

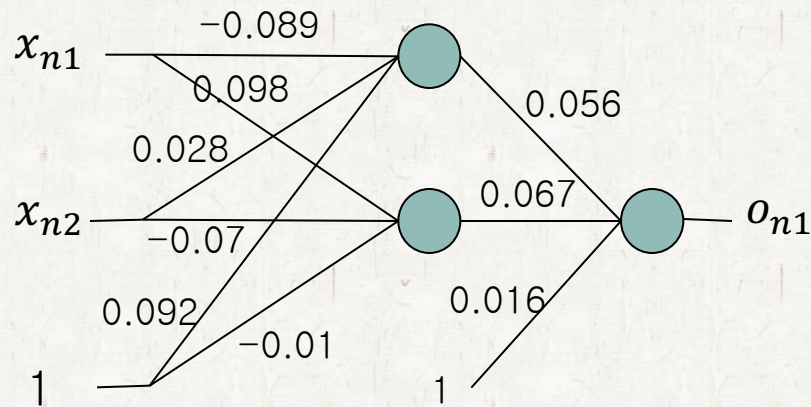
# Example of Error Back Propagation

# Example of Error Back Propagation (1)

## Example : XOR

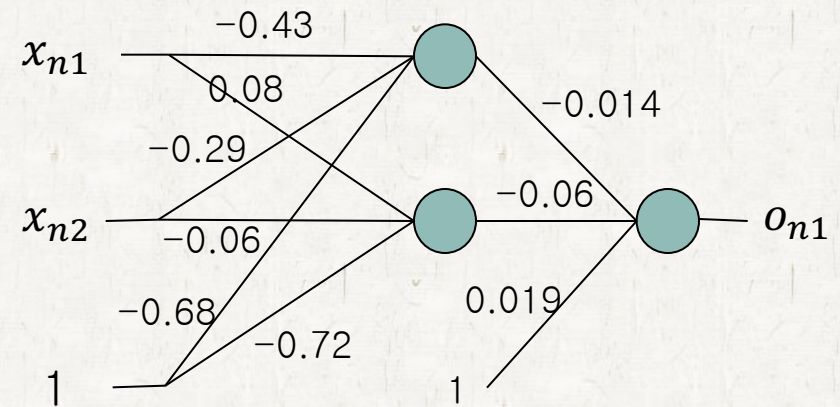
Iteration : 0

$x_{n1}$	$x_{n2}$	$t_{n1}$	$o_{n1}$
1	1	0	0.52
1	0	1	0.50
0	1	1	0.52
0	0	0	0.55



Iteration : 1000

$x_{n1}$	$x_{n2}$	$t_{n1}$	$o_{n1}$
1	1	0	0.50
1	0	1	0.48
0	1	1	0.50
0	0	0	0.52

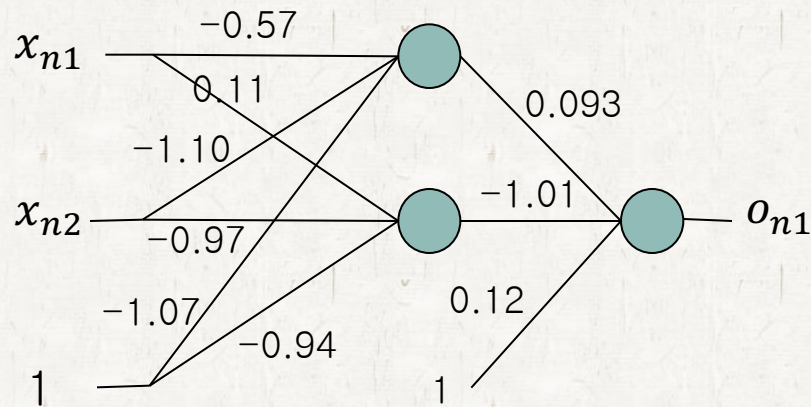


# Example of Error Back Propagation (2)

## Example : XOR

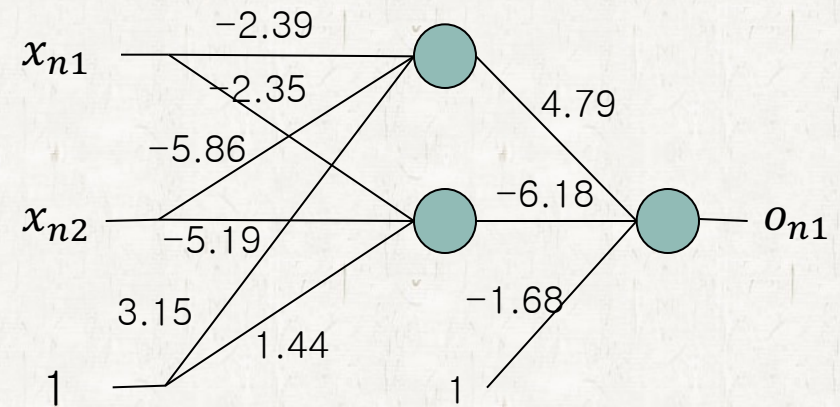
Iteration : 2000

$x_{n1}$	$x_{n2}$	$t_{n1}$	$o_{n1}$
1	1	0	0.53
1	0	1	0.48
0	1	1	0.50
0	0	0	0.48



Iteration : 3000

$x_{n1}$	$x_{n2}$	$t_{n1}$	$o_{n1}$
1	1	0	0.30
1	0	1	0.81
0	1	1	0.81
0	0	0	0.11

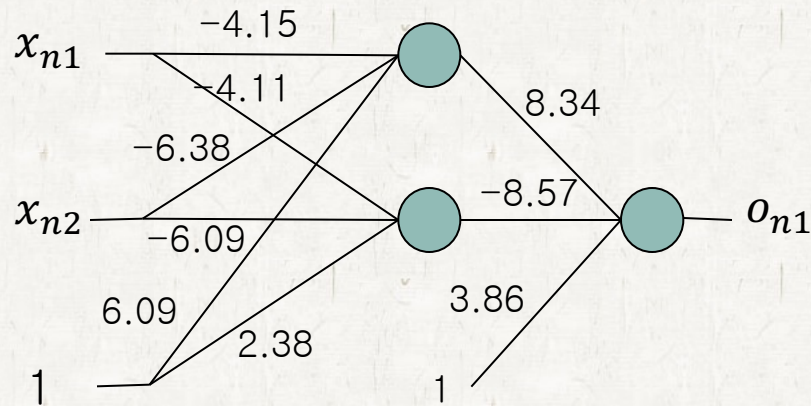


# Example of Error Back Propagation (3)

## Example : XOR

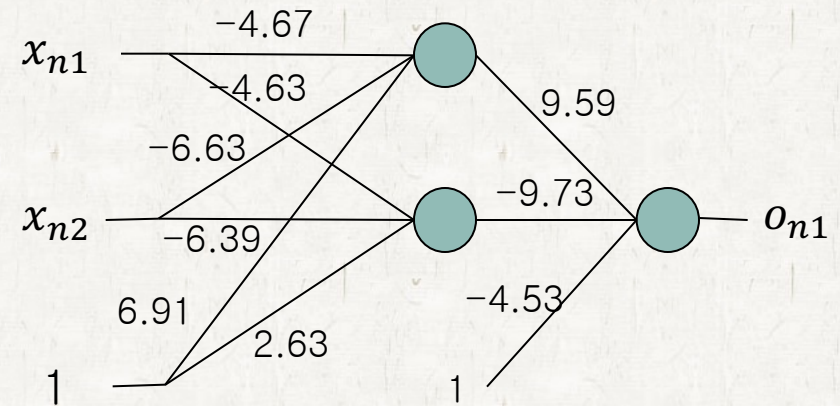
Iteration : 5000

$x_{n1}$	$x_{n2}$	$t_{n1}$	$o_{n1}$
1	1	0	0.05
1	0	1	0.96
0	1	1	0.96
0	0	0	0.03



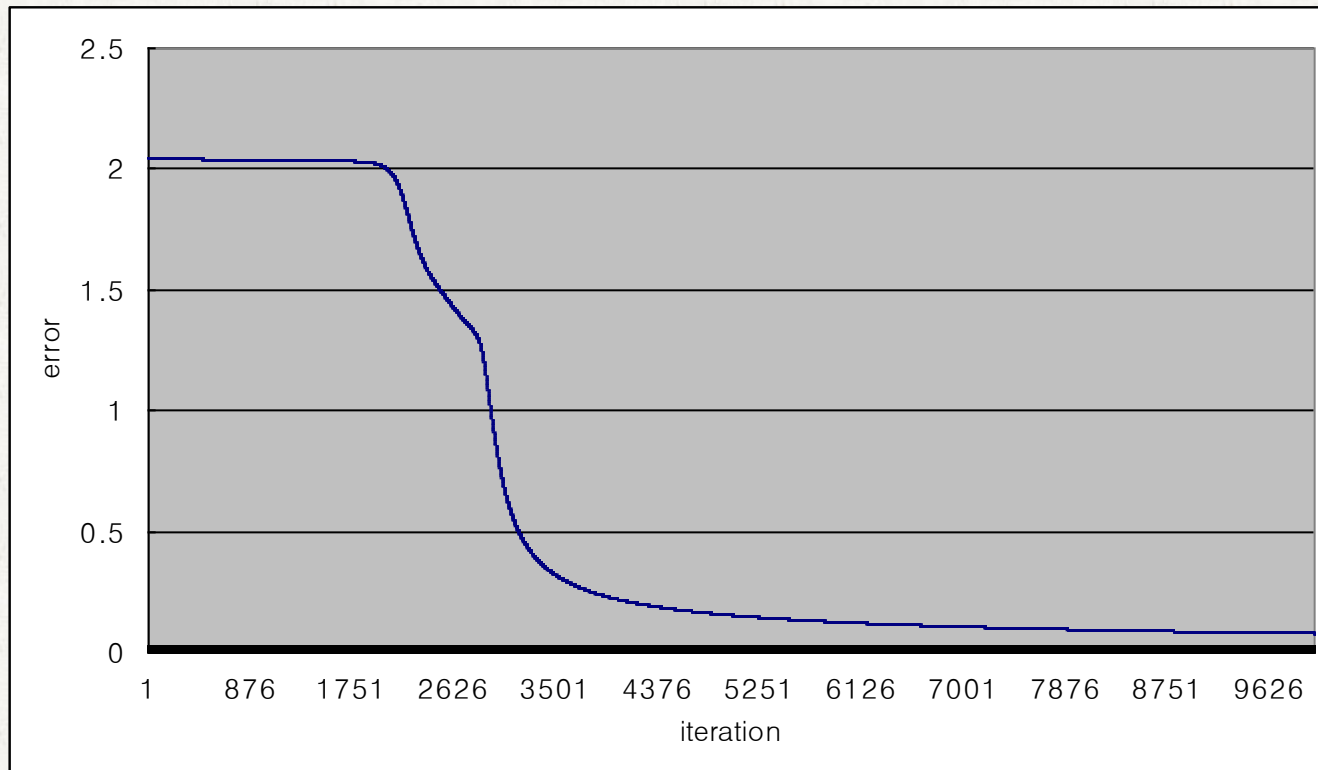
Iteration : 10000

$x_{n1}$	$x_{n2}$	$t_{n1}$	$o_{n1}$
1	1	0	0.02
1	0	1	0.98
0	1	1	0.98
0	0	0	0.02



# Example of Error Back Propagation (4)

- Example : XOR
- Error graph



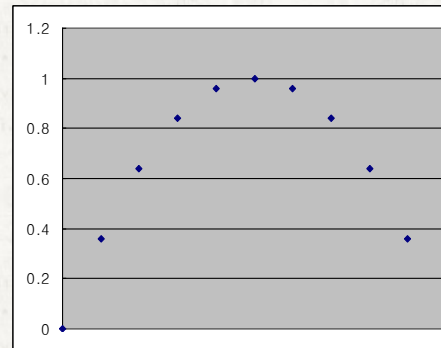
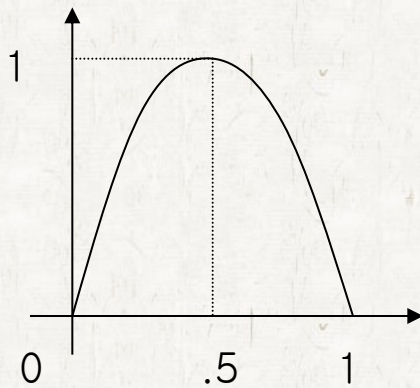


# Example of Error Back Propagation (5)

## ● Example2 :

- Hidden nodes : 4
- Iteration : 500,000
- Learning rate : 0.7

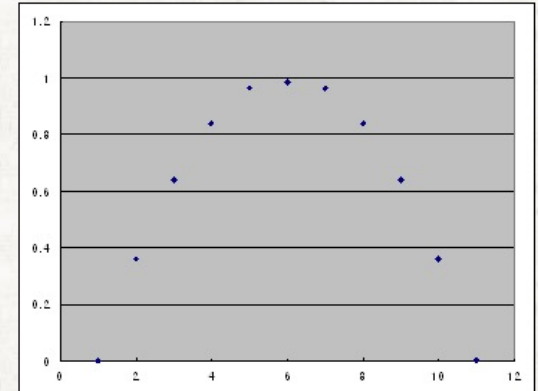
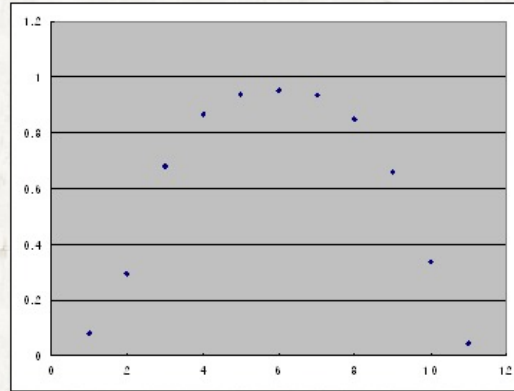
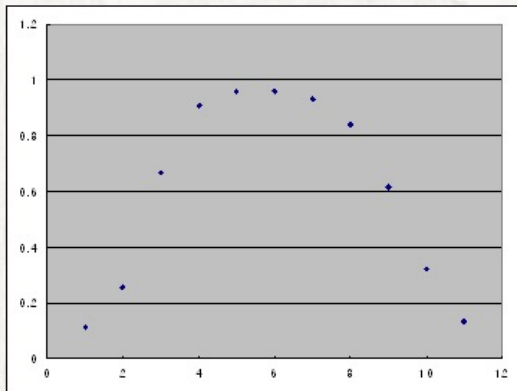
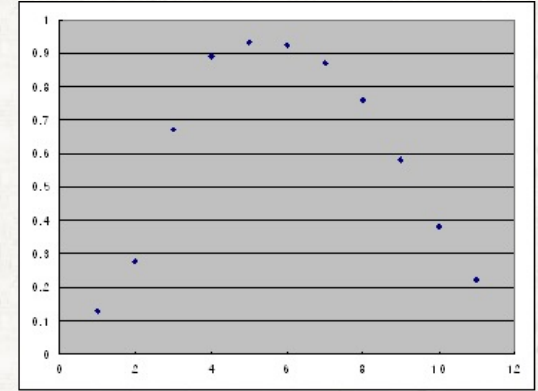
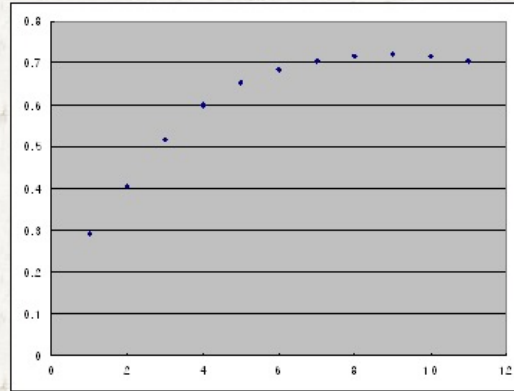
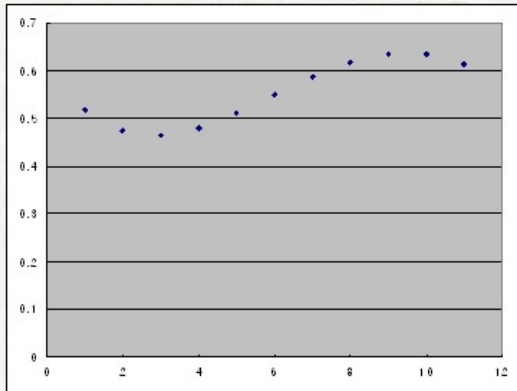
$$f(x) = 4x*(1-x)$$



Input	Output
0.00	0.00
0.10	0.36
0.20	0.64
0.30	0.84
0.40	0.96
0.50	1.00
0.60	0.96
0.70	0.84
0.80	0.64
0.90	0.36
1.00	0.00

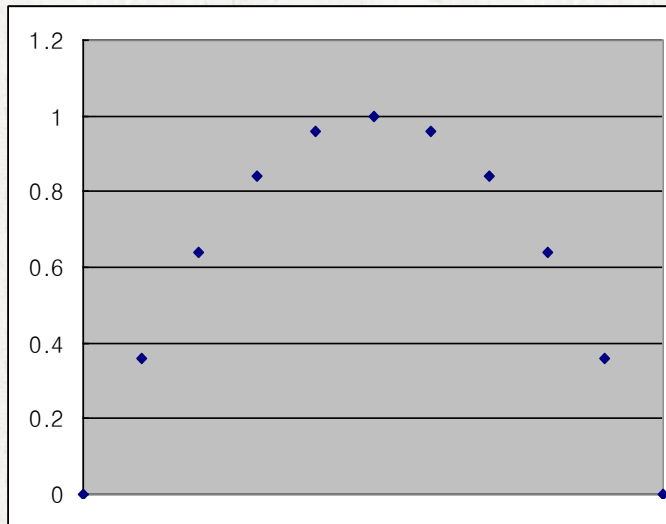
# Example of Error Back Propagation (6)

## Example2

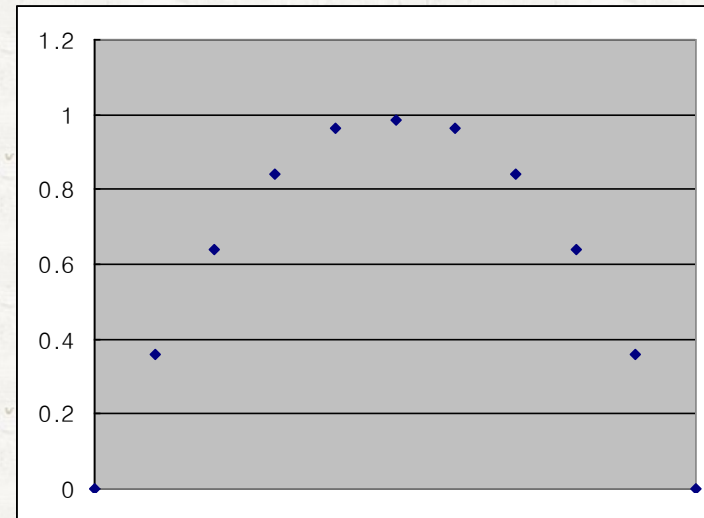


# Generalization and Overfitting (1)

- We gave only 11 points
  - A NN learned only that 11 points



Training data



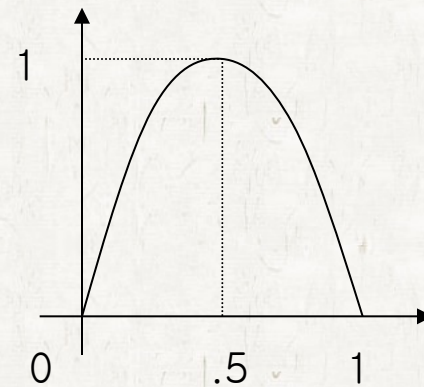
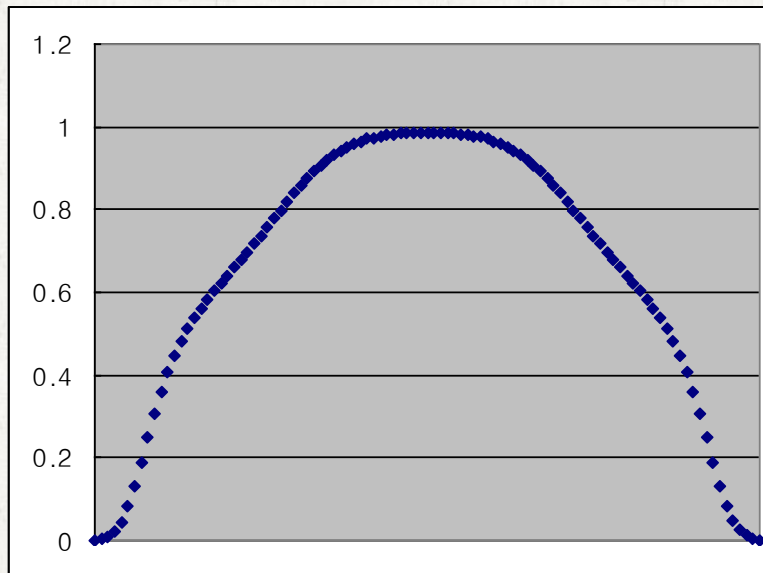
Training result

- Can the NN answer to the un-learned points?



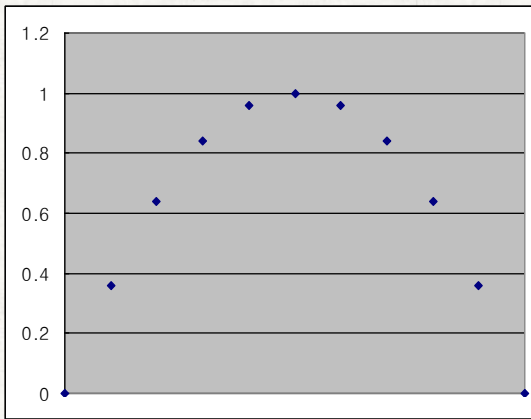
# Generalization and Overfitting (2)

- Yes, NNs generalize what they have learned

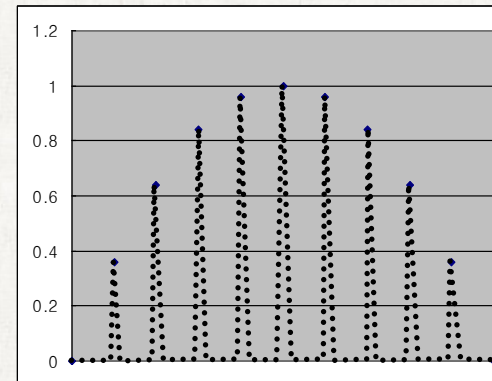
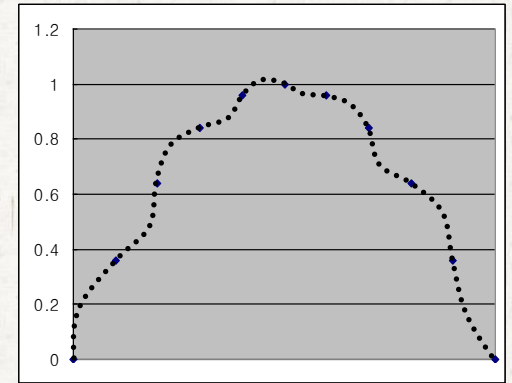
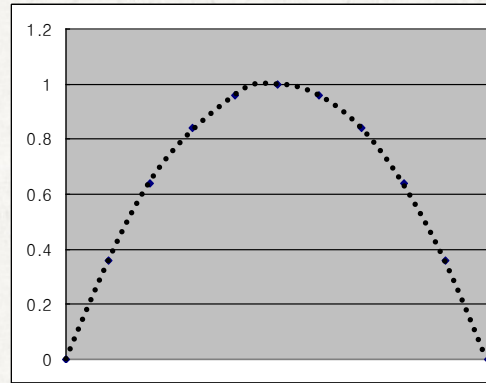


# Generalization and Overfitting (3)

Which one is better?

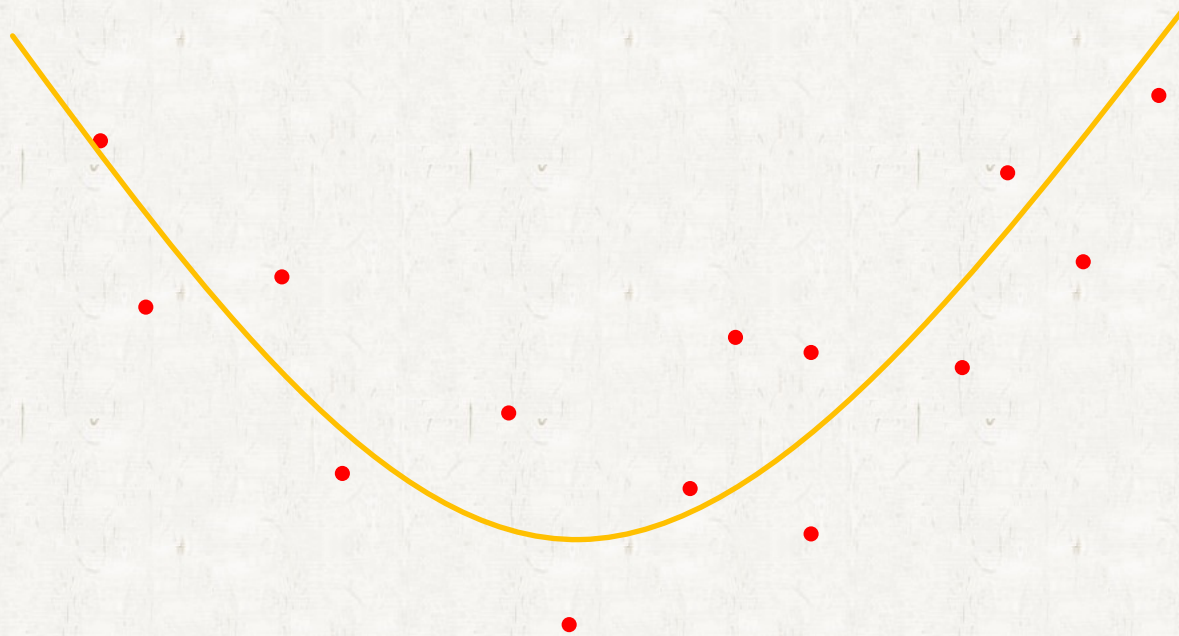


Training data



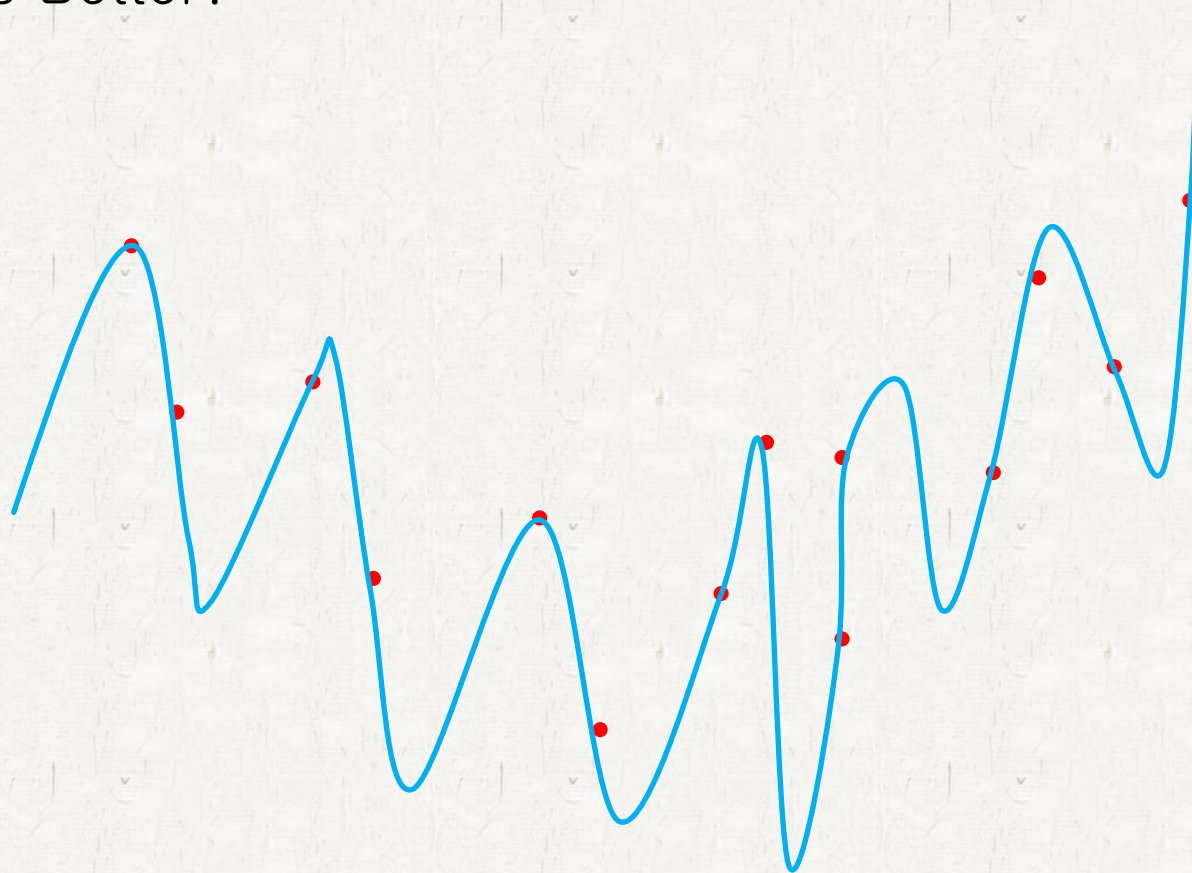
# Generalization and Overfitting (4)

Which is Better?

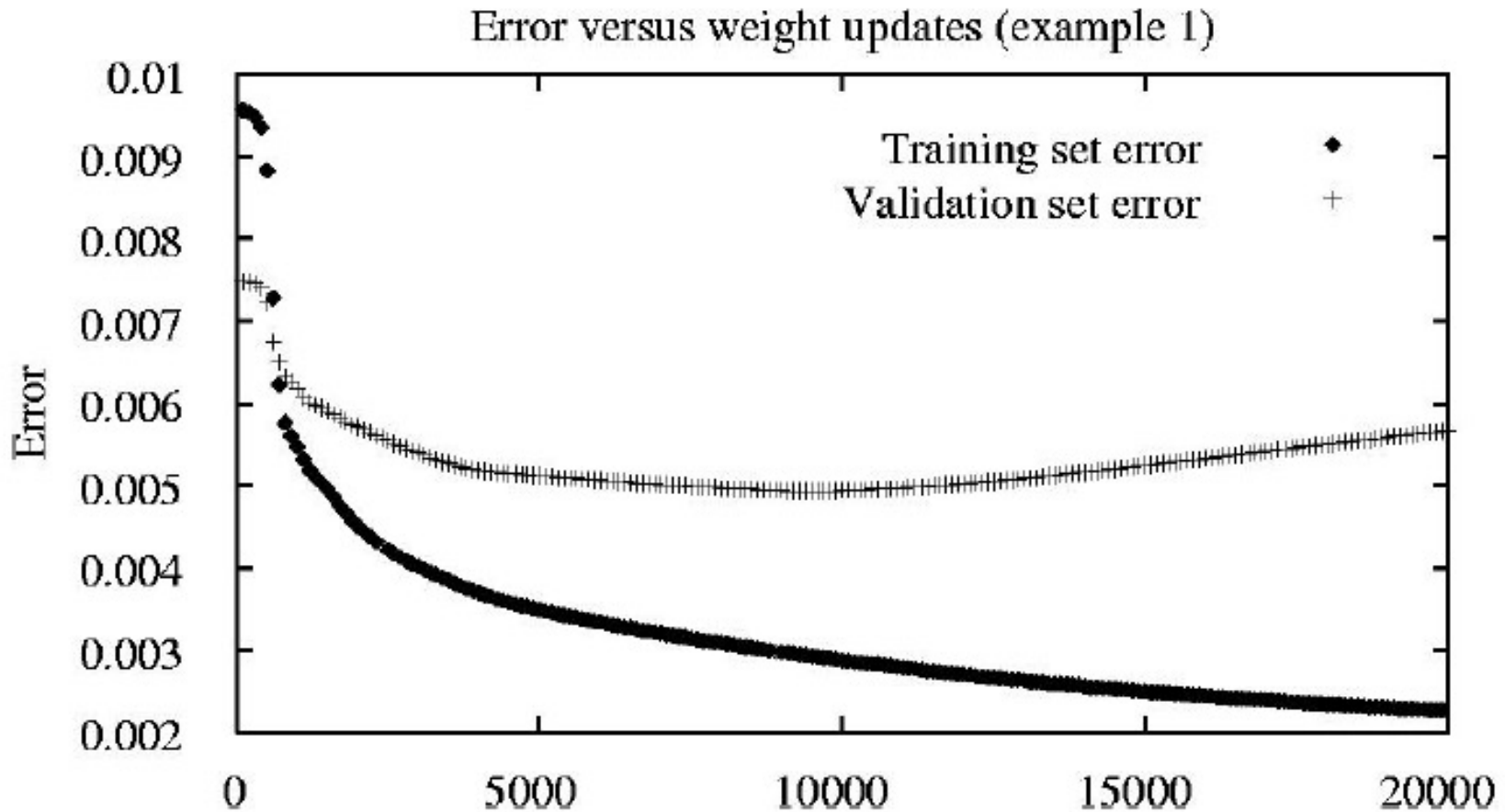


# Generalization and Overfitting (5)

Which is Better?



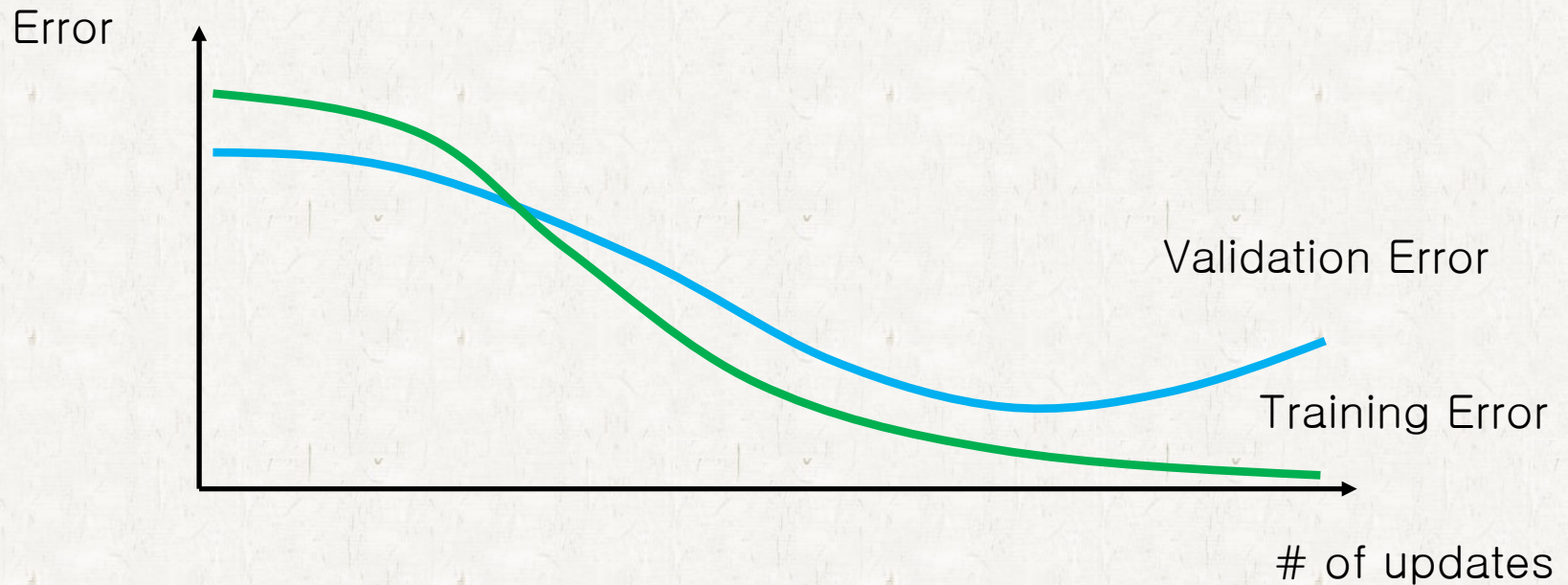
# Generalization and Overfitting (6)





# Generalization and Overfitting (7)

- Early Stopping



# Generalization and Overfitting (8)

- To increase generalization accuracy
  - Find the optimal number of neurons
  - Find the optimal number of training iterations
  - Use regularization
  - Use more training data