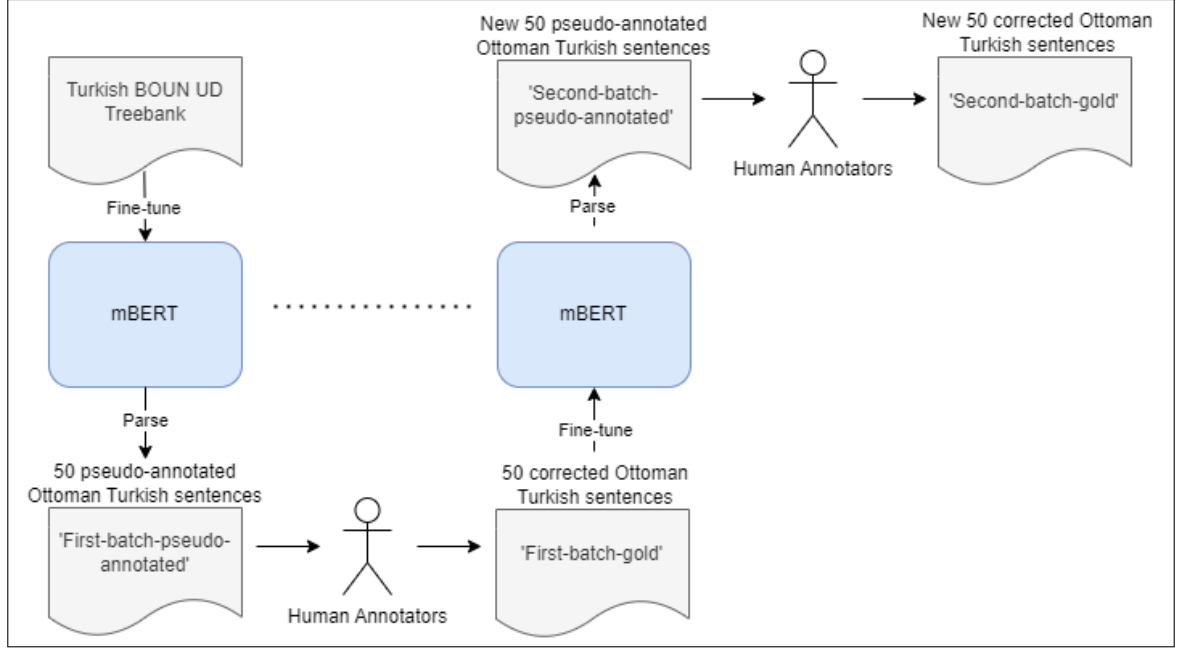


Figure 4: The experimental setup using the iterative annotation scheme.

	First Batch	Second Batch
Size (# of sentences)	50	50
Ave. word count	17.84	20.45
UAS	81.64	82.58
LAS	77.65	76.19

Table 1: Comparison of the two batches in terms of unlabelled and labelled attachment scores.

we did the experiment using the two batches of annotated Ottoman Turkish sentences.

4.1 Evaluation

In the experiment performed, we hypothesize that the difference in the annotations between ‘Second-Batch-Pseudo-Annotated’ and ‘Second-Batch-Gold’ should be less than the difference between ‘First-Batch-Pseudo-Annotated’ and ‘First-Batch-Gold.’ In other words, there should be fewer erroneous dependency relations to correct for human annotators in the second batch compared to the first batch.

To test this hypothesis, we measure the unlabelled and labelled attachment scores (UAS and LAS, respectively) between ‘First-Batch-Pseudo-Annotated’ and ‘First-Batch-Gold’ and between ‘Second-Batch-Pseudo-Annotated’ and ‘Second-Batch-Gold’. Table 1 depicts the UAS and LAS F-1 scores of these measurements.

In Table 1, we observe that further fine-

tuning the BERT-based model with Ottoman gold-annotated data increases the success of the model in accurately predicting dependency arcs. However, there is a performance drop in correctly identifying the types of dependency relations.

4.2 Quantitative Analysis

To understand the performance drop in dependency type prediction of the updated parsing model, which was fine-tuned with Ottoman Turkish data, we compute confusion matrices for the first and second batches separately in Figure 5.

We observe that in the second batch there are many more *nmod:poss* relations compared to the first batch. When we investigate the data, we see that a significant number of *nmod:poss* relations in the second batch consist of Persian grammatical structures, which pose several challenges to annotation (see Section 3.3). Such structures are almost not present in the first batch. To be precise, in the second batch, approximately 20% of the noun phrases are constructed using Persian grammar, whereas this figure is around 3% in the first batch. The number of light-verb compounds is also higher in the second batch.

In addition to this, when we take into account the average word count in a sentence given in Table 1, which is also higher in the second batch, we can conclude that annotating the second batch is a more challenging task for both the parsing model and human annotators. This might explain the slight per-

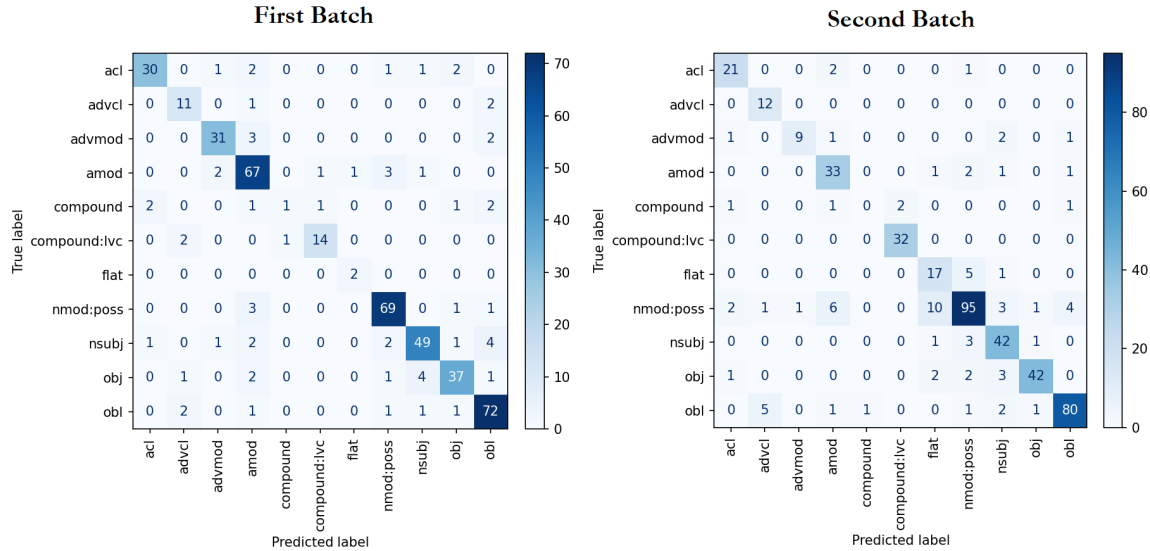


Figure 5: Confusion matrices of gold and predicted dependency types on the first batch and the second batch. The x-axis in each plot shows the dependency types in the pseudo-annotations of the corresponding batch. The y-axis shows the dependency types in the gold annotations.

formance drop in the LAS of the model when predicting the dependency types of the second batch.

Another factor that could affect the performance of the parsing model is the size of the fine-tuning data. The first batch is pseudo-annotated with the parser that is fine-tuned using BOUN, which has 7,803 annotated modern Turkish sentences in its training set. The second batch is pseudo-annotated after this parser is further fine-tuned with only 50 annotated Ottoman Turkish sentences. Such a small amount of data may not be sufficient for effectively fine-tuning the model. We anticipate that as we annotate new batches using this iterative annotation method, the performance of the parser will improve progressively.

Based on the results of the first and second batch runs, we can say that our iterative approach helps understand the difficulties of annotating Ottoman texts layer by layer. The first batch of fine-tuning process reveals mostly lexical issues. The results of the second batch of fine-tuning point to the complex grammatical issues that can be quite prevalent in certain types of texts.

4.3 Conclusion

Generation of a treebank for Ottoman Turkish is a difficult process that requires expertise in more than one language. The defunct grammatical forms and obsolete vocabulary make manual annotation a challenging task. We present an iterative approach utilizing a pretrained large language model, mul-

tilingual BERT, for annotating the first Ottoman Turkish dependency treebank. Our empirical findings suggest that performing the manual data annotation iteratively in a human-in-the-loop fashion improves and eases the process of dependency annotation. We anticipate that, when completed, the resulting treebank will enhance the NLP of Ottoman Turkish texts and enable a more profound exploration of Ottoman Turkish linguistic and cultural nuances.

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