OENG1116 – Modelling and Simulation of Engineering Systems

Course Outline of Non-Deterministic (Heuristic)

Course Lecturer:

Dr Hamid Khayyam
Office: 251-02-34
Phone: 03 9925 4630
Email: hamid.khayyam@rmit.edu.au

RMIT UNIVERSITY

Administration

Lecturer:

Dr. Hamid Khayyam

hamid.khayyam@rmit.edu.au

Lecture times: Thursday from 5:30 PM to 7:30 PM in 80.01.02

Tutorial times: Thursday from 7:30 PM to 9:30 PM in 56.04

Consultation : By email and meeting

Lecturer

Hamid Khayyam, (PhD, SMIEEE)

Studied:

Isfahan University – Bachelor of Science.

Iran University of Science and Technology – Masters of Industrial Engineering

Deakin University– PhD of Mechanical Engineering

Worked in industry:

- Team Leader – Carbon Nexus (Carbon Fiber) Deakin University
- Engineering Manager in Industrial Companies (Large Scale)

Objectives:

- Characterise engineering systems in terms of their essential elements, purpose, parameters, constraints, performance requirements, sub-systems, interconnections and environmental context.
- Engineering problem modelling and solving through the relationship between theoretical, mathematical, and computational modelling for predicting and optimizing performance and objective.
- Mathematical modelling real world situations related to engineering systems development, prediction and evaluation of outcomes against design criteria.
- Develop solutions and extract results from the information generated in the context of the engineering domain to assist engineering decision making.
- Interpret the model and apply the results to resolve critical issues in a real world environment.
- Develop different models to suit special characteristics of the system being modelled.

Objectives in Part B (Non-Deterministic Modelling) :

- Use computational methods to “learn” information directly from data without relying on a predetermined equation as a model.
- Provide data scientist with the ability to build, train, and deploy Machine Learning (ML) models quickly.

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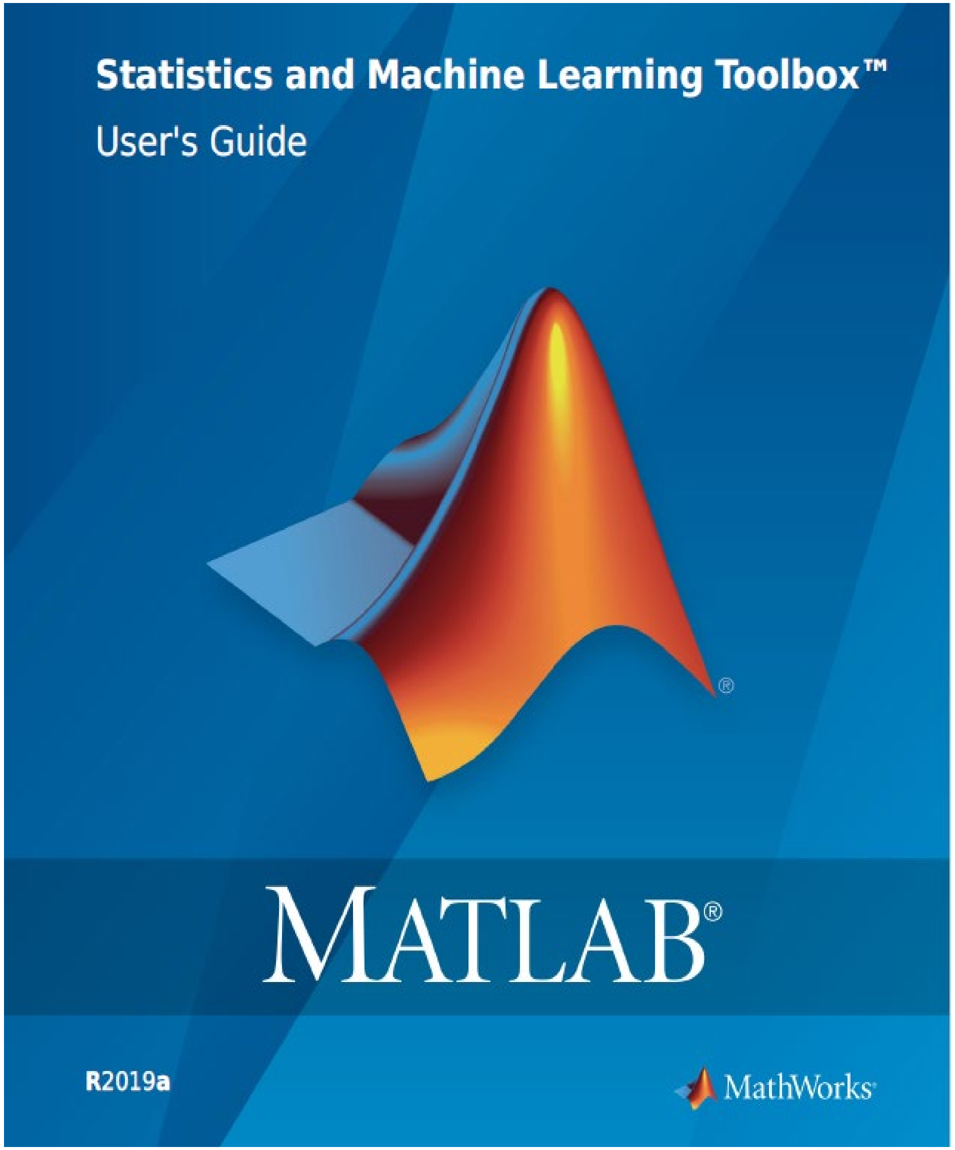

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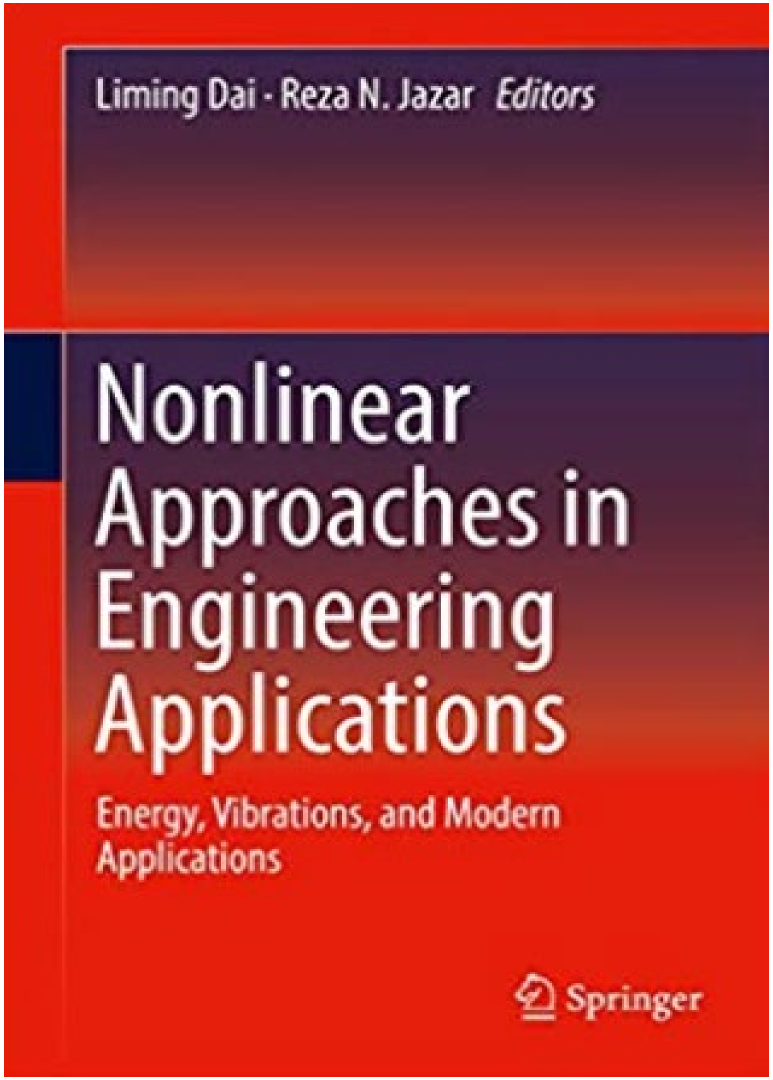

Chapter 12
Limited Data Modelling Approaches for Engineering Applications

Hamid Khayyam, Gelayol Golkarnarenji, and Reza N. Jazar

12.1 Introduction

Over the past several years, the study of various complex systems has been of great interest to researchers and scientists. Complex systems and problems are very pervasive and appear in different application areas including education, healthcare, medicine, finance, marketing, homeland security, defense, and environmental management, among others. In these systems, many components are involved with nonlinear interactions. Forecasting the future state of a complex system and designing such a system are very costly, time consuming, and compute intensive due to project times and technical constraints in industry. To overcome these complexities and save considerable amount of cost, time, and energy, modelling can be utilized. Modelling is generally defined as mathematical realization and computerized analysis of abstract representation of real systems. It helps achieve comprehensive insight into the functionality of the modelled systems, investigate the performance and behavior of processes, and finally optimize the process control. Mathematical modelling is an inexpensive and a powerful paradigm to deal with real-world complex problems. It comprises a wide range of computational methods. This technique can lower the costs by reducing the number of experiments and increasing the safety by forecasting the events, the results of laboratory tests, or the industrial data (Dobre and Sanchez Marcano 2007; Pham 1998; Rodrigues and Minceva 2005).

H. Khayyam (✉) • R.N. Jazar
School of Engieering, RMIT University, Melbourne, VIC, Australia
e-mail: hamid.khayyam@rmit.edu.au

G. Golkarnarenji
Institute for Frontier Materials, Carbon Nexus, Deakin University, Waurn Ponds, VIC, Australia

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L. Dai, R.N. Jazar (eds.), *Nonlinear Approaches in Engineering Applications*,
https://doi.org/10.1007/978-3-319-69480-1_12

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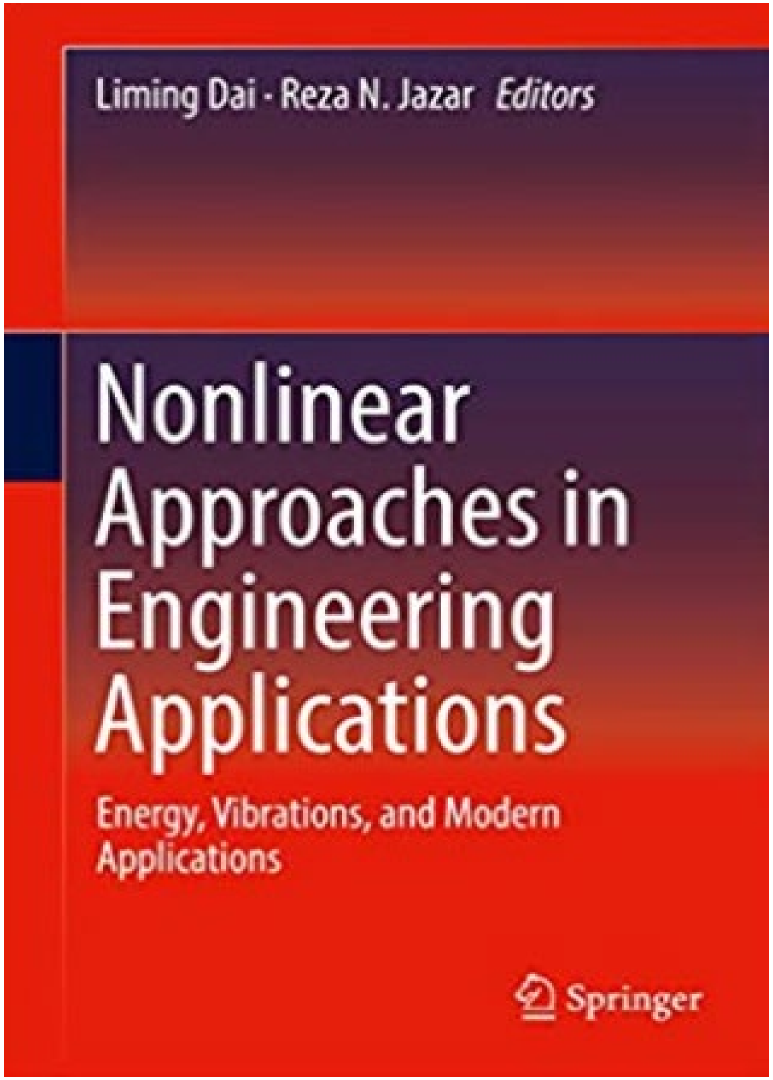

Chapter 10
Big Data Modelling Approaches for Engineering Applications

Bryn Crawford, Hamid Khayyam, Abbas S. Milani, Reza Jazar

1. Introduction

Engineering is intrinsically a field in which the application of science and mathematics is utilized to solve problems in pursuit of the design, operation, maintenance and other faculties of systems in complex systems. Many of these systems contain non-linear interactions and as such, require tools of varying robustness and power to describe them. Forecasting of future states or designing such systems are very costly, time consuming, and computationally intensive, due to finite project timelines and technical constraints within industry. Modelling can be effectively employed as an inexpensive and powerful tool to address these issues in pursuit of engineering objectives. Many computation methods are used to achieve the modeling of such systems. This technique can lower the cost of achieving desired goals, by reducing the number of experiments and even increase safety or reliability, by forecasting the events. This can be achieved with the results of laboratory tests or industrial data (Dobre & Sanchez Marcano 2007; Rodrigues & Minceva 2005).

Broadly speaking, there are two main categories of modeling (Rasmuson 2014a); deterministic and heuristic. Deterministic models are based on physical systems and are based on prior knowledge, giving insight into those physical systems, which are analytical and require a symbolic representation of the system in terms of predictive inputs that determine the desired system output. Heuristic modeling is applied to complex systems, to which applying deterministic modeling approaches would require infeasible time, resources and data volumes. Although the development of heuristic models may require less effort and are simpler, there are additional challenges in effectively using them, such as the size and quality of a dataset, combined with the complexity of the system being described through the modeling process. Many tasks may be achieved using modeling, including regression, classification and clustering. With the advent of larger datasets being available in the modern day, this has offered a paradigm shift in the way that modeling approaches are examined and applied.

B. Crawford and A. S. Milani

School of Engineering, University of British Columbia (UBC), Kelowna, Canada

H.Khayyam and R.N. Jazar

School of Engineering, RMIT University, Melbourne, VIC, Australia

E-mail address: abbas.milani@ubc.ca

Overview of Learning Resources

- Course-related resources will be provided on Canvas system, which is accessed through myRMIT.

- This can include lecture material, supplementary course notes, problem sheets and solutions, and useful references.

- Contact me to have access to the texts books.

Course Structure

- The course consists of lectures (2 hours/week)
  - Follows course textbooks
  - Interactive, group-based work in-class

- Tutorial / Laboratory work (2 hour/week)
  - Lab sessions Run and Testing Matlab Code

Course Marks:

➢ Assignment 2	35%	due Week 12
➢ Assignment 3 Part B	15%	due Week 12

Aggregate mark for final have to be over 50% to pass the course.

Assignment 2:

- Assignment 2 (Individual activity) 35% Friday, 5 June 2020

Solve by:

ANN	(10%)
SVM	(10%)
NLR	(10%)
Check RMSE, MSE and R	(2.5%)
Compare three methods	(2.5%)

Assignment 3 Part B:

- Assignment 2 (Group activity project) 15% 29 May June 2020

Solve by:

ANN and check RMSE, MSE and R	(10%)
Prediction data	(5%)

Assessment conditions:

- All Laboratory reports will be submitted via TurnItIn
- TurnItIn will be used for originality checking
- Penalties for lack of referencing / plagiarism will apply
- Unless an extension has been explicitly given in writing, late submissions will receive a late penalty of 10% of the maximum marks for this assignment per calendar day.
- 100% penalty for submissions later than 5 calendar days

Course structure

Week	Topic (80.02.1) 5:30 PM to 7:30 PM	Lecturer
7	Machine Learning- Artificial Neural Network (ANN) 1	Dr. Hamid Khayyam
8	Artificial Neural Network (ANN) 2	Dr. Hamid Khayyam
9	Support Vector Machine (SVM) 1	Dr. Hamid Khayyam
10	Support vector Machine (SVM) 2	Dr. Hamid Khayyam
11	Non-Linear Regression (NLR) 1	Dr. Hamid Khayyam
12	Non-Linear Regression (NLR) 2	Dr. Hamid Khayyam

Course structure (tour classes)

Week	Topic	Tutor 1	Tutor 2	Tutor 3	Tutor 4	Tutor 5
7	ANN 1	David	Mehran	Ahmad	Madiha	Hamid
8	ANN 2	David	Mehran	Ahmad	Madiha	Hamid
9	SVM 1	David	Mehran	Ahmad	Madiha	Hamid
10	SVM 2	David	Mehran	Ahmad	Madiha	Hamid
11	NLR 1	David	Mehran	Ahmad	Madiha	Hamid
12	NLR 2	David	Mehran	Ahmad	Madiha	Hamid

david.rodriguez-sanchez@rmit.edu.au

mehran.yarahmadian@rmit.edu.au

ahmad.asgharian.rezaei@rmit.edu.au

madiha.tariq@rmit.edu.au

hamid.khayyam@rmit.edu.au

Competencies

- Knowledge of contextual factors impacting the engineering discipline.
- Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.
- Fluent application of engineering techniques, tools and resources.
- Application of systematic engineering synthesis and design processes.
- Application of systematic approaches to the conduct and management of engineering projects.
- Ethical conduct and professional accountability
- Professional use and management of information.
- Orderly management of self, and professional conduct.
- Effective team membership and team leadership.