

PhD Scholarships - ARC Training Centre for Transforming Maintenance through Data Science

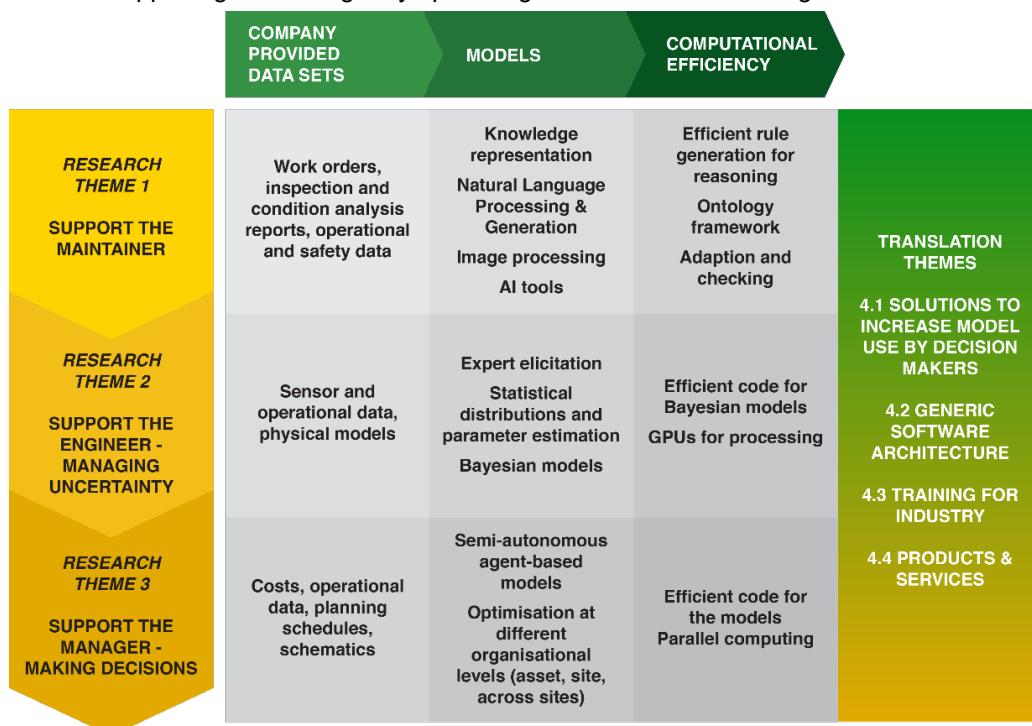
About this scholarship

Description/Applicant information

This Industrial Transformation Training Centre (ITTC) is a unique partnership between Curtin University, The University of Western Australia, CSIRO and industry partners Alcoa, BHP and Roy Hill, as well as CORE Innovation Hub and the Minerals Research Institute of Western Australia.

The ITTC seeks to transform the maintenance management process, enabling Australian companies to lead the way maintenance is conducted, increasing both productivity and profitability. The Centres research focuses on three themes

1. Supporting the Maintainer through the automation of the work management stages;
2. Supporting the Engineer with the next generation of data science products, improving prediction of critical equipment failure; and,
3. Supporting the Manager by optimising maintenance scheduling and execution.



Bringing together a range of disciplines and enabling collaboration to support the best in the research, the Centre is about balancing high quality research, focusing on current and future industry needs. Our Industry partners are supportive of the research effort, providing access to data that will be utilised to solve relevant industry problems.

If you want to be involved in research that has immediate relevance to industry and you are eligible to enrol in a PhD in an Australian University, please consider this scholarship opportunity.

Find details of the individual projects under Opportunities at <https://www.maintenance.org.au/>.

How to apply

Application process

Read the Themes and associated projects in www.maintenance.org.au or the “Further Information below.

Send an Expression of Interest (EOI), reflecting your academic background and why you are interested in pursuing a PhD in this field. Applicants should have a strong undergraduate degree and graduate/research experience in mathematics, statistics, computer science, or related disciplines within engineering. Programming experience is expected

Include in your EOI, the theme and project you feel you are most aligned and why.

The EOI should be a maximum of 500 words

Please attach your CV/Resume and your academic transcripts with your EOI and upload these files in PDF format to the HDR-EMS Form using this [link](#). If you have difficulty accessing the form, please email to eoimaintenance.org.au.

Applications are open now for 2020 Cohort.

Further information

Value

The scholarship offered in this opportunity will consist of student stipend of ~AUD \$30,000 to study for a PhD enrolled at either Curtin University or the University of Western Australia. Tenure is 3.0 years full-time, with the possibility of a single six-month extension.

During the tenure, the PhD student will spend a minimum of twelve months working with and supported by the Centres industry partners. The PhD student will also undertake an approved 6-month internship funded by our industry partners.

Whether the PhD student plans to move into industry at the end of their PhD or pursue an academic career, this is an invaluable opportunity for the student to develop a unique understanding of industry related research challenges.

Eligible courses

PhD programs only

Eligibility criteria

Meet the standard PhD course entry requirements for both institutions.

English - if English is not your first language, please visit the following link for details of the requirements:

[Curtin University - https://international.curtin.edu.au/apply/english-prerequisites/](https://international.curtin.edu.au/apply/english-prerequisites/)
[University of WA - https://study.uwa.edu.au/how-to-apply/entry-requirements](https://study.uwa.edu.au/how-to-apply/entry-requirements)

THEME 1 Proposed PhD projects Research

Theme 1: Support the maintainer

The projects detailed below are for a postgraduate studentship to work within theme 1, Supporting the Maintainer. This theme involves academics (primarily computer scientists) from Curtin University, The University of Western Australia and CSIRO and is coordinated by Prof. Melinda Hodkiewicz. Prof. Hodkiewicz is the BHP Fellow for Engineering for Remote Operations.

Project 1: Ontology for Maintenance

Data are key to the effective and safe maintenance of assets over their life cycle. This data is generated by, and drawn from, various sources such as maintenance management systems, design documentation, original equipment manufacturer manuals, process control systems, third party service providers, risk management assessments and failure investigations, to name just a few. However, due to the heterogeneity of data sources and diversity of data types, unlocking the real value of data and discovering the useful patterns of knowledge embedded in the maintenance data has always presented a major challenge. Ontologies can effectively address this challenge by semantic annotation, integration, consistency checking and organization of data. The aim of this project is to demonstrate automation of transactions involving data exchange about asset performance and maintenance work using interoperable and extensible ontologies.

Project 2: Natural Language Processing of Maintenance records

Each time a maintainer interacts with equipment, a work order record captures in linguistic text their observations of the asset and a record of what was done, when, and how. Given that there are multiple technicians within an enterprise, the human-generated data is often inconsistent, error-filled, and replete with domain-specific jargon. If this data could be parsed, it could lead to determinations such as failure mode identification, rework, problem spot identification, and more accurate mean time to repair (MTTR) or mean time between failure (MTBF), which can lead to improved maintenance strategy, reduced risk of failure and improved maintenance efficiency. This project will develop novel natural language processing and machine-learning approaches to achieve enable machine readability of maintenance records and use of the liberated data to support maintenance decision making.

Project 3: A conversational interface for Maintenance Planners

Maintenance planning is a complex task. Each week the planner approves new work notifications, reviews work orders already on the backlog, reviews scheduled preventive maintenance work orders due in the next maintenance work cycle and from the resulting list prioritizes the tasks. High priority tasks are moved to the planning stage. For each task, the planner needs estimates for the following types of questions: How long the job will take? How much and what types of labour will be required? What parts and materials will be required, and do we have them on hand? What are the costs? What tools, equipment or other resources, including external contractors, will be required? What permits will be required? What are the job hazards and how will they be managed? The aim of this project is to develop a dialog management system for knowledge capture and inference to enable semi-automated plan validation. In addition to computer science skills the PhD candidate should have HMI and UX interests and skills.

THEME 2 Proposed PhD projects

Research Theme 2: Support the engineer

Project 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 characterise and understand conditions of these systems across operations. The project will produce real-time diagnostic algorithms, which can be deployed and embedded within current operations.

Project 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.

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.

Project 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 progress is to improve fault diagnosis. The primary research question here is two levelled – first, how is that data best understood individual; 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.

THEME 3 Proposed PhD projects

Research Theme 3: Support the manager

The projects described below are for postgraduate students working in Theme 3, which aims to support managers through the development of automated decision-making and optimisation tools. This theme involves working with optimisation specialists and computer scientists from Curtin University and the University of Western Australia, in addition to software engineers from CSIRO and maintenance practitioners from the industry partners.

Project 1: Optimising Maintenance for Duplicate Assets

Process plants in the mining sector often contain large populations of duplicate assets – for example, precipitators in alumina production. Scheduling the periodic maintenance of these assets is a major

challenge because the assets are inter-connected and there is uncertainty around their condition – often the precise maintenance requirements only become known once the asset is taken out of service.

Currently, such maintenance is manually scheduled using “rules of thumb” driven by legacy practices rather than real data or rigorous science.

The aim of this project is to develop fast optimisation algorithms for scheduling maintenance in populations of inter-related duplicate assets, taking into account the condition estimates, constraints on resource/labour availability, production needs, safety compliance, and asset inter-connections and redundancy. This will lead to automated tools for ensuring schedule compliance, cost control, and reducing unplanned maintenance work. Key challenges in the project will include developing the correct optimisation models that add value to the industry partners and overcoming the dimensionality challenges that are common in large-scale industrial optimisation problems.

Project 2: Maintenance Scheduling under Plant Constraints

Maintenance plans for mining assets must adhere to numerous constraints ensuring plant integrity and safety – for example, a certain pump cannot be switched off at the same time as another pump. Existing software tools can identify constraint violations and clashes in a given maintenance schedule, but updating the schedule when clashes are detected is still a laborious manual process. Humans are unable to efficiently process the vast streams of data now available, nor can we visualise and balance the numerous competing factors necessary to determine an optimal maintenance schedule that minimises cost.

The aim of this project is to develop mathematical optimisation algorithms for automatically updating short-term and long-term maintenance schedules to avoid violations/clashes while optimising a specific performance index – for example, maximising plant throughput or minimising cost. These algorithms will incorporate tacit rules about which equipment can or cannot be repaired at the same time. Mathematical advances in optimisation theory will be required to deal with the extreme dimensions present in these scheduling problems.

Project 3: Optimising Maintenance Intervals

All assets – from individual mobile assets to the entire fixed plant – consist of multiple inter-related sub-systems with different maintenance cycle times. A key challenge in maintenance planning is to align these cycle times so that maintenance tasks requiring the same resources and isolations are performed at the same time, minimising rework and disruptions to production. For example, if one component has a cycle time of 6 months and another has a cycle time of 5 months, then it may be advantageous to reduce the 6-month cycle time (effectively over-maintaining the component) so that both components are maintained at the same time. Real-life maintenance projects may involve hundreds or thousands of components, well beyond the scale that humans can comprehend and hence necessitating automated approaches.

To this end, this project will involve developing optimisation algorithms for determining maintenance cycle times in an inter-connected system to maximise synergies, minimise downtime, and minimise the probability of failures. There will be various constraints to respect - for example, in the case of mobile assets, there are typically a limited number of maintenance bays for accommodating equipment undergoing maintenance. Other considerations include sub-system redundancy, journey times, OEM recommendations, and production needs.