machine learning model parameters: 1. input data：training features + labels/targets

2. model attributes: internal parameters that the model can adjust or optimize according to training data

3. hyperparameters: other input parameters to the model that users can specify

In [machine learning](https://en.wikipedia.org/wiki/Machine_learning), hyperparameter tuning, or hyperparameter optimization, is the problem of choosing a set of optimal hyperparameters for a learning algorithm. A hyperparameter is a [parameter](https://en.wikipedia.org/wiki/Parameter) whose value is used to control the learning process. By contrast, the values of other parameters (typically node weights) are learned. By experimenting and examining the results (accuracy, AUC, etc), researchers choose the hyperparameters that give the best results.

The same kind of machine learning model can require different constraints, weights or learning rates to generalize different data patterns. These measures are called hyperparameters, and have to be tuned so that the model can optimally solve the machine learning problem. Hyperparameter optimization finds a tuple of hyperparameters that yields an optimal model which minimizes a predefined [loss function](https://en.wikipedia.org/wiki/Loss_function) on given independent data. The objective function takes a tuple of hyperparameters and returns the associated loss. [Cross-validation](https://en.wikipedia.org/wiki/Cross-validation_(statistics)) is often used to estimate this generalization performance.

1. Train, validation, test
2. Hyperparameter tuning (search through hyperparameter combination and train models with each combination. The research goal is to get the model and its hyperparameter combination with the best performance on the training data.
3. Apply trained model