

Module 4: Supervised Classical Machine Learning

- 1 What is meant by **Supervised** ?
- 2 **Naive Bayes Classifier**
 - 2.1 Bayes Theorem.
 - 2.2 Continuous Probability Distributions.
 - 2.3 Estimation of population parameters for univariate case when data is continuous.
 - 2.3.1 Gradient Descent
 - 2.3.2 Newton's Method
 - 2.4 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
 - 2.5 **Coding Assignment 15.**
 - 2.6 Biclass Bayes Classifier for Univariate case when the data is continuous.
 - 2.7 Cross Validation and Testing
 - 2.8 High Variance and High Bias problem.
 - 2.9 **Portfolio Mini Project 1 on Bayes Classifier.**
 - 2.10 Discrete Probability Distributions.
 - 2.11 Estimation of population parameters for univariate case when the data is discrete.
 - 2.12 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
 - 2.13 **Coding Assignment 16.**
 - 2.14 Biclass Bayes Classifier for Univariate case when the data is discrete.
 - 2.15 Laplace Smoothing
 - 2.16 **Portfolio Mini Project 2 on Bayes Classifier.**
 - 2.17 Why the Bayes Classifier is called 'Naive' ?
 - 2.18 Estimation of population parameters for multivariate case when the data is continuous and each variable has identical non stationary distribution.
 - 2.19 Covariance Matrix Estimation, positive semi definiteness and singularity.
 - 2.20 Correcting the problems with Covariance Matrix
 - 2.20.1 Fisher Method
 - 2.20.2 Diagonal Covariance Estimators
 - 2.20.3 Regularization Methods
 - 2.21 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
 - 2.22 **Coding Assignment 17.**
 - 2.23 Biclass Bayes Classifier for Multivariate case when the data is continuous.
 - 2.24 **Portfolio Mini Project 3 on Bayes Classifier.**
 - 2.25 Estimation of population parameters for multivariate case when the data is discrete and each variable has identical non stationary distribution.
 - 2.26 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
 - 2.27 **Coding Assignment 18.**
 - 2.28 Biclass Bayes Classifier for Multivariate case when the data is discrete.
 - 2.29 **Portfolio Mini Project 4 on Bayes Classifier.**
 - 2.30 Biclass Bayes Classifier for multivariate case when all the variables have different continuous and discrete probability distributions.
 - 2.31 **Portfolio Mini Project 5 on Bayes Classifier.**
 - 2.32 Multiclass Bayes Classifier for multivariate case when all the variables have different continuous and discrete probability distributions.
 - 2.33 **Portfolio Project 4 on Bayes Classifier for Tabulated Data.**
 - 2.34 **Portfolio Project 5 on Bayes Classifier for Visual Data (Images).**
 - 2.35 **Portfolio Project 6 on Bayes Classifier for Textual Data (Text).**

3 Linear and Polynomial Regression

- 3.1 What is a Regressor ?
- 3.2 Dependent and Independent Random Variables.
- 3.3 Data Visualization
- 3.4 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
- 3.5 **Coding Assignment 19.**
- 3.6 Why and When Linear ?
- 3.7 High Bias V/s High Variance problem (Underfitting V/s Overfitting).
- 3.8 Population parameter estimation of Dependent Random Variable.
- 3.9 Likelihood Function.
- 3.10 Bayesian Inference.
- 3.11 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
- 3.12 **Coding Assignment 20.**
- 3.13 Linear Regression for Single Independent Random Variable.
- 3.14 Improving Linear Regression.
 - 3.14.1 Normalization.
 - 3.14.2 Regularization.
 - 3.14.2.1 Classical Regularization Theory.
 - 3.14.2.2 Generalized Regularization Theory.
 - 3.14.2.3 Estimating the regularization parameter.
 - 3.14.3 Trade-off between stability and bias.
- 3.15 Different ways of looking at Regularization.
 - 3.15.1 Adding Prior Information about the practical world.
 - 3.15.2 Adding Penalty.
- 4 Cross Validation and Testing.
- 5 **Portfolio Mini Project 6 on Univariate Linear Regression.**
- 6 Natural Features and Derived Features.
- 7 Multivariate Linear Regression with numerous Natural Features.
- 8 **Portfolio Mini Project 7 on Multivariate Linear Regression.**
- 9 Multivariate Regression with Natural and Derived Features.
- 10 The interpretation.
- 11 Model selection for multivariate regression.
 - 11.1 Kolmogorov Complexity Theory.
 - 11.2 MDL principle.
- 12 Looking at Multivariate Regression through matrices.
- 13 Normal Equation.
- 14 Interpretation of Normal Equation of Multivariate Regression.
- 15 Regularization Revisited
 - 15.1 Cross Correlation Matrices.
 - 15.2 Positive Definite Cross Correlation Matrices.
 - 15.3 Adding Prior information.
 - 15.4 Adding Penalty.
- 16 **Portfolio Project 7 on Multivariate Regression.**
- 17 **Logistic Regression**
 - 17.1 How come the word **Logistic** ?
 - 17.2 Why Logistic ?
 - 17.3 Dependent and Independent Random Variables.
 - 17.4 Data Visualization
 - 17.5 Dependent Random Variable as Binomial.
 - 17.6 Exponential Family of Distributions.

- 17.6.1 Natural Parameters.
- 17.6.2 Sufficient Statistics.
- 17.6.3 Required Functions.
- 17.7 Parameter Estimation.
- 17.8 Generalized Linear Models.
 - 17.8.1 Assumptions on Exponential Family of Distributions.
- 17.9 Likelihood Function.
- 17.10 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
- 17.11 **Coding Assignment 21.**
- 17.12 Univariate Biclass Logistic Regression.
- 17.13 **Portfolio Mini Project 8 on Univariate Logistic Regression.**
- 18 Similarities between Linear and Logistic Regression.
- 19 Differences between Linear and Logistic Regression.
- 20 From Multiclass Naive Bayes to Multiclass Logistic Regression.
- 21 Bayesian Inference in Univariate Biclass Logistic Regression.
- 22 Regularization Revisited
- 23 **Portfolio Project 8 on Multivariate Logistic Regression.**
- 24 **Some interesting results and observations.**
- 25 Exponential Family of Distributions Revisited
 - 25.1 Wide choice of distributions for Dependent Random Variable.
 - 25.2 Variety of Continuous Probability Distributions used.
 - 25.3 Variety of Discrete Probability Distributions used.
- 26 Generalized Linear Model Assumption.
- 27 Multiple point of views to look at the same problem of Prediction and Classification.
- 28 Bayesian Inference V/s Generalized Linear Models V/s Regression.
- 29 **Regression and Classification Trees**
 - 29.1 A Binary Tree.
 - 29.2 Terminology associated with Binary Tree.
 - 29.3 Decision Tree as special case of Binary Tree.
- 30 Recursive Binary Splitting.
- 31 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
- 32 **Coding Assignment 22.**
- 33 Introduction to Information Theory.
- 34 Entropy.
- 35 Information Gain.
- 36 Different Cost Functions.
 - 36.1 Mean Squared Error.
 - 36.2 Gini Index.
 - 36.3 Cross Entropy.
- 37 Feature Selection.
- 38 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
- 39 **Coding Assignment 23.**
- 40 Stopping Criteria.
- 41 Pruning.
 - 41.1 Common Method.
 - 41.2 Cost Complexity Pruning.
 - 41.3 **Portfolio Mini Project 9 on Regression Trees.**
 - 41.4 **Portfolio Mini Project 10 on Classification Trees.**
 - 41.5 Ensemble Methods

- 41.5.1 Bagging.
 - 41.5.1.1 Bagged Decision Trees.
 - 41.5.1.2 Random Forest.
 - 41.5.1.3 Extra Trees.
- 42 Boosting.
 - 42.1 AdaBoost.
 - 42.2 Stochastic Gradient Boosting.
 - 42.3 XGBoost.
 - 42.4 **Portfolio Project 9 on Boosting.**
- 43 **Time Series Forecasting**
 - 43.1 What is Time Series Forecasting.
 - 43.2 Time Series as Supervised Learning.
 - 43.3 Load and Explore Time Series Data.
 - 43.4 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
 - 43.5 **Coding Assignment 24.**
 - 43.6 Basic Feature Engineering.
 - 43.7 Data Visualization.
 - 43.8 Resampling and Interpolation.
 - 43.9 Power Transforms.
 - 43.10 Moving Average Smoothing.
 - 43.11 Introduction to White Noise.
 - 43.12 Introduction to Random Walk.
 - 43.13 Stationarity in Time Series Data.
 - 43.14 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
 - 43.15 **Coding Assignment 25.**
 - 43.16 Reframing Time Series Forecasting problems.
 - 43.17 Seasonality and Trends.
 - 43.18 Autoregression for Forecasting.
 - 43.19 **Portfolio Mini Project 11.**
 - 43.20 Moving Average Models for Forecasting.
 - 43.21 ARIMA model for Forecasting.
 - 43.22 **Portfolio Mini Project 12.**
 - 43.23 Autocorrelation and partial Autocorrelation.
 - 43.24 Grid Search for ARIMA Model Hyperparameters.
 - 43.25 Forecast Confidence Intervals.
 - 43.26 **Portfolio Project 10 on Time Series Forecasting.**
- 44 **Support Vector Machines**
 - 44.1 Why Support Vector Machines ?
 - 44.2 Linearly and Non linearly seperable datasets.
 - 44.3 **Support Vector Machines Classification for Linearly Seperable Datasets or Hard Margin SVM.**
 - 44.3.1 Optimal Seperating hyperplane.
 - 44.3.2 No man's land.
 - 44.3.3 Formulating the problem as maximizing the no man's land.
 - 44.3.4 Constructing the constraints from the criteria of no man's land.
 - 44.3.5 Non Convexity of Objective function.
 - 44.3.6 Final Formulation of primal problem
 - 44.3.6.1 Minimization of Primal Objective Function.
 - 44.3.6.2 Convex Quadratic Programming.
 - 44.3.6.3 Constrained Problem.

- 44.3.6.4 Linear Inequality Constraints.
- 44.3.6.5 Difficult to solve.
- 45 Construction of Lagrangian Function.
- 46 Dual Problem and its objective function.
- 47 Karush-Kuhn-Tucker Conditions.
- 48 Solving Primal Problem through Dual Problem.
- 49 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
- 50 **Coding Assignment 25.**
- 51 **Support Vector Machines Classification for Linearly Seperable Datasets with Noise or Soft Margin SVM.**
 - 51.1 Outlier reducing the margin.
 - 51.2 Outlier breaking linear seperability.
 - 51.3 Soft Margin to rescue.
 - 51.3.1 Slack Variables.
 - 51.3.2 Regularization.
 - 51.3.3 Soft Margin SVM Primal problem formulation.
 - 51.3.4 Dual Problem Formulation.
 - 51.3.5 Solving Primal Problem through Dual Problem.
 - 51.3.6 Box constraint on the values of Lagrange Multipliers.
 - 51.3.7 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
 - 51.3.8 **Coding Assignment 26.**
- 52 **Support Vector Machines Classification for Non Linearly Seperable Datasets.**
 - 52.1 Feature Transformations.
 - 52.2 Kernels.
 - 52.3 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
 - 52.4 **Coding Assignment 27.**
 - 52.5 Mercer Theorem.
 - 52.6 Kernel Trick.
 - 52.7 Kernel Types.
 - 52.8 Which Kernel to use ?
 - 52.9 Sequential Minimal Optimization
 - 52.9.1 Why Sequential Minimal Optimization ?
 - 52.9.2 The Idea behind Sequential Minimal Optimization.
 - 52.9.3 How did we get to Sequential Minimal Optimization ?
 - 52.9.4 Why is Sequential Minimal Optimization faster ?
 - 52.9.5 Sequential Minimal Optimization Algorithm
 - 52.9.5.1 Choosing First and Second Lagrange Multipliers.
 - 52.9.5.2 Solving Optimization Problem Analytically.
- 53 **Portfolio Mini Project 13 on Non linear SVM.**
- 54 **Portfolio Project 11 on Multi Class SVM.**
- 55 **Ensemble Learning**
 - 55.1 **Portfolio Project 12 on Ensemble Learning.**
- 56 **Neural Networks**
 - 56.1 A multivariate function as a directed graph.
 - 56.1.1 Forward pass in a directed graph.
 - 56.2 Partially derivating a function with respect to each variable.
 - 56.2.1 Reverse Pass in a directed graph.
 - 56.3 What is a Neural Network ?
 - 56.4 The Human Brain.

- 56.5 Models of a Neuron.
- 56.6 Neural Networks viewed as Directed graphs.
- 56.7 Feedback.
- 56.8 Rosenblatt's Perceptron.
- 56.9 Different interpretations of Rosenblatt's Perceptron.
- 56.10 Activation Functions.
 - 56.10.1 Linear.
 - 56.10.2 Non Linear.
 - 56.10.2.1 Sigmoid.
 - 56.10.2.2 Hyperbolic Tan.
 - 56.10.2.3 ReLU.
 - 56.10.2.4 Leaky ReLU.
 - 56.10.2.5 ELU.
- 56.11 Which activation function to use and when ?
- 56.12 Shallow Neural Networks.
- 56.13 Forward Pass or Forward Propagation in Neural Networks.
- 56.14 Backward Propagation in Neural Networks.
- 56.15 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
- 56.16 **Coding Assignment 28.**