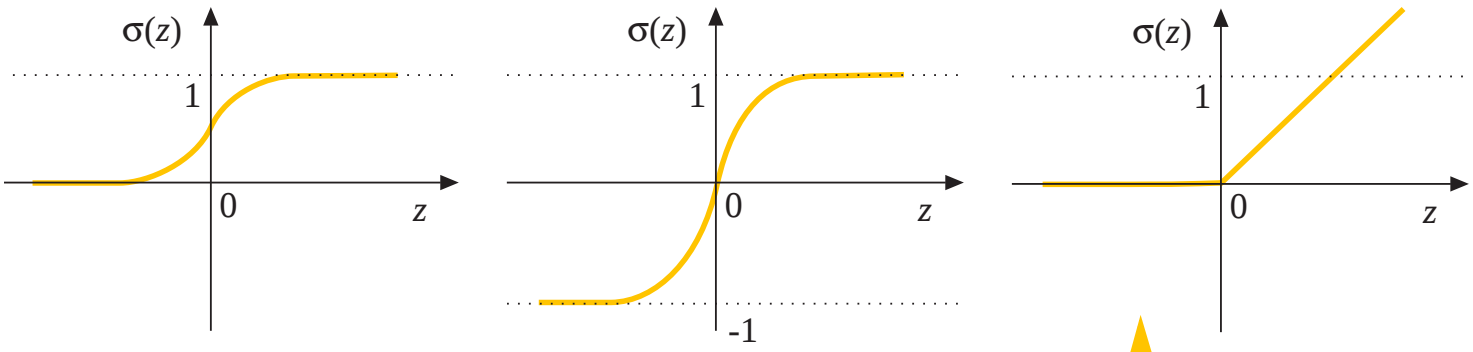
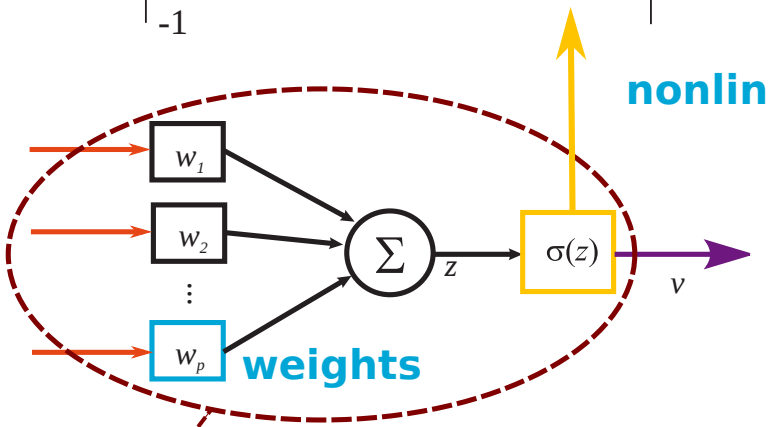
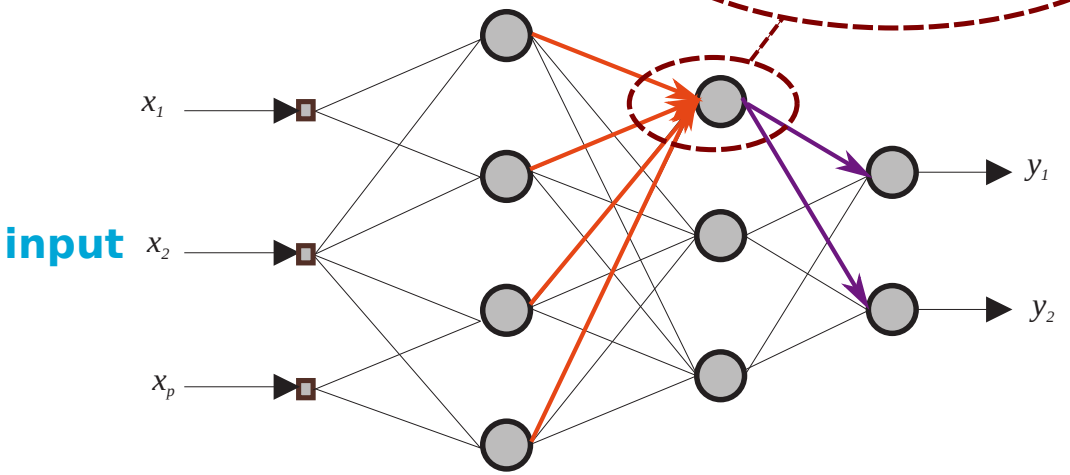
Recap artificial neural networks part 1







Foward pass:

$$y = f(x; w)$$

input

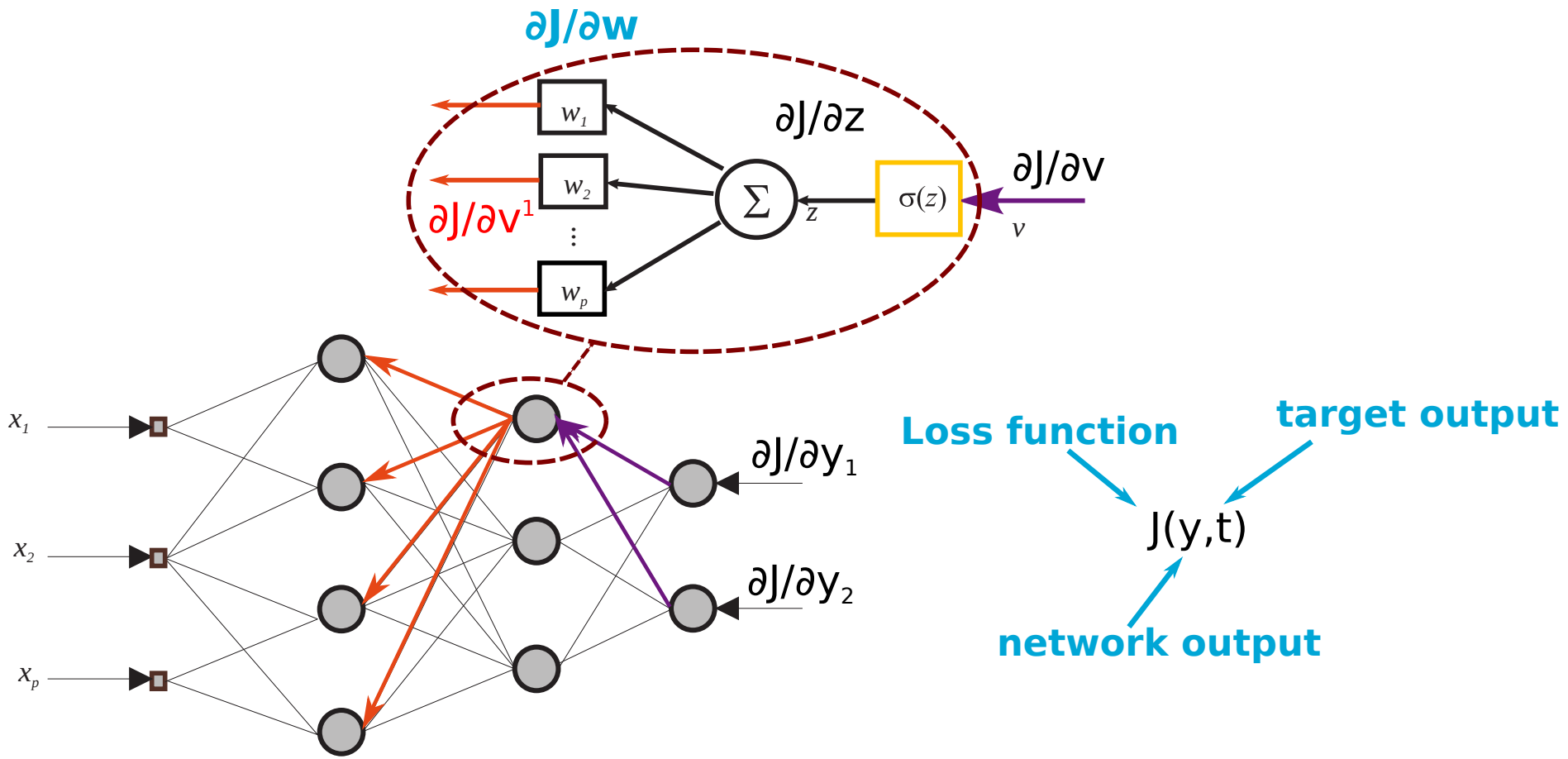
output

network structure

weights

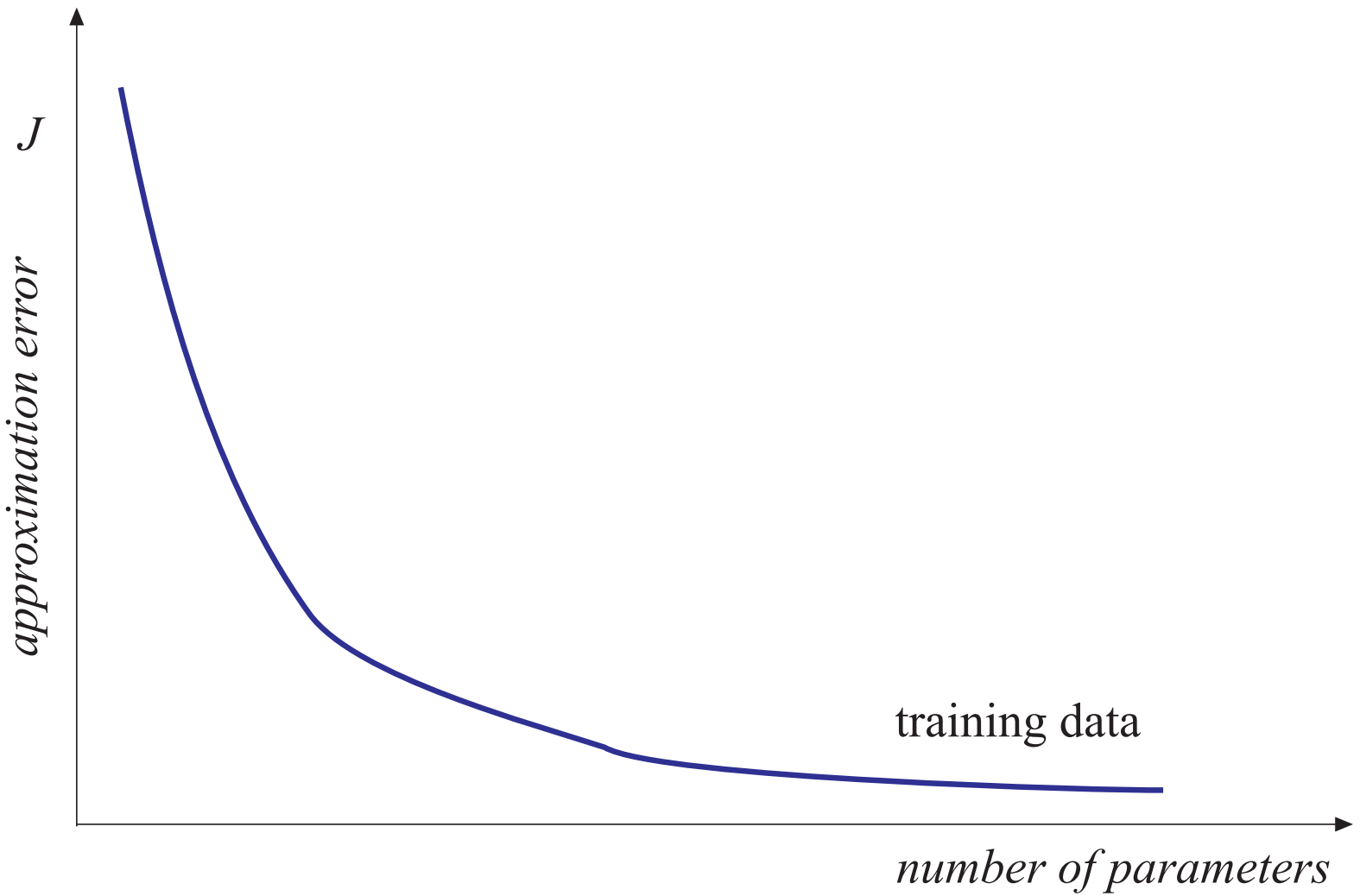
Recap artificial neural networks part 1

Backward pass: calculate $\nabla_W J$ and use it in an optimization algorithm to iteratively update the weights of the network to minimize the loss J.

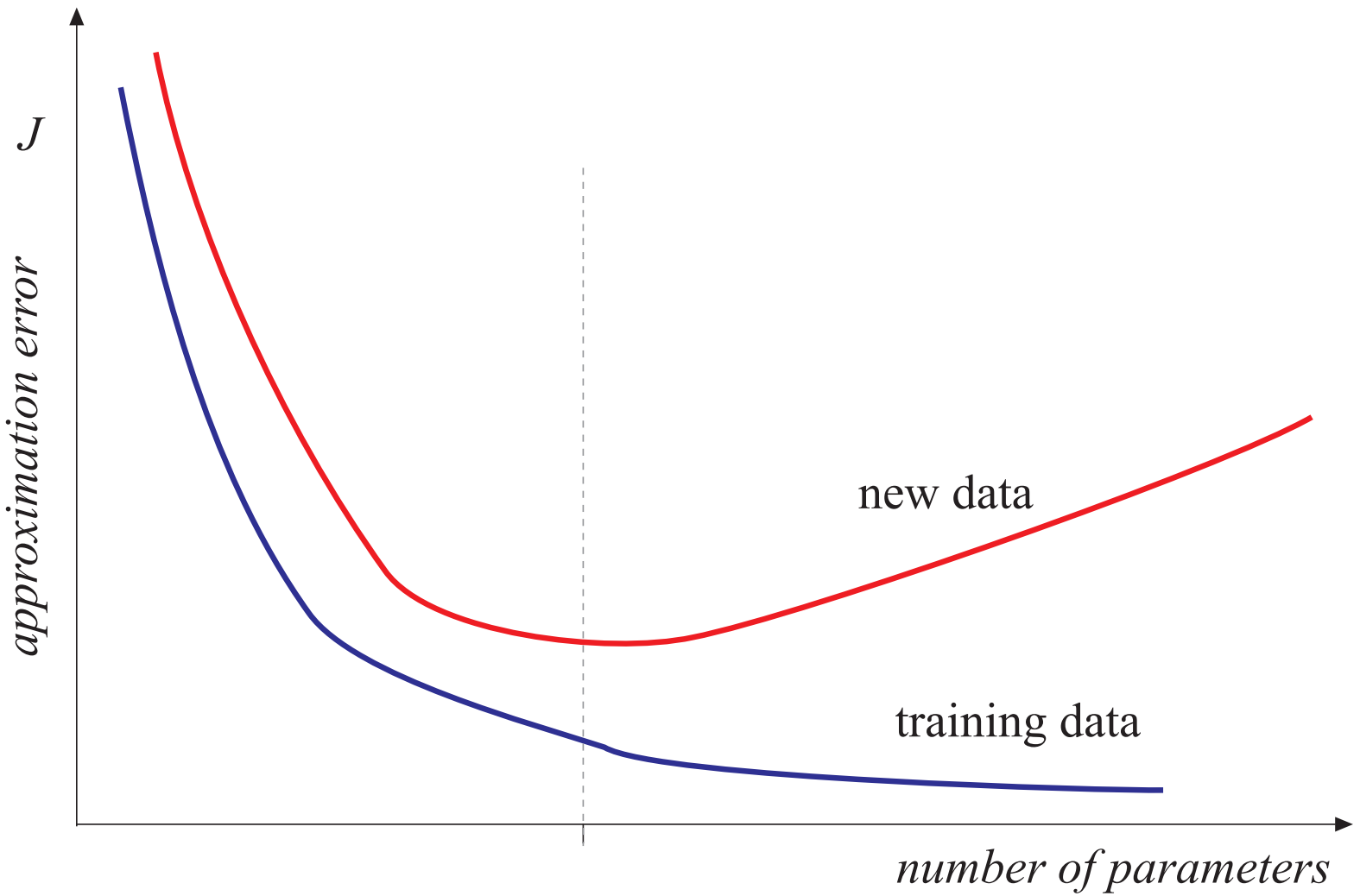


Outline

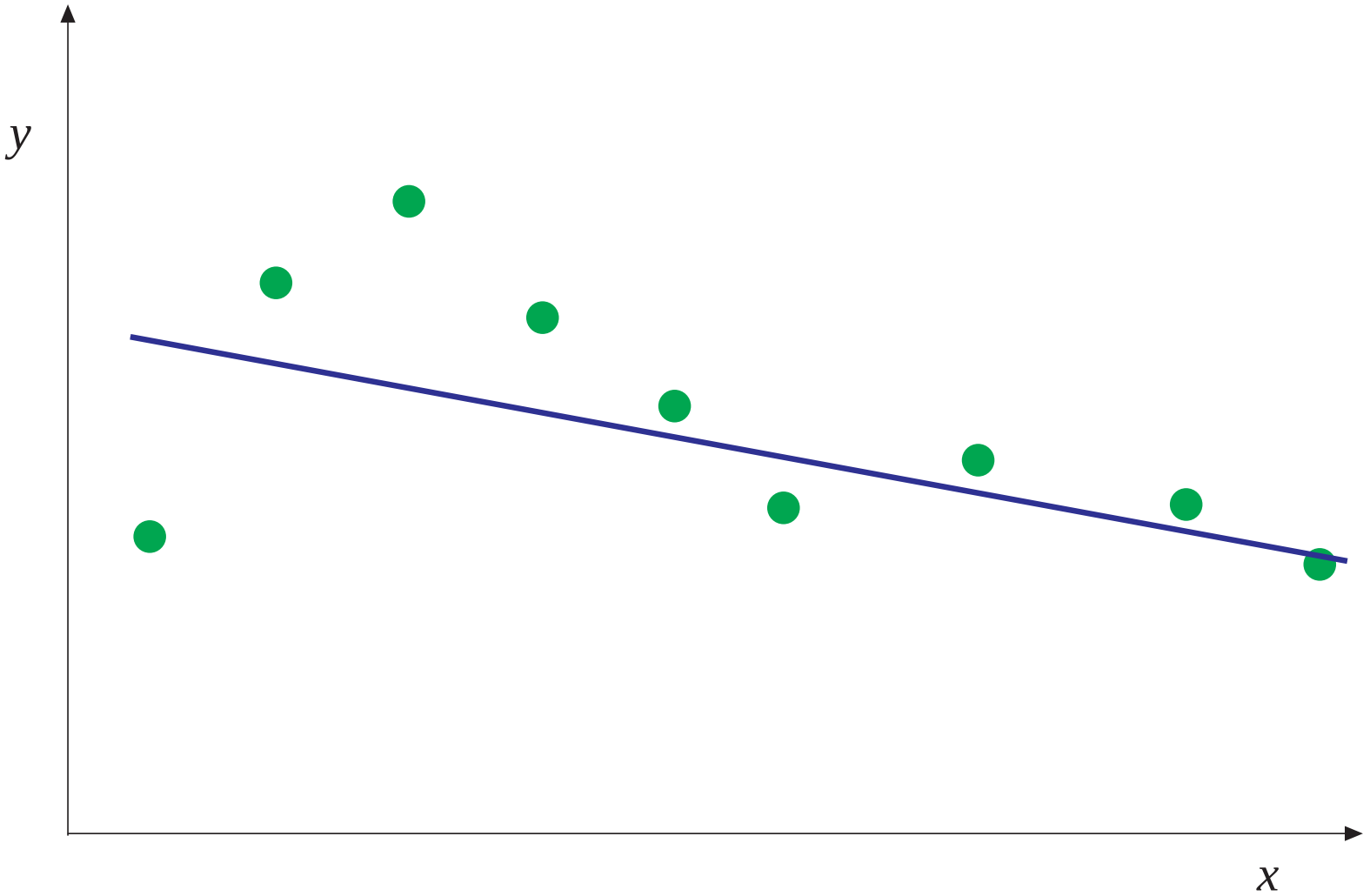
Approximation error vs. number of parameters



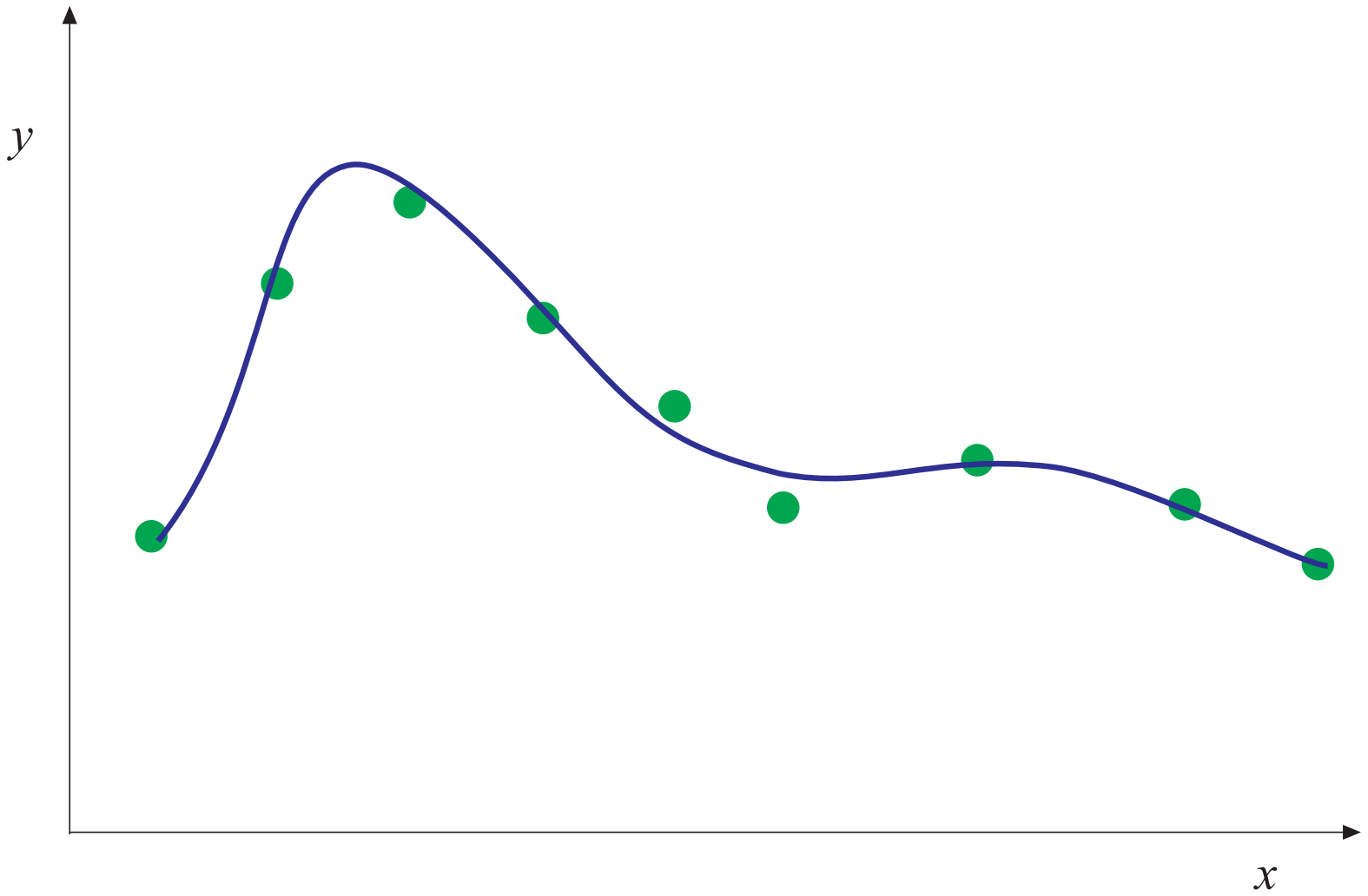
Approximation error vs. number of parameters



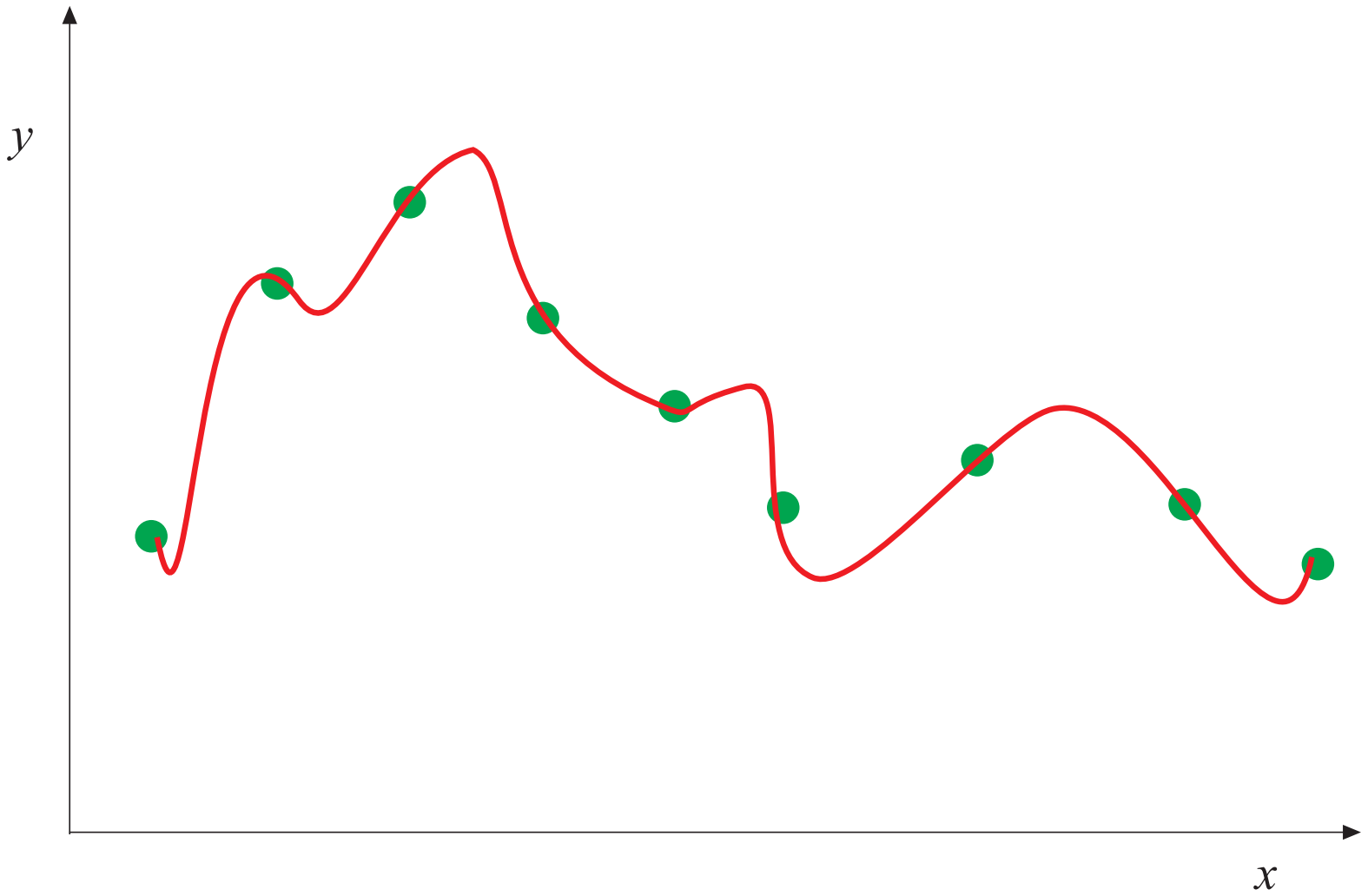
Underfitting



Good fit



Overfitting



Validation

System: $y = f(\mathbf{x})$ or $y(k+1) = f(\mathbf{x}(k), \mathbf{u}(k))$
Model: $\hat{y} = F(\mathbf{x}; \theta)$ or $\hat{y}(k+1) = F(\mathbf{x}(k), \mathbf{u}(k); \theta)$

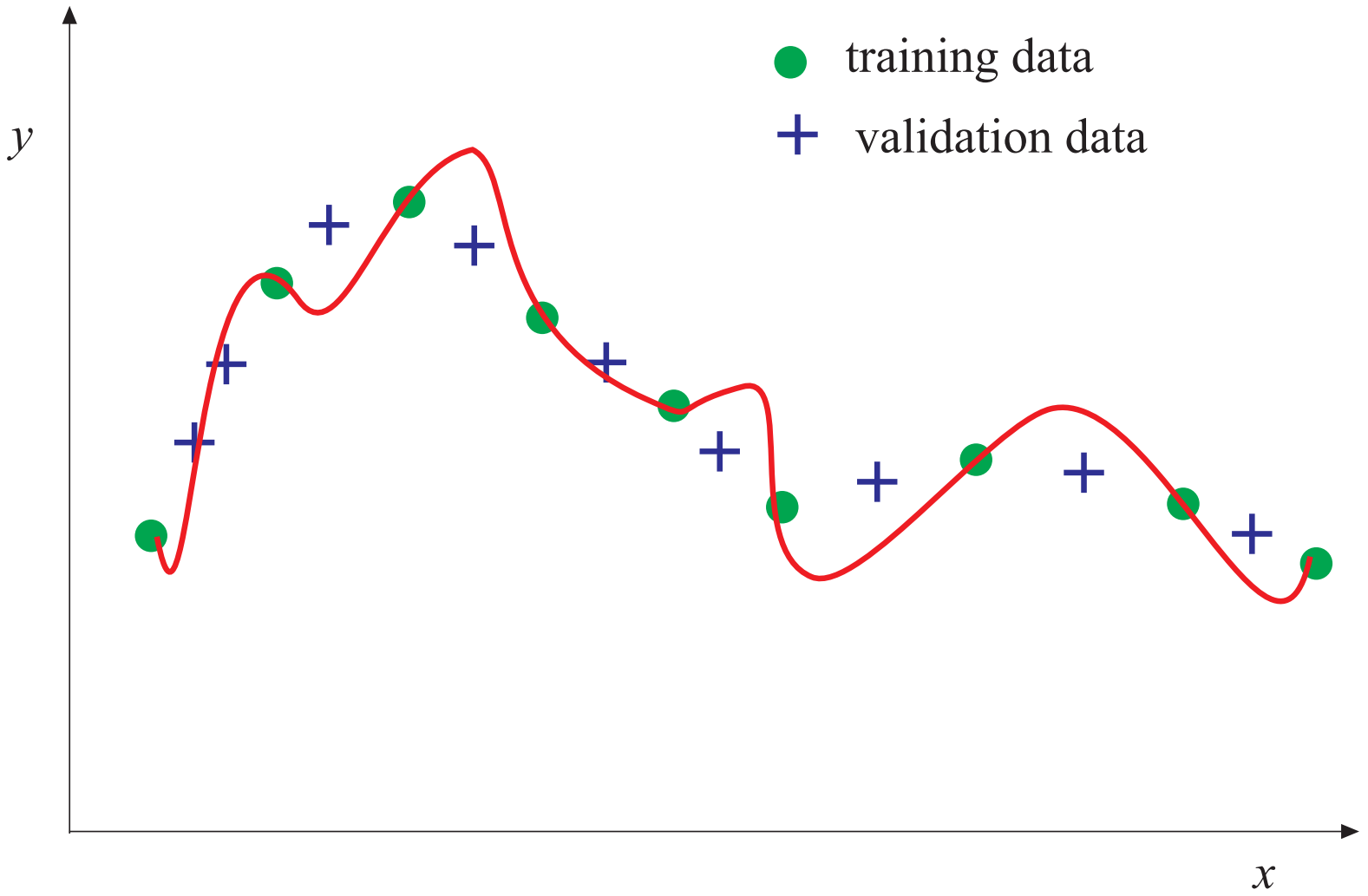
True criterion:

$$I = \int_X \|f(\mathbf{x}) - F(\mathbf{x})\| \mathbf{dx} \tag{1}$$

Usually cannot be computed as $f(\mathbf{x})$ is not available,
use available data to numerically approximate (1)

- use a validation set
- cross-validation (randomize)

Validation Data Set



Cross-Validation

- Regularity criterion (for two data sets):

$$RC = \frac{1}{2}\left[\frac{1}{N_A}\sum_{i=1}^{N_A}(y^A(i) - \hat{y}_B^A(i))^2 + \frac{1}{N_B}\sum_{i=1}^{N_B}(y^B(i) - \hat{y}_A^B(i))^2\right]$$

- v-fold cross-validation

Some Common Criteria

- Mean squared error (root mean square error):

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(y(i) - \hat{y}(i))^2$$

- Variance accounted for (VAF):

$$\text{VAF} = 100\% \cdot \left[1 - \frac{\text{var}(y - \hat{y})}{\text{var}(y)}\right]$$

- Check the correlation of the residual $y - \hat{y}$ to u, y and itself.

Test set

The *validation* set is used to select the right **hyper-parameters**.

- Structure of the network
- Cost function
- Optimization parameters
- ...

What might go wrong?

Test set

The *validation* set is used to select the right **hyper-parameters**.

- Structure of the network
- Cost function
- Optimization parameters
- ...

What might go wrong?

Use a separate *test* set to verify the hyper-parameters have not been over-fitted to the validation set.

Outline

Applications of neural nets

- Black-box modeling of systems from input-output data.
- Reconstruction (estimation) – soft sensors.
- Classification.
- Neurocomputing.
- Neurocontrol.