Medical Image Analysis

5. Medical image classification(4)

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https://tyami.github.io/

Contents

- Feature selection
- Feature visualization

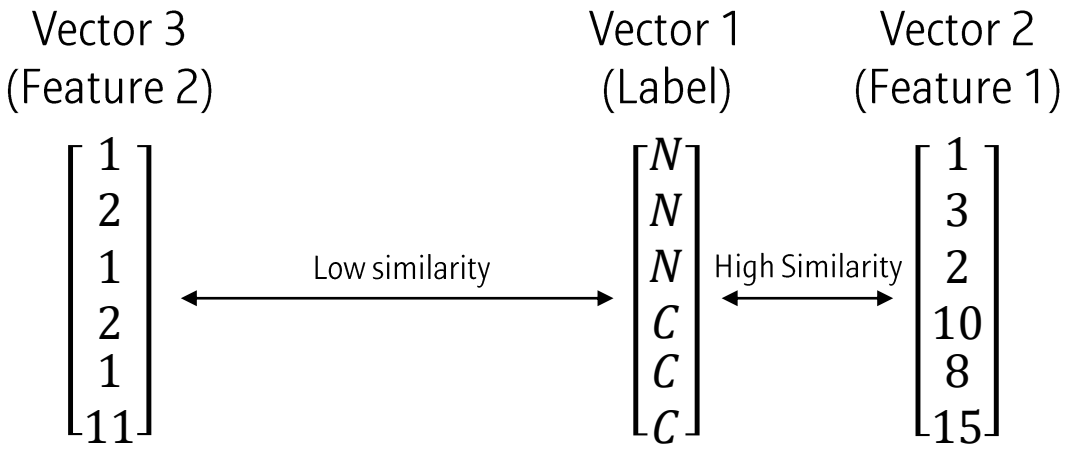
1. Feature selection using L1 regularization

- 이전 포스팅 (Regularization: Ridge (L2), Lasso (L1), and Elastic Net regression) 참고
  - https://tyami.github.io/machine%20learning/regularization-Ridge-Lasso-ElasticNet/#ridge-vs-lasso

measure of the amount of uncertainty in the (data) set

2. Feature selection using Entropy / Mutual information

Entropy



measure of the amount of uncertainty in the (data) set

2. Feature selection using Entropy / Mutual information

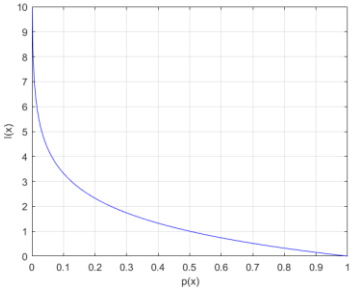
Entropy

- Probability

$$Probability = \boldsymbol{p(x)}$$

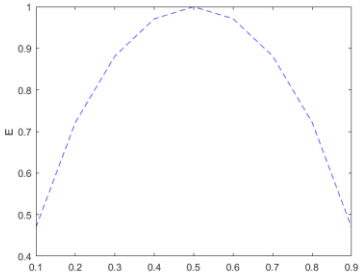
- Information

$$Information = I(x) = \boldsymbol{log}\frac{\mathbf{1}}{\boldsymbol{p(x)}} = -\boldsymbol{log}\, \boldsymbol{p(x)}$$



- Entropy = measure of the amount of uncertainty in the event set S (Expectancy of information)

$$Entropy = H(S) = \sum_{i=1}^{c} p_i I(x_i) = \sum_{i=1}^{c} p_i\, log\frac{1}{p_i} = -\sum_{\boldsymbol{i=1}}^{\boldsymbol{c}} \boldsymbol{p_i\, log\, p_i}$$



2. Feature selection using Entropy / Mutual information

Mutual information

$$\boldsymbol{Entropy} = \boldsymbol{H(S)} = -\sum_{i=1}^{c} p_i \log p_i$$

두 사건의 관계: Joint entropy

$$\boldsymbol{Joint\ Entropy} = H(X,Y) = -\sum_{i=1}^{N}\sum_{j=1}^{M} p(x_i, y_j) \log p(x_i, y_j)$$

두 사건이 독립일 때 Joint Entropy: $H(X,Y) = H(X) + H(Y)$

따라서, $H(X) + H(Y) - H(X,Y)$ 를 통해 두 벡터 간 관련성 measure 가능 → Mutual information

$$\boldsymbol{Mutual\ information} = I(X;Y) = H(X) + H(Y) - H(X,Y) = \sum_{i=1}^{N}\sum_{j=1}^{M} p(x_i, y_j) \log \frac{p(x_i, y_j)}{p(x_i)p(y_j)}$$

- 관련성이 없으면 (독립일 때) Mutual information=0
- 관련성이 크면 Mutual information이 커진다

2. Feature selection using Entropy / Mutual information

Mutual information-based algorithm: Decision tree ID3

- Feature와 Class간 Mutual information 계산을 통해 모델 학습

- Mutual information 을 이용한 알고리즘: Decision Tree ID3
  - 이전 포스팅 (의사결정 나무 (Decision Tree) ID3 알고리즘 설명) 참고
  - https://tyami.github.io/machine%20learning/decision-tree-2-ID3/

2. Feature selection using Entropy / Mutual information

Mutual information-based feature selection: minimum-redundancy-Maximum-Relevance(mRMR)

- Feature와 Class간, 그리고 Feature와 Feature간 Mutual information 계산을 통해 모델 학습
- 핵심: Class와 관련성이 높은 Feature를 찾되, 다음 부터는 비슷한 Feature는 뽑지 않겠다.
  - Feature-Class mutual information 을 높이고
  - Feature-Feature mutual information 을 낮춘다

c	f_1	f_2	f_3
Subject	Feature 1	Feature 2	Feature 3
Normal	3	5	5.1
Normal	8.7	9	5
Normal	6	8	4.9
Normal	6.5	7	5.2
AD	8	16	5
AD	8.5	15	5
AD	9.2	20	4.8
AD	7.9	20	4.9

Feature-Class Mutual information (높여야 함)

$$D(S,c) = \frac{1}{|S|}\sum_{f_i \in S} I(f_i;c)$$

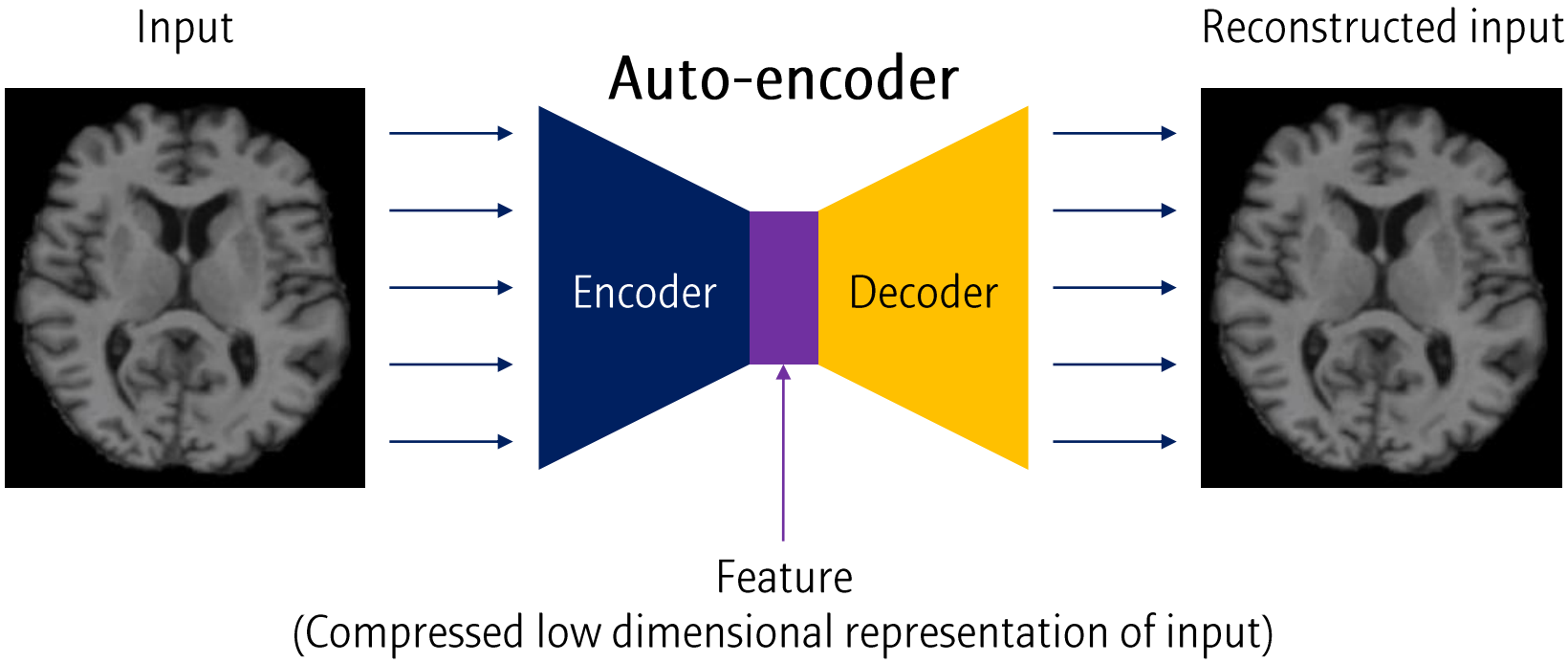
Feature-Feature Mutual information (낮춰야 함)

$$R(S) = \frac{1}{|S|^2}\sum_{f_i,f_j \in S} I(f_i,f_j)$$

$$mRMR = \max_S \left[\frac{1}{|S|}\sum_{f_i \in S} I(f_i;c) - \frac{1}{|S|^2}\sum_{f_i,f_j \in S} I(f_i,f_j)\right]$$

3. Feature extraction using Deep Learning

Auto-encoder



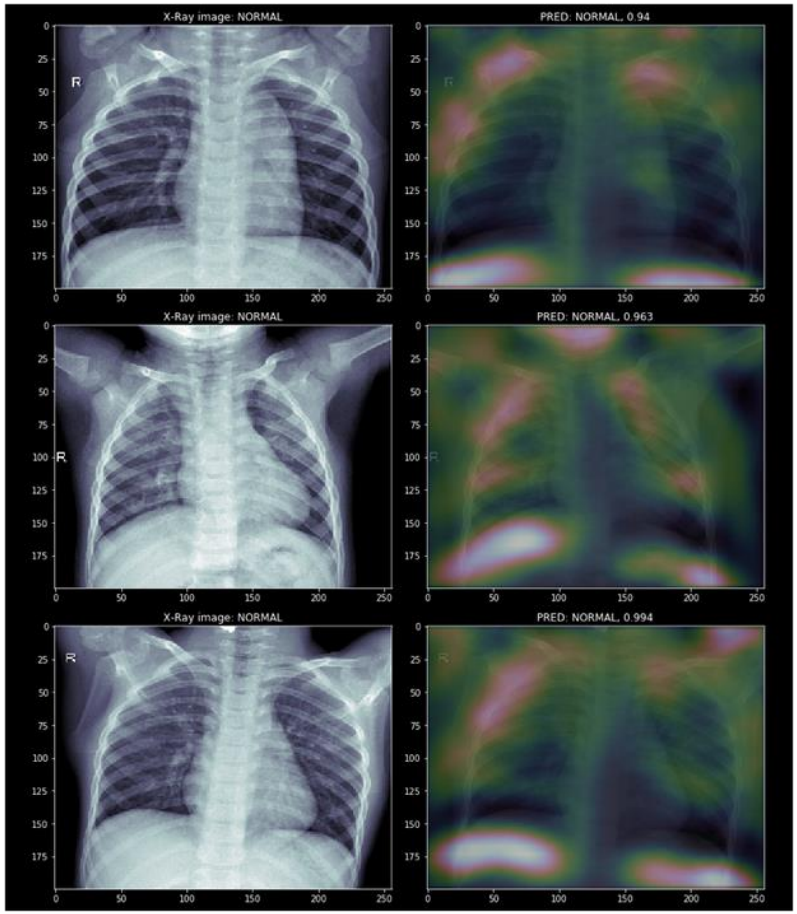
4. Class Activation Map

- 이전 포스팅 (CNN visualization: CAM and Grad-CAM 설명) 참고
  - https://tyami.github.io/deep%20learning/CNN-visualization-Grad-CAM/

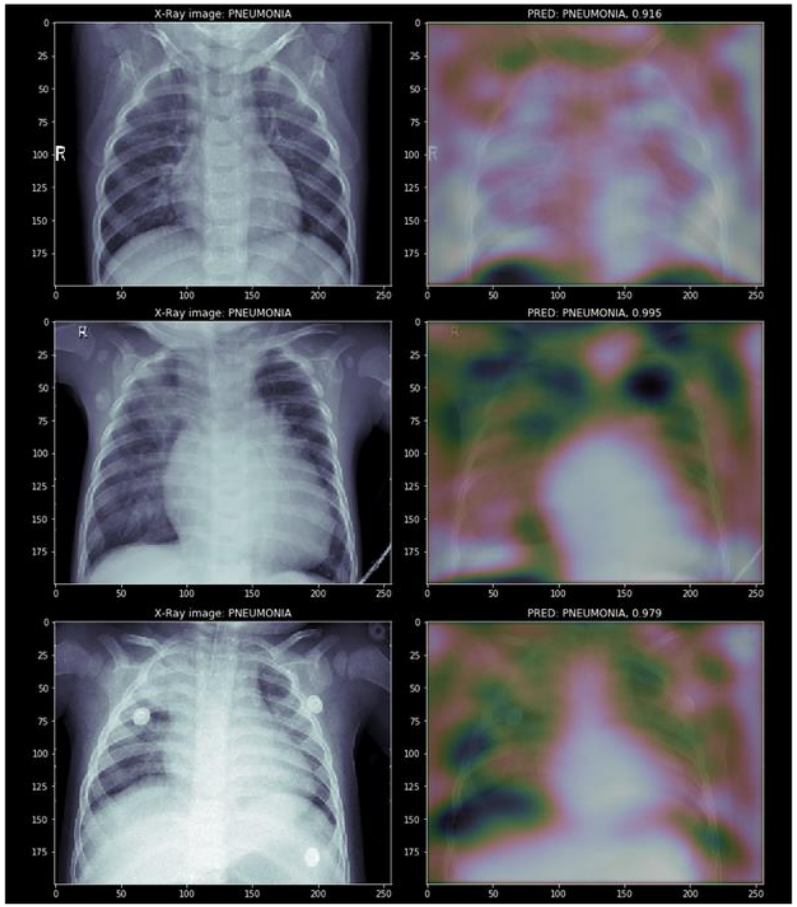
5. Weakly supervised learning

Example of CAM in medical image

Normal



Pneumonia



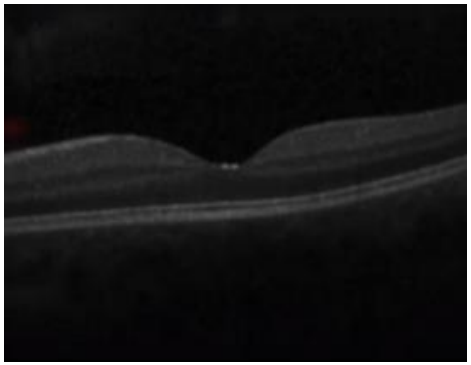
https://de-novo.org/2018/06/17/weakly-supervised-localization/

5. Weakly supervised learning

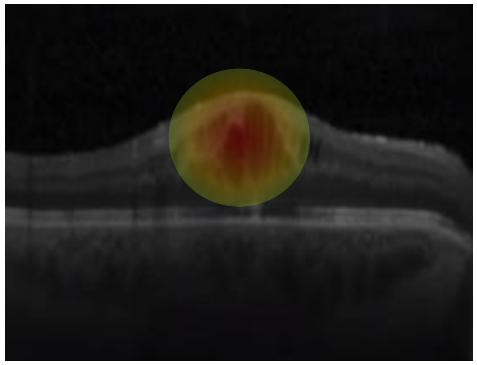
Definition of weakly supervised learning

"학습 과정에서는 알려주지 않은 정보를, Test 시 찾아내는 문제"

예시 (CAM)



Normal



Abnormal

예시

Training	Test
Image label	Bounding box
Bounding box	Pixel label

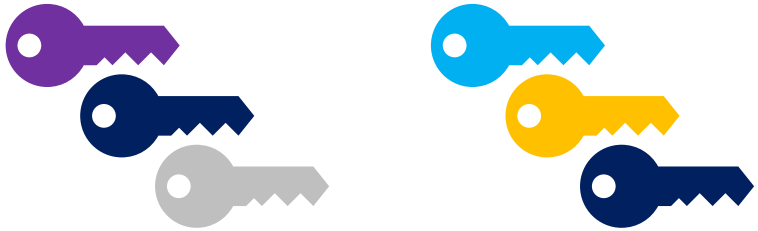
6. Multiple instance learning

Definition of Multiple instance learning

Positive training data (Open)

Instance

Negative training data (Not open)



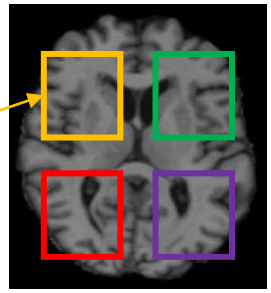
Test data (Open or not?)

6. Multiple instance learning

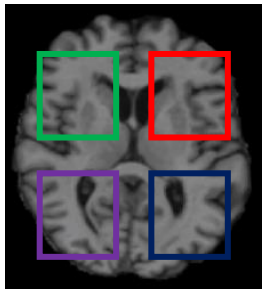
Medical example of Multiple instance learning

Positive training data (Cancer)

Instance

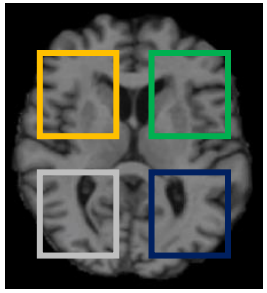


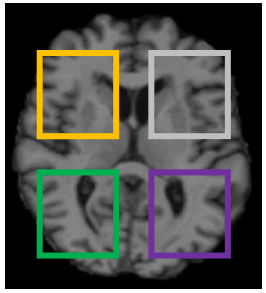
Cancer !



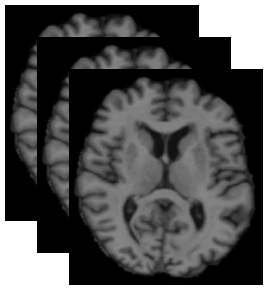
Cancer !

Negative training data (Normal)





Test data (Cancer or not?)



영상 단위 label만 있고, pixel label은 없을 때,
병변이 작을 때 활용