Lecture 13.1: Introduction to Context-free Grammar - 1

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In this lecture, you will learn about the limitations of Regular Language and introduce you to a new class of language and its corresponding description method formally called the Context-free Grammar.

A limitation of Finite Automata

We know that every regular language has an equivalent finite automaton (e.g. DFA or NFA). They are called finite because they have **a very limited memory** in the form of states.

Though many interesting problems can be solved by Finite Automata, Finite Automata has a serious limitation –

A Finite Automaton does not have a large (infinite) memory. As a result, a finite automaton can only "count" (that is, maintain a counter, where different states correspond to different values of the counter) a finite number of input scenarios.

For example, there is no finite automaton that recognizes the following languages:

- $L = \{w \mid w = 0^n 1^n, n \geq 1\}$ = The set of all binary strings consisting of a number of a's followed by equal number of **b**'s.
- $L = \{w \mid w = n_0(w) = n_1(w), n \geq 1\}$ = The set of all binary strings consisting of an equal number of 1's and 0's
- The set of strings over '(' and ')' that have "balanced" parentheses.

Context-free Grammar

A context-free Grammar (**CFG**) is an entirely different formalism for describing a class of languages called Context-free Language (**CFL**). It is more powerful than Regular expression and finite automaton in the sense that it can describe more languages than finite automaton.

- In a context free grammar, we express a language by a set of rules (called **production rules**). These rules describe how a string of the language can be generated.
- Consider the language, $L = \{w \mid w = 0^m 1^{2m}; \ m \geq 0\}$. This denotes the set of all binary strings consisting of a number of a's followed by twice the number of b's as a. This language can be expressed by the following CFG:

$$S \to 1S00$$
$$S \to \epsilon$$

  Each expression of the above is called a **production rule.**

In the next lecture, we shall learn more about CFG.

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