

Fake News Detection With Logistic Regression

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1) Problem description:

Fake news has become a problem of great impact in our information driven society because of the continuous and intense fakesters content distribution. Information quality in news feeds is under questionable veracity calling for automated tools to detect fake news articles. Due to many faces of fakesters, creating such tool is a challenging problem. In this work, we propose a model for fake news detection using content based features and Machine Learning (ML) algorithms. To conclude in most accurate model, we evaluate logistic regression.

2) Model design:

Logistic regression is a statistical model that in its basic form uses a logistic function to model a binary dependent variable, it also estimates the parameters of a logistic model (*a form of binary regression*). Mathematically, a binary logistic model has a dependent variable with two possible values, where the two values are labeled "0" as false and "1" as true.

It's used to model the probability of a certain class or event existing such as (pass/fail, win/lose, fake/true).

The sigmoid function is defined as:

$$h(z) = \frac{1}{1 + \exp^{-z}}$$

It maps the input 'z' to a value that ranges between 0 and 1, and so it can be treated as a probability.

Regression and a sigmoid:

Logistic regression takes a regular linear regression, and applies a sigmoid to the output of the linear regression.

Regression:

$$z = \theta_0 x_0 + \theta_1 x_1 + \theta_2 x_2 + \dots \theta_N x_N$$

Note that the θ values are "weights". If you took the Deep Learning Specialization, we referred to the weights with the w vector. In this course, we're using a different variable θ to refer to the weights.

Logistic regression:

$$h(z) = \frac{1}{1 + \exp^{-z}}$$
$$z = \theta_0 x_0 + \theta_1 x_1 + \theta_2 x_2 + \dots \theta_N x_N$$

We will refer to 'z' as the 'logits'.

Cost Functions and Gradient:

The **cost function** used for logistic regression is the average of the log loss across all training examples:

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

- m is the number of training examples
- $y(i)$ is the actual label of the i -th training example.
- $h(z(\theta)(i))$ is the model's prediction for the i -th training example.

The **loss function** for a single training example is:

$$Loss = -1 \times (y^{(i)} \log(h(z(\theta)^{(i)})) + (1 - y^{(i)}) \log(1 - h(z(\theta)^{(i)})))$$

- All the h values are between 0 and 1, so the logs will be negative. That is the reason for the factor of -1 applied to the sum of the two loss terms.
- Note that when the model predicts 1 ($h(z(\theta))=1$) and the label y is also 1, the loss for that training example is 0.
- Similarly, when the model predicts 0 ($h(z(\theta))=0$) and the actual label is also 0, the loss for that training example is 0.
- However, when the model prediction is close to 1 ($h(z(\theta))=0.9999$) and the label is 0, the second term of the log loss becomes a large negative number, which is then multiplied by the overall factor of -1 to convert it to a positive loss value. $-1 \times (1 - 0) \times \log(1 - 0.9999) \approx 9.2$ The closer the model prediction gets to 1, the larger the loss.

Update the weights:

To update your weight vector θ , you will apply gradient descent to iteratively improve your model's predictions.

The **gradient** of the cost function J with respect to one of the weights θ_j is:

$$\nabla_{\theta_j} J(\theta) = \frac{1}{m} \sum_{i=1}^m (h^{(i)} - y^{(i)}) x_j$$

- 'i' is the index across all 'm' training examples.
- 'j' is the index of the weight θ_j , so x_j is the feature associated with weight θ_j
- To update the weight θ_j , we adjust it by subtracting a fraction of the gradient determined by α :

$$\theta_j = \theta_j - \alpha \times \nabla_{\theta_j} J(\theta)$$

- The learning rate α is a value that we choose to control how big a single update will be.

Implement gradient descent function:

- The number of iterations `num_iters` is the number of times that you'll use the entire training set.
- For each iteration, you'll calculate the cost function using all training examples (there are `m` training examples), and for all features.
- Instead of updating a single weight θ_i at a time, we can update all the weights in the column vector:

$$\theta = \begin{pmatrix} \theta_0 \\ \theta_1 \\ \theta_2 \\ \vdots \\ \theta_n \end{pmatrix}$$

- θ has dimensions $(n+1, 1)$, where 'n' is the number of features, and there is one more element for the bias term θ_0 (note that the corresponding feature value x_0 is 1).
- The 'logits', 'z', are calculated by multiplying the feature matrix 'x' with the weight vector 'theta'. $z = \mathbf{x}\theta$
 - \mathbf{x} has dimensions $(m, n+1)$
 - θ : has dimensions $(n+1, 1)$
 - \mathbf{z} : has dimensions $(m, 1)$
- The prediction 'h', is calculated by applying the sigmoid to each element in 'z': $h = \text{sigmoid}(z)$, and has dimensions $(m, 1)$.
- The cost function J is calculated by taking the dot product of the vectors 'y' and 'log(h)'. Since both 'y' and 'h' are column vectors $(m, 1)$, transpose the vector to the left, so that matrix multiplication of a row vector with column vector performs the dot product.

$$J = \frac{-1}{m} \times (\mathbf{y}^T \cdot \log(\mathbf{h}) + (\mathbf{1} - \mathbf{y})^T \cdot \log(\mathbf{1} - \mathbf{h}))$$

- The update of theta is also vectorized. Because the dimensions of \mathbf{x} are (m, n+1), and both \mathbf{h} and \mathbf{y} are (m, 1), we need to transpose the \mathbf{x} and place it on the left in order to perform matrix multiplication, which then yields the (n+1, 1) answer we need:

$$\theta = \theta - \frac{\alpha}{m} \times (\mathbf{x}^T \cdot (\mathbf{h} - \mathbf{y}))$$

Extracting the features:

- Given a list of tweets, extract the features and store them in a matrix. You will extract two features.
 - The first feature is the number of positive words in a tweet.
 - The second feature is the number of negative words in a tweet.
- Then train your logistic regression classifier on these features.
- Test the classifier on a validation set.

Implement the extract features function:

- This function takes in a single tweet.
- Process the tweet using the imported `process_tweet()` function and save the list of tweet words.
- Loop through each word in the list of processed words
 - For each word, check the `freqs` dictionary for the count when that word has a positive '1' label. (Check for the key (word, 1.0))
 - Do the same for the count for when the word is associated with the negative label '0'. (Check for the key (word, 0.0).)

Training The Model:

To train the model:

- Stack the features for all training examples into a matrix X .
- Call `gradientDescent`, which you've implemented above.

Test your logistic regression:

Predict whether a tweet is positive or negative.

- Given a tweet, process it, then extract the features.
- Apply the model's learned weights on the features to get the logits.
- Apply the sigmoid to the logits to get the prediction (a value between 0 and 1).

$$y_{pred} = \text{sigmoid}(\mathbf{x} \cdot \boldsymbol{\theta})$$

Check performance using the test set:

After training the model using the training set above, check how your model might perform on real, unseen data, by testing it against the test set.

Implement `test_logistic_regression`

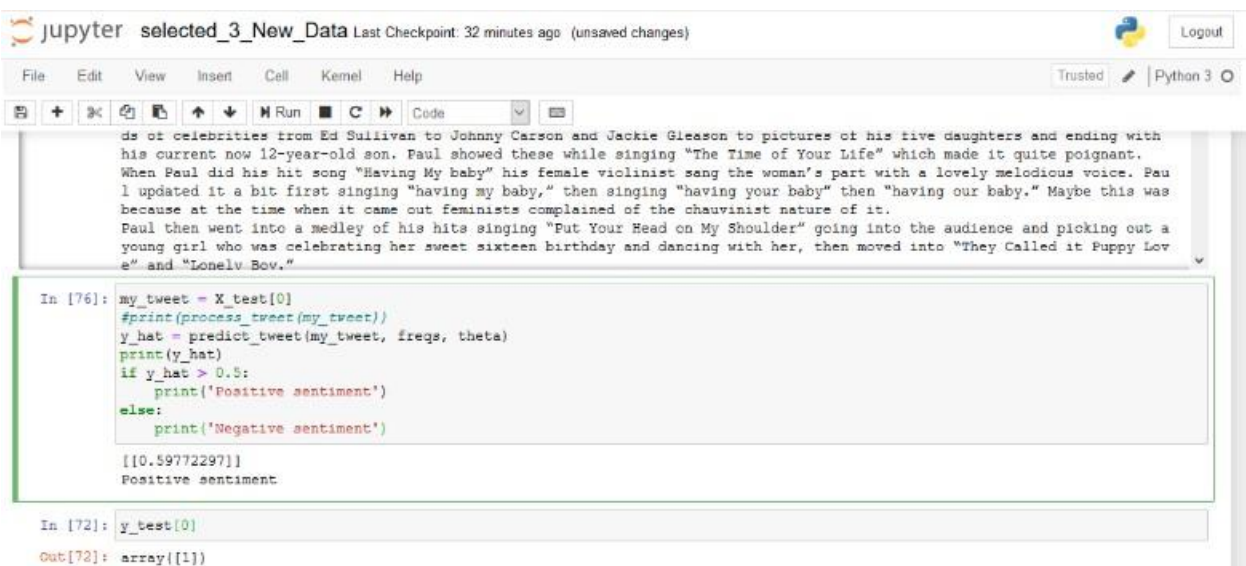
- Given the test data and the weights of your trained model, calculate the accuracy of your logistic regression model.
- Use your `predict_tweet()` function to make predictions on each tweet in the test set.
- If the prediction is > 0.5 , set the model's classification y_{hat} to 1, otherwise set the model's classification y_{hat} to 0.
- A prediction is accurate when y_{hat} equals test_y . Sum up all the instances when they are equal and divide by m .

Error Analysis:

In this phase a detection of misclassified news is occurred.

3) Experimental results:

Test the functionality of the model by figuring out if the news was actually predicted as true or not, in this case the model figured out that the news was true as it was in the data set



The screenshot shows a Jupyter Notebook window titled "selected_3_New_Data". The top bar includes the Jupyter logo, the title, and a "Last Checkpoint: 32 minutes ago (unsaved changes)" message. The interface has a menu bar (File, Edit, View, Insert, Cell, Kernel, Help) and a toolbar with icons for file operations, running, and code execution. The main area contains a text snippet and a code cell. The text snippet is a paragraph about Paul McCartney's song "The Time of Your Life". The code cell contains Python code for predicting sentiment from a tweet. The output of the code cell shows the predicted sentiment as "Positive sentiment".

```
ds of celebrities from Ed Sullivan to Johnny Carson and Jackie Gleason to pictures of his five daughters and ending with his current now 12-year-old son. Paul showed these while singing "The Time of Your Life" which made it quite poignant. When Paul did his hit song "Having My baby" his female violinist sang the woman's part with a lovely melodious voice. Paul updated it a bit first singing "having my baby," then singing "having your baby" then "having our baby." Maybe this was because at the time when it came out feminists complained of the chauvinist nature of it. Paul then went into a medley of his hits singing "Put Your Head on My Shoulder" going into the audience and picking out a young girl who was celebrating her sweet sixteen birthday and dancing with her, then moved into "They Called it Puppy Love" and "Lonely Boy."
```

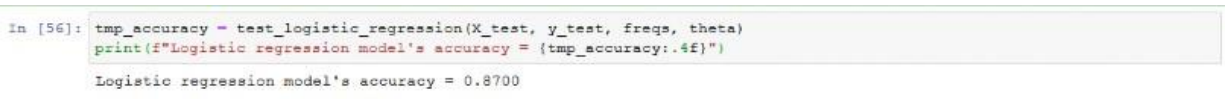
```
In [76]: my_tweet = X_test[0]
         #print(process_tweet(my_tweet))
         y_hat = predict_tweet(my_tweet, freqs, theta)
         print(y_hat)
         if y_hat > 0.5:
             print('Positive sentiment')
         else:
             print('Negative sentiment')

[[0.59772297]]
Positive sentiment
```

```
In [72]: y_test[0]
Out[72]: array([1])
```

4) Model performance:

The [accuracy](#) of the model:



The screenshot shows a Jupyter Notebook code cell with the following code and output:

```
In [56]: tmp_accuracy = test_logistic_regression(X_test, y_test, freqs, theta)
         print(f"Logistic regression model's accuracy = {tmp_accuracy:.4f}")

Logistic regression model's accuracy = 0.8700
```