Eclipse/IDEs

- generate class files with package structure, etc.
- auto-generate method stubs (auto-generate getters/setters)
- check syntax on the fly
- auto-complete as you type
- automatically add imports
- automatically add try/catch blocks
- debugging
- variable, method, parameter, renaming
- Javadoc

Javadoc

- human readable
- easily generated in most IDEs
- can use tools to automatically generate documentation

Multiclass classification

- **Examples**
  - Label: Same setup where we have a set of features for each example
  - Apple
  - Orange
  - Apple
  - Banana
  - Banana
  - Pineapple
  - Real-world examples?

Real world multiclass classification

- **Examples**
  - Document classification
  - Protein classification
  - Handwriting recognition
  - Face recognition
  - Most real-world applications tend to be multiclass
  - Sentiment analysis
  - Autonomous vehicles

Multiclass: current classifiers

- Any of these work out of the box?
- With small modifications?

k-Nearest Neighbor (k-NN)

- To classify an example $d$:
  - Find $k$ nearest neighbors of $d$
  - Choose as the label the majority label within the $k$ nearest neighbors

- No algorithmic changes!
**Decision Tree learning**

Base cases:
1. If all data belong to the same class, pick that label
2. If all the data have the same feature values, pick majority label
3. If we're out of features to examine, pick majority label
4. If we don't have any data left, pick majority label of parent
5. If some other stopping criteria exists to avoid overfitting, pick majority label

Otherwise:
- calculate the "score" for each feature if we used it to split the data
- pick the feature with the highest score, partition the data based on that data value and call recursively

*No algorithmic changes!*

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**Perceptron learning**

Hard to separate three classes with just one line 😊

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**Black box approach to multiclass**

Abstraction: we have a generic binary classifier, how can we use it to solve our new problem

- Optionally: also output a confidence/score

Can we solve our multiclass problem with this?