П1. Опишите - какой результата получен в нейросети в зависимости от:

Числа нейронов в слое

60, 50

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.7759 - loss: 0.6535 - val_accuracy: 0.8393 - val_loss: 0.4411
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8531 - loss: 0.4020 - val_accuracy: 0.8577 - val_loss: 0.4007
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8677 - loss: 0.3624 - val_accuracy: 0.8647 - val_loss: 0.3751
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 9s 3ms/step - accuracy: 0.8791 - loss: 0.3261 - val_accuracy: 0.8657 - val_loss: 0.3671
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8846 - loss: 0.3136 - val_accuracy: 0.8694 - val_loss: 0.3594
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8911 - loss: 0.2986 - val_accuracy: 0.8754 - val_loss: 0.3471
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8962 - loss: 0.2818 - val_accuracy: 0.8801 - val_loss: 0.3385
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 10s 4ms/step - accuracy: 0.8991 - loss: 0.2744 - val_accuracy: 0.8758 - val_loss: 0.3589
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8724 - loss: 0.3699
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 5ms/step - accuracy: 0.9025 - loss: 0.2618 - val_accuracy: 0.8790 - val_loss: 0.3412
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9030 - loss: 0.2616 - val_accuracy: 0.8778 - val_loss: 0.3456
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 3ms/step - accuracy: 0.9066 - loss: 0.2511 - val_accuracy: 0.8853 - val_loss: 0.3357
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9126 - loss: 0.2359 - val_accuracy: 0.8708 - val_loss: 0.3592
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9142 - loss: 0.2342 - val_accuracy: 0.8799 - val_loss: 0.3482
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9140 - loss: 0.2286 - val_accuracy: 0.8798 - val_loss: 0.3501
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 11s 4ms/step - accuracy: 0.9117 - loss: 0.2326 - val_accuracy: 0.8735 - val_loss: 0.3717
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9222 - loss: 0.2116 - val_accuracy: 0.8853 - val_loss: 0.3350
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8846 - loss: 0.3518
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.882
```

110, 100

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.7753 - loss: 0.6240 - val_accuracy: 0.8457 - val_loss: 0.4191
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 10s 4ms/step - accuracy: 0.8572 - loss: 0.3867 - val_accuracy: 0.8510 - val_loss: 0.4025
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8752 - loss: 0.3384 - val_accuracy: 0.8660 - val_loss: 0.3703
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8825 - loss: 0.3201 - val_accuracy: 0.8765 - val_loss: 0.3430
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8888 - loss: 0.3016 - val_accuracy: 0.8742 - val_loss: 0.3493
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8940 - loss: 0.2855 - val_accuracy: 0.8755 - val_loss: 0.3512
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9001 - loss: 0.2682 - val_accuracy: 0.8798 - val_loss: 0.3401
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9020 - loss: 0.2622 - val_accuracy: 0.8785 - val_loss: 0.3387
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 1ms/step - accuracy: 0.8706 - loss: 0.3653
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9077 - loss: 0.2492 - val_accuracy: 0.8752 - val_loss: 0.3530
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9093 - loss: 0.2456 - val_accuracy: 0.8787 - val_loss: 0.3413
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9110 - loss: 0.2347 - val_accuracy: 0.8784 - val_loss: 0.3446
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9146 - loss: 0.2260 - val_accuracy: 0.8825 - val_loss: 0.3420
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9199 - loss: 0.2169 - val_accuracy: 0.8848 - val_loss: 0.3441
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9193 - loss: 0.2137 - val_accuracy: 0.8843 - val_loss: 0.3382
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 3ms/step - accuracy: 0.9219 - loss: 0.2071 - val_accuracy: 0.8777 - val_loss: 0.3562
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9255 - loss: 0.1981 - val_accuracy: 0.8773 - val_loss: 0.3794
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8722 - loss: 0.4109
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.8726
```

160, 150

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.7754 - loss: 0.6186 - val_accuracy: 0.8548 - val_loss: 0.4009
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8545 - loss: 0.3917 - val_accuracy: 0.8617 - val_loss: 0.3827
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8698 - loss: 0.3496 - val_accuracy: 0.8647 - val_loss: 0.3693
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8815 - loss: 0.3219 - val_accuracy: 0.8783 - val_loss: 0.3315
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8897 - loss: 0.2955 - val_accuracy: 0.8643 - val_loss: 0.3657
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8947 - loss: 0.2858 - val_accuracy: 0.8751 - val_loss: 0.3501
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9009 - loss: 0.2730 - val_accuracy: 0.8795 - val_loss: 0.3387
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9047 - loss: 0.2559 - val_accuracy: 0.8742 - val_loss: 0.3497
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 1ms/step - accuracy: 0.8655 - loss: 0.3731
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9074 - loss: 0.2517 - val_accuracy: 0.8791 - val_loss: 0.3423
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9144 - loss: 0.2315 - val_accuracy: 0.8766 - val_loss: 0.3512
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9168 - loss: 0.2224 - val_accuracy: 0.8856 - val_loss: 0.3280
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9188 - loss: 0.2206 - val_accuracy: 0.8888 - val_loss: 0.3281
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9203 - loss: 0.2143 - val_accuracy: 0.8868 - val_loss: 0.3258
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 10s 4ms/step - accuracy: 0.9223 - loss: 0.2055 - val_accuracy: 0.8889 - val_loss: 0.3285
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 11s 4ms/step - accuracy: 0.9299 - loss: 0.1927 - val_accuracy: 0.8843 - val_loss: 0.3463
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9282 - loss: 0.1930 - val_accuracy: 0.8882 - val_loss: 0.3377
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8824 - loss: 0.3644
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.8832
```

210, 200

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 10s 6ms/step - accuracy: 0.7792 - loss: 0.6099 - val_accuracy: 0.8528 - val_loss: 0.3940
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 5ms/step - accuracy: 0.8529 - loss: 0.3962 - val_accuracy: 0.8590 - val_loss: 0.3899
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8711 - loss: 0.3496 - val_accuracy: 0.8697 - val_loss: 0.3619
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.8781 - loss: 0.3278 - val_accuracy: 0.8752 - val_loss: 0.3448
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8872 - loss: 0.3087 - val_accuracy: 0.8816 - val_loss: 0.3308
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8927 - loss: 0.2896 - val_accuracy: 0.8764 - val_loss: 0.3489
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8952 - loss: 0.2797 - val_accuracy: 0.8734 - val_loss: 0.3579
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.9028 - loss: 0.2607 - val_accuracy: 0.8792 - val_loss: 0.3341
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8788 - loss: 0.3508
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 8s 5ms/step - accuracy: 0.9087 - loss: 0.2440 - val_accuracy: 0.8812 - val_loss: 0.3479
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9095 - loss: 0.2435 - val_accuracy: 0.8863 - val_loss: 0.3337
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 10s 4ms/step - accuracy: 0.9164 - loss: 0.2267 - val_accuracy: 0.8806 - val_loss: 0.3338
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9161 - loss: 0.2201 - val_accuracy: 0.8854 - val_loss: 0.3260
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9207 - loss: 0.2148 - val_accuracy: 0.8799 - val_loss: 0.3520
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9211 - loss: 0.2120 - val_accuracy: 0.8846 - val_loss: 0.3495
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9260 - loss: 0.1965 - val_accuracy: 0.8858 - val_loss: 0.3329
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.9309 - loss: 0.1861 - val_accuracy: 0.8814 - val_loss: 0.3566
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8813 - loss: 0.3809
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.8796
```

Числа слоев при близких размерах сети

2 слоя (160, 150), всего 146 780 параметров:

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.7754 - loss: 0.6186 - val_accuracy: 0.8548 - val_loss: 0.4009
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8545 - loss: 0.3917 - val_accuracy: 0.8617 - val_loss: 0.3827
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8698 - loss: 0.3496 - val_accuracy: 0.8647 - val_loss: 0.3693
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8815 - loss: 0.3219 - val_accuracy: 0.8783 - val_loss: 0.3315
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8897 - loss: 0.2955 - val_accuracy: 0.8643 - val_loss: 0.3657
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8947 - loss: 0.2858 - val_accuracy: 0.8751 - val_loss: 0.3501
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9009 - loss: 0.2730 - val_accuracy: 0.8795 - val_loss: 0.3387
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9047 - loss: 0.2559 - val_accuracy: 0.8742 - val_loss: 0.3497
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 1ms/step - accuracy: 0.8655 - loss: 0.3731
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9074 - loss: 0.2517 - val_accuracy: 0.8791 - val_loss: 0.3423
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9144 - loss: 0.2315 - val_accuracy: 0.8766 - val_loss: 0.3512
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9168 - loss: 0.2224 - val_accuracy: 0.8856 - val_loss: 0.3280
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9188 - loss: 0.2206 - val_accuracy: 0.8888 - val_loss: 0.3281
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9203 - loss: 0.2143 - val_accuracy: 0.8868 - val_loss: 0.3258
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 10s 4ms/step - accuracy: 0.9223 - loss: 0.2055 - val_accuracy: 0.8889 - val_loss: 0.3285
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 11s 4ms/step - accuracy: 0.9299 - loss: 0.1927 - val_accuracy: 0.8843 - val_loss: 0.3463
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9282 - loss: 0.1930 - val_accuracy: 0.8882 - val_loss: 0.3377
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8824 - loss: 0.3644
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.8832
```

3 слоя (120, 120, 120), всего 146 210 параметров:

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.7695 - loss: 0.6349 - val_accuracy: 0.8351 - val_loss: 0.4655
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8536 - loss: 0.3946 - val_accuracy: 0.8682 - val_loss: 0.3665
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8737 - loss: 0.3517 - val_accuracy: 0.8519 - val_loss: 0.4115
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8771 - loss: 0.3349 - val_accuracy: 0.8741 - val_loss: 0.3515
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8832 - loss: 0.3151 - val_accuracy: 0.8712 - val_loss: 0.3627
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8882 - loss: 0.3013 - val_accuracy: 0.8708 - val_loss: 0.3601
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8940 - loss: 0.2876 - val_accuracy: 0.8789 - val_loss: 0.3420
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9001 - loss: 0.2728 - val_accuracy: 0.8792 - val_loss: 0.3510
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 1ms/step - accuracy: 0.8662 - loss: 0.3750
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9000 - loss: 0.2687 - val_accuracy: 0.8798 - val_loss: 0.3469
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9066 - loss: 0.2570 - val_accuracy: 0.8774 - val_loss: 0.3526
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9035 - loss: 0.2523 - val_accuracy: 0.8801 - val_loss: 0.3390
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9112 - loss: 0.2386 - val_accuracy: 0.8810 - val_loss: 0.3426
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 5ms/step - accuracy: 0.9126 - loss: 0.2319 - val_accuracy: 0.8812 - val_loss: 0.3410
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 8s 3ms/step - accuracy: 0.9148 - loss: 0.2251 - val_accuracy: 0.8793 - val_loss: 0.3434
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9163 - loss: 0.2283 - val_accuracy: 0.8872 - val_loss: 0.3348
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9220 - loss: 0.2111 - val_accuracy: 0.8841 - val_loss: 0.3467
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8771 - loss: 0.3721
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.8768
```

5 слоев (91, 91, 91, 91, 91), всего 146 627 параметров:

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 29s 4ms/step - accuracy: 0.7699 - loss: 0.6476 - val_accuracy: 0.8483 - val_loss: 0.4335
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8495 - loss: 0.4116 - val_accuracy: 0.8571 - val_loss: 0.4116
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8591 - loss: 0.3829 - val_accuracy: 0.8578 - val_loss: 0.4070
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8692 - loss: 0.3573 - val_accuracy: 0.8677 - val_loss: 0.3707
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8785 - loss: 0.3324 - val_accuracy: 0.8554 - val_loss: 0.4312
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8819 - loss: 0.3218 - val_accuracy: 0.8698 - val_loss: 0.3652
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8885 - loss: 0.3044 - val_accuracy: 0.8777 - val_loss: 0.3478
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 8s 5ms/step - accuracy: 0.8906 - loss: 0.3021 - val_accuracy: 0.8744 - val_loss: 0.3579
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 1ms/step - accuracy: 0.8712 - loss: 0.3740
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8948 - loss: 0.2837 - val_accuracy: 0.8794 - val_loss: 0.3437
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8979 - loss: 0.2771 - val_accuracy: 0.8788 - val_loss: 0.3430
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9010 - loss: 0.2713 - val_accuracy: 0.8748 - val_loss: 0.3562
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9059 - loss: 0.2576 - val_accuracy: 0.8806 - val_loss: 0.3480
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9070 - loss: 0.2514 - val_accuracy: 0.8830 - val_loss: 0.3448
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9053 - loss: 0.2478 - val_accuracy: 0.8808 - val_loss: 0.3591
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9065 - loss: 0.2530 - val_accuracy: 0.8774 - val_loss: 0.3452
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9092 - loss: 0.2431 - val_accuracy: 0.8788 - val_loss: 0.3607
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8704 - loss: 0.3797
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.8704
```

10 слоев (64, 64, 64, 64, 64, 64, 64, 64, 64, 64), всего 146 826 параметров:

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 8s 4ms/step - accuracy: 0.7367 - loss: 0.7403 - val_accuracy: 0.8229 - val_loss: 0.4963
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 10s 4ms/step - accuracy: 0.8375 - loss: 0.4617 - val_accuracy: 0.8312 - val_loss: 0.4864
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8498 - loss: 0.4247 - val_accuracy: 0.8532 - val_loss: 0.4202
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8567 - loss: 0.4092 - val_accuracy: 0.8617 - val_loss: 0.3948
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8665 - loss: 0.3745 - val_accuracy: 0.8576 - val_loss: 0.4106
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8732 - loss: 0.3587 - val_accuracy: 0.8597 - val_loss: 0.3984
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8712 - loss: 0.3666 - val_accuracy: 0.8732 - val_loss: 0.3825
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8748 - loss: 0.3501 - val_accuracy: 0.8618 - val_loss: 0.3829
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 1ms/step - accuracy: 0.8555 - loss: 0.4042
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8793 - loss: 0.3379 - val_accuracy: 0.8545 - val_loss: 0.4096
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 5ms/step - accuracy: 0.8797 - loss: 0.3376 - val_accuracy: 0.8642 - val_loss: 0.3928
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8852 - loss: 0.3237 - val_accuracy: 0.8658 - val_loss: 0.3921
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 5ms/step - accuracy: 0.8874 - loss: 0.3176 - val_accuracy: 0.8654 - val_loss: 0.3882
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8810 - loss: 0.3296 - val_accuracy: 0.8707 - val_loss: 0.3790
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8893 - loss: 0.3163 - val_accuracy: 0.8690 - val_loss: 0.3974
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8902 - loss: 0.3076 - val_accuracy: 0.8698 - val_loss: 0.3856
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 5ms/step - accuracy: 0.8865 - loss: 0.3156 - val_accuracy: 0.8702 - val_loss: 0.3684
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8622 - loss: 0.3941
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.8623
```

П2. Проверьте работу разных оптимизаторов для одной из моделей

Модель 3 слоя (120, 120, 120)

SGD

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 2ms/step - accuracy: 0.7195 - loss: 0.8730 - val_accuracy: 0.8313 - val_loss: 0.4690
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 3s 2ms/step - accuracy: 0.8419 - loss: 0.4418 - val_accuracy: 0.8508 - val_loss: 0.4133
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 3ms/step - accuracy: 0.8561 - loss: 0.3979 - val_accuracy: 0.8607 - val_loss: 0.3898
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 3s 2ms/step - accuracy: 0.8689 - loss: 0.3629 - val_accuracy: 0.8658 - val_loss: 0.3744
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 2ms/step - accuracy: 0.8753 - loss: 0.3473 - val_accuracy: 0.8708 - val_loss: 0.3548
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8798 - loss: 0.3286 - val_accuracy: 0.8674 - val_loss: 0.3641
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 3s 2ms/step - accuracy: 0.8826 - loss: 0.3203 - val_accuracy: 0.8739 - val_loss: 0.3454
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 3s 2ms/step - accuracy: 0.8915 - loss: 0.2980 - val_accuracy: 0.8690 - val_loss: 0.3680
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8579 - loss: 0.3919
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 3ms/step - accuracy: 0.8951 - loss: 0.2888 - val_accuracy: 0.8721 - val_loss: 0.3471
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 2ms/step - accuracy: 0.8967 - loss: 0.2813 - val_accuracy: 0.8806 - val_loss: 0.3337
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 2ms/step - accuracy: 0.9004 - loss: 0.2734 - val_accuracy: 0.8783 - val_loss: 0.3326
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 3ms/step - accuracy: 0.9026 - loss: 0.2653 - val_accuracy: 0.8802 - val_loss: 0.3260
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 2ms/step - accuracy: 0.9086 - loss: 0.2511 - val_accuracy: 0.8799 - val_loss: 0.3337
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 2ms/step - accuracy: 0.9104 - loss: 0.2520 - val_accuracy: 0.8838 - val_loss: 0.3225
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 3ms/step - accuracy: 0.9106 - loss: 0.2408 - val_accuracy: 0.8838 - val_loss: 0.3256
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 2ms/step - accuracy: 0.9164 - loss: 0.2341 - val_accuracy: 0.8764 - val_loss: 0.3404
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8660 - loss: 0.3757
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step
Result acc =  0.8692
```

Adam

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.7779 - loss: 0.6149 - val_accuracy: 0.8362 - val_loss: 0.4438
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8553 - loss: 0.4015 - val_accuracy: 0.8611 - val_loss: 0.3811
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8702 - loss: 0.3581 - val_accuracy: 0.8673 - val_loss: 0.3680
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8783 - loss: 0.3303 - val_accuracy: 0.8669 - val_loss: 0.3682
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8827 - loss: 0.3162 - val_accuracy: 0.8707 - val_loss: 0.3590
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8883 - loss: 0.3014 - val_accuracy: 0.8765 - val_loss: 0.3533
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8937 - loss: 0.2864 - val_accuracy: 0.8633 - val_loss: 0.3721
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.8976 - loss: 0.2819 - val_accuracy: 0.8789 - val_loss: 0.3350
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 2ms/step - accuracy: 0.8673 - loss: 0.3663
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9023 - loss: 0.2629 - val_accuracy: 0.8808 - val_loss: 0.3500
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9056 - loss: 0.2574 - val_accuracy: 0.8816 - val_loss: 0.3309
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9072 - loss: 0.2494 - val_accuracy: 0.8838 - val_loss: 0.3294
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9100 - loss: 0.2417 - val_accuracy: 0.8813 - val_loss: 0.3387
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9118 - loss: 0.2358 - val_accuracy: 0.8806 - val_loss: 0.3403
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 7s 4ms/step - accuracy: 0.9103 - loss: 0.2373 - val_accuracy: 0.8797 - val_loss: 0.3411
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.9162 - loss: 0.2229 - val_accuracy: 0.8893 - val_loss: 0.3255
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9187 - loss: 0.2188 - val_accuracy: 0.8874 - val_loss: 0.3330
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step - accuracy: 0.8807 - loss: 0.3632
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.8805
```

RMSProp

```
Learning model:
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 3ms/step - accuracy: 0.7543 - loss: 0.6655 - val_accuracy: 0.8464 - val_loss: 0.4212
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8503 - loss: 0.4110 - val_accuracy: 0.8622 - val_loss: 0.3933
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8686 - loss: 0.3654 - val_accuracy: 0.8583 - val_loss: 0.3843
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8735 - loss: 0.3465 - val_accuracy: 0.8599 - val_loss: 0.3793
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8799 - loss: 0.3292 - val_accuracy: 0.8602 - val_loss: 0.4106
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8835 - loss: 0.3206 - val_accuracy: 0.8749 - val_loss: 0.3447
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8888 - loss: 0.3065 - val_accuracy: 0.8705 - val_loss: 0.3561
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 3ms/step - accuracy: 0.8916 - loss: 0.3013 - val_accuracy: 0.8635 - val_loss: 0.3842
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 1ms/step - accuracy: 0.8586 - loss: 0.3984
Epoch 1/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 4ms/step - accuracy: 0.8942 - loss: 0.2868 - val_accuracy: 0.8826 - val_loss: 0.3352
Epoch 2/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.8973 - loss: 0.2822 - val_accuracy: 0.8743 - val_loss: 0.3609
Epoch 3/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 4s 3ms/step - accuracy: 0.9017 - loss: 0.2759 - val_accuracy: 0.8708 - val_loss: 0.3718
Epoch 4/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9017 - loss: 0.2730 - val_accuracy: 0.8733 - val_loss: 0.3551
Epoch 5/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9037 - loss: 0.2689 - val_accuracy: 0.8798 - val_loss: 0.3446
Epoch 6/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9030 - loss: 0.2627 - val_accuracy: 0.8787 - val_loss: 0.3547
Epoch 7/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 5s 3ms/step - accuracy: 0.9089 - loss: 0.2561 - val_accuracy: 0.8829 - val_loss: 0.3369
Epoch 8/8
1500/1500 ━━━━━━━━━━━━━━━━━━━━ 6s 4ms/step - accuracy: 0.9093 - loss: 0.2556 - val_accuracy: 0.8824 - val_loss: 0.3470
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8756 - loss: 0.3678
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.8737
```

П3. Что помогло улучшить качество классификации в нейросети на тестовом наборе?

Для повышения качества классификации лучше всего помог оптимизатор «adam». Также лучше всего показала себя сеть с умеренным количеством слоев – 2 слоя (160, 150).

П4. Для одного из варианта сетей сформируйте матрицу ошибок по классам.

```
Predict:
313/313 ━━━━━━━━━━━━━━━━━━━━ 0s 1ms/step
Result acc =  0.8748
Classification Report:
              precision    recall  f1-score   support

 T-shirt/top     0.7815    0.8690    0.8229      1000
     Trouser     0.9938    0.9580    0.9756      1000
    Pullover     0.7623    0.8210    0.7906      1000
       Dress     0.8876    0.8840    0.8858      1000
        Coat     0.8586    0.7590    0.8057      1000
      Sandal     0.9175    0.9670    0.9416      1000
       Shirt     0.6977    0.6900    0.6938      1000
     Sneaker     0.9195    0.9480    0.9335      1000
         Bag     0.9762    0.9450    0.9604      1000
  Ankle boot     0.9805    0.9070    0.9423      1000

    accuracy                         0.8748     10000
   macro avg     0.8775    0.8748    0.8752     10000
weighted avg     0.8775    0.8748    0.8752     10000
```

Как видим класс Shirt имеет самые низкие показатели возможно из-за того, что он легко путается с другими классами. Средние классы это Pullover и T-shirt/top так как они имеют схожее изображение. И самые лучше результаты у Trouser, Ankle boot, Bag, Sneaker и Sandal так как данные объекты имеют уникальное изображение которое легко определяется.