Epoch, Iteration, and Batch size

1 epoch is to pass an entire dataset through the neural network once.

Iteration is the number of mini-batch.

Batch size is the total number of training samples present in a single min-batch.

Examples

- We can divide the dataset of 10,000 examples into mini batches of 500 then it will take 20 iterations to complete 1 epoch.
- The batch size is usually 2^2, 2^3, 2^4, 2^5 [...] based on GPU memory.

Gradient Descent

- Gradient descent is an optimization algorithm used to minimize some functions by moving in a certain direction.
- Gradient descent in machine/deep learning is used to update the parameters of models. (weights in neural networks)
- Gradient descent is very useful for supervised learning.

x	y
2	4
3	6
4	8
5	10
6	12

$$y = x * 2$$

x	y
2	6
3	9
4	12
5	15
6	18

$$y = x * 3$$

x	y
2	-1.5
3	-1
4	-0.5
5	0
6	0.5

Gradient Descent helps you find these parameters.

$$y = x * 0.5 - 2.5$$

Weight Bias

x	y
2	8
3	11
4	14
5	17
6	20

y = x * 3 + 2

Binary Classification

Age	Have_Car	Have_Insurance
21	0	0
48	1	1
28	0	0
19	0	0
56	1	1
65	1	1
32	1	0
24	0	1
43	1	0
22	0	0
53	1	1

x

y

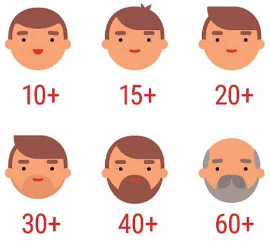
$$y = f(x)$$

Binary Cross Entropy (Log Loss) =

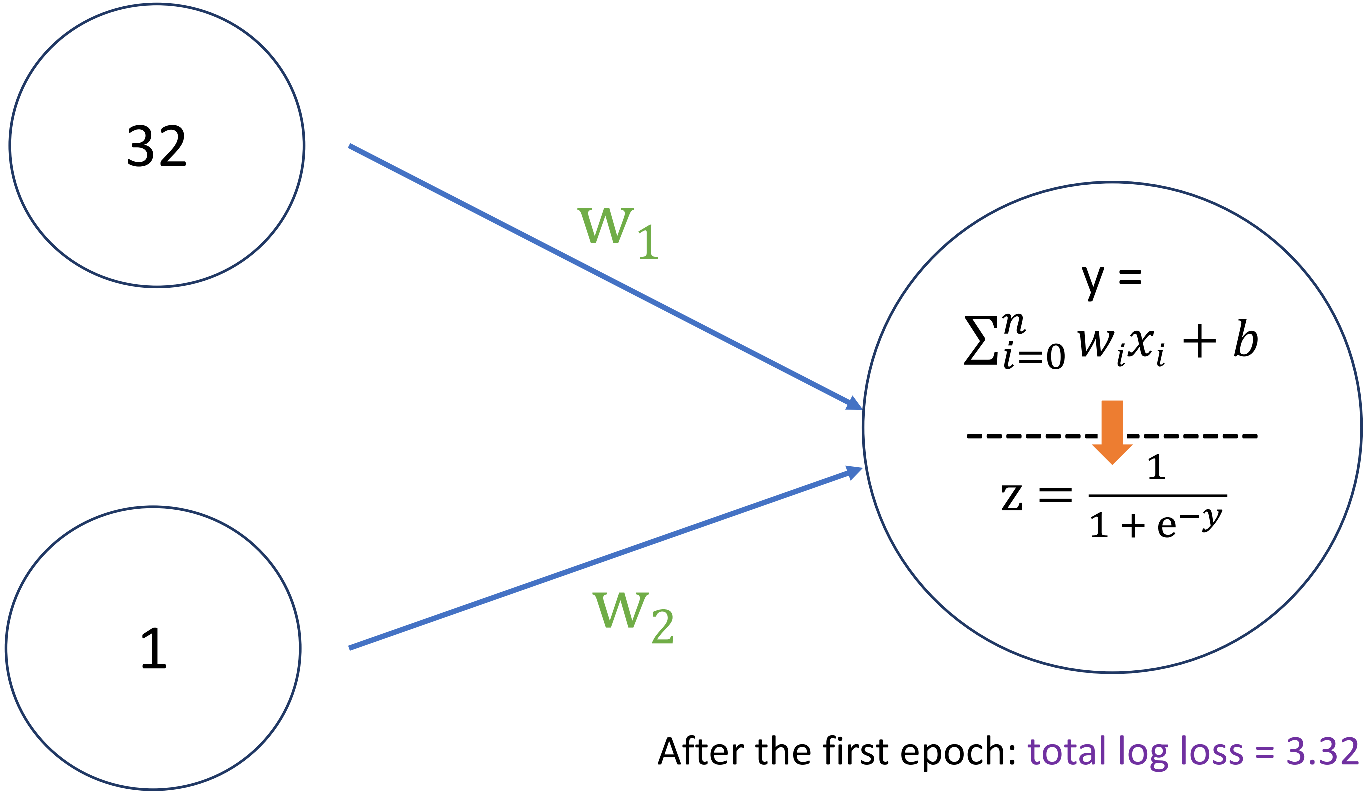
$$-\frac{1}{n}\sum_{i=0}^{n} y_i * \log(\hat{y}_i) + (1 - yi) * \log(1-(\hat{y}_i))$$

Age	Have_Car	Have_Insurance
21	0	0
48	1	1
28	0	0
19	0	0
56	1	1
65	1	1
32	1	0
24	0	1
43	1	0
22	0	0
53	1	1

Age



Have_Car



After the first epoch: total log loss = 3.32

y = w_1 * X_1 + w_2 * X_2 + bias

$$w_1 = w_1 - \text{learning rate} * \partial / \partial w_1$$

$$w_2 = w_2 - \text{learning rate} * \partial / \partial w_2$$

$$w_3 = w_3 - \text{learning rate} * \partial / \partial w_3$$

$$b = b - \text{learning rate} * \partial / \partial b$$

Learning rate is normally 0.01.

$w_1 = w_1 -$ learning rate * $\partial/\partial w_1$

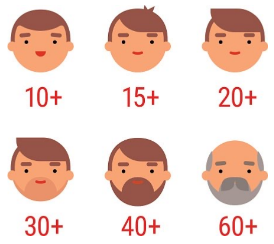
$\partial/\partial w_1 = \frac{1}{n}\sum_{i=1}^{n} x_i(\hat{y}_i - yi)$

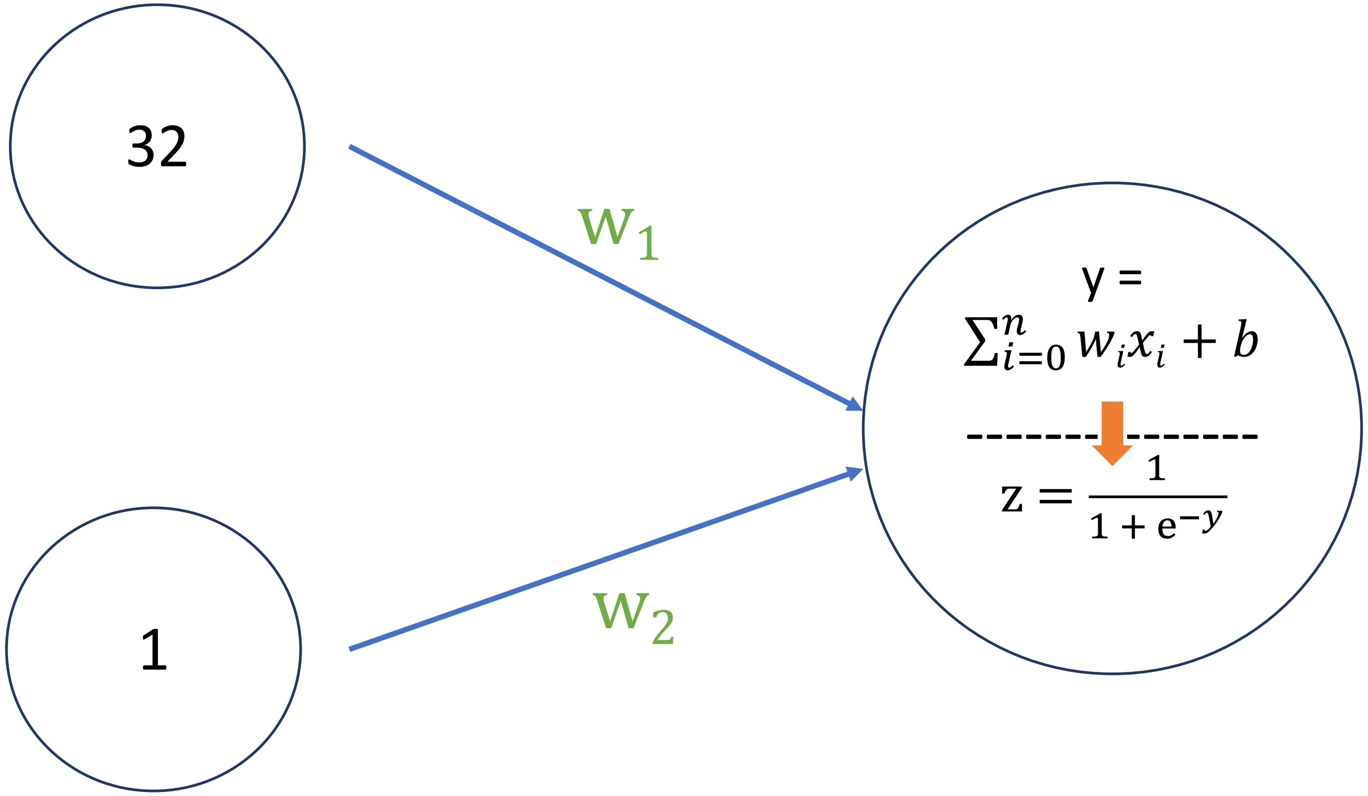
$b = b -$ learning rate * $\partial/\partial b$

$\partial/\partial b = \frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - yi)$

epoch = 1

Age





Have_Car

$w_1 = w_1$ – learning rate * $\partial / \partial w_1$

$w_1 = 1 - 0.2 = 0.8$

$w_2 = w_2$ – learning rate * $\partial / \partial w_2$

$w_2 = 0.9 - 0.15 = 0.75$

$b = b$ – learning rate * $\partial / \partial b$

$b = 0 - 0.2 = -0.2$

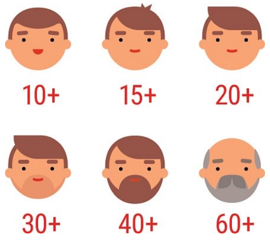
$y = w_1 * X_1 + w_2 * X_2 + \text{bias}$

$y = 1 * X_1 + 1 * X_2 + 0$

$$MAE = \frac{1}{n}\sum_{i=0}^{n} abs(y_i - \hat{y}_i)$$

Age	Have_Car	Have_Insurance
21	0	0
48	1	1
28	0	0
19	0	0
56	1	1
65	1	1
32	1	0
24	0	1
43	1	0
22	0	0
53	1	1

Age



Have_Car

32

1

$y = w_1 * X_1 + w_2 * X_2 + bias$

$w_1=1$

$w_2=1$

bias=0

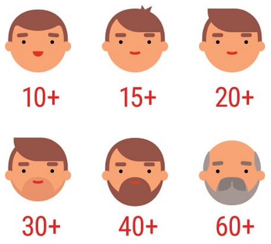
$$y = \sum_{i=0}^{n} w_i x_i + b$$

$$z = \frac{1}{1 + e^{-y}}$$

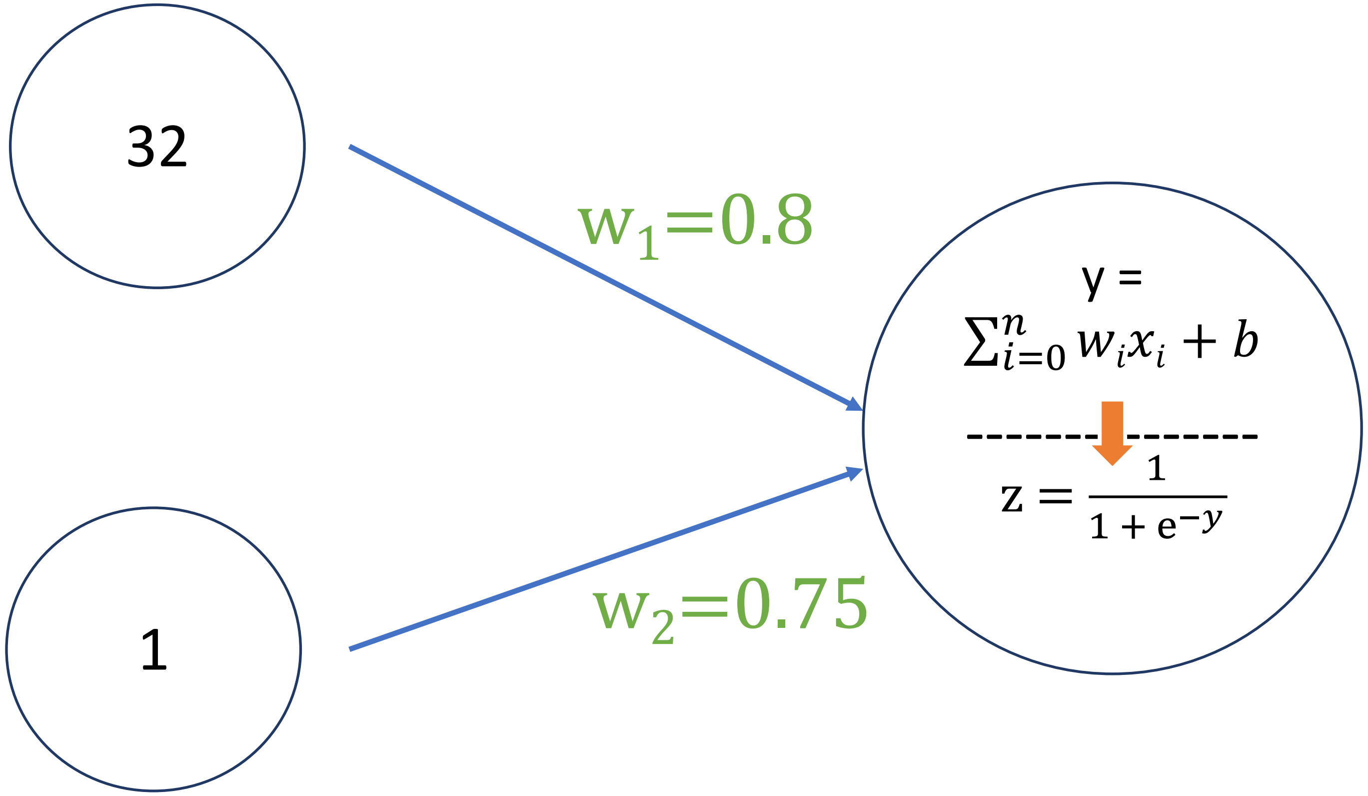
Total Error = $error_1 + error_2 + error_3 + \ldots$

epoch = 2

Age



Have_Car



w_1 = w_1 – learning rate * $\partial / \partial w_1$

w_1 = 0.8 – 0.1 = 0.7

w_2 = w_2 – learning rate * $\partial / \partial w_2$

w_2 = 0.75 – 0.15 = 0.6

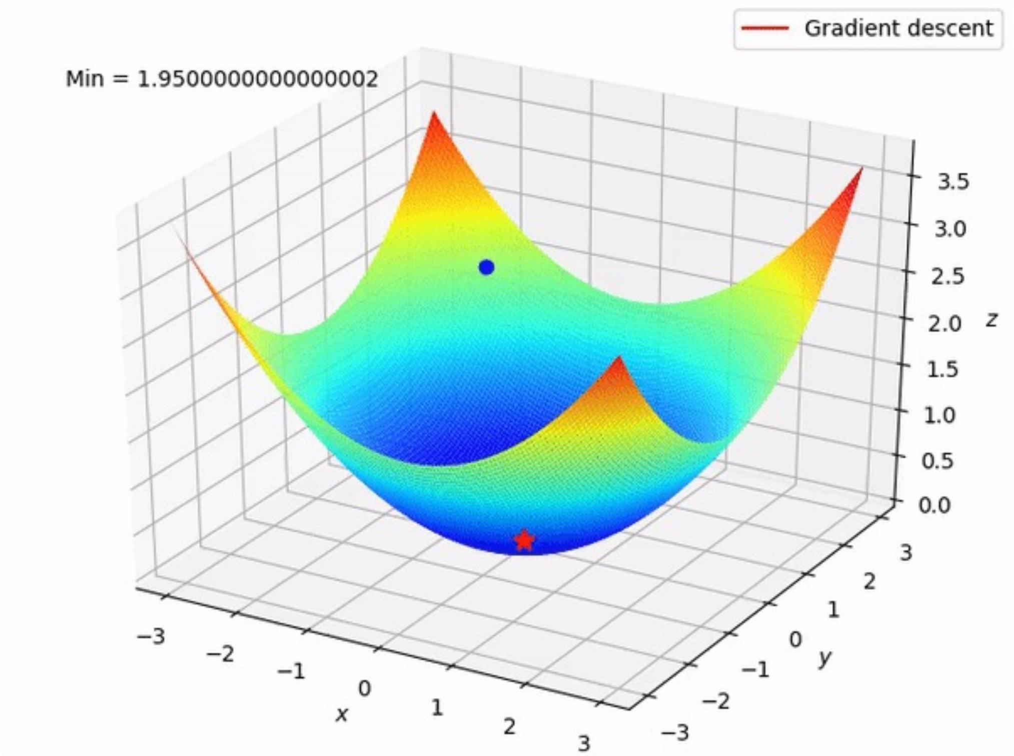
b = b – learning rate * $\partial / \partial b$

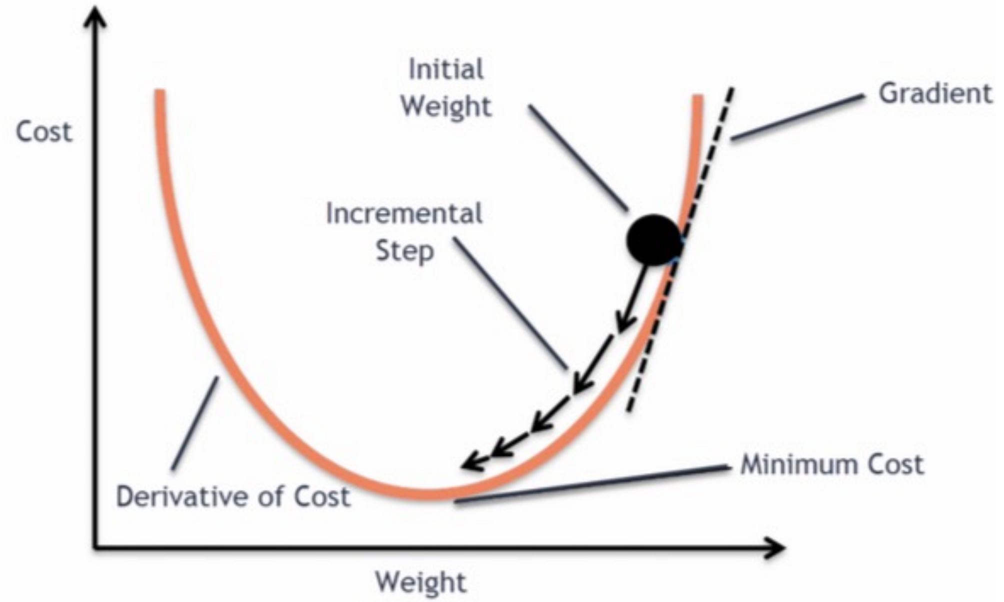
b = -0.2 – 0.1 = -0.3

y = w_1 * X_1 + w_2 * X_2 + bias

y = 0.8 * X_1 + 0.75 * X_2 – 0.2

Gradient Descent

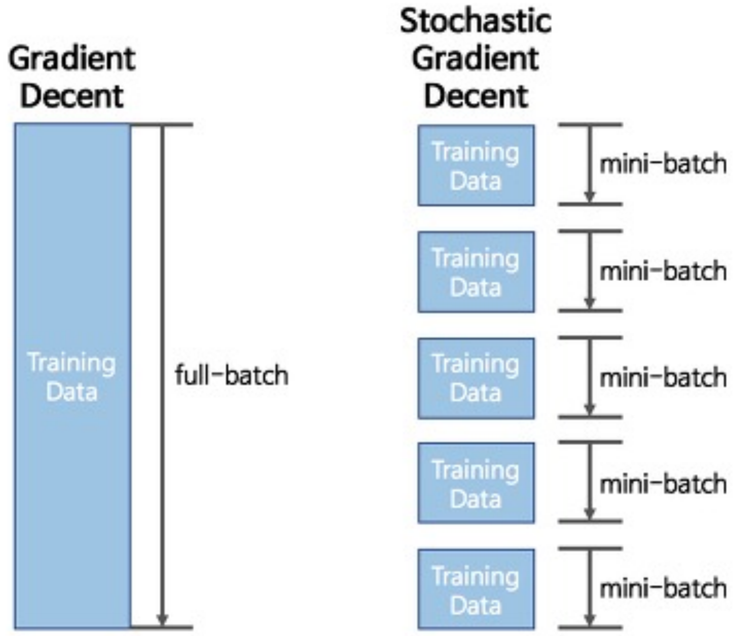




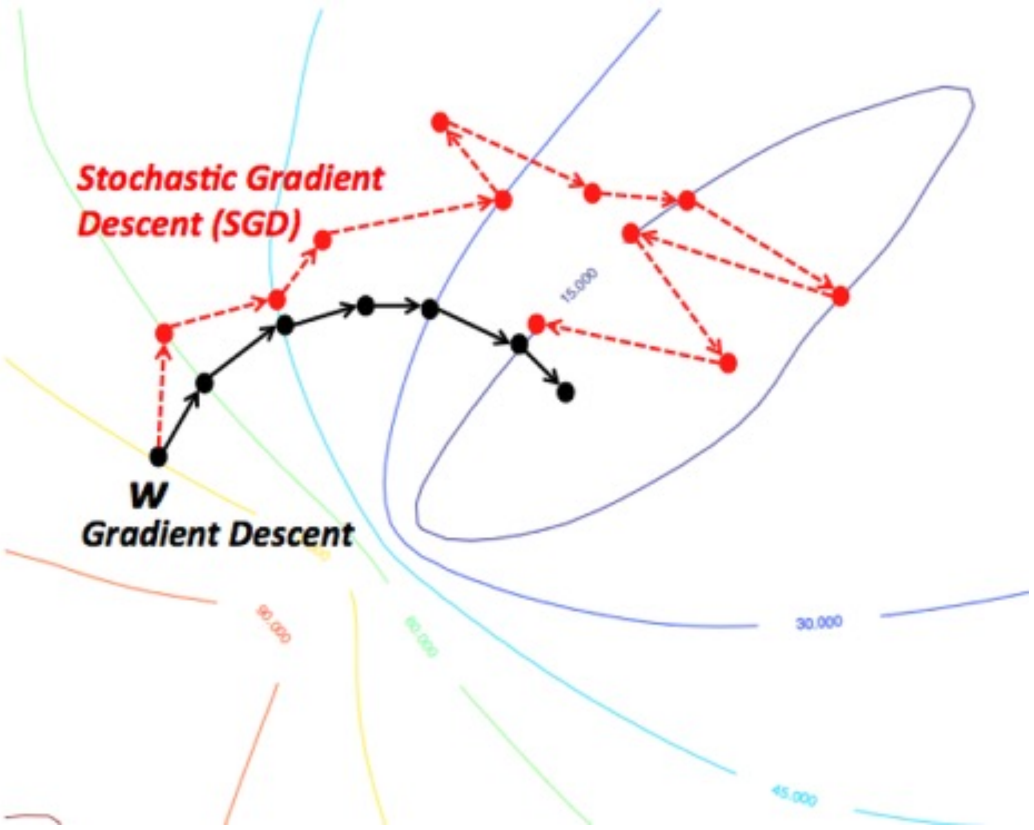
Gradient Descent

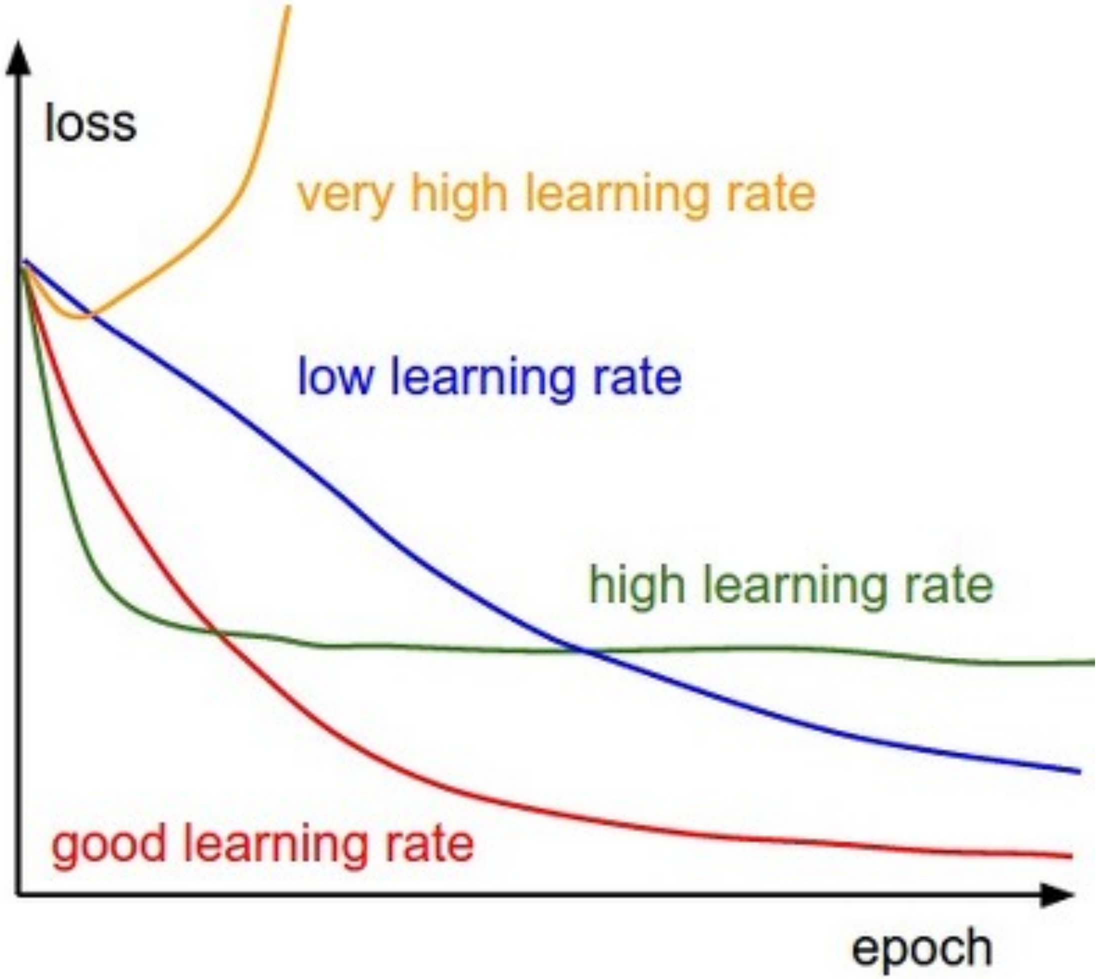
Batch Gradient Descent updates parameters for the entire training dataset.

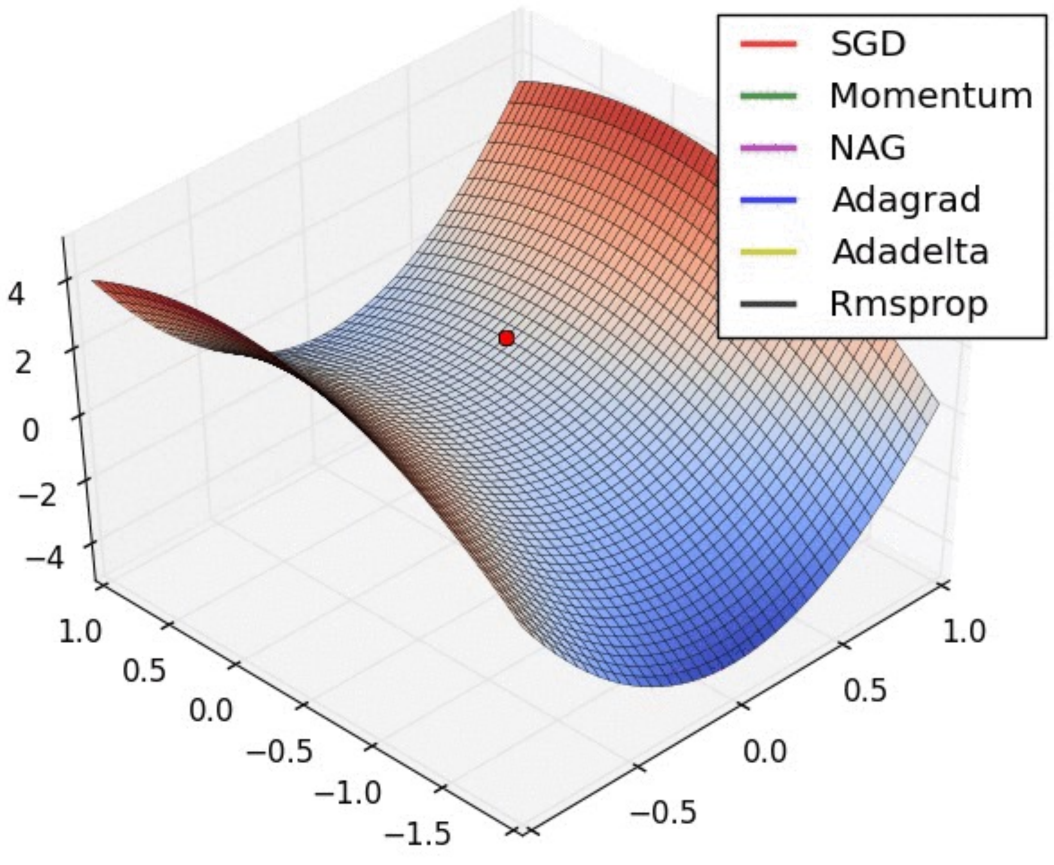
Stochastic Gradient Descent updates parameters for each training example and label.

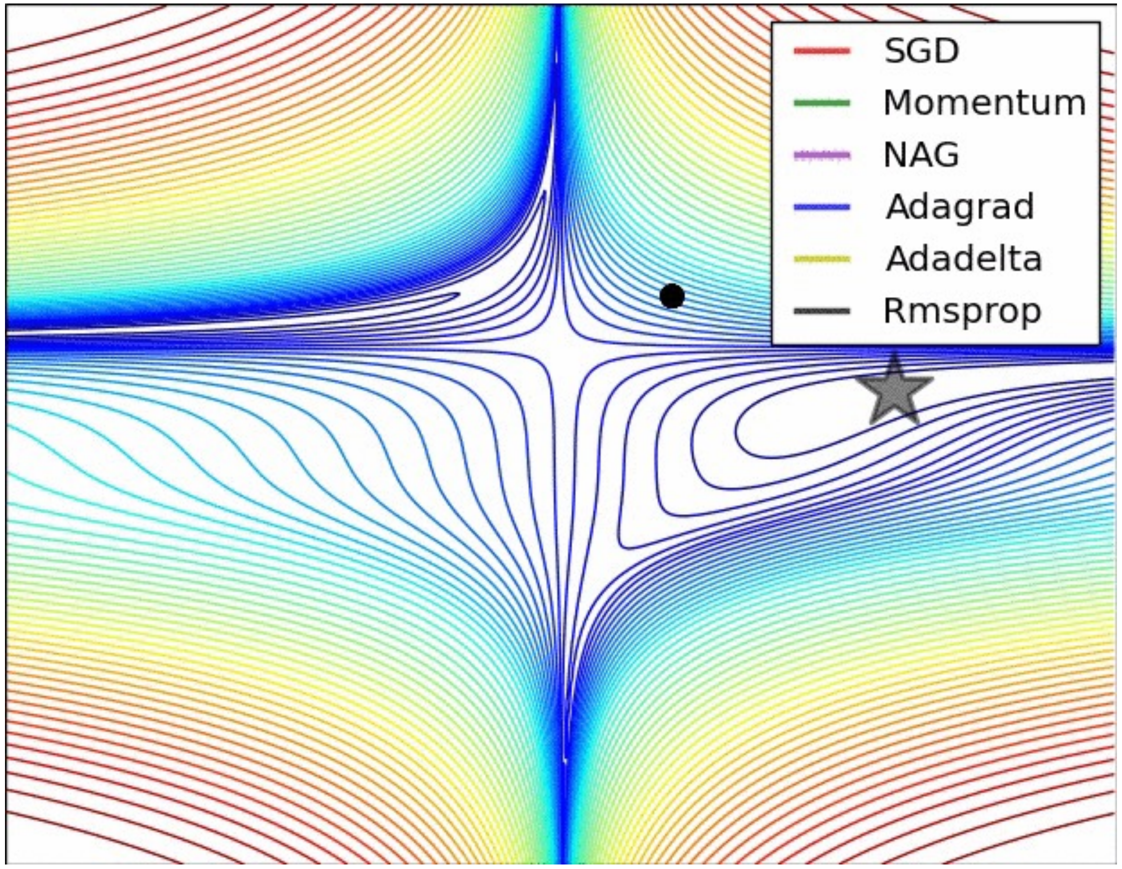


Mini-batch Gradient Descent is a mixture of Batch Gradient Descent and Stochastic Gradient Descent.


Stochastic Gradient
Descent (SGD)
W
Gradient Descent


loss
very high learning rate
low learning rate
high learning rate
good learning rate
epoch


SGD
Momentum
NAG
Adagrad
Adadelta
Rmsprop
4
2
0
−2
−4
1.0
0.5
0.0
−0.5
−1.0
−1.5
1.0
0.5
0.0
−0.5


SGD
Momentum
NAG
Adagrad
Adadelta
Rmsprop

Batch Gradient Descent (BGD)

```
for i in range(m):
        gradient=evaluate_gradient(training_data)
        weight=weight-learning_rate * gradient
```

Stochastic Gradient Descent (SGD)

```
for i in range(m):
        np.random.shuffle(training_data)
        for one_data in training_data:
                gradient=evaluate_gradient(one_data)
                weight=weight-learning_rate * gradient
```

Mini-batch Gradient Descent

```
for i in range(m):
    np.random.shuffle(training_data)
    for one_batch in get_mini_batches(training_data,one_batch_size=32):
        gradient=evaluate_gradient(one_batch)
        weight=weight-learning_rate * gradient
```

PyTorch: Optimizer

- **optimizer = optim.SGD(model.parameters(), lr=**0.01**, momentum=**0.9**)**
- **optimizer = optim.Adam([var1, var2], lr=**0.0001**)**
  (https://pytorch.org/docs/stable/optim.html)

TensorFlow-Keras: Optimizer

- **tf.keras.optimizers.SGD**
- **tf.keras.optimizers.Adam**
- **https://pytorch.org/docs/stable/optim.html#module-torch.optim**