CS 5000: Theory of Computability
Assignment 5
Grammars and Stack Machines

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1 Learning Objectives

1. Regular Grammars and Languages
2. Context-Free Grammars
3. Stack Machines

Problem 1

At the end of my lecture on Thursday, September 28, a student came and ask me if there is a grammar in between linear and context-free. Of course, there is no such grammar, because all linear grammars are context-free, but not all context-free grammars are linear. In other words, once we break the linear constraints, e.g., by adding more variables in the right-hand sides, we get context-free rules. But this was a very interesting question! I am grateful to that student for asking it. So, let's look at it from a slightly different angle. We know that a language is linear if it is generated by a linear grammar, either left-linear or right-linear. But are all languages generated by non-linear grammars necessarily non-linear? Let's do a simple investigation. Let L be a language over $\{a, b\}$ generated by the following grammar:

1. $S \to aSa$
2. $S \to \epsilon$

Is this grammar linear? Is L linear? If L is not linear, explain why not. If L is linear, explain why. So, are all languages generated by non-linear grammars necessarily non-linear?

Problem 2

Write a context-free grammar G that generates all strings of balanced left and right parentheses, e.g., (), (()), ()(), (()()), (()(())), etc. Construct a stack machine M for it it.

Problem 3

Recall that a *palindrome* is a string that reads the same left to right and right to left, e.g., aba, abba, abaaba, etc. Write a context-free grammar G for the language of palindromes over $\{a, b\}$ and construct a stack machine M for it.

Problem 4

Consider the context-free grammar below. What language does this grammar generate?

1. $S \to 0B|1A$
2. $A \to 0|0S|1AA$
3. $B \to 1|1S|0BB$

Problem 5

Consider the context-free grammar below. What language does this grammar generate?

1. $S \to \epsilon|0S|1T$
2. $T \to 0T|1S$

What to Submit?

Submit your solutions via Canvas.