Theme 2: Support the Engineer

The nature of failure data sets poses particular challenges to modellers. Failures, particularly of critical equipment, are rare. Lots of equipment are replaced in whole or in part before end of life. As a result failure data-sets are unbalanced and sparse. Failures are seldom labelled accurately, and there is often no ground truth for validation.

Condition monitoring data, when available, is often collected at different time intervals. Poor quality data results in greater model complexity that at best muddies inference, and at worst misleads inference and produces persistent prediction bias. These contextual issues, if not dealt with rigorously in model selection and validation practice, leads to poor model performance and a loss of trust by decision makers. To manage these risks, this theme is explicitly cross-disciplinary combining the Bayesian statistics, engineering, nonlinear system identification, machine learning and deep learning.

Initial project areas for Theme 2 include:

1

Dynamic modelling and nonlinear time series

Early signs of asset failure result in nonlinear changes in system dynamics of complex systems. That is, many assets consist of complex interacting part, and are a non-autonomous component in a larger system. Failure of each component will result in subtle changes in the dynamical behaviour of that system and these changes are best detected with a suite of new nonlinear signal processing tools. The ability to detect these would provide an earlier indication than traditional linear condition monitoring techniques. The aim of this project is to develop and to apply a range of nonlinear time series analysis methodologies – including state-space based dynamical reconstruction, frequency domain characterization, and novel machine learning paradigms – to provide a new and improved indicator of asset failure. Condition monitoring data is collected across a range of assets across all our industry partners – this may include chemical reaction and mixing processes, pump vibration time series data, multi-modal condition monitoring of heavy equipment or process throughput control. In all cases this time varying condition data provides a proxy for the system health, which is imperfectly understood. The aim of this project is to develop the tools to better characterize and understand conditions of these systems across operations. The project will produce real-time diagnostic algorithms which can be deploy and embedded within current operations.

2

Bayesian models for failure prediction and remaining useful life estimation

This project aims to deliver improved predictability of failure (with uncertainty estimates) for individual assets (rather than a population of assets) from longitudinal data. Remaining useful life (RUL) estimation provides a probabilistic maximum likelihood estimate of the expected time to failure. This is naturally a stochastic quantity. The aim of this project is to apply Bayesian methodologies in conjunction with other data driven modelling paradigms to optimally estimate expected failure. This will include an estimate not only of the RUL, but also the uncertainty of this estimate. Combined, these quantities can then be drawn upon for optimal maintenance scheduling and planning and for empirical expected-value based planning of asset replacement and retirement.

Publications

- A Novel Approach to Time Series Complexity via Reservoir Computing (...) —
  Conference Publishing

  Braden Thorne

  Authors: Braden Thorne, Thomas Jüngling , Michael Small , Debora Correa , and Ayham Zaitouny
  2022-12-07
- Constrained Markov Order Surrogates (...) —
  Journal Article

  Dr Debora Correa

  Authors: Corrêa, D. C., Moore, J. M., Jüngling, T., & Small, M.
  2020-02-28
- Data-Driven Approach for Labelling Process Plant Event Data (...) —
  Journal Article

  Dr Debora Correa

  Authors: Débora Corrêa, Adriano Polpo, Michael Small, Shreyas Srikanth, Kylie Hollins, Melinda Hodkiewicz
  2022-01-24
- Deforestation-induced surface warming is influenced by the fragmentation and spatial extent of forest loss in Maritime Southeast Asia (...) —
  Journal Article

  Dr Debora Correa

All three industrial partners are currently monitoring machine and process operations of relevance to these techniques. In all cases, whenever assets are deployed within a larger complex system, planning of RUL and estimates of prediction uncertainty will allow for improved operation. The outcome of this project will be algorithms to provide RUL estimates across elements of the processing chain. Integrating these will result in improved maintenance scheduling and planned obsolescence.

3

Fault diagnosis and prediction through advanced spectral analysis techniques

In addition to time series data (the subject of the preceding two projects, and probably a good justification to seek progress on them first), asset health is often monitored with multi-modal data. By combining that data from different modalities (video, spectral, time series) the objective of this project is to improve fault diagnosis. The primary research question here is two levelled – first, how is that data best understood individually; and, second, how can one best integrate data from different modalities for optimal prediction?

Additional information concerning corrosion, contamination, degradation, congestion and failure can be obtained from video and image data (in addition to time series and audio). The combination of 2D (image) and 3D (video) data with techniques honed for 1D (time series/audio) data requires both novel mathematics and new computation algorithms. The objective of this project is to develop the algorithmic techniques to allow for integration of multi-channel multi-modal and multi-dimensional data from multiple sources for better predictions. Applications will include proves monitoring and overall system health across a range of industrial processes in mining, oil and gas and processing.

4

Optimise maintenance management work flow

Equipment maintenance typically involves many different individuals with different duties within an organisation interacting with the equipment. Each transaction (work request, routine maintenance, replacement, service, etc.) is recorded in a Maintenance Work Management System (typically SAP or equivalent systems) and provides a rich quantitative data set of records of interaction and interdependence among individuals and equipment. Whereas the other projects in Theme 2 view the physical assets as a complex system, here we treat the maintenance workforce as a virtual complex system of human capital. The topology of this system, and how it interacts with the maintenance objects defines a set of complicated interdependencies which lead to redundancy (and hence reliability) or leanness (and hence fragility) in the maintenance system. The object of this project is to describe and optimize that system, identify bottlenecks and inefficiencies in across the entire maintenance process.

Authors: Crompton, O., Corrêa, D., Duncan, J. and Thompson, S.,
2021-09-03
- Detecting Asset Cascading Failures Using Complex Network Analysis (...) —

Journal Article

Dr Ayham Zaitouny

Authors: Jaymin Moffatt; Ayham Zaitouny; Melinda Hodkiewicz; Michael Small
2021-08-27
- Developing and evaluating predictive conveyor belt wear models (...) —

Journal Article

Prof Melinda Hodkiewicz

Authors: Callum Webb, Joanna Sikorska, Ramzan Nazim Khan, Melinda Hodkiewicz
2020-06-18
- Evaluating the Accuracy of Bluetooth-Based Travel Time on Arterial Roads: A Case Study of Perth, Western Australia (...) —

Journal Article

Dr Aloke Phatak

Authors: Liu, Y., Xia, J., & Phatak, A.
2020-02-21
- Fast automatic detection of geological boundaries from multivariate log data using recurrence (...) —

Journal Article

Dr Ayham Zaitouny

Authors: Michael Small; June Hill; Irina Emelyanova; Michael Ben Clennell
2019-11-12

- Fast automatic detection of geological boundaries from multivariate log data using recurrence. (...) —

Journal Article

Dr Ayham Zaitouny

Authors: Zaitouny, A., Small, M., Hill, J., Emelyanova, I. and Clennell, M.B., 2020. Fast automatic detection of geological boundaries from multivariate log data using recurrence. Computers & Geosciences, 135, p. 104362.

2019-11-12

- Grading your models: Assessing dynamics learning of models using persistent homology (...) —

Journal Article

Dr Debora Correa

Authors: Eugene Tan, Débora Corrêa, Thomas Stemler, Michael Small

2021-12-01

- Informative Bayesian Survival Analysis to Handle Heavy Censoring in Lifetime Data (...) —

Conference Publishing

Ryan Leadbetter

Authors: Ryan Leadbetter; Aloke Phatak; Adriano Polpo; Melinda Hodkiewicz

2021-12-15

- Interpretable Survival Models for Predictive Maintenance (...) —

Conference Publishing

A/Prof Adriano Polpo

Authors: Paul Castle, Janet Ham, Melinda Hodkiewicz, Adriano Polpo
2020-11-01
- Managing streamed sensor data for mobile equipment prognostics. (...) —

Journal Article

Dr Debora Correa

Authors: Griffiths, T., Corrêa, D., Hodkiewicz, M., & Polpo, A. (2022). Managing streamed sensor data for mobile equipment prognostics. Data-Centric Engineering, 3, E11. doi:10.1017/dce.2022.4
2022-04-07
- Modeling Failure Risks in Load-Sharing Systems With Heterogeneous Components (...) —

Journal Article

Tim Pesch

Authors: Tim Michael Pesch , Erhard Cramer , Edward Cripps , and Adriano Polpo , Senior Member, IEEE
2024-02-21
- Modelling failure risks in load sharing systems with heterogeneous components (...) —

Journal Article

Tim Pesch

Authors: Tim Pesch, Erhard

Cramer, Edward Cripps, Adriano Polpo
2023-07-20
- Objective Domain Boundaries Detection in New Caledonian Nickel Laterite from Spectra Using Quadrant Scan (...) —

Journal Article

Dr Ayham Zaitouny

Authors: Zaitouny A, Ramanaidou E, Hill J, Walker DM, Small M
2022-01-01
- On detecting dynamical regime change using a transformation cost metric between persistent homology diagrams. (...) —

Journal Article

Dr Debora Correa

Authors: Dee Algar, S., Corrêa, D.C. and Walker, D.M
2021-12-17
- On using the modularity of recurrence network communities to detect change-point behaviour (...) —

Journal Article

Dr Ayham Zaitouny

Authors: David M. Walker, Ayham Zaitouny, Debora C. Correa*
2021-03-01
- Optimal Thresholding of Predictors in Mineral Prospectivity Analysis (...) —

Journal Article

Dr Aloke Phatak

Authors: Adrian Baddeley, Warick Brown, Robin K. Milne, Gopalan Nair, Suman Rakshit, Tom Lawrence, Aloke Phatak, and Shih Ching Fu
2020-11-11

- Parameter extraction with reservoir computing: Nonlinear time series analysis and application to industrial maintenance (...) —

Journal Article

Braden Thorne

Authors: Thorne, B., Jüngling, T., Small, M., & Hodkiewicz, M. (2021).
2021-03-01

- Quadrant scan for multi-scale transition detection (...) —

Journal Article

Dr Ayham Zaitouny

Authors: Zaitouny, A., Walker, D.M. and Small, M., 2019.
2019-10-08

- Quantifying the generalization capacity of Markov models for melody prediction (...) —

Journal Article

Dr Debora Correa

Authors: Corrêa, D. C., Jüngling, T., & Small, M.,
2020-02-17

- Reconstruction of Complex Dynamical Systems from Time Series using Reservoir Computing (...) —

Journal Article

Prof Michael Small

Authors: Jüngling, T., Lymburn, T., Stemler, T., Corrêa, D., Walker, D. & Small, M.,
2019-05-01

- Recurrence-based reconstruction of dynamic pricing attractors (...) —

Journal Article

Dr Shuixiu Lu

Authors: Shuixiu Lu - Sebastian Oberst
2023-06-13

- Reliability inference with extended sequential order statistics (...) —

Journal Article

Tim Pesch

Authors: Tim Pesch, Adriano Polpo, Edward Cripps, Erhard Cramer

2023-04-11

- Reservoir time series analysis: Using the response of complex dynamical systems as a universal indicator of change (...) —

Journal Article

Braden Thorne

Authors: Thorne, Braden Jüngling, Thomas Small, Michael Corrêa, Débora Zaitouny, Ayham

2022-02-10

- Selecting embedding delays: An overview of embedding techniques and a new method using persistent homology (...) —

Journal Article

Dr Debora Correa

Authors: Eugene Tan, Shannon Alga, Débora Corrêa, Michael Small, Thomas Stemler and David Walker1

2023-03-01

- Sensitization to immune checkpoint blockade through activation of a STAT1/NK axis in the tumor microenvironment (...) —

Journal Article

Dr Ayham Zaitouny

Authors: Rachael M. Zemek, Emma De Jong, Wee Loong Chin, Iona S. Schuster, Vanessa

S. Fear, Thomas H. Casey, Cath Forbes, Sarah J. Dart, Connull Leslie, Ayham Zaitouny, Michael Small, Louis Boon, Alistair R. R. Forrest, Daithi O. Muiri, Mariapia A. Degli-Esposti
2019-07-17

- Stillbirth risk prediction using machine learning for a large cohort of births from Western Australia, 1980–2015 (...) —

Journal Article

Dr Aloke Phatak

Authors: Malacova, E., Tippaya, S., Bailey, H.D. et al.
2020-03-24

- Variable Selection for Conveyor-Belt Mean Wear Rate Prediction (...) —

Journal Article

Prof Melinda Hodkiewicz

Authors: Joanna Z Sikorska*, Callum Webb, Nazim Khan and Melinda Hodkiewicz
2021-02-26

Presentations

- A Computer Vision Based Approach to Measuring Remaining Useful Life of Sizer Barrels (...) —

Braden Thorne

PhD Student

Theme 2

2022-05-06

- A Novel Approach to Time Series Complexity via Reservoir Computing - AJCAI 2022 (...) —

Braden Thorne

PhD Student

Theme 2

2022-12-07

- Advances in Time Series Analysis With Reservoir Computing (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Braden Thorne

PhD Student

Theme 2

2023-08-22

- An alternative approach to conventional methods of belt wear modelling and forecasting (...) —

Curtin University

Ryan Leadbetter

PhD Student

Theme 2

2022-05-06

- An Introduction to Time Series Analysis with Reservoir Computing (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Braden Thorne

PhD Student

Theme 2

2021-09-10

- Applied Mathematics and Complex Systems Seminars (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Dr Debora Correa

Chief Investigator

Theme 2

2020-08-13

- Conveyor Belt Wear Forecasting through a Bayesian Hierarchical Modeling Framework using Functional Data Analysis and Gamma Processes by Ryan Leadbetter (...) —

Curtin University

Ryan Leadbetter

PhD Student

Theme 2

2023-02-21

- Conveyor belt wear forecasting through a Bayesian Hierarchical Modeling framework using functional data analysis and gamma processes. (...) —

Curtin University

Ryan Leadbetter

PhD Student

Theme 2
2022-09-29

- Critical Transitions in Complex Systems (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Prof Michael Small

Theme Lead

Theme 2
2023-05-29

- DARE presentation - Conveyor Belt Wear Forecasting through a Bayesian Hierarchical Modeling Framework using Functional Data Analysis and Gamma Processes by Ryan Leadbetter (...) —

Curtin University

Ryan Leadbetter

PhD Student

Theme 2

2023-02-21

- Decision Support for Prognostics of Complex Systems: A Practical Approach Using Bayesian Networks (...) —

Curtin University

Ryan Leadbetter

PhD Student

Theme 2

2020-10-09

- Degradation modelling in mining and mineral processing equipment: a comparison of two statistical approaches (...) —

Gabriel Jesus Gonzalez

PhD Student

Theme 2

2022-07-01

- Detecting transitions in dynamical and industrial systems (...) —

Prof Michael Small

Theme Lead

Theme 2

2023-09-02

- Dynamical System Approaches to Online Fault Detection (...) —

Braden Thorne

PhD Student

Theme 2

2023-07-21

- ESREL 2020 PSAM 15 - The 30th European Safety and Reliability Conference (...) —

A/Prof Adriano Polpo

Chief Investigator

Theme 2

2020-11-05

- Estimating the remaining useful life of process piping using Bayesian methods (...) —

Curtin University

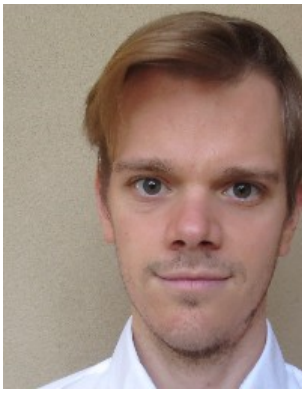
Gabriel Jesus Gonzalez

PhD Student

Theme 2

2021-08-27

- Estimation and Testing with Extended Sequential Order Statistics (...) —



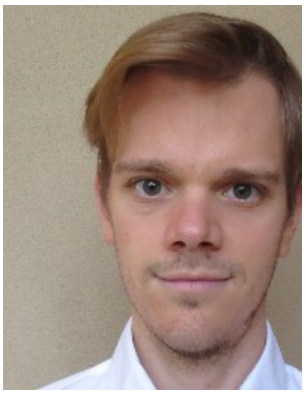
THE UNIVERSITY OF WESTERN AUSTRALIA

Tim Pesch

PhD Student

Theme 2
2023-08-18

- Estimation with ESOS (...) —



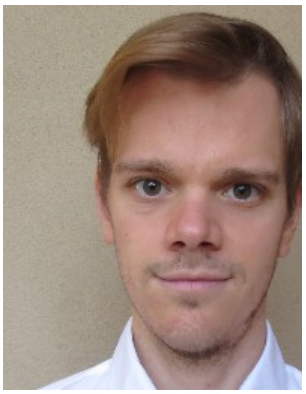
THE UNIVERSITY OF WESTERN AUSTRALIA

Tim Pesch

PhD Student

Theme 2
2023-05-09

- Estimation with Extended Single Order Statistics (...) —



Tim Pesch

PhD Student

Theme 2

2023-05-09

- Forecasting Conveyor Belt Wear using Bayesian Hierarchical Modelling (...) —

Ryan Leadbetter

PhD Student

Theme 2

2022-11-17

- Get the most out of condition monitoring data: Improving conveyor belt wear forecasts to make better maintenance decisions (...) —

Ryan Leadbetter

PhD Student

Theme 2

2023-06-27

- Get the most out of condition monitoring data: Improving conveyor belt wear forecasts to make better maintenance decisions. (...) —

Curtin University

Ryan Leadbetter

PhD Student

Theme 2
2023-06-16

- ICIAM,2019, (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Prof Michael Small

Theme Lead

Theme 2
2019-07-15

- ICMIAM Estimating the remaining useful life of process piping using Bayesian methods (...) —

Gabriel Jesus Gonzalez

PhD Student

Theme 2
2021-12-14

- ICMIAM Informative Bayesian Survival Methods to Handle Heavy Censoring in Lifetime Data (...) —

Curtin University

Ryan Leadbetter

PhD Student

Theme 2
2021-12-14

- Intelligent Maintenance Conference 2020 (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Dr Debora Correa

Chief Investigator

Theme 2

2020-09-08

- International Workshop on Complex Systems and Networks (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Prof Michael Small

Theme Lead

Theme 2

2019-09-24

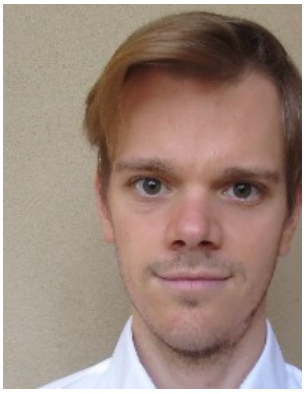
- Learning the dynamics: from radial basis functions to reservoir computers. (...) —

Prof Michael Small

Theme Lead

Theme 2
2021-11-04

- Lifetime Prediction for Systems with heterogeneous Components (...) —



Tim Pesch

PhD Student

Theme 2

2022-08-12

- Managing Streamed Sensor Data for Mobile Equipment Failure Prediction (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Dr Debora Correa

Chief Investigator

Theme 2

2020-09-08

- Master Class - Complex Time Series Modelling (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Dr Debora Correa

Chief Investigator

Theme 2
2021-04-15

- Master Class - Deterministic Dynamics, Machine Learning & Tipping Points (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Prof Michael Small

Theme Lead

Theme 2

2021-03-04

- Master Class - Pattern Recognition and Change Point Detection (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Dr Ayham Zaitouny

Research Fellow

Theme 2

2021-03-04

- Nonlinear time series analysis of industrial data with uncertainty (...) —

Dr Shuixiu Lu

Research Fellow

Theme 2
2023-08-18

- Raising the Bar (...) —

Prof Michael Small

Theme Lead

Theme 2

2019-11-22

- Reservoir Computing Approaches to Parameter Extraction with Applications (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

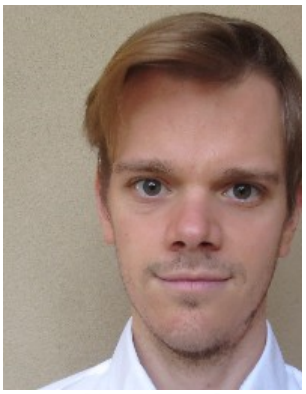
Braden Thorne

PhD Student

Theme 2

2021-06-11

- Sequential Order Statistics for Non-identical Component Lifetimes (...) —



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Tim Pesch

PhD Student

Theme 2
2021-10-26

- SIAM 2019 (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

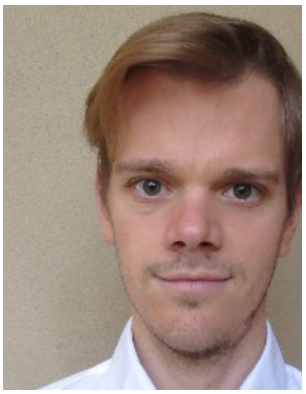
Prof Michael Small

Theme Lead

Theme 2

2019-05-20

- SOS for non-id components (...) —



THE UNIVERSITY OF WESTERN AUSTRALIA

Tim Pesch

PhD Student

Theme 2

2021-10-26

- Sydney dynamics group workshop (...) —

THE UNIVERSITY OF WESTERN AUSTRALIA

Dr Ayham Zaitouny

Research Fellow

Theme 2

2019-11-05

- The Benefits of Reservoir Computing Embedding for Recurrence Analysis (...) —

Braden Thorne

PhD Student

Theme 2

2023-08-28

- The International Conference on Smart Computing & Communications (ICSCC 2019) (...) —

Curtin University

Prof Andrew Rohl

Training Centre Director

Directorate
2019-06-29

- What does the Data Say or Why I don't like analogies? (...)

—

THE UNIVERSITY OF WESTERN AUSTRALIA

Prof Michael Small

Theme Lead

Theme 2

2022-12-08

- WMC Presentation - Get the most out of condition monitoring data: Improving conveyor belt wear forecasts to make better maintenance decisions (...) —

Curtin University

Ryan Leadbetter

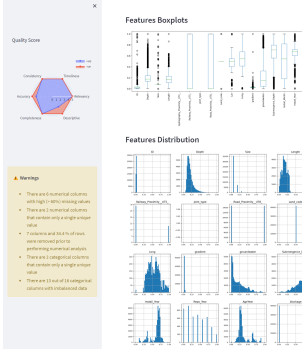
PhD Student

Theme 2

2023-06-27

Tools

- IDEA Tool (...) —



2022-07-06

Evaluate the appropriateness of data for the purposes of maintenance predictive analytics

Theme 2 Theme 5

The Team

Lead

- Prof Michael Small (...) —

Prof Michael Small

Theme Lead

Theme 2

Chief Investigators

- Dr Debora Correa (...) —

Dr Debora Correa

Chief Investigator

Theme 2

- Dr Edward Cripps (...) —

Dr Edward Cripps

Chief Investigator

Theme 2

Partner Investigators

Content by label

There is no content with the specified labels

Research Fellows

- Dr Shuixiu Lu (...) —

Dr Shuixiu Lu

Research Fellow

Theme 2

PhD Students

- Braden Thorne (...) —

Braden Thorne

PhD Student

Theme 2

- Gabriel Jesus Gonzalez (...) —

Gabriel Jesus Gonzalez

PhD Student

Theme 2

- Ryan Leadbetter (...) —

Ryan Leadbetter

PhD Student

Theme 2

- Tim Pesch (...) —

Tim Pesch

PhD Student

Theme 2