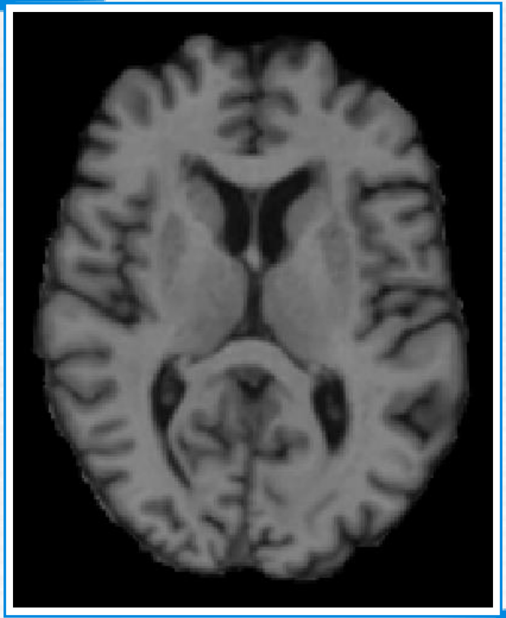
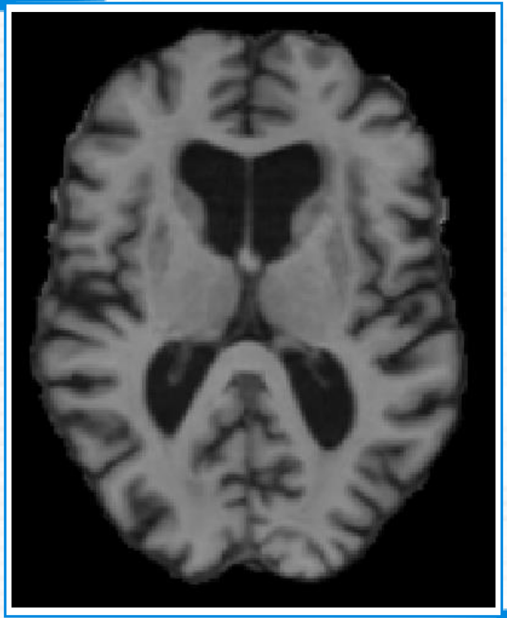
Medical Image Classification

- Brain image classification



Normal



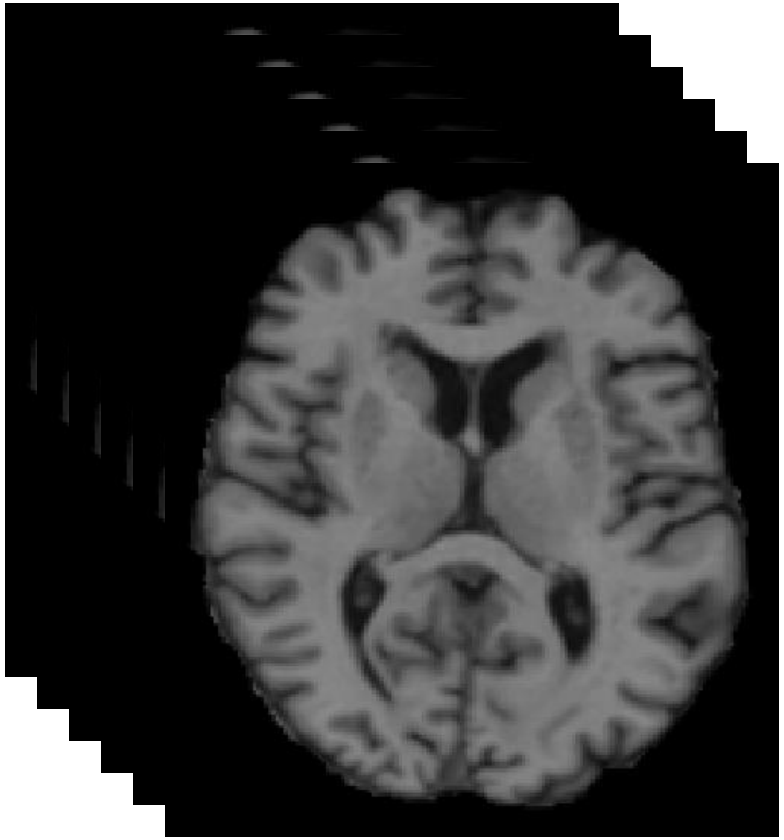
Mild Cognitive Impairment

Alzheimer's Disease

출처 http://adni.loni.usc.edu/data-samples/

Medical Image Classification

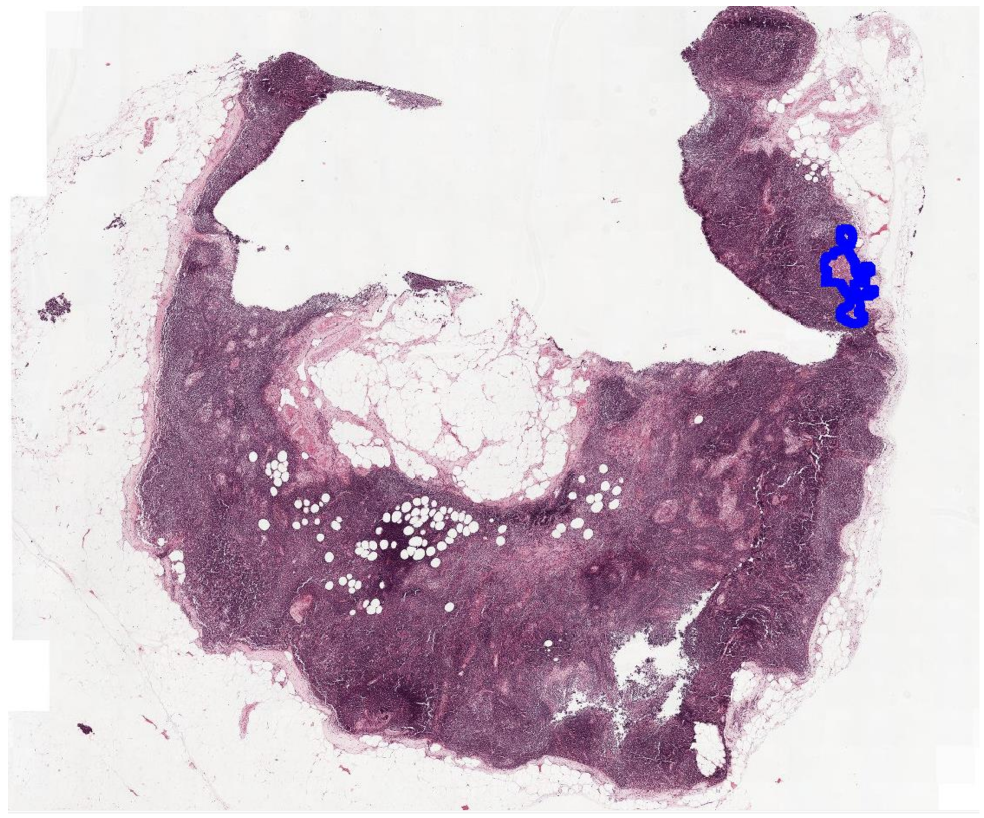
Subject	Age	Gender
Normal	40	M
Normal	50	F
Normal	60	M
Normal	70	M
AD	70	F
AD	90	F
AD	80	F
AD	50	M

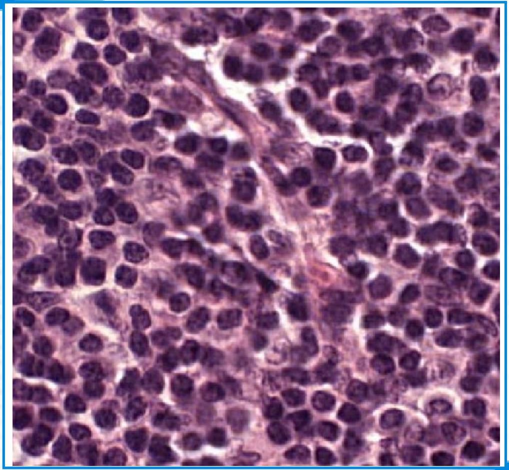


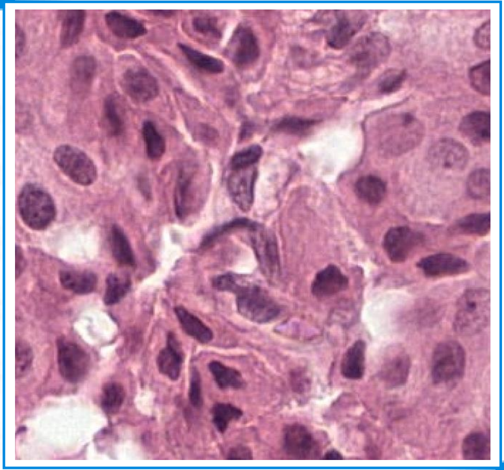
출처 http://adni.loni.usc.edu/data-samples/

Medical Image Classification

- Pathology image classification







출처 https://camelyon17.grand-challenge.org/Data/

Challenges in Medical Image Classification

- Limited data
- Large image size
- Small changes
- Demographic scores

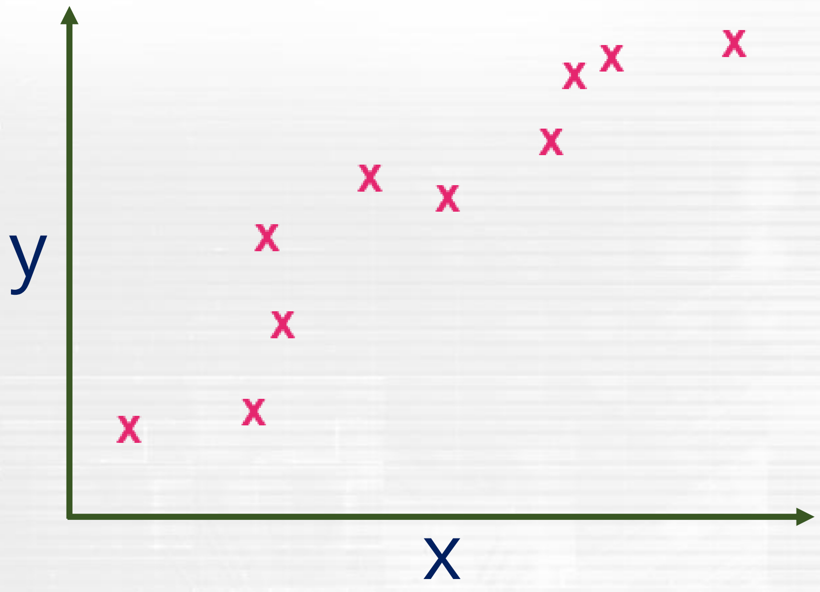
Classification

	Conventional methods	Deep Learning methods
Classification	Logistic regression Neural network Support vector machine Random forest	Deep neural network Convolutional neural network

Acknowledgement

- Andrew Ng:
  - https://www.coursera.org/learn/machine-learning
  - https://www.coursera.org/specializations/deep-learning
- 김성훈:
  - https://www.youtube.com/playlist?list=PLlMkM4tgfjnLSOjrEJN31gZATbcj_MpUm

Linear Regression

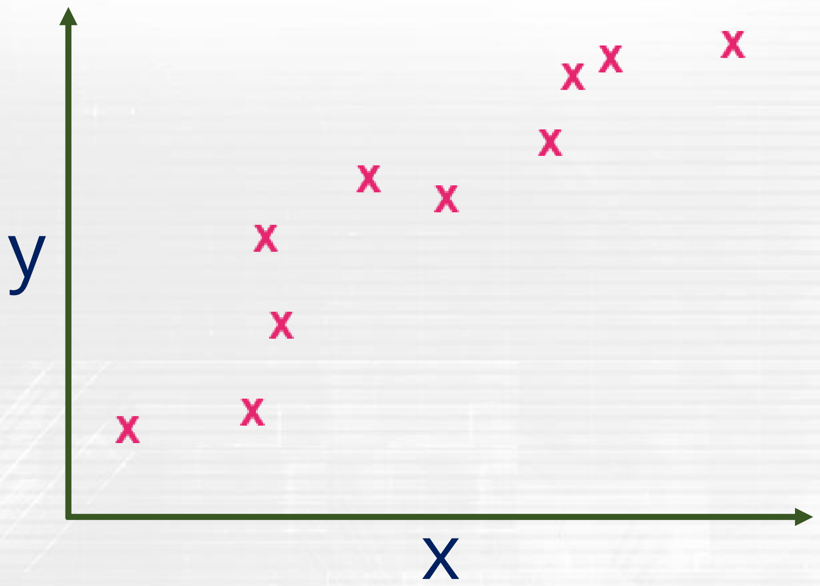


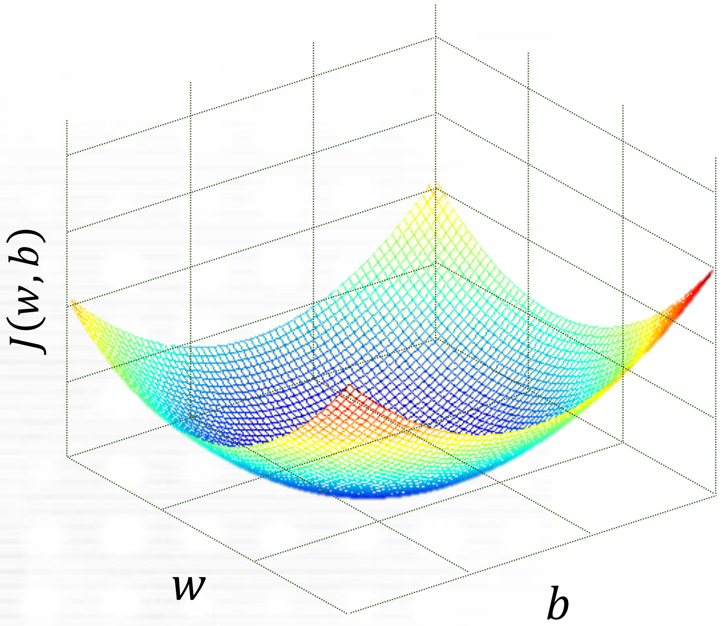
$$h_{w,b}(x) = wx + b$$

$$J(w,b) = \frac{1}{2m}\sum_{i=1}^{m}\left(h_{w,b}\left(x^{(i)}\right) - y^{(i)}\right)^2$$

$$\underset{w,b}{\text{minimize}}\, J(w,b)$$

Cost Function





$$J(w,b) = \frac{1}{2m}\sum_{i=1}^{m}(h_{w,b}(x^{(i)}) - y^{(i)})^2$$

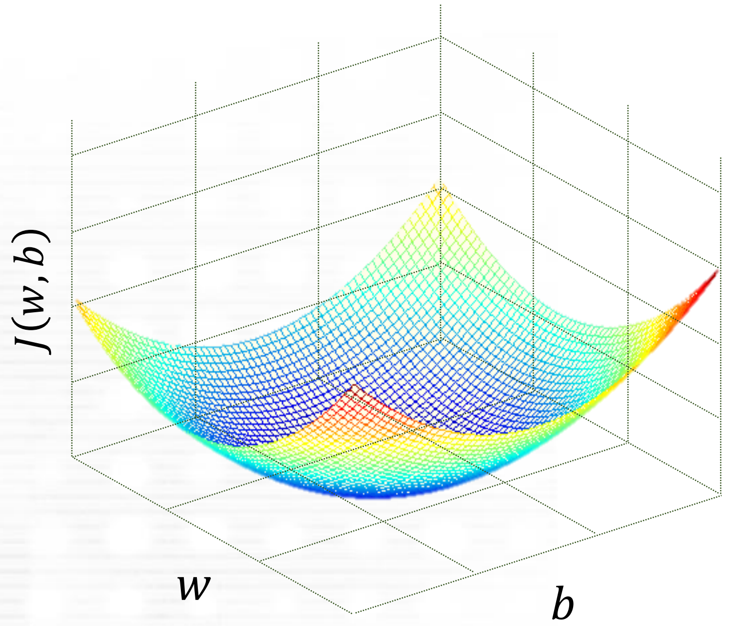
Gradient Descent

repeat {

$$b := b - \alpha \frac{\partial}{\partial b} J(w, b)$$

$$w := w - \alpha \frac{\partial}{\partial w} J(w, b)$$

}



repeat {

$$w_j := w_j - \alpha \frac{\partial}{\partial w_j} J$$

}

Gradient Descent

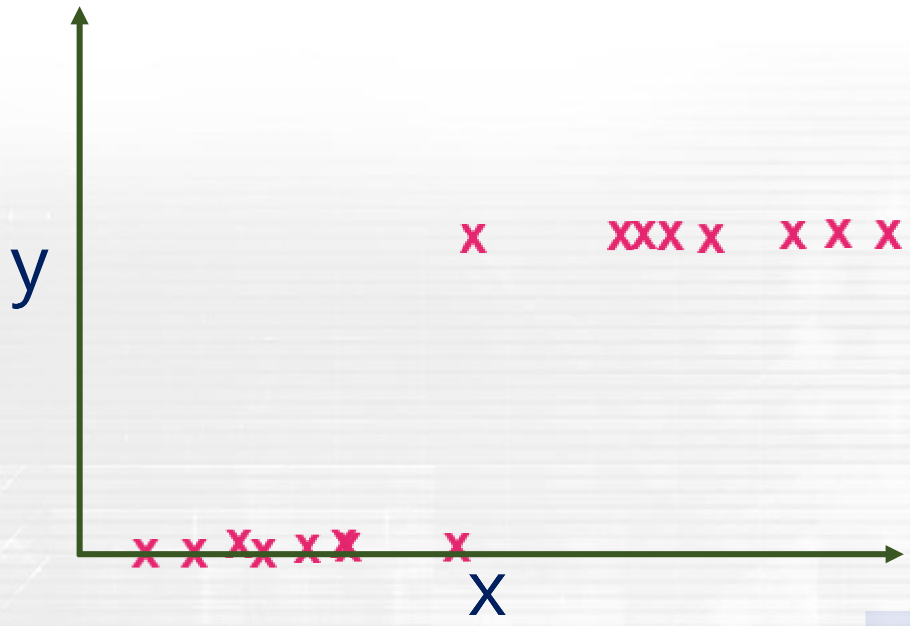
$$J(w, b) = \frac{1}{2m}\sum_{i=1}^{m}(h_{w,b}(x^{(i)}) - y^{(i)})^2$$

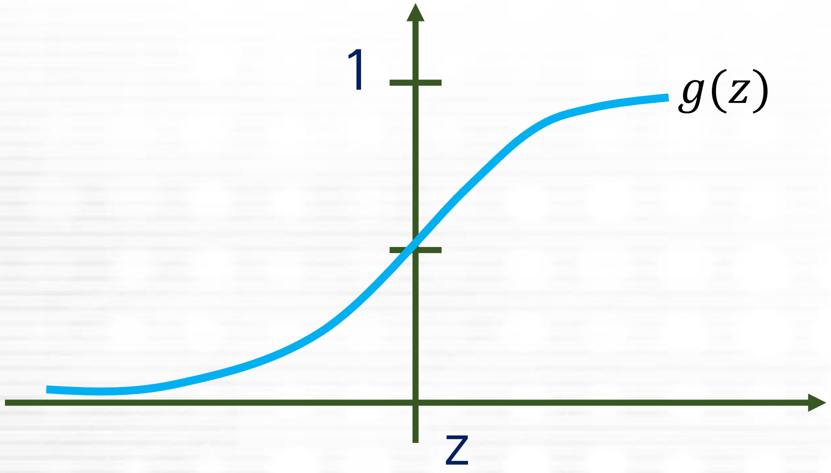
repeat {

$$w_j := w_j - \alpha\frac{1}{m}\sum_{i=1}^{m}\left(h_w\left(x^{(i)}\right) - y^{(i)}\right)\cdot x^{(i)}$$

}

Logistic Regression





$$h_{w,b}(x) = \frac{1}{1 + e^{-(wx+b)}}$$

$$h_{w,b}(x) = g(wx + b)$$

$$h_{w,b}(x) = g(w^T x + b)$$

Cost Function

$$J(w) = \frac{1}{m}\sum_{i=1}^{m} \mathrm{Cost}\left(h_w\left(x^{(i)}\right), y^{(i)}\right)$$

$$= -\frac{1}{m}\left[\sum_{i=1}^{m} y^{(i)} \log h_w\left(x^{(i)}\right) + (1 - y^{(i)}) \log(1 - h_w\left(x^{(i)}\right))\right]$$

Gradient Descent

repeat {

$$w_j := w_j - \alpha \frac{\partial}{\partial w_j} J$$

}

$$J(w) = -\frac{1}{m}\left[\sum_{i=1}^{m} y^{(i)} \log h_w\left(x^{(i)}\right) + (1 - y^{(i)}) \log(1 - h_w\left(x^{(i)}\right))\right]$$

Gradient Descent

repeat {

$$w_j := w_j - \alpha \frac{\partial}{\partial w_j} J$$

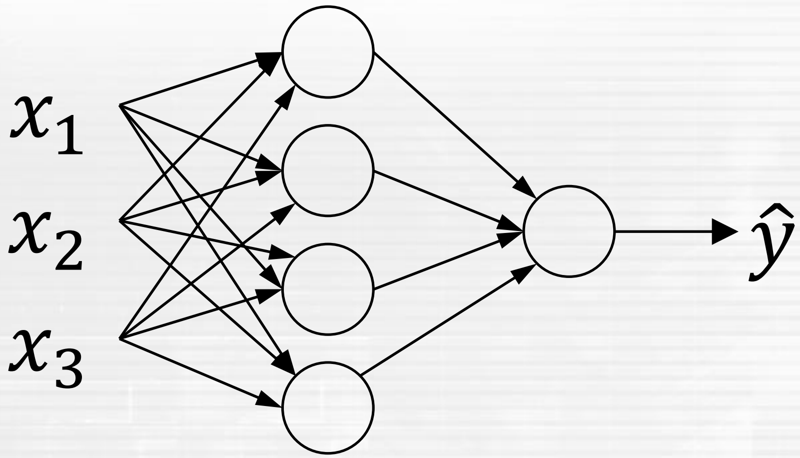
}

repeat {

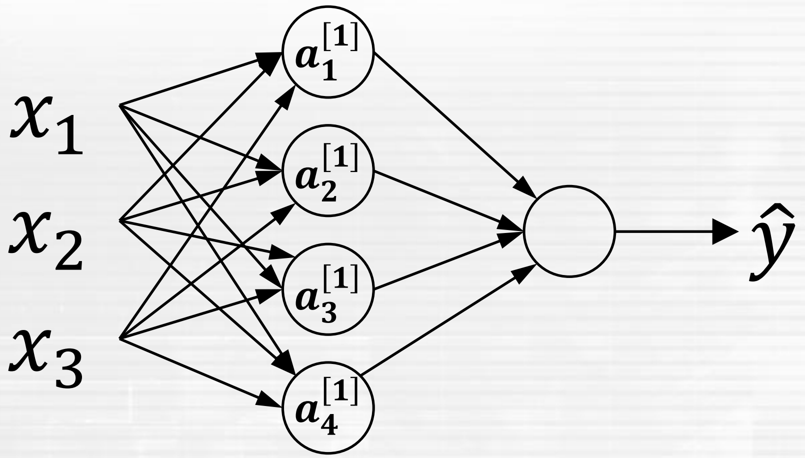
$$w_j := w_j - \alpha \frac{1}{m} \sum_{i=1}^{m} \left(h_w\left(x^{(i)}\right) - y^{(i)} \right) \cdot x^{(i)}$$

}

Neural Network



Neural Network



Given input x:

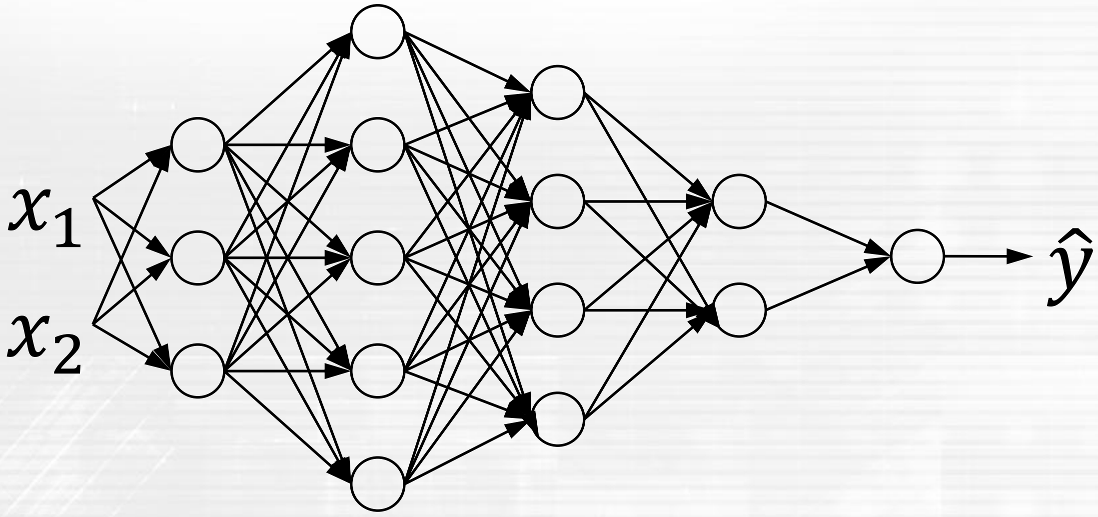
$$z^{[1]} = W^{[1]}x + b^{[1]}$$

$$a^{[1]} = \sigma(z^{[1]})$$

$$z^{[2]} = W^{[2]}a^{[1]} + b^{[2]}$$

$$a^{[2]} = \sigma(z^{[2]})$$

Deep Neural Network



Given input x:

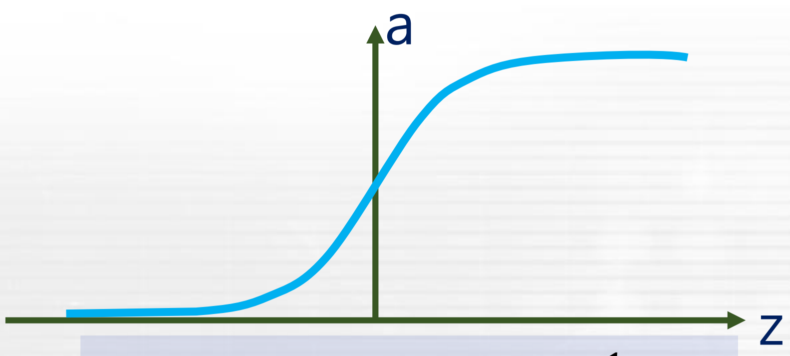
$$z^{[1]} = W^{[1]}x + b^{[1]}$$
$$a^{[1]} = \sigma(z^{[1]})$$

$$z^{[2]} = W^{[2]}a^{[1]} + b^{[2]}$$
$$a^{[2]} = \sigma(z^{[2]})$$

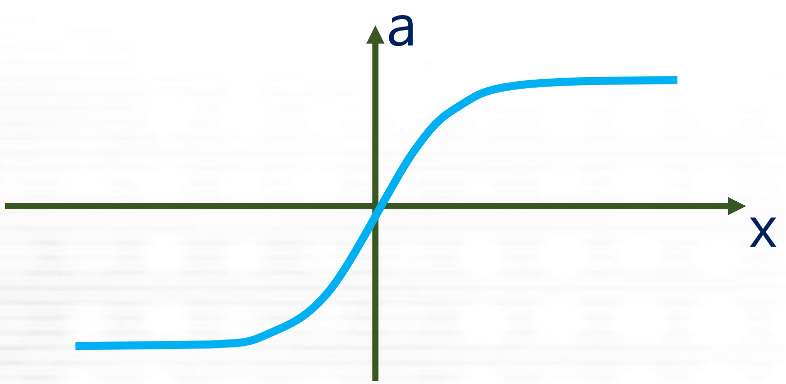
$$z^{[3]} = W^{[3]}a^{[2]} + b^{[3]}$$
$$a^{[3]} = \sigma(z^{[3]})$$

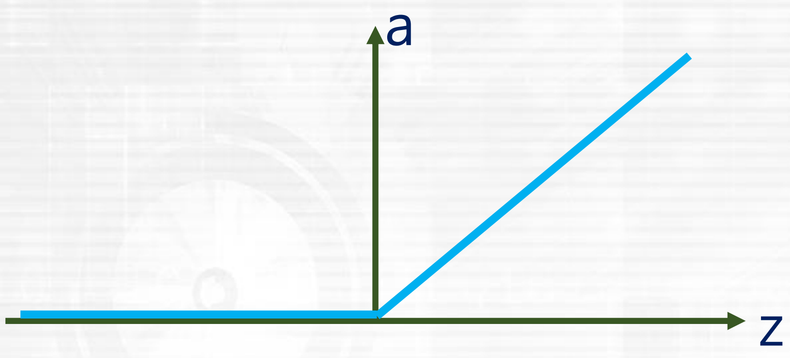
$$z^{[4]} = W^{[4]}a^{[3]} + b^{[4]}$$
$$a^{[4]} = \sigma(z^{[4]})$$

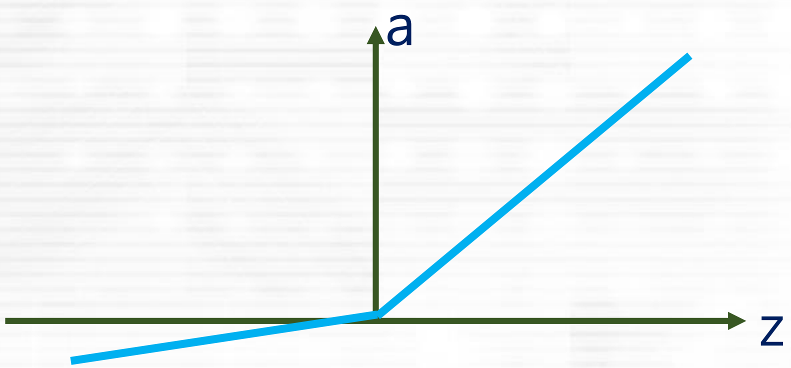
Activation Functions



sigmoid: $a = \frac{1}{1+e^{-z}}$

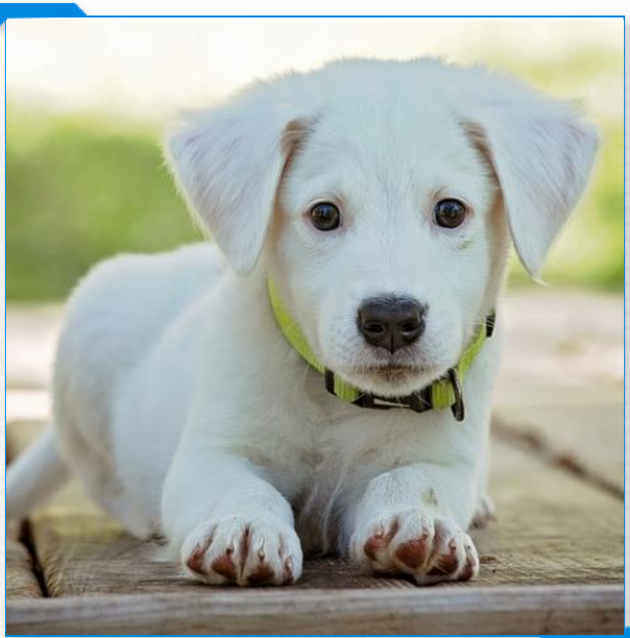


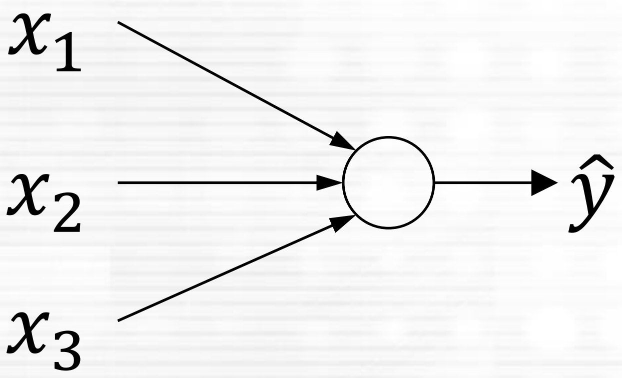




Classification

Classification

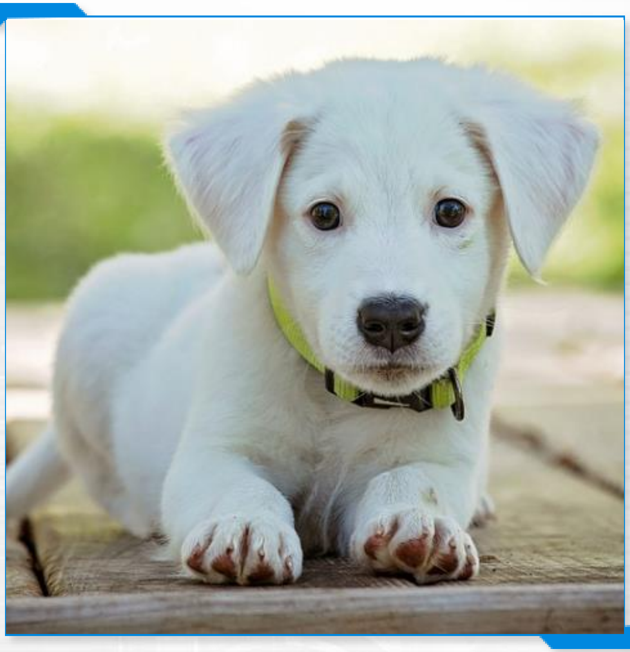


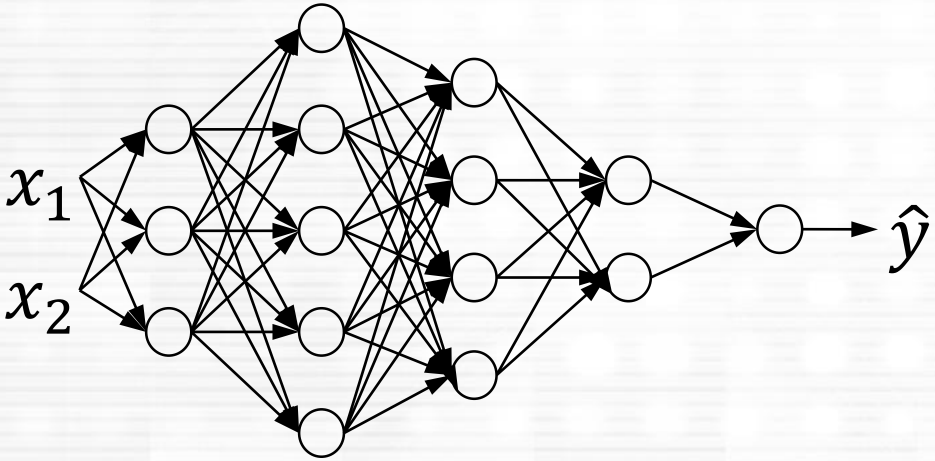


0 Dog
1 Cat

출처 pixabay

Classification

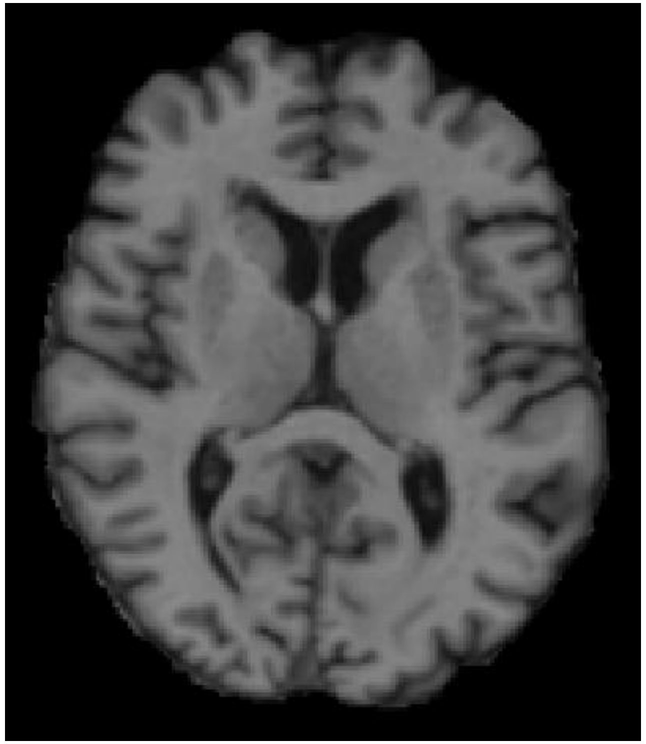




0 Dog
1 Cat

출처 pixabay

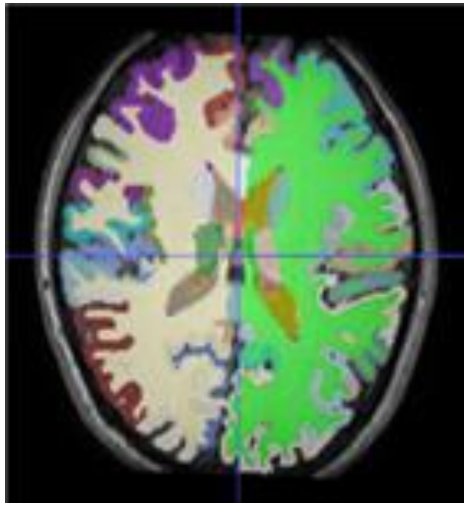
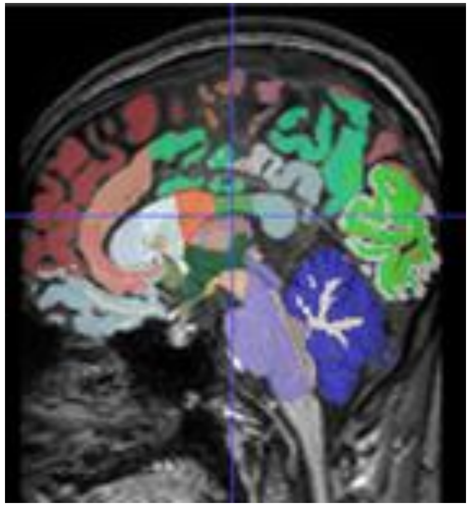
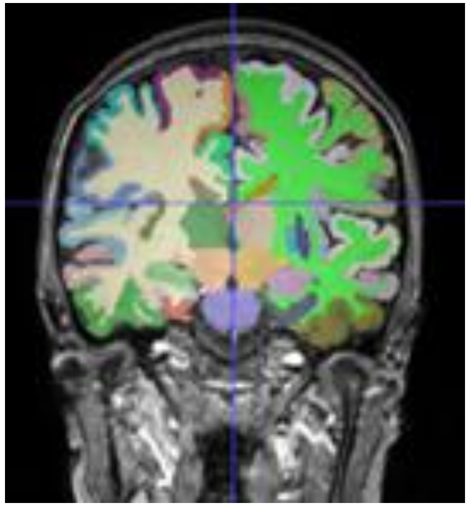
Classification



출처 http://adni.loni.usc.edu/data-samples/

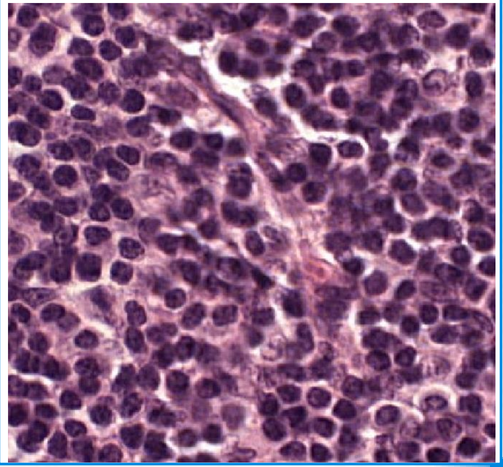
Feature Extraction

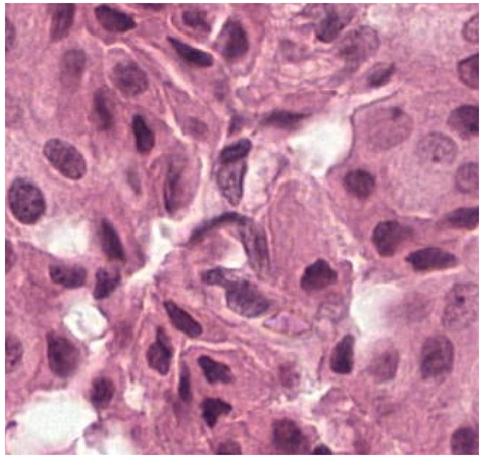
- FSL & Freesurfer

출처 https://surfer.nmr.mgh.harvard.edu/fswiki/FreeSurferWiki

Feature Extraction





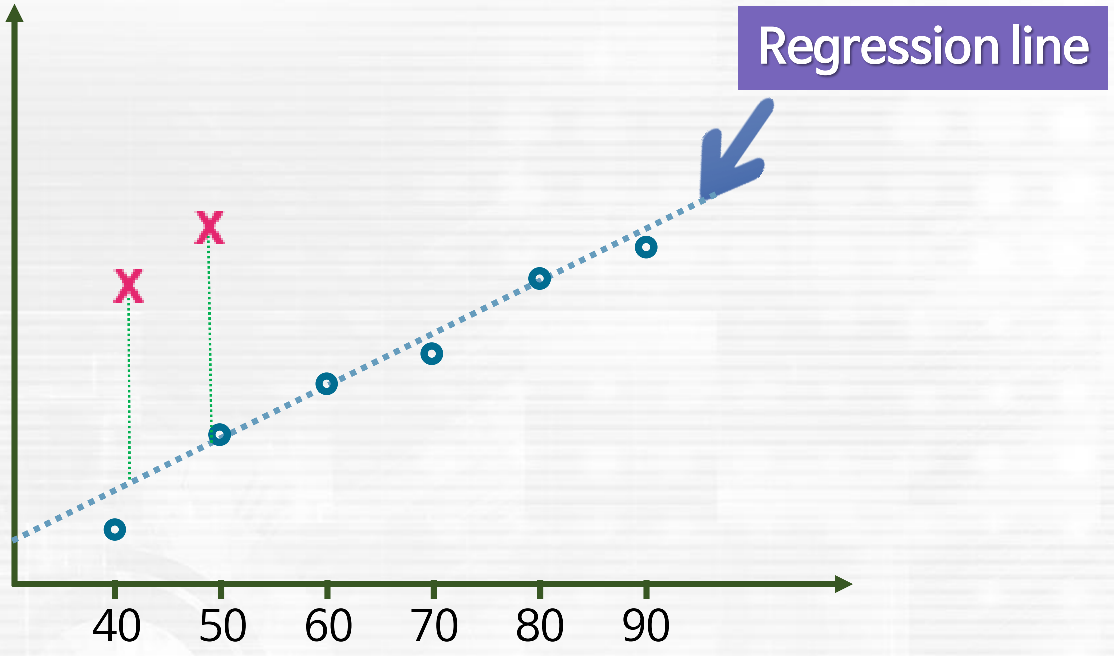
출처 https://camelyon17.grand-challenge.org/Data/

Demographic Scores

- Brain change is affected by multiple factors
- Linear regression using normal subjects

Subject	Age	Gender	Feature 1	Feature 2	Feature 3
Normal	40	M	3	10	5.1
Normal	50	F	5	9	5
Normal	60	M	6	8	4.9
Normal	70	M	6.5	7	5.2
Normal	80	F	8	6	5
Normal	90	F	8.5	5	5
AD	50	F	9.2	20	4.8
AD	40	M	7.9	20	4.9

Linear Regression



Overall Procedure

- Training
- Testing

Demographic Scores

Subject	Age	Gender	Feature 1	Feature 2	Feature 3
Normal	40	M	3	10	5.1
Normal	50	F	5	9	5
Normal	60	M	6	8	4.9
Normal	70	M	6.5	7	5.2
Normal	80	F	8	6	5
Normal	90	F	8.5	5	5
AD	50	F	9.2	20	4.8
AD	40	M	7.9	20	4.9