



# **SUPERVISED MACHINE LEARNING**

**OPTIMIZATION FRAMEWORK AND APPLICATIONS  
WITH SAS AND R**

Tanya Kolosova and Samuel Berestizhevsky



165  
6,800 -  
สำนักหอสมุด มหาวิทยาลัยเชียงใหม่ โทร ๐๕๒๕๘๖๘๔๗๕  
๐๑๒๕๘๕๙๐

# Supervised Machine Learning

## Optimization Framework and Applications with SAS and R



Tanya Kolosova PhD  
Associates in Analytics Inc., Boca Raton, Florida

Samuel Berestizhevsky MSc  
Associates in Analytics Inc., Boca Raton, Florida



CRC Press  
Taylor & Francis Group  
Boca Raton London New York

CRC Press is an imprint of the  
Taylor & Francis Group, an Informa business  
A CHAPMAN & HALL BOOK

---

# *Contents*

---

Acknowledgments .....	xiii
Authors .....	xv
Introduction: Challenges in the Application of Machine Learning Classification Methods.....	xvii

## **Part I**

<b>1. Introduction to the AI Framework .....</b>	<b>3</b>
1.1 Components of the AI Framework and Their Interaction.....	3
1.2 AI Framework in Detail .....	5
1.2.1 Creating Training and Test Datasets.....	5
1.2.2 Design of Experiments for a Classifier .....	6
1.2.3 Firth Logistic Regression .....	6
1.2.4 Data Contamination .....	6
1.2.5 Best Classifiers.....	7
1.3 SAS Procedures for the AI Framework Components .....	7
1.4 R Libraries for the AI Framework Components.....	7
References .....	8
<b>2. Supervised Machine Learning and Its Deployment in SAS and R .....</b>	<b>9</b>
2.1 Introduction .....	9
2.2 Principles of Supervised Machine Learning .....	10
2.3 Neural Network .....	12
2.3.1 Introduction .....	12
2.3.2 Neural Network Components.....	13
2.3.2.1 Activation Function .....	13
2.3.2.2 Neurons .....	14
2.3.2.3 Networks .....	15
2.3.3 R for Neural Networks.....	16
2.4 Support Vector Machine .....	16
2.4.1 Introduction .....	16
2.4.2 Kernel.....	18
2.4.3 Margin.....	19
2.4.4 Optimization .....	20
2.4.5 Bias–Variance Trade-off and SVM Hyperparameters....	20
2.4.6 R for SVM.....	21
2.5 SVM Modification Using Firth’s Regression .....	22
2.5.1 Introduction .....	22
2.5.2 Logistic Regression.....	23
2.5.3 Problem of Separation .....	23

2.5.4	R for Firth's Regression.....	25
2.5.5	SAS for Firth's Regression.....	25
2.6	Summary .....	27
	References .....	27
<b>3.</b>	<b>Bootstrap Methods and Their Deployment in SAS and R .....</b>	<b>29</b>
3.1	Introduction .....	29
3.2	Overview of Bootstrap Methods.....	30
3.2.1	The Basic Bootstrap .....	31
3.2.2	Hypothesis Tests, Estimates, and Confidence Intervals... <td>32</td>	32
3.2.3	Bias Reduction.....	34
3.2.4	The Parametric Bootstrap .....	35
3.2.5	m-out-of-n Bootstrap .....	36
3.2.6	Bootstrap Samples Similarity.....	36
3.3	Implementation of Bootstrap in SAS and R .....	37
3.3.1	m-out-of-n in SAS.....	37
3.3.2	m-out-of-n in R .....	38
3.4	Summary .....	39
	References .....	40
<b>4.</b>	<b>Outliers Detection and Its Deployment in SAS and R .....</b>	<b>41</b>
4.1	Introduction .....	41
4.2	Outliers Detection and Treatment.....	42
4.2.1	Minimum Covariance Determinant Method .....	42
4.2.2	MCD in SAS .....	43
4.3	Bias Reduction .....	44
4.4	Summary .....	45
	References .....	45
<b>5.</b>	<b>Design of Experiments and Its Deployment in SAS and R .....</b>	<b>47</b>
5.1	Introduction .....	47
5.2	Application of DoE in AI Framework .....	48
5.2.1	Terminology of DoE .....	49
5.2.1.1	Experiment.....	49
5.2.1.2	Experimental Unit.....	49
5.2.1.3	Factor .....	49
5.2.1.4	Treatment.....	49
5.2.2	Principles of DoE.....	49
5.2.2.1	Randomization .....	49
5.2.2.2	Statistical Replication.....	50
5.2.2.3	Blocking .....	50
5.2.2.4	Orthogonality .....	50
5.2.3	Full-Factorial Experiment.....	50
5.2.4	Fractional Factorial Experiment .....	57
5.2.5	Linear Mixed Models .....	58

5.2.6	Factors and Response Variables in the AI Framework.....	59
5.2.7	Example.....	60
5.2.8	Analysis of Linear Mixed Model Using SAS .....	62
5.2.9	Analysis of Linear Mixed Model Using R.....	65
5.3	Summary.....	66
	References .....	67

## Part II

6.	Introduction to the SAS- and R-Based Table-Driven Environment....	71
6.1	Principles of Code-Free Design.....	71
6.2	The Data Dictionary Components for the AI Framework .....	72
6.2.1	Relational Model.....	72
6.2.2	Table .....	73
6.2.3	Data Aspects .....	73
6.2.4	Relational Data Structure .....	73
6.2.5	Domains.....	74
6.2.6	Relations and Tables.....	74
6.2.7	Functions.....	74
6.2.8	One-to-one Relationship.....	75
6.2.9	One-to-many Relationship .....	75
6.2.10	Primary Key.....	75
6.2.11	Foreign Key .....	75
6.2.12	Missing Values .....	75
6.2.13	Data Dictionary .....	76
6.3	Properties of the Data Dictionary.....	76
6.3.1	The Library Table .....	76
6.3.2	The Object Table.....	77
6.3.3	The Location Table.....	77
6.3.4	The Message Table .....	77
6.3.5	The Property Table .....	78
6.3.6	Meaning .....	79
6.3.7	The Link Table.....	79
6.3.8	Process of Application Data Model Definition.....	79
6.3.9	Features of the Data Dictionary .....	80
6.3.10	The Components of the Optimization Framework and Their Definitions in the Data Dictionary.....	81
6.4	Deployment of Code-Free Design with SAS and R.....	81
6.4.1	How to Generate Application Objects .....	81
6.4.2	Generating R Datasets from the Data Dictionary Metadata.....	84
6.4.3	SAS and R Interoperability .....	86
6.5	Summary .....	88
	Reference .....	88

<b>7. Input Data Component.....</b>	89
7.1 Overview of Data Management.....	89
7.1.1 Data Dictionary .....	89
7.1.1.1 The Input Data Dictionary .....	89
7.1.1.2 Input and Structure Tables .....	90
7.1.1.3 Outlier_Detection and Bias_Correction Tables...	91
7.1.1.4 Bootstrap Table .....	92
7.1.1.5 Output Table .....	93
7.1.2 SAS Macro Program .....	95
7.1.3 R Program .....	98
7.2 Summary.....	98
<b>8. Design of Experiment for Machine Learning Component.....</b>	99
8.1 Data Dictionary .....	99
8.1.1 Experiment Table .....	100
8.1.2 Features Table.....	100
8.1.3 Metrics Table.....	101
8.1.4 ML_Method Table.....	102
8.1.5 Hyperparameters_Domain Table.....	102
8.1.6 Results Table .....	102
8.1.7 Results_Metrics Table.....	103
8.2 SAS Macro Program .....	105
8.3 R Programs .....	105
8.4 Summary.....	106
Reference .....	106
<b>9. “Contaminated” Training Datasets Component.....</b>	107
9.1 Data Dictionary .....	107
9.1.1 Contamination Table .....	108
9.1.2 Cont_Experiment Table.....	109
9.1.3 Cont_Results Table.....	109
9.1.4 Cont_Metric Table.....	110
9.2 SAS Macro Program .....	110
9.3 R Programs .....	110
9.4 Summary.....	111
Reference .....	111
<b>Part III</b>	
<b>10. Insurance Industry: Underwriters’ Decision-Making Process.....</b>	115
10.1 Introduction.....	115
10.2 Review of Underwriters’ Performance .....	116
10.2.1 Metrics of Underwriters’ Performance.....	116
10.2.1.1 Hit Ratio.....	116

<b>10. Insurance Industry: Underwriters’ Decision-Making Process.....</b>	115
10.1 Introduction.....	115
10.2 Review of Underwriters’ Performance .....	116
10.2.1 Metrics of Underwriters’ Performance.....	116
10.2.1.1 Hit Ratio.....	116

10.2.1.2	Conversion Rate .....	116
10.2.1.3	Dynamic Conversion Rate .....	117
10.2.1.4	Time-to-Deal .....	118
10.2.2	Analysis of Underwriters' Performance.....	119
10.2.2.1	Data Description.....	119
10.2.2.2	Application Flow .....	119
10.2.2.3	Dynamic Conversion Rate per Underwriter ..	121
10.2.2.4	Time-to-Deal per Underwriter .....	122
10.3	Traditional Approach to Knowledge Delivery .....	123
10.4	Anatomy of Artificial Intelligence Solution .....	124
10.4.1	Data Structure .....	124
10.4.2	Classification Approach .....	125
10.4.3	Bias–Variance Trade-Off and SVM Hyperparameters ..	125
10.4.4	Building the Classifier.....	127
10.4.5	“Contamination” of Training Datasets .....	130
10.4.6	Experimental Results .....	130
10.5	Summary.....	132
	References .....	132
<b>11.</b>	<b>Insurance Industry: Claims Modeling and Prediction.....</b>	<b>135</b>
11.1	Introduction .....	135
11.2	Data .....	136
11.3	The Cox Model for Claims Event Analysis .....	136
11.4	Application of the Cox Model for Claims Analysis .....	138
11.4.1	Data Transformation .....	139
11.4.2	Cox Model Assumption Validation.....	141
11.4.3	Bayesian Machine Learning Approach .....	144
11.4.4	Deployment with SAS .....	144
11.4.5	Interpretation of Results .....	146
11.5	Summary .....	152
	References .....	153
<b>Index</b> .....		<b>155</b>