

## req.1 Simulating Primitive Recursion

inc:req:pri:  
sec Now we can show that definition by primitive recursion can be “simulated” by regular minimization using the beta function. Suppose we have  $f(\vec{z})$  and  $g(u, v, \vec{z})$ . Then the function  $h(x, \vec{z})$  defined from  $f$  and  $g$  by primitive recursion is

$$\begin{aligned}h(0, \vec{z}) &= f(\vec{z}) \\h(x + 1, \vec{z}) &= g(x, h(x, \vec{z}), \vec{z}).\end{aligned}$$

We need to show that  $h$  can be defined from  $f$  and  $g$  using just composition and regular minimization, using the basic functions and functions defined from them using composition and regular minimization (such as  $\beta$ ).

inc:req:pri:  
lem:prim-rec **Lemma req.1.** *If  $h$  can be defined from  $f$  and  $g$  using primitive recursion, it can be defined from  $f$ ,  $g$ , the functions zero, succ,  $P_i^n$ , add, mult,  $\chi_=$ , using composition and regular minimization.*

*Proof.* First, define an auxiliary function  $\hat{h}(x, \vec{z})$  which returns the least number  $d$  such that  $d$  codes a sequence which satisfies

1.  $(d)_0 = f(\vec{z})$ , and
2. for each  $i < x$ ,  $(d)_{i+1} = g(i, (d)_i, \vec{z})$ ,

where now  $(d)_i$  is short for  $\beta(d, i)$ . In other words,  $\hat{h}$  returns the sequence  $\langle h(0, \vec{z}), h(1, \vec{z}), \dots, h(x, \vec{z}) \rangle$ . We can write  $\hat{h}$  as

$$\hat{h}(x, z) = \mu d (\beta(d, 0) = f(\vec{z}) \wedge \forall i < x \beta(d, i + 1) = g(i, \beta(d, i), \vec{z})).$$

Note: no primitive recursion is needed here, just minimization. The function we minimize is regular because of the beta function lemma ??.

But now we have

$$h(x, \vec{z}) = \beta(\hat{h}(x, \vec{z}), x),$$

so  $h$  can be defined from the basic functions using just composition and regular minimization.  $\square$

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## Bibliography