Chapter 14 Report:
Classifying Images with CNNs

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1 Overview

In this chapter, I studied convolutional neural networks (CNNs) and their application in image classification tasks. CNNs are designed to extract hierarchical features from images, which makes them highly effective for vision-related problems.

2 Key Concepts

2.1 Convolutional Neural Networks

- CNNs mimic the human visual cortex and automatically learn features from raw data.
- Feature hierarchies: low-level features $\rightarrow$ high-level representations.
- Key ideas: **sparse connectivity** and **parameter sharing**.
- Pooling layers reduce spatial dimensions and help with generalization.

2.2 Discrete Convolution

$$y[i] = \sum_{k=-\infty}^{+\infty} x[i-k] \cdot w[k]$$
$$Y[i,j] = \sum_{k_1} \sum_{k_2} X[i-k_1, j-k_2] \cdot W[k_1, k_2]$$

Important hyperparameters: padding (full, same, valid), stride.

2.3 Pooling Layers

- Max-pooling and mean-pooling.
- Improve robustness to noise, reduce overfitting.
- Can use overlapping or non-overlapping pooling.

2.4 CNN Implementation

- Handling multiple input/output channels:

$$Z^{\text{conv}}[:,:,k] = \sum_{c=1}^{C_{in}} W[:,:,c,k] * X[:,:,c]$$
$$Z[:,:,k] = Z^{\text{conv}} + b[k]$$
$$A[:,:,k] = \sigma(Z[:,:,k])$$

2.5 Regularization

- L2 regularization (weight decay) and dropout help prevent overfitting.
- Dropout encourages robust feature learning.

2.6 Loss Functions

- Binary classification: `BCEWithLogitsLoss`, `BCELoss`
- Multiclass: `CrossEntropyLoss`, `NLLLoss`

2.7 Other Techniques

- **Data augmentation**: enhances generalization.
- **Global average pooling**: reduces parameters.

3 Practice Notes (To Do)

- Thêm phần báo cáo mô hình: độ chính xác, loss, biểu đồ learning curve.
- Ghi lại thông số mạng và kết quả tuning hyperparameters.
- Viết nhận xét cá nhân, khó khăn gặp phải khi cài CNN bằng PyTorch.

4 References

- LeCun et al. (1989), *Handwritten Digit Recognition with a Back-Propagation Network.*
- Krizhevsky et al. (2012), *ImageNet Classification with Deep CNNs.*
- Srivastava et al. (2014), *Dropout: A Simple Way to Prevent Overfitting.*
- Kingma and Ba (2014), *Adam: A Method for Stochastic Optimization.*