AdaGrad often performs well for simple quadratic problems, but unfortunately it often stops too early when training neural networks. The learning rate gets scaled down so much that the algorithm ends up stopping entirely before reaching the global optimum. So even though TensorFlow has an `AdagradOptimizer`, you should not use it to train deep neural networks (it may be efficient for simpler tasks such as Linear Regression, though).

RMSProp

Although AdaGrad slows down a bit too fast and ends up never converging to the global optimum, the *RMSProp* algorithm[14] fixes this by accumulating only the gradients from the most recent iterations (as opposed to all the gradients since the beginning of training). It does so by using exponential decay in the first step (see Equation 11-7).

Equation 11-7. RMSProp algorithm

1. $\mathbf{s} \leftarrow \beta \mathbf{s} + (1 - \beta) \nabla_\theta J(\theta) \otimes \nabla_\theta J(\theta)$
2. $\theta \leftarrow \theta - \eta \, \nabla_\theta J(\theta) \oslash \sqrt{\mathbf{s} + \epsilon}$

The decay rate β is typically set to 0.9. Yes, it is once again a new hyperparameter, but this default value often works well, so you may not need to tune it at all.

As you might expect, TensorFlow has an `RMSPropOptimizer` class:

```
optimizer = tf.train.RMSPropOptimizer(learning_rate=learning_rate,
                                      momentum=0.9, decay=0.9, epsilon=1e-10)
```

Except on very simple problems, this optimizer almost always performs much better than AdaGrad. It also generally performs better than Momentum optimization and Nesterov Accelerated Gradients. In fact, it was the preferred optimization algorithm of many researchers until Adam optimization came around.

Adam Optimization

Adam,[15] which stands for *adaptive moment estimation*, combines the ideas of Momentum optimization and RMSProp: just like Momentum optimization it keeps track of an exponentially decaying average of past gradients, and just like RMSProp it keeps

14 This algorithm was created by Tijmen Tieleman and Geoffrey Hinton in 2012, and presented by Geoffrey Hinton in his Coursera class on neural networks (slides: *http://goo.gl/RsQeis*; video: *https://goo.gl/XUbIyJ*). Amusingly, since the authors have not written a paper to describe it, researchers often cite "slide 29 in lecture 6" in their papers.

15 "Adam: A Method for Stochastic Optimization," D. Kingma, J. Ba (2015).