INTRODUCTION TO GRADIENT DESCENT

Gradient descent is an optimization algorithm that's used when training a machine learning model. It's based on a convex function and tweaks its parameters iteratively to minimize a given function to its local minimum.

WHAT IS GRADIENT DESCENT?

Gradient Descent is an optimization algorithm for finding a local minimum of a differentiable function. Gradient descent is simply used to find the values of a function's parameters (coefficients) that minimize a cost function as far as possible.

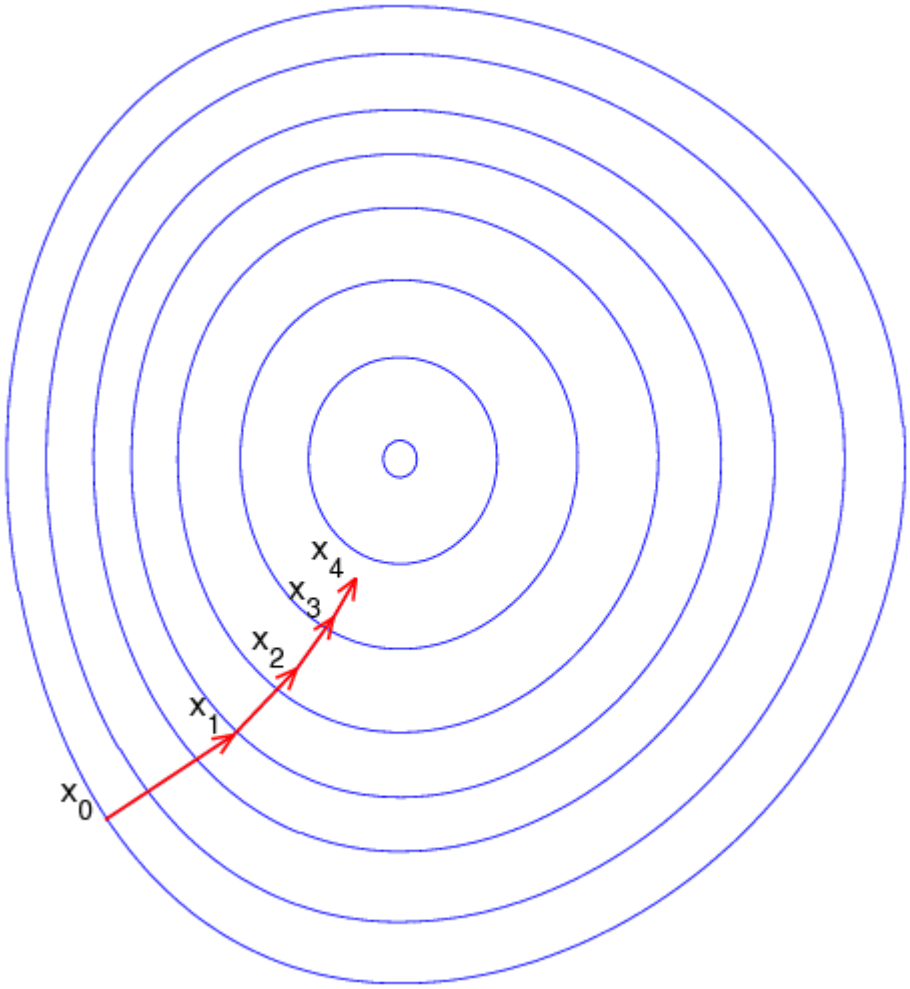
You start by defining the initial parameter's values and from there gradient descent uses calculus to iteratively adjust the values so they minimize the given cost-function. To understand this concept full, it's important to know about gradients.

WHAT IS A GRADIENT?

A gradient simply measures the change in all weights with regard to the change in error. You can also think of a gradient as the slope of a function. The higher the gradient, the steeper the slope and the faster a model can learn. But if the slope is zero, the model stops learning. In mathematical terms, a gradient is a partial derivative with respect to its inputs.

Imagine a blindfolded man who wants to climb to the top of a hill with the fewest steps along the way as possible. He might start climbing the hill by taking really big steps in the steepest direction, which he can do as long as he is not close to the top. As he comes closer to the top, however, his steps will get smaller and smaller to avoid overshooting it. This process can be described mathematically using the gradient.

Imagine the image below illustrates our hill from a top-down view and the red arrows are the steps of our climber. Think of a gradient in this context as a vector that contains the direction of the steepest step the blindfolded man can take and also how long that step should be.

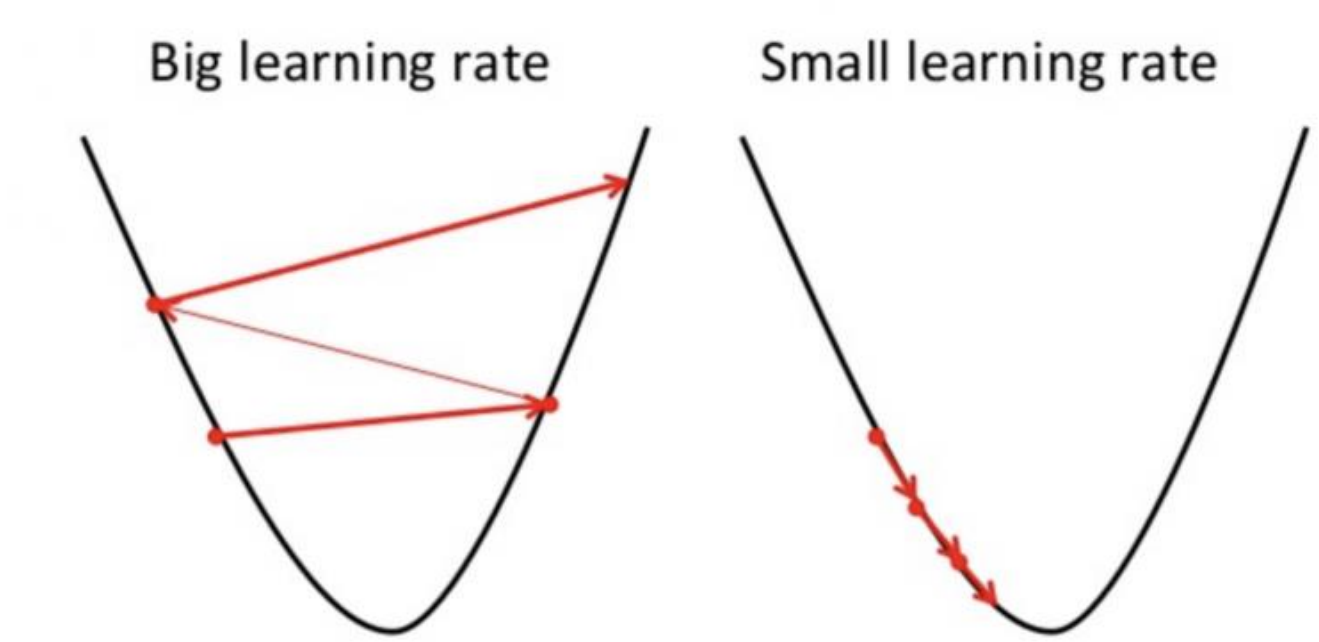


Note that the gradient ranging from X0 to X1 is much longer than the one reaching from X3 to X4. This is because the steepness/slope of the hill, which determines the length of the vector, is less. This perfectly represents the example of the hill because the hill is getting less steep the higher it's climbed. Therefore a reduced gradient goes along with a reduced slope and a reduced step size for the hill climber.

IMPORTANCE OF THE LEARNING RATE

How big the steps are gradient descent takes into the direction of the local minimum are determined by the learning rate, which figures out how fast or slow we will move towards the optimal weights.

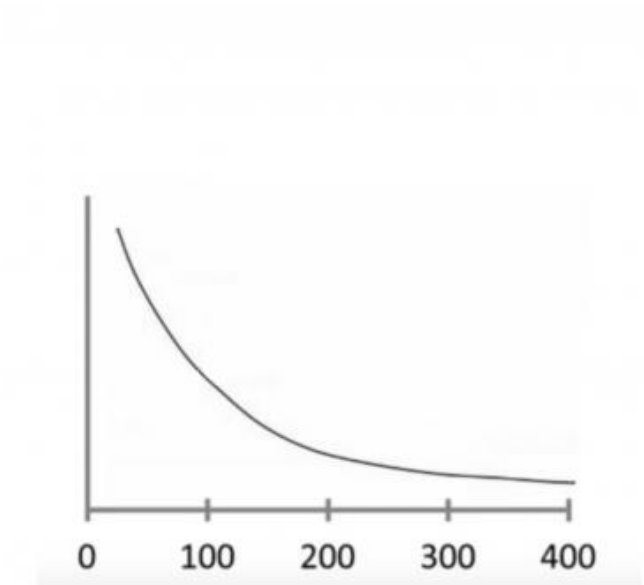
For gradient descent to reach the local minimum we must set the learning rate to an appropriate value, which is neither too low nor too high. This is important because if the steps it takes are too big, it may not reach the local minimum because it bounces back and forth between the convex function of gradient descent (see left image below). If we set the learning rate to a very small value, gradient descent will eventually reach the local minimum but that may take a while (see the right image).

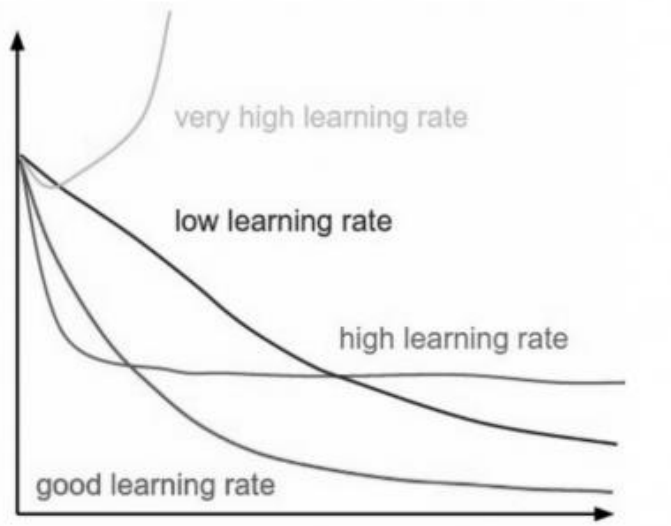


So, the learning rate should never be too high or too low for this reason. You can check if you're learning rate is doing well by plotting it on a graph.

HOW TO MAKE SURE IT WORKS PROPERLY

A good way to make sure gradient descent runs properly is by plotting the cost function as the optimization runs. Put the number of iterations on the x-axis and the value of the cost-function on the y-axis. This helps you see the value of your cost function after each iteration of gradient descent, and provides a way to easily spot how appropriate your learning rate is. You can just try different values for it and plot them all together. The left image below shows such a plot, while the image on the right illustrates the difference between good and bad learning rates.





If gradient descent is working properly, the cost function should decrease after every iteration.

Also, when starting out with gradient descent on a given problem, simply try 0.001, 0.003, 0.01, 0.03, 0.1, 0.3, 1, etc., as the learning rates and look at which one performs the best.

Source: https://builtin.com/data-science/gradient-descent