

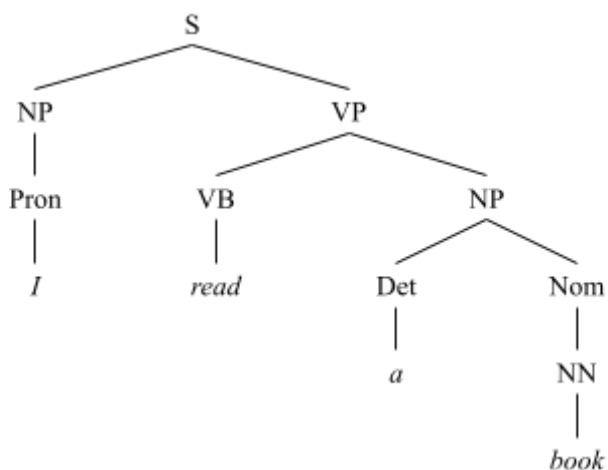
Assignment 3

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1. Part 1: The Grammar

Parse Tree

The following is the parse tree for the sentence “I read a book” using the provided grammar.



Conversion to CNF

The following is the conversion of the provided grammar to Chomsky normal form. The gray text represents how the grammar is expanded.

Grammar	CNF
$S \rightarrow NP VP$	$S \rightarrow NP VP$
$S \rightarrow Aux NP VP$	$S \rightarrow X1 VP$
	$X1 \rightarrow Aux NP$
$S \rightarrow VP$	$S \rightarrow VP \rightarrow VB \rightarrow book \mid include \mid prefer \mid read \mid left$
	$S \rightarrow VP \rightarrow VB NP$
	$S \rightarrow VP \rightarrow VB NP PP \rightarrow X2 PP$
	$S \rightarrow VP \rightarrow VB PP$
	$S \rightarrow VP PP$
$NP \rightarrow Pron$	$NP \rightarrow Pron \rightarrow I \mid she \mid me$
$NP \rightarrow NNP$	$NP \rightarrow NNP \rightarrow Houston \mid United$
$NP \rightarrow Det Nom$	$NP \rightarrow Det Nom$
$Nom \rightarrow NN$	$Nom \rightarrow NN \rightarrow book \mid flight \mid meal \mid money \mid morning$
$Nom \rightarrow Nom NN$	$Nom \rightarrow Nom NN$
$Nom \rightarrow Nom PP$	$Nom \rightarrow Nom PP$
$VP \rightarrow VB$	$VP \rightarrow VB \rightarrow book \mid include \mid prefer \mid read \mid left$
$VP \rightarrow VB NP$	$VP \rightarrow VB NP$

VP → VB NP PP	VP → X2 PP
	X2 → VB PP
VP → VB PP	VP → VB PP
VP → VP PP	VP → VP PP
PP → Prep NP	PP → Prep NP
Det → that this the a	Det → that this the a
NN → book flight meal money morning	NN → book flight meal money morning
NNP → Houston United	NNP → Houston United
Prep → from to on near through	Prep → from to on near through
Pron → I she me	Pron → I she me
VB → book include prefer read left	VB → book include prefer read left
Aux → does	Aux → does

2. Part 2: CKY Recognizer

Implementation

The grammar recognizer was implemented using the following CKY algorithm.

function CKY-PARSE(*words, grammar*) **returns** *table*

```

for j ← from 1 to LENGTH(words) do
  for all {A | A → words[j] ∈ grammar}
    table[j − 1, j] ← table[j − 1, j] ∪ A
  for i ← from j − 2 down to 0 do
    for k ← i + 1 to j − 1 do
      for all {A | A → BC ∈ grammar and B ∈ table[i, k] and C ∈ table[k, j]}
        table[i, j] ← table[i, j] ∪ A

```

Results

The following are the recognizer results for the provided sentences.

sentence='I read a book'

I	read	a	book
NP, Pron	S		S
	S, VP, VB		S, VP
		Det	NP
			S, Nom, VP, NN, VB

parseable = True

sentence='Does the flight include a meal'

Does	the	flight	include	a	meal
Aux		X1	S		S
	Det	NP	S		S
		Nom, NN			
			S, VP, VB		S, VP
				Det	NP
					Nom, NN

parseable = True

sentence='She does prefer this book'

She	does	prefer	this	book
NP, Pron				
	Aux	S, VP, VB		S, VP
			Det	NP
				S, Nom, VP, NN, VB

parseable = False

sentence='The morning flight left from Houston'

The	morning	flight	left	from	Houston
Det	NP	NP	S		S
	Nom, NN	Nom			
		Nom, NN	S, VP, VB		S, VP, VP, X2
				Prep	PP
					NP, NNP

parseable = True

sentence='She left on a United flight'

She	left	on	a	United	flight
NP, Pron	S				
	S, VP, VB				
		Prep	Det		
				NP, NNP	
					Nom, NN

parseable = False

3. Part 3: CKY Parser

Implementation

The grammar parser was implemented by adding a 2d-list named `pointers` that traces the parse tree, on top of the CKY algorithm.

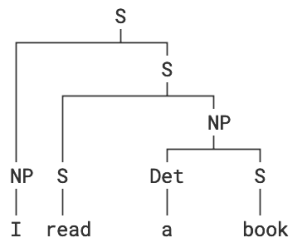
Results

sentence='I read a book'

I	read	a	book
NP, Pron	S		S
	S, VP, VB		S, VP
		Det	NP
			S, Nom, VP, NN, VB

parseable = True

```
tree=[S [NP I] [S [S read] [NP [Det a] [S book]]]]
tree=
```



sentence='Book the flight through Houston'

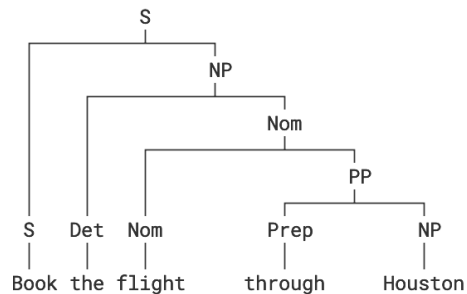
Book	the	flight	through	Houston
S, Nom, VP, NN, VB	Det	S, VP NP Nom, NN	Prep	S, VP, S, VP NP Nom PP NP, NNP

parseable = True

```

tree=[S
  [S Book]
  [NP [Det the] [Nom [Nom flight] [PP [Prep through] [NP Houston]]]]]
tree=

```



sentence='Does she prefer the morning flight'

Does	she	prefer	the	morning	flight
Aux	X1 NP, Pron	S S S, VP, VB	Det	S S S, VP NP Nom, NN	S S S, VP NP Nom Nom, NN

parseable = True

```

tree=[S
  [X1 [Aux Does] [NP she]]
  [S [S prefer] [NP [Det the] [Nom [Nom morning] [Nom flight]]]]]
tree=

```

