# Syntactic Analysis

## Context Free Grammar

# Introduction

- From words we now move to phrases and sentences.
- Syntax – grammatical agreement of words in a sentence and their relationship with each other.
- Objective of Syntactic Analysis
  - To find the syntactic structure of the sentence
  - This structure is usually depicted as a tree (aka parse tree or syntactic tree)

# Parse Tree

- Nodes represent the phrases
- Leaves corresponds to words
- Root is the whole sentence and always starts with symbol ‘S’
- This identification is done by a process known as parsing.
- Mathematical Model for Natural Language in constituent structure – CFG (PSG)

# Context Free Grammar

- Defined for Natural Language by Noam Chomsky (1957).
- Components
  - A set of non terminal nodes, N
  - A set of terminal nodes, T
  - A designated start symbol, S, this is one of the symbols from N
  - A set of productions, P, of the form:

$$A \rightarrow \alpha$$

# CFG

- Phase Structure Rule

  A $\in$ N and $\alpha$ is a string consisting of terminal

  and non terminal symbols. The rule A $\rightarrow$ $\alpha$ says that “A can be rewritten as $\alpha$”

- This specifies which symbol can occur in a phrase and in what order
  - Example: S $\rightarrow$ NP VP
  - S consists of NP followed by VP

# CFG

- Language is usually defined through the concept of derivation.
- Rewrite the symbol appearing on LHS of production by its RHS
- CFG can be used to generate a sentence or assign a structure to a given sentence
- In generation, read arrow as ‘rewrite the symbol on left with symbol on right’.

# Tanu reads a book

- S $\rightarrow$ NP VP R1
- NP $\rightarrow$ N R2
- NP $\rightarrow$ Det N R3
- VP $\rightarrow$ V NP R4
- VP $\rightarrow$ V R5
- N $\rightarrow$ Tanu | She | book R6
- V $\rightarrow$ reads | sings| sleeps R7

# CFG

- Fundamental idea of syntax is that words group together to form constituents (phrases), each of which act as a single unit.
- They combine with other constituents to form larger constituents, and eventually a sentence.
- This whole constituency can be classified as
  - Phrase Level Construction
  - Sentence Level Construction

# Phrase Level Construction

- Fundamental notion is NLP
- One of simplest ways to decide whether a group of words in a phrase, is to see if it can be substituted with some other group of words in a phrase. Example
  - Tanu reads a book
  - Those girls read a book
  - She reads a good book
  - Tanu reads a comic book

# Phrase Level Construction

- In Linguistics these constituents represent a paradigmatic relationship.
  - Elements which can substitute each other in certain syntactic position are said to be members of one paradigm.
- Phrase types are named after their heads, which is a lexical category that determines the properties of the phrase.
- Thus, if the head is a noun, the phrase is called as a Noun Phrase.

# Noun Phrase

- Head is a noun or pronoun
- Optionally accompanied by a set of modifiers.
- Function as subject or object or complement.
- Modifiers of NP can be determiners and/or adjective phrases

# Phase Structure Rules for NP

- NP $\rightarrow$ Pronoun
- NP $\rightarrow$ Det Noun
- NP $\rightarrow$ Noun
- NP $\rightarrow$ Adj Noun
- NP $\rightarrow$ Det Adj Noun

We can combine all these rules in a single CFG Rule

- NP $\rightarrow$ (Det) (Adj) Noun

# NP Rules

- We can also include a Prepositional Phrase (PP) with NP
- More than one adjective can be incorporated by allowing Adjective Phrase (AP) in place of Adjective.
- So the rule can be modified as
- NP $\rightarrow$ (Det) (AP) Noun (PP)

# NP Examples

- The Sun
- The foggy morning
- She
- Chilled water
- A beautiful morning in Banasthali
- Cold banana shake

- Last phrase has two nouns.
- A sequence of nouns are termed as Nominal.

# NP Rules

- None of the rules discussed so far can handle nominal
- So we modify our rule

➢ NP $\rightarrow$ (Det) (AP) Nom (PP)

➢ Nom $\rightarrow$ Noun | Noun Nom

# Verb Phrase

- Head is a Verb
- Fairly large range of phrases that modify a verb which makes VP a bit more complex
- VP organizes various elements of the sentence that depends syntactically on the verb

# VP Examples

- Ramesh *slept* (VP $\rightarrow$ Verb)
- The boy *kicked the ball* (VP $\rightarrow$ Verb NP)
- Ramesh *slept in the garden*

  (VP $\rightarrow$ Verb PP)
- Tanu gave the girl a book

  (VP $\rightarrow$ Verb NP NP)
- Tanu gave the girl a book with a blue cover

  (VP $\rightarrow$ Verb NP NP PP)

# VP Examples

- Tanu gave the girl a book with a blue cover in the class

  (VP $\rightarrow$ Verb NP NP PP PP)

- Tanu gave the girl a book with a blue cover in the class with a coral paintings

  (VP $\rightarrow$ Verb NP NP PP PP PP)

- Tanu gave the girl a book with a blue cover in the class with a coral paintings on the first floor

  (VP $\rightarrow$ Verb NP NP PP PP PP PP)

# VP Examples

- Since we can have multiple PPs, we can write the rule as:
- **VP → Verb (NP) (NP) (PP)***
- Things are further complicated by the fact that objects can be entire sentences
- I *know that you the President of India*
- **VP → Verb S**

# Prepositional Phrase

- Head is preposition
- Consist of preposition, possibly followed by some other constituent
- Generally a NP
- We played hockey *at the stadium*

  (PP $\rightarrow$ Prep NP)
- Ramesh went *outside*

  (PP $\rightarrow$ Prep)
- Phrase Structure rule that captures this property is as follown

  PP $\rightarrow$ Prep (NP)

# Adjective Phrase

- Head is adjective
- Consists of adjective, which may preceed an adverb and is followed by a PP
- Ankita is *clever* (AP $\rightarrow$ Adj)
- The train is *very late* (AP $\rightarrow$ Adv Adj)
- My sister is *fond of animals* (AP $\rightarrow$ Adj PP)
- Phrase structure rule for AP can be written as

$$AP \rightarrow (Adv)\ Adj\ (PP)$$

# Adverb Phrase

- Head is adverb
- Possibly preceded by a degree adverb
- Time passes *very quickly*
- AdvP → (Interns) Adv
- Degree (very, rather, too)
- Location (here, everywhere)
- Manner in which something is done (slowly, hesitantly, quickly)
- Time (now, yesterday)
- Frequency of something (frequently, rarely, never, everyday)

# Sentence Level Constructions

- After phrases, lets now focus on sentences
- Sentence can have varying structures
- Four commonly known structures are
    - Declarative structure
    - Imperative structure
    - Yes-No structure
    - Wh-question structure

# Declarative Structures

- Sentences with a declarative structures have a subject followed a predicate
- Subject is NP and predicate is VP
- E.g. I like horse riding
- Phrase structure rule for this kind of sentence structure is

$$S \rightarrow NP\ VP$$

# Imperative Structures

- Begin with a Verb Phrase and lack subject
- Subject in these sentences is implicit and is understood to be ‘you’.
- Generally used as commands or suggestions. Thus called imperative.
- Phrase structure rule for this structure is

$$S \rightarrow VP$$

- Look at the door
- Give me the book
- Stop talking
- Show me the design

# Yes-No Question Structures

- These structures ask questions which can be answered in yes or no.
- These sentences begin with an auxiliary verb, followed by a subject, NP and followed by VP
- Examples

  Do you have a red pen?

  Is there a vacant quarter?

  Is the game over?

  Can you show me your album?

$$S \rightarrow \text{Aux NP VP}$$

# Wh-Question Structures

- These sentences are more complex
- Begin with wh words (Who, Which, Where, What, Why and How)
- Wh-Question may have a wh-phrase as a subject or may include another subject.
- Which team won the match?

  $S \rightarrow$ Wh-NP VP
- Which cameras can you show me in you shop?

  $S \rightarrow$ Wh-NP Aux NP VP

# Summary of Grammar Rules

- S $\rightarrow$ NP VP
- S $\rightarrow$ VP
- S $\rightarrow$ Aux NP VP
- S $\rightarrow$ Wh-NP VP
- S $\rightarrow$ Wh-NP Aux NP VP
- NP $\rightarrow$ (Det) (AP) Nom (PP)
- VP $\rightarrow$ Verb (NP) (NP) (PP)*
- VP $\rightarrow$ Verb S
- PP $\rightarrow$ Prep (NP)
- AP $\rightarrow$ (Adv) Adj (PP)

# Coordination

- These rules are not exhaustive.
- There can be other sentence level constructions.
- Coordination is one such structure.
- It refers to conjoining phrases with conjunctions like ‘and’, ‘or’, ‘but’ etc.

# Coordination -- Examples

- A coordinate NP can consist of two other noun phrases separated by a conjunction ‘and’.
- I ate an apple and a banana.
- I ate [NP [NP an apple] and [NP a banana]].
- Similarly, two VPs can be conjoined as follows
- It is dazzling and raining
- It is [VP [VP dazzling] and [VP raining]]
- Two sentences can also be conjoined.
- [S [S I am reading a book] and [S I am also watching a movie]]

# Coordination Rules

- NP $\rightarrow$ NP and NP
- VP $\rightarrow$ VP and VP
- S $\rightarrow$ S and S