Assignment 2

Find global minimum point and value for function

$f(x,y) = x^2+y^2+10$

Do manual calculations to 2 iterations.

step 1 :- $x=-1$, $y=1$, $\eta=0.1$, epoches $=2$

step 2 :- iter $=1$

step 3 :- $\frac{\partial f}{\partial x} = 2x = -2$

$\frac{\partial f}{\partial y} = 2y = 2$

step 4 :- $dx = -\eta\frac{\partial f}{\partial x} = -2(-0.1) = 0.2$

$\Delta y = -\eta\frac{df}{dy} = -(0.1)(2) = -0.2$

step 5 :- $x = x+\Delta x = -1+0.2 = -0.8$

$y = y+\Delta y = 1-0.2 = 0.8$

step 6 :- iter $=$ iter $+1 = 1+1 = 2$

step 7 :- if $(2>2)$

go to step 8

else

go to step 3

step 3 :- $\frac{df}{dx} = 2x = 2(-0.8) = -1.6$

$\frac{df}{dy} = 2y = 2(0.8) = 1.6$

step 4 :- $\Delta x = -\eta\frac{\partial f}{\partial x} = -0.1(-1.6) = 0.16$

$\Delta y = -\eta\frac{\partial f}{\partial y}$

$= -(0.1)(1.6) = -0.16$

step 5 : $x = x + \Delta x = -0.8 + 0.16 = -0.64$

$y = y + \Delta y = 0.8 - 0.16 = 0.64$

step 6 :- $it = it + 1 = 2 + 1 = 3$

step 7 :- if ( it > epoches)

$3 > 2$

go to step 8

else

go to step 3

step 8 : $x = -0.64$

$y = 0.64$

$f(x,y) = x^2 + y^2 + 10$

$= (0.64)^2 + (0.64)^2 + 10$

$= 0.4 + 0.4 + 10 = 10.8$

Assignment - 3

let us consider sample dataset have 1 input $x_i$ a and one o/p ($y_i$ a) and no. of samples. develop a sample regression model using stochastic gradient descent optimiser.

| sample | $x_i$ a | $y_i$ a |
|---|---|---|
| 1 | 0.2 | 3.4 |
| 2 | 0.4 | 3.8 |
| 3 | 0.6 | 4.2 |
| 4 | 0.8 | 4.6 |

1) $x, y, m=1$ , $c=-1$ , $\eta=0.1$ , epoches $=2$ , $n_s=2$

2) it $=1$

3) sample $=1$

4) $\frac{\partial E}{\partial m} = -(3.4-(1))(0.2)-(-1))0.2$

$= -0.84$

$\frac{\partial E}{\partial c} = -(3.4(1))(0.2+1)$

$= -4.2$

5) $\Delta m = -(0.1)(0.84) = 0.084$ $\qquad \Delta c = -(0.1)(-4.2)$

$= 0.42$

6) $m = m + \Delta m$

$= 1+0.84 = 1.084$

$c = c + \Delta c$

$= -1+0.42 = -0.58$

7) sample $+=1$ $=2$

8) if $(2>2)$

go to step 9

else

step 4

4) $\frac{\partial f}{\partial m} = -(3.8 - (1.084)(0.4) + 0.58)\ 0.4$

$= -1.5785$

$\frac{\partial f}{\partial c} = -(3.8 - (1.084)(0.4) + 0.58)$

$= -3.9464$

5) $\Delta m = -(0.1)(-1.5785) = 0.1578$

$\Delta c = -(0.1)(-3.9464) = 0.3046$

6) $m = m + \Delta m = 1.84 + 0.1578 = 1.2418$

$c = c + \Delta c = -0.58 + 0.3946 = -0.1854$

7) sample = +1

8) if (3 > 2)

go to step 9

else

step 4

9) it += 1

10) if (2 > 2)

go to step 11

else

step 3

3) sample = 1

4) $\frac{\partial E}{\partial m} = -(3.4 - (1.2)(0.2) + 0.18))0.2$

$= -0.668$

$\frac{\partial E}{\partial c} = -(3.4 - (1.2)(0.2) + 0.18$

$= -3.34$

5) $\Delta m = -(0.1)(-0.668) = 0.0668$

6) $m = \Delta m + m = 1.24 + 0.066 = 1.3$

$c = \Delta c + c = 0.18 + 0.33 = 0.15$

7) sample $= +1$

8) if $(2 > 2)$

go to step 9

else

step 4

4) $\frac{\partial E}{\partial m} = -(3.8 - (1.3)(0.4) - 0.15)\,0.4$

$= -1.25$

$\frac{\partial E}{\partial c} = -(3.8 - (1.3)(0.4) - 0.15)$

$= -3.13$

5) $\Delta m = -(0.1)(-1.25) = 0.12$

$\Delta c = -(0.1)(-3.13) = 0.31$

6) $m = m + \Delta m = 1.3 + 0.12 = 1.42$

$c = c + \Delta c = 0.15 + 0.31 = 0.46$

7) sample $+= 1$

8) if $(3 > 2)$

go to step 9.

9) $it = it + 1$

10) if $(it > ep)$

$3 > 2$

step 11

11) print m & c

$m = 1.42$

$c = 0.46$

# Assignment-5

let us consider a sample dataset have 1 i/p ($x_i$) and 1 o/p ($y_i$) and no. of samples develop a SLR model using MBGD

| sample(i) | $x_i$ | $y_i$ | |
|---|---|---|---|
| 1 | 0.2 | 3.4 | → batch=1 |
| 2 | 0.4 | 3.8 | |
| 3 | 0.6 | 4.2 | |
| 4 | 0.8 | 4.6 | → batch=2 |

1) $[x, y]$; $m=1$, $c=-1$, $\eta=0.1$, epochs $=2$, $bs=2$

2) $nb = \frac{ns}{bs} = \frac{4}{2} = 2$

3) it=1

4) Batch=1

5) $\frac{\partial E}{\partial m} = \frac{-1}{bs} \cdot \sum_{i=1}^{bs} (y_i - mx_i - c)\, x_i$

$= \frac{-1}{2}\left[ \left( (3.4-(1)(0.2)+1)\, 0.2 \right] + \left[ 3.8-0.4+1 \right) 0.4 \right]$

$= -1.34$

$\frac{\partial E}{\partial c} = -\frac{1}{2}\left[ (3.4-0.241) + (3.8-0.4+1) \right]$

$= -4.3$

6) $\Delta m = -(0.1)(-1.34) = 0.134$

$= -(0.1)(-4.3) = 0.43$

7) $m = m + \Delta m = 1 + 0.134 = 1.134$

$c = c + \Delta c = -1 + 0.43 = -0.57$

8) Batch += 1

9) if (2>2)

go to step10 else step 5.

5) $\frac{\partial E}{\partial m} = \frac{-1}{2}\left[4.2-(1.1(0.6))+0.57\right)0.6 +$

$(4.6-(1.134)(0.8)+0.57)0.8]$

$= 2.932$

$\frac{\partial E}{\partial c} = \frac{-1}{2}\{4.2-(1.134)(0.6)+0.57) +$

$4.6-(1.34)(0.8)+0.57)]$

$= -4.17$

6) $\Delta m = 0.2932$

$\Delta c = 0.417$

7) $m = 1.13 + 0.293 = 1.42$

$c = -0.57 + 0.4 = -0.15$

8) Batch += 1

9) if (batch > nb)

3 > 2

go to step10

10) it += 1

11) if (2>2) go to step12 else step 4

4) Batch = 1

$\frac{\partial E}{\partial m} = \frac{-1}{2}[3.4-(1.4)(0.2)+0.5)0.2 +$

$3.8-(1.4)(0.4)+0.15)0.4]$

$= -1.0029$

$\frac{\partial E}{\partial m} = \frac{-1}{2}\{3.4-(1.42)(0.2)+0.1523) +$

$3.8-(1.4)(0.4)+0.15]$

$= -3.3241$

6) $\Delta m = -0.1(-1.0029) = 0.1002$

$\Delta c = -0.1(-3.3241) = 0.332$

7) $m += \Delta m = 1.42 + 0.1002 = 1.5$

$c += \Delta c = -0.15 + 0.3 = 0.17$

8) Batch += 1.

9) if (2>2) go to step 10 else step 7

10) $\frac{\partial E}{\partial m} = \frac{-1}{2}\left[4.2 - (1.5(0.6) - 0.17)\,0.6 + 4.6 - (1.5(0.8) - 0.17(0.8))\right)$

$= -2.21$

$\frac{\partial E}{\partial c} = -3.151$

6) $\Delta m = -0.1 \times -2.21 = 0.221$

$\Delta c = -0.1 \times -3.15 = 0.315$

7) $m += \Delta m = 1.5 + 0.22 = 1.7$

$c += \Delta c = 0.17 + 0.3 = 0.4$

8) Batch += 1

9) if (Batch > nb) go to step 10 else step 5

10) itt=1

11) if (3>2) go step 12

12) print m, c

$m = 1.748$

$c = 0.494$

Assignment-7

let consider a sample dataset have one i/p ($x_i$) and ($y_i$) and no. of samples a develop a sample Linear regression model by BGD

| sample | $x_i$ | $y_i$ |
|---|---|---|
| 1 | 0.2 | 3.4 |
| 2 | 0.4 | 3.8 |
| 3 | 0.6 | 4.2 |
| 4 | 0.8 | 4.6 |

1) $[x,y]$; $m=1, c=-1, \eta=0.1$; epochs $=2$, $ns=2$

2) it $=1$

3) $$\frac{\partial E}{\partial m} = \frac{-1}{n_s}\sum_{i=1}^{ns}(y_i - mx_i - c)\,x_i$$

$$= \frac{-1}{2}\left[3.4-(1)(0.2)+1)0.2 + (3.8-(1)(0.4)+1)0.4\right]$$

$$= -1.34$$

$$\frac{\partial E}{\partial c} = \frac{-1}{2}\left[(3.4-0.2+1)+(3.8-0.4+1)\right]$$

$$= -4.3$$

4) $$\Delta m = -\eta\frac{\partial E}{\partial m}$$

$$= -0.1 \times -1.34 = 0.134$$

$$\Delta c = -\eta\frac{\partial E}{\partial c}$$

$$= -0.1(4.3) = 0.43$$

5) $m += \Delta m$

$= 1 + 0.134 = 1.13$

$c += \Delta c$

$= -0.1 \times -4.3 = 0.43$

6) it+=1

7) if(2>2)

go to step8;

3) $\frac{\partial E}{\partial m} = \frac{1}{2}[3.4 - (1.134)(0.2) + 0.54)(0.2) +$

$3.8 - (1.134)(0.4) + 0.57)0.4)$

$= -1.157$

$\frac{\partial E}{\partial c} = -\frac{1}{2}[3.4 - (1.34)(0.2) + 0.57) +$

$3.8 - (1.134)(0.4) + 0.57)]$

$= -3.829$

4) $\Delta m = -0.1 \times 1.15 = 0.1157$

$\Delta c = -0.1 \times -3.8 = 0.3829$

5) $m += \Delta m \Rightarrow 1.134 + 0.1157 = 1.2497$

$c += \Delta c \Rightarrow -0.57 + 0.3829 \Rightarrow -0.187$

6) it+=1

7) if(it > epo) go to step8

3 > 2

8) m = 1.24 c = -0.187

Assignment - 9

let us consider a sample blataset have 1 input $(x_i)$ and one output $(y_i)$ and no. of samples develop a simple linear regression model using momentum optimiser

| sample | $x_i$ | $y_i$ |
|---|---|---|
| 1 | 0.2 | 3.4 |
| 2 | 0.4 | 3.8 |
| 3 | 0.6 | 4.2 |
| 4 | 0.8 | 4.6 |

do manual calculations for 2 iterations with 1st 2 samples

Step 1: $[x, y]$. $m=1, c=1, \eta=0.1$, epoch = 2, $\gamma=0.9$,

$v_m = v_c = 0$

2) itr = 1

3) sample = 1

4) $g_m = \frac{\partial E}{\partial m} = -(y_i - m x_i - c) x_i$

$= -(3.4 - (1)(0.2) + 1)(0.2)$

$= -0.84$

$g_c = \frac{\partial E}{\partial c} = -(y_i - m x_i - c) = -(3.4 - 0.2 + 1) = -4.2$

5) $v_m = \gamma v_m - \eta g_m$

$= (0.9)(0) - (-0.1)(-0.84)$

$= 0 - 0.084 = -0.084$

$v_c = \gamma v_c - \eta g_c$

$= 0.9 \times 0 - (-0.1)(-4.2) = -0.42$

6) $m = m + v_m = 1 + (-0.84) = -0.916$

$c = c + v_c = -1 - 0.42 = -1.42$

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7) sample += 1

1+1=2

8) If (sample > ns) go to step 9

else : go-to step 4

9) Iter += 1

1+1=2

10) If (it > epoch) go to step 4

else step.3

3) sample = 1

4) $g_m = \frac{\partial t}{\partial m} = -(3.4-(0.646)(0.2)+2.283)(0.2)$

$= -1.110$

$g_c = \frac{\partial t}{\partial c} = -3.4-(0.6)(0.2)+2.28)$

$= -5.5$

5) $v_m = \gamma v_m - \eta g_m = (0.9)(-0.269) - (0.1(-1.110))$

$= -0.353$

$v_c = \gamma v_c - \eta g_c$

$= (0.9)(-0.363) - (-0.1 \times -5.5)$

$= -1.332$

6) $m = m + v_m \Rightarrow 0.6463 + (-0.353) = 0.293$

$c = c + v_c \Rightarrow -2.283 - 1.332 = -3.615$

7) sample += 1

1+1=2

8) If (sample > ns) go to step 4

else goto step 4

4) $g_m = -(3.8-(0.293)(0.4)+3.615)(0.4) = -2.919$

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$g_c = -(3.8 - (0.293)(0.4) + \cancel{8.0}\ 3.615)$

$= -7.297$

5) $v_m = (0.9)(-0.353) - (-0.1 \times -2.919) = 0.6096$

$v_c = 0.9)(-1.332) - (-0.1(-7.297) = -1.9285$

6) $m + = v_m \Rightarrow 0.293 - 0.609 = -0.316$

$c + = v_c \Rightarrow -3.615 - 1.928 = -5.543$

7) sample $+= 1 \Rightarrow 2+1=3$

8) if (sample > ns) : goto step 9

else goto step 4

9) iter $+= 1$

$2+1=3$

10) if (iter > epochs) goto step 11

$3 > 2$

else goto step 3

11) print m, c

$m = -0.316$, $c = -5.543$

# Assignment - 11

let us consider a sample dataset have 1 i/p $x_i$ and one o/p $y_i$ and no. of sample 4. develop a SLR model using nestrov accelarated gradient (NAG) optimiser

| sample | $x_{ia}$ | $y_{ia}$ |
|---|---|---|
| 1 | 0.2 | 3.4 |
| 2 | 0.4 | 3.8 |
| 3 | 0.6 | 4.2 |
| 4 | 0.8 | 4.6 |

⇒ do manual calculation for 2 iteration with 1st 2 sample

→ step 1: $x, y$; $m=1$, $c=-1$, $\eta=0.1$, epoch $=2$, $\gamma=0.4$

$v_m = v_c = 0$, $n_s = 2$.

step 2: iter $=1$

step 3: sample $=1$

$$g_m = \frac{\partial E}{\partial m} = -(y_i - (m + \gamma_m) x_i - (c + \gamma c)) x_i$$

$$= -(3.4 - (1 + 0.9)0)0.2 - (-1 + (0.9)0)0.2$$

$$= 0.84$$

$$g_c = \frac{\partial E}{\partial c} = -4.2$$

step 5: $v_m = \gamma v_m - \eta g_m$

$= 0.084$

$v_c = \gamma v_c - \eta g_c$

$= -0.42$

step 6: $m + = v_m = 1 - 0.084 = 0.916$

$c + = v_c = -1 - 0.42 = -1.42$

7: sample += 1 ⇒ 1+1 = 2

8: if (sample > $n_s$) go to step 9
else go to step 4

4: $g_m = \frac{\partial E}{\partial m} = -(3.8-(0.916+(0.9(-0.8))0.4)) - (-1.42+(0.6-0.034)(0.4))$

$= -1.983$

$g_c = \frac{\partial E}{\partial c} = -4.954$

5: $v_m = \gamma v_m - \eta g_m$

$= 0.9\cdot(-0.84) - (-0.1(-1.983))$

$= -0.2739$

6: $m += v_m = 0.916 - 0.2739 = 0.6421$

$v_c = -1.42 - 0.8739 = -2.293$

7: sample += 1

8. if (sample > ns) goto step 9
else step 4

9: itr += 1

10: if (itr > epochs) go to step 11
else go to step 3

3: sample = 1

4: $\frac{\partial E}{\partial m} \Rightarrow -(3.4-(0.64+(0.9)\cdot(0.27))(0.2)) - (-2.293+(0.9)(0.2))$

$g_m = -1.171$

$g_c = -5.85$

5: $v_m = \gamma v_m = -\eta g_m = (0.9)(-0.273)] (-0.1(-1.1))$

$= -0.36$

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$-0.3627$

$v_c = v_c \gamma - \eta g_c$

$= -1.37$

6) $m + = v_m \Rightarrow 0.6421 + (-0.3627) = 0.2794$

$c + = v_c \Rightarrow -2.2989 - 1.3707 = -3.6646$

7) sample $+ = 1$

8) if (sample > ns) : go to step 9 else 4

4) $g_m = -2.985$

$g_c = -7.4645$

5) $v_m = 0.9(-0.3627) - (-0.1(-2.985))$

$= -0.6299$

$v_c = 0.9(-1.37) - (-0.1 - 7.46)$

$= -1.9800$

6) $m + = v_m = 0.29 - (0.62) = -0.3$

$c + = v_c = -3.6646 - 1.980 = -4.64$

7) sample $+ = 1 \Rightarrow 2 + 1 = 3$

8) if (sample > ns) : go to step 9 else 4

9) $it + = 1 \Rightarrow 2 + 1 = 3$

10) if (it > epoch) : go to step 4

else : go to step 3

11) print m, c

$m = 0.3275$

$c = -4.6646$

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# Assignment - 13

let us consider a sample dataset have 1 i/p $(x_i c)$ and 1 o/p $(x_i a)$ and no. of sample 4 develop a simple linear regression model using ADAGRAD optimiser.

| Sample (i) | $x_i a$ | $y_i a$ |
|---|---|---|
| 1 | 0.2 | 3.4 |
| 2 | 0.4 | 3.8 |
| 3 | 0.6 | 4.2 |
| 4 | 0.8 | 4.6 |

1) $[x, y]$, epochs $= 2$, $m=1$, $c=-1$, $G_m = G_c = 0$, $\eta = 0.1$, $\varepsilon = 10^{-8}$

2) iter $=1$

3) sample $=1$

4) $g_m = -0.84$
$g_c = -4.2$

7) $G_m = 0.705$
$G_c = 17.64$

8) $$\Delta m = \frac{-\eta}{\sqrt{G_m + \varepsilon}} g_m = \frac{-0.1}{\sqrt{0.70 + 10^{-8}}} (0.8) = 0.09$$

$$\Delta c = \frac{-(0.1)}{\sqrt{17.6 + 10^{-8}}} \times 4.2 = 0.09$$

7) $m = m + \Delta m = 1 + 0.09 = 1.09$

$c = c + \Delta c = -1 + 0.09 = -0.91$

8) $s = s + 1 \Rightarrow 1 + 1 = 2$

9) if $(s > ns)$ go to step 10 else step 4

4) $g_m = -(3.5 - (1.09)(0.4) + 0.91)0.4) = -1.7$

$g_c = -4.27$

5) $G_m = 3.5$

$G_c = 35.37$

6) $\Delta m = 0.08$

$\Delta c = 0.07$

7) $m = \Delta m + c = 1.17$

$c = -0.84$

8) $s = +1 \Rightarrow 3$

9) if $(s > ns)$ goto 10 else 4

10) $it + = 1 \Rightarrow 1 + 1 \Rightarrow 2$

11) if $(it > epoch)$ go to 12 else 3

$2 > 2$

3) $s = 1$

4) $g_m = -0.80$

$g_c = -4.0$

5) $\Delta m = \frac{-0.1}{\sqrt{4.23 + 10^{-8}}} (0.8) = 0.038$

$\Delta c = \frac{-0.1}{\sqrt{5.18 + 10^{-8}}} (4.0) = 0.05$

7) $m = m + \Delta m = 0.038 + 1.17 = 1.208$

$c = c + \Delta c = -0.84 + 0.05 = -0.79$

8) if (sample > ns) go to step 10 else go 4

4) $g_m = -(3.8 - (1.20)(0.4) + 0.70)(0.4)$

$= -1.69$

$g_c = -(3.8 - (-1.20)(0.4) + 0.7) = -4.11$

5) $G_m = 4.23 + (-1.64)^2 = 6.9$

$G_c = 51.8 + (-4.11)^2 = 68.7$

6) $\Delta m = \frac{-0.1}{\sqrt{6.0 + 10^{-8}}} (1.64) = 0.06$

$\Delta c = \frac{-0.1}{\sqrt{68.7 + 10^{-8}}} (4.11) = 0.04$

7) $m = m + \Delta m = 1.2 + 0.06 = 1.26$

$c = c + \Delta m = -0.7 + 0.04 = -0.75$

8) Sample += 1 => 3

9) if (sample > ns) go to step 10 else go 4
$3 > 2$

10) iter += 1 => 2 + 1 = 3

11) if (iter > epoch) go to 12 else go to 3

12) $m = 1.26$
$c = -0.75$

Assignment - 15

let us consider a sample dataset have 1 i/p ($x_{i9}$) and 1 o/p ($y_{i9}$) and no. of sample 2. develop a simple linear regression model using RMSPROP optimiser

| sample | $x_{i9}$ | $y_{i9}$ |
|---|---|---|
| 1 | 0.2 | 3.4 |
| 2 | 0.4 | 3.8 |
| 3 | 0.6 | 4.2 |
| 4 | 0.8 | 4.6 |

1) $[0, 4]$. $\eta = 0.1$, epoch $= 2$, $m = 1$, $c = -1$, $\gamma = 0.9$, $E_m = E_c$

$\varepsilon = 10^{-8}$

2) . iter = 1

3) sample = 1

4) $g_m = -(3.4 - (1)(0.2) + 1)(0.2) = -0.84$

$g_c = -(3.4 - (1)(0.2) + 1)(4) = -4.2$

5) $E_m = (0.9)(0) + (1 - 0.9)(0.84)^2 = 0.07$

$E_c = (0.9)(0) + (1 - 0.9)(-4.2)^2 = 1.764$

6) $\Delta m = \dfrac{-0.1}{\sqrt{0.07 + 10^{-8}}} (0.84) = 0.31$

$\Delta c = \dfrac{-0.1}{\sqrt{1.76 + 10^{-8}}} - (4.2) = 0.31$

7) $m = m + \Delta m = 1 + 0.31 = 1.31$

$c = -0.69$

8) sample + = 1

1 + 1 = 2

9) if $(s > n_s)$ go 10 else 4

4) $g_m = -(3.8 - (1.31)(0.4) + (0.69))(0.4) = -1.5$

$g_c = -(3.8 - (1.31)(0.4) + (0.69)) = -3.9$

5) $E_m = 0.28$

$E_c = 3.1$

6) $\Delta m = \frac{-0.1}{\sqrt{0.28 + 10^{-8}}}(1.5) = 0.28$

$\Delta c = \frac{-0.1}{\sqrt{3.1 + 10^{-8}}}(3.9) = 0.22$

7) $m = m + \Delta m \Rightarrow 1.31 + 0.28 = 1.59$

$c = c + \Delta c \Rightarrow -0.69 + 0.22 = -0.47$

8) sample + = 1

2 + 1 = 3

9) if (sample > ns) goto step 10 else 4

3 > 2

10) it = it + 1

11) if (it > epoch) go 12 else step 3

3) s = 1

4) $g_m = -(3.4 - 1.59(0.2) + 0.47)(0.2) = -0.7$

$g_c = -(3.4 - (1.59)(0.2) + 0.47) = -3.5$

5) $E_m = 0.9(0.28) + (0.1)(-0.7)^2 = 0.3$

$E_c = 0.9(3.1) + (0.1)(-3.5)^2 = 4.0$

6)

$\Delta m = 0.12$

$\Delta c = 0.17$

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7) $m + = \Delta m = 1.7$

$c + = \Delta c = 0.3$

8) (s > ns) goto 10

$2 > 2$

else goto 4

9) $g_m = -(3.8 - (1.7)(0.4) + 0.3)(0.4) = -1.4$

$g_c = -(3.8 - (1.71)(0.4) + 0.3) = -3.6$

5) $E_m = (0.4)(0.3) + (0.1)(1.4)^2 = 0.46$

$E_c = (0.9)(4.0) + (0.1)(-3.6)^2 = 4.89$

6) $\Delta m = 0.2$

$\Delta c = 0.16$

7) $m + = \Delta m = 1.91$

$c + = \Delta c = -0.14$

8) sample + = 1 => 2 + 1 = 3

9) if (sample > ns) go to 10 else 4

10) it + = 1 => 2 + 1 = 3

11) if (it > epoch) go to step 12 else go 3

12) $m = 1.91$

$c = -0.14$