**Тема:** Остаточные свёрточные нейронные сети. Батч-нормализация

**Цель:** реализовать сверточную сеть с блоками слоев с соединениями напрямую (остаточными блоками)

**Особенности реализации:** torch.nn, использована выборка CIFAR-10 (<https://www.cs.toronto.edu/~kriz/cifar.html>)

Изображение выглядит как снимок экрана, коллаж

Контент, сгенерированный ИИ, может содержать ошибки.  
**Эксперимент:**

Код тут: <https://colab.research.google.com/drive/1t80kK6zyoOnEfT0n_DwjF04cZMEkRTg->

Я реализовала сверточную сеть с остаточными блоками с соединением напрямую с батч нормализацией и функцией активации ReLU. Для подбора параметров, при которых достигается наивысшее качество классификации, я перебрала разные значения параметров  
**Изображение выглядит как текст, снимок экрана, Шрифт

Контент, сгенерированный ИИ, может содержать ошибки.  
Результаты эксперимента:**

Testing config: {'epochs': 10, 'learning\_rate': 0.001, 'num\_blocks': 2, 'base\_channels': 32, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 47.73%

Epoch 2/10 | Val Acc: 55.21%

Epoch 3/10 | Val Acc: 54.37%

Epoch 4/10 | Val Acc: 63.60%

Epoch 5/10 | Val Acc: 63.10%

Epoch 6/10 | Val Acc: 66.39%

Epoch 7/10 | Val Acc: 69.37%

Epoch 8/10 | Val Acc: 63.06%

Epoch 9/10 | Val Acc: 66.59%

Epoch 10/10 | Val Acc: 72.27%

New best config! Acc: 72.27%

Testing config: {'epochs': 10, 'learning\_rate': 0.001, 'num\_blocks': 2, 'base\_channels': 32, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 48.79%

Epoch 2/10 | Val Acc: 56.76%

Epoch 3/10 | Val Acc: 60.98%

Epoch 4/10 | Val Acc: 62.48%

Epoch 5/10 | Val Acc: 65.90%

Epoch 6/10 | Val Acc: 65.94%

Epoch 7/10 | Val Acc: 61.22%

Epoch 8/10 | Val Acc: 57.93%

Epoch 9/10 | Val Acc: 71.82%

Epoch 10/10 | Val Acc: 72.28%

New best config! Acc: 72.28%

Testing config: {'epochs': 10, 'learning\_rate': 0.001, 'num\_blocks': 2, 'base\_channels': 64, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 50.55%

Epoch 2/10 | Val Acc: 58.92%

Epoch 3/10 | Val Acc: 61.44%

Epoch 4/10 | Val Acc: 60.44%

Epoch 5/10 | Val Acc: 64.86%

Epoch 6/10 | Val Acc: 67.57%

Epoch 7/10 | Val Acc: 59.46%

Epoch 8/10 | Val Acc: 72.71%

Epoch 9/10 | Val Acc: 74.70%

Epoch 10/10 | Val Acc: 74.10%

New best config! Acc: 74.70%

Testing config: {'epochs': 10, 'learning\_rate': 0.001, 'num\_blocks': 2, 'base\_channels': 64, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 49.07%

Epoch 2/10 | Val Acc: 59.72%

Epoch 3/10 | Val Acc: 56.88%

Epoch 4/10 | Val Acc: 62.59%

Epoch 5/10 | Val Acc: 65.24%

Epoch 6/10 | Val Acc: 68.95%

Epoch 7/10 | Val Acc: 72.32%

Epoch 8/10 | Val Acc: 75.16%

Epoch 9/10 | Val Acc: 74.22%

Epoch 10/10 | Val Acc: 72.94%

New best config! Acc: 75.16%

Testing config: {'epochs': 10, 'learning\_rate': 0.001, 'num\_blocks': 3, 'base\_channels': 32, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 54.04%

Epoch 2/10 | Val Acc: 64.15%

Epoch 3/10 | Val Acc: 66.89%

Epoch 4/10 | Val Acc: 72.08%

Epoch 5/10 | Val Acc: 76.08%

Epoch 6/10 | Val Acc: 76.01%

Epoch 7/10 | Val Acc: 76.71%

Epoch 8/10 | Val Acc: 78.52%

Epoch 9/10 | Val Acc: 79.01%

Epoch 10/10 | Val Acc: 80.19%

New best config! Acc: 80.19%

Testing config: {'epochs': 10, 'learning\_rate': 0.001, 'num\_blocks': 3, 'base\_channels': 32, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 57.19%

Epoch 2/10 | Val Acc: 67.59%

Epoch 3/10 | Val Acc: 66.65%

Epoch 4/10 | Val Acc: 74.04%

Epoch 5/10 | Val Acc: 75.35%

Epoch 6/10 | Val Acc: 77.19%

Epoch 7/10 | Val Acc: 79.76%

Epoch 8/10 | Val Acc: 71.67%

Epoch 9/10 | Val Acc: 79.44%

Epoch 10/10 | Val Acc: 79.55%

Testing config: {'epochs': 10, 'learning\_rate': 0.001, 'num\_blocks': 3, 'base\_channels': 64, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 55.46%

Epoch 2/10 | Val Acc: 63.73%

Epoch 3/10 | Val Acc: 64.43%

Epoch 4/10 | Val Acc: 73.16%

Epoch 5/10 | Val Acc: 79.59%

Epoch 6/10 | Val Acc: 76.21%

Epoch 7/10 | Val Acc: 76.04%

Epoch 8/10 | Val Acc: 81.22%

Epoch 9/10 | Val Acc: 80.34%

Epoch 10/10 | Val Acc: 81.48%

New best config! Acc: 81.48%

Testing config: {'epochs': 10, 'learning\_rate': 0.001, 'num\_blocks': 3, 'base\_channels': 64, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 50.87%

Epoch 2/10 | Val Acc: 63.15%

Epoch 3/10 | Val Acc: 70.86%

Epoch 4/10 | Val Acc: 74.01%

Epoch 5/10 | Val Acc: 75.58%

Epoch 6/10 | Val Acc: 74.84%

Epoch 7/10 | Val Acc: 78.02%

Epoch 8/10 | Val Acc: 73.34%

Epoch 9/10 | Val Acc: 81.38%

Epoch 10/10 | Val Acc: 81.03%

Testing config: {'epochs': 10, 'learning\_rate': 0.0005, 'num\_blocks': 2, 'base\_channels': 32, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 43.85%

Epoch 2/10 | Val Acc: 53.70%

Epoch 3/10 | Val Acc: 57.15%

Epoch 4/10 | Val Acc: 59.46%

Epoch 5/10 | Val Acc: 62.54%

Epoch 6/10 | Val Acc: 60.81%

Epoch 7/10 | Val Acc: 65.23%

Epoch 8/10 | Val Acc: 64.11%

Epoch 9/10 | Val Acc: 67.53%

Epoch 10/10 | Val Acc: 68.65%

Testing config: {'epochs': 10, 'learning\_rate': 0.0005, 'num\_blocks': 2, 'base\_channels': 32, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 49.75%

Epoch 2/10 | Val Acc: 48.05%

Epoch 3/10 | Val Acc: 60.29%

Epoch 4/10 | Val Acc: 64.52%

Epoch 5/10 | Val Acc: 62.44%

Epoch 6/10 | Val Acc: 63.00%

Epoch 7/10 | Val Acc: 60.61%

Epoch 8/10 | Val Acc: 61.70%

Epoch 9/10 | Val Acc: 63.55%

Epoch 10/10 | Val Acc: 67.48%

Testing config: {'epochs': 10, 'learning\_rate': 0.0005, 'num\_blocks': 2, 'base\_channels': 64, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

1/10 | Val Acc: 45.77%

2/10 | Val Acc: 55.91%

3/10 | Val Acc: 60.39%

4/10 | Val Acc: 55.76%

5/10 | Val Acc: 59.87%

6/10 | Val Acc: 61.82%

7/10 | Val Acc: 69.19%

8/10 | Val Acc: 67.83%

9/10 | Val Acc: 72.71%

10/10 | Val Acc: 73.03%

Testing config: {'epochs': 10, 'learning\_rate': 0.0005, 'num\_blocks': 2, 'base\_channels': 64, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 47.83%

Epoch 2/10 | Val Acc: 55.61%

Epoch 3/10 | Val Acc: 54.00%

Epoch 4/10 | Val Acc: 65.15%

Epoch 5/10 | Val Acc: 58.08%

Epoch 6/10 | Val Acc: 63.59%

Epoch 7/10 | Val Acc: 63.33%

Epoch 8/10 | Val Acc: 70.80%

Epoch 9/10 | Val Acc: 66.51%

Epoch 10/10 | Val Acc: 68.62%

Testing config: {'epochs': 10, 'learning\_rate': 0.0005, 'num\_blocks': 3, 'base\_channels': 32, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 55.70%

Epoch 2/10 | Val Acc: 63.87%

Epoch 3/10 | Val Acc: 68.31%

Epoch 4/10 | Val Acc: 69.99%

Epoch 5/10 | Val Acc: 74.40%

Epoch 6/10 | Val Acc: 73.54%

Epoch 7/10 | Val Acc: 72.96%

Epoch 8/10 | Val Acc: 75.04%

Epoch 9/10 | Val Acc: 76.67%

Epoch 10/10 | Val Acc: 77.31%

Testing config: {'epochs': 10, 'learning\_rate': 0.0005, 'num\_blocks': 3, 'base\_channels': 32, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 58.62%

Epoch 2/10 | Val Acc: 66.37%

Epoch 3/10 | Val Acc: 66.47%

Epoch 4/10 | Val Acc: 72.11%

Epoch 5/10 | Val Acc: 74.69%

Epoch 6/10 | Val Acc: 74.64%

Epoch 7/10 | Val Acc: 75.53%

Epoch 8/10 | Val Acc: 75.47%

Epoch 9/10 | Val Acc: 78.06%

Epoch 10/10 | Val Acc: 78.58%

Testing config: {'epochs': 10, 'learning\_rate': 0.0005, 'num\_blocks': 3, 'base\_channels': 64, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 56.35%

Epoch 2/10 | Val Acc: 65.31%

Epoch 3/10 | Val Acc: 72.76%

Epoch 4/10 | Val Acc: 73.39%

Epoch 5/10 | Val Acc: 77.62%

Epoch 6/10 | Val Acc: 79.45%

Epoch 7/10 | Val Acc: 77.09%

Epoch 8/10 | Val Acc: 78.24%

Epoch 9/10 | Val Acc: 81.24%

Epoch 10/10 | Val Acc: 81.12%

Testing config: {'epochs': 10, 'learning\_rate': 0.0005, 'num\_blocks': 3, 'base\_channels': 64, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/10 | Val Acc: 61.68%

Epoch 2/10 | Val Acc: 64.72%

Epoch 3/10 | Val Acc: 71.27%

Epoch 4/10 | Val Acc: 75.78%

Epoch 5/10 | Val Acc: 77.16%

Epoch 6/10 | Val Acc: 77.76%

Epoch 7/10 | Val Acc: 81.47%

Epoch 8/10 | Val Acc: 79.05%

Epoch 9/10 | Val Acc: 79.18%

Epoch 10/10 | Val Acc: 82.24%

New best config! Acc: 82.24%

Testing config: {'epochs': 20, 'learning\_rate': 0.001, 'num\_blocks': 2, 'base\_channels': 32, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 49.84%

Epoch 2/20 | Val Acc: 53.43%

Epoch 3/20 | Val Acc: 54.80%

Epoch 4/20 | Val Acc: 61.44%

Epoch 5/20 | Val Acc: 62.41%

Epoch 6/20 | Val Acc: 62.55%

Epoch 7/20 | Val Acc: 66.33%

Epoch 8/20 | Val Acc: 65.82%

Epoch 9/20 | Val Acc: 61.22%

Epoch 10/20 | Val Acc: 70.24%

Epoch 11/20 | Val Acc: 62.42%

Epoch 12/20 | Val Acc: 66.19%

Epoch 13/20 | Val Acc: 71.44%

Epoch 14/20 | Val Acc: 69.78%

Epoch 15/20 | Val Acc: 73.17%

Epoch 16/20 | Val Acc: 73.25%

Epoch 17/20 | Val Acc: 74.28%

Epoch 18/20 | Val Acc: 71.74%

Epoch 19/20 | Val Acc: 75.27%

Epoch 20/20 | Val Acc: 76.08%

Testing config: {'epochs': 20, 'learning\_rate': 0.001, 'num\_blocks': 2, 'base\_channels': 32, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 42.18%

Epoch 2/20 | Val Acc: 46.61%

Epoch 3/20 | Val Acc: 54.07%

Epoch 4/20 | Val Acc: 64.32%

Epoch 5/20 | Val Acc: 64.51%

Epoch 6/20 | Val Acc: 67.98%

Epoch 7/20 | Val Acc: 67.26%

Epoch 8/20 | Val Acc: 66.46%

Epoch 9/20 | Val Acc: 63.32%

Epoch 10/20 | Val Acc: 68.65%

Epoch 11/20 | Val Acc: 68.62%

Epoch 12/20 | Val Acc: 68.55%

Epoch 13/20 | Val Acc: 72.09%

Epoch 14/20 | Val Acc: 73.08%

Epoch 15/20 | Val Acc: 73.27%

Epoch 16/20 | Val Acc: 74.76%

Epoch 17/20 | Val Acc: 75.57%

Epoch 18/20 | Val Acc: 75.97%

Epoch 19/20 | Val Acc: 74.56%

Epoch 20/20 | Val Acc: 75.54%

Testing config: {'epochs': 20, 'learning\_rate': 0.001, 'num\_blocks': 2, 'base\_channels': 64, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 50.20%

Epoch 2/20 | Val Acc: 54.87%

Epoch 3/20 | Val Acc: 64.67%

Epoch 4/20 | Val Acc: 66.31%

Epoch 5/20 | Val Acc: 59.70%

Epoch 6/20 | Val Acc: 68.45%

Epoch 7/20 | Val Acc: 72.33%

Epoch 8/20 | Val Acc: 70.46%

Epoch 9/20 | Val Acc: 72.55%

Epoch 10/20 | Val Acc: 70.82%

Epoch 11/20 | Val Acc: 72.88%

Epoch 12/20 | Val Acc: 69.98%

Epoch 13/20 | Val Acc: 74.79%

Epoch 14/20 | Val Acc: 70.44%

Epoch 15/20 | Val Acc: 74.87%

Epoch 16/20 | Val Acc: 71.96%

Epoch 17/20 | Val Acc: 76.88%

Epoch 18/20 | Val Acc: 70.12%

Epoch 19/20 | Val Acc: 78.93%

Epoch 20/20 | Val Acc: 78.47%

Testing config: {'epochs': 20, 'learning\_rate': 0.001, 'num\_blocks': 2, 'base\_channels': 64, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 46.64%

Epoch 2/20 | Val Acc: 53.59%

Epoch 3/20 | Val Acc: 56.72%

Epoch 4/20 | Val Acc: 57.70%

Epoch 5/20 | Val Acc: 67.78%

Epoch 6/20 | Val Acc: 64.02%

Epoch 7/20 | Val Acc: 71.08%

Epoch 8/20 | Val Acc: 66.57%

Epoch 9/20 | Val Acc: 73.37%

Epoch 10/20 | Val Acc: 74.63%

Epoch 11/20 | Val Acc: 72.19%

Epoch 12/20 | Val Acc: 73.69%

Epoch 13/20 | Val Acc: 76.16%

Epoch 14/20 | Val Acc: 80.03%

Epoch 15/20 | Val Acc: 73.81%

Epoch 16/20 | Val Acc: 77.48%

Epoch 17/20 | Val Acc: 75.73%

Epoch 18/20 | Val Acc: 77.99%

Epoch 19/20 | Val Acc: 78.54%

Epoch 20/20 | Val Acc: 80.27%

Testing config: {'epochs': 20, 'learning\_rate': 0.001, 'num\_blocks': 3, 'base\_channels': 32, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 56.99%

Epoch 2/20 | Val Acc: 65.72%

Epoch 3/20 | Val Acc: 67.39%

Epoch 4/20 | Val Acc: 73.11%

Epoch 5/20 | Val Acc: 74.90%

Epoch 6/20 | Val Acc: 74.78%

Epoch 7/20 | Val Acc: 75.50%

Epoch 8/20 | Val Acc: 76.68%

Epoch 9/20 | Val Acc: 77.12%

Epoch 10/20 | Val Acc: 78.44%

Epoch 11/20 | Val Acc: 79.36%

Epoch 12/20 | Val Acc: 79.77%

Epoch 13/20 | Val Acc: 78.70%

Epoch 14/20 | Val Acc: 77.37%

Epoch 15/20 | Val Acc: 79.93%

Epoch 16/20 | Val Acc: 78.80%

Epoch 17/20 | Val Acc: 79.32%

Epoch 18/20 | Val Acc: 79.78%

Epoch 19/20 | Val Acc: 78.99%

Epoch 20/20 | Val Acc: 79.81%

Testing config: {'epochs': 20, 'learning\_rate': 0.001, 'num\_blocks': 3, 'base\_channels': 32, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 59.82%

Epoch 2/20 | Val Acc: 63.14%

Epoch 3/20 | Val Acc: 70.65%

Epoch 4/20 | Val Acc: 70.95%

Epoch 5/20 | Val Acc: 70.52%

Epoch 6/20 | Val Acc: 76.35%

Epoch 7/20 | Val Acc: 76.78%

Epoch 8/20 | Val Acc: 78.80%

Epoch 9/20 | Val Acc: 79.13%

Epoch 10/20 | Val Acc: 78.84%

Epoch 11/20 | Val Acc: 77.52%

Epoch 12/20 | Val Acc: 80.43%

Epoch 13/20 | Val Acc: 80.05%

Epoch 14/20 | Val Acc: 80.04%

Epoch 15/20 | Val Acc: 79.58%

Epoch 16/20 | Val Acc: 79.28%

Epoch 17/20 | Val Acc: 80.43%

Epoch 18/20 | Val Acc: 78.53%

Epoch 19/20 | Val Acc: 80.24%

Epoch 20/20 | Val Acc: 78.01%

Testing config: {'epochs': 20, 'learning\_rate': 0.001, 'num\_blocks': 3, 'base\_channels': 64, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 57.69%

Epoch 2/20 | Val Acc: 66.86%

Epoch 3/20 | Val Acc: 64.80%

Epoch 4/20 | Val Acc: 72.08%

Epoch 5/20 | Val Acc: 72.23%

Epoch 6/20 | Val Acc: 77.86%

Epoch 7/20 | Val Acc: 78.77%

Epoch 8/20 | Val Acc: 80.06%

Epoch 9/20 | Val Acc: 79.87%

Epoch 10/20 | Val Acc: 80.21%

Epoch 11/20 | Val Acc: 79.63%

Epoch 12/20 | Val Acc: 80.32%

Epoch 13/20 | Val Acc: 81.54%

Epoch 14/20 | Val Acc: 81.01%

Epoch 15/20 | Val Acc: 81.41%

Epoch 16/20 | Val Acc: 81.08%

Epoch 17/20 | Val Acc: 82.01%

Epoch 18/20 | Val Acc: 79.57%

Epoch 19/20 | Val Acc: 79.62%

Epoch 20/20 | Val Acc: 81.57%

Testing config: {'epochs': 20, 'learning\_rate': 0.001, 'num\_blocks': 3, 'base\_channels': 64, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 60.28%

Epoch 2/20 | Val Acc: 67.38%

Epoch 3/20 | Val Acc: 67.66%

Epoch 4/20 | Val Acc: 74.58%

Epoch 5/20 | Val Acc: 75.50%

Epoch 6/20 | Val Acc: 79.91%

Epoch 7/20 | Val Acc: 74.51%

Epoch 8/20 | Val Acc: 76.63%

Epoch 9/20 | Val Acc: 79.39%

Epoch 10/20 | Val Acc: 80.39%

Epoch 11/20 | Val Acc: 80.64%

Epoch 12/20 | Val Acc: 82.19%

Epoch 13/20 | Val Acc: 81.17%

Epoch 14/20 | Val Acc: 82.27%

Epoch 15/20 | Val Acc: 81.82%

Epoch 16/20 | Val Acc: 80.51%

Epoch 17/20 | Val Acc: 82.10%

Epoch 18/20 | Val Acc: 81.67%

Epoch 19/20 | Val Acc: 80.09%

Epoch 20/20 | Val Acc: 82.25%

New best config! Acc: 82.27%

Testing config: {'epochs': 20, 'learning\_rate': 0.0005, 'num\_blocks': 2, 'base\_channels': 32, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 48.39%

Epoch 2/20 | Val Acc: 52.05%

Epoch 3/20 | Val Acc: 57.41%

Epoch 4/20 | Val Acc: 54.15%

Epoch 5/20 | Val Acc: 61.72%

Epoch 6/20 | Val Acc: 55.77%

Epoch 7/20 | Val Acc: 65.86%

Epoch 8/20 | Val Acc: 64.15%

Epoch 9/20 | Val Acc: 65.72%

Epoch 10/20 | Val Acc: 69.15%

Epoch 11/20 | Val Acc: 69.65%

Epoch 12/20 | Val Acc: 64.11%

Epoch 13/20 | Val Acc: 69.28%

Epoch 14/20 | Val Acc: 66.67%

Epoch 15/20 | Val Acc: 69.23%

Epoch 16/20 | Val Acc: 64.86%

Epoch 17/20 | Val Acc: 65.46%

Epoch 18/20 | Val Acc: 72.73%

Epoch 19/20 | Val Acc: 72.13%

Epoch 20/20 | Val Acc: 71.46%

Testing config: {'epochs': 20, 'learning\_rate': 0.0005, 'num\_blocks': 2, 'base\_channels': 32, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 51.11%

Epoch 2/20 | Val Acc: 54.88%

Epoch 3/20 | Val Acc: 58.07%

Epoch 4/20 | Val Acc: 59.98%

Epoch 5/20 | Val Acc: 59.45%

Epoch 6/20 | Val Acc: 65.87%

Epoch 7/20 | Val Acc: 67.99%

Epoch 8/20 | Val Acc: 66.52%

Epoch 9/20 | Val Acc: 66.63%

Epoch 10/20 | Val Acc: 69.36%

Epoch 11/20 | Val Acc: 69.95%

Epoch 12/20 | Val Acc: 65.44%

Epoch 13/20 | Val Acc: 69.05%

Epoch 14/20 | Val Acc: 72.86%

Epoch 15/20 | Val Acc: 67.93%

Epoch 16/20 | Val Acc: 70.81%

Epoch 17/20 | Val Acc: 71.49%

Epoch 18/20 | Val Acc: 69.29%

Epoch 19/20 | Val Acc: 73.51%

Epoch 20/20 | Val Acc: 75.73%

Testing config: {'epochs': 20, 'learning\_rate': 0.0005, 'num\_blocks': 2, 'base\_channels': 64, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 36.54%

Epoch 2/20 | Val Acc: 59.04%

Epoch 3/20 | Val Acc: 60.90%

Epoch 4/20 | Val Acc: 62.84%

Epoch 5/20 | Val Acc: 62.65%

Epoch 6/20 | Val Acc: 62.91%

Epoch 7/20 | Val Acc: 63.32%

Epoch 8/20 | Val Acc: 67.60%

Epoch 9/20 | Val Acc: 68.74%

Epoch 10/20 | Val Acc: 65.45%

Epoch 11/20 | Val Acc: 74.29%

Epoch 12/20 | Val Acc: 70.19%

Epoch 13/20 | Val Acc: 71.44%

Epoch 14/20 | Val Acc: 76.10%

Epoch 15/20 | Val Acc: 66.77%

Epoch 16/20 | Val Acc: 68.63%

Epoch 17/20 | Val Acc: 71.25%

Epoch 18/20 | Val Acc: 78.01%

Epoch 19/20 | Val Acc: 72.60%

Epoch 20/20 | Val Acc: 73.57%

Testing config: {'epochs': 20, 'learning\_rate': 0.0005, 'num\_blocks': 2, 'base\_channels': 64, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 54.17%

Epoch 2/20 | Val Acc: 55.93%

Epoch 3/20 | Val Acc: 60.51%

Epoch 4/20 | Val Acc: 56.74%

Epoch 5/20 | Val Acc: 67.37%

Epoch 6/20 | Val Acc: 62.31%

Epoch 7/20 | Val Acc: 67.29%

Epoch 8/20 | Val Acc: 72.99%

Epoch 9/20 | Val Acc: 71.92%

Epoch 10/20 | Val Acc: 67.36%

Epoch 11/20 | Val Acc: 72.85%

Epoch 12/20 | Val Acc: 69.16%

Epoch 13/20 | Val Acc: 70.53%

Epoch 14/20 | Val Acc: 74.03%

Epoch 15/20 | Val Acc: 73.12%

Epoch 16/20 | Val Acc: 73.62%

Epoch 17/20 | Val Acc: 72.45%

Epoch 18/20 | Val Acc: 75.50%

Epoch 19/20 | Val Acc: 76.52%

Epoch 20/20 | Val Acc: 75.91%

Testing config: {'epochs': 20, 'learning\_rate': 0.0005, 'num\_blocks': 3, 'base\_channels': 32, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 50.29%

Epoch 2/20 | Val Acc: 62.76%

Epoch 3/20 | Val Acc: 67.87%

Epoch 4/20 | Val Acc: 68.57%

Epoch 5/20 | Val Acc: 74.05%

Epoch 6/20 | Val Acc: 73.51%

Epoch 7/20 | Val Acc: 75.66%

Epoch 8/20 | Val Acc: 75.11%

Epoch 9/20 | Val Acc: 78.67%

Epoch 10/20 | Val Acc: 78.64%

Epoch 11/20 | Val Acc: 77.61%

Epoch 12/20 | Val Acc: 77.39%

Epoch 13/20 | Val Acc: 77.83%

Epoch 14/20 | Val Acc: 79.03%

Epoch 15/20 | Val Acc: 77.57%

Epoch 16/20 | Val Acc: 75.82%

Epoch 17/20 | Val Acc: 75.45%

Epoch 18/20 | Val Acc: 76.68%

Epoch 19/20 | Val Acc: 76.35%

Epoch 20/20 | Val Acc: 79.12%

Testing config: {'epochs': 20, 'learning\_rate': 0.0005, 'num\_blocks': 3, 'base\_channels': 32, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 55.55%

Epoch 2/20 | Val Acc: 63.04%

Epoch 3/20 | Val Acc: 68.20%

Epoch 4/20 | Val Acc: 72.67%

Epoch 5/20 | Val Acc: 71.66%

Epoch 6/20 | Val Acc: 73.05%

Epoch 7/20 | Val Acc: 76.37%

Epoch 8/20 | Val Acc: 78.87%

Epoch 9/20 | Val Acc: 79.12%

Epoch 10/20 | Val Acc: 76.89%

Epoch 11/20 | Val Acc: 76.57%

Epoch 12/20 | Val Acc: 79.42%

Epoch 13/20 | Val Acc: 77.96%

Epoch 14/20 | Val Acc: 77.42%

Epoch 15/20 | Val Acc: 77.24%

Epoch 16/20 | Val Acc: 77.76%

Epoch 17/20 | Val Acc: 78.46%

Epoch 18/20 | Val Acc: 79.60%

Epoch 19/20 | Val Acc: 78.80%

Epoch 20/20 | Val Acc: 78.76%

Testing config: {'epochs': 20, 'learning\_rate': 0.0005, 'num\_blocks': 3, 'base\_channels': 64, 'mlp\_hidden\_layers': [128, 64], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 57.36%

Epoch 2/20 | Val Acc: 61.27%

Epoch 3/20 | Val Acc: 72.93%

Epoch 4/20 | Val Acc: 72.56%

Epoch 5/20 | Val Acc: 74.22%

Epoch 6/20 | Val Acc: 79.93%

Epoch 7/20 | Val Acc: 78.87%

Epoch 8/20 | Val Acc: 78.54%

Epoch 9/20 | Val Acc: 78.80%

Epoch 10/20 | Val Acc: 77.80%

Epoch 11/20 | Val Acc: 79.70%

Epoch 12/20 | Val Acc: 81.31%

Epoch 13/20 | Val Acc: 80.69%

Epoch 14/20 | Val Acc: 80.31%

Epoch 15/20 | Val Acc: 79.88%

Epoch 16/20 | Val Acc: 79.77%

Epoch 17/20 | Val Acc: 79.78%

Epoch 18/20 | Val Acc: 81.02%

Epoch 19/20 | Val Acc: 80.74%

Epoch 20/20 | Val Acc: 78.36%

Testing config: {'epochs': 20, 'learning\_rate': 0.0005, 'num\_blocks': 3, 'base\_channels': 64, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Epoch 1/20 | Val Acc: 57.23%

Epoch 2/20 | Val Acc: 66.29%

Epoch 3/20 | Val Acc: 70.98%

Epoch 4/20 | Val Acc: 73.93%

Epoch 5/20 | Val Acc: 75.94%

Epoch 6/20 | Val Acc: 76.89%

Epoch 7/20 | Val Acc: 78.44%

Epoch 8/20 | Val Acc: 77.19%

Epoch 9/20 | Val Acc: 78.94%

Epoch 10/20 | Val Acc: 80.58%

Epoch 11/20 | Val Acc: 77.53%

Epoch 12/20 | Val Acc: 81.21%

Epoch 13/20 | Val Acc: 80.88%

Epoch 14/20 | Val Acc: 79.78%

Epoch 15/20 | Val Acc: 79.26%

Epoch 16/20 | Val Acc: 78.97%

Epoch 17/20 | Val Acc: 78.98%

Epoch 18/20 | Val Acc: 81.27%

Epoch 19/20 | Val Acc: 81.12%

Epoch 20/20 | Val Acc: 79.73%

Best configuration: {'epochs': 20, 'learning\_rate': 0.001, 'num\_blocks': 3, 'base\_channels': 64, 'mlp\_hidden\_layers': [256, 128], 'num\_classes': 10}

Best validation accuracy: 82.27%

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Epochs | Learning rate | Num blocks | Base channels | Mlp layers | Accuracy |
| 10 | 0.001 | 2 | 32 | 128, 64 | 72,27 |
| 10 | 0.001 | 2 | 32 | 256, 128 | 72,28 |
| 10 | 0.001 | 2 | 64 | 128, 64 | 74,10 |
| 10 | 0.001 | 2 | 64 | 256, 128 | 72,94 |
| 10 | 0.001 | 3 | 32 | 128, 64 | 80.19 |
| 10 | 0.001 | 3 | 32 | 256, 128 | 79.55 |
| 10 | 0.001 | 3 | 64 | 128, 64 | 81.48 |
| 10 | 0.001 | 3 | 64 | 256, 128 | 81.03 |
| 10 | 0.0005 | 2 | 32 | 128, 64 | 68.65 |
| 10 | 0.0005 | 2 | 32 | 256, 128 | 67.48 |
| 10 | 0.0005 | 2 | 64 | 128, 64 | 73.03 |
| 10 | 0.0005 | 2 | 64 | 256, 128 | 68.62 |
| 10 | 0.0005 | 3 | 32 | 128, 64 | 77.31 |
| 10 | 0.0005 | 3 | 32 | 256, 128 | 78.58 |
| 10 | 0.0005 | 3 | 64 | 128, 64 | 81.12 |
| 10 | 0.0005 | 3 | 64 | 256, 128 | 82.24 |
| 20 | 0.001 | 2 | 32 | 128, 64 | 76.08 |
| 20 | 0.001 | 2 | 32 | 256, 128 | 75.54 |
| 20 | 0.001 | 2 | 64 | 128, 64 | 78.47 |
| 20 | 0.001 | 2 | 64 | 256, 128 | 80.27 |
| 20 | 0.001 | 3 | 32 | 128, 64 | 79.81 |
| 20 | 0.001 | 3 | 32 | 256, 128 | 78.01 |
| 20 | 0.001 | 3 | 64 | 128, 64 | 81.57 |
| 20 | 0.001 | 3 | 64 | 256, 128 | 82.27 |
| 20 | 0.0005 | 2 | 32 | 128, 64 | 71.46 |
| 20 | 0.0005 | 2 | 32 | 256, 128 | 75.73 |
| 20 | 0.0005 | 2 | 64 | 128, 64 | 73.57 |
| 20 | 0.0005 | 2 | 64 | 256, 128 | 75.91 |
| 20 | 0.0005 | 3 | 32 | 128, 64 | 79.12 |
| 20 | 0.0005 | 3 | 32 | 256, 128 | 78.76 |
| 20 | 0.0005 | 3 | 64 | 128, 64 | 78.36 |
| 20 | 0.0005 | 3 | 64 | 256, 128 | 79.73 |

**Вывод:**

Максимальная точность, которой мне удалось добиться – 82.27%, была достигнута при следующих параметрах: 'epochs': 20, 'learning\_rate': 0.001, 'num\_blocks': 3, 'base\_channels': 64, 'mlp\_hidden\_layers': [256, 128]. Однако, анализируя результаты перебора параметров, можно заметить, что как при 10 эпохах точность может достигать 82,24% (почти максимум), так и при 20 эпохах давать резултаты в районе 71-75%. Можно утверждать, что увеличение числа эпох не дает особо выигрыша.   
Значительно точность увеличивается с увеличением числа блоков (3 вместо 2). Уменьшение learning rate на 2 блоках уменьшает точность. Также слегка улучшается точность предсказаний с увеличением числа скрытых слоев в многослойном перцептроне.