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Week 10 -Hw2

5. Backward Pass

- Please calculate $w3^+$
  Please also explain how you get the formulas.

Step	Description	Formula	Calculated answer
1	**Complete and optimize the formula to calculate w3's impact to E_{total}** Expressing the formula with ○ w3's impact to E_{o1} ○ w3's impact to E_{o2}		
2	**Complete and optimize the formula to calculate w3's impact to E_{o1}** Expressing the formula with chain rule		
3	**Complete and optimize the formula to calculate w3's impact to E_{o2}** Expressing the formula with chain rule		
4	**Complete and optimize the formula to calculate w3's impact to net_{h2}**		
5	**Complete and optimize the formula to calculate net_{h2}'s impact to out_{h2}**		
6	**Complete and optimize the formula to calculate out_{h2}'s impact to net_{o1}**		
7	**Complete and optimize the formula to calculate net_{o1} to out_{o1}**		
8	**Complete and optimize the formula to calculate out_{o1} to E_{o1}** Expressed with $target_{o1}$ and out_{o1}		
9	**$w3^+$** New W3		

Solution:

Step	Description	Formula	Calculated Answer
1	**Complete and optimize the formula to calculate w3's impact to E_{total}** Expressing the formula with ○ w3's impact to E_{o1} ○ w3's impact to E_{o2}	∂Etotal / ∂w3= ∂Eo1 / ∂w3 + ∂Eo2 / ∂w3	
2	**Complete and optimize the formula to calculate w3's impact to E_{o1}** Expressing the formula with chain rule	(∂neth2 / ∂w3) * (∂outh2 / ∂neth2) * (∂neto1 / ∂outh2) * (∂outo1 / ∂neto1) * (∂Eo1 / ∂outo1)	

3	**Complete and optimize the formula to calculate w3's impact to E_{o2}** Expressing the formula with chain rule	(∂neth2 / ∂w3) * (∂outh2 / ∂neth2) * (∂neto2 / ∂outh2) * (∂outo2 / ∂neto2) * (∂Eo2 / ∂outo2)	
4	**Complete and optimize the formula to calculate w3's impact to net_{h2}**	∂(i1 * w3 + i2 * w4 + b1 * 1) / ∂w3 = i2	
5	**Complete and optimize the formula to calculate net_{h2}'s impact to out_{h2}**	outh2 (1 - outh2)	
6	**Complete and optimize the formula to calculate out_{h2}'s impact to net_{o1}**	∂(w5 * outh1 + w6 * outh2 + b2 * 1) / ∂outh2 = w6	
7	**Complete and optimize the formula to calculate net_{o1} to out_{o1}**	outo1 (1 - outo1)	
8	**Complete and optimize the formula to calculate out_{o1} to E_{o1}** Expressed with $target_{o1}$ and out_{o1}	∂ ((targeto1 - outo1) 2 / 2) / ∂outo1 = outo1 - targeto1	
9	**$w3^{+}$** New W3	W3 + = w3 –n * ∂Etotal / ∂w3	

Calculated Result:

Step 1: Expressing the formula with:

w3's impact to Eo1

∂Eo1 / ∂w3 => (∂neth2 / ∂w3) * (∂outh2 / ∂neth2) * (∂neto1 / ∂outh2) * (∂outo1 / ∂neto1) * (∂Eo1 / ∂outo1)

∂neth2 / ∂w3 => ∂(i1 * w3 + i2 * w4 + b1 * 1) / ∂w3 = i1 ∂outh2 / ∂neth2 : outh2 (1 - outh2)

∂neto1 / ∂outh2: ∂(w5 * outh1 + w6 * outh2 + b2 * 1) / ∂outh2 = w6

∂outo1 / ∂neto1 : outo1 (1 - outo1) ∂Eo1 / ∂outo1: ∂((targeto1 - outo1) 2 / 2) / ∂outo1 = outo1 - targeto1

w3's impact to Eo2

∂Eo2 / ∂w3: (∂neth2 / ∂w3) * (∂outh2 / ∂neth2) * (∂neto2 / ∂outh2) * (∂outo2 / ∂neto2) * (∂Eo2 / ∂outo2)

∂neth2 / ∂w3: ∂(i1 * w3 + i2 * w4 + b1 * 1) / ∂w3 = i1

∂outh2 / ∂neth2: outh2 (1 - outh2)

∂neto2 / ∂outh2: ∂(w7 * outh1 + w8 * outh2 + b2 * 1) / ∂outh2 = w8

∂outo2 / ∂neto2: outo2 (1 - outo2)

∂Eo2 / ∂outo2: ∂((targeto2 - outo2) 2 / 2) / ∂outo2 = outo2 - targeto2

Step 2: Complete and optimize the formula to calculate w3's impact to Eo1

Expressing the formula with chain rule ∂Eo1 / ∂w3 = (∂neth2 / ∂w3) * (∂outh2 / ∂neth2) * (∂neto1 / ∂outh2) * (∂outo1 / ∂neto1) * (∂Eo1 / ∂outo1)

∂Etotal / ∂outh2 = ∂E01 / ∂outh2 + ∂E02 / ∂outh2

∂E01 / ∂outh2 :

∂E01 / ∂outh2 = ∂E01 / ∂net01 * ∂neto1 / ∂outh2

But , ∂E01 / ∂net01 = ∂Eo1 / ∂outo1 * ∂outo1 / ∂neto1,

Hence Substitute ∂E01 / ∂net01 in ∂E01 / ∂outh2 formula – ∂E01 / ∂outh2 = ∂Eo1 / ∂outo1 * ∂outo1 / ∂neto1 * ∂neto1 / ∂outh2

Also

Substitute ∂E01 / ∂outh2 in ∂Etotal / ∂w3 formula for how w3's impact to Eo1:

∂Etotal / ∂w3 = ∂Eo1 / ∂outo1 * ∂outo1 / ∂neto1 * ∂neto1 / ∂outh2 * ∂outh2 / ∂neth2 * ∂neth2 /∂w3

∂Eo1 / ∂w3 = (∂neth2 / ∂w3) * (∂outh2 / ∂neth2) * (∂neto1 / ∂outh2) * (∂outo1 / ∂neto1) * (∂Eo1 /∂outo1)

Step 3 : Complete and optimize the formula to calculate w3's impact to Eo2 Expressing the formula with the chain rule

∂Etotal / ∂w3 = ∂Etotal / ∂outh2 * ∂outh2 / ∂neth2 * ∂neth2 / ∂w3 ∂Etotal / ∂outh2 = ∂E01 / ∂outh2 + ∂E02 / ∂outh2

∂E02 / ∂outh2:

∂E02 / ∂outh2 = ∂E02 / ∂net02 * ∂neto2 / ∂outh2

But,∂E02 / ∂net02 = ∂Eo2 / ∂outo2 * ∂outo2 / ∂neto2

Substitute ∂E02 / ∂net02 in ∂E02 / ∂outh2 formula,

∂E02 / ∂outh2 = ∂Eo2 / ∂outo2 * ∂outo2 / ∂neto2 * ∂neto2 / ∂outh2

Substitute ∂E02 / ∂outh2 in ∂Etotal / ∂w3 formula for how w3's impact to Eo2:

∂Etotal / ∂w3 = ∂Eo2 / ∂outo2 * ∂outo2 / ∂neto2 * ∂neto2 / ∂outh2 * ∂outh2 / ∂neth2 * ∂neth2 / ∂w3

∂Eo2 / ∂w3 = (∂neth2 / ∂w3) * (∂outh2 / ∂neth2) * (∂neto2 / ∂outh2) * (∂outo2 / ∂neto2) * (∂Eo2 / ∂outo2)

Step4: Complete and optimize the formula to calculate w3's impact to neth2

∂neth2 / ∂w3 = ∂(i1 * w3 + i2 * w4 + b1 * 1) / ∂w3

∂(i1 * w3 + 0 + 0) / ∂w3 = i1 = 0.05

Step5: Complete and optimize the formula to calculate neth2 's impact to outh2

∂outh2 / ∂neth2 = outh2 (1 - outh2) = 0.59688437826(1- 0.59688437826) = 0.24061341724

Step6: Complete and optimize the formula to calculate outh2 's impact to neto1

∂neto1 / ∂outh2 = ∂(w5 * outh1 + w6 * outh2 + b2 * 1) / ∂outh2 ∂(0 + w6 * outh2 + 0) / ∂outh2 = w6 = 0.45

Step7: Complete and optimize the formula to calculate neto1 to outo1

∂outo1 / ∂neto1 = outo1 (1 - outo1) =0.75136507(1-0.75136507) = 0.186815602

Step8: Complete and optimize the formula to calculate neto1 to outo1

∂Eo1 / ∂outo1 = ∂((targeto1 - outo1) 2 / 2) / ∂outo1

$$E_{total} = \frac{1}{2}(target_{o1} - out_{o1})^2 + \frac{1}{2}(target_{o2} - out_{o2})^2$$

$$\frac{\partial E_{total}}{\partial out_{o1}} = -(target_{o1} - out_{o1}) = -(0.01 - 0.75136507) = 0.74136507$$

Step 9: w3+ New W3

W3 + = w3 –n * ∂Etotal / ∂w3 ==> 0.25 - (0.5 * 0.00049771273) ==> 0.24975114363 W3 + = 0.24975114363