Lab03-Recursive Function

CS363-Computability Theory, Xiaofeng Gao, Spring 2016

∗ Please upload your assignment to FTP or submit a paper version on the next class
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1. Show that the following functions are primitive recursive:

   (a) $half(n) = \begin{cases} \frac{n}{2}, & \text{if } n \text{ is even,} \\ \frac{n-1}{2}, & \text{if } n \text{ is odd.} \end{cases}$

   Proof:
$$half(0) = 0$$
   .
$$half(x+1) = \begin{cases} \frac{x}{2}, & \text{if } x \text{ is even,} \\ \frac{x+1}{2}, & \text{if } x \text{ is odd.} \end{cases} = \begin{cases} half(x), & \text{if } x \text{ is even,} \\ half(x)+1, & \text{if } x \text{ is odd.} \end{cases}$$

   So, the function is primitive recursive.

   (b) $\max\{x_1, x_2, \cdots, x_n\}$ = the maximum of x_1, x_2, $\cdots$, x_n.

   (c) $f(x)$ = the sum of all prime divisors of x.

   (d) $g(x) = x^x$.

2. Show the computability of the following functions by minimalisation.

   (a) $f^{-1}(x)$, if $f(x)$ is a total injective computable function.

   (b) $f(a) = \begin{cases} \text{the least non-negative integral root of } p(x) - a \ (a \in \mathbb{N}), \\ \text{undefined if there's no such root,} \end{cases}$

   where $p(x)$ is a polynomial with integer coefficients.

   (c) $f(x, y) = \begin{cases} x/y & \text{if } y \neq 0 \text{ and } y|x, \\ \text{undefined} & \text{otherwise.} \end{cases}$

3. Let $\pi(x, y) = 2^x(2y+1) - 1$. Show that π is a computable bijection from $\mathbb{N}^2$ to $\mathbb{N}$, and that the functions π_1, π_2 such that $\pi(\pi_1(z), \pi_2(z)) = z$ for all z are computable.

4. Show that the following function is primitive recursive (with the help of $\pi(x, y)$, perhaps):
$$\begin{aligned} f(0) &= 1, \\ f(1) &= 1, \\ f(n+2) &= f(n) + f(n+1). \end{aligned}$$

5. Coding Technology.

   Any number $x \in \mathbb{N}$ has a unique expression as

   (1) $x = \sum_{i=0}^{\infty} \alpha_i 2^i$, with $\alpha_i = 0$ or 1, for all i.

   Hence, if $x > 0$, there are unique expressions for x in the forms

   (2) $x = 2^{b_1} + 2^{b_2} + \ldots + 2^{b_l}$, with $0 \le b_1 < b_2 < \ldots < b_l$ and $l \ge 1$, and

(3) $x = 2^{a_1} + 2^{a_1+a_2+1} + \ldots + 2^{a_1+a_2+\ldots+a_k+k-1}$. (The expression (3) is a way of regarding x as coding the sequence $(a_1, a_2, \ldots, a_l)$ of numbers)

Show that each of the functions α, l, b, a defined below is computable.

(a) $\alpha(i, x) = \alpha_i$ as in the expression (1);

(b) $l(x) = \begin{cases} l \text{ as in (2)}, & \text{if } x > 0, \\ 0 & \text{otherwise;} \end{cases}$

(c) $b(x) = \begin{cases} b_i \text{ as in (2)}, & \text{if } x > 0 \text{ and } 1 \leq i \leq l, \\ 0 & \text{otherwise;} \end{cases}$

(d) $a(i, x) = \begin{cases} a_i \text{ as in (3)}, & \text{if } x > 0 \text{ and } 1 \leq i \leq l, \\ 0 & \text{otherwise;} \end{cases}$