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Creating a new two-step recursive memory method with eight-order based on Kung and Traub's method

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The proof of Theorem (2.1) by Mathematica:

We use the self-explained mathematical approach to avoid the tedious and humdrum algebraic manipulation. Defining functions is one of the strong features of Mathematica. Let us start with a simple example of defining the formula $f(n) = n^2 + 4$ as a function

f[n_] $:= n^2 + 4$

First notice that in defining a function we use := . The symbol n is a dummy variable and, as expected, one plugs in the data in place of n.

First, we define the Taylor's series of $f(x)$ as follows:

$\mathrm{f}(\mathrm{x}_k) = f'(\alpha)(e_k + c_2 e_k^2 + c_3 e_k^3 + c_4 e_k^4) + O(e_k^5)$ In the software "Mathematica" is defined as follows:

$$f[e\_] = fla(e + c_2 e^2 + \cdots + c_4 e^4).$$

let us define the errors $fla = f'(\alpha)$, $e = x - \alpha$, $ew = w - \alpha$, $ey = y - \alpha$, and $e1 = \hat{x} - \alpha$, and introduce the following abbreviations used in $c_k = \frac{f^{(k)}(\alpha)}{k! f'(\alpha)}$ and $g0 = g(0)$, $g1 = g'(0)$. Note that since α is a simple zero of $f(x)$, the $f'(\alpha) \neq 0$, $f(\alpha) = 0$. We define

$$In[1] : f[e\_] = fla(e + c_2 e^2 + \cdots + c_4 e^4),$$

$$In[2] : f[x\_, y\_] = \frac{f[x] - f[y]}{x - y};$$

$$In[3] : ew = e + \beta f[e];$$

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$$In[4]:ey=e-Series[\frac{f[e]}{f[e,ew]+\gamma f[ew]},\{e,0,4\}];$$

$$In[5]:t=\frac{f[ey]}{f[e]};$$

$$In[6]:g[t\_]=g0+g1*t+g2*\frac{t^2}{2};$$

$$In[7]:g0=1;$$

$$In[8]:g1=-1;$$

$In[9]:e1=ey-g[t\_]*(\frac{1}{1-\frac{f[ey]}{f[e]}})^2*$

$Series[\frac{f[ey]}{f[ew,ey]+\gamma f[ew]+\lambda(ey-ew)(ey-e)},\{e,0,4\}]//FullSimplify$

Out[9]:$e_{k+1}=$

$$\left[\frac{\begin{array}{l}(1+\beta fla)^2(\gamma+c_2)(fla\,g2(1+\beta fla)\gamma^2-2\lambda+flac_2(2\\(-2+g2(1+\beta fla))\gamma+(-4+g2(1+\beta fla))c_2+2flac_3))\end{array}}{-2fla}\right]e_k^4+O(e_k^5)$$

This completes the proof.