Argmax and Softmax

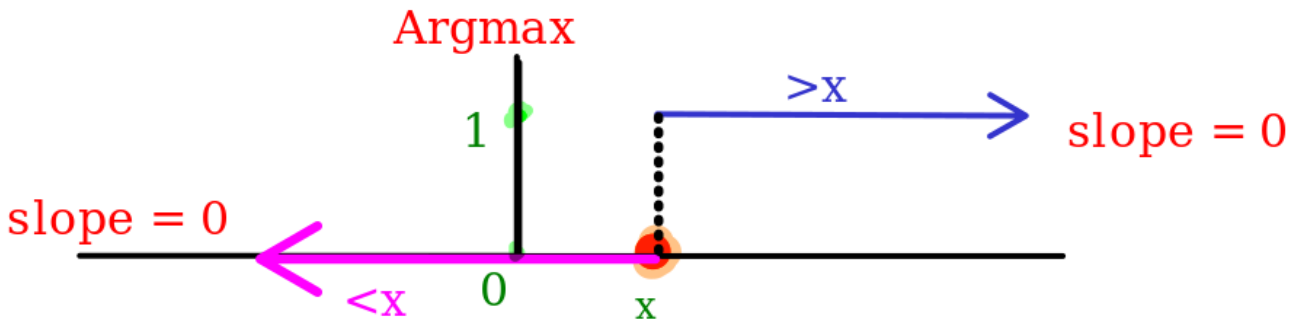
Argmax:

It simply converts the highest output to 1 and convert rest of the outputs to 0.
for example, argmax([0.23, 0.99, -102, 10]) => [0, 0, 0, 1]
i.e., it just converted the maximum number to 1 and rest of the outputs to 0.

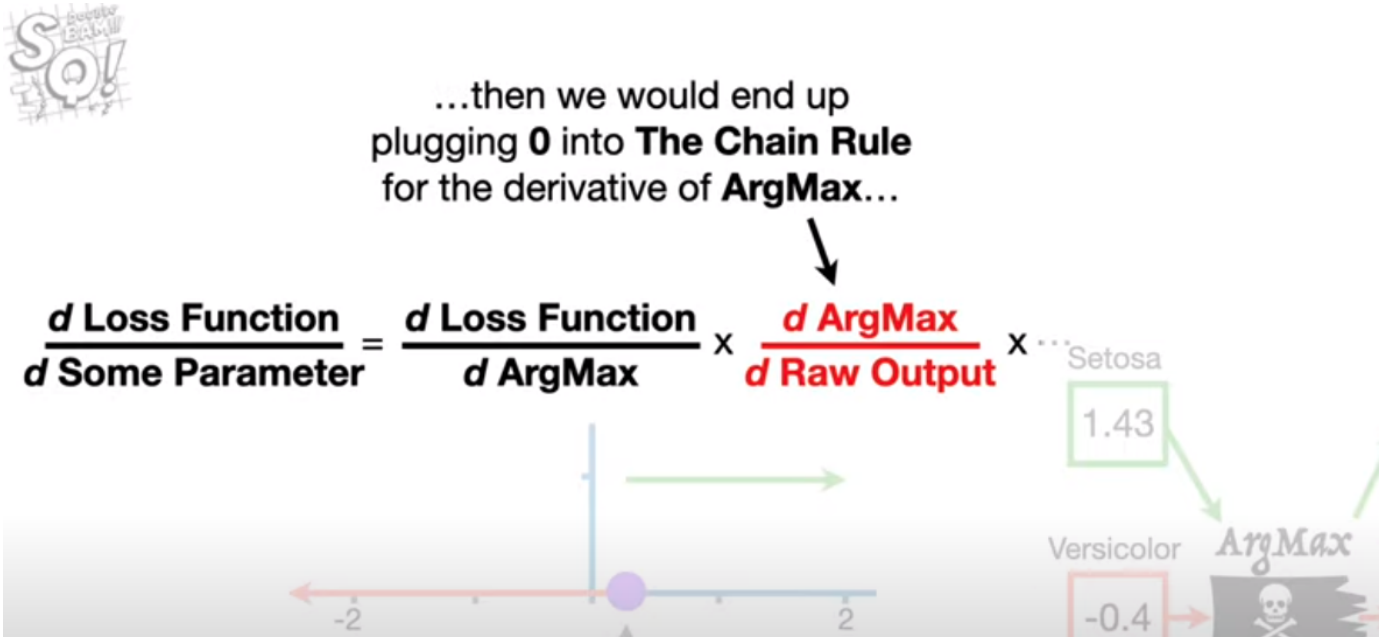
The only problem is that we can't use argmax to optimize weights and biases since its derivative is always = 0 (as it produces a constant output always 0 or 1).

for eg:

let `x` be the second largest observation in the outputs.



Any number greater than `x` is the largest number and is converted to `1`, on the other hand, rest of the observations are converted to `0`. This shows that both the lines have `slope = 0`, and hence, their `derivative is also 0`.



The whole derivative would become 0, and hence Gradient descent won't proceed.

Softmax:

SoftMax function uses the formulae:

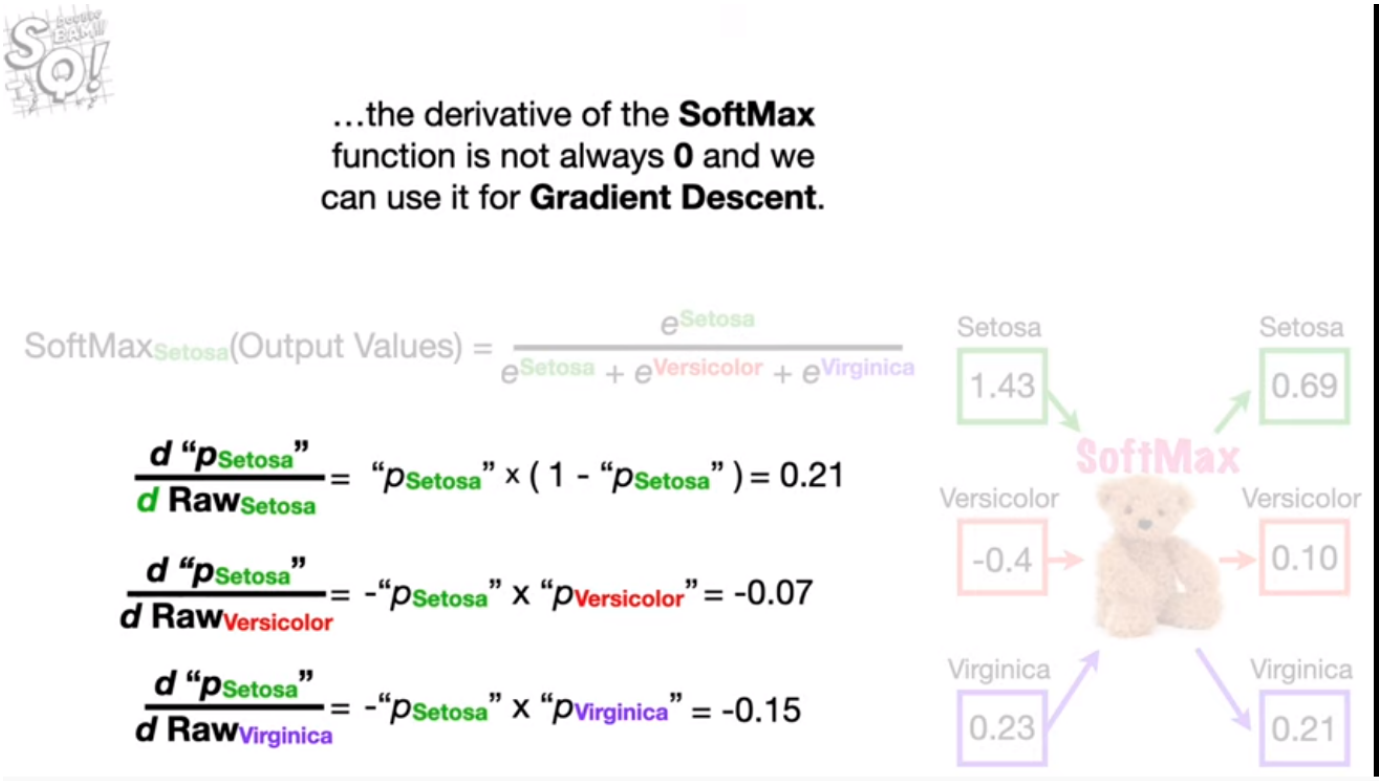
$$softmax_{(output\ value)_i} = \frac{e^{(output\ value)_i}}{\sum_{j=1}^{n} e^{(output\ value)_j}}$$

here,

- `i` is one of the output values
- the denominator is the sum of exponentials of all output values.

In simple manner:

$$e^x / (e^x + e^y + e^z)$$



The derivatives are obtained by simple `Quotient Rule of Derivatives`.

Quotient Rule:

$$\frac{dy}{dx} = \frac{u'v - uv'}{v^2}$$

where, $y = \frac{u}{v};\ u' = \frac{du}{dx};\ v' = \frac{dv}{dx}$

Conclusion:

- Neural Networks with multiple outputs use **SOFTMAX** for **Training**.
- And, use **ARGMAX**, which has easy to understand outputs, to make classification of new observations.

Reference links:

1. https://www.youtube.com/watch?v=KpKog-L9veg&list=PLblh5JKOoLUIxGDQs4LFFD--41Vzf-ME1&index=9
2. https://medium.com/@s_hash_wat/argmax-and-softmax-496714956aab