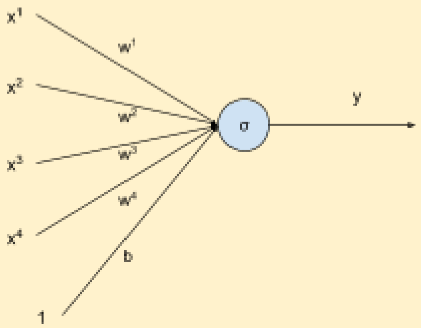
PadhAI: Variants of Gradient Descent

One Fourth Labs

Why do we need an adaptive learning rate?

Why do we need an adaptive learning rate for every feature?

1. Consider input data with 4 features being processed through a sigmoid neuron



2. Here $y = f(x) = \frac{1}{1+e^{-(w.x+b)}}$
   a. $x = \{x^1, x^2, x^3, x^4\}$
   b. $w = \{w^1, w^2, w^3, w^4\}$
3. From our gradient formula, we know that the value of the input feature plays a role in the gradient calculation i.e. $\nabla w^n = (f(x) - y) \, * \, f(x) \, * \, (1 - f(x)) \, * \, x^n$
4. In real world scenarios, many features in the data are **sparse**, i.e. they take on a 0 value for most of the training inputs. Therefore, the derivatives corresponding to these 0 valued points are also 0, and the weight update is going to be 0.
5. To aid these sparse features, a larger learning rate can be applied to the **non-zero valued points** of these sparse features.
6. Example:
   a. Consider a subject at college that you are taught for only 5 minutes a day
   b. For those 5 minutes, maximising your attention span would allow for maximum knowledge retention
   c. In this case, the 5-minute subject would be a sparse feature i.e. a feature that does not occur very often in the training data
   d. And the attention span would be our learning rate. A high learning rate for the sparse features allows us to maximise the learning (weight updation) we get from it.
7. Conversely, **dense** features are those with non-zero values for most of the data points. They must be dealt with by using a lower learning rate.
8. Can we have a different learning rate for each parameter(weights) which takes care of the frequency(sparsity/density) of features?