Introduction to click-through rates

PREDICTING CTR WITH MACHINE LEARNING IN PYTHON

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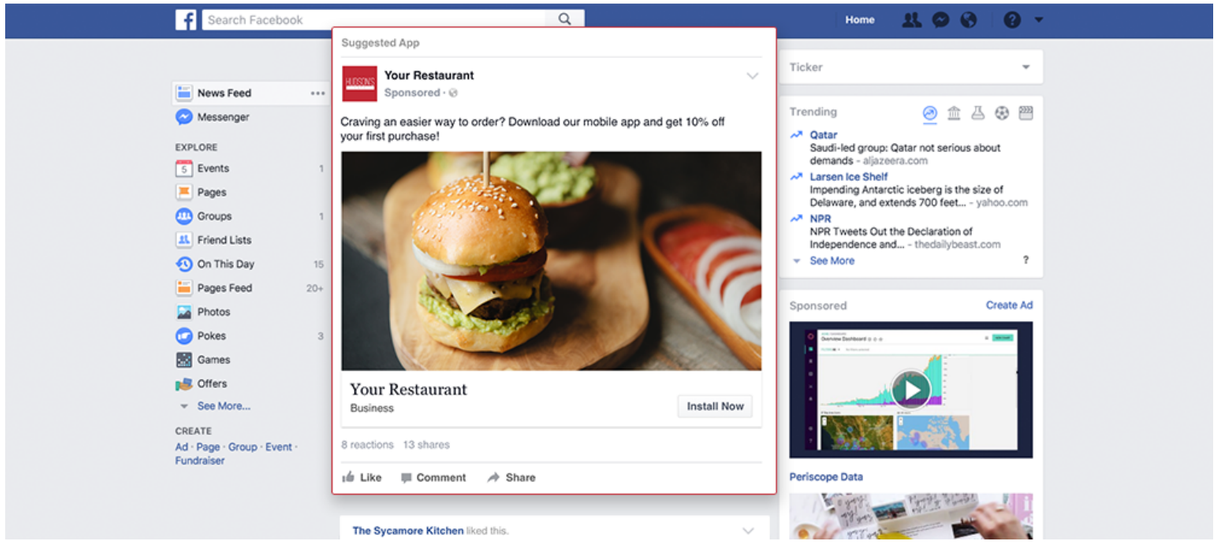
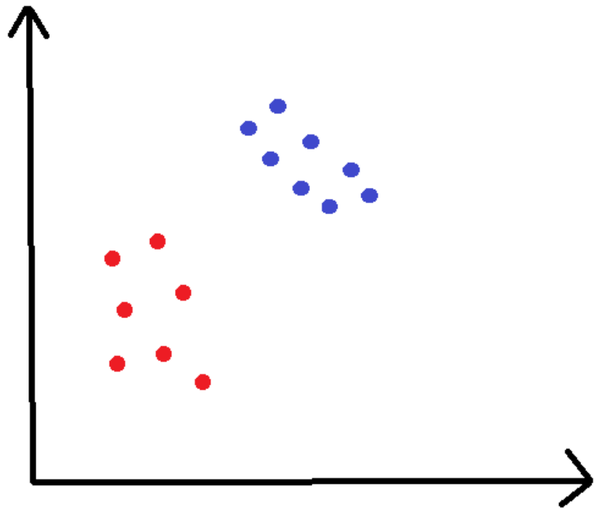
Click-through rates

- Click-through rate: # of clicks on ads / # of views of ads
- Companies and marketers serving ads want to maximize click-through rate
- Prediction of click-through rates is critical for companies and marketers



A classification lens

- Classification: assigning categories to observations
- Classifiers use training data and are evaluated on testing data
- Target: a binary variable, 0/1 for non-click or click
- Feature: any variable used to help predict the target



A brief look sample data

click	hour	banner_pos	device_type	device_conn_type
0	14102100	0	1	2
0	14102100	0	1	0
0	14102100	0	1	0
0	14102100	0	1	0
0	14102100	1	1	0

- Each row represents a particular outcome of click or not click for a given user for a given ad
- Filtering for columns can be done through `.isin()` : `df.columns.isin(['device'])]`
- Assuming `y` is a column of clicks, CTR can be found by: `y.sum()/len(y)`

Analyzing features

```
print(df.device_type.value_counts())
```

```
1    45902
0    2947
```

```
print(df.groupby('device_type')['click'].sum())
```

```
0     633
1    7890
```

Let's practice!

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Overview of machine learning models

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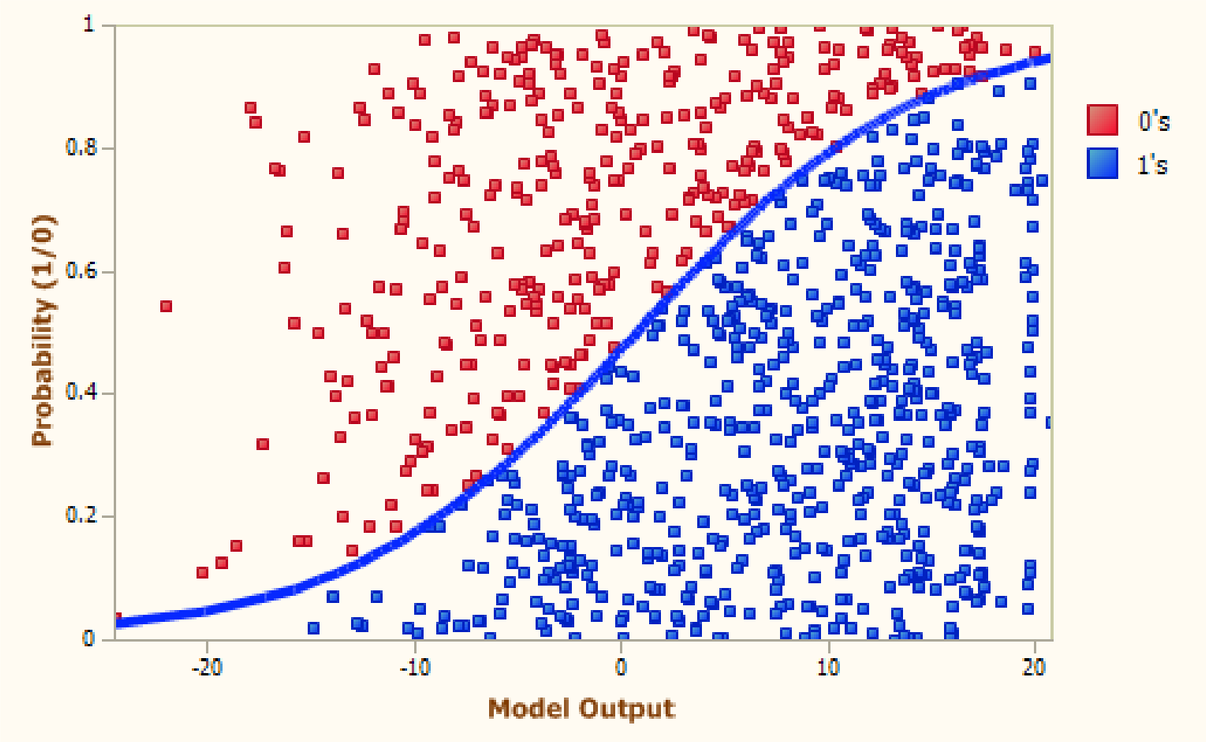
Logistic regression



- Logistic regression: linear classifier between dependent variable and independent variables

Training the model

- Can create the model via: `clf = LogisticRegression()`
- Each classifier has a `fit()` method which takes in an `X_train, y_train` :

```
clf.fit(X_train, y_train)
```

- `X_train` is the vector of training features, `y_train` is the vector of training targets
- Classifier should only see training data to avoid "seeing answers beforehand"

Testing the model

- Each classifier has a `predict()` method which takes in an `X_test` to generate a `y_test` as follows:

```
array([0, 1, 1, ..., 1, 0, 1])
```

  - `predict_proba()` method produces probability scores

```
array([0.2, 0.8], [0.4, 0.6] ..., [0.1, 0.9] [0.3, 0.7]])
```

  - Score reflects probability of a particular ad being clicked by particular user

Evaluating the model

- Accuracy: the percentage of test targets correctly identified
- `accuracy_score(y_test, y_pred)`
- Should not be the only metric to evaluate model, particularly in imbalanced datasets
- CTR prediction is an example where classes are imbalanced

Let's practice!

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CTR prediction using decision trees

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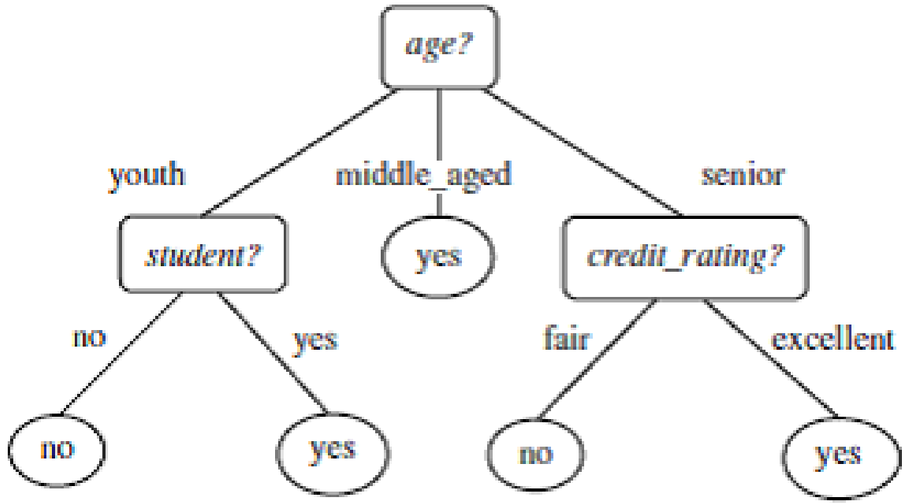
Decision trees



- Nodes represent the features
- Branches represent the decisions based on features

- Sample outcomes are shown in table below:
- First split is based on age of application
- For youth group, second split is based on student status
- Model provides heuristics for understanding

	is_student	loan
middle_aged		1
youth	no	0
youth	yes	1

Training and testing the model

- Create via: `clf = DecisionTreeClassifier()`
- Similar to logistic regression, a decision tree also involves `clf.fit(X_train, y_train)` for training data and `clf.predict(X_test)` for testing labels:

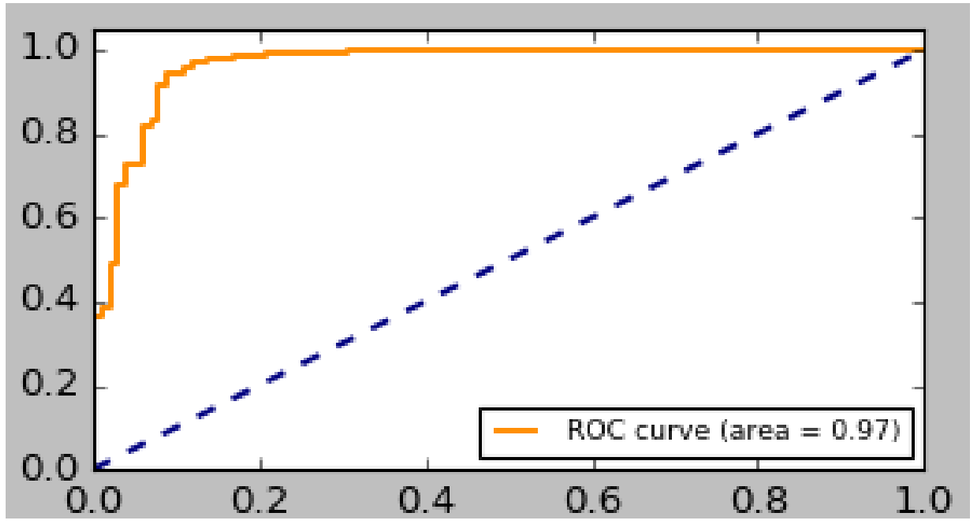
```
array([0, 1, 1, ..., 1, 0, 1])
```

- `clf.predict_proba(X_test)` for probability scores:

```
array([0.2, 0.8], [0.4, 0.6] ..., [0.1, 0.9] [0.3, 0.7]])
```

- Example for randomly splitting training and testing data, where testing data is 30% of total sample size: `train_test_split(X, y, test_size = .3, random_state = 0)`

Evaluation with ROC curve



- True positive rate (Y-axis) = #(classifier predicts positive, actually positive) / #(positives)
- False positive rate (X-axis) = #(classifier predicts positive, actually negative) / #(negatives)
- Dotted blue line: baseline AUC of 0.5
- Want orange line (AUC) to be as close to 1 as possible

AUC of ROC curve

```
Y_score = clf.predict_proba(X_test)
```

```
fpr, tpr, thresholds = roc_curve(Y_test, Y_score[:, 1])
```

- `roc_curve()` inputs: test and score arrays

```
roc_auc = auc(fpr, tpr)
```

- `auc()` input: false-positive and true-positive arrays
- If model is accurate and CTR is low, you may want to reassess how the ad message is relayed and what audience it is targeted for

Let's practice!

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