```
1  C:\Users\ChunJiangWuYueMing\.conda\envs\ml_exp_torch\python.exe C:\PycharmPro
2  使用设备: cpu
3  开始训练CNN模型...
4  Epoch 1/20 [训练]: 100%|████████| 750/750 [00:42<00:00, 17.66it/s, loss=0.155]
5  Epoch 2/20 [训练]:   0%|          | 0/750 [00:00<?, ?it/s]Epoch 1: 训练损失=0.2475, 验证损失
6  保存最佳模型 (验证损失: 0.0591)
7  Epoch 2/20 [训练]: 100%|████████| 750/750 [02:06<00:00,  5.92it/s, loss=0.161]
8  Epoch 3/20 [训练]:   0%|          | 0/750 [00:00<?, ?it/s]Epoch 2: 训练损失=0.0896, 验证损失
9  保存最佳模型 (验证损失: 0.0446)
10 Epoch 3/20 [训练]: 100%|████████| 750/750 [00:21<00:00, 35.69it/s, loss=0.0555]
11 Epoch 4/20 [训练]:   0%|          | 0/750 [00:00<?, ?it/s]Epoch 3: 训练损失=0.0655, 验证损失
12 保存最佳模型 (验证损失: 0.0382)
13 Epoch 4/20 [训练]: 100%|████████| 750/750 [02:18<00:00,  5.41it/s, loss=0.0756]
14 Epoch 5/20 [训练]:   0%|          | 0/750 [00:00<?, ?it/s]Epoch 4: 训练损失=0.0503, 验证损失
15 保存最佳模型 (验证损失: 0.0350)
16 Epoch 5/20 [训练]: 100%|████████| 750/750 [02:17<00:00,  5.44it/s, loss=0.0325]
17 Epoch 6/20 [训练]:   0%|          | 0/750 [00:00<?, ?it/s]Epoch 5: 训练损失=0.0428, 验证损失
18 保存最佳模型 (验证损失: 0.0306)
19 Epoch 6/20 [训练]: 100%|████████| 750/750 [02:19<00:00,  5.39it/s, loss=0.018]
20 Epoch 7/20 [训练]:   0%|          | 0/750 [00:00<?, ?it/s]Epoch 6: 训练损失=0.0376, 验证损失
21 Epoch 7/20 [训练]: 100%|████████| 750/750 [02:19<00:00,  5.38it/s, loss=0.158]
```

22 Epoch 7: 训练损失=0.0345, 验证损失=0.0330, 验证准确率=0.9905

23 Epoch 8/20 [训练]: 100%| 750/750 [01:05<00:00, 11.41it/s, loss=0.0817]

24 Epoch 9/20 [训练]:   0%| |0/750 [00:00<?, ?it/s]Epoch 8: 训练损失=0.0297, 验证损失

25 保存最佳模型 (验证损失: 0.0279)

26 Epoch 9/20 [训练]: 100%| 750/750 [02:21<00:00, 5.30it/s, loss=0.0135]

27 Epoch 10/20 [训练]:   0%| |0/750 [00:00<?, ?it/s]Epoch 9: 训练损失=0.0268, 验证损

28 Epoch 10/20 [训练]: 100%| 750/750 [02:26<00:00, 5.13it/s, loss=0.0578

29 Epoch 11/20 [训练]:   0%| |0/750 [00:00<?, ?it/s]Epoch 10: 训练损失=0.0235, 验证指

30 Epoch 11/20 [训练]: 100%| 750/750 [00:45<00:00, 16.58it/s, loss=0.091]

31 Epoch 11: 训练损失=0.0229, 验证损失=0.0273, 验证准确率=0.9920

32 保存最佳模型 (验证损失: 0.0273)

33 Epoch 12/20 [训练]: 100%| 750/750 [00:21<00:00, 35.36it/s, loss=0.0057

34 Epoch 12: 训练损失=0.0195, 验证损失=0.0284, 验证准确率=0.9926

35 Epoch 13/20 [训练]: 100%| 750/750 [00:20<00:00, 36.31it/s, loss=0.0568

36 Epoch 13: 训练损失=0.0190, 验证损失=0.0281, 验证准确率=0.9929

37 Epoch 14/20 [训练]: 100%| 750/750 [00:20<00:00, 36.14it/s, loss=0.015]

38 Epoch 15/20 [训练]:   0%| |0/750 [00:00<?, ?it/s]Epoch 14: 训练损失=0.0173, 验证指

39 Epoch 15/20 [训练]: 100%| 750/750 [00:21<00:00, 35.22it/s, loss=0.054]

40 Epoch 16/20 [训练]:   0%| |0/750 [00:00<?, ?it/s]Epoch 15: 训练损失=0.0169, 验证指

41 Epoch 16/20 [训练]: 100%| 750/750 [00:23<00:00, 32.18it/s, loss=0.0022

42 Epoch 17/20 [训练]:   0%| |0/750 [00:00<?, ?it/s]Epoch 16: 训练损失=0.0155, 验证指

43　Epoch 17/20 [训练]: 100%|███████| 750/750 [00:21<00:00, 34.89it/s, loss=0.0011

44　Epoch 17: 训练损失=0.0143, 验证损失=0.0301, 验证准确率=0.9930

45　Epoch 18/20 [训练]: 100%|███████| 750/750 [00:21<00:00, 34.86it/s, loss=0.0004

46　Epoch 19/20 [训练]:　0%|　　|0/750 [00:00<?, ?it/s]Epoch 18: 训练损失=0.0127, 验证损

47　Epoch 19/20 [训练]: 100%|███████| 750/750 [00:21<00:00, 34.70it/s, loss=0.0083

48　Epoch 19: 训练损失=0.0129, 验证损失=0.0396, 验证准确率=0.9921

49　Epoch 20/20 [训练]: 100%|███████| 750/750 [00:21<00:00, 35.28it/s, loss=0.0001

50　Epoch 20: 训练损失=0.0134, 验证损失=0.0386, 验证准确率=0.9916

51　训练完成! 损失曲线已保存到 results/figures/loss_curves.png

52

53　在测试集上评估模型...

54

55　CNN模型测试集性能:

56　准确率: 0.9935

57　精确率: 0.9934

58　召回率: 0.9935

59　F1值: 0.9934

60

61　总训练时间: 1429.43 秒 (23.82 分钟)

62　训练日志已保存到 results/logs/cnn_training_log.json

63

64   Process finished with exit code 0

65