

Machine Learning

**1D and 2D partial dependent plots with RandomForestClassifier and
DecisionTreeClassifier**

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1. Partial Dependence Plots

- Uses

shows how features affect prediction

calculated after the model has been fit

```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.tree import DecisionTreeClassifier

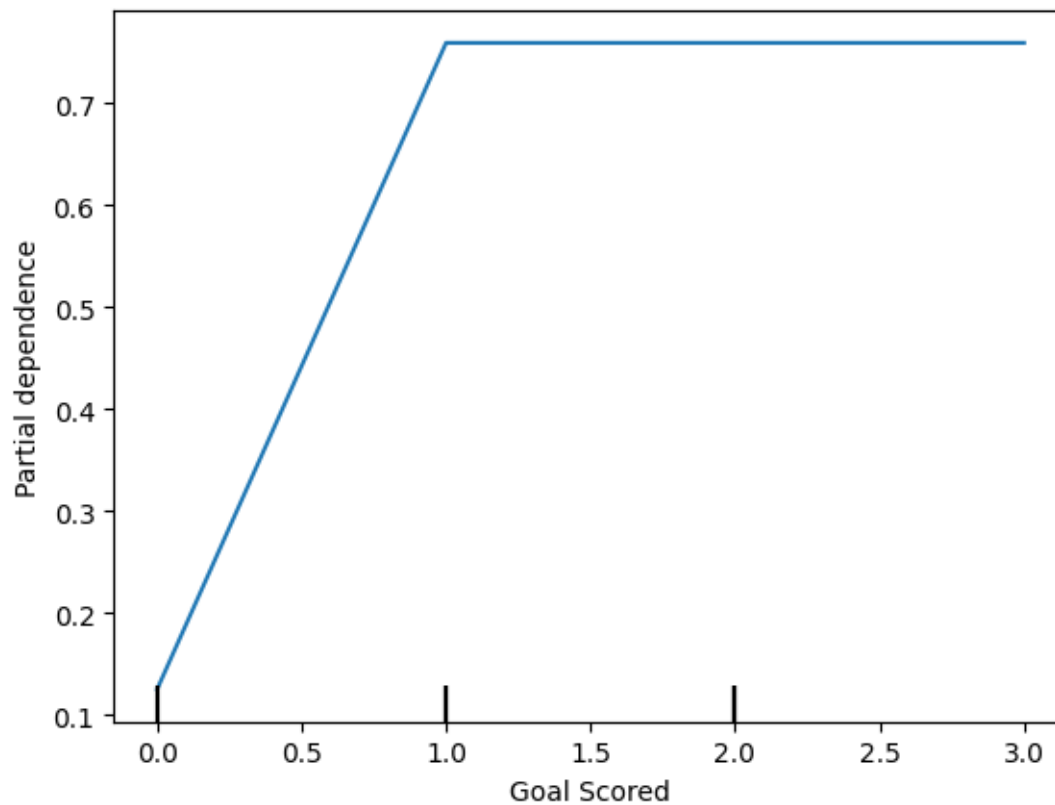
data = pd.read_csv('FIFA 2018 Statistics.csv')
y = (data['Man of the Match'] == "Yes") # Convert from string "Yes"/"No" to binary
feature_names = [i for i in data.columns if data[i].dtype in [np.int64]]
X = data[feature_names]
train_X, val_X, train_y, val_y = train_test_split(X, y, random_state=1)
tree_model = DecisionTreeClassifier(random_state=0, max_depth=5, min_samples_split=5).fit(

from sklearn import tree
import graphviz

tree_graph = tree.export_graphviz(tree_model, out_file = None, feature_names = feature_names,
graphviz.Source(tree_graph)

from matplotlib import pyplot as plt
from sklearn.inspection import PartialDependenceDisplay

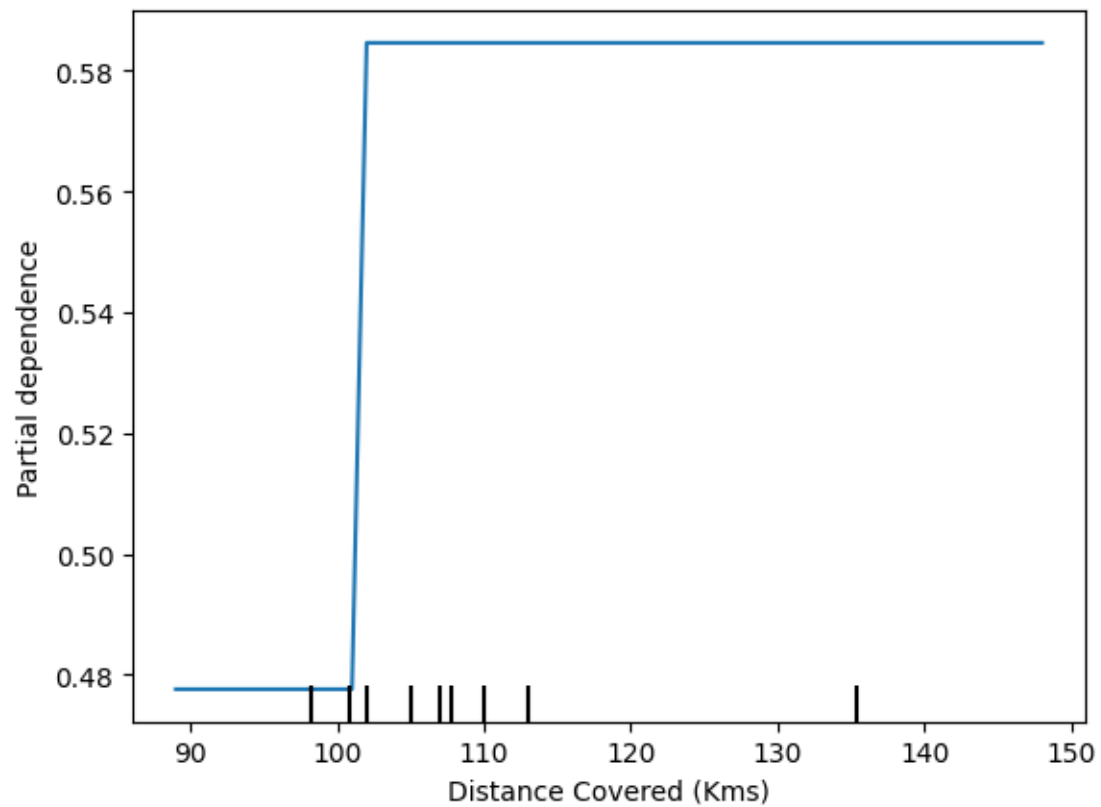
#create plot
disp1 = PartialDependenceDisplay.from_estimator(tree_model, val_X, ['Goal Scored'])
plt.show()
```



- Inference from graph-
scoring a goal makes a person 'Man of the match'
But extra goal seems to have no impact.

```
feature_to_plot = 'Distance Covered (Kms)'
```

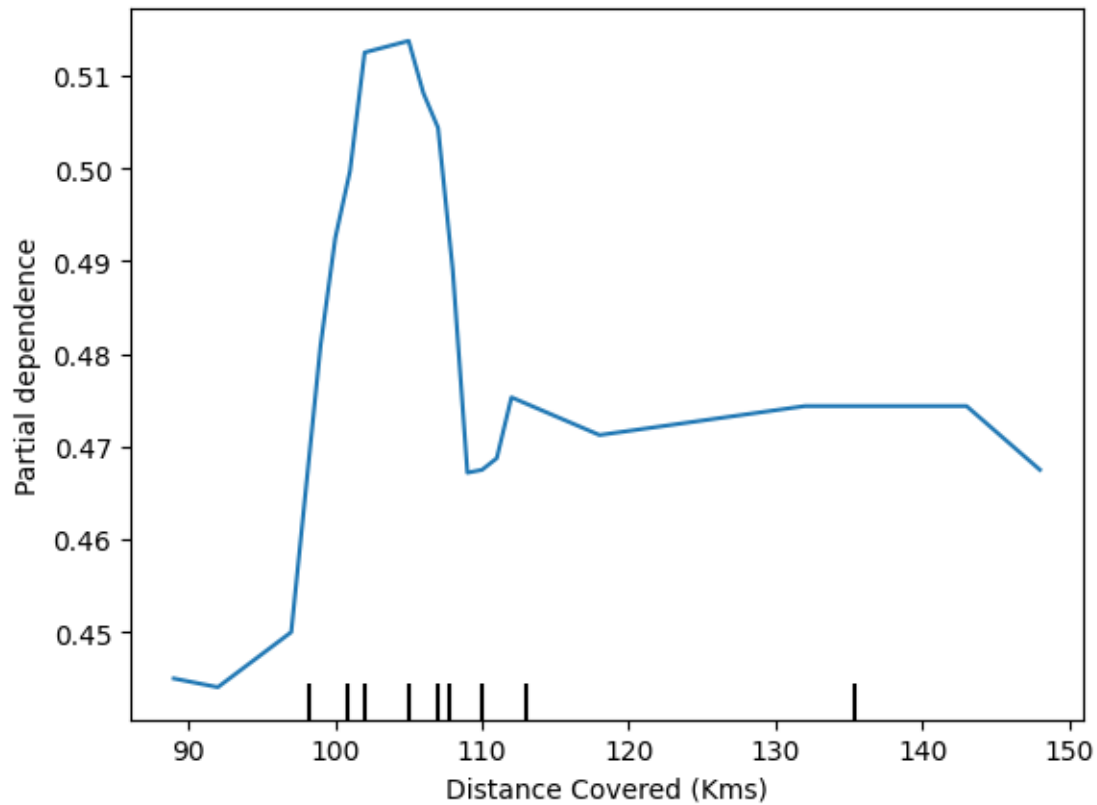
```
disp2 = PartialDependenceDisplay.from_estimator (tree_model, val_X, [feature_to_plot])  
plt.show()
```



```
# same plot with Random_forest

rf_model = RandomForestClassifier(random_state = 0).fit(train_X, train_y)

disp3 = PartialDependenceDisplay.from_estimator(rf_model, val_X, [feature_to_plot])
plt.show()
```



- Inference

The above graphs feature that if a player covers 100 kms, he becomes ‘Man of the match’

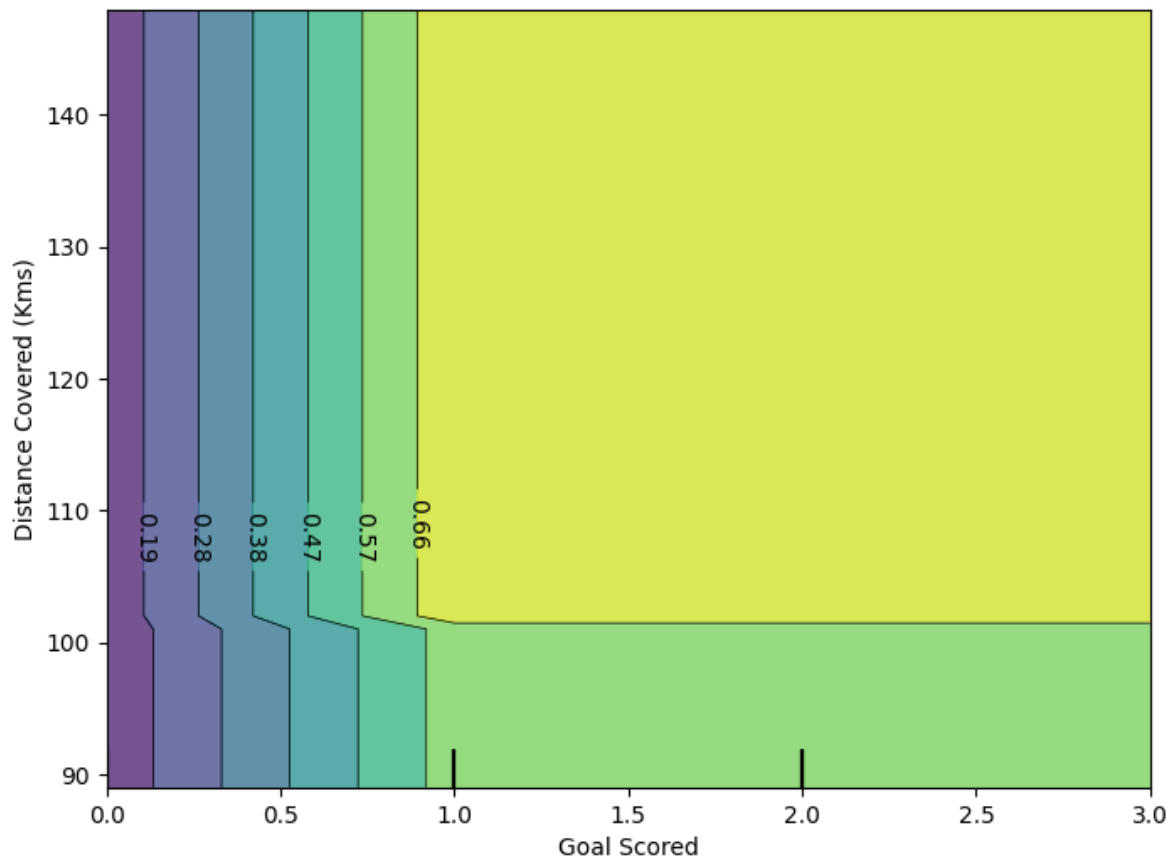
1st model- DecisionTreeClassifier

2nd model - RandomForestClassifier

2. 2D Partial Dependence Plots

```
fig, ax = plt.subplots(figsize = (8,6))
f_names = [{"Goal Scored", "Distance Covered (Kms)"}]

# similar to previous, except use tuple features
disp4 = PartialDependenceDisplay.from_estimator(tree_model, val_X, f_names, ax = ax)
plt.show()
```



3. Practice exercise

```
# import libraries
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import RandomForestRegressor
from matplotlib import pyplot as plt
from sklearn.inspection import PartialDependenceDisplay

# load data
data2 = pd.read_csv('train.csv')

# Remove data with extreme outlier coordinates or negative fares
data2 = data2.query('pickup_latitude > 40.7 and pickup_latitude < 40.8 and ' +
                    'dropoff_latitude > 40.7 and dropoff_latitude < 40.8 and ' +
                    'pickup_longitude > -74 and pickup_longitude < -73.9 and ' +
                    'dropoff_longitude > -74 and dropoff_longitude < -73.9 and ' +
```

```

        'fare_amount > 0'
    )

y = data2.fare_amount

base_features = ['pickup_longitude',
                 'pickup_latitude',
                 'dropoff_longitude',
                 'dropoff_latitude']

X = data2[base_features]

# train the model
train_X, val_X, train_y, val_y = train_test_split(X, y, random_state=1)
first_model = RandomForestRegressor(n_estimators=30, random_state=1).fit(train_X, train_y)
print("Data sample:")
data2.head()

```

Data sample:

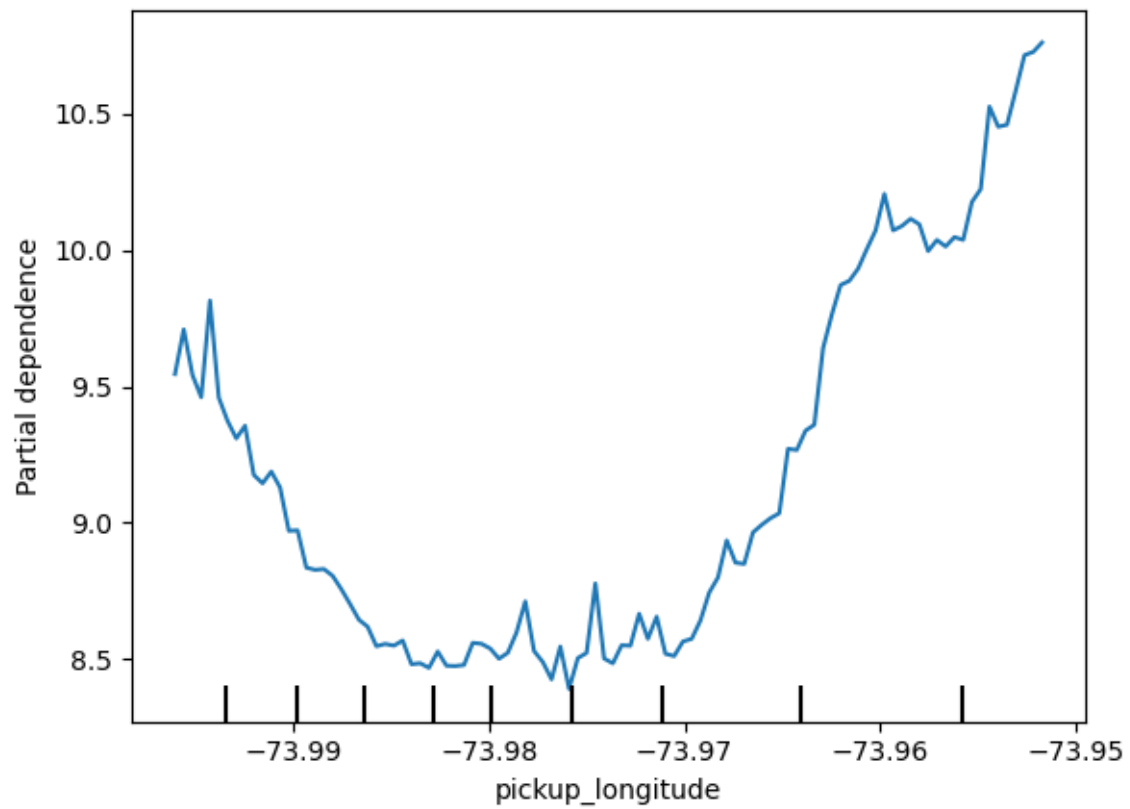
	key	fare_amount	pickup_datetime	pickup_longitude	pickup_latitude
2	2011-08-18 00:35:00.000000049	5.7	2011-08-18 00:35:00 UTC	-73.982738	40.761270
3	2012-04-21 04:30:42.00000001	7.7	2012-04-21 04:30:42 UTC	-73.987130	40.733143
4	2010-03-09 07:51:00.000000135	5.3	2010-03-09 07:51:00 UTC	-73.968095	40.768008
6	2012-11-20 20:35:00.00000001	7.5	2012-11-20 20:35:00 UTC	-73.980002	40.751662
7	2012-01-04 17:22:00.000000081	16.5	2012-01-04 17:22:00 UTC	-73.951300	40.774138

```

feature_name = 'pickup_longitude'

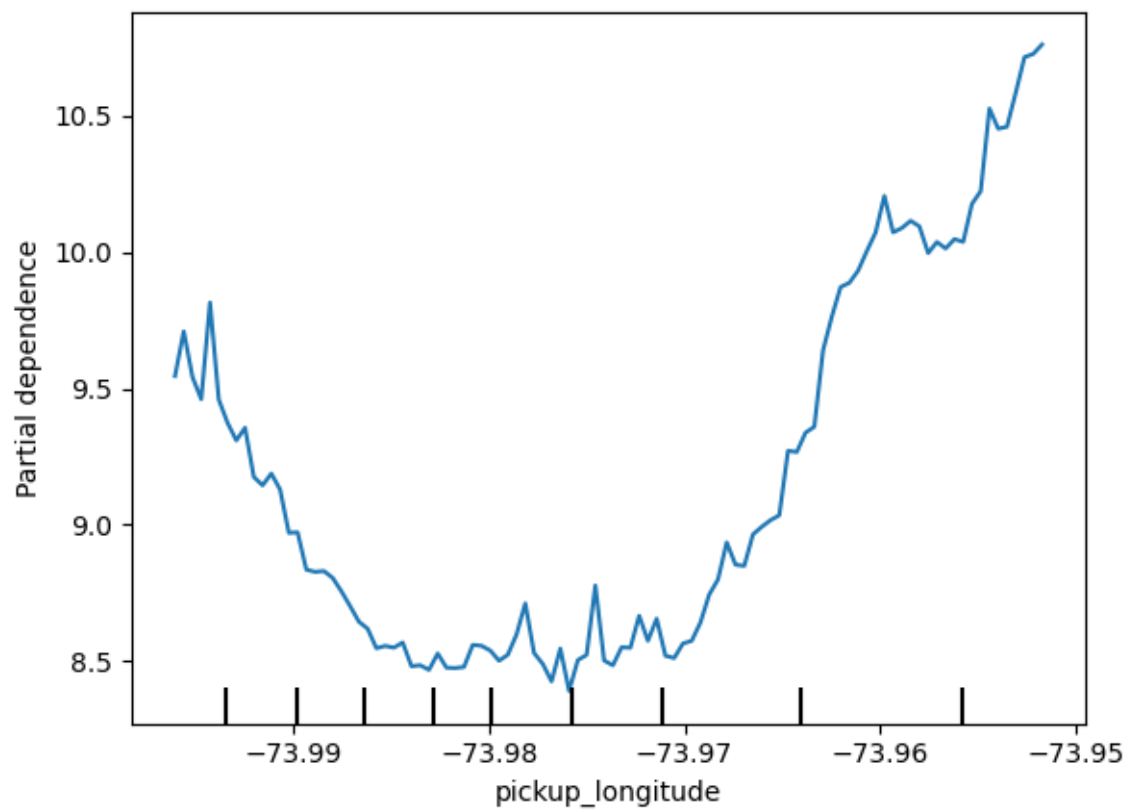
PartialDependenceDisplay.from_estimator (first_model, val_X, [feature_name])
plt.show()

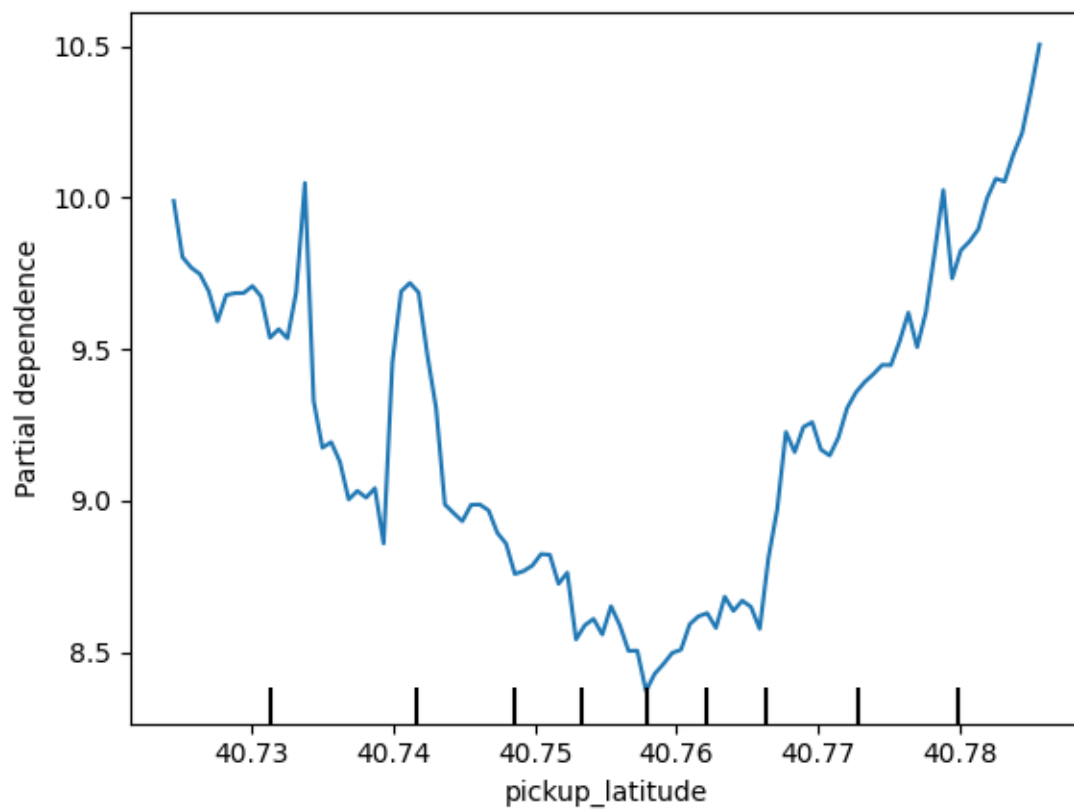
```

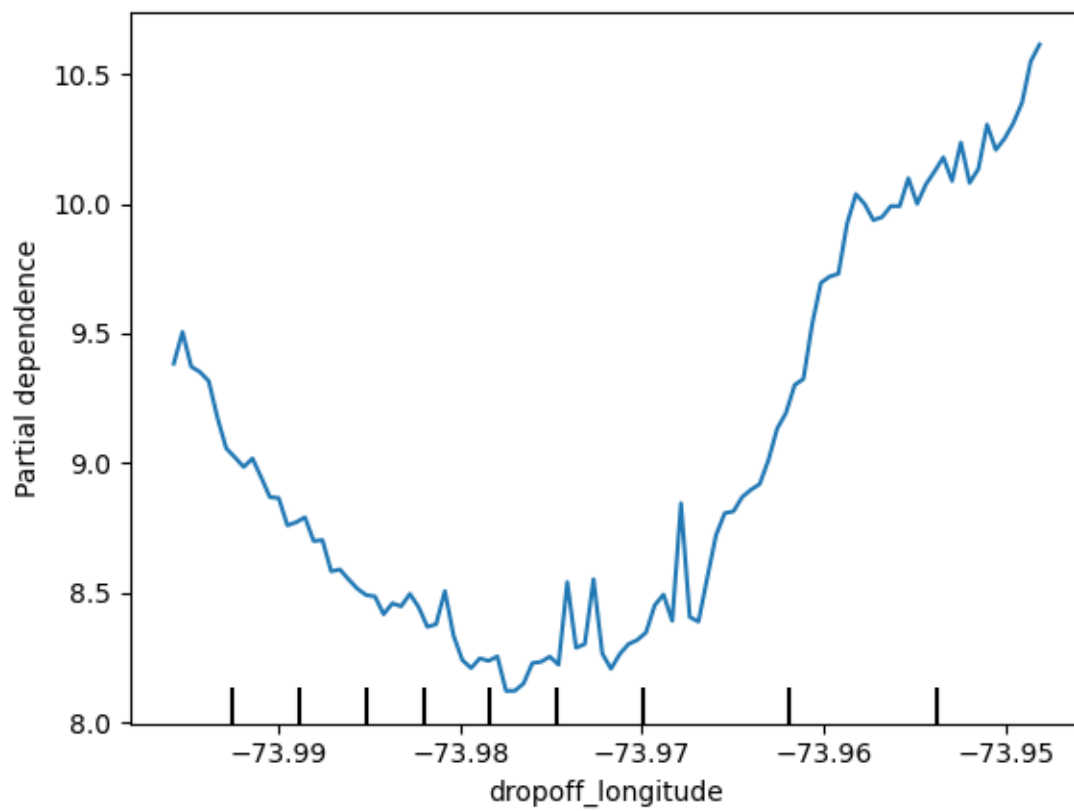


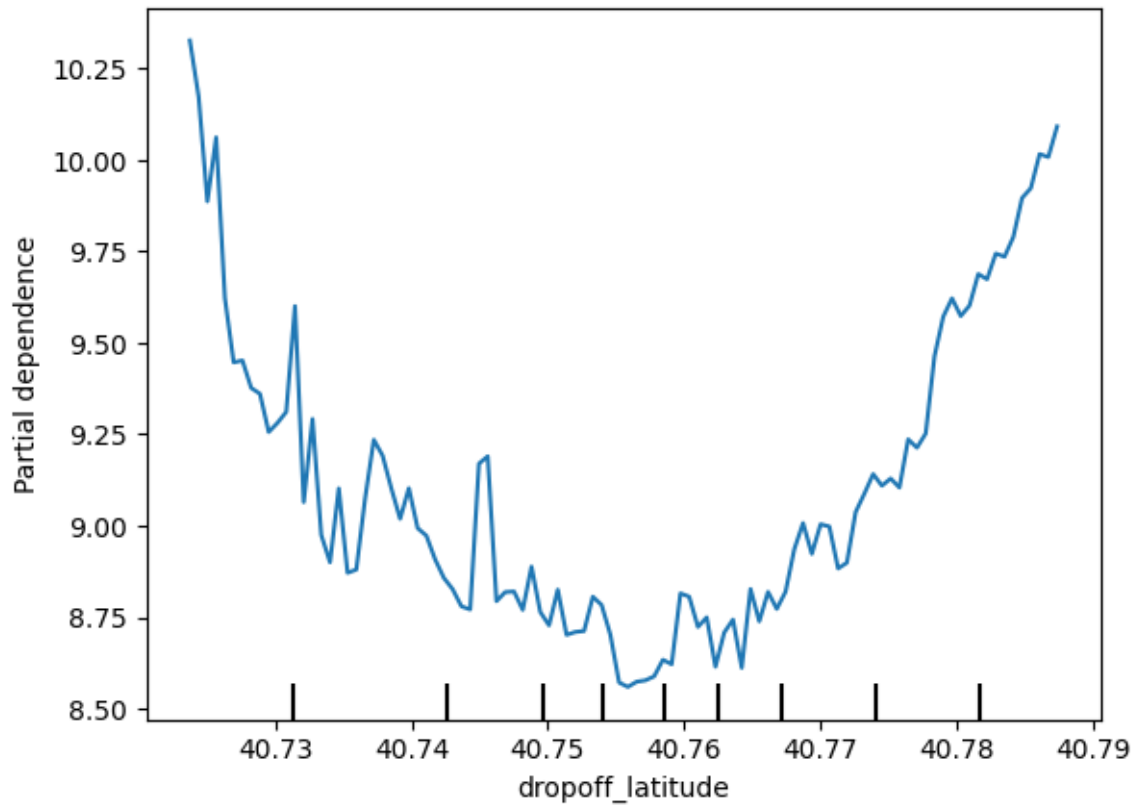
```
# apply 'for' loop for all base_features

for feature_name in base_features:
    PartialDependenceDisplay.from_estimator(first_model, val_X, [feature_name])
    plt.show()
```



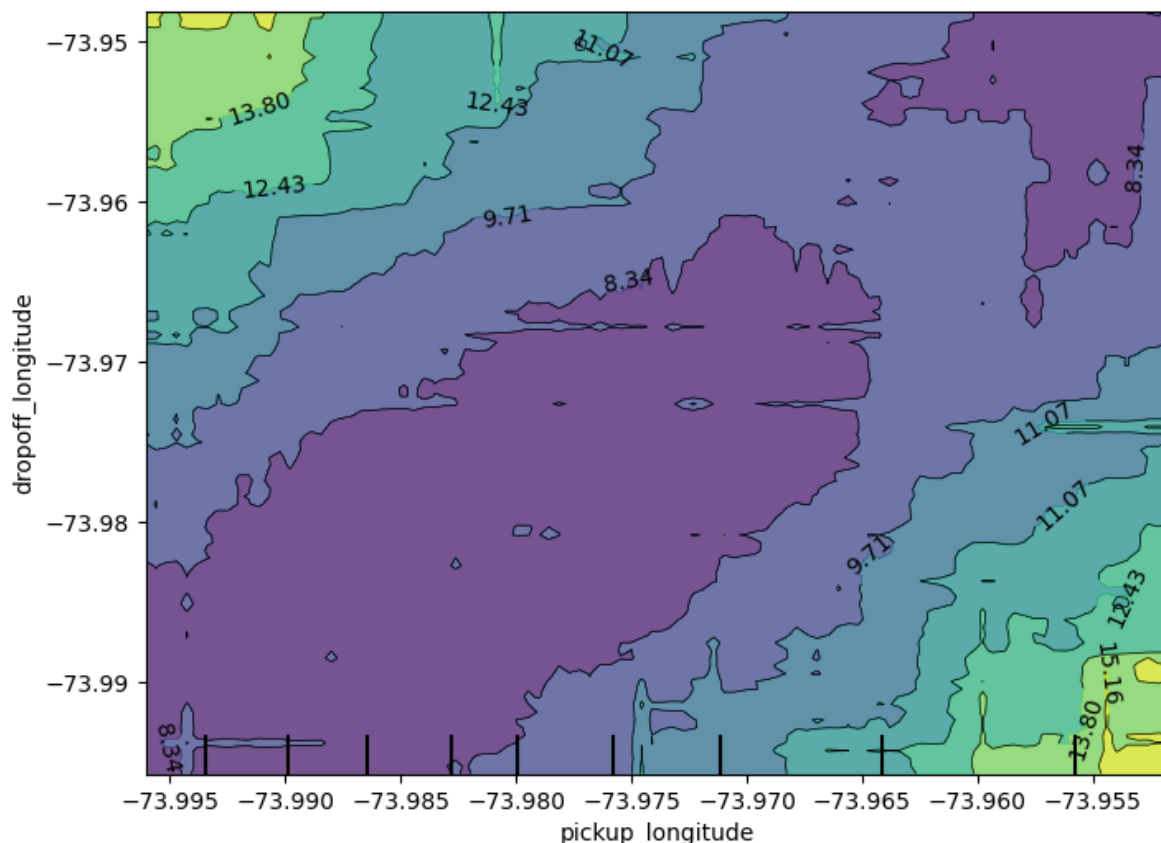




```
# 2D partial Dependence plots
fig, ax = plt.subplots(figsize = (8, 6))

feature_names = [['pickup_longitude', 'dropoff_longitude']]
PartialDependenceDisplay.from_estimator (first_model, val_X, feature_names, ax= ax)
```

<sklearn.inspection._plot.partial_dependence.PartialDependenceDisplay at 0x1e6ada40650>



Consider a scenario where you have only 2 predictive features, which we will call `feat_A` and `feat_B`.

Both features have minimum values of -1 and maximum values of 1. The partial dependence plot for `feat_A` increases steeply over its whole range, whereas the partial dependence plot for feature B increases at a slower rate (less steeply) over its whole range.

Does this guarantee that `feat_A` will have a higher permutation importance than `feat_B`? Why or why not?

No. This doesn't guarantee `feat_a` is more important. For example, `feat_a` could have a big effect in the cases where it varies, but could have a single value 99% of the time. In that case, permuting `feat_a` wouldn't matter much, since most values would be unchanged.

1. Creates two features, `X1` and `X2`, having random values in the range `[-2, 2]`.
2. Creates a target variable `y`, which is always 1.
3. Trains a `RandomForestRegressor` model to predict `y` given `X1` and `X2`.

4. Creates a PDP plot for X1 and a scatter plot of X1 vs. y.

Do you have a prediction about what the PDP plot will look like?

```
# import libraries
import numpy as np
from sklearn.ensemble import RandomForestRegressor
from sklearn.inspection import PartialDependenceDisplay
import matplotlib.pyplot as plt

# generate random data
np.random.seed(0) # for reproducibility
X1 = np.random.uniform(-2, 2, 100)
X2 = np.random.uniform(-2, 2, 100)
X = np.column_stack([X1, X2])

# create target variable y
#y = np.ones([X.shape[0]])
y = -2 * X1 * (X1<-1) + X1 - 2 * X1 * (X1>1) - X2

# train RandomForestRegressor
model = RandomForestRegressor()
model.fit(X,y)

# plot
fig, ax = plt.subplots(figsize=(8, 6))
PartialDependenceDisplay.from_estimator(model, X, features = [0], ax= ax)
ax.set_title('display feature X1')
plt.show()

# Scatter Plot of X1 vs. y
plt.figure(figsize=(8, 6))
plt.scatter(X1, y)
plt.title("Scatter Plot of X1 vs. y")
plt.xlabel("X1")
plt.ylabel("y")
plt.show()
```

