7주차(2/3)

순방향 신경망 예제

파이썬으로 배우는 기계학습

한동대학교
김영섭 교수

순방향 신경망 예제

- 학습 목표
  - 예제를 통해 순방향 신경망을 깊이 있게 이해한다

- 학습 내용
  - **MNIST** 자료 이해 하기
  - 다층 신경망 설계 하기
  - 순방향 신경망 신호처리
  - 순방향 신경망 예제 구현 하기

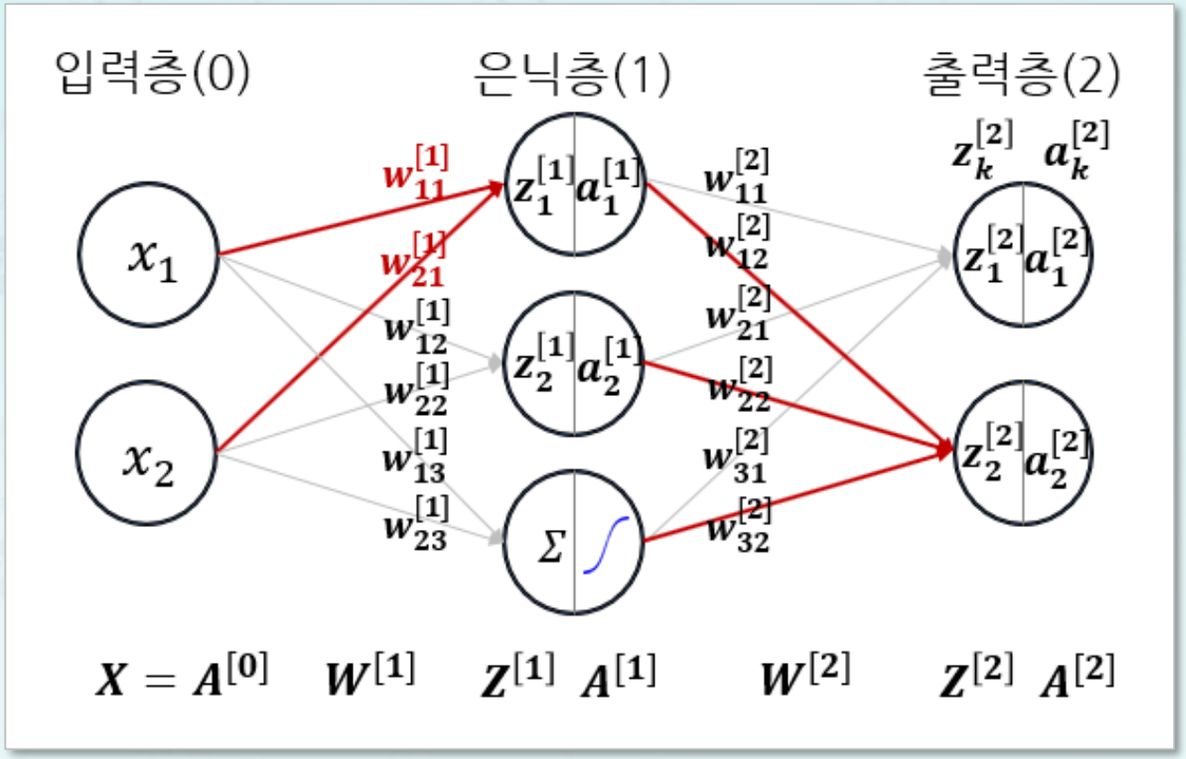
1. 다층 신경망: 입력 자료

1. 다층 신경망: 입력 자료

- **MNIST**

1. 다층 신경망: 신호 표기(복습)

- 다층 신경망



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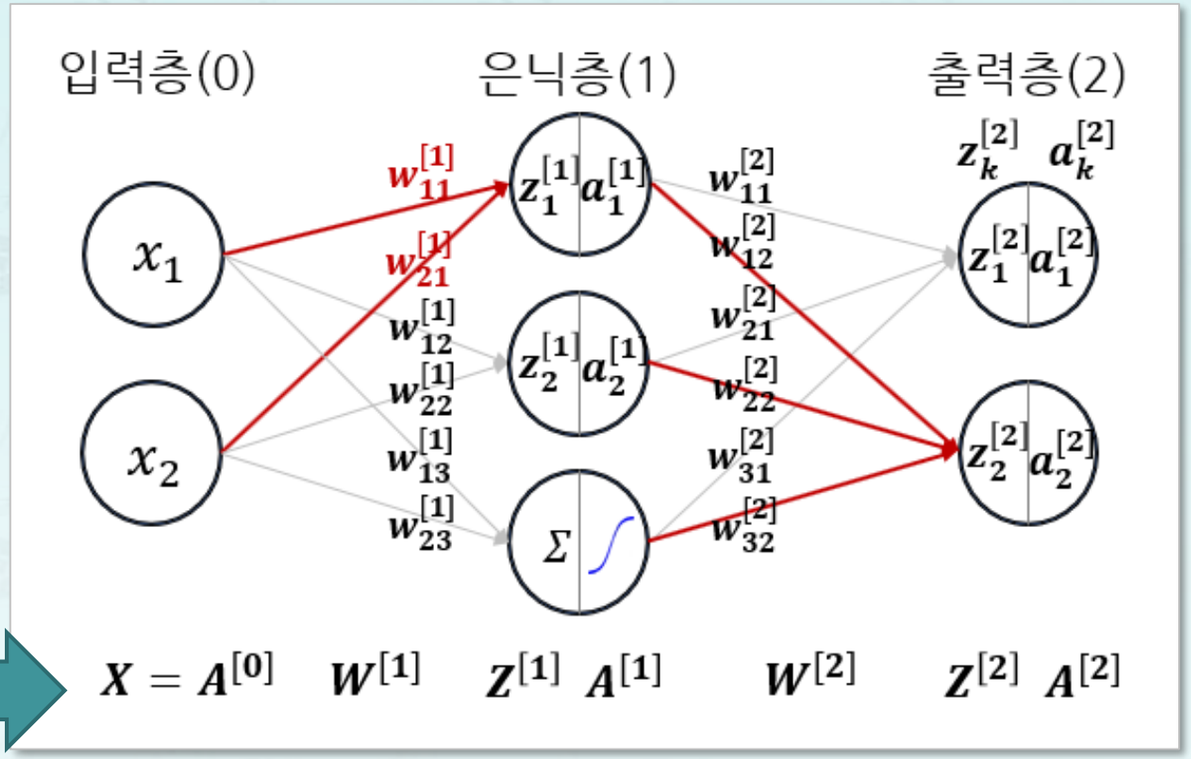
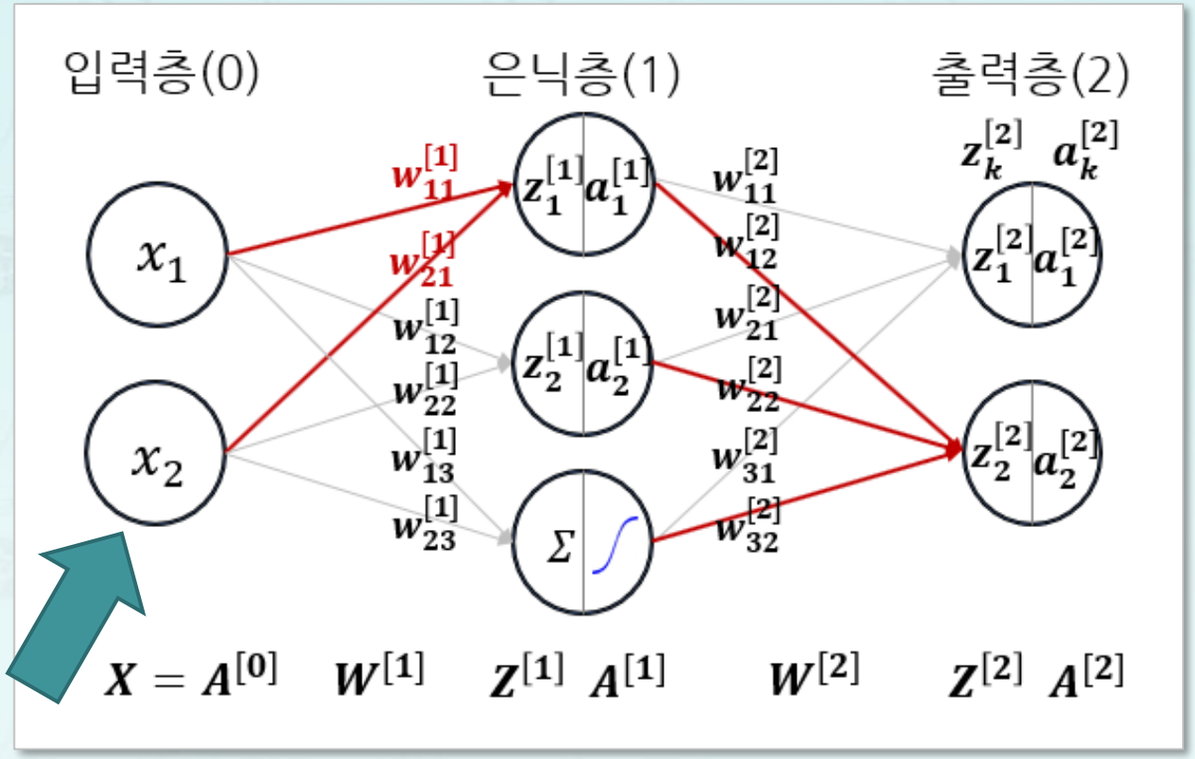


1. 다층 신경망: 입력 자료

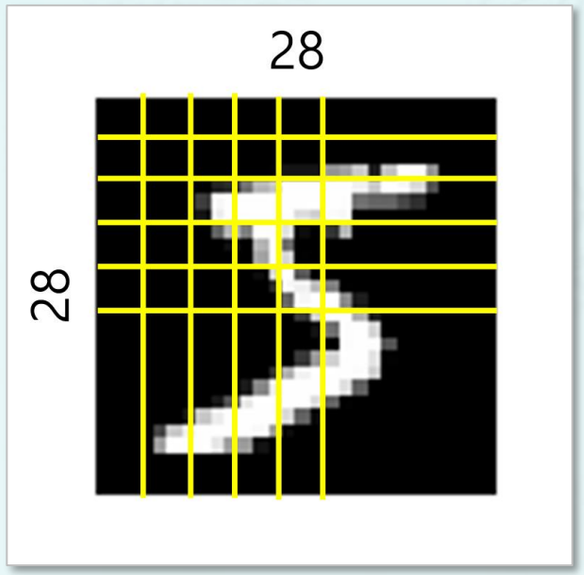
- **MNIST**

- 다층 신경망



1. 다층 신경망: 입력 자료

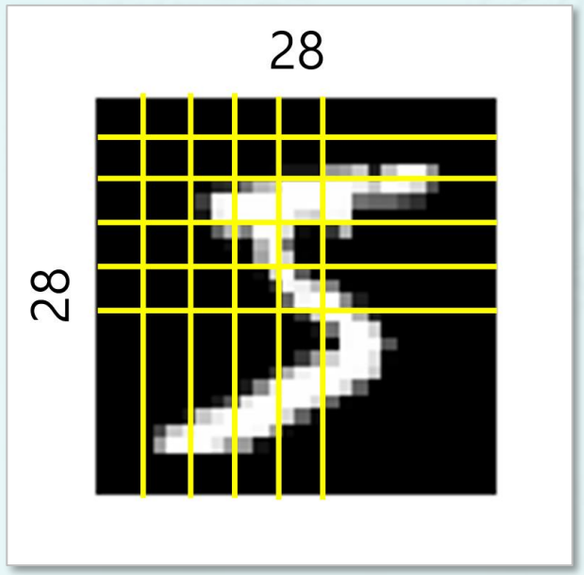
- **MNIST**
  - **28x28**



- 다층 신경망

1. 다층 신경망: 신경망 구조

- **MNIST**
  - **28x28**



- 입력층 : **784(28x28)**

1. 다층 신경망: 신경망 구조

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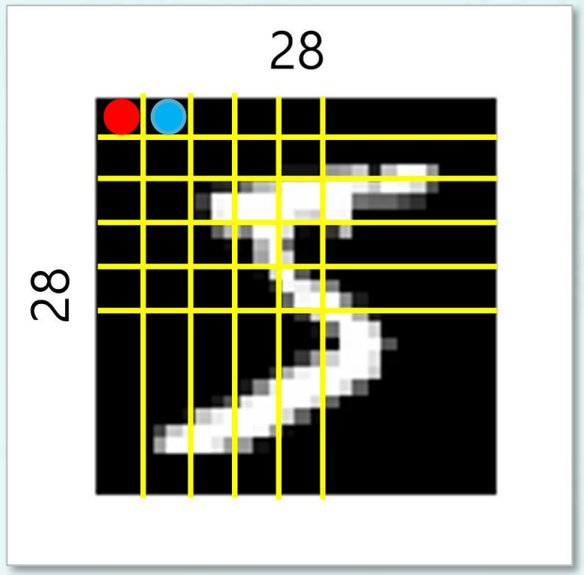
  - **28x28**
- 입력층 : **784(28x28)**



$$\mathbf{X} \in \mathbb{R}^{nxm}$$

$$\mathbf{X} = \begin{pmatrix} x_1^{(0)} \\ x_2^{(0)} \\ \vdots \\ x_{783}^{(0)} \\ x_{784}^{(0)} \end{pmatrix}$$

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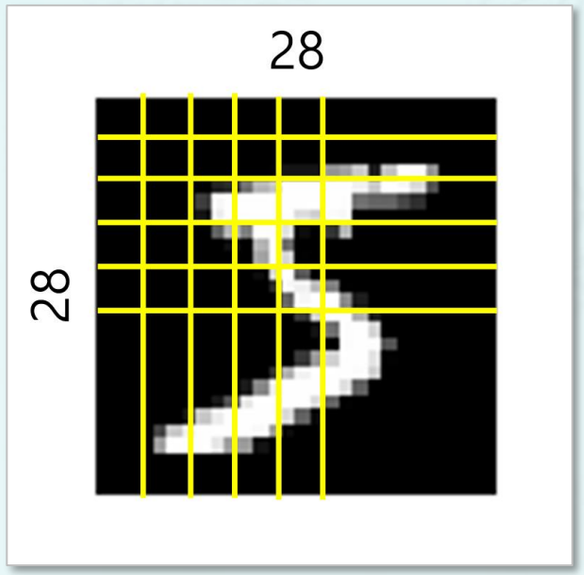

- 입력층 : **784(28x28)**
- 은닉층 : **100**

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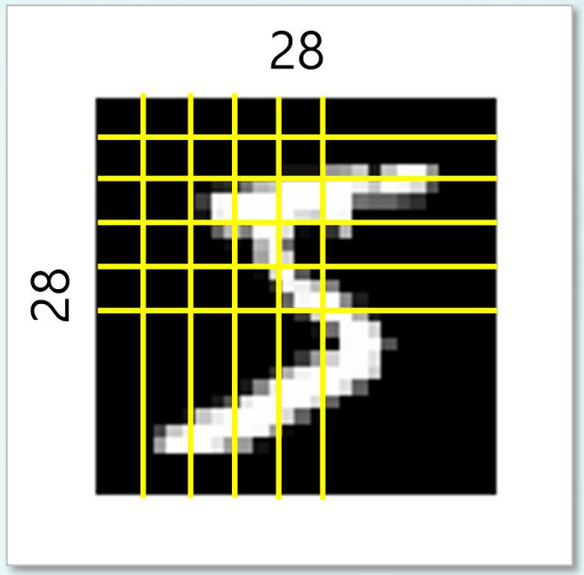
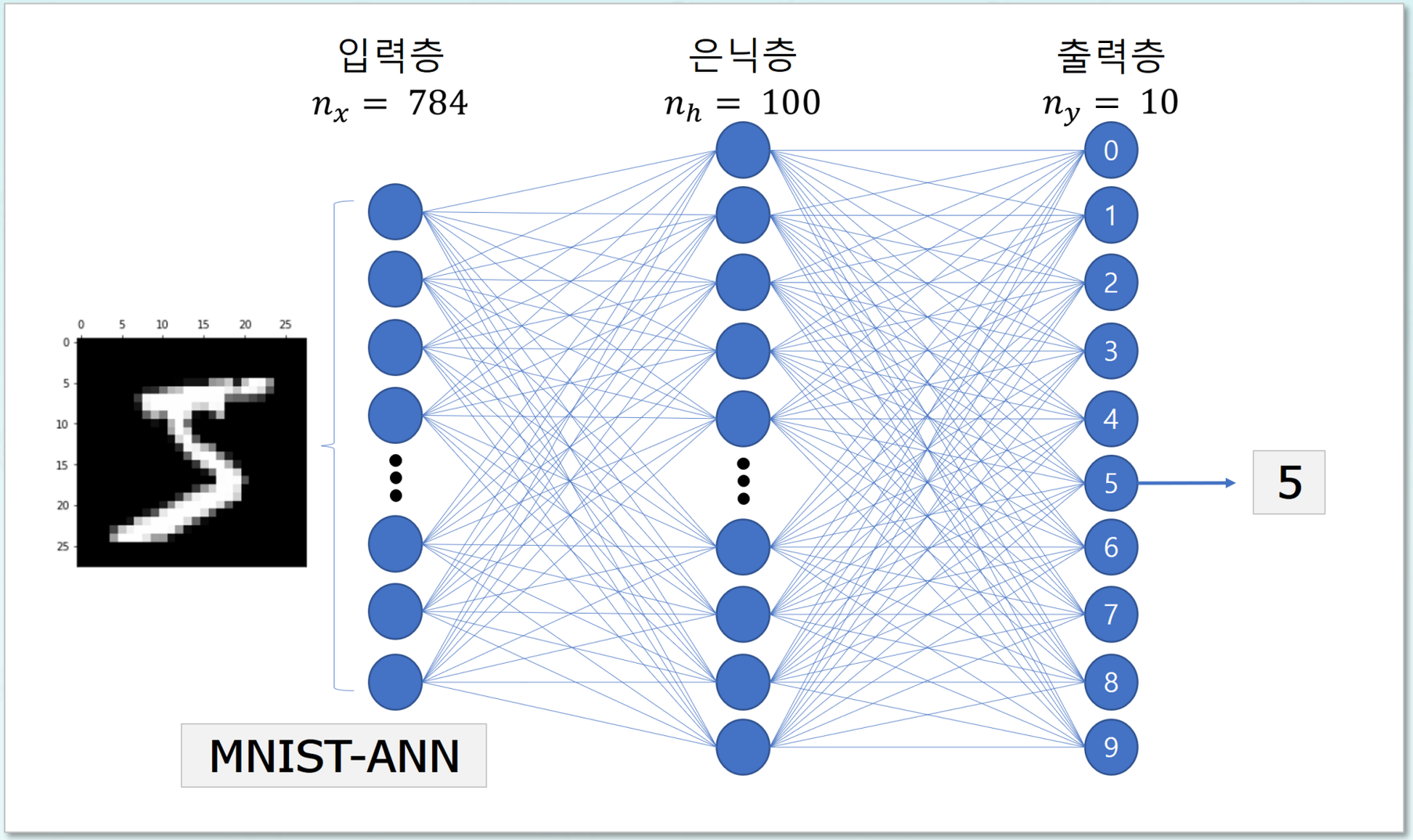


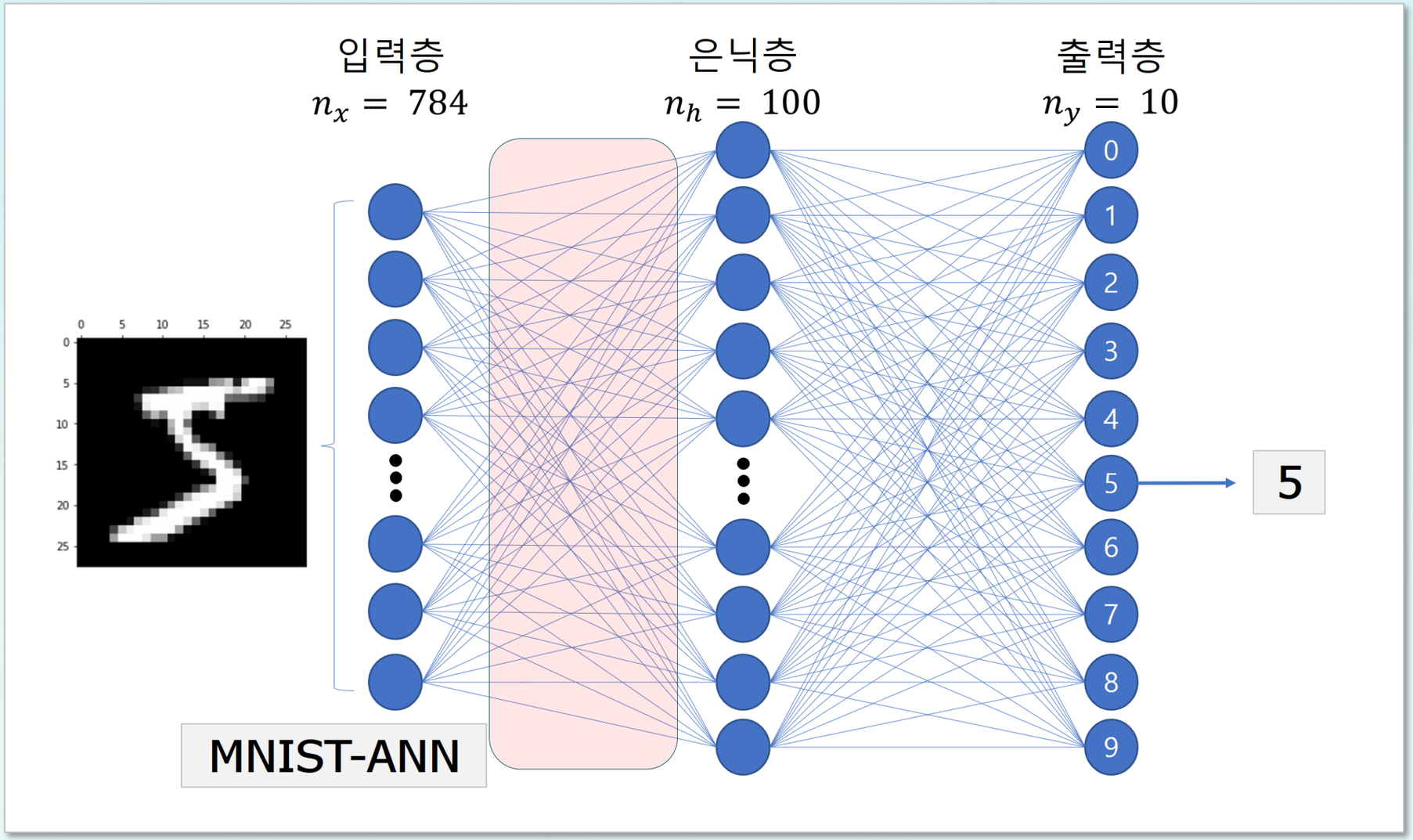
- 입력층 : **784(28x28)**
- 은닉층 : **100**
- 출력층 : **10**

1. 다층 신경망: 신경망 구조



1. 다층 신경망: 신경망 구조

- 가중치
  - **784x100**



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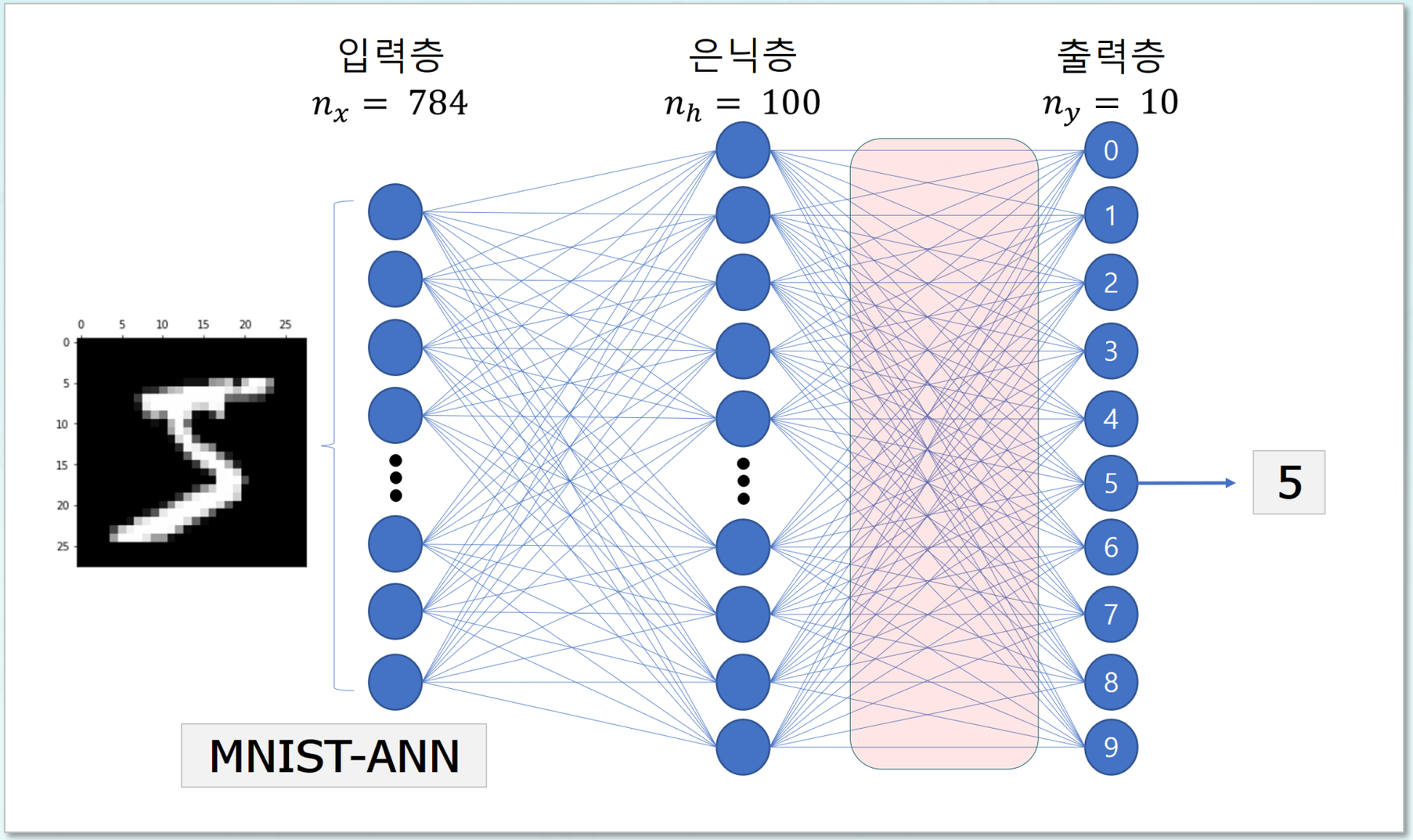
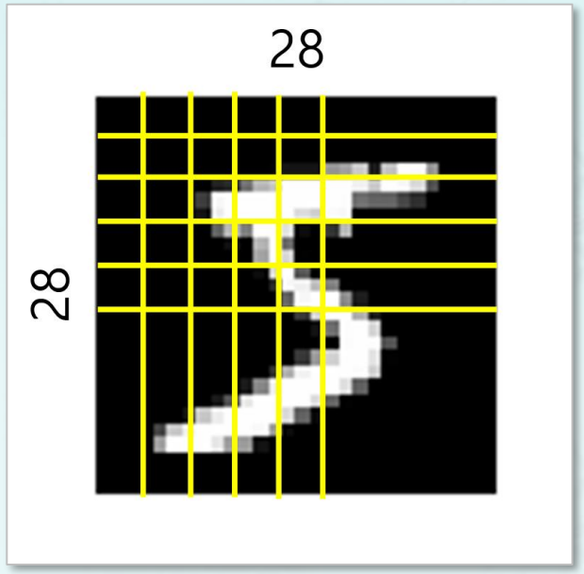
- 가중치
  - **784x100**
  - **100x10**



2. 숫자 인식 인공 신경망 구현: 입력 자료

- X^{nxm}
- n = 784, m = 1



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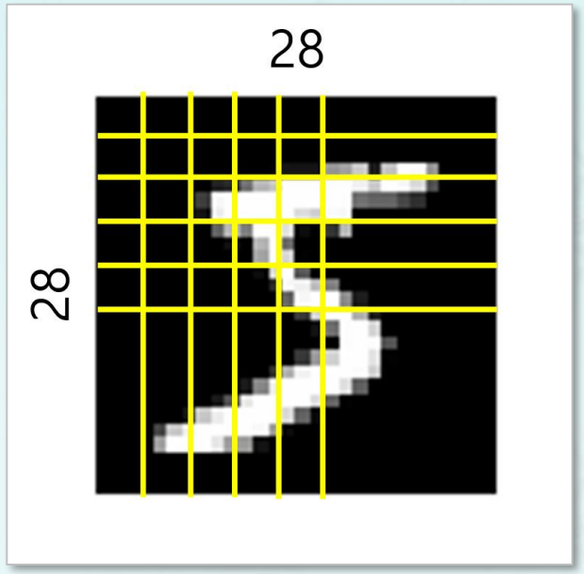

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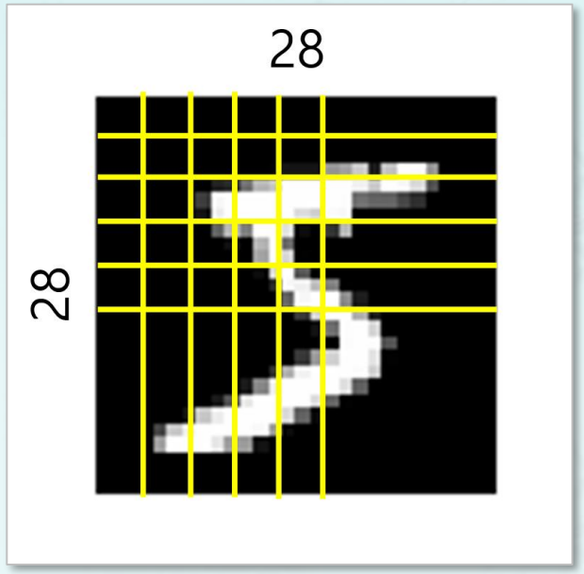

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2. 숫자 인식 인공 신경망 구현: 가중치 불러오기

- 사전에 학습된 가중치
- **96%** 성능

2. 숫자 인식 인공 신경망 구현: 가중치 불러오기

- $W^{[1]}$ = 100x784

$$W^{[1]} = \begin{pmatrix} w_1^{(1)} & w_1^{(2)} & \cdots & W_1^{(783)} & w_1^{(784)} \\ w_2^{(1)} & w_2^{(2)} & \cdots & W_2^{(783)} & w_2^{(784)} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ w_{100}^{(1)} & w_{100}^{(2)} & \cdots & w_{100}^{(783)} & w_{100}^{(784)} \end{pmatrix}$$

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```
!type data/w_xh.txt
```

```
!cat data/w_xh.txt
```

```
[-1.65955991e-01  4.40648987e-01
 -7.06488218e-01 -8.15322810e-01
 -2.06465052e-01  7.76334680e-02
 -5.92088802e-01  7.54060585e-01
 -1.65390395e-01  1.17379657e-01
```

2. 숫자 인식 인공 신경망 구현: 은닉층 순입력 계산

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$$
\begin{aligned}
\mathbf{Z}^{[1]} &= W^{[1]} A^{[0]} \\
&= \begin{pmatrix} w_{11}^{(1)} & w_{21}^{(1)} \\ w_{12}^{(1)} & w_{22}^{(1)} \\ w_{13}^{(1)} & w_{23}^{(1)} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} \\
&= \begin{pmatrix} z_1^{(1)} \\ z_2^{(1)} \\ z_3^{(1)} \end{pmatrix}
\end{aligned}
$$

2. 숫자 인식 인공 신경망 구현: 은닉층 순입력 계산

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&= \begin{pmatrix} z_1^{(1)} \\ z_2^{(1)} \\ z_3^{(1)} \end{pmatrix}
\end{aligned}
$$

$$
\mathbf{W}^{[1]}\mathbf{X}^{[0]} = \begin{pmatrix} w_1^{(1)} & w_1^{(2)} & \cdots & w_1^{(783)} & w_1^{(784)} \\ w_2^{(1)} & w_2^{(2)} & \cdots & w_2^{(783} & w_2^{(784)} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ w_{100}^{(1)} & w_{100}^{(2)} & \cdots & w_{100}^{(783)} & w_{100}^{(784)} \end{pmatrix} \begin{pmatrix} x_1^{(0)} \\ x_2^{(0)} \\ \vdots \\ x_{783}^{(0)} \\ x_{784}^{(0)} \end{pmatrix}
$$

$$
\mathbf{A}^{[1]} = sigmoid(\mathbf{Z}^{[1]})
$$

2. 숫자 인식 인공 신경망 구현: 출력층 계산

- $A^{[1]}$: 100x1

$$W^{[2]}A^{[1]} = \begin{pmatrix} w_1^{(1)} & w_1^{(2)} & \cdots & w_1^{(99)} & w_1^{(100)} \\ w_2^{(1)} & w_2^{(2)} & \cdots & w_2^{(99)} & w_2^{(100)} \\ \vdots & \vdots & \vdots & \vdots & \\ w_{10}^{(1)} & w_{10}^{(2)} & \cdots & w_{10}^{(99)} & w_{10}^{(100)} \end{pmatrix} \begin{pmatrix} a_1^{(1)} \\ a_2^{(1)} \\ \vdots \\ a_{99}^{(1)} \\ a_{100}^{(1)} \end{pmatrix}$$

2. 숫자 인식 인공 신경망 구현: 출력층 계산

- $A^{[1]}$: 100x1
- $W^{[2]}$: 10x100

$$W^{[2]}A^{[1]} = \begin{pmatrix} w_1^{(1)} & w_1^{(2)} & \cdots & w_1^{(99)} & w_1^{(100)} \\ w_2^{(1)} & w_2^{(2)} & \cdots & w_2^{(99)} & w_2^{(100)} \\ \vdots & \vdots & \vdots & \vdots & \\ w_{10}^{(1)} & w_{10}^{(2)} & \cdots & w_{10}^{(99)} & w_{10}^{(100)} \end{pmatrix} \begin{pmatrix} a_1^{(1)} \\ a_2^{(1)} \\ \vdots \\ a_{99}^{(1)} \\ a_{100}^{(1)} \end{pmatrix}$$

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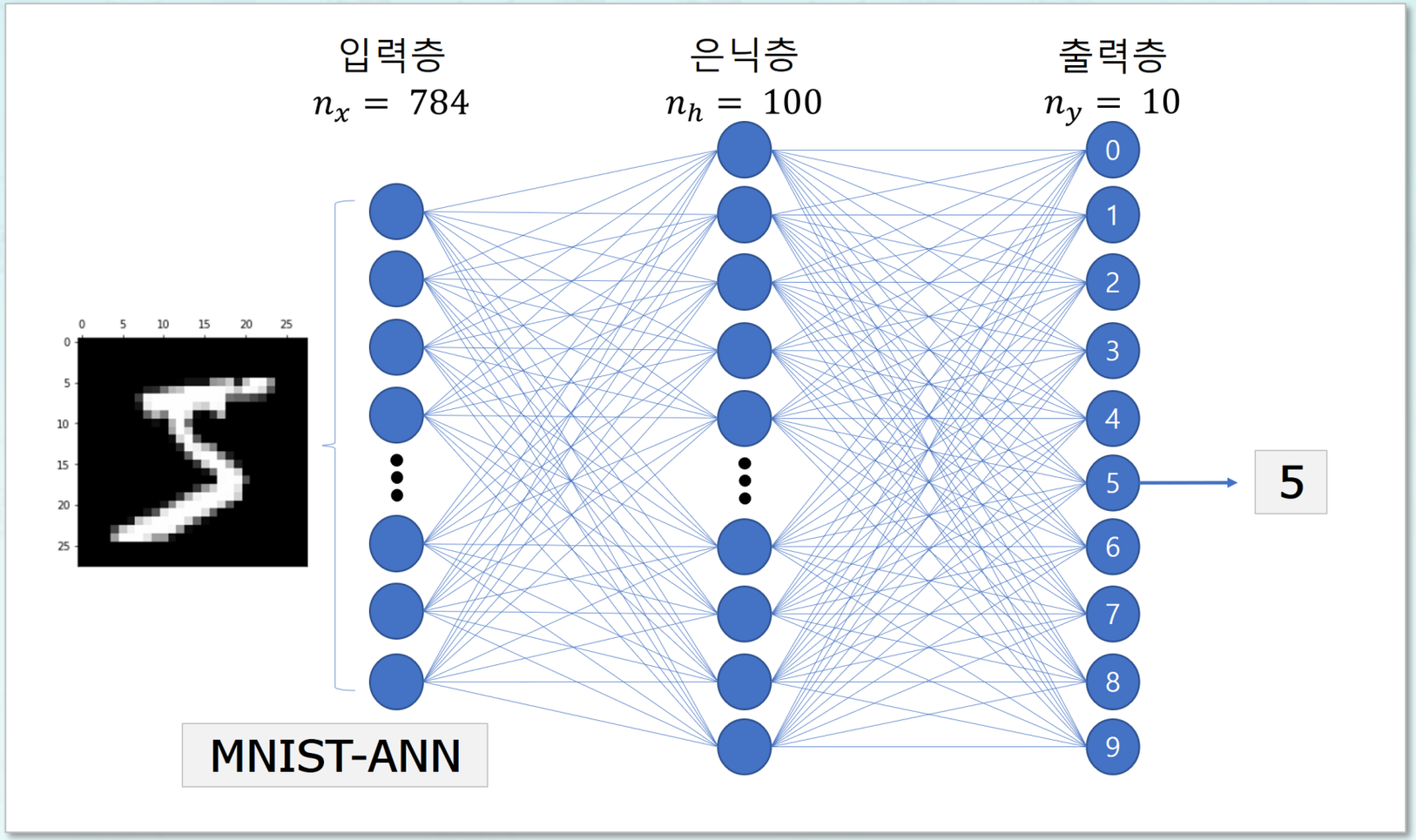
- $A^{[1]}$: 100x1
- $W^{[2]}$: 10x100

$$W^{[2]}A^{[1]} = \begin{pmatrix} w_1^{(1)} & w_1^{(2)} & \cdots & w_1^{(99)} & w_1^{(100)} \\ w_2^{(1)} & w_2^{(2)} & \cdots & w_2^{(99)} & w_2^{(100)} \\ \vdots & \vdots & \vdots & \vdots & \\ w_{10}^{(1)} & w_{10}^{(2)} & \cdots & w_{10}^{(99)} & w_{10}^{(100)} \end{pmatrix} \begin{pmatrix} a_1^{(1)} \\ a_2^{(1)} \\ \vdots \\ a_{99}^{(1)} \\ a_{100}^{(1)} \end{pmatrix}$$

$$\mathbf{A}^{[2]} = sigmoid(\mathbf{Z}^{[2]})$$

2. 숫자 인식 인공 신경망 구현: 인공 신경망 구조



2. 숫자 인식 인공 신경망 구현

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```

2. 숫자 인식 인공 신경망 구현: 라이브러리 추가

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```

2. 숫자 인식 인공 신경망 구현: 함수 생성

```
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```

```
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```

2. 숫자 인식 인공 신경망 구현: 입력 자료 불러오기

- 입력 자료 불러오기

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```

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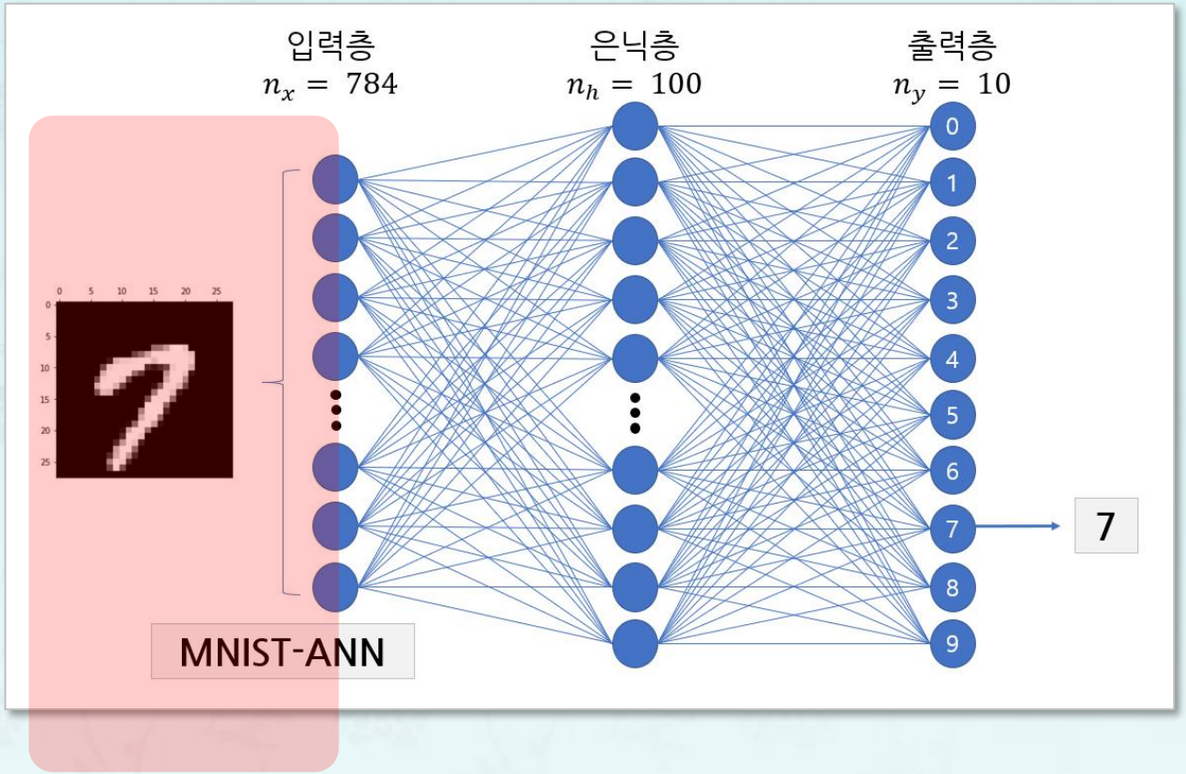

2. 숫자 인식 인공 신경망 구현: 가중치 불러오기

- 가중치 불러오기

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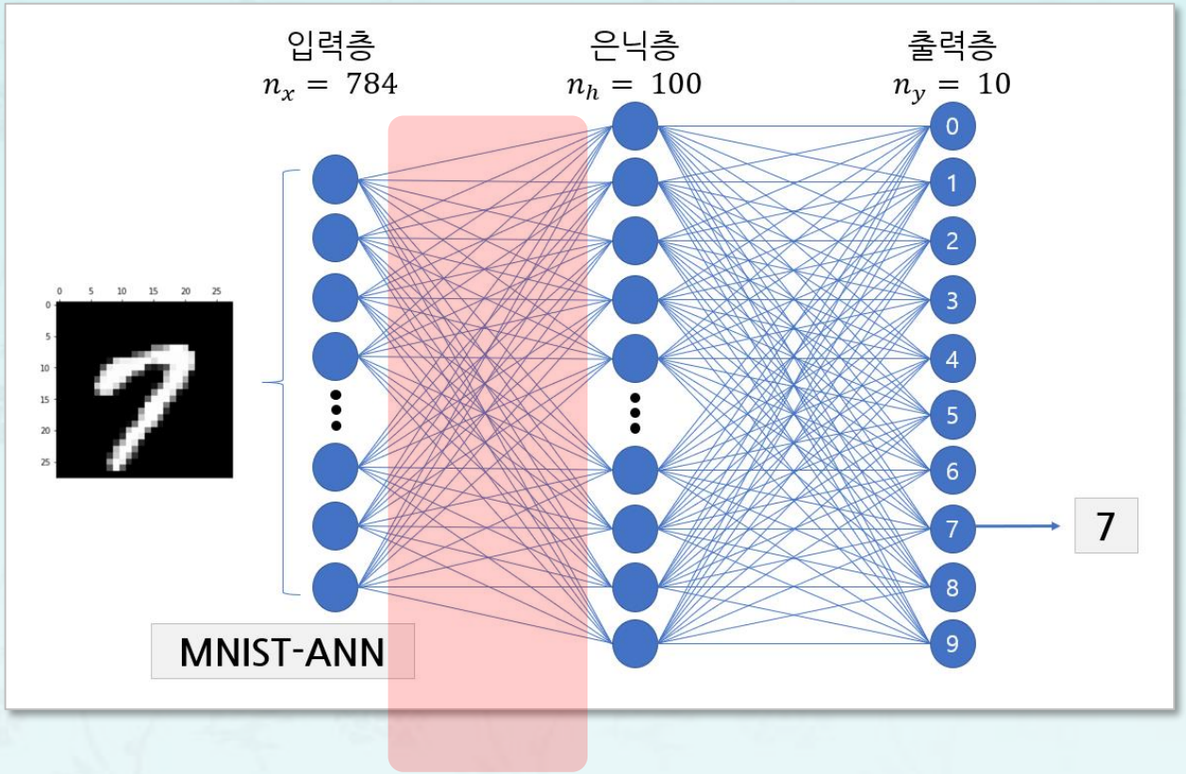

2. 숫자 인식 인공 신경망 구현: 순입력 계산하기

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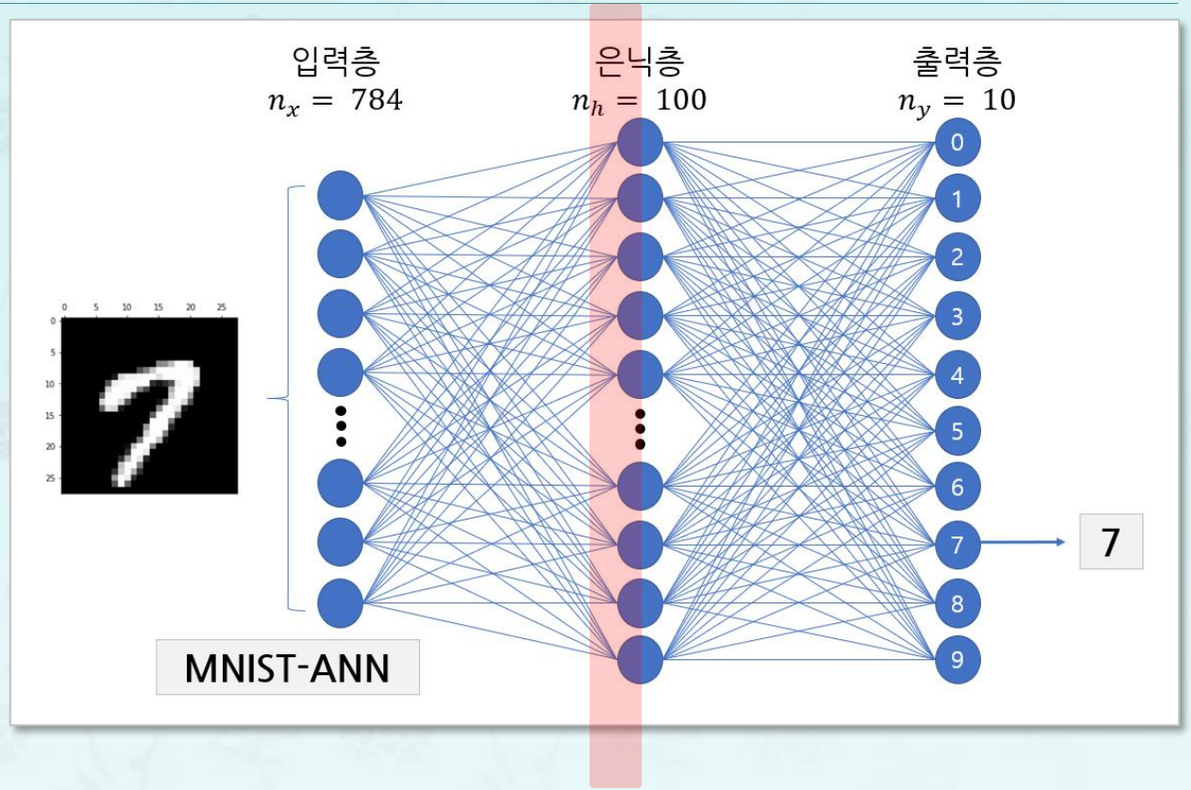
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```



2. 숫자 인식 인공 신경망 구현: 은닉층 계산하기

- 은닉층 계산

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```

$$W^{[1]} = \begin{pmatrix} w_1^{(1)} & w_1^{(2)} & \cdots & W_1^{(783)} & w_1^{(784)} \\ w_2^{(1)} & w_2^{(2)} & \cdots & W_2^{(783)} & w_2^{(784)} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ w_{100}^{(1)} & w_{100}^{(2)} & \cdots & w_{100}^{(783)} & w_{100}^{(784)} \end{pmatrix}$$

$$\mathbf{A}^{[1]} = sigmoid(\mathbf{Z}^{[1]})$$

2. 숫자 인식 인공 신경망 구현: 은닉층 계산하기

- 은닉층 계산

```
import joy
import numpy as np
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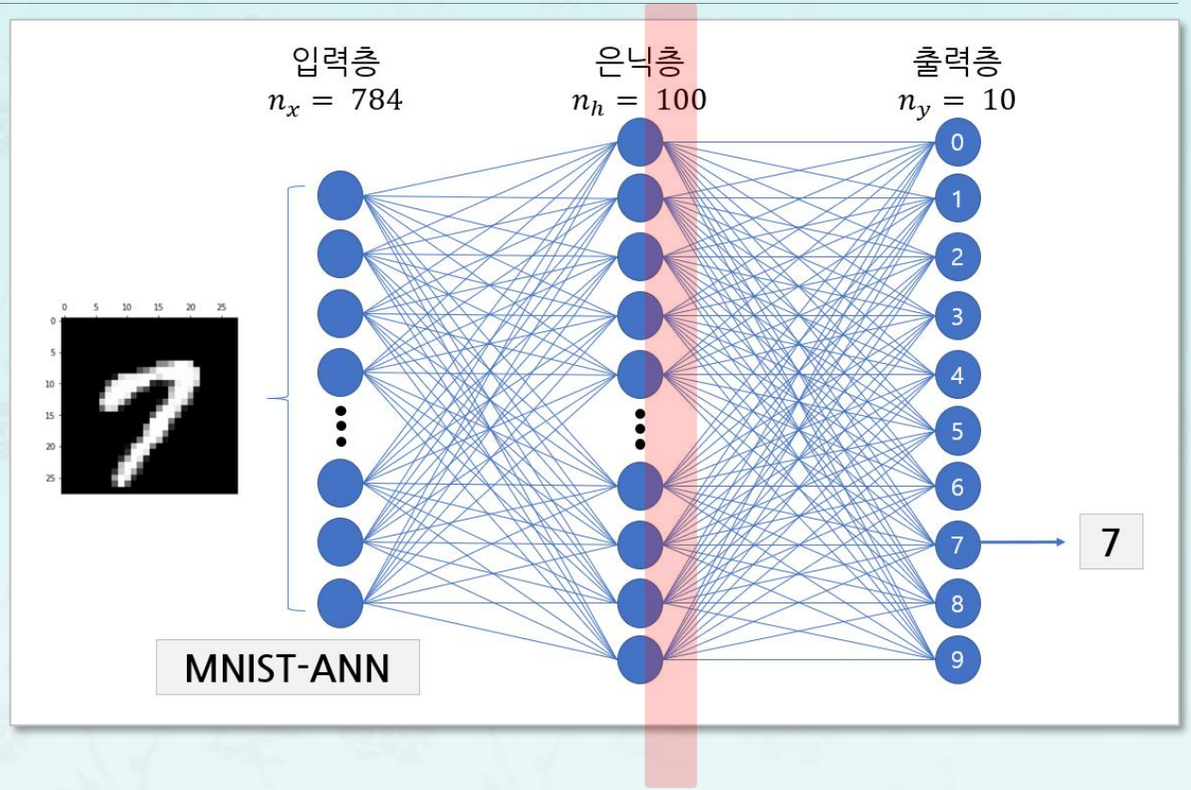
```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```



2. 숫자 인식 인공 신경망 구현: 가중치 불러오기

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```

$$W^{[2]} = \begin{pmatrix} w_1^{(1)} & w_1^{(2)} & \cdots & W_1^{(99)} & w_1^{(100)} \\ w_2^{(1)} & w_2^{(2)} & \cdots & W_2^{(99)} & w_2^{(100)} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ w_{100}^{(1)} & w_{100}^{(2)} & \cdots & w_{100}^{(99)} & w_{100}^{(100)} \end{pmatrix}$$

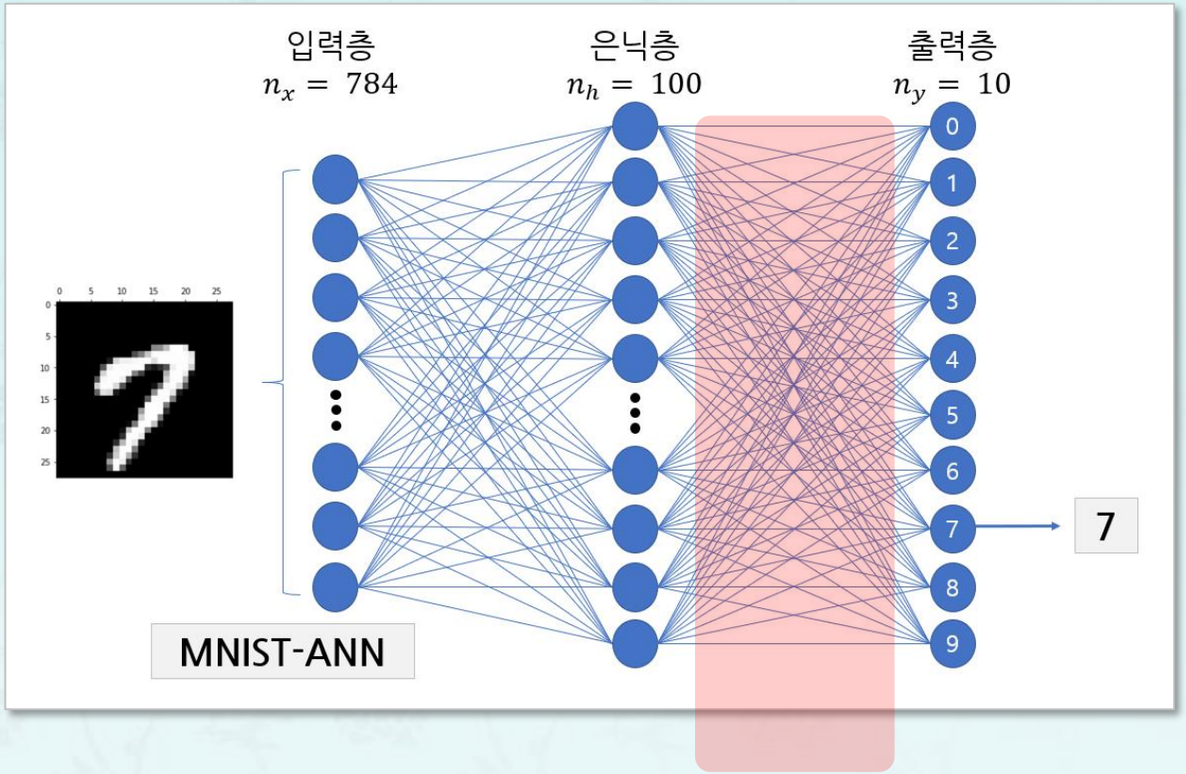
2. 숫자 인식 인공 신경망 구현

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```



2. 숫자 인식 인공 신경망 구현: 은닉층 계산

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```

$$W^{[2]}A^{[1]} = \begin{pmatrix} w_1^{(1)} & w_1^{(2)} & \cdots & w_1^{(99)} & w_1^{(100)} \\ w_2^{(1)} & w_2^{(2)} & \cdots & w_2^{(99)} & w_2^{(100)} \\ \vdots & \vdots & \vdots & \vdots & \\ w_{10}^{(1)} & w_{10}^{(2)} & \cdots & w_{10}^{(99)} & w_{10}^{(100)} \end{pmatrix} \begin{pmatrix} a_1^{(1)} \\ a_2^{(1)} \\ \vdots \\ a_{99}^{(1)} \\ a_{100}^{(1)} \end{pmatrix}$$

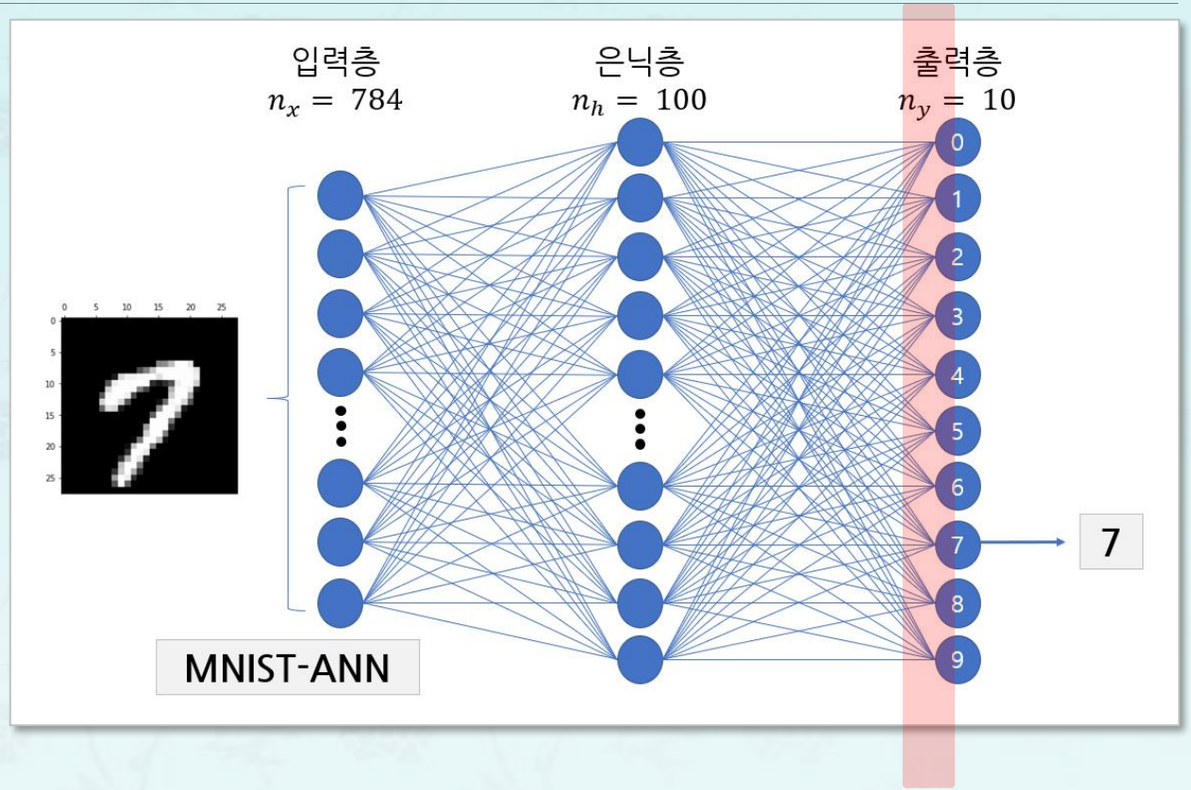
2. 숫자 인식 인공 신경망 구현: 은닉층 계산하기

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```



2. 숫자 인식 인공 신경망 구현: 출력층 계산하기

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```

$$W^{[2]}A^{[1]} = \begin{pmatrix} w_1^{(1)} & w_1^{(2)} & \cdots & w_1^{(99)} & w_1^{(100)} \\ w_2^{(1)} & w_2^{(2)} & \cdots & w_2^{(99)} & w_2^{(100)} \\ \vdots & \vdots & \vdots & \vdots & \\ w_{10}^{(1)} & w_{10}^{(2)} & \cdots & w_{10}^{(99)} & w_{10}^{(100)} \end{pmatrix} \begin{pmatrix} a_1^{(1)} \\ a_2^{(1)} \\ \vdots \\ a_{99}^{(1)} \\ a_{100}^{(1)} \end{pmatrix}$$

$$\mathbf{A}^{[2]} = sigmoid(\mathbf{Z}^{[2]})$$

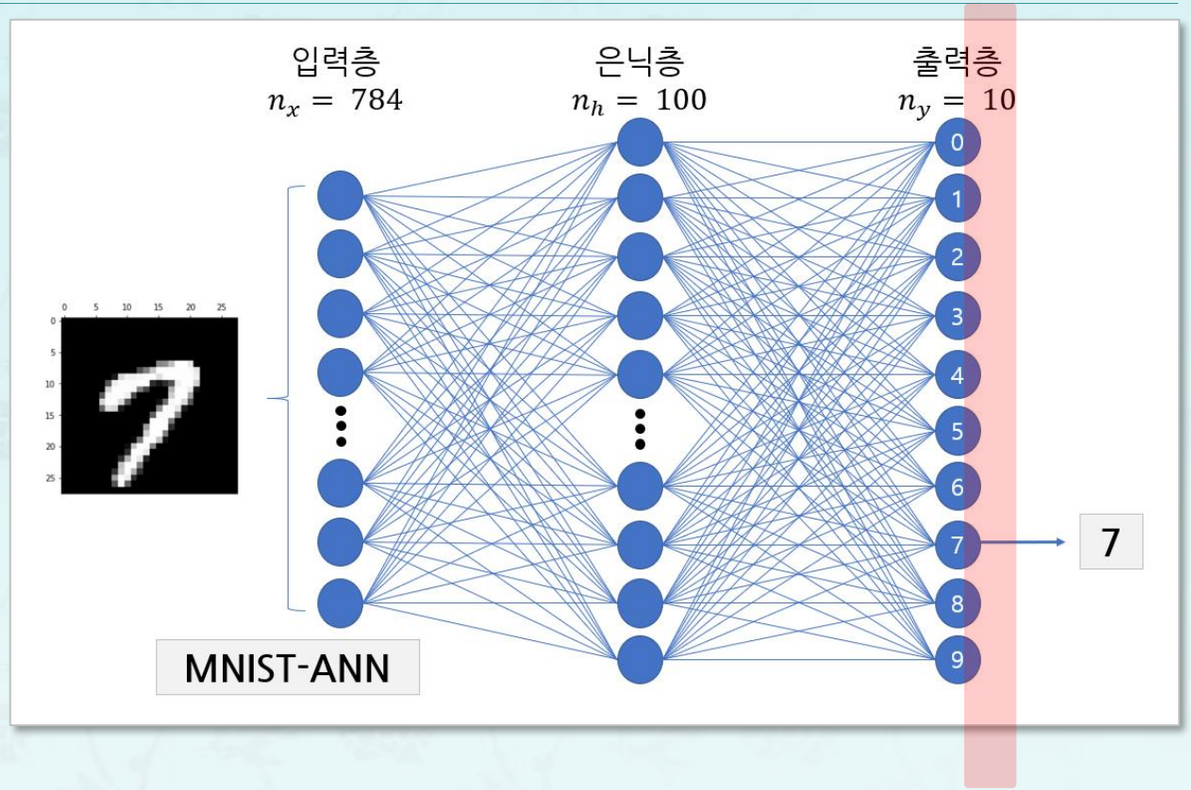
2. 숫자 인식 인공 신경망 구현: 출력층 계산하기

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```



2. 숫자 인식 인공 신경망 구현: 예측하기

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```

```
image: 7
predict: [0.
          0.002
          0.001
          0.
          0.
          0.001
          0.
          0.979
          0.006
          0.003]
```

2. 숫자 인식 인공 신경망 구현: 예측하기

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```

```
image: 7
predict: [0.
          0.002
          0.001
          0.
          0.
          0.001
          0.
          0.979
          0.006
          0.003]
```

2. 숫자 인식 인공 신경망 구현: 예측하기

```
import joy
import numpy as np
g = lambda x : 1 / (1 + np.exp(-x))
```

```
(X, y) = joy.load_mnist_num(7)
W1 = joy.load_mnist_weight('data/w_xh.weights')
Z1 = np.dot(W1, X)
A1 = g(Z1)

W2 = joy.load_mnist_weight('data/w_hy.weights')
Z2 = np.dot(W2, A1)
yhat = g(Z2)

print('image:', y)
print('predict:', np.round_(yhat, 3))
```

```
image: 7
predict: [0.
          0.002
          0.001
          0.
          0.
          0.001
          0.
          0.979
          0.006
          0.003]
```

0
1
2
3
4
5
6
7
8
9

순방향 신경망 예제

- 학습 정리
  - 예제를 통해 순방향 신경망을 깊이 있게 이해하기
  - 자료의 특성 이해하기
  - 순방향 신경망 설계
  - 가중치 불러오기

- 차시 예고
  - **7-3** 아달라인 경사하강법 소개

7주차(2/3)

순방향 신경망 예제

파이썬으로 배우는 기계학습

한동대학교
김영섭 교수

여러분 곁에 항상 열려 있는 K-MOOC 강의실에서 만나 뵙기를 바랍니다.