Review of classification methods

FRAUD DETECTION IN PYTHON

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What is classification?

Goal of classification: Use known fraud cases to train a model to recognize new fraud cases

Examples:

- Email spam/Not spam
- Transaction online fraudulent: Yes/No
- Tumor Malignant/Benign?

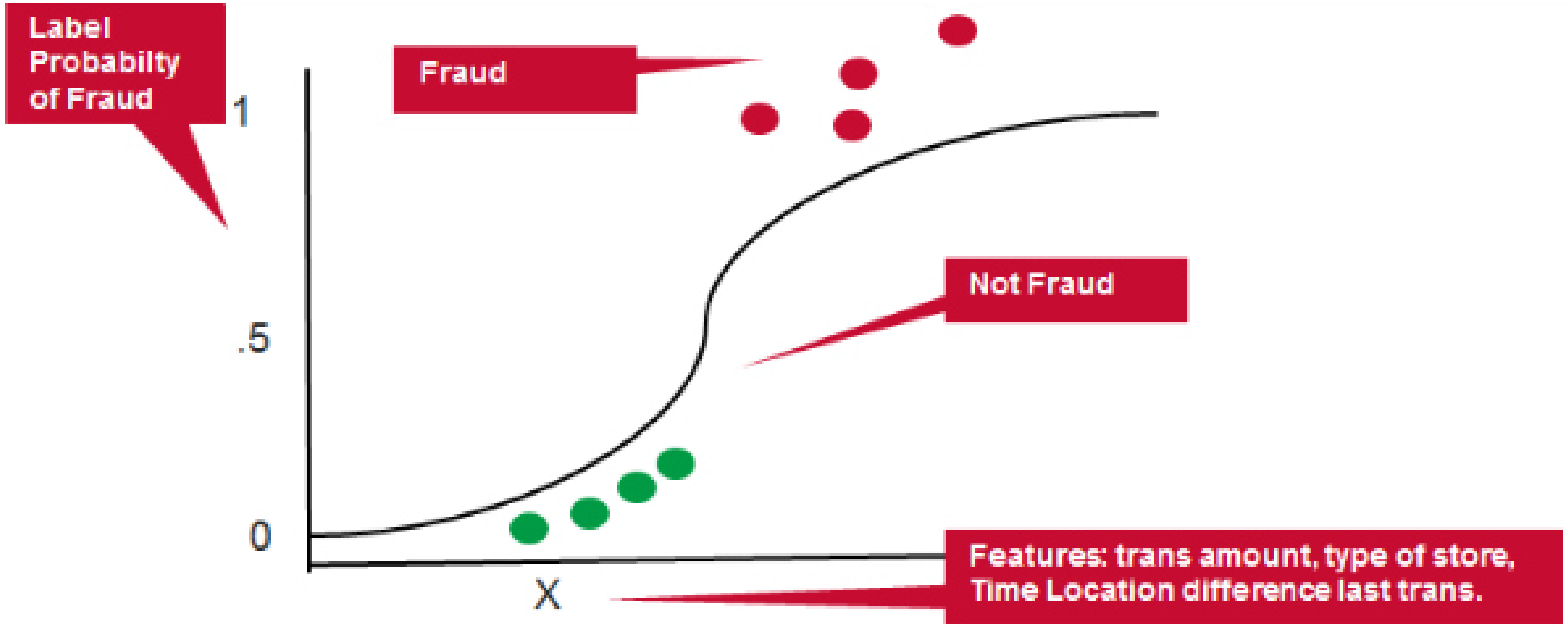
Variable to predict: $y \in 0, 1$

0: Negative class ("majority" normal cases)

1: Positive class ("minority" fraud cases)

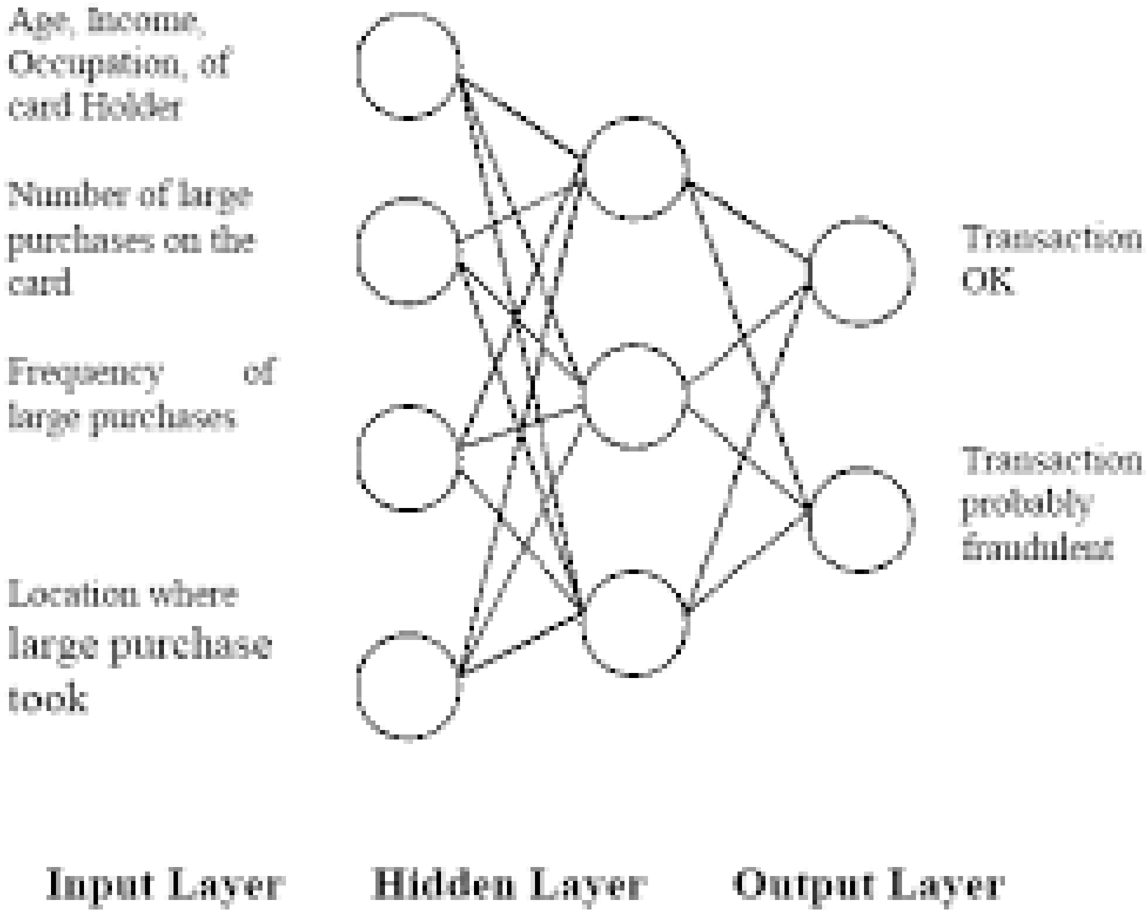
Classification methods commonly used for fraud detection

- Logistic regression


Label Probabilty of Fraud
Fraud
1
.5
Not Fraud
0
X
Features: trans amount, type of store, Time Location difference last trans.

Classification methods commonly used for fraud detection

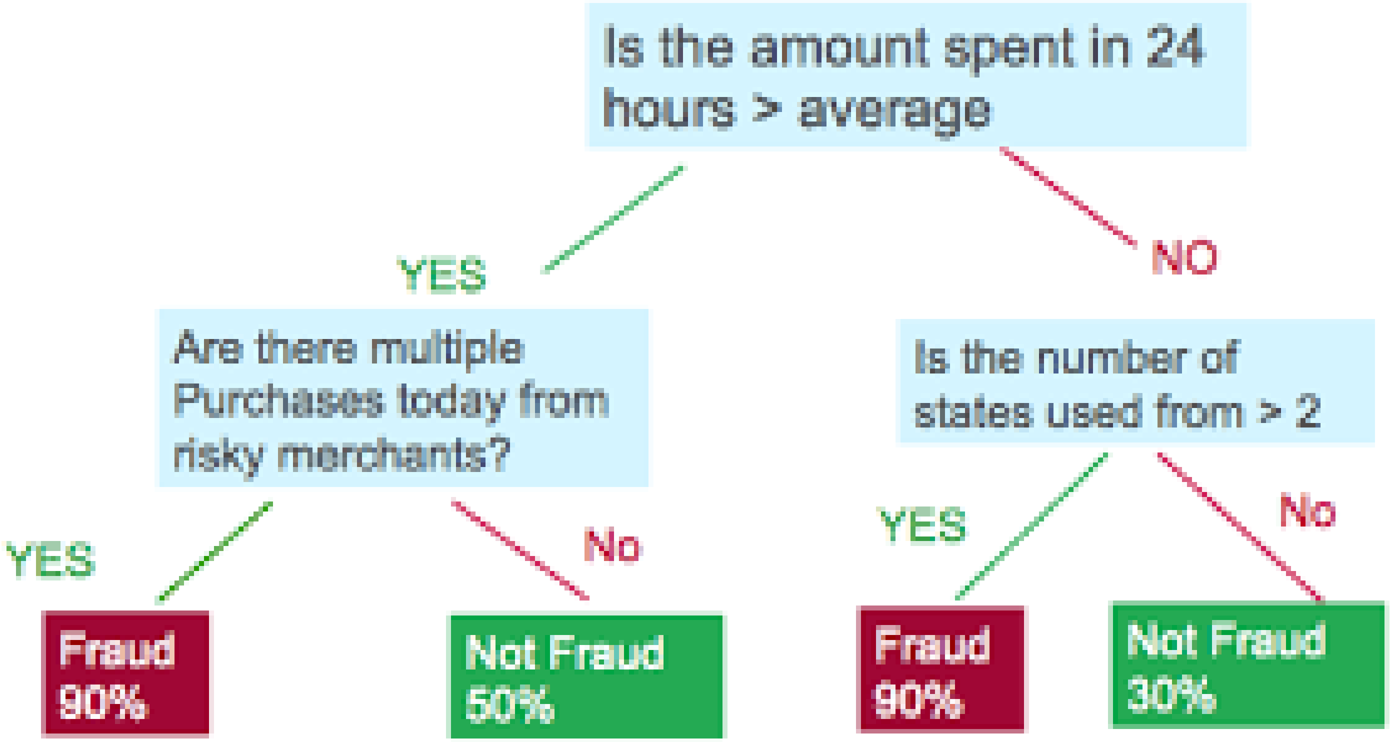
- Neural network



Age, Income, Occupation, of card Holder
Number of large purchases on the card
Frequency of large purchases
Location where large purchase took
Transaction OK
Transaction probably fraudulent
Input Layer
Hidden Layer
Output Layer

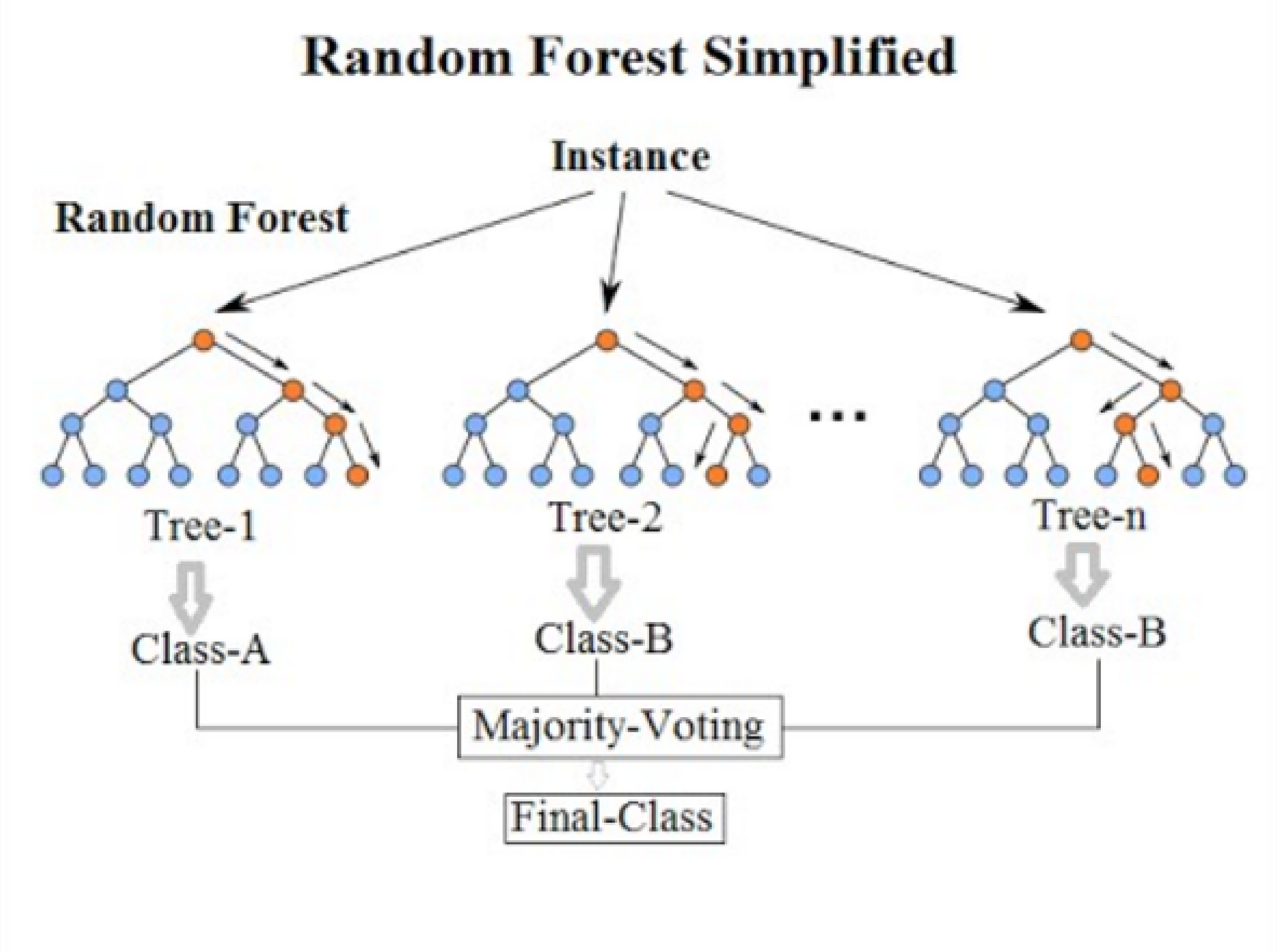
Classification methods commonly used for fraud detection

- Decision trees
- Random forests


Is the amount spent in 24 hours > average
YES
NO
Are there multiple Purchases today from risky merchants?
Is the number of states used from > 2
YES
No
YES
No
Fraud 90%
Not Fraud 50%
Fraud 90%
Not Fraud 30%

Decision trees and random forests

- Random forests are a collection of trees on random subsets of features



Random forests for fraud detection

```python
from sklearn.ensemble import RandomForestClassifier
model = RandomForestClassifier(random_state=42)
model.fit(X_train, y_train)
predicted = model.predict(X_test)
print (metrics.accuracy_score(y_test, predicted))
```

```
0.991324200913242
```

Let's practice!

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Performance evaluation

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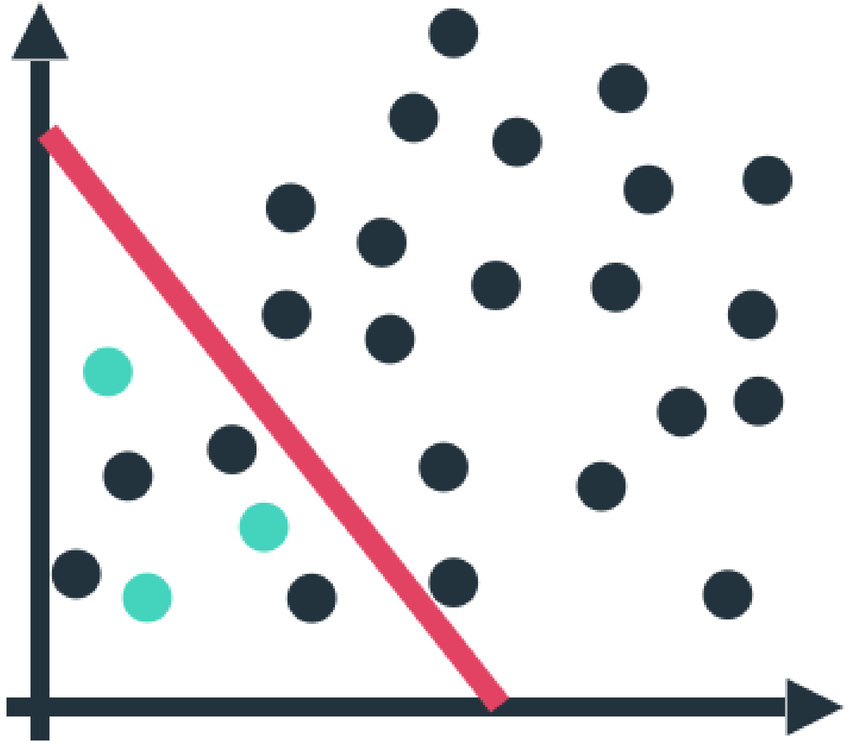
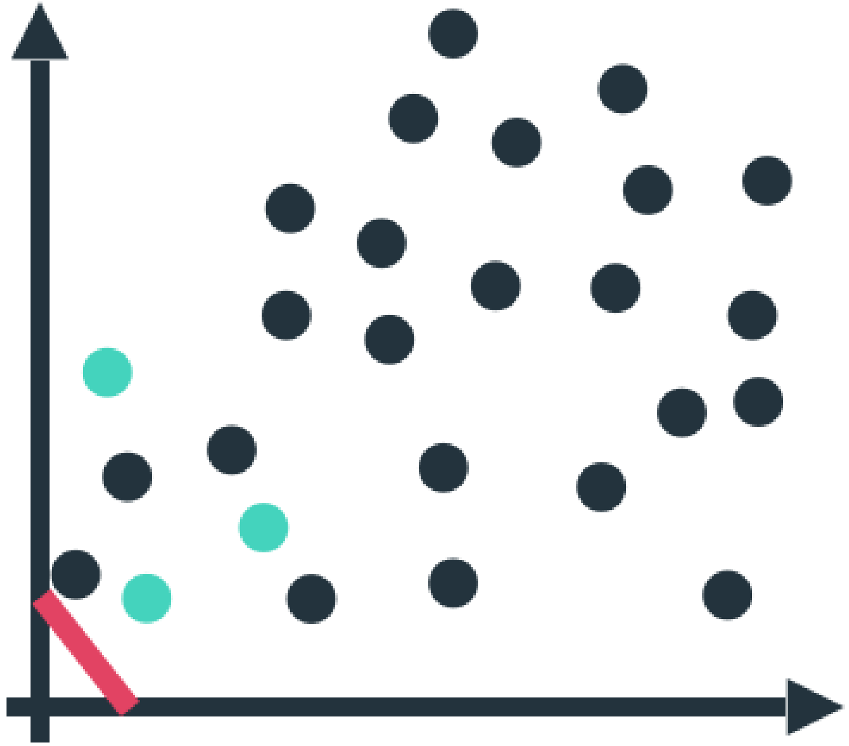
Accuracy isn't everything

Throw accuracy out of the window when working on fraud detection problems

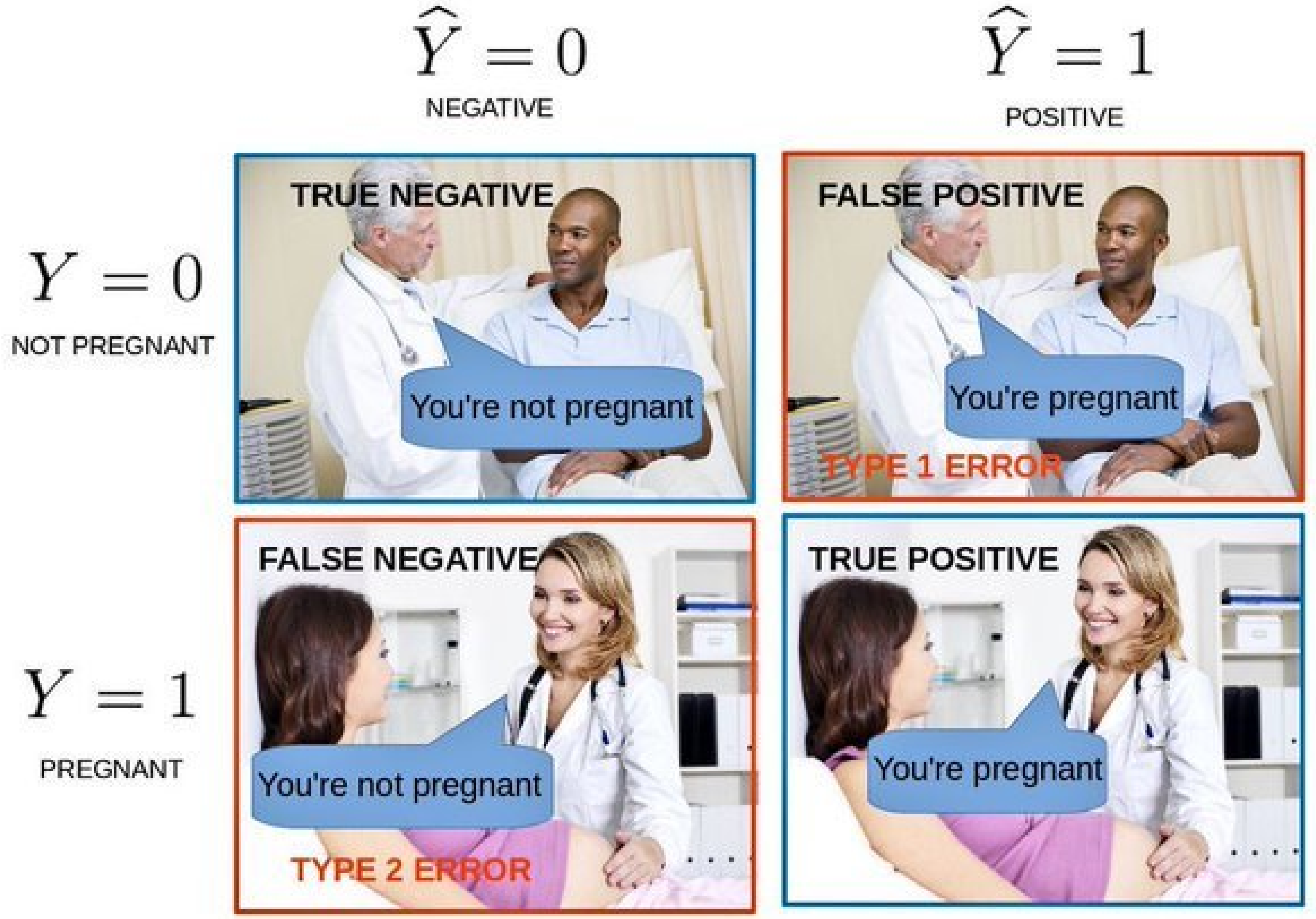


Accuracy = 93%

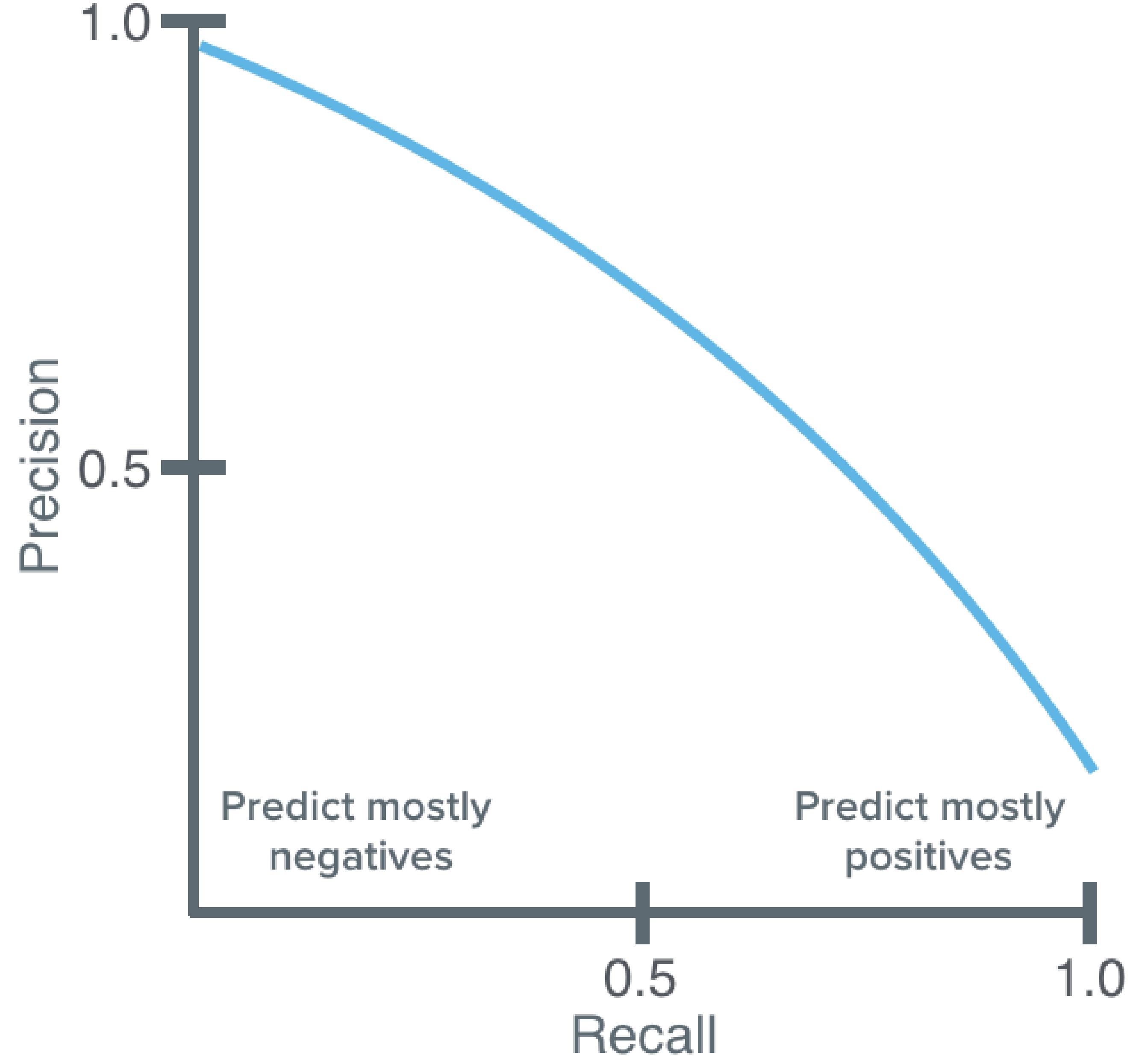


Accuracy = 97%

False positives, false negatives, and actual fraud caught



Precision-recall tradeoff



$$Precision = \frac{\#True\ Positives}{\#True\ Positives + \#False\ Positives}$$

$$Recall = \frac{\#True\ Positives}{\#True\ Positives + \#False\ Negatives}$$

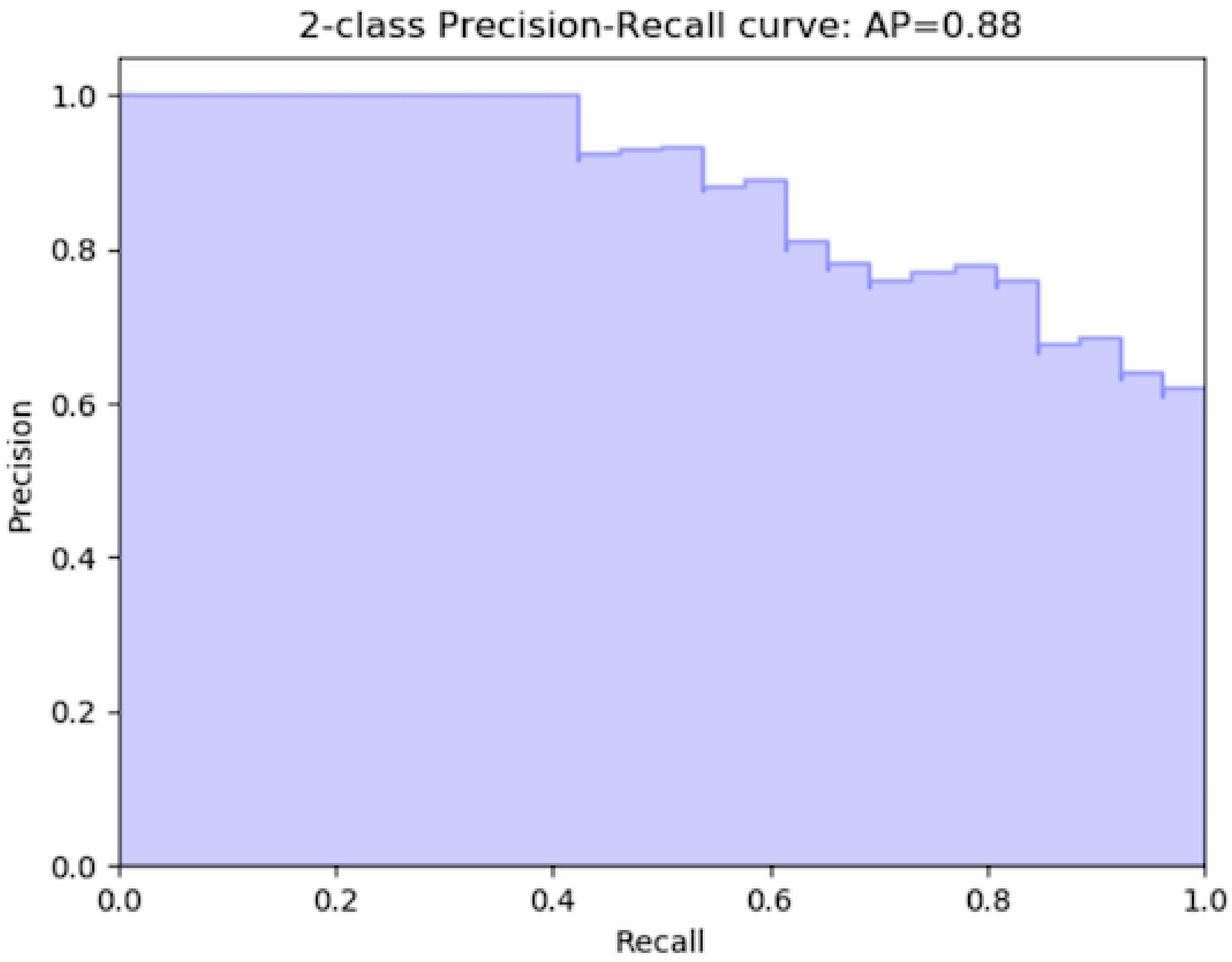
$$F - measure = \frac{2 \times Precision \times Recall}{Precision + Recall}$$

$$= \frac{2 \times TP}{2 \times TP + FP + FN}$$

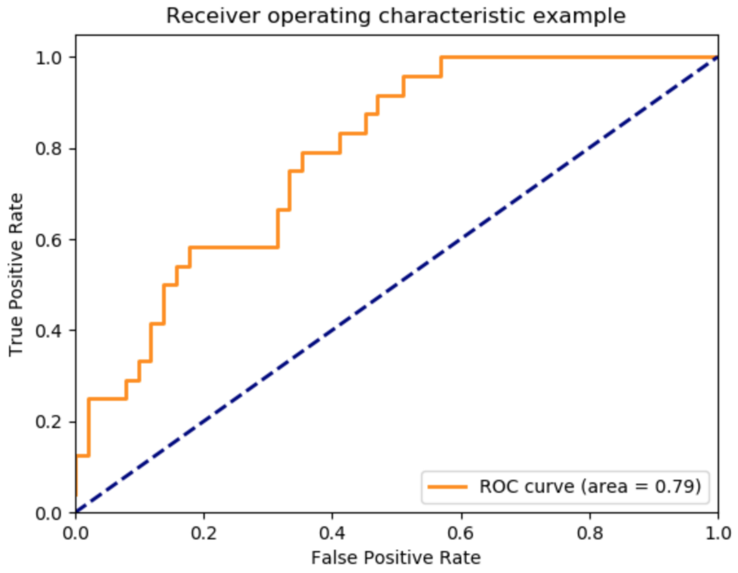
Obtaining performance metrics

```python
# Import the packages
from sklearn.metrics import precision_recall_curve
from sklearn.metrics import average_precision_score
# Calculate average precision and the PR curve
average_precision = average_precision_score(y_test, predicted)
# Obtain precision and recall
precision, recall, _ = precision_recall_curve(y_test, predicted)
```

Precision-recall Curve



ROC curve to compare algorithms



```
# Obtain model probabilities
probs = model.predict_proba(X_test)
# Print ROC_AUC score using probabilities
print(metrics.roc_auc_score(y_test, probs[:, 1]))
```

```
0.9338879319822626
```

```python
from sklearn.metrics import classification_report, confusion_matrix
# Obtain predictions
predicted = model.predict(X_test)
# Print classification report using predictions
print(classification_report(y_test, predicted))
```

```
  precision    recall  f1-score   support

        0.0       0.99      1.00      1.00      2099
        1.0       0.96      0.80      0.87        91

avg / total       0.99      0.99      0.99      2190
```

```python
# Print confusion matrix using predictions
print(confusion_matrix(y_test, predicted))
```

```
[[2096    3]
 [  18   73]]
```

Let's practice!

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Adjusting your algorithm weights

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Balanced weights

```
model = RandomForestClassifier(class_weight='balanced')
```

```
model = RandomForestClassifier(class_weight='balanced_subsample')
```

```
model = LogisticRegression(class_weight='balanced')
```

```
model = SVC(kernel='linear', class_weight='balanced', probability=True)
```

Hyperparameter tuning for fraud detection

```
model = RandomForestClassifier(class_weight={0:1,1:4},random_state=1)

model = LogisticRegression(class_weight={0:1,1:4}, random_state=1)
```

```
model = RandomForestClassifier(n_estimators=10,
                               criterion='gini',
                               max_depth=None,
                               min_samples_split=2,
                               min_samples_leaf=1,
                               max_features='auto',
                               n_jobs=-1,
                               class_weight=None)
```

Using GridSearchCV

```python
from sklearn.model_selection import GridSearchCV
# Create the parameter grid
param_grid = {
    'max_depth': [80, 90, 100, 110],
    'max_features': [2, 3],
    'min_samples_leaf': [3, 4, 5],
    'min_samples_split': [8, 10, 12],
    'n_estimators': [100, 200, 300, 1000]
}
# Define which model to use
model = RandomForestRegressor()
# Instantiate the grid search model
grid_search_model = GridSearchCV(estimator = model,
param_grid = param_grid, cv = 5,
n_jobs = -1, scoring='f1')
```

Finding the best model with GridSearchCV

```
# Fit the grid search to the data
grid_search_model.fit(X_train, y_train)
# Get the optimal parameters
grid_search_model.best_params_
```

```
{'bootstrap': True,
 'max_depth': 80,
 'max_features': 3,
 'min_samples_leaf': 5,
 'min_samples_split': 12,
 'n_estimators': 100}
```

```
# Get the best_estimator results
grid_search.best_estimator_
grid_search.best_score_
```

Let's practice!

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Ensemble methods

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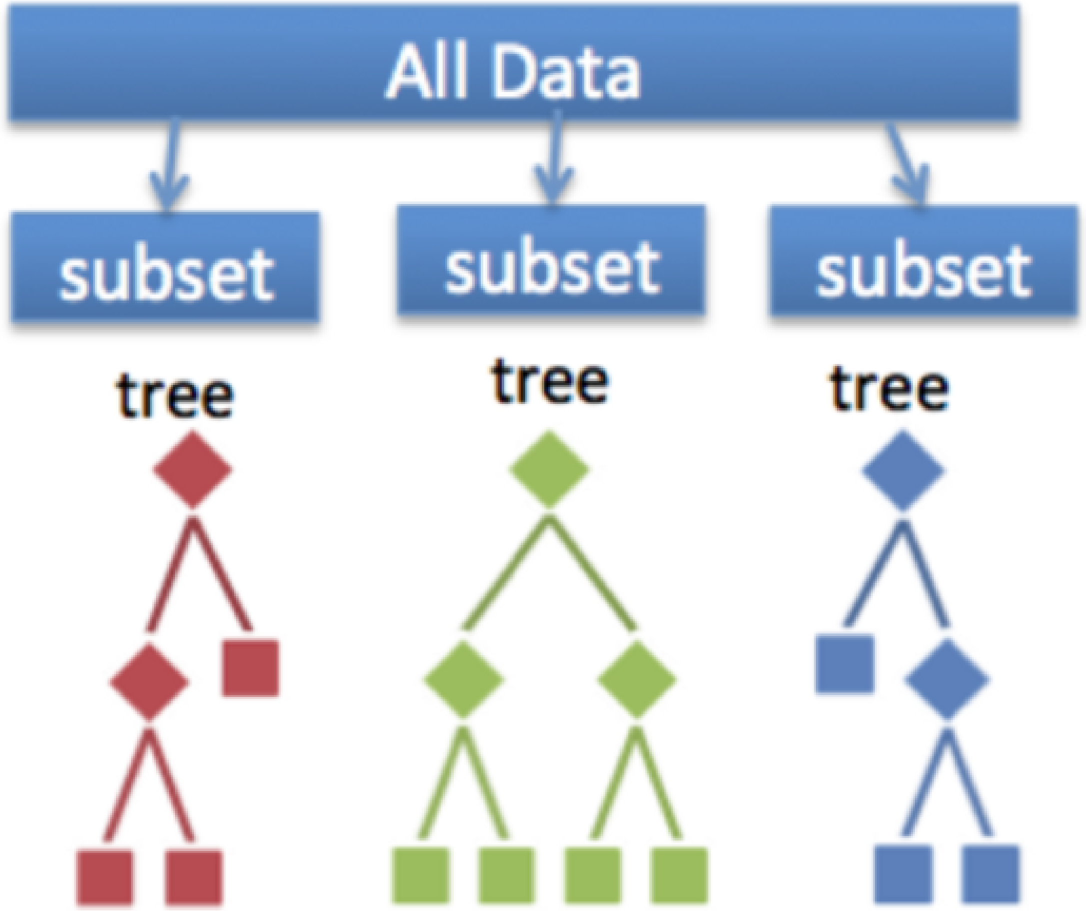
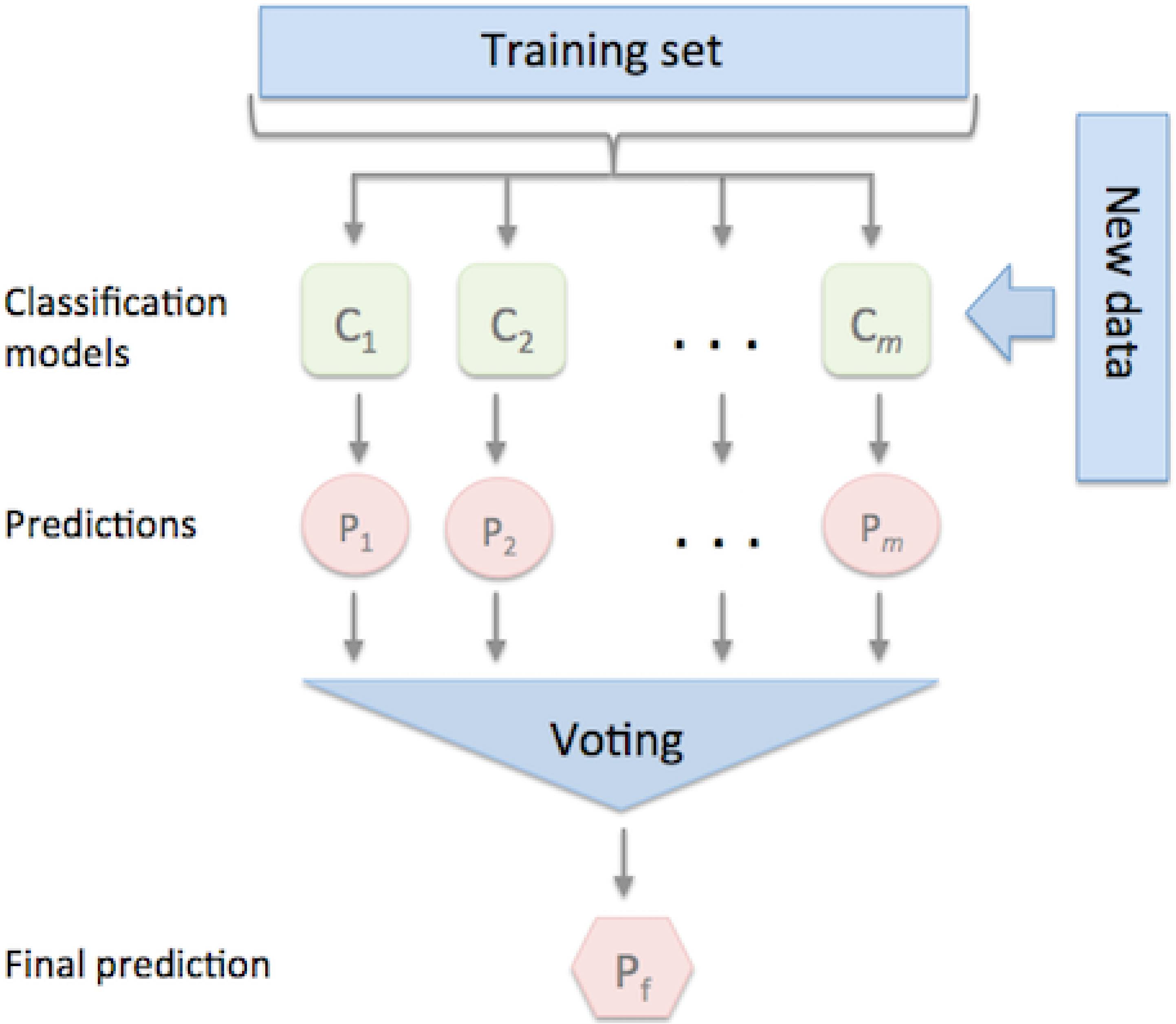
What are ensemble methods: bagging versus stacking



Stacking ensemble methods



Why use ensemble methods for fraud detection

Ensemble methods:

- Are robust
- Can help you avoid overfitting
- Can typically improve prediction performance
- Are a winning formula at prestigious Kaggle competitions

Voting classifier

```
from sklearn.ensemble import VotingClassifier
clf1 = LogisticRegression(random_state=1)
clf2 = RandomForestClassifier(random_state=1)
clf3 = GaussianNB()
ensemble_model = VotingClassifier(estimators=[('lr', clf1),
('rf', clf2), ('gnb', clf3)], voting='hard')
ensemble_model.fit(X_train, y_train)
ensemble_model.predict(X_test)
VotingClassifier(estimators=[('lr', clf1), ('rf', clf2),
('gnb', clf3)], voting='soft', weights=[2,1,1])
```

Reliable labels for fraud detection

Let's practice!