Let consider a sample dataset have one input (x_i^d) and One output (y_i^d) and number of samples 4. Develop a simple linear regression model using ADAGRAD optimizer

Sample (i)	x_i^d	y_i^d
1	0.2	3.4
2	0.4	3.8
3	0.6	4.2
4	0.8	4.6

Manual Calculations:

Step 1: $[x, y]$, $\eta = 0.1$, epochs $= 1$, $m = 1$, $c = -1$, $\varepsilon = 10^{-8}$ s,

$G_m = G_c = 0$

Step 2: itr $= 1$

Step 3: sample $= 1$

Step 4: $g_m = -(y_i - mx_i - c)\, x_i$

$= -(3.4 - (1 \times 0.2) + 1)\, 0.2$

$= -0.84$

$g_c = -4.2$

Step 5: $G_m = G_m + (g_m)^2 = 0 + (0.84)^2 = 0.7056$

$G_c = G_c + (g_c)^2 = 0 + (4.2)^2 = 17.64$

step 6: $\Delta m = \dfrac{-0.1}{\sqrt{0.7056 + 10^{-8}}} \times 0.84$

$= 0.09999$

$\Delta c = \dfrac{-0.1}{\sqrt{17.64 + 10^{-8}}} \times -4.2$

$= 0.09999$

step 7: $m = m + \Delta m = 1 + 0.9999 = 1.9999$

$c = c + \Delta c = -1 + 0.9999 = -0.001$

step 8: sample = sample + 1

$= 1 + 1 = 2$

step 9: $2 > 2$

false → goto step 4

step 4: $g_m = -(y_i - m x_i - c)\, x_i$

$= -(3.8 - (1 \times 1.999) + 0.001)\, 0.4$

$= -0.72044$

$g_c = -1.8011$

step 5: $G_m = G_m + (g_m)^2 = 0.7056 + 0.5190 = 1.2246$

$G_c = G_c + (g_c)^2 = 17.64 + 3.2439 = 20.8839$

step 6: $\Delta m = \dfrac{-0.1}{\sqrt{1.2246 + 10^{-8}}} \times (-0.72044) = 0.065102$

$\Delta c = \dfrac{-0.1}{\sqrt{20.8839 + 10^{-8}}} \times (-1.8011) = 0.03941$

step7: $m = 1.9999 + 0.065102 = 2.0150$

$c = -0.01 + 0.3941 = 0.3937$

steps8: Sample = sample + 1 = 2+1 = 3

step9: $3 > 2$

true → goto next step

step10: itr = itr + 1 = 1+1 = 2

step11: itr > epochs

$2 > 2$

false → goto step ~~4~~ 3

step3: sample = 1

step4: $g_m = -(2.5939)0.2 = -0.5187$

$g_c = -2.5939$

step5: $G_m = G_m + (g_m)^2$

$= 1.2246 + 0.2090 = 1.4935$

$G_c = G_c + (g_c)^2$

$= 20.8839 + 6.7283 = 27.6122$

step6: $\Delta m = \frac{-0.1}{\sqrt{1.4936 + 10^{-8}}} \times (-0.5187) = 0.01789$

$\Delta c = \frac{-0.1}{\sqrt{27.6122 + 10^{-8}}} \times (-2.5939) = 0.04936$

step7: $m = m + \Delta m = 2.08289$

$c = c + \Delta c = 0.44246$

step8: sample = sample + 1 = 2

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step 9: $2 > 2$

false → goto step 4

step 4: $g_m = -(3.8 - (2.08289 \times 0.4) - 0.44246)0.4$

$= -2.00972$

$g_c = -2.5243$

step 5: $G_m = 1.4936 + (-1.00972)^2 = 2.5131$

$G_c = 27.61227 + (-2.5243)^2 = 33.9842$

step 6: $\Delta m = \dfrac{-0.1}{\sqrt{2.5131 + 10^8}} \times (-1.00972) = 0.06369$

$\Delta c = \dfrac{-0.1}{\sqrt{33.9842 + 10^8}} \times (-2.5243) = 0.0433$

step 7: $m = m + \Delta m = 2.08289 + 0.06369 = 2.1465$

$c = c + \Delta c = 0.48576$

step 8: sample = sample + 1 = 2+1 = 3

step 9: $3 > 2$

true → goto next step

step 10: itr = itr + 1

$= 2+1 = 3$.

step 11: $3 \geq$ epochs

$3 > 2$

true → go to next step

step 12: print m, c

Calculate MSE

$$= \frac{1}{2\times2} \Sigma (y_i - y_p)^2$$

$$= \frac{1}{4} \left[(3.4 - (2.14655 \times 0.2) - 0.48576)^2 + (3.8 - (2.14658 \times 0.4) - 0.48576)^2 \right]$$

$$= 3.05121$$

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