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?

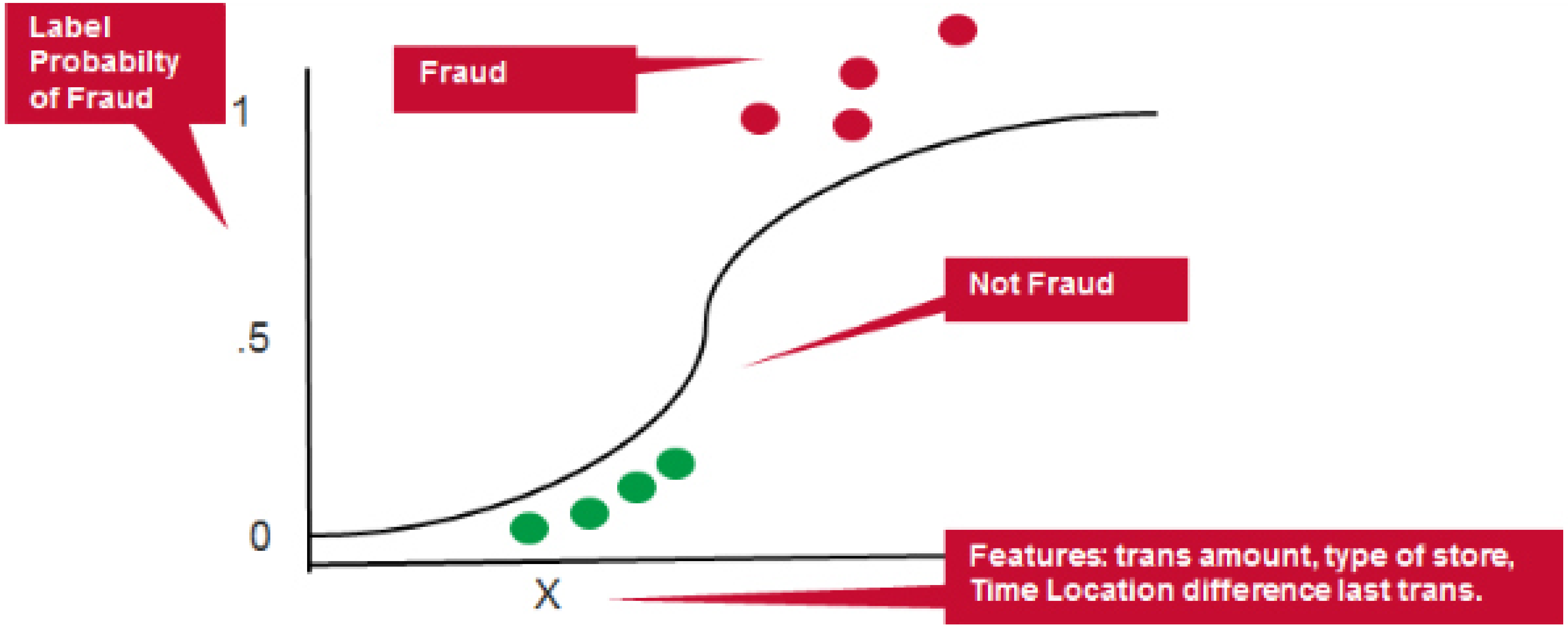
Variable to predict: $y \in 0, 1$

0: Negative class ("majority" normal cases)

1: Positive class ("minority" fraud cases)

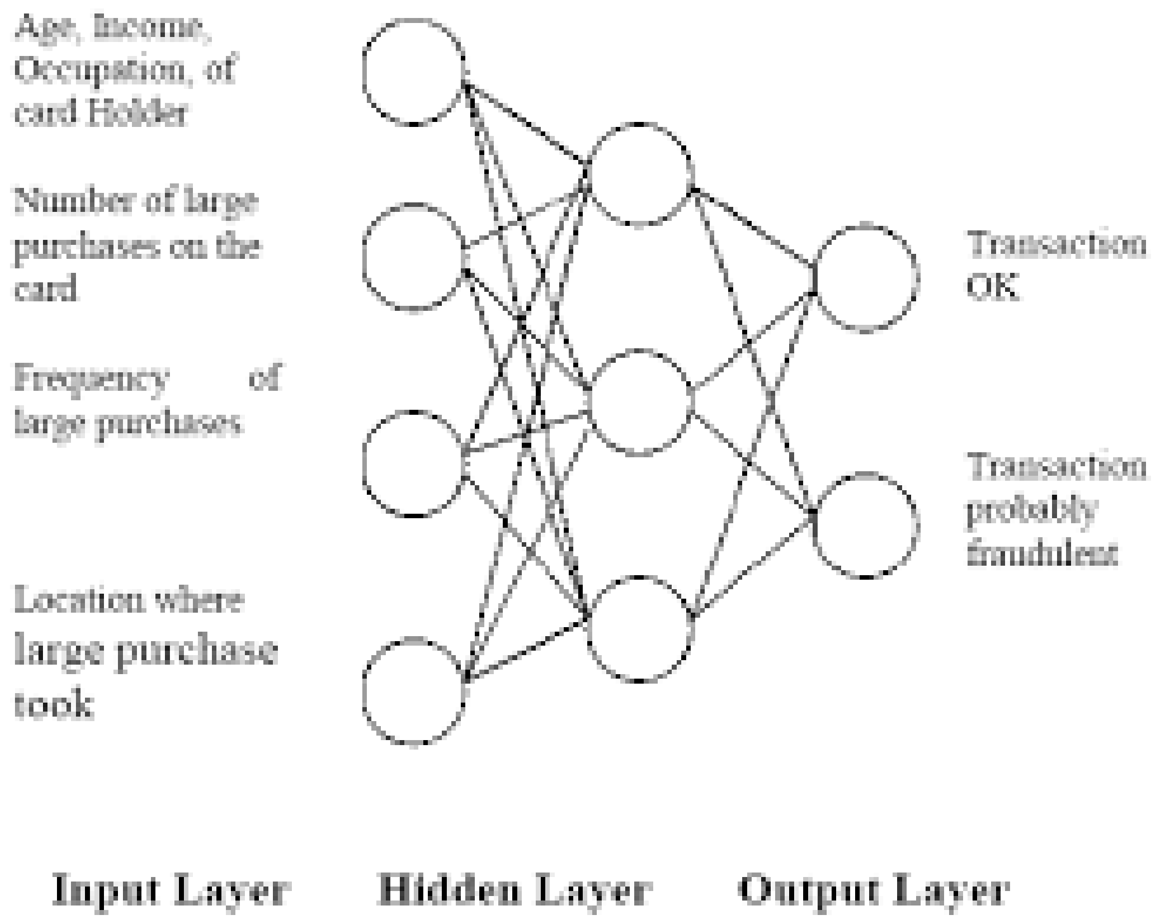
Classification methods commonly used for fraud detection

- Logistic regression



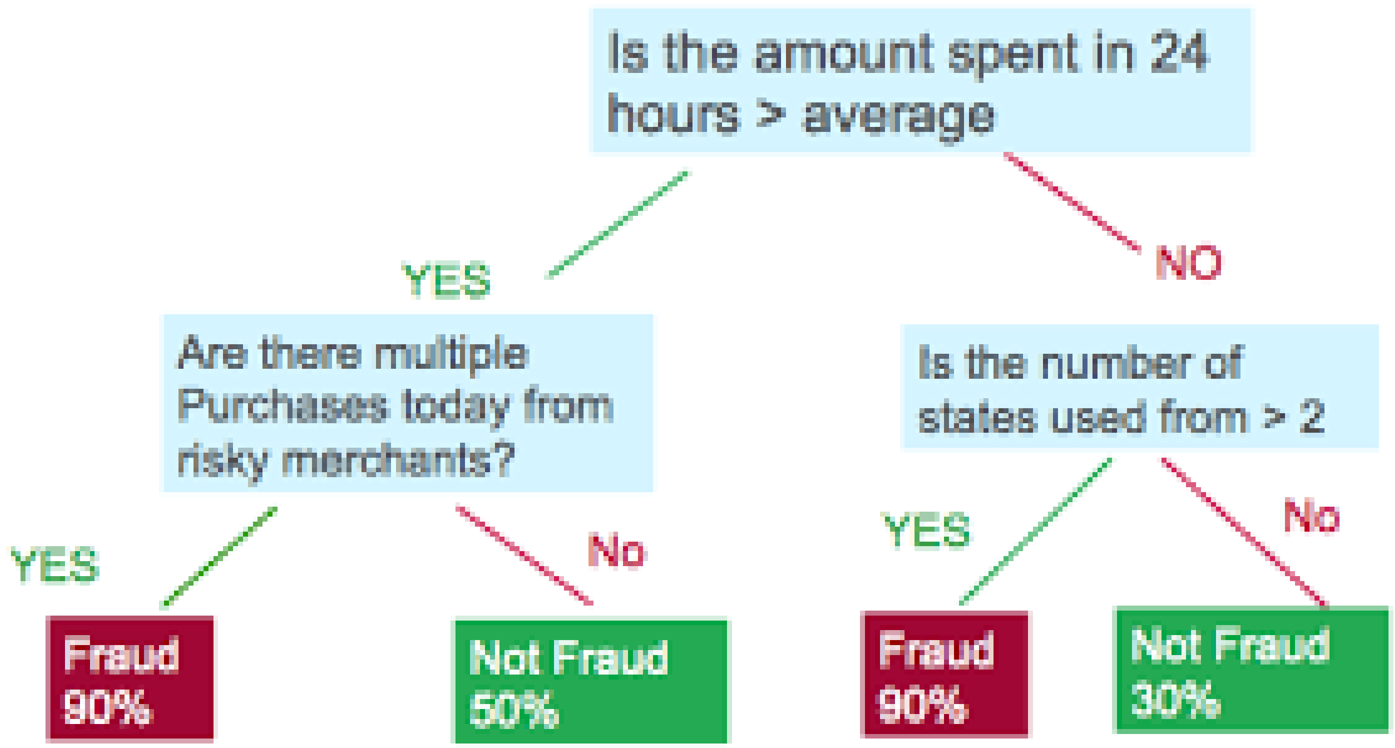
Classification methods commonly used for fraud detection

- Neural network



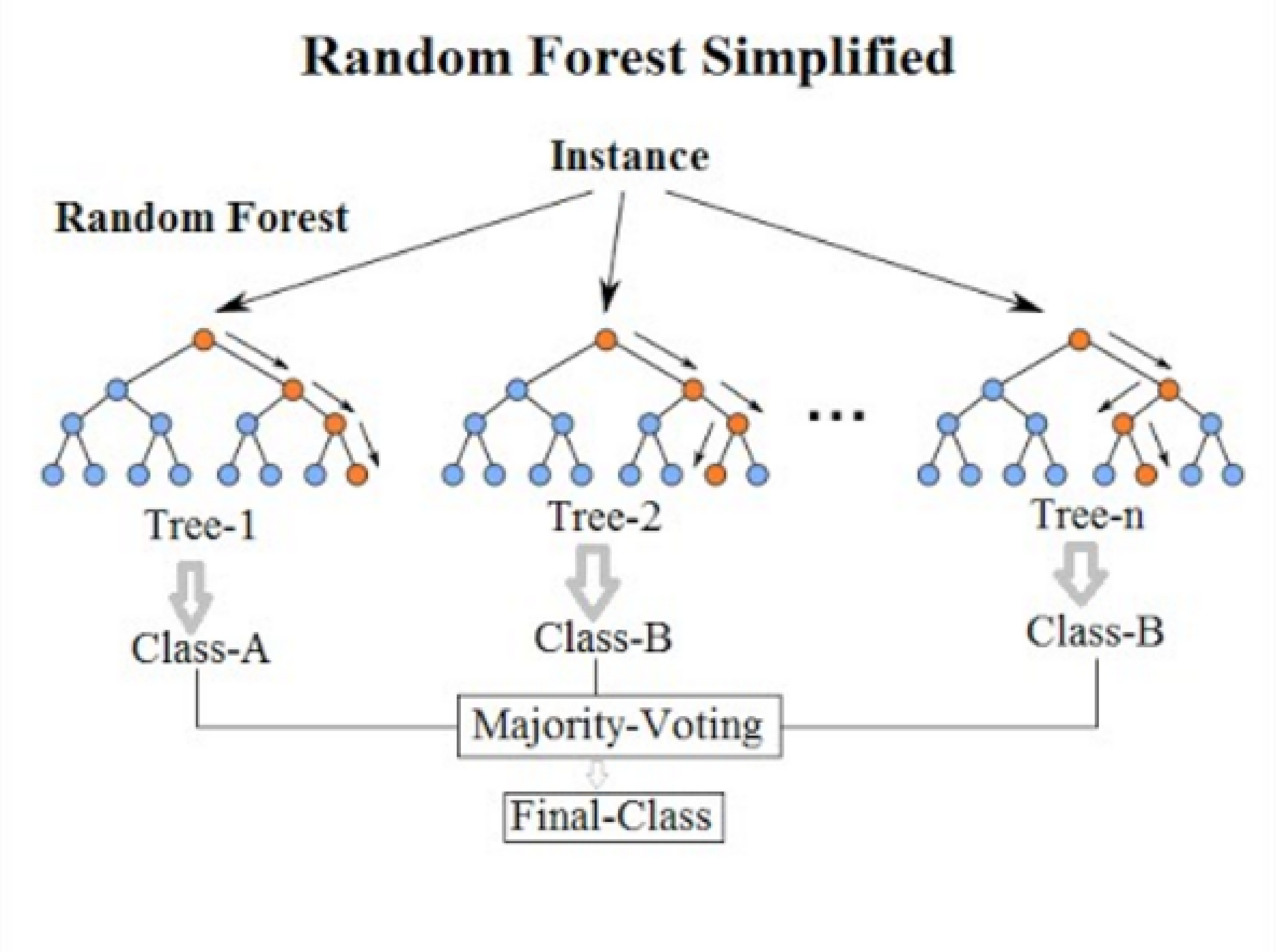
Classification methods commonly used for fraud detection

- Decision trees
- Random forests



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!

Performance evaluation

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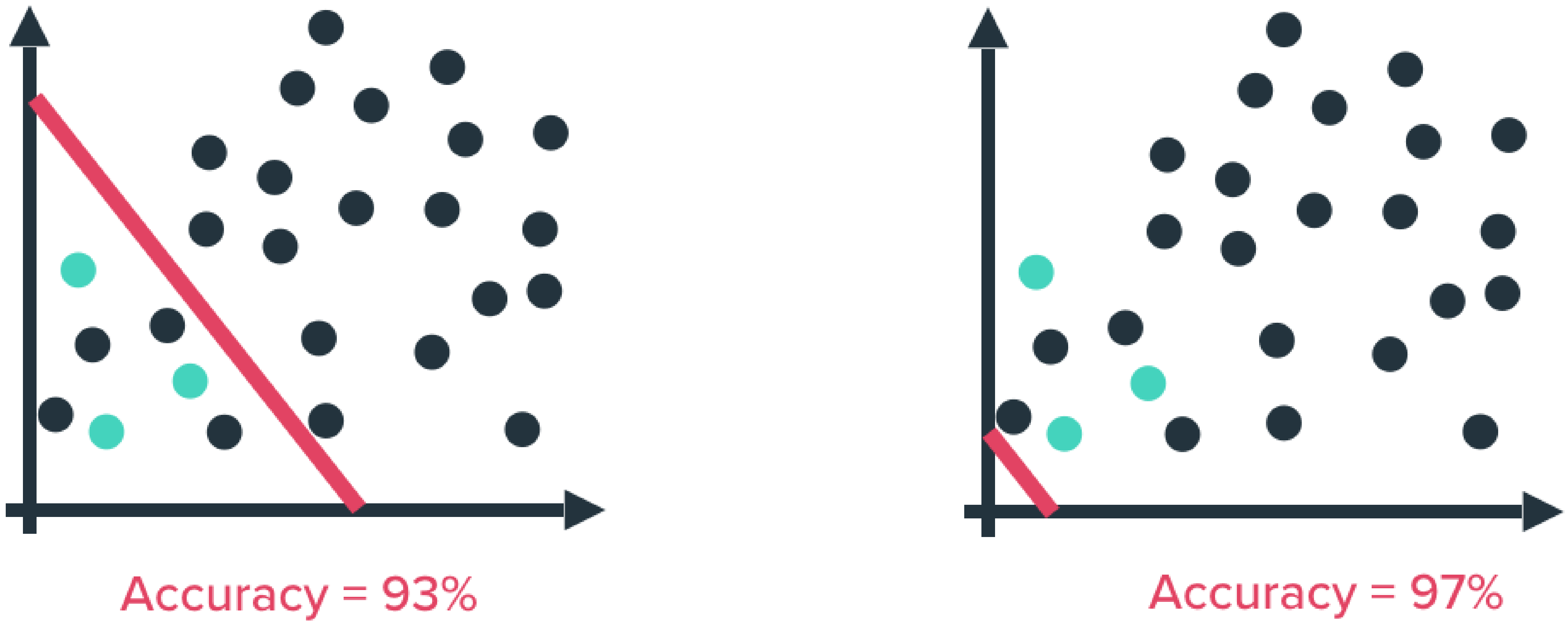
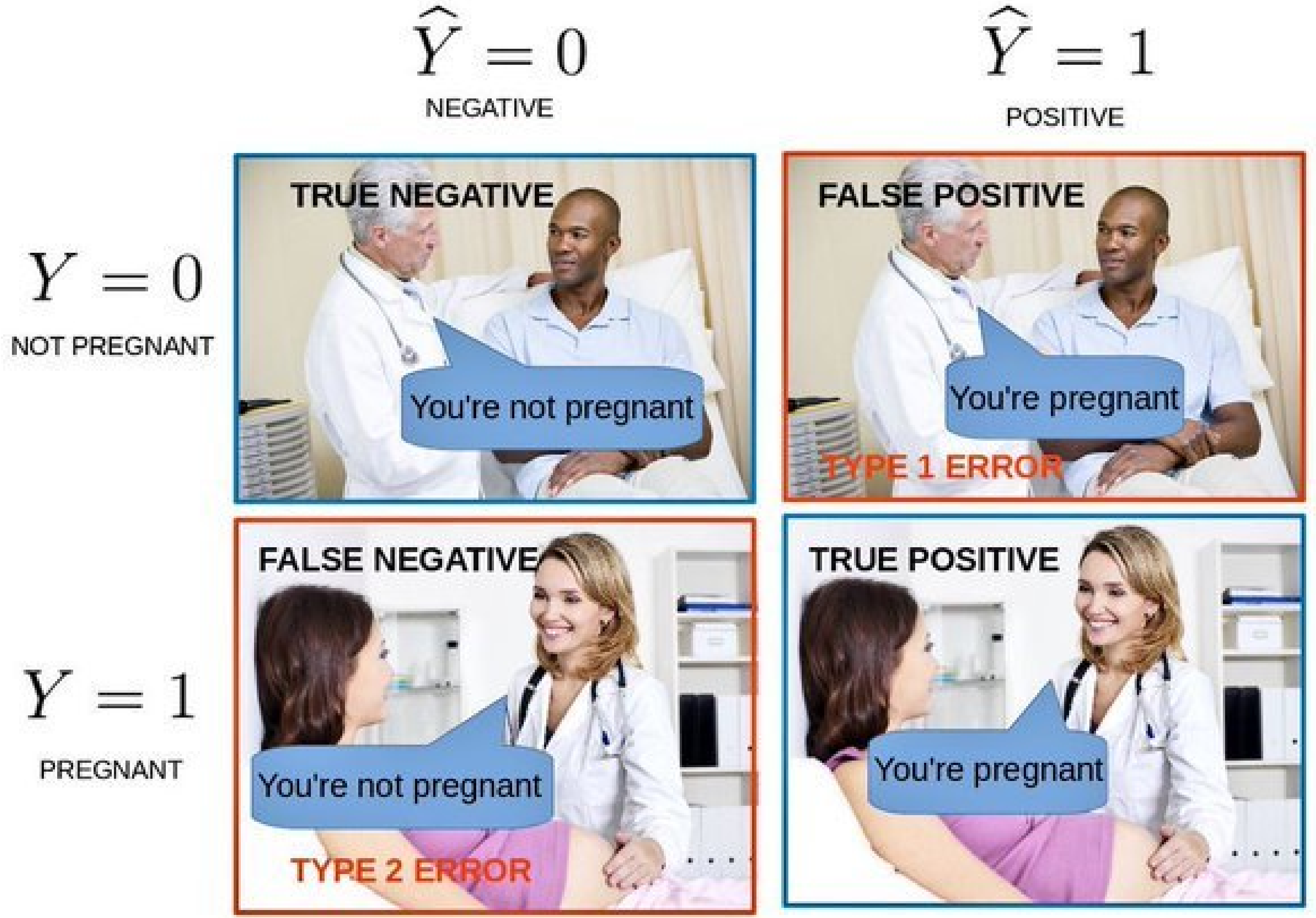
Accuracy isn't everything

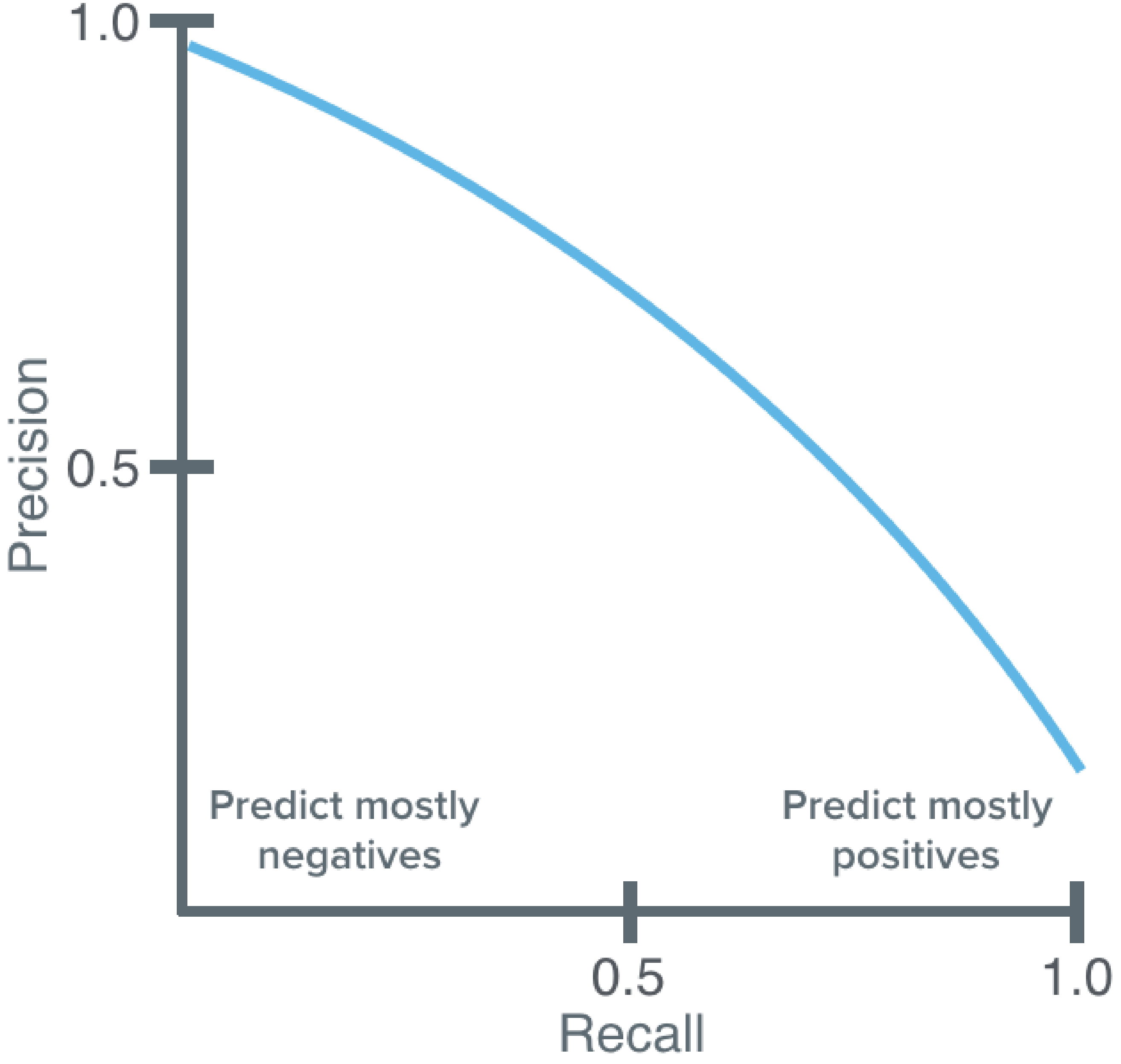
Throw accuracy out of the window when working on fraud detection problems



False positives, false negatives, and actual fraud caught



Precision-recall tradeoff



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

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

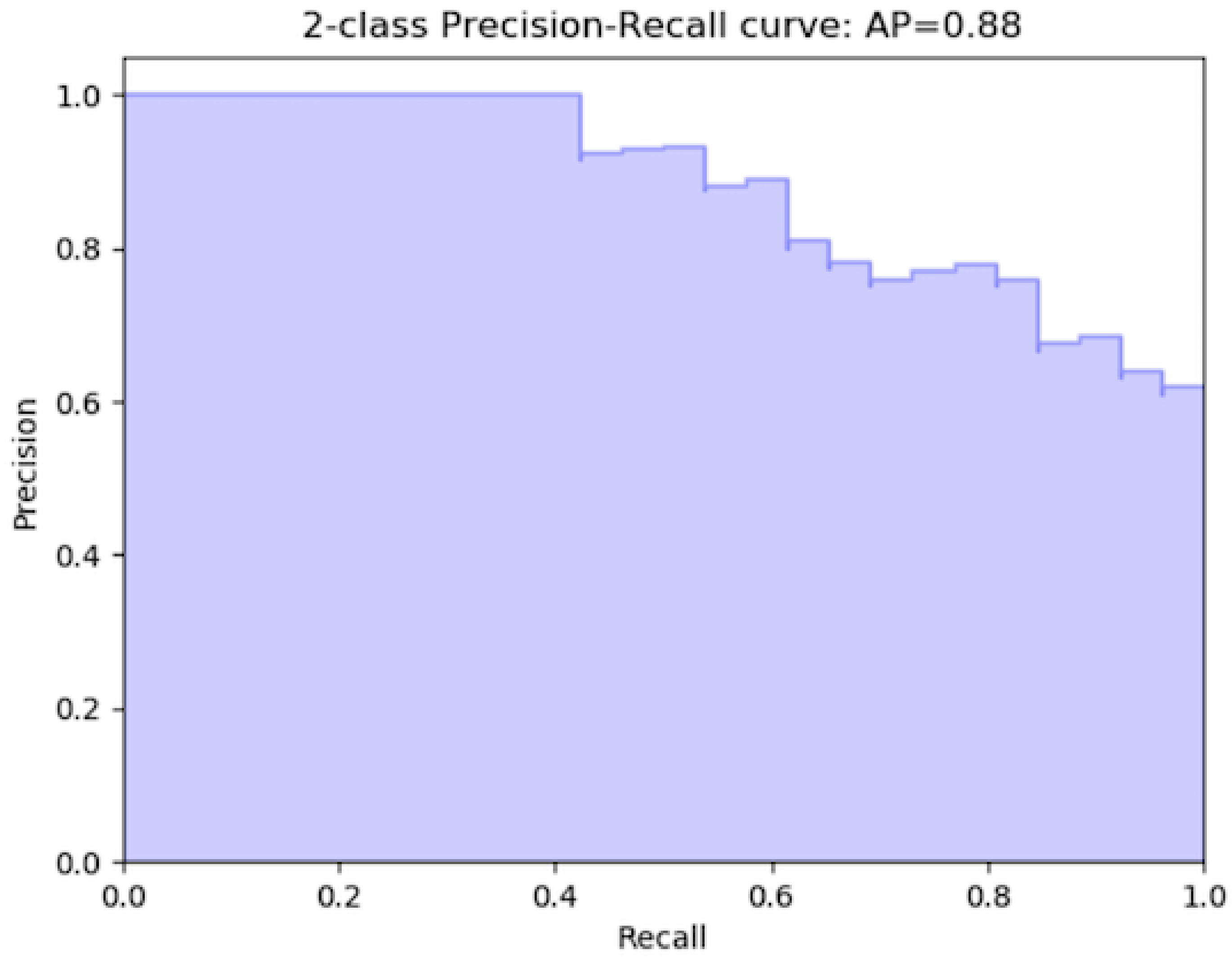
$$F - measure = \frac{2 \times Precision \times Recall}{Precision + Recall}$$

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

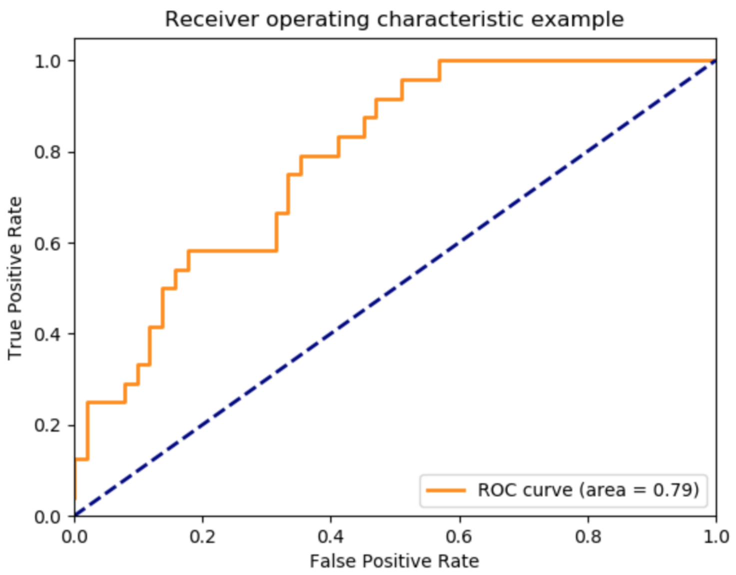
Obtaining performance metrics

```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

```
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

```python
# 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}
```

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

Let's practice!

Ensemble methods

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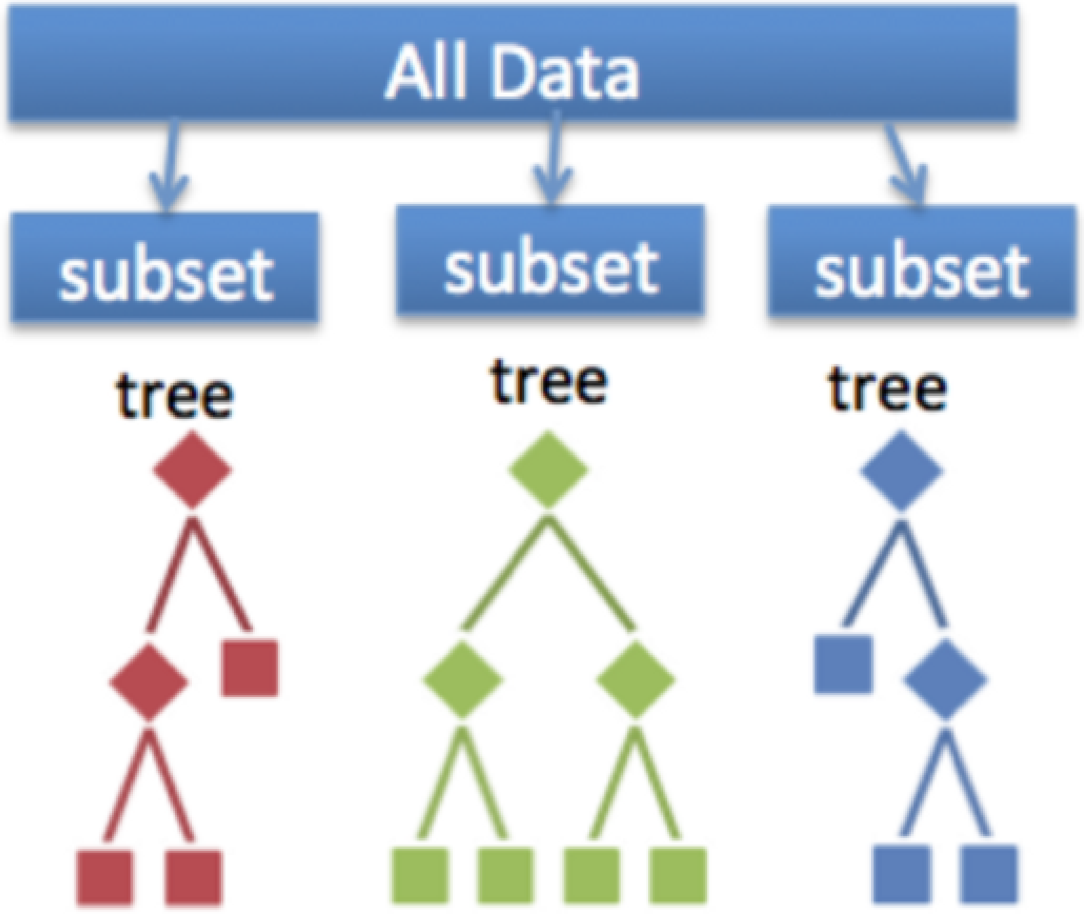
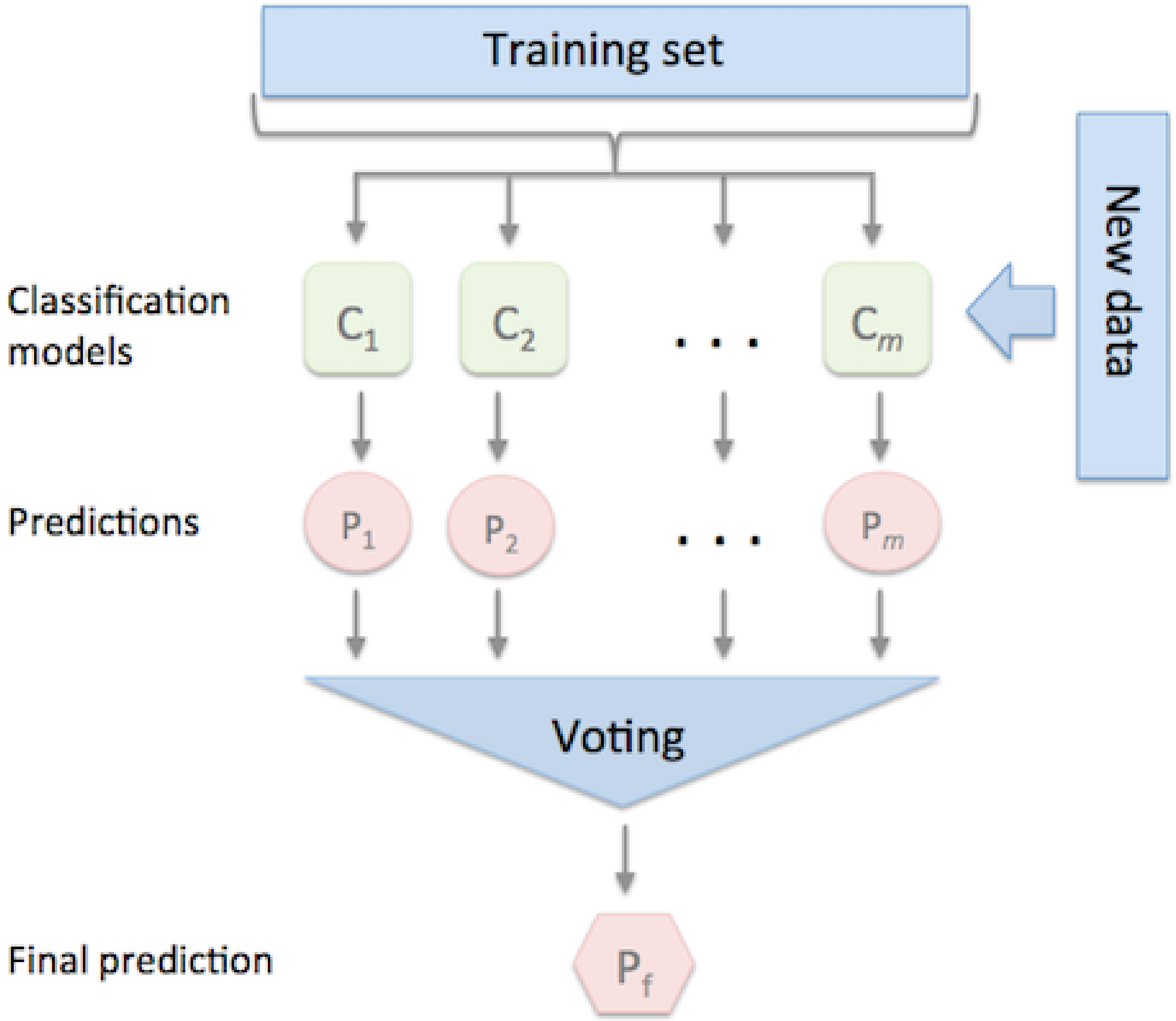
What are ensemble methods: bagging versus stacking



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!

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