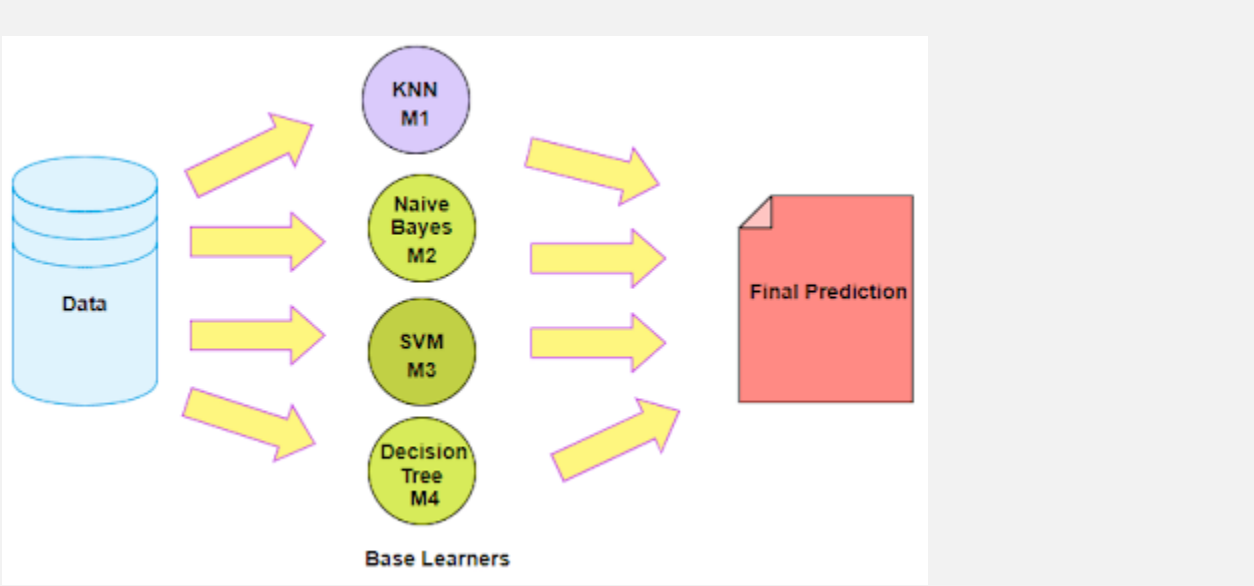
Random Forest Regression

Try to understand one of the most important algorithms in machine learning i.e. Random Forest Algorithm. We will try to look at the things that make Random Forest so special and will try to implement it on a real life dataset.

Ensemble Learning

An Ensemble method is a technique that **combines the predictions from multiple machine learning algorithms** together to make more accurate predictions than any individual model. A model comprised of many models is called an **Ensemble model**.



Ensemble Learning Method

Types of Ensemble Learning:

1. Boosting.
2. Bootstrap Aggregation (Bagging).

1. Boosting

Boosting refers to a group of algorithms that utilize weighted averages to make weak learners into stronger learners. Boosting is all about “teamwork”. Each model that runs, dictates what features the next model will focus on.

In **boosting** as the name suggests, one is learning from other which in turn **boosts** the learning.

2. Bootstrap Aggregation (Bagging)

Bootstrap refers to **random sampling with replacement**. Bootstrap allows us to better **understand the bias and the variance** with the dataset. Bootstrap involves random sampling of small subset of data from the dataset.

It is a general procedure that can be used to **reduce the variance** for those **algorithm that have high variance, typically decision trees**. Bagging makes each model run independently and then **aggregates the outputs at the end without preference to any model**.

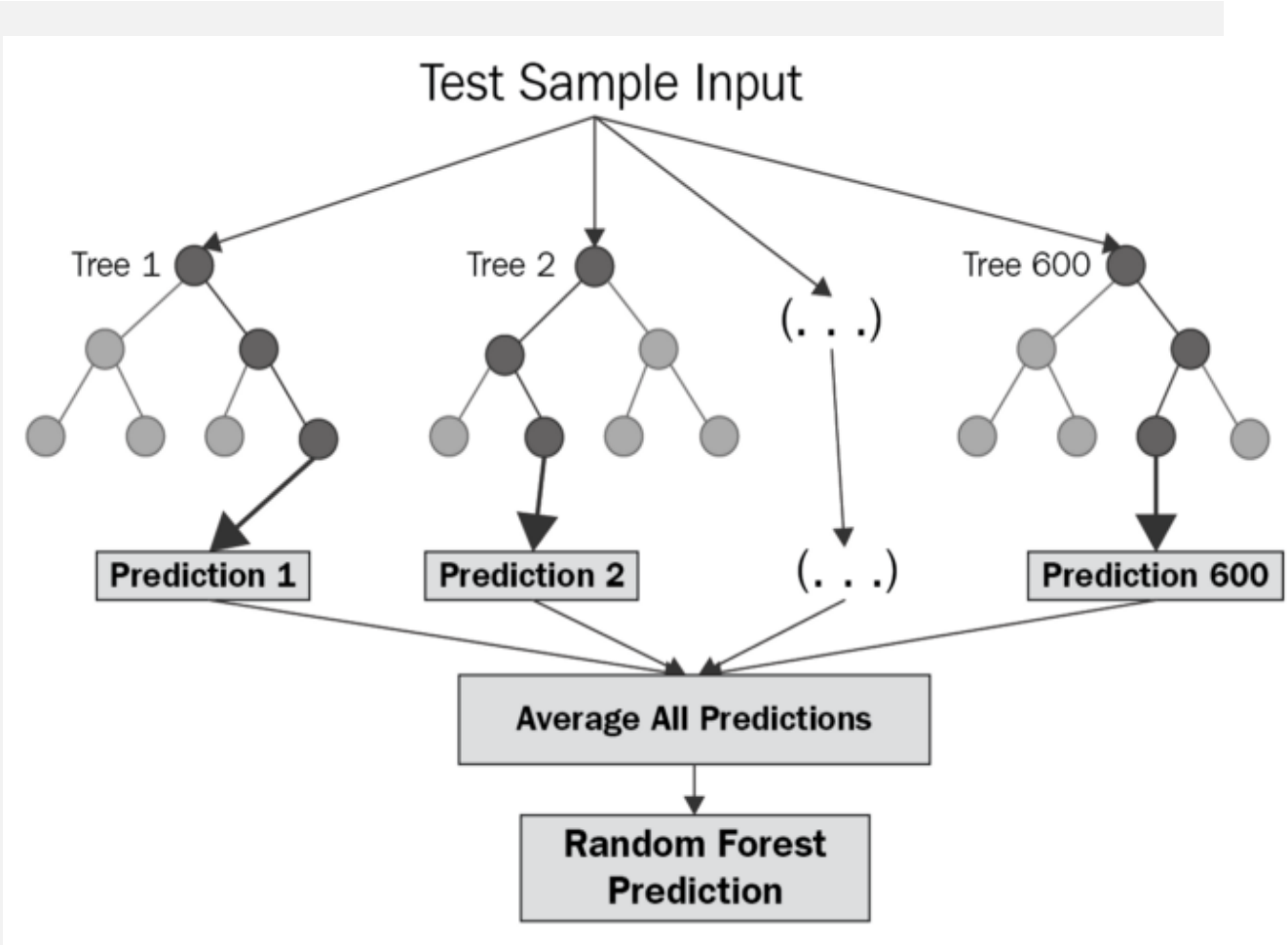
Problems with Decision Trees :(

Decision trees are sensitive to the specific data on which they are trained. If the training data is changed the resulting decision tree can be quite different and in turn the **predictions can be quite different**.

Also Decision trees are **computationally expensive to train**, carry a big risk of **overfitting**, and tend to find local optima because they can't go back after they have made a split.

To address these weaknesses, we turn to Random Forest :) which illustrates the power of combining many decision trees into one model.

Random Forest



Random Forest Structure

Random forest is a **Supervised Learning algorithm** which uses ensemble learning method for **classification and regression**.

Random forest is a **bagging** technique and **not a boosting** technique. The trees in **random forests** are run in parallel. There is no interaction between these trees while building the trees.

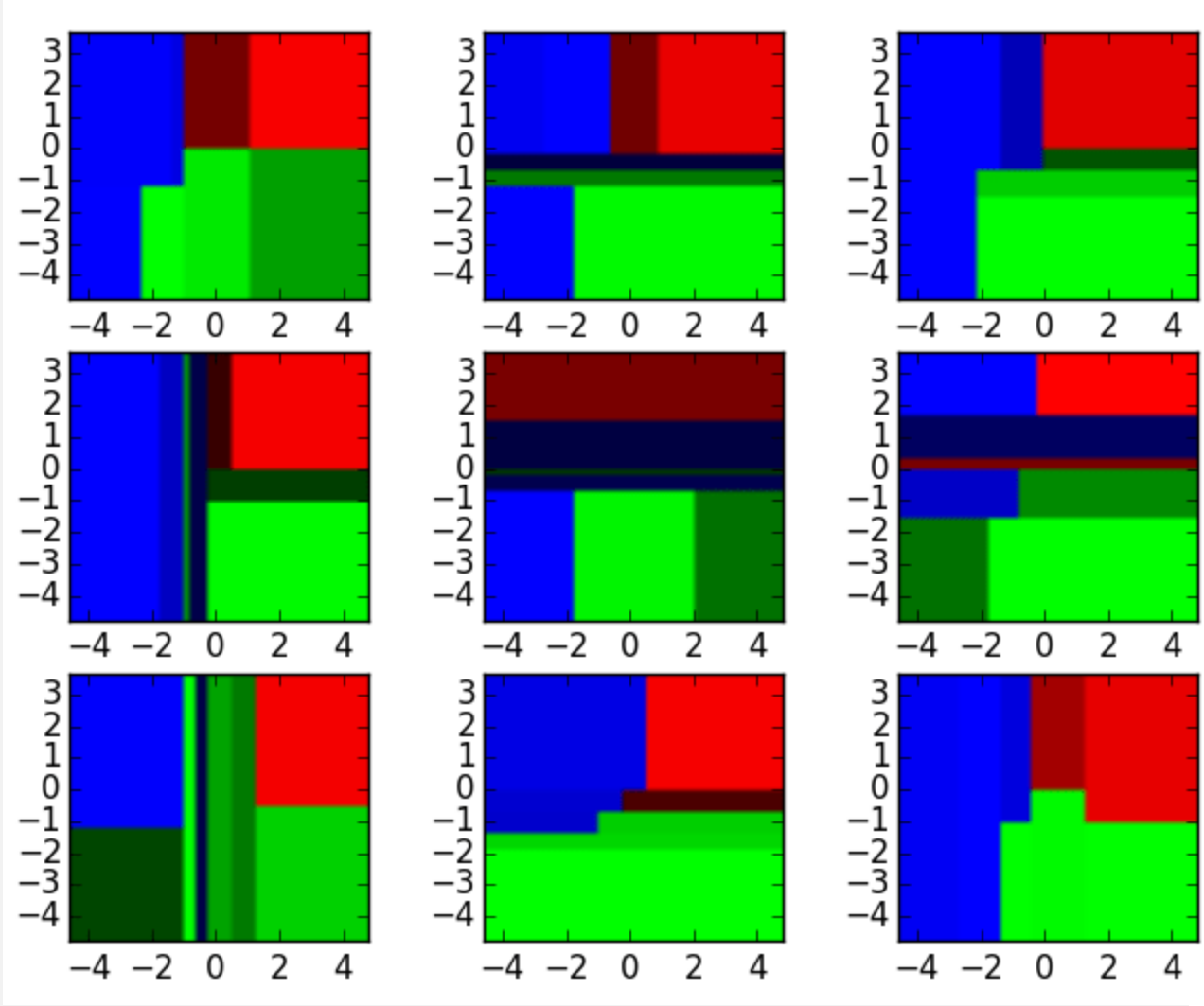
It operates by constructing a multitude of decision trees at training time and outputting the class that is the **mode** of the **classes (classification)** or **mean prediction (regression)** of the individual trees.

A random forest is a meta-estimator (i.e. it combines the result of multiple predictions) which **aggregates many decision trees**, with some helpful modifications:

1. The number of features that can be split on at each node is limited to some percentage of the total (which is known as the **hyperparameter**). This ensures that the ensemble model **does not rely too heavily on any individual feature**, and makes **fair use of all potentially predictive features**.
2. Each tree draws a random sample from the original data set when generating its splits, adding a further element of randomness that prevents **overfitting**.

The above modifications help prevent the trees from being too highly correlated.

For Example, See these nine decision tree classifiers below :

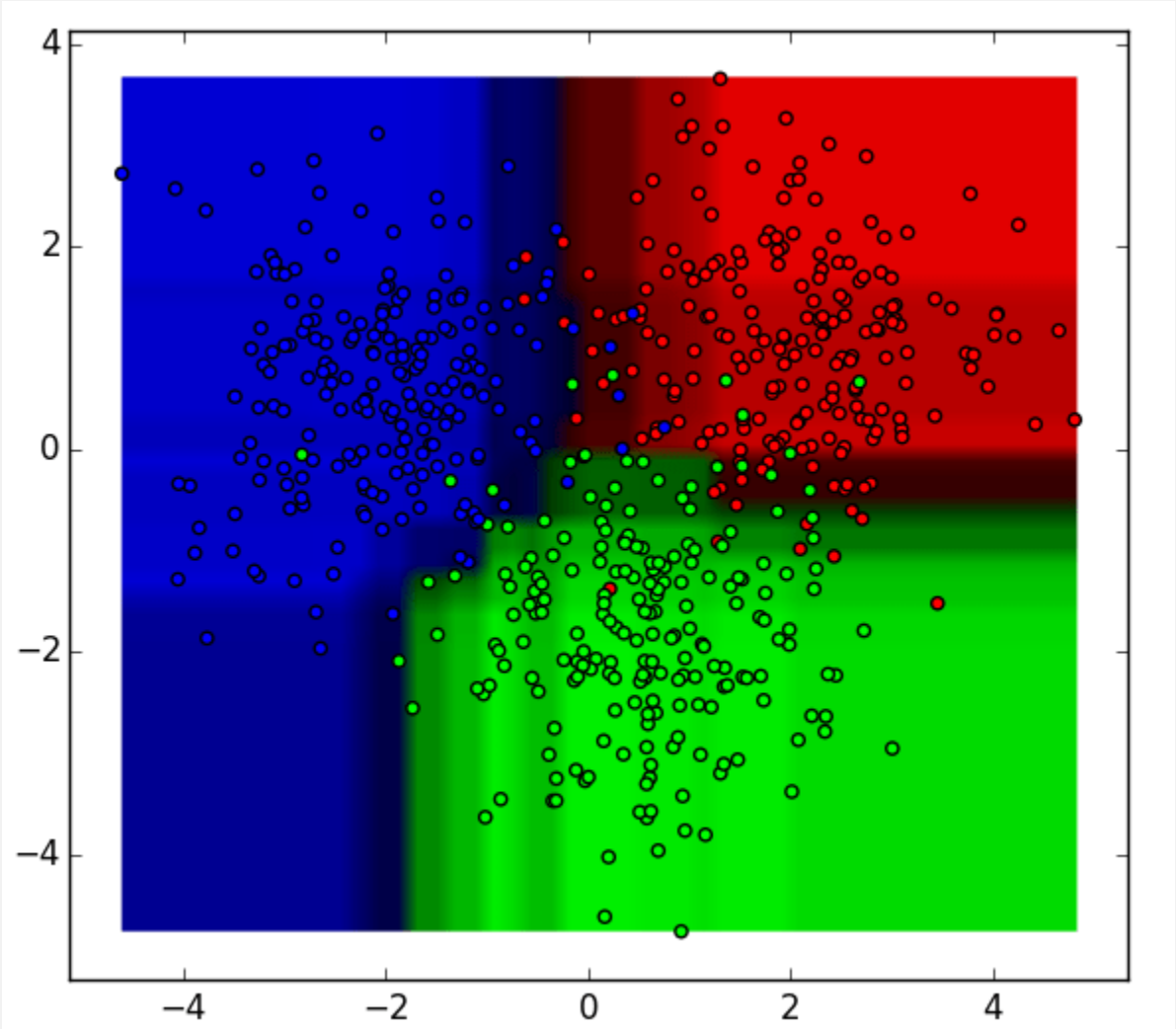


Nine Different Decision Tree Classifiers

These decision tree classifiers can be aggregated into a random forest ensemble which **combines their input**. Think of the horizontal and vertical axes of the above decision tree outputs as features x1 and x2. At certain values of each feature, the decision tree outputs a classification of “blue”, “green”, “red”, etc.

These above **results are aggregated**, through model votes or averaging, into a single ensemble model that ends up outperforming any individual decision tree’s output.

The aggregated result for the nine decision tree classifiers is shown below :



Random Forest ensemble for the above Decision Tree classifiers

Feature and Advantages of Random Forest :

1. It is one of the most accurate learning algorithms available. For many data sets, it produces a **highly accurate classifier**.

2. It runs efficiently on large databases.

3. It can **handle thousands of input variables** without variable deletion.

4. It gives estimates of what variables that are important in the classification.

5. It generates an internal **unbiased estimate of the generalization error** as the forest building progresses.

6. It has an **effective method for estimating missing data** and maintains accuracy when a large proportion of the data are missing.

Disadvantages of Random Forest :

1. Random forests have been observed to **overfit for some datasets** with noisy classification/regression tasks.

2. For data including categorical variables with different number of levels, **random forests are biased in favor of those attributes with more levels**. Therefore, the variable importance scores from random forest are not reliable for this type of data.

   1 . Normal 2. Type 1 cancer 3 Type 2 cancer 4 last Stage