Intelligent Systems, Revision

Pierre Gaillard

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INRIA

Hyperparameters

1. What is the difference between a parameter and an hyper-parameter?
2. Name the hyper-parameters of the following methods:

- KNN
- Logistic regression, with ℓ_2 regularization
- SVM with soft-margin
- Multi-layer perceptron
- Deep Convolutional Neural Network
- PCA
- Decision Tree

3. For each hyper-parameter, tell if you increase the parameter if it leads to more, same, or less regularization (more bias, less variance).
4. What is the standard solution to tune hyper-parameters?

Optimization

Often, to train algorithms, one needs to minimize an empirical loss

$$\widehat{\theta} \in \underset{w \in \mathbb{R}^d}{\arg\min} \frac{1}{n} \sum_{i=1}^{n} \ell\big(y_i, f_\theta(x_i)\big)$$

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2. When does overfitting may occur?
3. How to avoid it on such algorithms?
4. How do you solve such a problem?

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PCA vs. t-SNE

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Draw and explain an example where t-SNE work better than PCA.

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Comparison between the methods

PCA has a 2 big advantages compared to t-SNE:

- It is **deterministic**
- the axis are **interpretable** as they are a linear combination of the variables (cf. stat lectures).
- no parameter to tune (target entropy in case of t-SNE)

t-SNE has the advantage at looking only at local scale, which is often relevant, and is **non-linear** projection method.

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Exemple where t-SNE is better than PCA

If the samples are primarily similar to close neighbors, and the large distances between samples are less important, t-SNE can work better than PCA. A typical example is the spiral, where long distance is “irrelevant” and neighbor connectivity is important.

Conditional Log-Likelihood

What is conditional log-likelihood?

1. Assume that $X|Y = i \sim \mathcal{N}(\mu_i, I)$.
   a) What is the parameter to be estimated?
   b) Wat is the conditional log-likelihood in this case?
   c) Show that it can be written as $\sigma(w \cdot \varphi(x) + b)$. Determine w and b
3. What happens if $X|Y = i \sim \mathcal{N}(\mu_i, \Sigma_i)$?

Ridge regression

Let $(x_i, y_i)_{i=1,\dots,n}$ be some data in $\mathbb{R}^d \times \mathbb{R}$.

1) What problem does Ridge regression solves here?
2) Write the closed form expression of the parameter.
3) Assume that the data looks like (draw on blackboard), would it be a good algorithm? What could you use to fix it?

Activation function

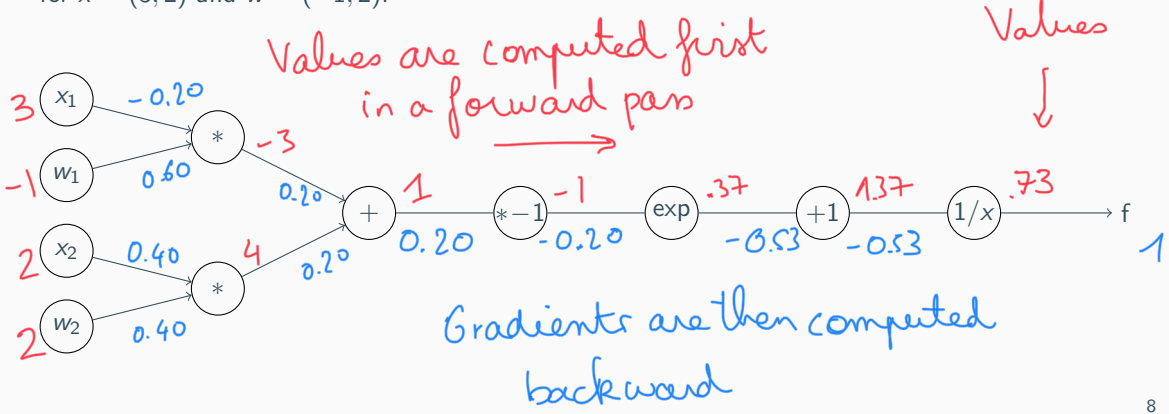
What is the sigmoid activation function? What are the problems with using a sigmoid activation function?

Back-propagation

Perform back-propagation on the following simple Neural Network that computes

$$f(x) = \frac{1}{1 + \exp(-(w_1 x_1 + w_2 x_2))}$$

for $x = (3, 2)$ and $w = (-1, 2)$.



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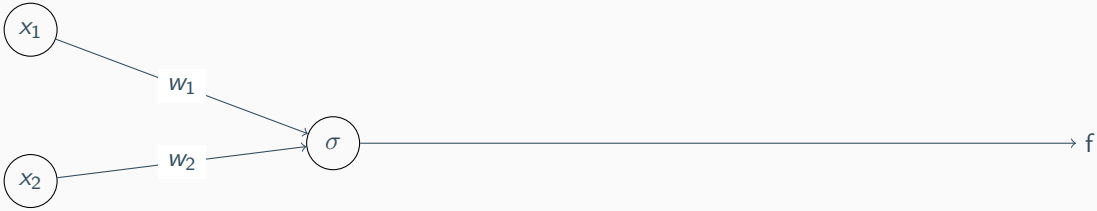

CNN

You have a 32x32x5 image and filter it with a 5x5x5 kernel, the way most convolutional neural networks are implemented. If you use no padding, what will be the output size of the activation map?

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28x28x1

Scores

What is the difference between Recall, Precision, and Accuracy?
Compute them for the following confusion matrix (on black-board).

Gaussian Mixture Models vs. Kmeans

What is the difference between Gaussian Mixture Model and Kmeans?

Draw examples of data.

How do you solve Gaussian Mixture Model?

References

Thank you!