TÉCNICO LISBOA

LEIC-T 2023/2024
Aprendizagem - Machine Learning
Homework 3
Deadline 20/10/2024 20:00
Submit on Fenix as pdf

I) Polynomial Regression (3 pts)

Consider a training set with 5 observations (sample) with dimension $D = 1$

$$x_1=-0.8,\ x_2=1,\ x_3=-1.2,\ x_4=1.4,\ x_5=1.9$$

With targets

$$t_1=-20,\ t_2=20,\ t_3=-10,\ t_4,=13,\ t_5=12$$

Consider as well the basis function

$$\phi_j(x) = x^j$$

which can lead to a polynomial regression of the third degree

$$y(x, \mathbf{w}) = \sum_{j=0}^{3} w_j \cdot \phi_j(x) = w_0 + w_1 \cdot x + w_2 \cdot x^2 + w_3 \cdot x^3.$$

(a) (1 pts)

Compute the design matrix Φ.

(b) (1 pts)

Compute the polynomial regression weights.

(c) (1 pts)

LASSO regression (l1 regularization) lacks a closed form solution, why?

II) Neural Network NN (4 pts)

Given the weights.:

$$W^{[1]} = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{pmatrix}$$

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$$b^{[1]} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

$$W^{[2]} = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$$

$$b^{[2]} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

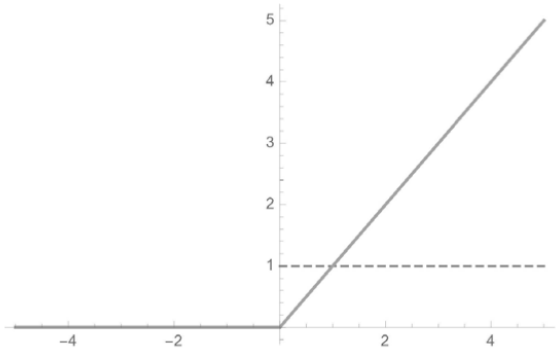
and the activation function ReLU

Rectifier also known as a ramp function

$$f(x) = \max(0, x). \tag{12.3}$$

is defined as the positive part of its argument [Jarrett *et al.* (2009)], [Nair and Hinton (2009)], [Goodfellow *et al.* (2016)]. The function is non-differentiable at zero; however, it is differentiable anywhere else and we can use the subderivative with sgn_0 function

$$f'(x) = sgn_0(x) = \begin{cases} 1 \text{ if } & x \geq 0 \\ 0 \text{ if } & x < 0 \end{cases}. \tag{12.4}$$



of the hidden layer and SoftMax of the output layer using the cross entropy error loss do a stochastic gradient descent update (with learning rate η = 0.1) for the training example:

$\mathbf{x}=(1,1,1,1,1)^T$ and the target $\mathbf{t}=(1,0)^T$,

III Software Experiments (3pts)

Download the jupyter notebook HM3_NN.ipynb.

Split the data using the command (in the notebook)

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```
digits = datasets.load_digits()
X, y = digits.data, digits.target
```
X_train, X_test, y_train, y_test = train_test_split(X, y, train_size=**0.7**,stratify=y,random_state=**your_group number**)

Compare the accuracy on the test set of Logistic Regression with NN.

```
MLPClassifier(hidden_layer_sizes=(10,4),random_state= your_group number,activation
='relu',solver='sgd')
```

Layer size 10, 4 means two hidden layers, first layer 10 neurons and second hidden layer 4 neurons.

Can you improve accuracy on the test set by changing the parameters of hidden_layer_size? Indicate your best parameters of the hidden layer size? Indicate the loss curve. What is your conclusion concer?

Pls do not spend too much time on the experiments!!