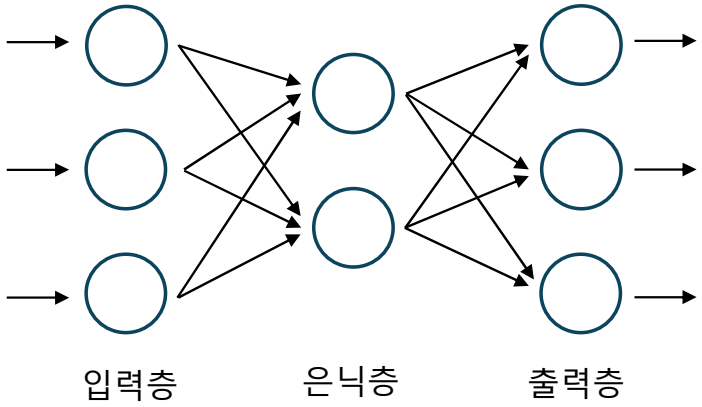
다층 신경망 학습방법

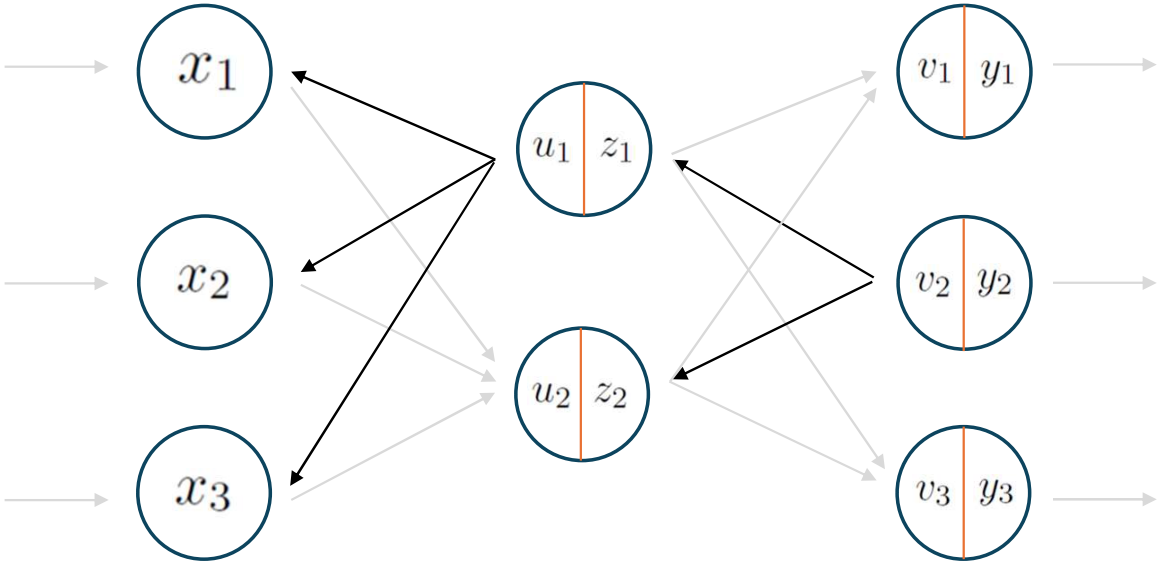
- 단층 신경망에 은닉층을 하나 추가한 모델은 30여 년이 지나서 등장
- 30여 년의 시간이 걸린 이유는 다층 신경망의 학습 규칙을 찾지 못한 데 있음



- Rumelhart의 연구진이 역전파법 제안하면서 다층 신경망의 학습 문제가 해결 (1986년)

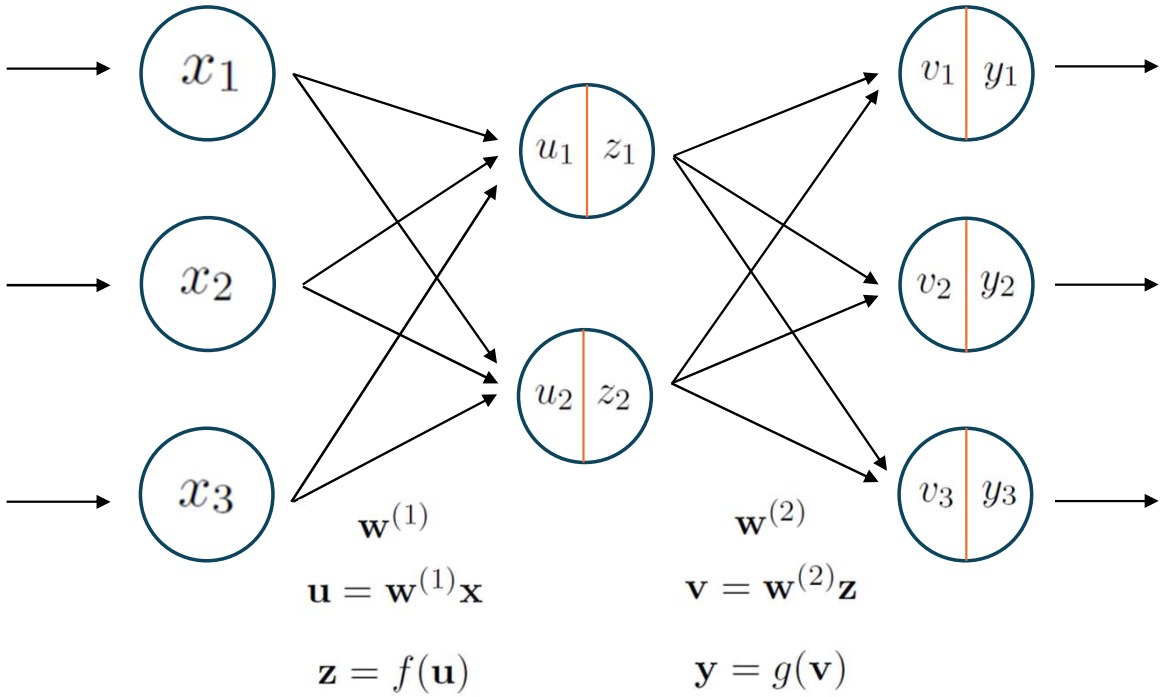
다층 신경망 학습방법

- 역전파(backpropagation) 알고리즘



다층 신경망 학습방법

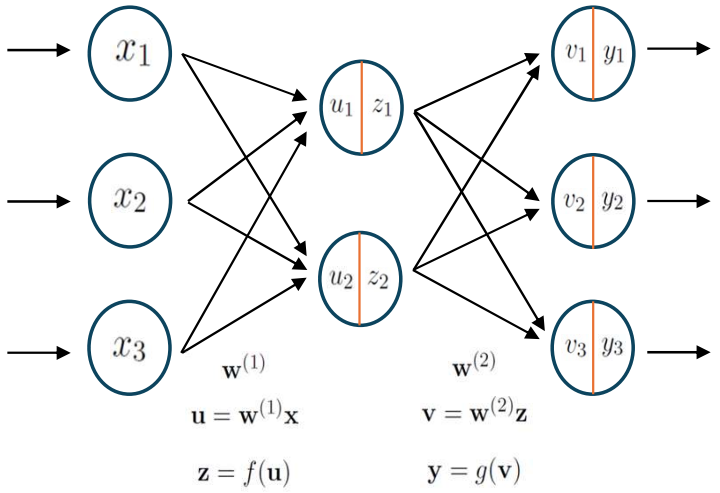
- 순전파 계산



다층 신경망 학습방법

- 역전파 계산

$$\frac{\partial E_n}{\partial w_{kj}^{(2)}} = \frac{\partial E_n}{\partial v_k} \frac{\partial (\sum_{j=1}^{J} w_{kj}^{(2)} z_j)}{\partial w_{kj}^{(2)}} = \frac{\partial E_n}{\partial v_k} z_j$$

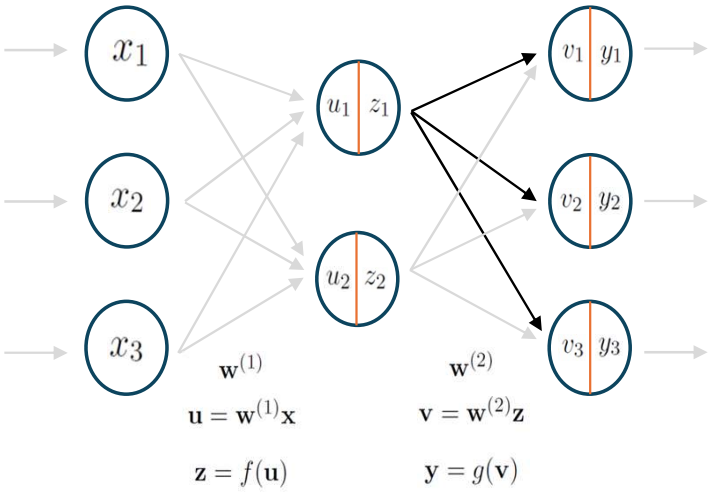


다층 신경망 학습방법

- 역전파 계산

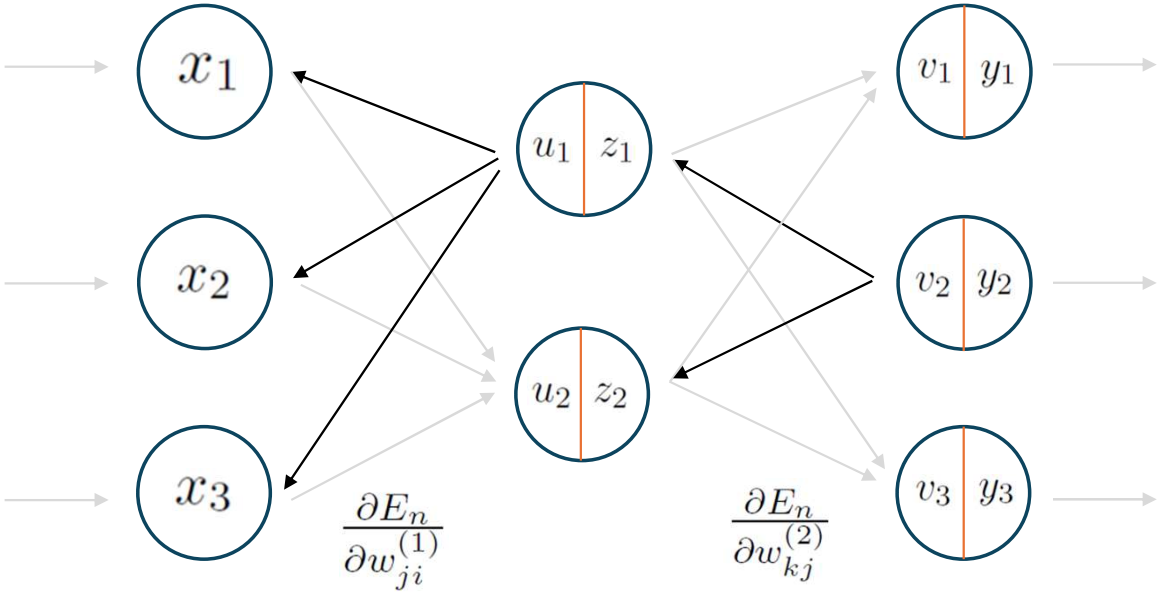
$$\frac{\partial E_n}{\partial w_{kj}^{(2)}} = \frac{\partial E_n}{\partial v_k}\frac{\partial(\sum_{j=1}^{J} w_{kj}^{(2)} z_j)}{\partial w_{kj}^{(2)}} = \frac{\partial E_n}{\partial v_k} z_j$$

$$\begin{aligned}
\frac{\partial E_n}{\partial w_{ji}^{(1)}} &= \frac{\partial E_n}{\partial u_j}\frac{\partial(\sum_{i=1}^{I} w_{ji}^{(1)} x_i)}{\partial w_{ji}^{(1)}} = \frac{\partial E_n}{\partial u_j} x_i \\
&= \left(\sum_{k=1}^{K} \frac{\partial E_n}{\partial v_k}\frac{\partial v_k}{\partial u_j}\right) x_i \\
&= \left(\sum_{k=1}^{K} \frac{\partial E_n}{\partial v_k}\frac{\partial(\sum_{j=1}^{J} w_{kj}^{(2)} f(u_j))}{\partial u_j}\right) x_i \\
&= \left(\sum_{k=1}^{K} \frac{\partial E_n}{\partial v_k} w_{kj}^{(2)} f'(u_j)\right) x_i
\end{aligned}$$



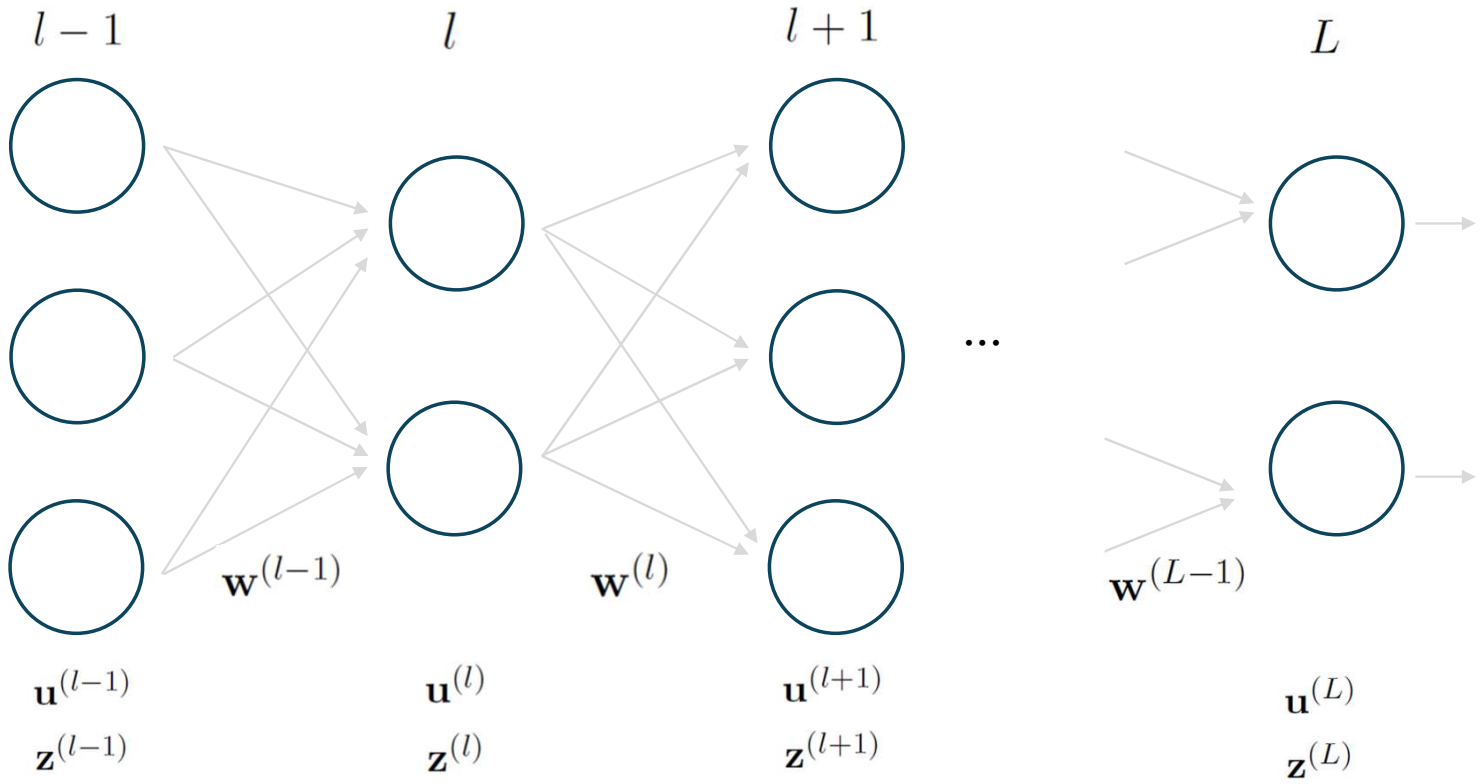
다층 신경망 학습방법

- 가중치 갱신



다층 신경망 학습방법

- 역전파 알고리즘의 일반화



다층 신경망 학습방법

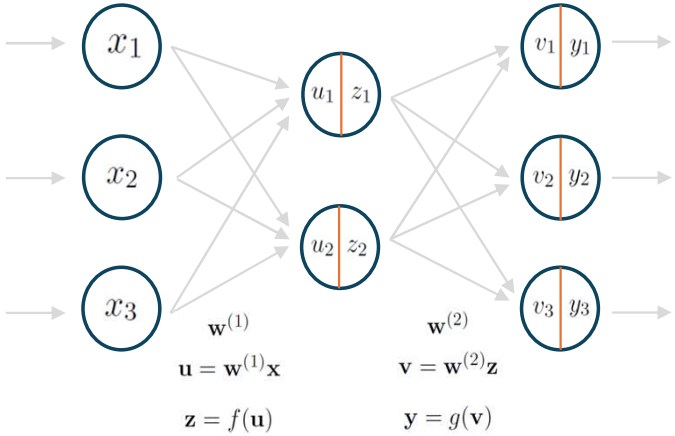
- 역전파 알고리즘의 일반화 (L층일 경우)

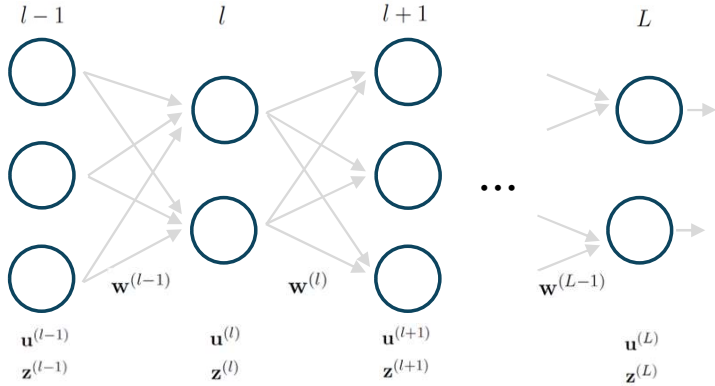
$$\frac{\partial E_n}{\partial w_{kj}^{(2)}} = \frac{\partial E_n}{\partial v_k} z_j \quad \Rightarrow \quad \frac{\partial E_n}{\partial w_{kj}^{(L-1)}} = \frac{\partial E_n}{\partial u_k^{(L)}} z_j^{(L-1)} = \delta_k^{(L)} z_j^{(L-1)}$$

$$\Rightarrow \quad \frac{\partial E_n}{\partial w_{ji}^{(l-1)}} = \frac{\partial E_n}{\partial u_j^{(l)}} z_i^{(l-1)} = \delta_j^{(l)} z_i^{(l-1)}$$

$$\frac{\partial E_n}{\partial u_j} = \sum_{k=1}^{K} (w_{kj}^{(2)} f'(u_j)) \frac{\partial E_n}{\partial v_k}$$

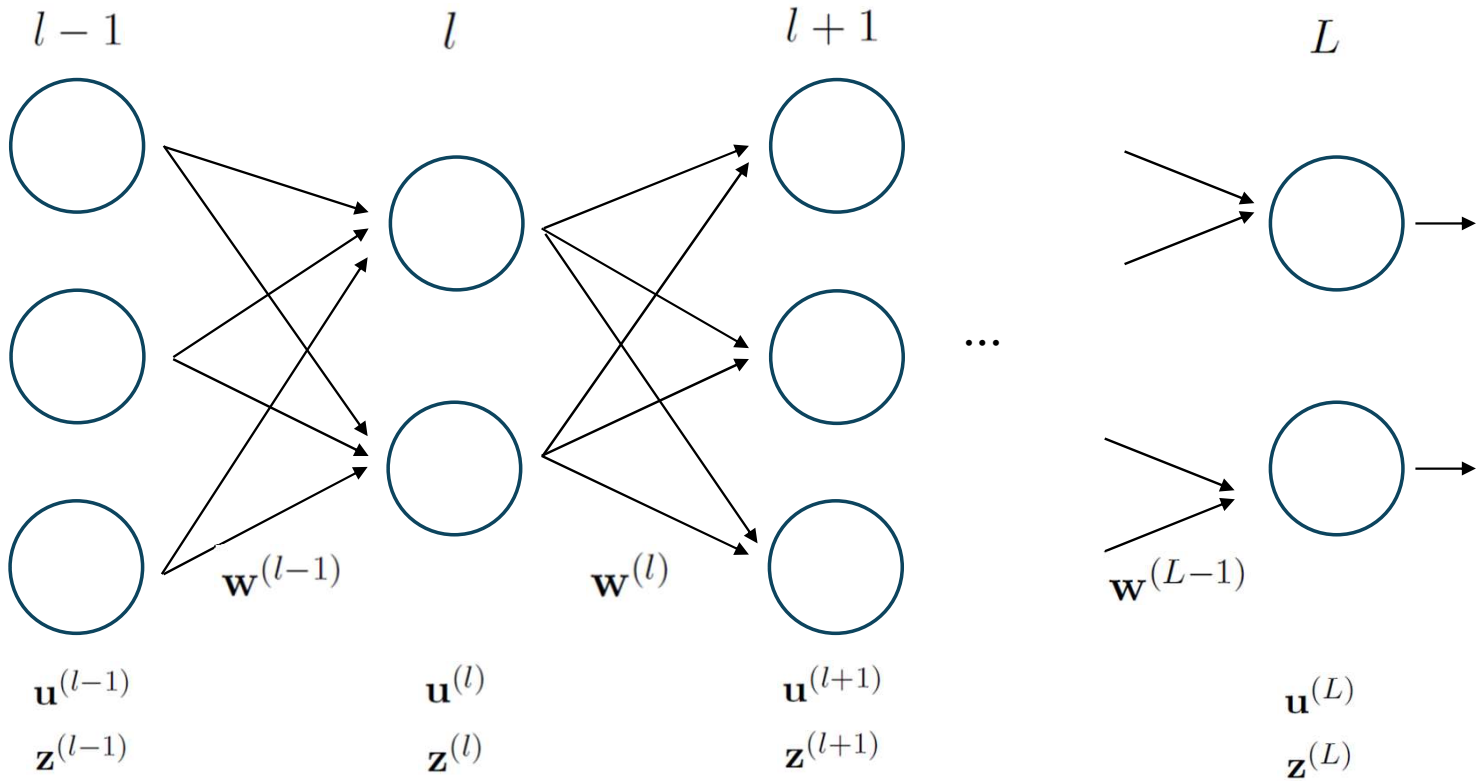
$$\Rightarrow \quad \delta_j^{(l)} = \frac{\partial E_n}{\partial u_j^{(l)}} = \sum_{k=1}^{K} (w_{kj}^{(l)} f'(u_j^{(l)})) \frac{\partial E_n}{\partial u_k^{(l+1)}} = \sum_{k=1}^{K} (w_{kj}^{(l)} f'(u_j^{(l)})) \delta_k^{(l+1)}$$





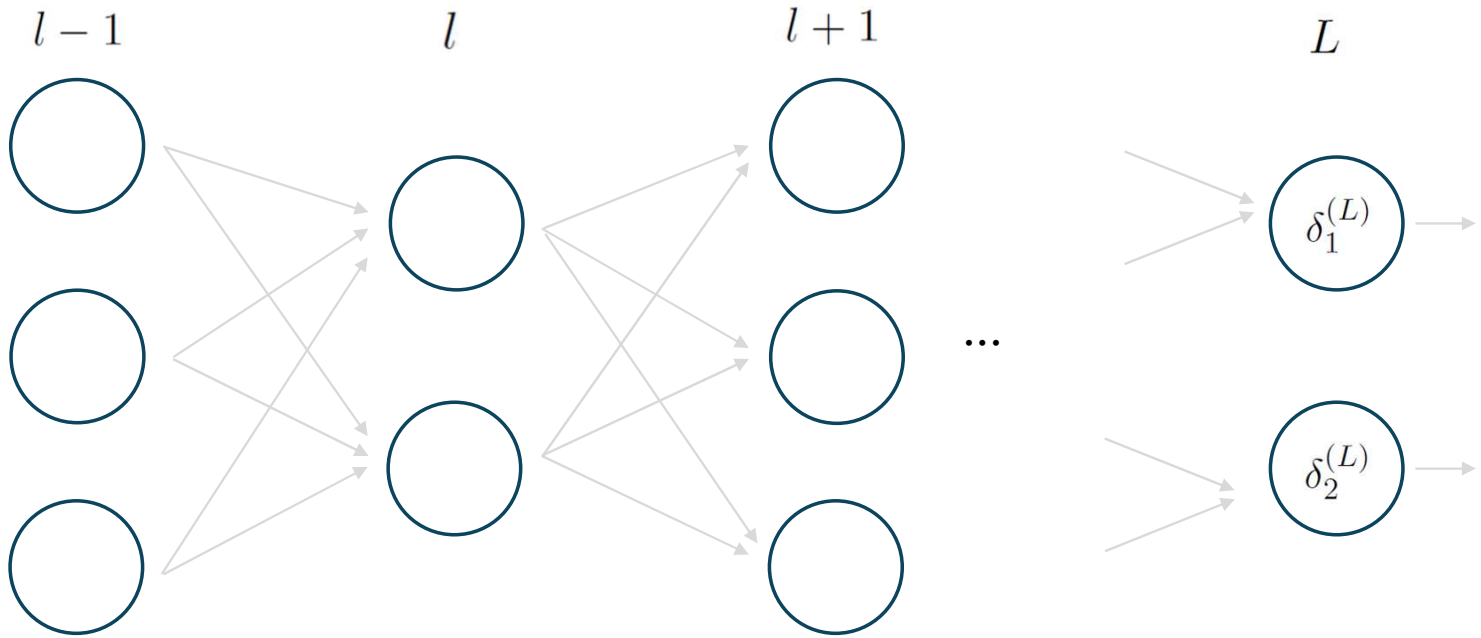
다층 신경망 학습방법

- 순전파 계산



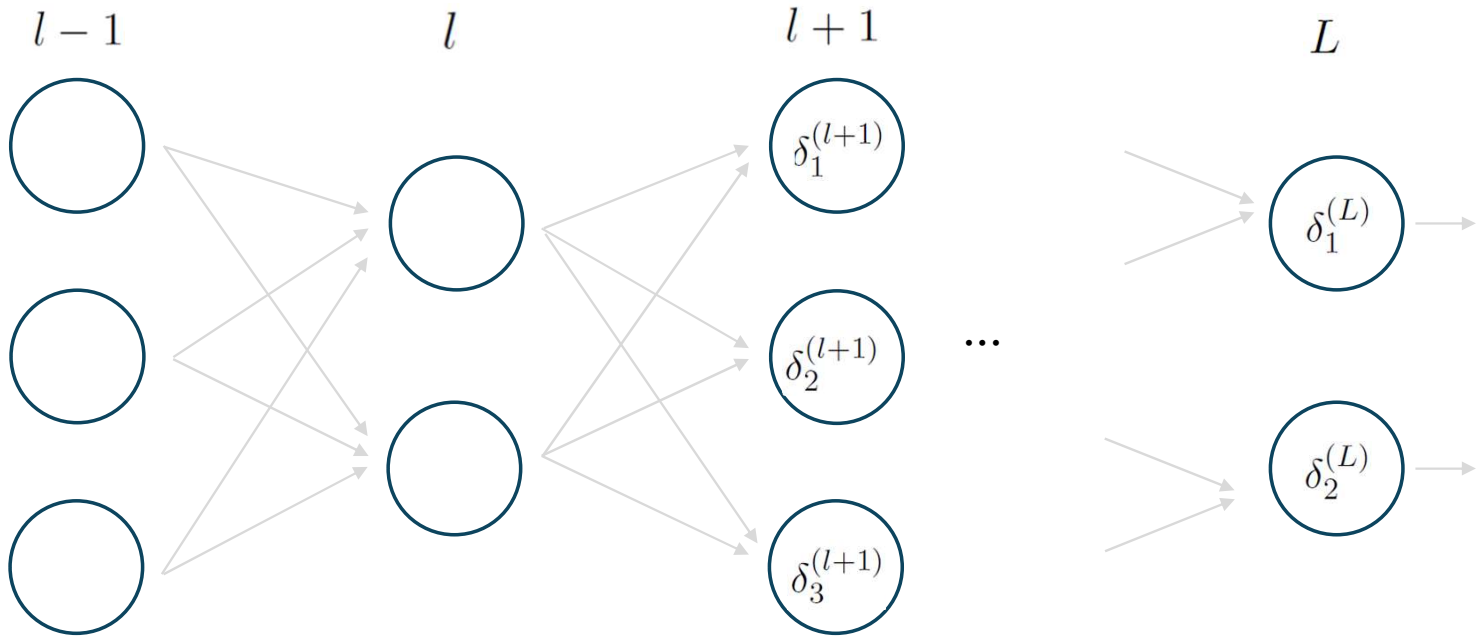
다층 신경망 학습방법

- 각 층의 $\delta^{(L)}, \delta^{(L-1)}, \cdots, \delta^{(2)}$을 계산



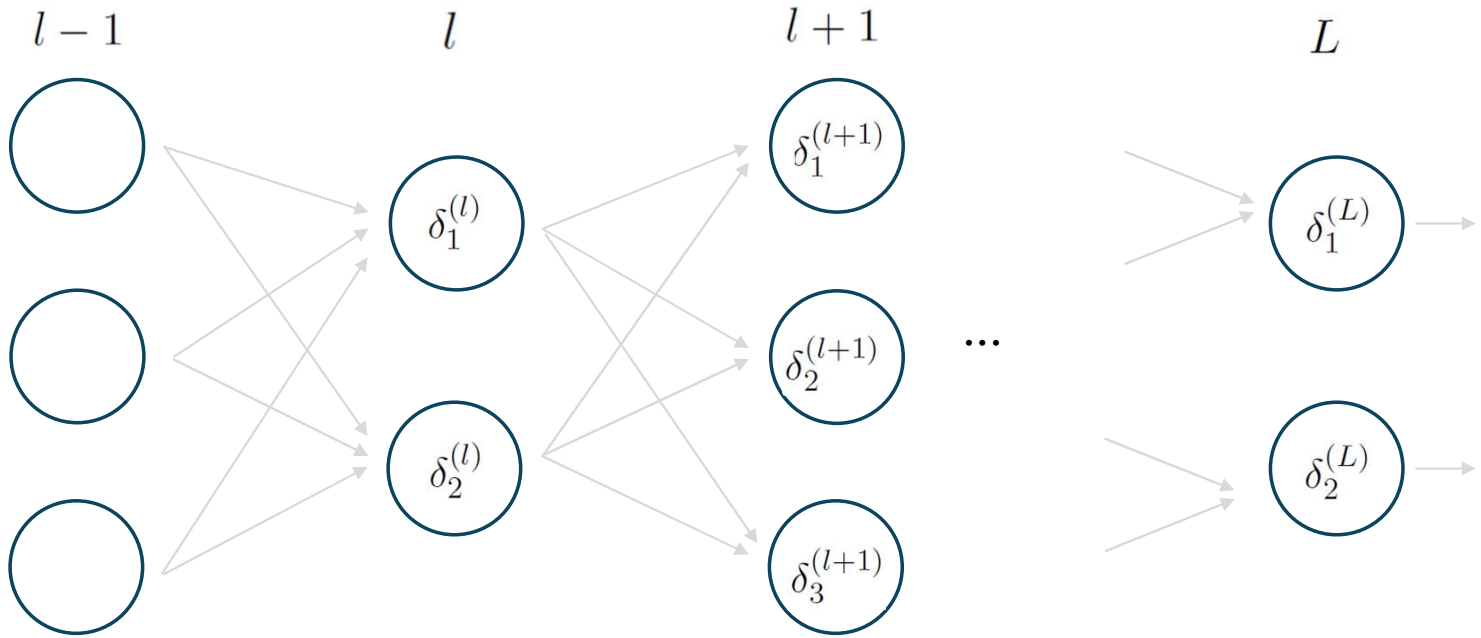
다층 신경망 학습방법

- 각 층의 $\delta^{(L)}, \delta^{(L-1)}, \cdots, \delta^{(2)}$을 계산



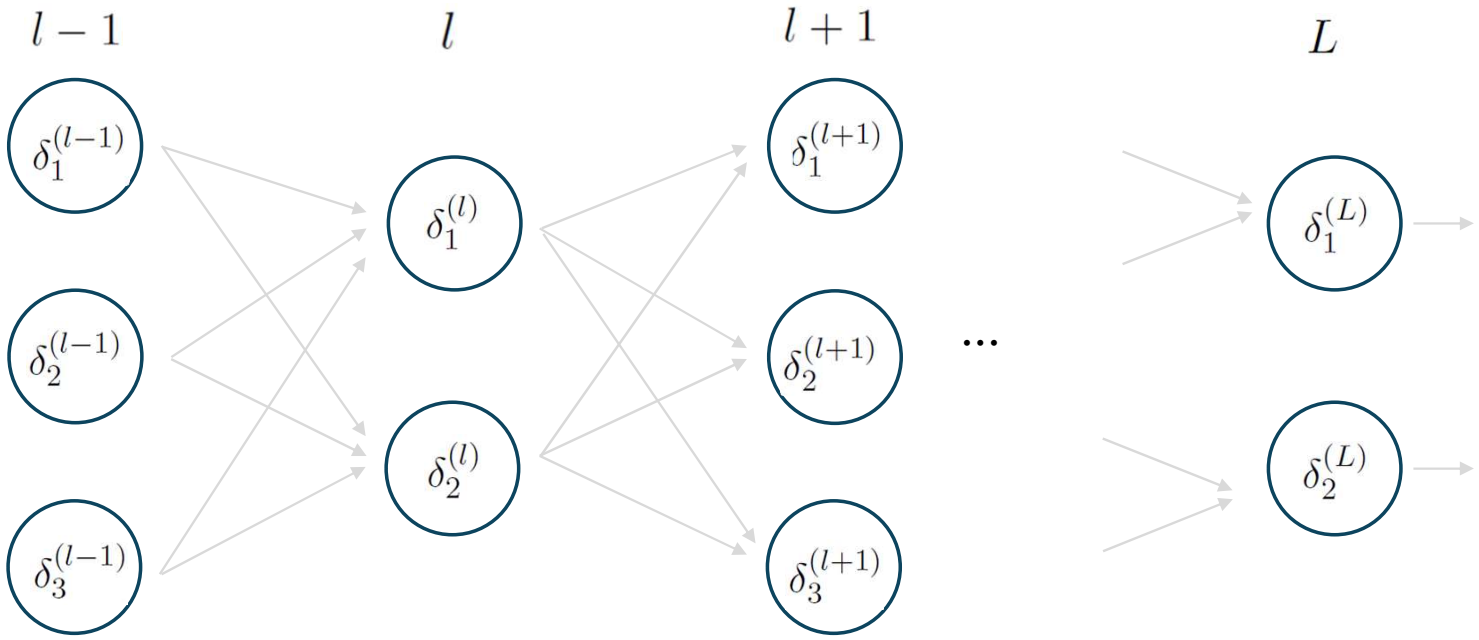
다층 신경망 학습방법

- 각 층의 $\delta^{(L)}, \delta^{(L-1)}, \cdots, \delta^{(2)}$을 계산



다층 신경망 학습방법

- 각 층의 $\delta^{(L)}, \delta^{(L-1)}, \cdots, \delta^{(2)}$을 계산



다층 신경망 학습방법

- 가중치 갱신