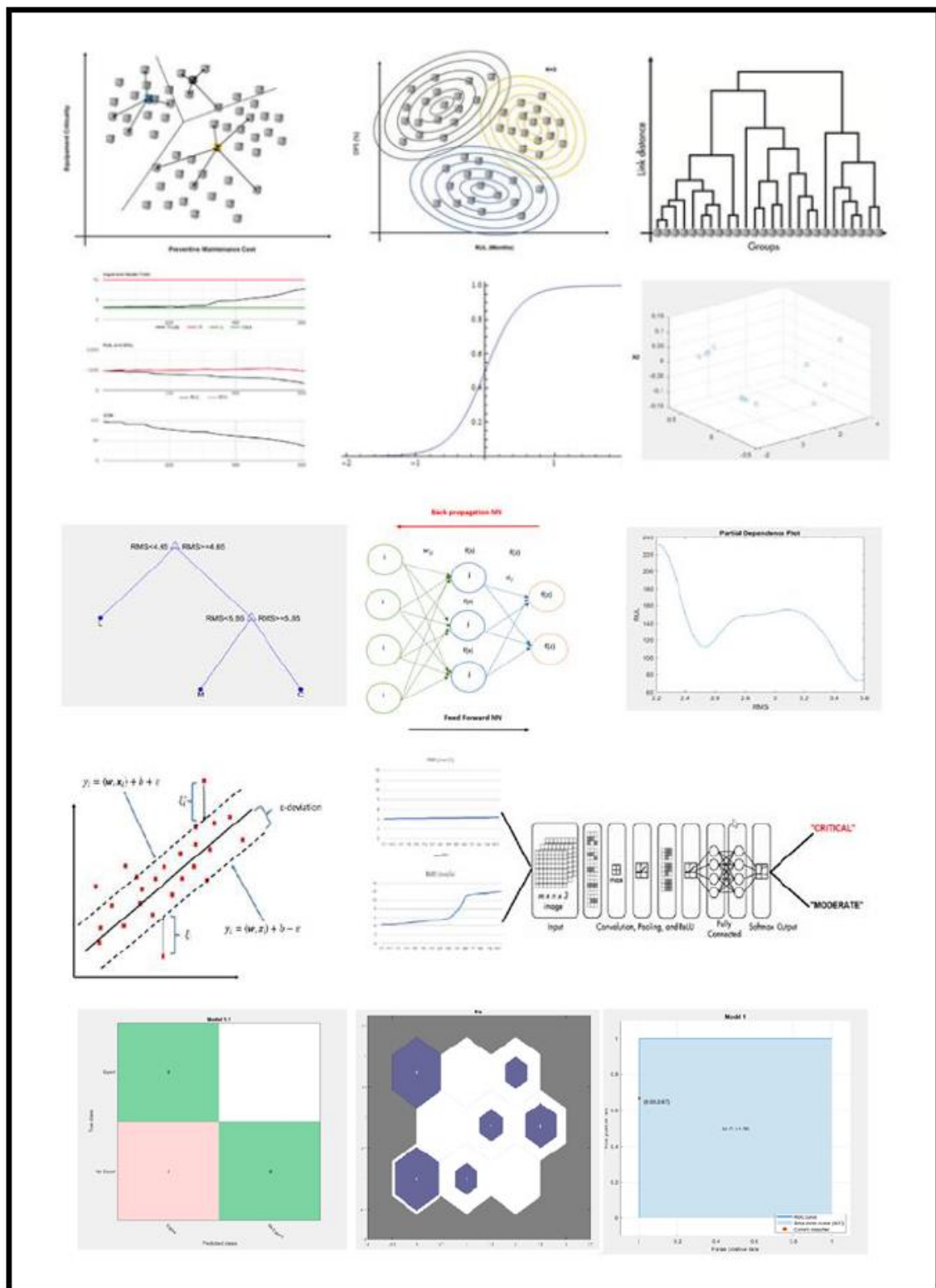


Artificial Intelligence for Maintenance 4.0



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Dedication

I dedicate this book to my daughter Carla Maria Calixto and my son Leonardo Calixto

Thanks

Thanks for my wife Isabel Katrin Calixto and my sons Leonardo Calixto and Carla Maria Calixto to make my life very special and inspired me to keep going writing.

“You can do fantastic things, but people will only value what you do when it bring some direct or indirect beneficial to them, then they you say that what are you doing is fantastic.”

Jagadish Vasudev, The Sadguru, India 2018

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Preface

The motivation for this book is to give my homely contribution to the application of Artificial Intelligence concept to the maintenance engineering. In the last 10 years, with the advent of Industry 4.0, new computational algorithms supported by mathematical methods have been implemented in all industries and more intensively in the process industry. Together with such new technology to capture data by using sensor, combined with Artificial Intelligence methods the new concept of Maintenance 4.0 came out. Therefore, this book is structured as follows:

The first chapter introduces the concept of Artificial intelligence and its application on the maintenance domain.

The second chapter introduces the maintenance concepts by explained the different types of maintenance as well as equipment criticality classification and state of art of maintenance management system.

The third Chapter introduces the Prognostic Health management concept and how to predict the Remaining Useful Life and State of Health based on sensor data or data from the non-destructive test.

The fourth Chapter introduces the concept of Different types of Machine learning methods such as Unsupervised Machine Learning and Supervised Machine Learning. The Fifth Chapter introduces the concept of Artificial Intelligence Unsupervised Machine Learning (UML) that aims to group data based on it's features by demonstrating examples of maintenance planning and equipment clustering. By doing so, different UML methods such as Principal Component Analysis (PCA), Multidimensional Scaling (MDS), K-Means, Gaussian Mixture, Hierarchical Cluster, and Neural Network Self Organized Map are presented.

The sixth chapter present the Artificial intelligence Supervised Machine Learning Classification that aims to classify the equipment based on different class of risk or criticality as well as to define high level of equipment degradation for alarm set up. Therefore, different method with several examples applied to maintenance such as K-Nearest Neighbor (K-NN), Decision Tree, Naïve Bayes, Discriminant Analysis, Support Vector Machine (SVM) and Neural Network Classification are presented.

The seventh chapter presents the Artificial Intelligence Supervised Machine Learning Regression methods that aims to predict a dependent variable such as RUL or SoH based on the past dependent and independent variable values. Therefore, different methods with several examples of RUL regression prediction take place such as Linear Regression, Support Vector Machine, Decision Tree, Ridge and Lasso methods, Stepwise and Neural network.

The eight chapters present the concept of Ensemble methods that aims to reduce the classification or regression prediction error by creating new subset samples from the main database. The different Ensemble methods such as Random tree

The ninth chapter aims to present the concept of Deep Neural Network and Convolutional Neural Network by given an example of image classification applied to RUL prediction.

The tenth chapter aims to present the concept of Asset Management Intelligence 4.0 that aims to encompass the concepts defined in the ISO55001 and the PHM and Artificial Intelligence concepts presented in the previous chapter. Therefore, AMI in a system that integrate the data and display intelligent information and prediction that enable maintenance leaders and expert out their effort in data assessment and fast decision rather than data collection, preparation, and predictions.