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A CCGbank for Turkish: From Dependency to CCG

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Introduction

- The aim of this study is to create a tool for semantic parsing (to be used in automated inquiry systems, chat-box tools, search engines).
- Dependency or tree structures do not provide one to one correspondence between syntax and semantics.
    - Information on argument structures of verbs and semantic types of lexical items is missing.
- CCG offers a categorical lexicon and a more transparent structure between syntax and semantics.
- CCGbanks have higher parsing scores than their treebank equivalents (Hockenmaier and Steedman, 2007; Bosco et al., 2000; Çakıcı, 2009; Ambati et al., 2018).
- CCG approach requires a bigger corpus for the machines to learn each lexical type.
- In this study we automatically transferred an already existing Turkish dependency corpora to a CCGbank.

Previous Studies in CCG

- The dependency to CCG conversion studies started in 2006 by Hockenmaier for the German language.
- Other conversion studies are as follows:
    - English (Hockenmaier and Steedman, 2007),
    - Chinese (Tse and Curran,2010),
    - Italian (Johan et al., 2009),
    - Hindi (Bhatt et al., 2009).
    - Turkish, Çakıcı (2009)
        - Çakıcı (2009) aimed a morphemic CCGbank lexicon for the first time. That is, she assigns categories to the morphological units as well as the lexical units.
        - At the time, there was only one dependency corpus present in Turkish and it was not big enough for a CCGbank. (METU Turkish Corpus (Atalay et al., 2003; Oflazer et al., 2003) contained 60k word tokens)

CCG: Definition

- **Combinatory Categorial Grammar (CCG) (Steedman, 2000):** a lexical grammar formalism that offers a transparent interface between syntax and semantics.

CCG: Lexicon

- **Combinatory Categorial Grammar (CCG) (Steedman, 2000):** a lexical grammar formalism that offers a transparent interface between syntax and semantics.
  - **The Lexicon:**

yemek-ler
food-PL
NP

daha
more
(NP/NP)/(NP/NP)

ye-di
eat-PAST
S

sağlıklı
healthy
NP/NP

ye-di
eat-PAST
S\NP

ye-di
eat-PAST
S\NP\NP$_{[nom]}$

CCG: Combining Lexical Items

● Forward Application : X/Y➡ X applied to Y becomes X	atomic categories
● Backward Application : X\Y ➡ X applied to Y becomes X	
● Forward Composition : (X/Y) combined with (Y/Z) becomes X/Z	complex categories
● Backward Composition : (Y\Z) combined with (X\Y) becomes X\Z	
● Forward Type-raising : X becomes T/(T\X)	type mismatch
● Backward Type-raising : X becomes T\(T/X)	

The Input: Dependency Treebanks

The input we applied the CCG algorithm consists of the following dependency treebanks:

- The Turkish Penn Treebank
  - Consists of a total of 87,367 word tokens which are translated from the original Penn Treebank corpus.
  - The data consists of translated sentences taken from journals such as Wall Street Journal Articles.
- FrameNet
  - Consists of 19,221 tokens and 140 different semantic frames
- KeNet
  - The largest treebank of Turkish with 178,70 tokens
  - Sentences consist of example sentences taken from the Turkish National dictionary.
- Atis
  - A domain specific treebank that is built from the audio recordings of people inquiring for flight information from automated systems (translated from English)
  - Consists of 45,875 tokens
- Tourism
  - A domain specific treebank that includes written customer reviews for a booking company
  - Consists of 92,200 tokens

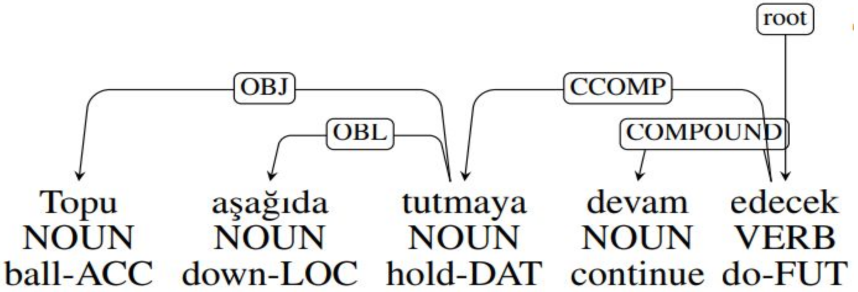
The Input: Framework

The treebanks we used were annotated under the framework provided by **the Universal Dependencies (UD).**

- The universal dependencies aim to achieve a cross-linguistically consistent treebank annotation.
- The Universal Dependency Project pioneered to develop treebanks for languages other than English since 2013.
- There are currently 200 treebanks over 100 languages released in the project.

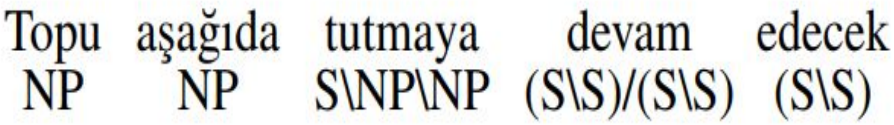
“From Dependency to CCG” in a nutshell

The dependency structure



"S/he will continue to hold the ball down"

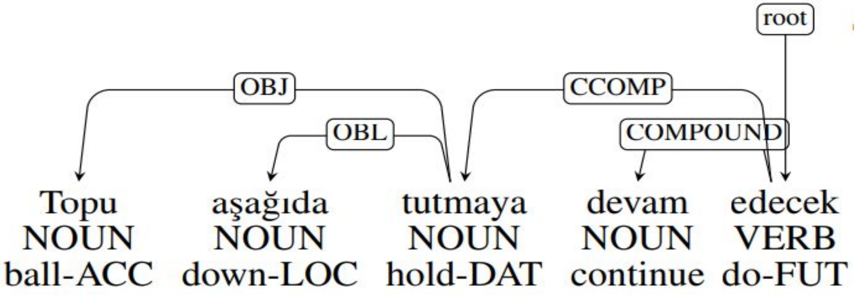
The CCG structure



Topu	aşağıda	tutmaya	devam	edecek
NP	NP	S\NP\NP	(S\S)/(S\S)	(S\S)

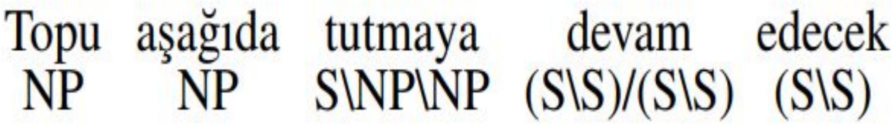
“From Dependency to CCG” in a nutshell

The dependency structure



"S/he will continue to hold the ball down"

The CCG structure



Topu	aşağıda	tutmaya	devam	edecek
NP	NP	S\NP\NP	(S\S)/(S\S)	(S\S)

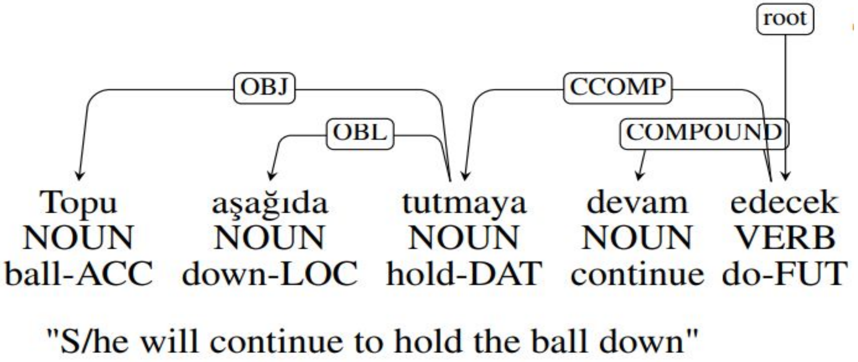
The CCG algorithm is based on:

- POS information of the word tokens,
- Head/complement relationship between the tokens,
- The dependency label between the tokens.

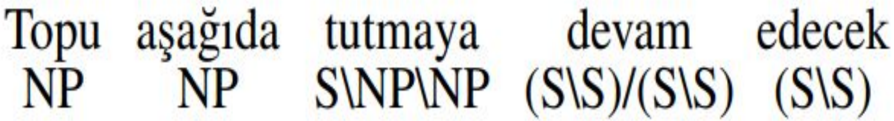
The CCG Algorithm: Identifying Arguments

- First step of the algorithm is to identify the arguments of the matrix predicate.
- Arguments can be nominal or clausal.
- Nominal arguments come from the relations such as OBJ or OBL.
    - The subject NP’s are marked as NP$_{[nom]}$.

- Clausal arguments such as CCOMP and XCOMP are added to the lexical item as S.



"S/he will continue to hold the ball down"



Topu	aşağıda	tutmaya	devam	edecek
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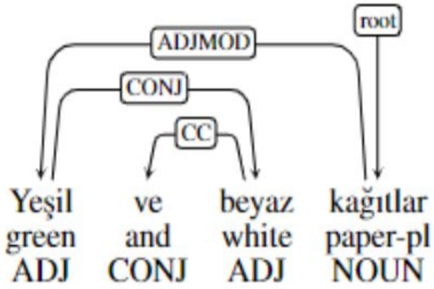
The CCG Algorithm: Conjuncts

- Conjuncts are given the category of (X\X)/X in the first iterations
- Then the variables take the category of the conjuncts (e.g. X = NP/NP)

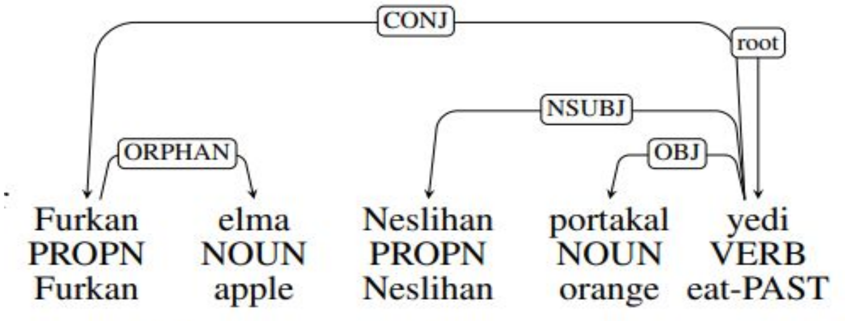
The dependency annotation:



The CCG annotation:

Yeşil	ve	beyaz	kağıtlar
Green	and	white	papers
(NP/NP)/(NP/NP)	(X\X)/X	NP/NP	NP

Ellipsis



"Neslihan ate oranges, Furkan apples."

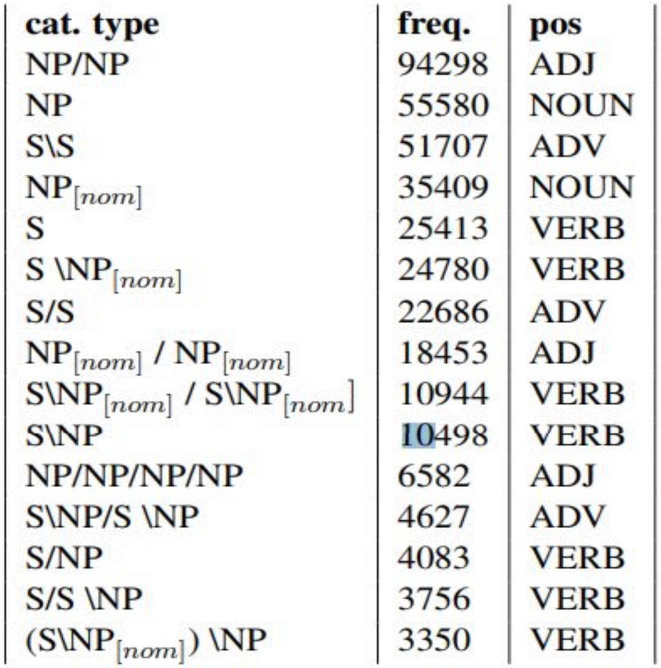
Figure1: ellipsis of the predicate

- The remaining argument is linked to the head of the clause with ORPHAN relation.
- ORPHAN relation signifies that “apple” is not an argument of Furkan.
- The CONJ relation adds an argument to the matrix predicate.

CCG translation:

Furkan	elma	Neslihan	portakal	yedi.
Furkan	apple	Neslihan	orange	eat-PAST
NP	NP	$NP_{[nom]}$	NP	$S\backslash NP_{[nom]}\backslash NP\backslash NP$

Results



cat. type	freq.	pos
NP/NP	94298	ADJ
NP	55580	NOUN
S\S	51707	ADV
$NP_{[nom]}$	35409	NOUN
S	25413	VERB
$S \backslash NP_{[nom]}$	24780	VERB
S/S	22686	ADV
$NP_{[nom]} / NP_{[nom]}$	18453	ADJ
$S\backslash NP_{[nom]} / S\backslash NP_{[nom]}$	10944	VERB
S\NP	10498	VERB
NP/NP/NP/NP	6582	ADJ
S\NP/S \NP	4627	ADV
S/NP	4083	VERB
S/S \NP	3756	VERB
$(S\backslash NP_{[nom]}) \backslash NP$	3350	VERB

Table: The most frequent 15 categories

- There are 630 different categories in this CCGbank with 516k words.
  - This number was around 530 in the previous CCG study in Turkish even with a corpus consist of 60k words.

- Simple/ atomic categories are more common.

Conclusion

- In this study, we presented the process of inducing a CCGbank for Turkish from an existing dependency treebank.
- Introduced an algorithm that can be applied to all dependency treebanks in Turkish with UD annotations.
- UD annotations are updated regularly, therefore, the algorithm might need updates for the upcoming treebanks and UD releases.
- The annotation frameworks become more and more morphemic in each release, so that we expect the algorithm to become less lexicalist in the future.

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