**Machine learning models**

These models are chosen based on the problem type (classification, regression, clustering, etc.), data characteristics, and desired outcomes.

They can be broadly grouped into several categories based on their common use cases and methodologies. Here’s a short summary of the main types:

1. **Supervised Learning**:
   * **Linear Regression**: Predicts continuous outcomes based on linear relationships between input features.
   * **Logistic Regression**: Used for binary classification problems, predicting the probability of a class label.
   * **Decision Trees**: Non-linear models that split data into branches to make predictions.
   * **Random Forests**: Ensemble method using multiple decision trees to improve accuracy and reduce overfitting.
   * **Support Vector Machines (SVM)**: Finds the optimal hyperplane to separate data points of different classes.
   * **Neural Networks**: Complex models inspired by the human brain, used for both regression and classification tasks.
2. **Unsupervised Learning**:
   * **K-Means Clustering**: Partitions data into K distinct clusters based on feature similarity.
   * **Hierarchical Clustering**: Builds a tree of clusters to represent data at different levels of granularity.
   * **Principal Component Analysis (PCA)**: Reduces the dimensionality of data while preserving as much variance as possible.
   * **t-SNE**: Visualizes high-dimensional data in two or three dimensions, preserving local structures.
   * **Autoencoders**: Neural networks used for dimensionality reduction and feature learning.
3. **Semi-Supervised Learning**:
   * Combines a small amount of labeled data with a large amount of unlabeled data to improve learning accuracy. Common models include variations of supervised models adapted for semi-supervised contexts.
4. **Reinforcement Learning**:
   * **Q-Learning**: A model-free algorithm that learns the value of actions in states to maximize cumulative reward.
   * **Deep Q-Networks (DQN)**: Combines Q-learning with deep neural networks to handle high-dimensional state spaces.
   * **Policy Gradient Methods**: Directly optimize the policy by gradient ascent on the expected reward.
5. **Deep Learning**:
   * **Convolutional Neural Networks (CNNs)**: Primarily used for image processing and computer vision tasks.
   * **Recurrent Neural Networks (RNNs)**: Suitable for sequential data like time series or natural language processing (NLP).
   * **Transformers**: State-of-the-art models for NLP tasks, leveraging self-attention mechanisms (e.g., BERT, GPT).
   * **Generative Adversarial Networks (GANs)**: Consist of two networks (generator and discriminator) that compete to generate realistic data.
6. **Ensemble Methods**:
   * **Boosting**: Sequentially builds models to correct errors of previous models (e.g., AdaBoost, Gradient Boosting, XGBoost).
   * **Bagging**: Combines predictions from multiple models trained on different subsets of data (e.g., Random Forests).

**Model evaluation**

Here's a summary of key ways to conduct model evaluation in machine learning:

**1. Data Splitting:**

* **Train-Test Split:**
  + Divide data into training (for model learning) and testing (for performance assessment).
  + Simple and quick, but can be influenced by the specific split.
* **Train-Validation-Test Split:**
  + Further split training data into training and validation sets.
  + Validation set helps fine-tune hyperparameters, while the test set provides a final, unbiased evaluation.

**2. Cross-Validation:**

* **K-Fold Cross-Validation:**
  + Divide data into 'k' folds.
  + Train the model on k-1 folds and test on the remaining fold, repeating 'k' times.
  + Provides a more robust estimate of performance.
* **Stratified Cross-Validation:**
  + Ensures each fold maintains the same class distribution as the original dataset.
  + Crucial for imbalanced datasets.

**3. Evaluation Metrics:**

* **Classification:**
  + Accuracy: Overall correctness.
  + Precision: True positives / predicted positives.
  + Recall: True positives / actual positives.
  + F1-Score: Harmonic mean of precision and recall.
  + ROC-AUC: Area under the Receiver Operating Characteristic curve.
* **Regression:**
  + Mean Absolute Error (MAE): Average absolute difference between predictions and actual values.
  + Mean Squared Error (MSE): Average squared difference.
  + Root Mean Squared Error (RMSE): Square root of MSE.
  + R-squared: measures the proportion of the variance in the dependent variable that is predictable from the independent variable(s).1

**4. Other Techniques:**

* **Learning Curves:**
  + Plot model performance against training set size.
  + Diagnose underfitting and overfitting.
* **Robustness Testing:**
  + Evaluate model performance on perturbed or noisy data.
  + Assess model stability.
* **Evaluating on Unseen Data:**
  + After model deployment, continual monitoring of real world performance.

**Key Considerations:**

* Choose metrics relevant to the problem and business objectives.
* Account for imbalanced datasets.
* Ensure proper data splitting to avoid bias.
* Continuously Monitor model performance after deployment.