Lecture 5: Convolutional Neural Network (CNN) - Building and Tuning

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CIS 6217 – Computer Vision for Data Representation

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Outline

1. Overfitting in CNN
2. Dropout Layer
3. Summary

Learning Outcomes

- Define and select appropriate performance metrics beyond accuracy.
- Design a baseline model and prepare data for training.
- Diagnose underfitting and overfitting using learning curves.
- Understand and tune hyperparameters such as learning rate, batch size, and epochs.
- Apply regularization and batch normalization to improve generalization.

Overview

- Importance of systematic DL project design.
- Common pitfalls: poor metrics, unbalanced data, overfitting.
- Roadmap:

metrics → baseline → evaluation → tuning → regularization.

What are the performance metrics in DL?

Performance Metrics

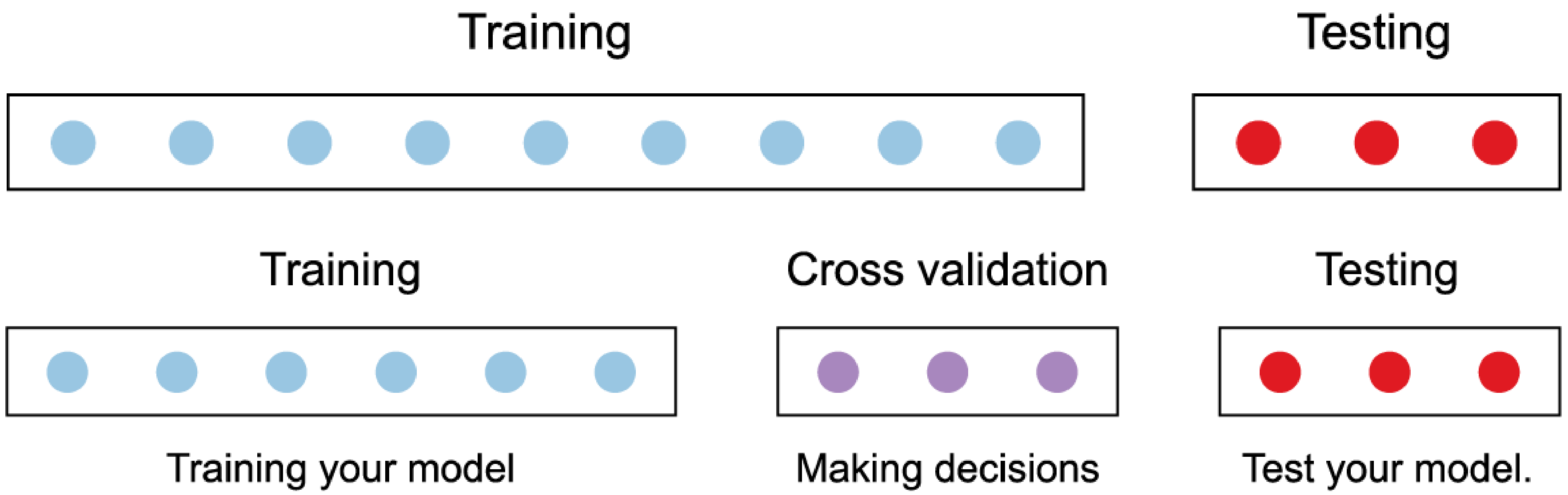
- Accuracy
- Precision
- Recall
- F1

Designing a Baseline Model

- Start with simple architecture (e.g., small CNN).
- Defines reference performance for future tuning.
- Avoid early complexity.

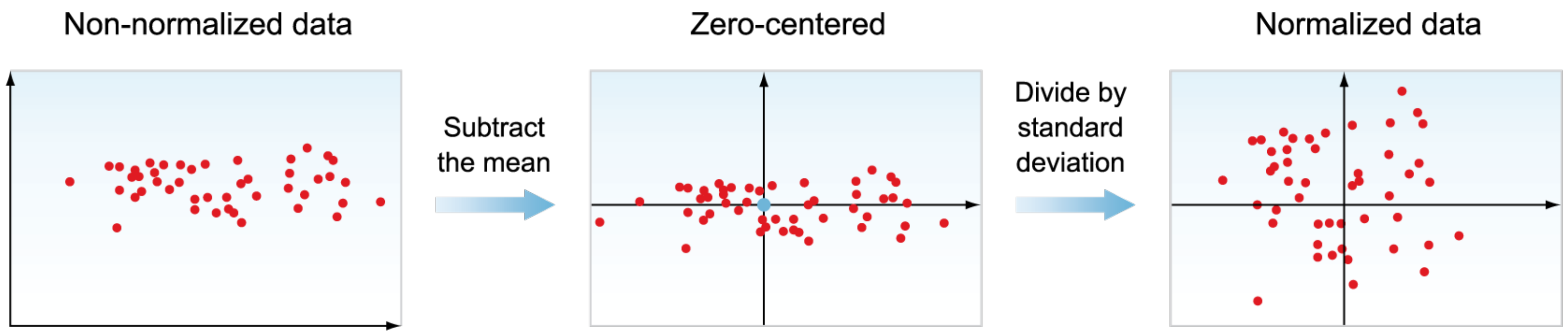
Data Preparation & Splitting

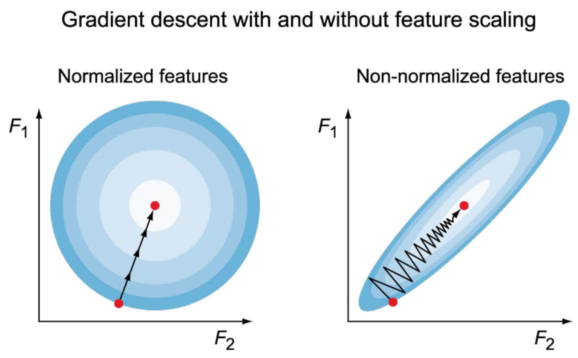
- Typical ratios: 70-15-15 or 80-10-10.
- Keep validation unseen until tuning.
- Ensure balanced representation.



Data Preprocessing

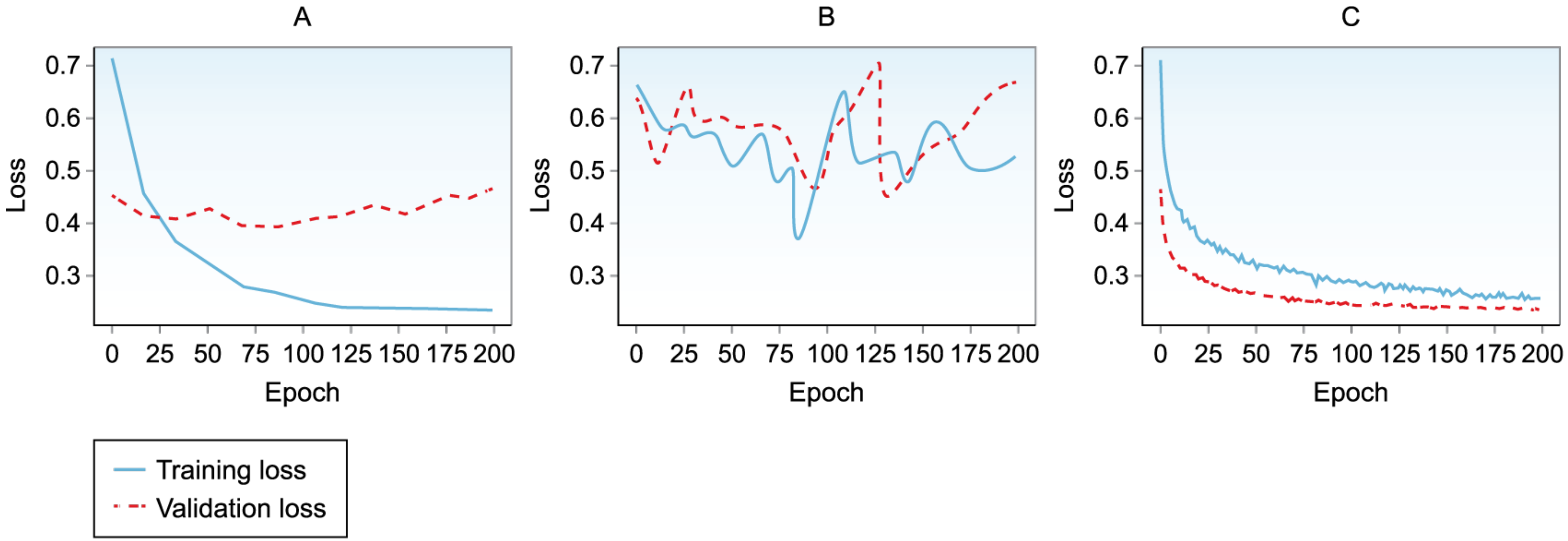
- Normalization.
- Resizing, color conversion, noise injection.
- Data augmentation increases diversity.





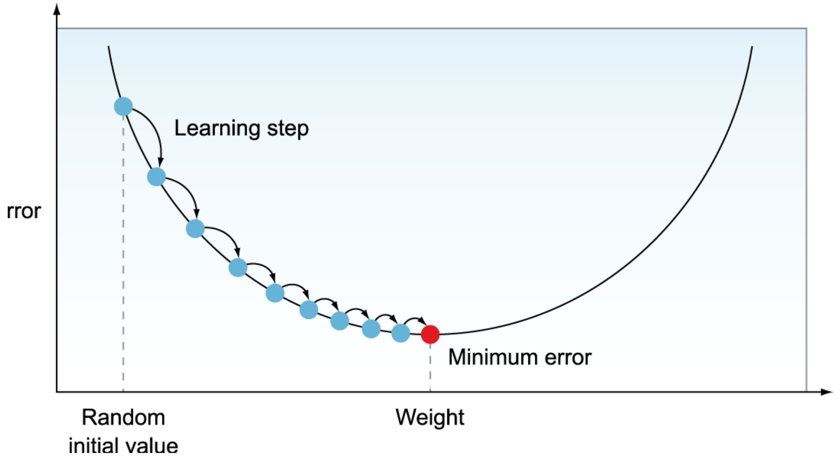
Learning Curves

- Plot loss vs epochs.
- Stable convergence = both curves flatten together.
- Divergence = overfitting.



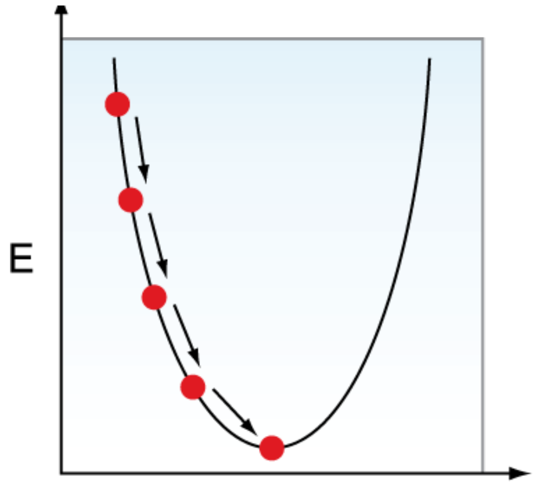
Network Architecture

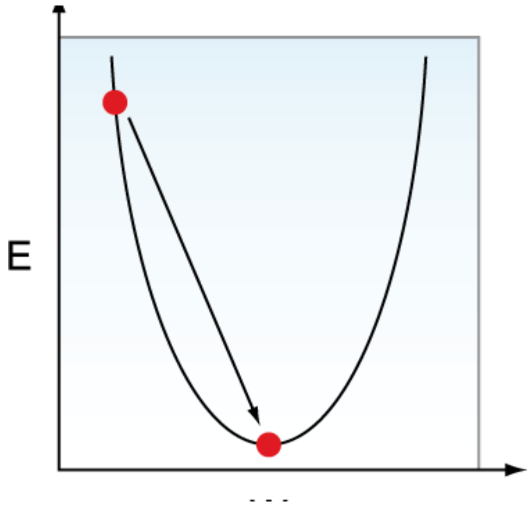
- Number of layers (depth).
- Number of filters (width).
- Kernel size (3×3, 5×5).
- Activation function.

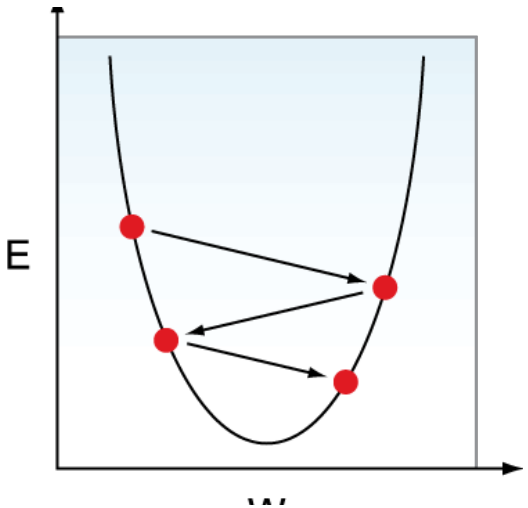


Learning rate

- SGD: constant lr per batch.
- Momentum: adds velocity term.
- Adam: adaptive moment estimation.

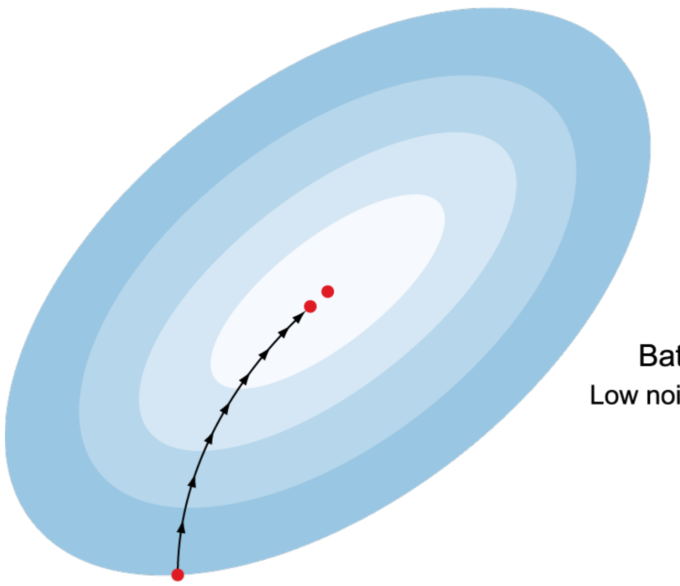


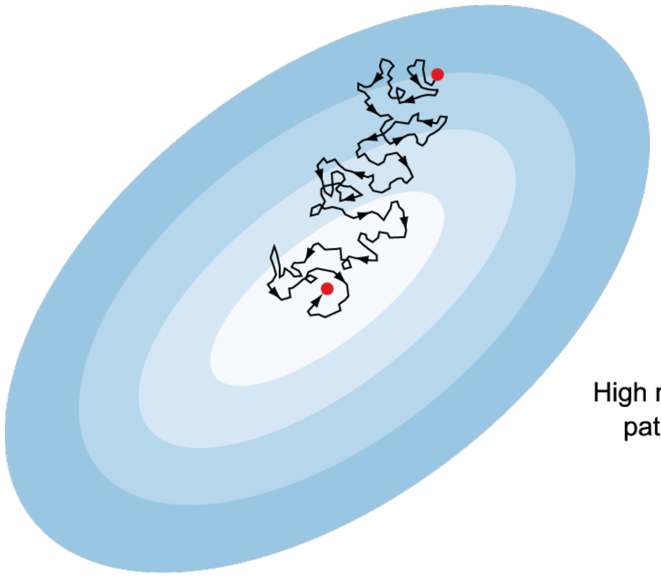




Gradient Descent

- Batch Gradient Descent
- Stochastic Gradient Descent
- Mini-Batch Gradient Descent





Number of Epochs and Early Stopping

Epoch 1, Training Error: 5.4353, Validation Error: 5.6394

Epoch 2, Training Error: 5.1364, Validation Error: 5.2216

Epoch 3, Training Error: 4.7343, Validation Error: 4.8337

Epoch 6, Training Error: 3.7312, Validation Error: 3.8324

Epoch 7, Training Error: 3.5324, Validation Error: 3.7215

Epoch 8, Training Error: 3.7343, Validation Error: 3.8337

References

- Guide to CNNs for CV – Khan et al. (2018)
- Deep Learning with Python – Chollet (2018)
- Deep Learning in Computer Vision – Awad & Hassaballah (2020)

- Deep Learning for Vision Systems by Mohamed Elgendy (2020)