Datascience X Logistic Regression

Harry Potter and a Data Scientist

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Summary: Write a classifier and save Hogwarts!

Contents

Chapter I

Foreword

This is what Wikipedia says about Yann Le Cun, one of the founding fathers of AI :

Yann Le Cun was born near Paris, France, in 1960. He is a researcher in artificial intelligence and computer vision (robotics). He is considered one of the inventors of deep learning.

Obtaining a B.S. degree from the ESIEE Paris in 1983, he graduated from the Pierre and Marie Curie University and received a PhD in 1987, during which he proposed an early form of the back-propagation learning algorithm which is commonly used by the gradient descent optimization algorithms to adjust the weight of neurons by calculating the gradient of the loss function. He was a postdoctoral research associate in Geoffrey Hinton's lab at the University of Toronto from 1987 to 1988.

Since 1980s Yann Le Cun has been working on machine learning, computer vision and deep learning : the ability of a computer to recognize representations (images, texts, videos, sounds) by repeatedly exposing them to the training samples.

In 1987, Yann Le Cun joined the University of Toronto and in 1988 the AT&T research facilities, where he developed the methods of supervised learning.

Yann Le Cun is also one of the main creators of the DjVu image compression technology (together with Léon Bottou and Patrick Haffner).

Yann Le Cun is a professor at the University of New York where he has created the Center for Data Science. He works in particular on technological development of autonomous cars.

On December 9, 2013, Yann Le Cun was invited by Mark Zuckerberg to join Facebook to design and run the artificial intelligence lab FAIR (« Facebook Artificial Intelligence Research ») in New York, Menlo Park and since 2015 in Paris, to work on the image recognition. He had previously refused a similar propose from Google.

In 2016, he was was the visiting professor of computer science on the "Chaire Annuelle Informatique et Sciences Numériques" at Collège de France in Paris.

Chapter II

Introduction

On no! Since its creation, the famous school of wizards, Hogwarts, had never known such an offense. The forces of evil have bewitched the Sorting Hat. It no longer responds, and is unable to fulfill his role of sorting the students to the houses.

The new academic year is approaching. Gladly, the Professor McGonagall was able to take action in such a stressful situation, since it is impossible for Hogwarts not to welcome new students. . . She decided to call on you, a muggle "datascientist" who is able to create miracles with the tool which all muggles know how to use: a "computer".

Despite the intrinsic reluctance of many wizards, the director of the school welcomes you to his office to explain the situation. You are here because his informant discovered that you are able to recreate a magic Sorting Hat using your muggle tools. You explain to him that in order for your "muggle" tools to work, you need students data. Hesitantly, Professor McGonagall gives you a dusty spellbook. Fortunately for you, a simple "Digitalis!" and the book turned into a USB stick.

Chapter III

Objectives

In this project *DataScience x Logistic Regression*, you will continue your exploration of *Machine Learning* by discovering different tools.

The use of the term *DataScience* in the title will be clearly considered by some to be abusive. That is true. We do not pretend to give you all the basics of *DataScience* in this topic. The subject is vast. We will only see here some bases which seemed to us useful for data exploration before sending it to the *machine learning* algorithm .

You will implement a linear classification model, as a continuation of the subject *linear regression* : a *logistic regression*. We also encourage you a lot to create a *machine learning* toolkit while you will move along the branch.

Summarizing :

- You will learn how to read a data set, to visualize it in different ways, to select and clean unnecessary information from your data.
- You will train a logistic regression that will solve classification problem.

Chapter IV

General instructions

You can use whatever language you want. However, we recommend that you choose a language with a library that facilitates plotting and calculation of statistical properties of a dataset.

Any functions that would do all the heavy-lifting for you (for example, using the `describe` function of the *Pandas*) library will be considered cheating.

Chapter V

Mandatory part

It is highly recommended to perform the steps in following order.

V.1 Data Analysis

We will see some basic steps of data exploration. Of course, these are not the only techniques available or the only one step to follow. Each data set and problem has to be approached in an unique way. You will surely find other ways to analyze your data in the future.

First of all, take a look at the available data. look in what format it is presented, if there are various types of data, the different ranges, and so on. It is important to make an idea of your raw material before starting. The more you work on data - the more you develop an intuition about how you will be able to use it.

In this part, Professor McGonagall asks you to produce a program called `describe.[extension]`. This program will take a *dataset* as a parameter. All it has to do is to display information for all numerical *features* like in the example:

```
$> describe.[extension] dataset_train.csv
              Feature 1     Feature 2     Feature 3     Feature 4
Count        149.000000    149.000000    149.000000    149.000000
Mean           5.848322      3.051007      3.774497      1.205369
Std            5.906338      3.081445      4.162021      1.424286
Min            4.300000      2.000000      1.000000      0.100000
25%            5.100000      2.800000      1.600000      0.300000
50%            5.800000      3.000000      4.400000      1.300000
75%            6.400000      3.300000      5.100000      1.800000
Max            7.900000      4.400000      6.900000      2.500000
```

`It is forbidden to use any function that makes the job done for you like: count, mean, std, min, max, percentile, etc ... no matter the language that you use. Of course, it is also forbidden to use the describe function of the Pandas library or any function that looks similar(more or less) to it from another library.`

V.2 Data Visualization

Data visualization is a powerful tool for a data scientist. It allows you to make insights and develop an intuition of what your data looks like. Visualizing your data also allows you to detect defects or anomalies.

In this section, you are asked to create a set of scripts, each using a particular visualization method to answer a question. There is not necessarily a single answer to the question.

V.2.1 Histogram

Make a script called `histogram.[extension]` which displays a *histogram* answering the next question :

Which Hogwarts course has a homogeneous score distribution between all four houses ?

V.2.2 Scatter plot

Make a script called `scatter_plot.[extension]` which displays a *scatter plot* answering the next question :

What are the two *features* that are similar ?

V.2.3 Pair plot

Make a script called `pair_plot.[extension]` which displays a *pair plot* or *scatter plot matrix* (according to the library that you are using).

From this visualization, what features are you going to use for your logistic regression?

V.3 Logistic Regression

You arrive at the last part: code your Magic Hat. To do this, you have to perform a multi-classifier using a logistic regression *one-vs-all*.

You will have to make two programs :

- First one will *train* your models, it's called `logreg_train.[extension]`. It takes as a parameter `dataset_train.csv`. For the mandatory part, you must use the technique of *gradient descent* to minimize the error. The program generates a file containing the weights that will be used for the prediction.
- A second has to be named `logreg_predict.[extension]`. It takes as a parameter `dataset_test.csv` and a file containing the weights trained by previous program. In order to evaluate the performance of your classifier this second program will have to generate a prediction file `houses.csv` formatted exactly as follows:

```
$> cat houses.csv
Index,Hogwarts House
0,Gryffindor
1,Hufflepuff
2,Ravenclaw
3,Hufflepuff
4,Slytherin
5,Ravenclaw
6,Hufflepuff
       [...]
```

Chapter VI

Bonus Part

It is possible to make a lot of interesting bonuses for this subject.
Here are some suggestions:

- Add more fields for `describe.[extension]`
- Implement a *stochastic gradient descent*
- Implement other optimization algorithms (Batch GD/mini-batch GD/ you name it)
- ...

Chapter VII

Turn-in and peer-evaluation

Turn in your work using your git repository, as usual. Only the work that's in your repository will be graded during the evaluation.

During the correction you will be evaluated on your turn-in (no functions that do all the heavy-lifting for you) as well as your ability to present, explain and justify your choices.

Your classifier will be evaluated on the data present in `dataset_test.csv`. Your answers will be evaluated using accuracy score of the *Scikit-Learn* library. Professor McGonagall agrees that your algorithm is comparable to the Sorting Hat only if it has a minimum precision of **98%** .

It will also be important to be able to explain the functioning of the used *machine learning* algorithms.

Chapter VIII

Attachments

VIII.1 Mathematics

Logistic regression works almost like the linear regression. Here is a cost (*loss*) function:

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m} y^i \log(h_\theta(x^i)) + (1-y^i)\log(1-h_\theta(x^i))$$

Where $h_\theta(x)$ is defined in the following way :

$$h_\theta(x) = g(\theta^T x)$$

With :

$$g(z) = \frac{1}{1+e^{-z}}$$

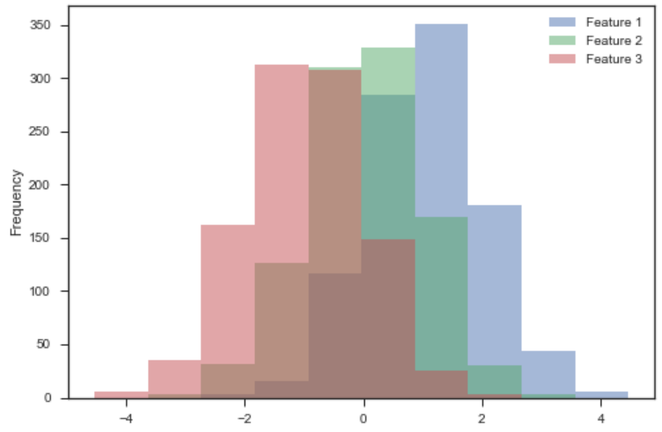
The loss function gives us the following partial derivative :

$$\frac{\partial}{\partial\theta_j} J(\theta) = \frac{1}{m}\sum_{i=1}^{m}(h_\theta(x^i) - y^i)x_j^i$$

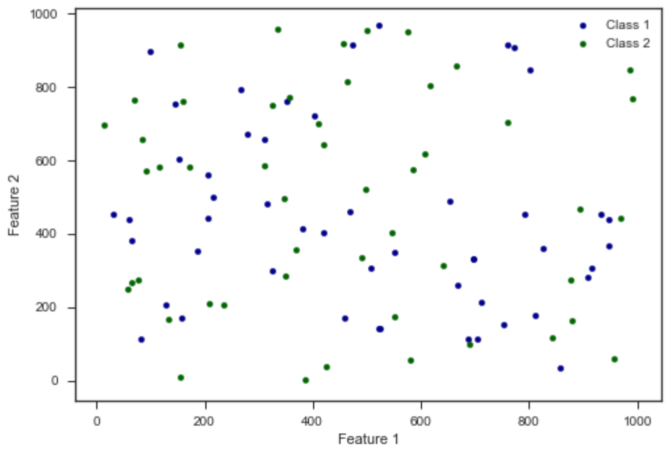
VIII.2 Data visualization examples

Here are some examples of data visualization :

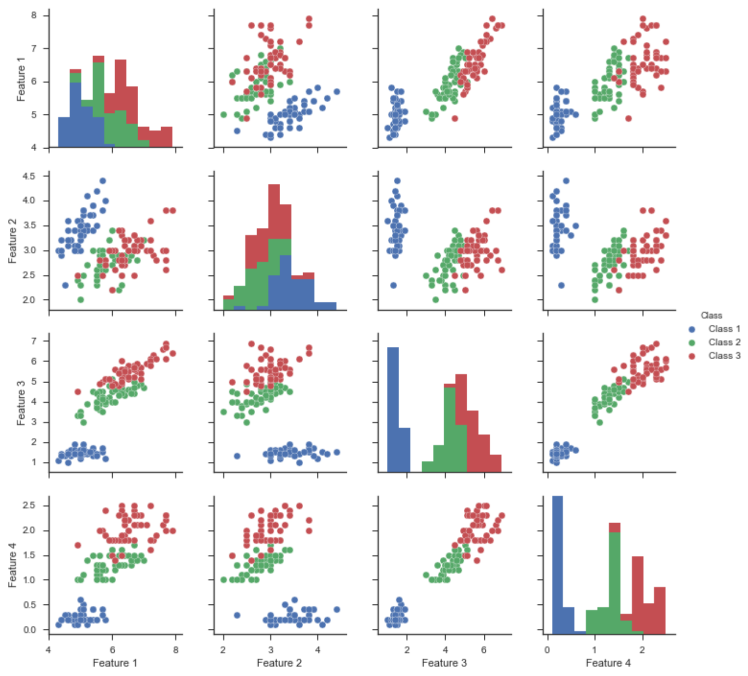
- Histogram



- Scatter plot



- Pair plot


Feature 1
Feature 2
Feature 3
Feature 4
Class
Class 1
Class 2
Class 3