Prediction of Stack Overflow Tag

NLP Custom Project

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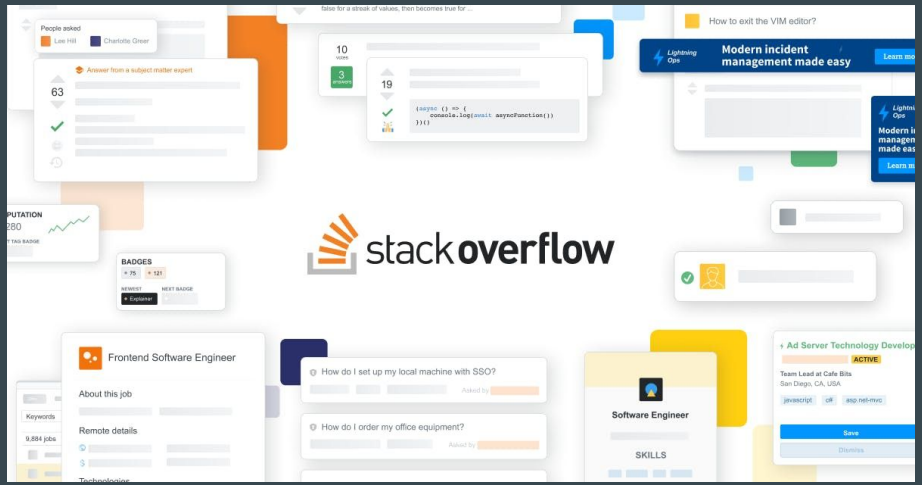
What is Stack Overflow?

Stack Overflow is a question and answer website for professional and enthusiast programmers.

The website serves as a platform for users to ask and answer questions, and, through membership and active participation, to vote questions and answers up or down similar to Reddit and edit questions and answers in a fashion similar to a wiki.



Motivation

I won't be lying if I assert that every developer/engineer/student has used the website Stack Overflow more than once in their journey. Widely considered as one of the largest and more trusted websites for developers to learn and share their knowledge, the website presently hosts in excess of 10,000,000 questions.

A tag is a word or phrase that describes the topic of the question. Tags are a means of connecting experts with questions they will be able to answer by sorting questions into specific, well-defined categories.

Spacy and Stopwords

- Stop words are those words in natural language that have a very little meaning, such as "is", "an", "the", etc.

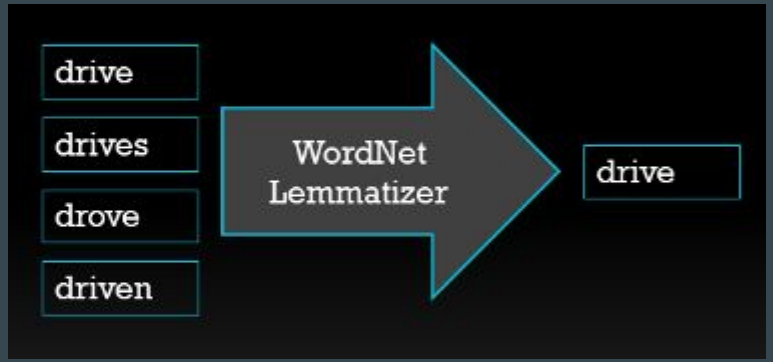
- Stop words are often removed from the text before training deep learning and machine learning models since stop words occur in abundance, hence providing little to no unique information that can be used for classification or clustering.

Spacy and Stopwords

- In Python, there are myriad of options to use in order to remove stop words. Some of the libraries are NLTK, SpaCy, Gensim, TextBlob.
- In this project, I used spaCy library.

Word Lemmatization

- Lemmatization is the process of converting a word to its base form.
- The difference between stemming and lemmatization is, lemmatization considers the context and converts the word to its meaningful base form, whereas stemming just removes the last few characters, often leading to incorrect meanings and spelling errors.
- In this project I used Wordnet Lemmatizer by NLTK



Sample Data

Question:

	Ids	OwnerUserId	CreationDate	ClosedDate	Score	Title	Body
0	80	26.0	2008-08-01T13:57:07Z	NaN	26	SQLStatement.execute() - multiple queries in o...	<p>I've written a database generation script i...
1	90	58.0	2008-08-01T14:41:24Z	2012-12-26T03:45:49Z	144	Good branching and merging tutorials for Torto...	<p>Are there any really good tutorials explain...
2	120	83.0	2008-08-01T15:50:08Z	NaN	21	ASP.NET Site Maps	<p>Has anyone got experience creating ...
3	180	2089740.0	2008-08-01T18:42:19Z	NaN	53	Function for creating color wheels	<p>This is something I've pseudo-solved many t...
4	260	91.0	2008-08-01T23:22:08Z	NaN	49	Adding scripting functionality to .NET applica...	<p>I have a little game written in C#. It uses...

Sample Data

Answers:

	Id	A_Score	A_Body
0	90	13	<p><a href="http://svnbook.red-bean.com/">Vers...
1	80	12	<p>I wound up using this. It is a kind of a ha...
2	180	1	<p>I've read somewhere the human eye can't dis...
3	260	4	<p>Yes, I thought about that, but I soon figur...
4	260	28	<p><a href="http://www.codeproject.com/Article...

Tags:

	Id	Tag
0	80	flex
1	80	actionscript-3
2	80	air
3	90	svn
4	90	tortoisesvn

Cleaning and Combining the dataset

	Title	Body	Tags
11	[how, to, get, the, value, of, built, encoded,...	I need to grab the base64-encoded representati...	c# asp.net
19	[can, i, logically, reorder, columns, in, a, t...	If I'm adding a column to a table in Microsoft...	sql-server
23	[convert, hashbytes, to, varchar]	I want to get the MD5 Hash of a string value i...	sql sql-server
34	[mysqlapache, error, in, php, mysql, query]	I am getting the following error:\n\n\n Acces...	php mysql
48	[the, difference, between, a, datagrid, and, a...	I've been doing ASP.NET development for a litt...	asp.net

TF-IDF Vectorization

- TF-IDF is an abbreviation for Term Frequency Inverse Document Frequency.
- It is used to convert a collection of raw documents to a matrix of TF-IDF features.
- It is the measure of originality of a word by comparing the number of times a word appears in a document with the number of documents it appears in.
- Here each question is considered as a document.

Categorical Encoding

- Few algorithms such as CATBOAST, decision-trees can handle categorical values very well but most of the algorithms expect numerical values to achieve state-of-the-art results.
- There are 2 main methods: One-Hot-Encoding and Label-Encoder
- In this project I used LabelEncoder method

Categorical Encoding

Label Encoding

Food Name	Categorical #	Calories
Apple	1	95
Chicken	2	231
Broccoli	3	50

One Hot Encoding

Apple	Chicken	Broccoli	Calories
1	0	0	95
0	1	0	231
0	0	1	50

Classifiers Used

- Logistic Regression
- XGB Classifier
- Multinomial Naive Bayes
- K-Nearest Neighbors(KNN)
- Random Forest Classifier

Logistic Regression

	precision	recall	f1-score	support
0	0.62	0.97	0.75	203
1	0.62	0.11	0.18	47
2	0.93	0.45	0.60	29
3	0.63	0.58	0.61	62
4	0.34	0.46	0.39	125
5	0.56	0.15	0.23	34
6	0.67	0.67	0.67	127
7	0.53	0.31	0.40	51
8	0.88	0.54	0.67	13
9	1.00	0.96	0.98	80
10	0.44	0.73	0.55	70
11	1.00	0.31	0.47	29
12	0.61	0.73	0.66	158
13	0.33	0.04	0.07	27
14	0.48	0.69	0.57	144
15	0.50	0.41	0.45	39
16	0.40	0.09	0.14	23
17	0.38	0.43	0.40	144
18	0.27	0.09	0.13	34
19	0.20	0.04	0.07	24
20	0.36	0.38	0.37	104
21	1.00	0.20	0.33	15
22	0.45	0.69	0.54	45
23	0.50	0.17	0.25	24
24	0.65	0.61	0.63	116
25	0.64	0.47	0.54	15
26	0.52	0.32	0.40	37
27	0.76	0.79	0.78	155
28	0.90	0.58	0.70	33
29	0.75	0.75	0.75	83
30	0.74	0.54	0.63	59
31	0.49	0.56	0.52	39
32	0.77	0.22	0.34	46
33	0.00	0.00	0.00	13
34	0.26	0.50	0.34	20
35	0.00	0.00	0.00	14
36	0.00	0.00	0.00	16
accuracy			0.57	2297
macro avg	0.55	0.42	0.44	2297
weighted avg	0.57	0.57	0.54	2297

XGB Classifier

	precision	recall	f1-score	support
0	0.65	0.88	0.75	203
1	0.51	0.40	0.45	47
2	0.68	0.45	0.54	29
3	0.58	0.48	0.53	62
4	0.32	0.52	0.39	125
5	0.45	0.26	0.33	34
6	0.65	0.65	0.65	127
7	0.45	0.33	0.38	51
8	0.90	0.69	0.78	13
9	0.96	0.95	0.96	80
10	0.48	0.60	0.53	70
11	0.65	0.45	0.53	29
12	0.62	0.64	0.63	158
13	0.25	0.07	0.11	27
14	0.49	0.66	0.56	144
15	0.47	0.44	0.45	39
16	0.15	0.09	0.11	23
17	0.49	0.36	0.41	144
18	0.08	0.03	0.04	34
19	0.33	0.17	0.22	24
20	0.41	0.44	0.43	104
21	0.89	0.53	0.67	15
22	0.45	0.67	0.54	45
23	0.33	0.17	0.22	24
24	0.60	0.56	0.58	116
25	0.42	0.53	0.47	15
26	0.50	0.27	0.35	37
27	0.79	0.79	0.79	155
28	0.96	0.73	0.83	33
29	0.79	0.80	0.79	83
30	0.74	0.63	0.68	59
31	0.44	0.51	0.48	39
32	0.38	0.20	0.26	46
33	0.40	0.15	0.22	13
34	0.32	0.50	0.39	20
35	0.33	0.21	0.26	14
36	0.89	0.50	0.64	16
accuracy			0.57	2297
macro avg	0.54	0.47	0.49	2297
weighted avg	0.56	0.57	0.55	2297

Multinomial Naive Bayes

	precision	recall	f1-score	support
0	0.14	1.00	0.25	203
1	0.00	0.00	0.00	47
2	0.00	0.00	0.00	29
3	1.00	0.02	0.03	62
4	0.60	0.02	0.05	125
5	0.00	0.00	0.00	34
6	0.72	0.49	0.58	127
7	0.00	0.00	0.00	51
8	0.00	0.00	0.00	13
9	1.00	0.79	0.88	80
10	0.45	0.56	0.50	70
11	0.00	0.00	0.00	29
12	0.57	0.44	0.50	158
13	0.00	0.00	0.00	27
14	0.32	0.69	0.44	144
15	0.00	0.00	0.00	39
16	0.00	0.00	0.00	23
17	0.32	0.17	0.22	144
18	0.00	0.00	0.00	34
19	0.00	0.00	0.00	24
20	0.33	0.01	0.02	104
21	0.00	0.00	0.00	15
22	0.29	0.04	0.08	45
23	0.00	0.00	0.00	24
24	0.86	0.05	0.10	116
25	0.00	0.00	0.00	15
26	0.00	0.00	0.00	37
27	0.70	0.59	0.64	155
28	0.00	0.00	0.00	33
29	1.00	0.10	0.18	83
30	0.00	0.00	0.00	59
31	0.00	0.00	0.00	39
32	0.00	0.00	0.00	46
33	0.00	0.00	0.00	13
34	0.00	0.00	0.00	20
35	0.00	0.00	0.00	14
36	0.00	0.00	0.00	16
accuracy			0.29	2297
macro avg	0.22	0.13	0.12	2297
weighted avg	0.39	0.29	0.24	2297

K-Nearest Neighbors(KNN)

	precision	recall	f1-score	support
0	0.48	0.81	0.60	203
1	0.07	0.09	0.08	47
2	0.29	0.34	0.32	29
3	0.27	0.44	0.34	62
4	0.09	0.70	0.16	125
5	0.33	0.03	0.05	34
6	0.69	0.34	0.46	127
7	0.52	0.22	0.31	51
8	0.78	0.54	0.64	13
9	0.95	0.90	0.92	80
10	0.36	0.36	0.36	70
11	1.00	0.24	0.39	29
12	0.49	0.22	0.31	158
13	0.11	0.04	0.06	27
14	0.44	0.22	0.30	144
15	0.38	0.13	0.19	39
16	0.33	0.04	0.08	23
17	0.26	0.10	0.15	144
18	0.38	0.09	0.14	34
19	0.00	0.00	0.00	24
20	0.27	0.09	0.13	104
21	1.00	0.07	0.12	15
22	0.29	0.24	0.27	45
23	0.00	0.00	0.00	24
24	0.48	0.09	0.16	116
25	0.32	0.67	0.43	15
26	0.00	0.00	0.00	37
27	0.75	0.37	0.50	155
28	1.00	0.12	0.22	33
29	0.86	0.23	0.36	83
30	0.63	0.20	0.31	59
31	0.30	0.21	0.24	39
32	0.29	0.04	0.08	46
33	0.00	0.00	0.00	13
34	0.17	0.05	0.08	20
35	1.00	0.07	0.13	14
36	0.00	0.00	0.00	16
accuracy			0.30	2297
macro avg	0.42	0.22	0.24	2297
weighted avg	0.45	0.30	0.30	2297

Random Forest Classifier

	precision	recall	f1-score	support
0	0.09	1.00	0.17	203
1	0.00	0.00	0.00	47
2	0.00	0.00	0.00	29
3	0.00	0.00	0.00	62
4	0.00	0.00	0.00	125
5	0.00	0.00	0.00	34
6	1.00	0.07	0.13	127
7	0.00	0.00	0.00	51
8	0.00	0.00	0.00	13
9	1.00	0.31	0.48	80
10	0.60	0.09	0.15	70
11	0.00	0.00	0.00	29
12	0.00	0.00	0.00	158
13	0.00	0.00	0.00	27
14	0.38	0.02	0.04	144
15	0.00	0.00	0.00	39
16	0.00	0.00	0.00	23
17	0.00	0.00	0.00	144
18	0.00	0.00	0.00	34
19	0.00	0.00	0.00	24
20	0.00	0.00	0.00	104
21	0.00	0.00	0.00	15
22	0.00	0.00	0.00	45
23	0.00	0.00	0.00	24
24	0.00	0.00	0.00	116
25	0.00	0.00	0.00	15
26	0.00	0.00	0.00	37
27	0.92	0.08	0.14	155
28	0.00	0.00	0.00	33
29	0.00	0.00	0.00	83
30	0.00	0.00	0.00	59
31	0.00	0.00	0.00	39
32	0.00	0.00	0.00	46
33	0.00	0.00	0.00	13
34	0.00	0.00	0.00	20
35	0.00	0.00	0.00	14
36	0.00	0.00	0.00	16
accuracy			0.11	2297
macro avg	0.11	0.04	0.03	2297
weighted avg	0.20	0.11	0.06	2297

Accuracy/F1 Score

Logistic Regression	0.54
XGB Classifier	0.57
Multinomial Naive Bayes	0.29
K-Nearest Neighbors(KNN)	0.30
Random Forest Classifier	0.1

Thank you