ITS64304: Theory of Computation
Tutorial – 1: Language and Grammar

Aim

The aim of this tutorial is to learn regular and context free grammar. By the end of this tutorial, you should be able to analyze and construct grammar for a given specification and determine the language for a given grammar. (Aligns with Module Learning Outcome 1)

Taylor's Graduate Capabilities (TGCs) developed.

1.1 Grammars

Examples

1) Construct a grammar over $\{a, b\}$ that recognizes the language $\{a^i b^{2i} \mid i \geq 1\}$

e.g., valid strings are: abb, aabbbb, aaabbbbbb, etc.

S → abb | ???

Solutions

1) Start writing the shortest possible string followed by the next shortest and so on, until you can see a pattern. The pattern seen could then be written as a rule.
   The shortest string possible in this case is *abb*, then *aabbbb*, then *aaabbbbbb* and so on. You repeat *a* once and *b* twice every time. This could be written as $S \rightarrow aSbb$, and we also need $S \rightarrow abb$. Hence the grammar for the above question could be written as,
   $S \rightarrow aSbb \mid abb$

Questions

Questions 1. a), b), d), e), f), g) and 2, b) and c) must be done in the tutorial class facilitated by the tutor. The rest of the questions labelled as "Assignment 1 task" must be done as take-home exercise as part of your Assignment 1.

1. For each of the following languages, construct a grammar that recognizes it.
   a) $\{w \in \{a, b\}^* \mid w \text{ has even length}\}$
   b) $\{w \in \{a, b\}^* \mid w \text{ has odd length}\}$
   c) $\{w \in \{a, b\}^* \mid w$ has b's followed by a's$\}$

      //this language specification means, one or more b is followed by one or more a.

      E.g., valid strings are: ba, baaaaaaaaaaaaaa, bbbbbbbbbba,

      baba, bbbaaaaaba bbbbaababababa ← These are some examples of invalid strings in the given language specification.

      Assignment 1 task:

      Based on direction given, please do this problem as take-home exercise as part of your Assignment 1. You are strongly encouraged to use the Padlet on myTIMeS under this module site to share your answer to initiate appreciation or constructive criticism from your peers on your solution. This would help to learn from each other among students as peers in terms of collaborative learning.

   d) $\{w \in \{a, b\}^* \mid w \text{ has } \geq 3b\text{'s}\}$
   e) $\{a^n b^n \mid n \geq 0\}$
   f) $\{a^n b^n c^m \mid n \geq 0, m \geq 1\}$
   g) $\{a^m b^n c^m \mid m \geq 0, n \geq 1\}$

2. For each of the following Regular Expressions, write a regular grammar that defines the same language.

Regular Grammar: The left-hand side of the rule has only one letter and essentially it must be a non-terminal (upper-case letters). On the right-hand side of the rule at the maximum it can have only two letters or characters.

Context Free Grammar (CFG): The left-hand side of the rule has only one letter and essentially it must be a non-terminal. There are no restrictions on the right-hand side of the rule. Meaning, the right-hand side of the rule can have any number of letters or characters.

a) $a^*b^*c^*$

E.g., valid strings are λ, a, b, c, ab, ac, bc, aaaabccccc, abbbc, aabccccc, aaaaa, bbbbb, ccccc, etc.
Invalid strings are cb, ca, cab, cba etc.

Assignment 1 task:
Based on direction given, Pls do this problem as take-home exercise as part of your Assignment 1. You are strongly encouraged to use the Padlet on myTIMeS under this module site to share your answer to initiate appreciation or constructive criticism from your peers on your solution. This would help to learn from each other among students as peers in terms of *collaborative learning*.

b) $(a \cup b \cup c)^* a(a \cup b \cup c)^* b(a \cup b \cup c)^* \cup (a \cup b \cup c)^* b(a \cup b \cup c)^* a(a \cup b \cup c)^*$

c) $a(a \cup b \cup c)^* b(a \cup b \cup c)^*$

Reflection

Are Context Free Grammars more powerful than regular expressions? In the Padlet record your answers and observations.

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