Course: Theory of Computation

HW7: Decidability

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1. Show that the set of all finite strings over the alphabet { a, b, c, d } is countable. Must show a correspondence.

As all strings over the alphabet $\{a, b, c, d\}$ are finite, namely there are $k (k \in \mathcal{N})$ number of letters which are selected from alphabet $\{a, b, c, d\}$ in each string, then we can build a correspondence as following

Number of letters in the string	Number of strings
1	$C_4^1 = 4$
2	$C_4^1 * C_4^1 = 4^2$
3	$C_4^1 * C_4^1 * C_4^1 = 4^3$
:	:
n	4^n

It can be seen that there is correspondence between numbers of strings with n letters in the string and set of natural numbers \mathcal{N} , so the set of all finite strings over the alphabet $\{a, b, c, d\}$ has same size of \mathcal{N} , according to definition 4.14, this set is countable

2. Show that the set of all strings over the alphabet of $\{a, b, c, d\}$ is uncountable. Must use diagonalization. Solution: Since the strings over the alphabet of $\{a, b, c, d\}$ may have finite length or infinite length, suppose there is correspondence f between $\mathcal N$ and the set of string over the alphabet of $\{a, b, c, d\}$, let f(1)=abcd, f(2)=dac,

f(3)=daa,...,

n	<i>f</i> (n)
1	abcd
2	dac
3	daa
4	bccda
:	:

we can construct a string w with infinite number of letters over the alphabet of $\{a, b, c, d\}$, the first letter of w is different from that of f(1), let it be c, so $w \ne f(1)$; the second letter of w is anything different from the second letter of f(2), let it be d, then f(2); the third letter of f(3) is different from that of f(3), let it be c, so f(3); continuing this way down the diagonal of the table for f(3), we obtain all digits of f(3), as shown in the following table

n	<i>f</i> (n)
1	abcd
2	dac
3	daa
4	bccda
:	:

w=cdca.....

According to the procedure of constructing string w, we know that w is not f(n) for any n, since it differ from f(n) in the nth letter, namely $w \neq f(n)$; so the correspondence between natural number set \mathcal{N} and the set of all string over the alphabet $\{a, b, c, d\}$ does not exist. So the set of all strings over the alphabet $\{a, b, c, d\}$ is uncountable.

 4.21 Let S = {(M) M is a DFA that accept w^R whenever it accepts w} show that S is decidable Solution: let TM G for S and G="on input (M), where M is DFA what accept w 1 simulate DFA M on input w^R 2 if input w^R end M with accept state, then accept, if input w^R end M with reject state, then reject so the TM G can decide S, therefore S is decidable 4.28 Let C = {(G, x) G is CFG, x is a substring of some y ∈ L(G)}, show that C is decidable. Solution: let TM R is for C: R="on put (G, x), where G is CFG, and s is a string, 1 mark all the terminals of G that are symbols in string x; 2 repeat until no new variables get marked; 3 Mark any variable A where G have a rule A → U₁U₂···U_k and each symbol U₁, U₂,···U_k has alremarked; 4 if start variable is not marked, reject; otherwise accept because TM R can decide the problem C, so C is decidable. 		
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obbasso 1111 It can abolae the problem of so o is declarate.	Solution: G=" So the TM 4.28 Let C = Solution: le R="on p 1 m 2 re 3 M marked;	Let TM G for S and son input $\langle M \rangle$, where M is DFA what accept w 1 simulate DFA M on input w^R 2 if input w^R end M with $accept$ state, then $accept$, if input w^R end M with $reject$ state, then $reject$ G can decide S , therefore S is decidable $ \begin{cases} \langle G, x \rangle G \text{ is } CFG, x \text{ is a substring of some } y \in L(G) \\ \rangle, \text{ show that } C \text{ is decidable.} \end{cases} $ TM R is for C : For $\langle G, x \rangle$, where G is CFG, and G is a string, ark all the terminals of G that are symbols in string G is a symbol on the period of G that are symbols in string G is a symbol of G that are symbols are all the terminals of G that are symbols in string G is an each symbol of G that are symbols are all the terminals of G that are symbols in string G is G in the terminal of G that are symbols in string G is G in the terminal of G that are symbols in string G is an each symbol G in the symbol of G in the symbol of G is a string of G in the symbol of G in the symbol of G is a string of G in the symbol of G in the symbol of G is a string of G in the symbol of G is a string of G in the symbol of G in the symbol of G is a symbol of G in the symbol of G in the symbol of G is a symbol of G in the symbol of G in the symbol of G is a symbol of G .
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