Theoretical Computer Science (M21276)

Part A/8: Application of context-free languages

(Oct 16-20, 2023)

Question 1. Consider the following grammar G with non-terminal start symbol S and terminal symbols 0, 1:

$$S \to 0S1 \mid SS \mid 10$$

Show a parse tree produced by G for each of the following strings:

(a) 010110

(b) 00101101

Question 2. Consider the fragment of English grammar given in the lecture. Use it to construct a parse tree (using top down parsing) for the following sentences:
(a) "The boy sees a flower."
(b) "A girl likes the boy with the flower."

Question 3. Show that the following grammar is ambiguous: S the start non-terminal, A, B two non-terminals and a, b terminals

$$S \to AB \mid aaB$$
$$A \to a \mid Aa$$
$$B \to b$$

Question 4. Show that the following grammar is ambiguous: S the start non-terminal, a, b terminals

$$S \to aSbS \mid bSaS \mid \Lambda$$

Question 5. Consider the following grammar G with the non-terminal start symbol S, two non-terminals B, C and terminal symbols a, c, d, e, f, g, x, y, z:

$$S \to xyz \mid aBC$$
$$B \to c \mid cd$$
$$C \to eg \mid df$$

Use two different methods of parsing (top-down and bottom-up) to derive the strings
(a) $acddf$,
(b) $acdg$.

Question 6. Give an example of a string (of length at least 5) from the language described by the grammar $S \to aSc \mid b$ with the initial non-terminal S. Show that you can find

unique derivations generating the string from left looking only at the current symbol. ($LL(1)$ grammar).

Question 7. Give an example of a string (of length at least 5) from the language described by the grammar $S \to AB$, $A \to aA \mid a$, $B \to bB \mid c$. Show that you can always find derivations used for generation of your string (from left) looking only at most two symbols ahead. ($LL(2)$ grammar).
Can you rewrite this grammar as an $LL(1)$ grammar?

Question 8. Explain why the following grammar is $LR(1)$ and not $LL(1)$: $S \to a \mid ab$

Question 9. Explain why the following grammar is unambiguous and not $LR(1)$: $S \to Uab \mid Vac$, $U \to d$, $V \to d$.

Question 10. Find a language which is described by the grammar: $S \to Sa \mid b$. Show that the grammar is not $LL(1)$.
Can you find the $LL(1)$ grammar for the same language?

Question 11. Show that the following grammar is $LR(1)$, but not an $LR(0)$ grammar. $S \to AB$, $A \to aAb$, $A \to \Lambda$, $B \to Bb$, $B \to b$. Describe the language which is generated by this grammar. Also, find the derivation tree for a^2b^4.

Question 12. Find an $LL(k)$ grammar for the language $\{aa^n \mid n \in \mathbb{N}\} \cup \{aab^n \mid n \in \mathbb{N}\}$. What is k for your grammar?

Question 13. Find the minimum k such that the following grammar is $LL(k)$ grammar: $S \to SS \mid aSb \mid ab$.

Question 14. Find the minimum k such that the following grammar is $LR(k)$ grammar: $S \to ADC \mid aaaddd$, $A \to aaa$, $D \to ddd$, $C \to Cc \mid c$.

Question 15. Find the minimum values k_1, k_2 such that the following grammar is $LL(k_1)$, $LR(k_2)$ grammar: $S \to A \mid B$, $A \to aAb \mid 0$, $B \to aBbb \mid 1$.

Question 16. Is it possible for a regular grammar to be ambiguous?