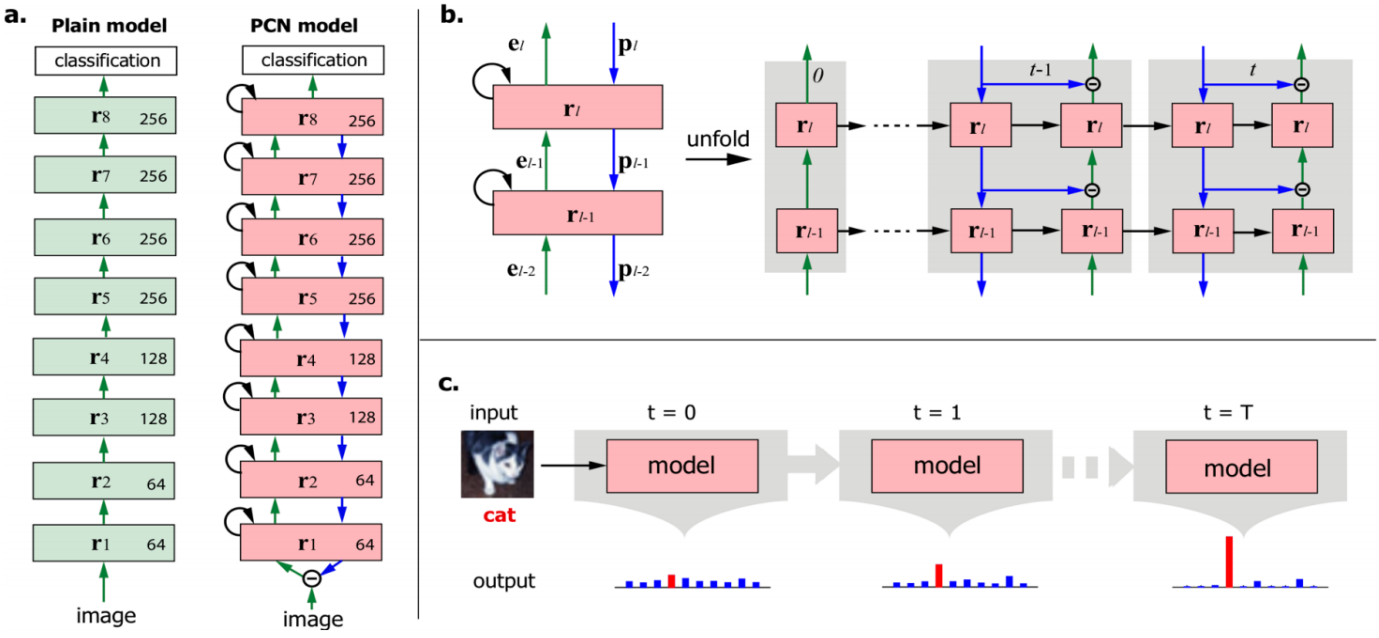
Review briefly predictive encoding and create a predictive encoding model on CIFAR10 and attack it to verify its robustness.

This task said to create a predictive encoding model on CIFAR10, and attack it to verify its robustness.

So first, I have a look at [2].Then i know that, [3] is a deep convolutional recurrent neural network inspired by the principles of predictive coding.
But it is trained for next-frame video prediction not the image.
And then i find a paper named [1], they propose a predictive coding networks(PCN) for Object Recognition.
The PCN is used for object recogntion, so i have a implement with it on CIFAR10.

The network structure is like the next figure.



So this network have 9 layers, like a.
b is Two-layer substructure of PCN.Feedback (blue), feedforward (green), and recurrent (black) connections convey the top-down prediction, the bottom-up prediction error, and the past information, respectively.

The next is the Algorithm for the PCN network.

Algorithm 1 Deep Predictive Coding Network

1. Input static image: $\mathbf{x}$
2. $\mathbf{r}_0(t) \leftarrow \mathbf{x}$
3. *% initialize representations*
4. **for** $l = 0$ **to** L-1 **do**
5. $\quad \mathbf{r}_{l+1}(0) \leftarrow \text{ReLU}\left(\text{FFConv}\left(\mathbf{r}_l(0)\right)\right)$
6. *% recurrent computation with T cycles*
7. **for** t = 1 to T **do**
8. $\quad$ *% nonlinear feedback process*
9. $\quad$ **for** $l = $ L **to** 1 **do**
10. $\quad\quad \mathbf{p}_{l-1}(t\text{-}1) \leftarrow \text{FBConv}\left(\mathbf{r}_l(t\text{-}1)\right)$
11. $\quad\quad$ **if** $l > 1$ **do**
12. $\quad\quad\quad \mathbf{r}_{l-1}(t\text{-}1) \leftarrow \text{ReLU}\left((1\text{-}b)\mathbf{r}_{l\text{-}1}(t\text{-}1) + b\mathbf{p}_{l\text{-}1}(t\text{-}1)\right)$
13. $\quad$ *% nonlinear feedforward process*
14. $\quad$ **for** $l = 0$ **to** L-1 **do**
15. $\quad\quad \mathbf{e}_l(t) \leftarrow \mathbf{r}_l(t) - \mathbf{p}_l(t\text{-}1)$
16. $\quad\quad \mathbf{r}_{l+1}(t) \leftarrow \text{ReLU}\left(\mathbf{r}_{l+1}(t\text{-}1) + a\ \text{FFConv}\left(\mathbf{e}_l(t)\right)\right)$
17. *% classification*
18. Output $\mathbf{r}_{\text{L}}(\text{T})$ for classification

> These figure from [1].

The traing log is below:

```
Training Setting: batchsize=128 | epoch=246 | lr=1.0e-05
Training: Epoch=246 | Loss: 0.000 |  Acc: 99.998% (49999/50000) | best acc: 93.750
Testing: Epoch=246 | Loss: 0.467 |  Acc: 93.580% (9358/10000) | best_acc: 93.750

Training Setting: batchsize=128 | epoch=247 | lr=1.0e-05
Training: Epoch=247 | Loss: 0.000 |  Acc: 100.000% (50000/50000) | best acc: 93.750
Testing: Epoch=247 | Loss: 0.467 |  Acc: 93.590% (9359/10000) | best_acc: 93.750

Training Setting: batchsize=128 | epoch=248 | lr=1.0e-05
Training: Epoch=248 | Loss: 0.000 |  Acc: 99.994% (49997/50000) | best acc: 93.750
Testing: Epoch=248 | Loss: 0.466 |  Acc: 93.600% (9360/10000) | best_acc: 93.750

Training Setting: batchsize=128 | epoch=249 | lr=1.0e-05
Training: Epoch=249 | Loss: 0.001 |  Acc: 99.988% (49994/50000) | best acc: 93.750
Testing: Epoch=249 | Loss: 0.466 |  Acc: 93.590% (9359/10000) | best_acc: 93.750
```

And then, like task B3, i use the adversarial attack to verify its robustness.
The training log is saved in ./log folder, and the adversarial attack result is saved in the same folder.
The result is below:

```
without attack  Test Accuracy = 9375 / 10000 = 93.75%
Epsilon: 0      Test Accuracy = 5348 / 10000 = 53.48%
Epsilon: 0.05   Test Accuracy = 4372 / 10000 = 43.72%
Epsilon: 0.1    Test Accuracy = 3749 / 10000 = 37.49%
Epsilon: 0.15   Test Accuracy = 3312 / 10000 = 33.12%
Epsilon: 0.2    Test Accuracy = 2989 / 10000 = 29.89%
Epsilon: 0.25   Test Accuracy = 2752 / 10000 = 27.52%
Epsilon: 0.3    Test Accuracy = 2547 / 10000 = 25.47%
Epsilon: 0.5    Test Accuracy = 2027 / 10000 = 20.27%
Epsilon: 1.0    Test Accuracy = 1483 / 10000 = 14.83%
```

I train the PCN in 250 epochs, and adversarial attack epsilons in [0, .05, .1, .15, .2, .25, .3, .5, 1.]

Reference

1. Wen H, Han K, Shi J, et al. Deep predictive coding network for object recognition[C]//International Conference on Machine Learning. PMLR, 2018: 5266-5275.
2. a-new-kind-of-deep-neural-networks
3. PredNet