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M/BLOG/CATEGORY/MACHINE-LEARNING/)

TEGORY/PYTHON-2/)

tion problems (Case studies included)

/BLOG/AUTHOR/SHUBHAM-JAIN/), AUGUST 26, 2017

Fer some reason, Regression and Classification problems end up taking most of the attention in machine
learning world. People don't realize the wide variety of machine learning problems which can exist.
(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+CVDL101+CVDL101_T1/about?

utm_source=CV101AVBlogBanner&utm_medium=Stickybanner2utm_campaign=CV101banner)
I, on the other hand, love exploring different variety of problems and sharing my learning with the community
here.

Previously, I shared my learnings on Genetic algorithms with the community
(https://www.analyticsvidhya.com/blog/2017/07/introduction-to-genetic-algorithm/). Continuing on with my
search, I intend to cover a topic which has much less widespread but a nagging problem in the data science
community – which is multi-label classification.

In this article, I will give you an intuitive explanation of what multi-label classification entails, along with
illustration of how to solve the problem. I hope it will show you the horizon of what data science
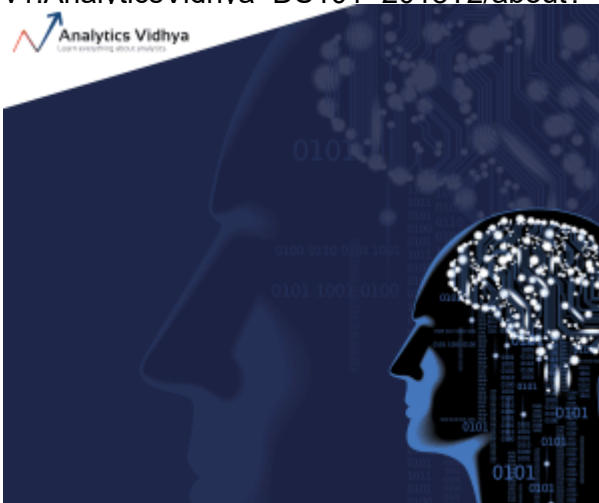encompasses. So lets get on with it!

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What is Multi-Label Classification?

(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+CVDL101+CVDL101_T1/about?
utm_source=CV101AVBlogBanner&utm_medium=Stickybanner2utm_campaign=CV101banner)

What if I ask you that does this image contains a house? The option will be **YES** or **NO**.

Consider another case, like what all things (or labels) are relevant to this picture?

House	Tree	Beach	Cloud	Mountain	Animal
Yes	Yes	no	Yes	no	no

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These types of problems, where we have a set of target variables, are known as **multi-label classification** problems. So, is there any difference between these two cases? Clearly, yes because in the second case any image may contain a different set of these multiple labels for different images.

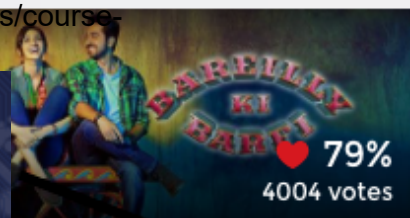But before going deep into multi-label, I just wanted to clear one thing as many of you might be confused that ~~...~~ em.

~~...~~ etween these two sets of problems.

~~...~~ ence between these two. For this, I hope that below image ~~...~~ nd it.

(https://trainings.analyticsvidhya.com/courses/course-v1:AnalyticsVidhya+DS101+2018T2/about?

(https://trainings.analyticsvidhya.com/courses/course-v1:AnalyticsVidhya+CVDL101+CVDL101_T1/about?
For any movie, Central Board of Film Certification, issue a certificate depending on the contents of the movie.
utm_source=CV101AVBlogBanner&utm_medium=Stickybanner2utm_campaign=CV101banner)

For example, if you look above, this movie has been rated as **'U/A'** (meaning 'Parental Guidance for children below the age of 12 years') certificate. There are other types of certificates classes like **'A'** (Restricted to adults) or **'U'** (Unrestricted Public Exhibition), but it is sure that each movie can only be categorized with only one out of those three type of certificates.

In short, there are multiple categories but each instance is assigned only one, therefore such problems are known as **multi-class classification** problem.

Again, if you look back at the image, this movie has been categorized into comedy and romance genre. But there is a difference that this time each movie could fall into one or more different sets of categories.

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Therefore, each instance can be assigned with multiple categories, so these types of problems are known as **multi-label classification** problem, where we have a set of target labels.

Great! Now you can distinguish between a multi-label and multi-class problem. So, let's start how to deal with these types of problems.
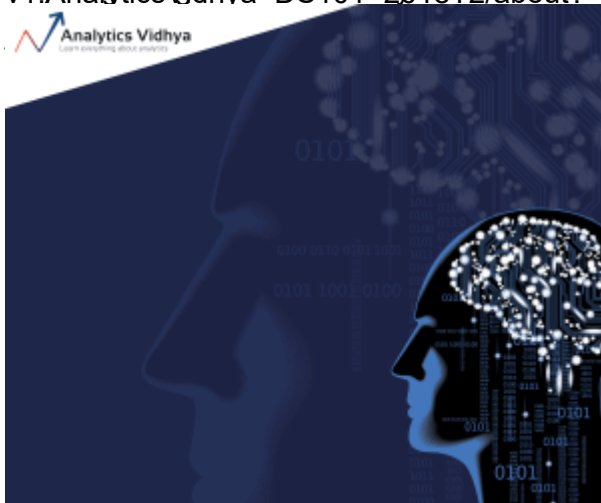
...bel Datasets

...cikit-multilearn (http://scikit.ml/api/datasets.html) for multi label

...g on a multi-label dataset. You can find a real-world data set ...net/datasets-mlc.html) provided by MULAN package. These

(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+DS101+2018T2/about?

So for getting started with any of these datasets, look at the python code below for loading it onto your ... the yeast data set from the repository.

```
...rs/shubhamjain/Documents/yeast/yeast-train.arff')
```

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	Att1	Att2	Att3	Att4	Att5	Att6	Att7	Att8	Att9	Att10	...	Class5	Class6	Class7	Class8	Class9	Cla
0	0.093700	0.139771	0.062774	0.007698	0.083873	-0.119156	0.073305	0.005510	0.027523	0.043477	...	b'0'	b'0'	b'0'	b'0'	b'0'	
1	-0.022711	-0.050504	-0.035691	-0.065434	-0.084516	-0.378560	0.038212	0.085770	0.182613	-0.055544	...	b'0'	b'0'	b'1'	b'1'	b'0'	
2	-0.090407	0.021198	0.208712	0.102752	0.119315	0.041729	-0.021728	0.019603	-0.063853	-0.053756	...	b'0'	b'0'	b'0'	b'0'	b'0'	
3	-0.085235	0.009540	-0.013228	0.094063	-0.013592	-0.030719	-0.116062	-0.131674	-0.165448	-0.123053	...	b'0'	b'0'	b'0'	b'0'	b'0'	
4	-0.088765	-0.026743	0.002075	-0.043819	-0.005465	0.004306	-0.055865	-0.071484	-0.159025	-0.111348	...	b'0'	b'0'	b'0'	b'0'	b'0'	

5 rows × 117 columns

Here, **Att** represents the attributes or the independent variables and **Class** represents the target variables.

For practice purpose, we have another option to generate an artificial multi-label dataset.

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```
from sklearn.datasets import make_multilabel_classification


# this will generate a random multi-label dataset
X, y = make_multilabel_classification(sparse = True, n_labels = 20,
                                                     ...led = False)
```

...e.

...re sparse matrix means a matrix having a large number of zero

...each instance.

return_indicator: If 'sparse' return Y in the sparse binary indicator format.

...ght not belong to any class.

...arse matrix everywhere, and scikit-multilearn also recommends
...ery rare for a real-world data set to be dense. Generally, the
...s very less.

...us quickly learn the techniques to solve a multi-label problem.

4. Techniques for Solving a Multi-Label classification problem

Basically, there are three methods to solve a multi-label classification problem, namely:

1. Problem Transformation
2. Adapted Algorithm
3. Ensemble approaches

4.1 Problem Transformation

In this method, we will try to transform our multi-label problem into single-label problem(s).

This method can be carried out in three different ways as:

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1. Binary Relevance
2. Classifier Chains
3. Label Powerset

4.1.1 Binary Relevance

y treats each label as a separate single class classification

below. We have the data set like this, where X is the
riable.

	Y_1	Y_2	Y_3	Y_4
	0	1	1	0
	1	0	0	0
	0	1	0	0
	1	0	0	1
	0	0	0	1

(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+DS101+2018T2/about?

to 4 different single class classification problems as shown in the

X	Y_2	X	Y_3	X	Y_4
$x^{(1)}$	1	$x^{(1)}$	1	$x^{(1)}$	0
$x^{(2)}$	0	$x^{(2)}$	0	$x^{(2)}$	0
$x^{(3)}$	1	$x^{(3)}$	0	$x^{(3)}$	0
$x^{(4)}$	0	$x^{(4)}$	0	$x^{(4)}$	1
$x^{(5)}$	0	$x^{(5)}$	0	$x^{(5)}$	1

(https://trainings.analyticsvidhya.com/courses/course-
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We don't have to do this manually, the multi-learn library provides its implementation in python. So, let's us quickly look at its implementation on the randomly generated data.

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```
# using binary relevance
from skmultilearn.problem_transform import BinaryRelevance
from sklearn.naive_bayes import GaussianNB
```

classifier

ifier

)

(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+DS101+2018T2/about?   orithm but you can use any other classification algorithm.

e can't simply use our normal metrics to calculate the accuracy
se **accuracy score** metric. This function calculates subset
should exactly match with the true set of labels.

tions.

e

(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+CVDL101+CVDL101_T1/about?
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So, we have attained an accuracy score of **45%**, which is not too bad. Let's us quickly look at its pros and
cons.

It is most simple and efficient method but the only drawback of this method is that it doesn't consider labels
correlation because it treats every target variable independently.

4.1.2 Classifier Chains

In this, the first classifier is trained just on the input data and then each next classifier is trained on the input
space and all the previous classifiers in the chain.

Let's try to this understand this by an example. In the dataset given below, we have X as the input space and
Y's as the labels.

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X	y1	y2	y3	y4
x1	0	1	1	0
x2	1	0	0	0
x3	0	1	0	0

...nsformed into 4 different single label problems, just like shown ... and the white part represent the target variable.

X	y1	y2	y3
x1	0	1	1
x2	1	0	0
x3	0	1	0

Classifier 3

X	y1	y2	y3	y4
x1	0	1	1	0
x2	1	0	0	0
x3	0	1	0	0

Classifier 4

This is quite similar to binary relevance, the only difference being it forms chains in order to preserve label correlation. So, let's try to implement this using multi-learn library.

(https://trainings.analyticsvidhya.com/courses/course-v1:AnalyticsVidhya+DS101+201812/about?

```
... ClassifierChain
NB

l classifier
fier
)

# train
classifier.fit(X_train, y_train)
```

(https://trainings.analyticsvidhya.com/courses/course-v1:AnalyticsVidhya+CVDL101+CVDL101_T1/about?
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```
# predict

predictions = classifier.predict(X_test)


accuracy_score(y_test,predictions)
```

```
0.21212121212121213
```

We can see that using this we obtained an accuracy of about **21%**, which is very less than binary relevance. This is maybe due to the absence of label correlation since we have randomly generated the data.

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4.1.3 Label Powerset

In this, we transform the problem into a multi-class problem with one multi-class classifier is trained on all unique label combinations found in the training data.

	y1	y2	y3	y4
0	0	1	1	0
1	1	0	0	0
0	0	1	0	0
0	0	1	1	0
1	1	1	1	1
0	0	1	0	0

(https://trainings.analyticsvidhya.com/courses/course-v1:AnalyticsVidhya+DS101+2018T2/about?

labels, similarly, x3 and x6 have the same set of labels. So, single multi-class problem as shown below.

X	y1
x1	1
x2	2
x3	3
x4	1
x5	4
x6	3

(https://trainings.analyticsvidhya.com/courses/course-v1:AnalyticsVidhya+CVDL101+CVDL101_T1/about?
So, label powerset has given a unique class to every possible label combination that is present in the training utm_source=CV101AVBlogBanner&utm_medium=Stickybanner2utm_campaign=CV101banner)
set.

Let's us look at its implementation in python.

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```
# using Label Powerset

from skmultilearn.problem_transform import LabelPowerset

from sklearn.naive_bayes import GaussianNB
```


classifier

ifier

(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+DS101+2018T2/about?

the three we have discussed till now. The only disadvantage of
mber of classes become more. Thus, increasing the model
acy.

e multi-label classification problem.

(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+CVDL101+CVDL101_T1/about?
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4.2 Adapted Algorithm

Adapted algorithm, as the name suggests, adapting the algorithm to directly perform multi-label classification, rather than transforming the problem into different subsets of problems.

For example, multi-label version of kNN is represented by MLkNN. So, let us quickly implement this on our randomly generated data set.

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```
from skmultilearn.adapt import MLkNN


classifier = MLkNN(k=20)
```

0.69
(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+DS101+2018T2/about?
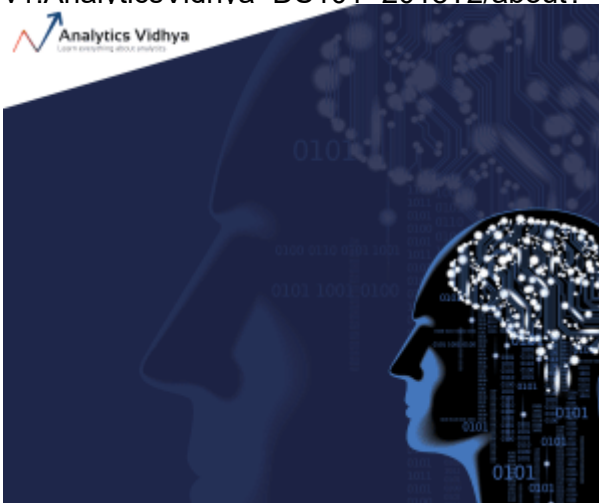
of **69%** on your test data.

abel classification in some of the algorithm like Random Forest
ll them and predict the output.

cikit.ml/api/api/skmultilearn.adapt.html#module-
about other types of adapted algorithm.

(https://trainings.analyticsvidhya.com/courses/course-

4.3 Ensemble Approaches
v1:AnalyticsVidhya+CVDL101+CVDL101_T1/about?
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Ensemble always produces better results. Scikit-Multilearn library provides different ensembling classification
functions, which you can use for obtaining better results.

For the direct implementation, you can check out here (http://scikit.ml/api/classify.html#ensemble-
approaches).

5. Case Studies

Multi-label classification problems are very common in the real world. So, let us look at some of the areas
where we can find the use of them.

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1. Audio Categorization

We have already seen songs being classified into different genres. They are also been classified on the basis of emotions or moods like "relaxing-calm", or "sad-lonely" etc.

(https://trainings.analyticsvidhya.com/courses/course-
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s/tsoumakas-ismir08.pdf)

a wide range of applications. Images can be labeled to indicate

may contain: two people, smiling, sses, sky, outdoor, water

(https://trainings.analyticsvidhya.com/courses/course-
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Multi-Label classification has a lot of use in the field of bioinformatics, for example, classification of genes in the yeast data set

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It is also used to predict multiple functions of proteins using several unlabeled proteins. You can check this paper (https://cs.gmu.edu/~carlotta/publications/TCBB13.pdf) for more information.

4. Text Categorization

You all must once check out google news. So, what google news does is, it labels every news to one or more categories such that it is displayed under different categories. For example, take a look at the image below.

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Technology ⟶ Label

Reliance Jio's another wave of disruption sends rivals scurrying for safety

Economic Times · 1h ago

RELATED COVERAGE

Jio Phone specifications

India

s Paused After 'Millions' Pre-Book a Unit

pre-bookings suspended, register your interest for the phone now

Times, India Edition · 1h ago

→

ge source: Google news

ction/topic/TECHNOLOGY.en_in/Technology?ned=in&hl=en-IN)

ies of India, Technology, Latest etc. because it has been classified into these different labels. Thus making it a multi label classification problem.

(https://trainings.analyticsvidhya.com/courses/course-
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nd comment down below if you wish to share it with the

of multi-label classification problems. I have also covered the
ctical use cases where you may have to handle it using multi-

hen you face these kinds of problems. If you have any
me below!

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v1:AnalyticsVidhya+CVDL101+CVDL101_T1/about?
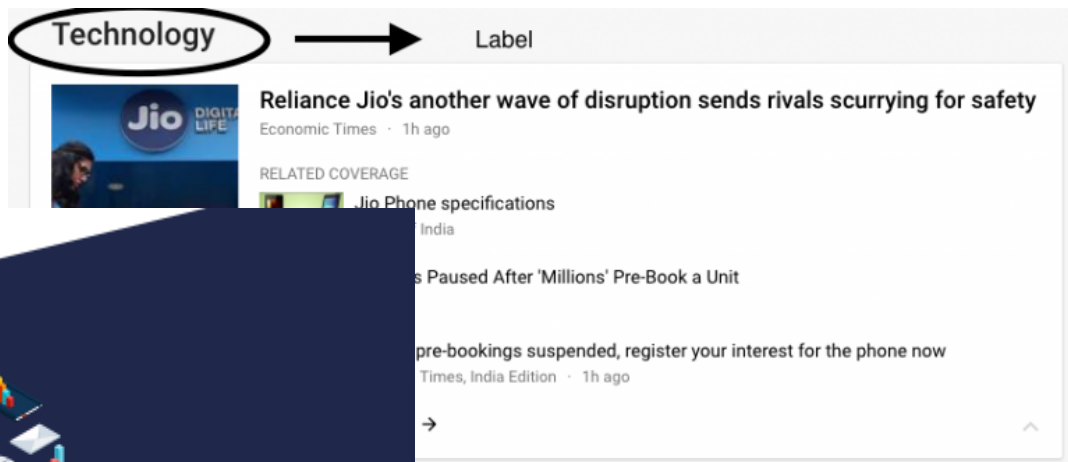utm_source=CV101AVBlogBanner&utm_medium=Stickybanner2ut   banner)

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N (HTTPS://WWW.ANALYTICSVIDHYA.COM/BLOG/TAG/CASE-STUDIES-OF-

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jain/)

Shubham Jain
(Https://Www.Analyticsvidhya.Com/Blog/Author/Shubham-Jain/)

I am currently pursing my B.Tech in Ceramic Engineering from IIT (B.H.U) Varanasi. I am an aspiring
data scientist and a ML enthusiast. I am really passionate about changing the world by using artificial

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intelligence.

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in (https://www.linkedin.com/in/shubham-jain-25a104108/)

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social-media-analysis/)

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m/blog/2016/11/building-a-
machine-learning-deep-learning-
workstation-for-under-5000/)

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boosting-gbm-python/)

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Getting to know CapsuleNets
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(https://www.analyticsvidhya.co
m/blog/2018/04/essentials-of-
deep-learning-getting-to-know-
capsulenets/)

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m/blog/2017/12/15-data-science-
repositories-github-2017/)

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(https://www.analyticsvidhya.co
m/blog/2016/02/complete-guide-
parameter-tuning-gradient-
boosting-gbm-python/)

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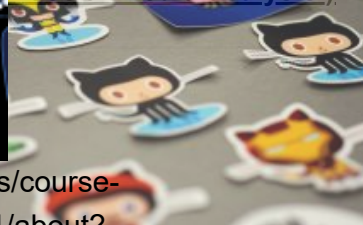
21 COMMENTS

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HEMANTHKUMAR E   **Reply**

August 28, 2017 at 10:49 am (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-classification/#comment-135304)

Hi, Shubham great article.

... lem is transformed to single multi class problem you have drawn
... you got the values in y1 column. Can you explain?

... e great knowledge in ML. Great!!

                                                                                                      Reply

...alyticsvidhya.com/blog/2017/08/introduction-to-multi-label-

...of labels has been a separate category. Thus, transforming it
... multi-class problem. For example, in the above problem:
x1 and x4 have the same set of labels about they are given same class. Further x3 and x6 also have the same
... all the other are unique, so they are given different classes.

                                                                                                      Reply

...y.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-

Dear Shubham,
Can you please tell me the step by step procedure for extracting features from text, extracting features from
audio and extracting features from video for sentiment analysis. Its very useful for my research please.

SAHAR   **Reply**

August 28, 2017 at 2:29 pm (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-classification/#comment-135322)

Thank you, Shubham, for making this concept so easy for us to understand.

I just have a suggestion: could you please include your code sufficiently so that we could quickly copy/paste it
and see the result ? For example, your are using 'X_train' and 'y_train', but haven't defined them. Or, some
"import"s are missing.
It also took me a while to install skmultilearn. It would have been useful if you would had given a quick hint.

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Many thanks once more.

SHUBHAM JAIN   **Reply**

August 30, 2017 at 9:38 am (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-

ain' and 'y_train' are formed by using the train_test_split method

p install scikit-multilearn' on the terminal.

issed out and I will definitely take care of this next time.

(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+DS101+2018T2/about?   **Reply**

nalyticsvidhya.com/blog/2017/08/introduction-to-multi-label-

an you explain a bit in case of text multi-label classification,

to converts raw input (string) to test/train data?

GUNJAN JHAWAR   **Reply**

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August 30, 2017 at 7:58 am (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-
classification/#comment-135556)

Great article. Fun to read.

STÉPHANE   **Reply**

August 31, 2017 at 10:52 pm (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-
classification/#comment-135864)

Great article and very applied. thanks mate !

MARCO   Subscribe! **Reply**

September 5, 2017 at 7:43 pm (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-classification/#comment-136445)

Hi

phamjain/Documents/yeast/yeast-train.arff')

Reply

ww.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-classification/#comment-137437)

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n be further split into train and test data for modelling purposes.

Reply

ww.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-

Reply

September 26, 2017 at 7:58 am (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-classification/#comment-138018)

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utm_source=CV101AVBlogBanner&utm_medium=Stickybanner2utm_campaign=CV101banner)

Hi,

Nice tutorial. Do you have any suggestion to get class data and its associated attributes stored in a mysql table into the form as the yeast datasets (atr1 ,atr2 … arN … class1, class2 … class N) ?

SUSAN ABRAHAM

Reply

October 2, 2017 at 9:35 pm (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-classification/#comment-138511)

Hi ,

This article is nice , would like to know what will be the output if an new instance is given what will be the predicted labels?

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ELLERY (HTTPS://GITHUB.COM/ALUCARD001)   **Reply**

October 3, 2017 at 2:38 pm (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-classification/#comment-138585)

st to Chinese here: https://github.com/alucard001/Solving-Multi-
com/alucard001/Solving-Multi-Label-Classification-problems).

Reply

October 4, 2017 at 4:09 pm (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-

(https://trainings.analyticsvidhya.com/courses/course-
v1:AnalyticsVidhya+DS101+2018T2/about?

handling multi-target variables on regression problems

Reply

.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-

Thanks/for your great tutorial.
I have a dataset of a multi-label class problem. I want to know the number of classes Label Powerset will make.
Please tell me how I am doing this.

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v1:AnalyticsVidhya+CVDL101+CVDL101_T1/about?
utm_source=AVBlog&utm_medium=Stickybanner2utm_campaign=CV101banner)

USMAN HAIDER   **Reply**

November 8, 2017 at 3:04 pm (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-classification/#comment-142730)

Hi Shubham Jain,
Awesome tutorial. I'm working on a multi-label classification model and I'm using Label Power Set. I have used your code but when I call 'fit()' method I get following error.
[[[TypeError: no supported conversion for types: (dtype('O'),)]]]]

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I haven't used any column with dtype (string/object). All the columns are either category,int,float. Can you help me with this?

My total target labels are Y (1,2,3,4,5,6). Total 6 unique columns

Reply

.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-

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analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-

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Reply

lyticsvidhya.com/blog/2017/08/introduction-to-multi-label-

en link for Mulan package is not working it's showing error: "503

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v1:AnalyticsVidhya+CVDL101_T1/about?
utm_source=CVDLAVBlogBanner&utm_medium=Stickybanner2&utm_campaign=CVDLBanner)

AISHWARYA SINGH

Reply

May 18, 2018 at 8:08 pm (https://www.analyticsvidhya.com/blog/2017/08/introduction-to-multi-label-
classification/#comment-153374)

Hi,

The link works fine for me. You can access the dataset from **here (http://mulan.sourceforge.net/datasets-mlc.html)**.

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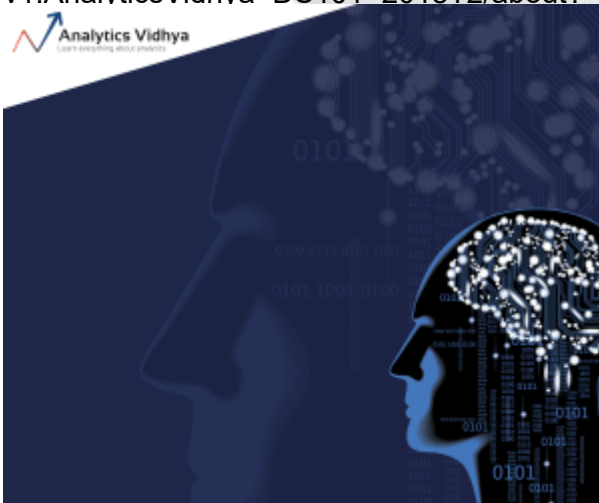
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