CAP 781
MACHINE LEARNING

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UNIT – II
Supervised Learning

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Content

- Regression
- Linear Regression
- Polynomial Regression
- Classification
- Logistic Regression
- k-Nearest Neighbors (k-NN)
- Support Vector Machines (SVM)
- Decision Trees and Random Forests
- Ensemble Methods
- Bagging, Boosting
- Model Evaluation Techniques
- Cross Validation
- Hyperparameter Tuning
- Introduction to Scikit-learn
- Hands-on with Real-world Datasets

Linear Regression

- Simple Linear Regression
  (**Jupyter Lab:** 4.LinearRegression.ipynb)
- Multilinear Regression
  (**Jupyter Lab:** 4.LinearRegression.ipynb)
- Polynomial Regression (Linear in Parameters)
  (**Jupyter Lab:** 5.PolynomialRegression.ipynb)

Non-Linear Regression

Non-linear regression is a type of regression analysis where the relationship between the dependent variable (output) and independent variable(s) (input) cannot be described using a straight line (linear equation).

Instead, it uses equations that are non-linear in their parameters, often involving exponents, logarithms, trigonometric functions, or other transformations.

- Non-Linear Regression

  (**Jupyter Lab:** 6.NonLinearRegression.ipynb)

Non-Linear Regression

- In non-linear regression, the model:
  - Does not follow the form $y=mx+b$.
  - Can involve more complex relationships, such as $y=ax^2+bx+c$, $y=ae^{bx}$, or $y=sin(ax+b)$.
- The characteristics of non-linear regression are:
  - The model's parameters appear in a non-linear fashion.
  - The curve fitting process often requires iterative algorithms to minimize errors.
- Non-linear regression is used when the data exhibits a non-linear pattern that cannot be captured by linear models, even with transformations.

Is Polynomial Regression an Example of Non-Linear Regression?

No, **polynomial regression** is not considered non-linear regression because:

- The relationship between the dependent and independent variable in polynomial regression is non-linear (e.g., $y=ax^2+bx+c$), but **the model is linear in terms of the parameters a,b,c**.
- The equation can be rewritten in matrix form where it remains linear with respect to the coefficients.

Since the optimization problem involves finding linear coefficients (despite the powers of x), polynomial regression falls under **linear regression**.

Differences

- **Polynomial regression**: Non-linear relationship between input and output but linear in parameters → **linear regression**.
- **Non-linear regression**: Non-linear relationship between input, output, and parameters → Requires non-linear optimization techniques.
- **Examples**
  - **Polynomial Regression (Linear in Parameters)**:
    - $y=ax^2+bx+c$
  - **True Non-Linear Regression**:
    - $y=a.b^x+c$

  Here, a and b appear in a non-linear form, making it a non-linear regression model.

Classification

- Logistic Regression
  (**Jupyter Lab: 7**.LogisticRegression.ipynb)
- Decision Trees
  - (**Jupyter Lab: 8**.Decision_Tree.ipynb)
- k-Nearest Neighbors (k-NN)
  (**Jupyter Lab: 9.**Classification_KNN.ipynb)
- Classification Evaluation Metrics
  - (**Jupyter Lab: 10.**Classification_Evaluation.ipynb)
- Random Forests
  (**Jupyter Lab: 11**.RandomForest.ipynb)
- Support Vector Machines (SVM)
  (**Jupyter Lab: 12**.SupportVectorMachine.ipynb)