THE SUPERVISED LEARNING WORKSHOP

A NEW, INTERACTIVE APPROACH TO UNDERSTANDING SUPERVISED LEARNING ALGORITHMS



SECOND EDITION

BLAINE BATEMAN, ASHISH RANJAN JHA, BENJAMIN JOHNSTON, AND ISHITA MATHUR

The Supervised Learning Workshop Second Edition

A New, Interactive Approach to Understanding Supervised Learning Algorithms

Blaine Bateman, Ashish Ranjan Jha, Benjamin Johnston, and Ishita Mathur



The Supervised Learning Workshop

Second Edition

Copyright © 2020 Packt Publishing

All rights reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, without the prior written permission of the publisher, except in the case of brief quotations embedded in critical articles or reviews.

Every effort has been made in the preparation of this book to ensure the accuracy of the information presented. However, the information contained in this book is sold without warranty, either express or implied. Neither the authors, nor Packt Publishing, and its dealers and distributors will be held liable for any damages caused or alleged to be caused directly or indirectly by this book.

Packt Publishing has endeavored to provide trademark information about all of the companies and products mentioned in this book by the appropriate use of capitals. However, Packt Publishing cannot guarantee the accuracy of this information.

Authors: Blaine Bateman, Ashish Ranjan Jha, Benjamin Johnston, and Ishita Mathur

Reviewers: Tiffany Ford, Sukanya Mandal, Ashish Pratik Patil, and Ratan Singh

Managing Editor: Snehal Tambe
Acquisitions Editor: Anindya Sil
Production Editor: Samita Warang

Editorial Board: Shubhopriya Banerjee, Bharat Botle, Ewan Buckingham, Megan Carlisle, Mahesh Dhyani, Manasa Kumar, Alex Mazonowicz, Bridget Neale, Dominic Pereira, Shiny Poojary, Abhishek Rane, Brendan Rodrigues, Mugdha Sawarkar, Erol Staveley, Ankita Thakur, Nitesh Thakur, and Jonathan Wray

First published: April 2019

Second edition: February 2020

Production reference: 1280220

ISBN 978-1-80020-904-6

Published by Packt Publishing Ltd.

Livery Place, 35 Livery Street

Birmingham B3 2PB, UK

Table of Contents

Preface i
Chapter 1: Fundamentals of Supervised
Learning Algorithms 1
Introduction 2
When to Use Supervised Learning3
Python Packages and Modules 4
Loading Data in Pandas5
Exercise 1.01: Loading and Summarizing the Titanic Dataset 7
Exercise 1.02: Indexing and Selecting Data
Exercise 1.03: Advanced Indexing and Selection
Pandas Methods 17
Exercise 1.04: Splitting, Applying, and Combining Data Sources
Quantiles23
Lambda Functions24
Exercise 1.05: Creating Lambda Functions25
Data Quality Considerations
Managing Missing Data28
Class Imbalance
Low Sample Size 34
Activity 1.01: Implementing Pandas Functions
Summary 37

Chapter 2: Exploratory Data Analysis and Visualization 39)
Introduction 40)
Exploratory Data Analysis (EDA)40)
Summary Statistics and Central Values42	2
Exercise 2.01: Summarizing the Statistics of Our Dataset	3
Missing Values 48	3
Finding Missing Values49)
Exercise 2.02: Visualizing Missing Values50)
Imputation Strategies for Missing Values54	1
Exercise 2.03: Performing Imputation Using Pandas55	5
Exercise 2.04: Performing Imputation Using Scikit-Learn56	5
Exercise 2.05: Performing Imputation Using Inferred Values58	3
Activity 2.01: Summary Statistics and Missing Values61	I
Distribution of Values 65	5
Target Variable 65	5
Exercise 2.06: Plotting a Bar Chart65	5
Categorical Data67	7
Exercise 2.07: Identifying Data Types for Categorical Variables 68	3
Exercise 2.08: Calculating Category Value Counts70)
Exercise 2.09: Plotting a Pie Chart71	ĺ
Continuous Data73	3
Skewness75	5
Kurtosis	5
Exercise 2.10: Plotting a Histogram75	5
Exercise 2.11: Computing Skew and Kurtosis77	7
Activity 2.02: Visually Representing the Distribution of Values)

Relationships within the Data 84
Relationship between Two Continuous Variables 84
Pearson's Coefficient of Correlation 85
Exercise 2.12: Plotting a Scatter Plot
Exercise 2.13: Plotting a Correlation Heatmap
Using Pairplots90
Exercise 2.14: Implementing a Pairplot
Relationship between a Continuous and a Categorical Variable 92
Exercise 2.15: Plotting a Bar Chart
Exercise 2.16: Visualizing a Box Plot95
Relationship Between Two Categorical Variables97
Exercise 2.17: Plotting a Stacked Bar Chart
Activity 2.03: Relationships within the Data99
Summary 105
Summary
Chapter 3: Linear Regression 107
Chapter 3: Linear Regression 107
Chapter 3: Linear Regression 107 Introduction
Chapter 3: Linear Regression 107 Introduction
Chapter 3: Linear Regression107Introduction108Regression and Classification Problems108The Machine Learning Workflow109
Chapter 3: Linear Regression107Introduction108Regression and Classification Problems108The Machine Learning Workflow109Business Understanding110
Chapter 3: Linear Regression107Introduction108Regression and Classification Problems108The Machine Learning Workflow109Business Understanding110Data Understanding110
Chapter 3: Linear Regression107Introduction108Regression and Classification Problems108The Machine Learning Workflow109Business Understanding110Data Understanding110Data Preparation111
Chapter 3: Linear Regression107Introduction108Regression and Classification Problems108The Machine Learning Workflow109Business Understanding110Data Understanding110Data Preparation111Modeling111
Chapter 3: Linear Regression107Introduction108Regression and Classification Problems108The Machine Learning Workflow109Business Understanding110Data Understanding110Data Preparation111Modeling111Evaluation112

Linear Regression 125
Least Squares Method 126
The Scikit-Learn Model API 126
Exercise 3.02: Fitting a Linear Model Using the Least Squares Method 127
Activity 3.02: Linear Regression Using the Least Squares Method 132
Linear Regression with Categorical Variables 137
Exercise 3.03: Introducing Dummy Variables 139
Activity 3.03: Dummy Variables 150
Polynomial Models with Linear Regression 152
Exercise 3.04: Polynomial Models with Linear Regression
Activity 3.04: Feature Engineering with Linear Regression
Generic Model Training 163
Gradient Descent 165
Exercise 3.05: Linear Regression with Gradient Descent
Exercise 3.06: Optimizing Gradient Descent
Activity 3.05: Gradient Descent
Multiple Linear Regression 183
Exercise 3.07: Multiple Linear Regression
Summary 193
Chapter 4: Autoregression 195
Introduction 196
Autoregression Models 196
Exercise 4.01: Creating an Autoregression Model 197
Activity 4.01: Autoregression Model Based on Periodic Data 214
Summary 221

Chapter 5: Classification Techniques 223
Introduction 224
Ordinary Least Squares as a Classifier 224
Exercise 5.01: Ordinary Least Squares as a Classifier 226
Logistic Regression
Exercise 5.02: Logistic Regression as a Classifier – Binary Classifier 236
Exercise 5.03: Logistic Regression – Multiclass Classifier
Activity 5.01: Ordinary Least Squares Classifier – Binary Classifier 248
Select K Best Feature Selection249
Exercise 5.04: Breast Cancer Diagnosis Classification Using Logistic Regression
Classification Using K-Nearest Neighbors
Exercise 5.05: KNN Classification
Exercise 5.06: Visualizing KNN Boundaries259
Activity 5.02: KNN Multiclass Classifier 266
Classification Using Decision Trees
Exercise 5.07: ID3 Classification
Classification and Regression Tree280
Exercise 5.08: Breast Cancer Diagnosis Classification Using a CART Decision Tree
Activity 5.03: Binary Classification Using a CART Decision Tree 284
Artificial Neural Networks
Exercise 5.09: Neural Networks – Multiclass Classifier 288
Activity 5.04: Breast Cancer Diagnosis Classification Using Artificial Neural Networks
Summary 29 ²

Chapter 6: Ensemble Modeling 29	97
Introduction 2	.98
One-Hot Encoding 2	99
Exercise 6.01: Importing Modules and Preparing the Dataset	300
Overfitting and Underfitting 3	02
Underfitting 3	304
Overfitting 3	305
Overcoming the Problem of Underfitting and Overfitting	306
Bagging 3	07
Bootstrapping 3	
Exercise 6.02: Using the Bagging Classifier	
Random Forest 3	312
Exercise 6.03: Building the Ensemble Model Using Random Forest 3	313
Boosting 3	14
Adaptive Boosting 3	
Exercise 6.04: Implementing Adaptive Boosting 3	316
Gradient Boosting 3	319
Exercise 6.05: Implementing GradientBoostingClassifier to Build an Ensemble Model	320
Stacking 3	21
Exercise 6.06: Building a Stacked Model 3	324
Activity 6.01: Stacking with Standalone and Ensemble Algorithms 3	328
Summary 3	31
Chapter 7: Model Evaluation 33	33_
Introduction 3	34
Importing the Modules and Preparing Our Dataset 3	

Evaluation Metrics
Regression Metrics
Exercise 7.01: Calculating Regression Metrics
Classification Metrics
Numerical Metrics
Curve Plots346
Exercise 7.02: Calculating Classification Metrics
Splitting a Dataset
Hold-Out Data
K-Fold Cross-Validation 352
Sampling
Exercise 7.03: Performing K-Fold Cross-Validation with Stratified Sampling
Performance Improvement Tactics
Variation in Train and Test Errors
Learning Curve
Validation Curve357
Hyperparameter Tuning 358
Exercise 7.04: Hyperparameter Tuning with Random Search 360
Feature Importance 364
Exercise 7.05: Feature Importance Using Random Forest
Activity 7.01: Final Test Project
Summary 369
Appendix 371
Index 467