

# Optimizing Neural Networks

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# Agenda

- Neural Networks Quiz
- Advanced Optimizers beyond SGD
- Dropout for Regularization
- Batch Normalization for Regularization
- Weight Initialization Techniques

# Let's begin the discussion by answering a few questions on neural networks

# Neural Networks Quiz

What does momentum in SGD with Momentum help achieve?

A

Accelerates convergence using past gradients

B

Adjusts learning rates adaptively

C

Reduces the variance of gradient updates

D

Prevents overshooting during optimization

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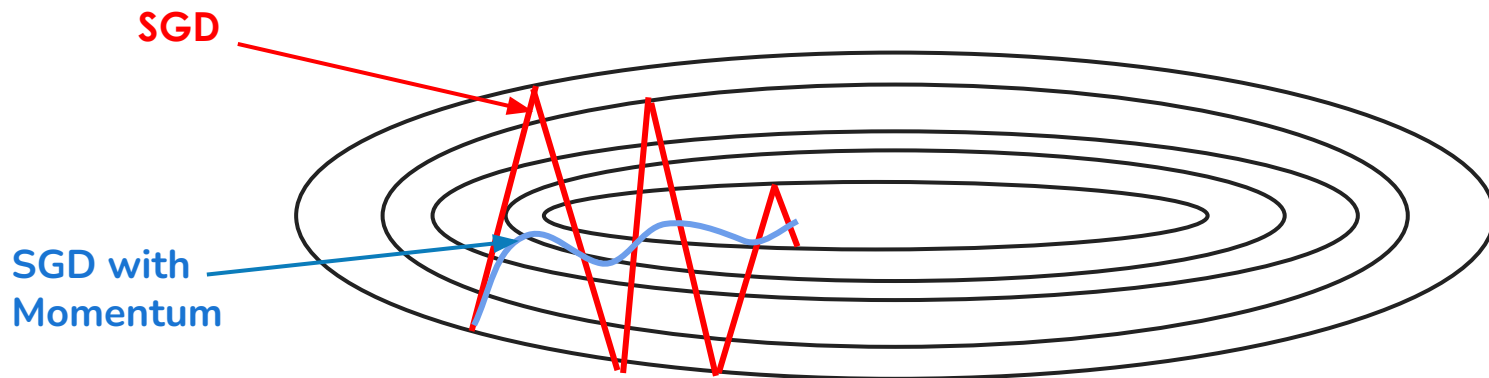
D

Prevents overshooting during optimization

# Stochastic Gradient Descent with Momentum

SGD with momentum **accelerates convergence** by incorporating past gradients to maintain a consistent direction towards the minima

Momentum enhances this process by **reducing oscillations** and **facilitating smoother optimization trajectories**



# Neural Networks Quiz

Which statement correctly describes how Adam and SGD with Momentum handle the learning rate?

A

The learning rate is constant throughout training for both Adam and SGD with Momentum.

B

Adam adjusts the learning rates separately for each parameter, while SGD with Momentum maintains a fixed learning rate.

C

SGD with Momentum changes the learning rate depending on gradient magnitude, whereas Adam sticks to a consistent learning rate.

D

Both Adam and SGD with Momentum utilize a dynamic learning rate approach throughout the training process.

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# Learning Rates in ADAM & SGD with momentum

## SGD with Momentum

Stochastic Gradient Descent with Momentum

Adds a momentum component

Fixed Learning Rate

## Adam

Adaptive Moment Estimation

Adds a momentum component

Adaptive Learning Rate

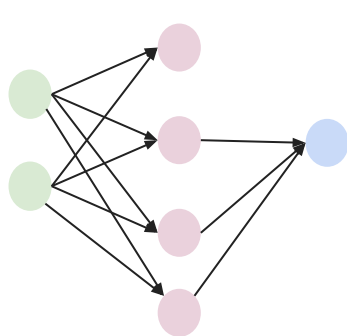
The learning rate is different for each model parameter and depends on the value of the gradient

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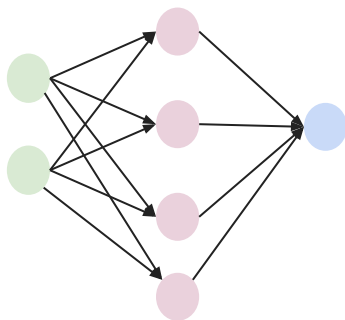
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# Neural Networks Quiz

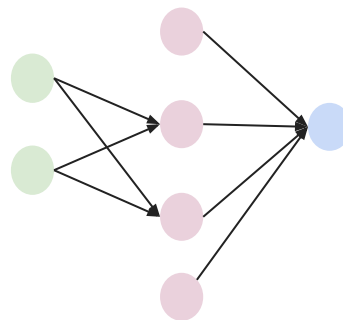
Which of the following neural networks best represents a dropout rate of 0.5?



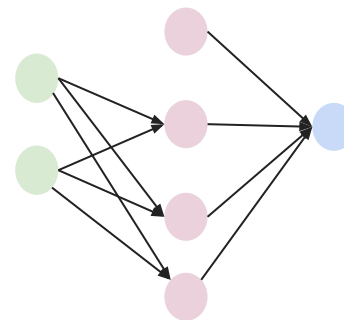
A



B



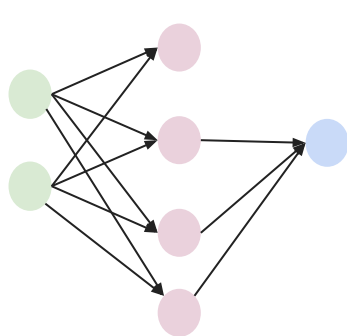
C



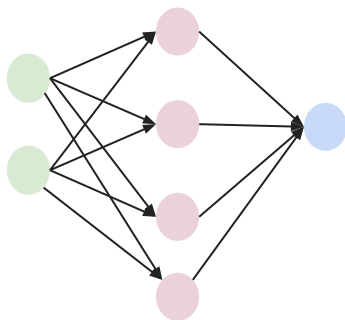
D

# Neural Networks Quiz

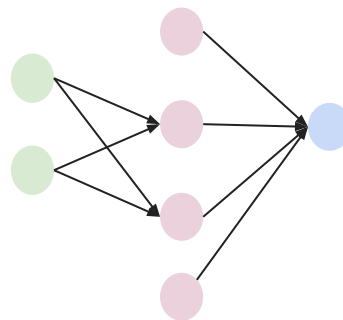
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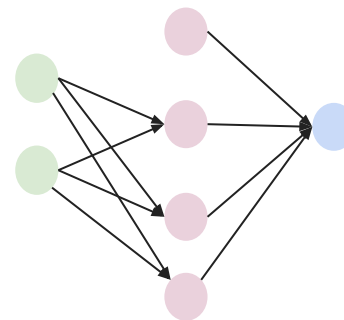
A



B



C



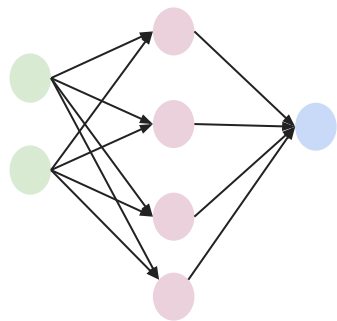
D

# Dropout

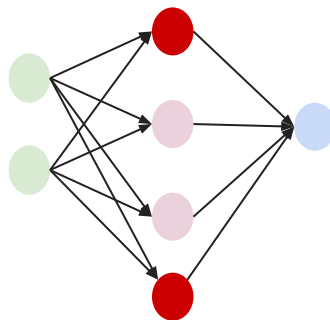
**Step 1** - Choose a dropout rate  $p$  ( $p = 0.5$  here)

**Step 2** - Randomly select  $100 \cdot p\%$  of the neurons (50% here)

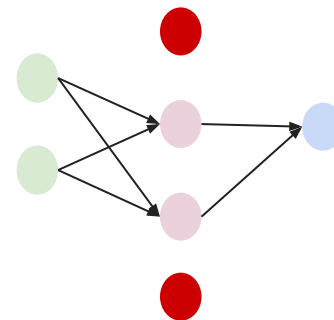
**Step 3** - Deactivate the selected neurons by setting them to zero.



1



2



3

# Neural Networks Quiz

How does Dropout contribute to dealing with overfitting in neural networks?

A

Decreasing the complexity of the neural network

B

Increasing the complexity of the neural network

C

Changing the activation function of a neuron

D

By adding Gaussian noise to the input

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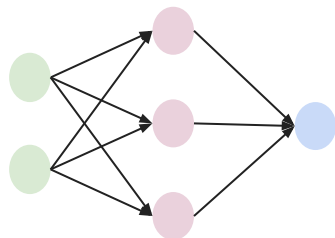
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# Dropout for Regularization

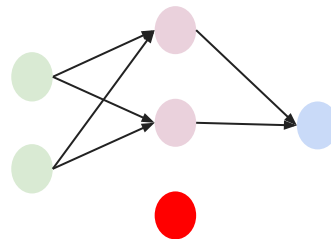
**Dropout prevents overfitting** by randomly deactivating neurons during training

**Independence:** Fosters independent learning among neurons

**Ensemble:** Creates a diverse ensemble of networks as neurons are deactivated randomly during training and the final result is an average prediction



**Before Dropout**



**After Dropout**

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# Neural Networks Quiz

How many learnable parameters are there in a batch normalization layer?

A

4

B

3

C

0

D

2

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# Neural Networks Quiz

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# Batch Normalization - Working

**Step 1 - Normalization:** Normalize  $X$  (input) by subtracting its mean and dividing by its standard deviation.

**No learnable parameters in Step 1**

**Step 2 - Scaling:** Scale the output of Step 1 by multiplying it with a learnable parameter  $\gamma$

**Step 3 - Shifting:** Shift the output of Step 2 by adding an offset (learnable parameter  $\beta$ )

# Neural Networks Quiz

Which of the following accurately describes the purpose of batch normalization in neural networks?

A

Minimizing overfitting by adding noise to the input data.

B

Preventing vanishing gradients by initializing weights appropriately.

C

Reducing internal covariate shift by normalizing layer activations.

D

Decreasing model complexity by adding more parameters.

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# Batch Normalization - Purpose

**Stabilizing Training:** Reduces internal covariate shift.

**Regularization:** Acts as a form of regularization.

**Improved Gradient Flow:** Enhances gradient flow for faster convergence.

# Neural Networks Quiz

How does weight initialization contribute to improved learning in a neural network?

A

By introducing uniform gradients.

B

By ensuring symmetric neuron behavior.

C

By adjusting initial weights.

D

By hindering adaptation.

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# Weight Initialization

**Sets up the starting point for learning in a neural network**

Helps break symmetry among neurons

Prevents gradient problems

Makes learning faster and more efficient overall



# Neural Networks Quiz

What is the common problem that can arise when weights are initialized randomly in a neural network?

A

Vanishing Gradients

B

Exploding Gradients

C

Vanishing or Exploding Gradients

D

Learning rate becoming too high

# Neural Networks Quiz

What is the common problem that can arise when weights are initialized randomly in a neural network?

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Vanishing or Exploding Gradients

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Learning rate becoming too high

# Weight Initialization

**Randomly initializing weights** in a neural network can lead to **two critical problems** during training

**Vanishing gradients:** Occurs when the gradients (derivatives) become extremely small, slowing down or halting the learning process

**Exploding gradients:** Occurs when the gradients become excessively large, causing instability and hindering effective learning

Specific weight initialization strategies help overcome these problems

**Xavier (or Glorot) Initialization** - sigmoid and tanh activations

**He Initialization** - ReLU and variants of ReLU

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# Happy Learning !

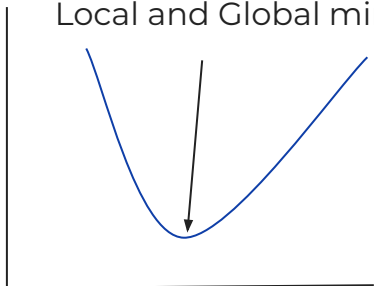


# APPENDIX

# Need for Advanced Optimizers

## Convex Optimization

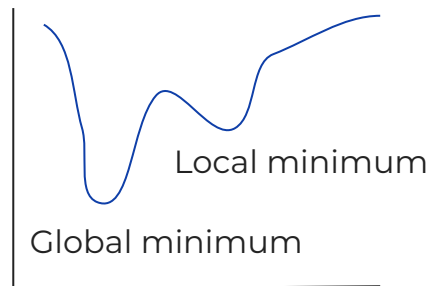
Local and Global minima



**Efficient optimization,  
Global convergence**

**Guaranteed global  
convergence under  
conditions**

## Non-Convex Optimization



**Complex, Local optima,  
Challenging optimization**

**No guarantee, Prone to local  
optima**