

# Theme 1: Support the Maintainer

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. These records contain unstructured text containing jargon, abbreviations, and incomplete data. Of primary interest are the needs to establish the as-found condition, the causality of failure regarding the failure mechanism and cause, and what maintenance work was done. This data is often in the work order texts but is not stored in a machine-readable way. These shortcomings lead to inadequate information about the asset condition, the failure cause and what work was actioned. As a result maintenance staff rely heavily on word-of-mouth and ad-hoc data exchange. The absence of standard schema for maintenance data representation hinders the ability to convert semantic meanings in the maintenance work orders into axiom based reasoning and useful information. We need to enable maintainers and the staff that support them to efficiently capture, retrieve, absorb, process and exchange knowledge about equipment and maintenance work.

Initial project areas for Theme 1 include:

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.

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.

3

## A conversational interface for Maintenance Planners

### Publications

- [A Whole-of-Organisation Approach for Reliability Analytics \(...\)](#) —

### Book Chapter

[Prof Melinda Hodkiewicz](#)

**Authors: Melinda Hodkiewicz, Tyler Bikaun, Michael Stewart**

2023-02-16

- [An ontology for reasoning over engineering textual data stored inFMEA spreadsheet tables \(...\)](#) —

### Journal Article

[Prof Melinda Hodkiewicz](#)

**Authors: Melinda Hodkiewicz,, Johan W. Klüwerb, Caitlin Woodsc, Thomas Smokerc, Emily Low**

2021-05-27

- [Cleaning and visualization of unstructured text in safety records \(...\)](#) —

### Conference Publishing

[Dr Michael Stewart](#)

**Authors: Michael Stewart1, Wei Liu1, Rachel Cardell-Oliver1 And Mark Griffin**

2020-11-01

- [CylE: Cylinder Embeddings for Multi-hop Reasoning over Knowledge Graphs \(...\)](#) —

### Conference Publishing

[Chau Nguyen](#)

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 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.

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**Authors: Chau  
Nguyen, Tim  
French, Wei Liu,  
Michael Stewart**

2023-05-02

- [CySpider: A Neural Semantic Parsing Corpus with Baseline Models for Property Graphs \(...\)](#)

**Conference  
Publishing**

[Ziyu Zhao](#)

**Authors: Ziyu  
Zhao, Wei Liu, Tim  
French & Michael  
Stewart**

2023-11-27

- [Data-driven reliability analysis of Boeing 787 Dreamliner - ScienceDirect \(...\)](#) —

**Journal Article**

[Prof Melinda  
Hodkiewicz](#)

**Authors: G Pandian,  
M Pecht, E Zio, M  
Hodkiewicz**

2020-03-12

- [Digitalization and reasoning over engineering textual data stored in spreadsheet tables \(...\)](#) —

**Conference  
Publishing**

[Prof Melinda  
Hodkiewicz](#)

**Authors: Melinda  
Hodkiewicz, Johan  
W. Klüwer, Caitlin  
Woods, Thomas  
Smoker, Tim French**

2020-12-18

- [DRAT: Data risk assessment Tool for University-Industry collaborations \(...\)](#) —

**Journal Article**

[Prof Melinda  
Hodkiewicz](#)

**Authors: Sikorska, J., Bradley, S., Hodkiewicz, M. and Fraser, R.**

2020-12-11

- [E2EET: from pipeline to end-to-end entity typing via transformer-based embeddings \(...\)](#) —

Journal Article

[Dr Michael Stewart](#)

**Authors: Michael Stewart, Wei Liu**

2021-11-30

- [Framework for Validation of Permanently Installed MEMS-Based Acquisition Devices Using Soft Sensor Models \(...\)](#) —

Journal Article

[Prof Melinda Hodkiewicz](#)

**Authors: A Bartels, E Cripps, A Keating, I Milne, B Travaglione, M Hodkiewicz**

2020-07-28

- [Maintenance in an Industry 4.0 and COVID world - the case for Remote Operations \(..\)](#) —

Conference  
Publishing

[Prof Melinda Hodkiewicz](#)

**Authors: None**

2020-11-01

- [MWO2KG and Echidna: Constructing and exploring knowledge graphs from maintenance data \(...\)](#) —

Journal Article

[Dr Michael Stewart](#)

**Authors: Stewart M, Hodkiewicz M, Liu W, French T**

2022-11-05

- [Pipeline for machine reading of unstructured maintenance work order records \(...\)](#) —

## Conference Publishing

[A/Prof Wei Liu](#)

**Authors: Yiyang  
Gao, Caitlin Woods,  
Tim French, Melinda  
Hodkiewicz**

2020-11-01

- [RelOps-A Whole-of-Organisation Approach for Reliability Analytics \(...\)](#) —

## Book Chapter

[Prof Melinda  
Hodkiewicz](#)

**Authors: Melinda  
Hodkiewicz, Tyler  
Bikaun, Michael  
Stewart**

2023-02-16

- [Rethinking maintenance terminology for an industry 4.0 future \(...\)](#) —

## Journal Article

[Prof Melinda  
Hodkiewicz](#)

**Authors: Melinda  
Hodkiewicz, Sarah  
Lukens, Michael P.  
Brundage, Thurston  
Sexton**

2021-03-21

- [SConE: Simplified cone embeddings with symbolic operators for complex logical queries \(...\)](#) —

## Conference Publishing

[Chau Nguyen](#)

**Authors: Chau  
Nguyen, Tim  
French, Wei Liu,  
Michael Stewart**

2023-07-14

- [Semi-automated Estimation of Reliability Measures from MaintenanceWork Order Records \(...\)](#) —

## Conference Publishing

[Tyler Bikaun](#)

**Authors: Bikaun, T.,  
& Hodkiewicz, M.**

2021-06-21

- [Sensing system for low cost condition monitoring of remote assets \(...\)](#) —

## Conference Publishing

[Prof Melinda  
Hodkiewicz](#)

**Authors: Aiden J.  
Ziegelaar, Ben C.  
Travaglione,  
Melinda R.  
Hodkiewicz**

2020-12-18

- [Seq2KG: An End-to-End Neural Model for Domain Agnostic Knowledge Graph \(not Text Graph\) Construction from Text \(...\)](#) —

## Conference Publishing

[Dr Michael Stewart](#)

**Authors: Michael  
Stewart, Wei Liu**

2020-09-01

- [Technical Language Processing: Unlocking Maintenance Knowledge \(...\)](#) —

## Journal Article

[Prof Melinda  
Hodkiewicz](#)

**Authors: Michael P.  
Brundage, Thurston  
Sexton, Melinda  
Hodkiewicz, Alden  
Dima, Sarah Lukens**

2020-12-11

- [Template Libraries for Industrial Asset Maintenance: A methodology for scalable and maintainable ontologies \(...\)](#) —

## Conference Publishing

[Prof Melinda  
Hodkiewicz](#)

**Authors: Lupp, D.L.,  
Hodkiewicz, M., and  
Skjæveland, M.G.**

- 2020-11-02
- [Using Context-Free Grammar  
to Generate Synthetic  
Technical Short Texts \(...\)](#) —

## Conference Publishing

[Tyler Bikaun](#)

**Authors: Tyler  
Bikaun, Michael  
Stewart, Melinda  
Hodkiewicz**

2022-12-03

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## Presentations

- [A fresh look at the Future of  
Technical Language  
Processing Research in the  
eyes of ChatGPT \(...\)](#) —



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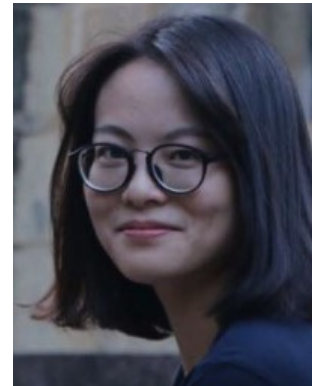
[A/Prof Wei Liu](#)

## Theme Lead

### Theme 1

2023-04-21

- [A pattern-based natural language interface for knowledge graph querying \(...\)](#)  
—



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Ziyu Zhao

PhD Student

### Theme 1

2021-09-09

- [A technical language processing-based solution to automatically calculating lubrication-related costs from maintenance work orders - presentation at PHM 2021, TLP Workshop \(...\)](#) —



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Dr Michael Stewart

Research Fellow

### Theme 1

2021-11-29

- [AI on maintenance data - challenges to value delivery \(...\)](#)



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Prof Melinda  
Hodkiewicz

Chief Investigator

### Theme 1

2023-02-14

- [AI On Maintenance Data - Challenges To Value Delivery.](#)  
(...) —



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Hodkiewicz

Chief Investigator

### Theme 1

2021-12-12

- [Answering Logical Queries on Technical Knowledge Graphs \(](#)  
...)



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**Chau Nguyen**

PhD Student

**Theme 1**

2023-09-15

- [APOS Workshop Data Automation \(...\)](#) —



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Hodkiewicz**

Chief Investigator

## Theme 1

2020-06-16

- Breakfast seminar - Sirius Centre and Energy Valley in Oslo (...) —



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Hodkiewicz

Chief Investigator

## Theme 1

2019-06-24

- Cleaning and Visualization of Unstructured Text in Safety Records ESREL 2020 PSAM 15 (...) —



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Dr Michael Stewart

Research Fellow

### Theme 1

2020-11-04

- Common definitions for mining technology (...) —



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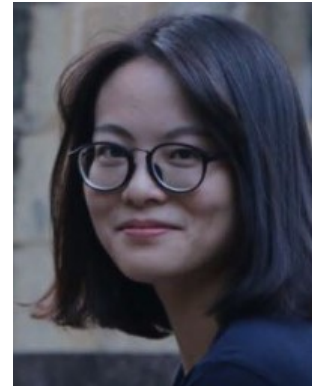
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Hodkiewicz

Chief Investigator

## Theme 1

2022-10-26

- [Cost Aggregate Queries on Knowledge Graph Augmented by Reference Data Libraries \(...\)](#)  
—



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Ziyu Zhao

PhD Student

## Theme 1

2022-07-01

- [CylE: Cylinder Embeddings for Multi-hop Reasoning over Knowledge Graphs - poster presentation \(...\)](#) —



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Chau Nguyen

PhD Student

### Theme 1

2023-05-03

- [Cylinder Embeddings for Multi-hop Reasoning over Knowledge Graphs \(...\)](#) —



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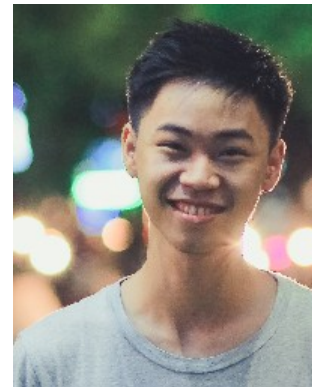
Chau Nguyen

PhD Student

## Theme 1

2023-06-02

- [EACL 2023 - CylE: Cylinder Embeddings for Multi-hop Reasoning over Knowledge Graphs \(...\)](#) —



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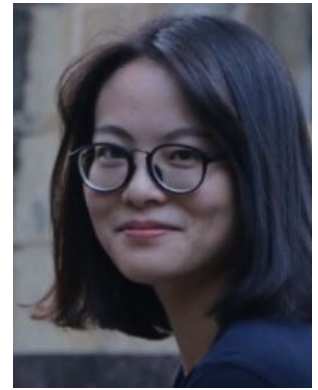
**Chau Nguyen**

PhD Student

## Theme 1

2023-05-04

- [Exploiting Domain Knowledge for Neural Technical Language Processing. \(...\)](#) —



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Ziyu Zhao

PhD Student

### Theme 1

2020-04-24

- [Failure project briefing Oslo \(...\)](#)



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Hodkiewicz

Chief Investigator

## Theme 1

2024-02-27

- [Failure Project presentation \(...\)](#)



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Chief Investigator

## Theme 1

2024-02-08

- [Future of Mining conference Sydney \(...\)](#) —



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Hodkiewicz

Chief Investigator

### Theme 1

2019-03-25

- How is intelligence artificially learnt (...) —



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A/Prof Wei Liu

Theme Lead

## Theme 1

2022-09-01

- ICMIAM AI on maintenance data -challenges to value delivery (...) —



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Hodkiewicz

Chief Investigator

## Theme 1

2021-12-15

- Improving how engineers communicate - with computers (...) —



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Hodkiewicz

Chief Investigator

### Theme 1

2021-10-26

- [Industrial data and the resurrection of ontologies \(...\)](#)



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Hodkiewicz

Chief Investigator

**Theme 1**

2023-07-21

- [Industrial Data Extraction and Use - SIEMENS Technology \(..\)](#) —



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Hodkiewicz

Chief Investigator

**Theme 1**

2024-02-21

- [Industrial Knowledge Graphs for Maintenance applications \(..\)](#) —



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Chief Investigator

### Theme 1

2023-03-01

- Integrating Domain Knowledge into Neural Technical Language Processing (...) —



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PhD Student

### Theme 1

2020-09-25

- [Intelligent Maintenance Conference 2020 \(...\)](#) —



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Dr Debora Correa

Chief Investigator

### Theme 2

2020-09-08

- [IOF Maintenance Working Group tutorial \(...\)](#) —



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Hodkiewicz  
Chief Investigator

**Theme 1**  
2024-02-07

- [ISWC 2019 \(...\)](#) —



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Hodkiewicz

## Chief Investigator

### Theme 1

2019-10-26

- [Key Note Speaker - Maintenance in an industry 4.0 and COVID-19 world – the case for remote operations \(...\)](#)  
—



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[Prof Melinda  
Hodkiewicz](#)

## Chief Investigator

### Theme 1

2020-11-05

- [Knowledge-Graph-Based Question Answering \(...\)](#) —



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Ziyu Zhao

PhD Student

### Theme 1

2022-02-18

- Large Language Models for Failure Mode Classification: An Investigation (...) —



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Dr Michael Stewart

Research Fellow

## Theme 1

2023-11-17

- [Latest advances in Natural Language Processing and how this can improve automation \(...\) —](#)



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A/Prof Wei Liu

Theme Lead

## Theme 1

2022-07-21

- [LexiClean: An annotation tool for rapid multi-task lexical normalisation \(...\) —](#)



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Tyler Bikaun

PhD Student

### Theme 1

2021-11-09

- [Mineral Resource Institute of Western Australia - PhD Research Showcase Poster \(...\)](#)



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Tyler Bikaun

PhD Student

### Theme 1

2021-08-03

- [Mini-symposium Ontologies for Infra and Building Sector](#) 16th April 2019, Delft (...) —



Prof Melinda  
Hodkiewicz

Chief Investigator

### Theme 1

2019-04-16

- [Modular ontologies for maintenance texts](#) (...) —



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Hodkiewicz

Chief Investigator

### Theme 1

2021-11-04

- [Natural Language Query For Technical Knowledge Graph Navigation \(...\)](#) —



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Ziyu Zhao

## PhD Student

### Theme 1

2022-12-12

- [NLP meets ontologies for industrial knowledge graphs on maintenance texts \(...\)](#) —



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Hodkiewicz

Chief Investigator

### Theme 1

2023-04-21

- [NLP Workshop \(...\)](#) —



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Dr Michael Stewart

Research Fellow

### Theme 1

2020-02-10

- [Ontologies meet NLP \(...\)](#) —



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## Theme 1

2022-11-10

- [Ontologies meet NLP - with a spare parts perspective \(...\)](#) —



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[Prof Melinda  
Hodkiewicz](#)

Chief Investigator

## Theme 1

2023-02-07

- [Ontologies meet NLP NLP- with a spare parts perspective \(...\)](#) —



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### Theme 1

2023-01-30

- [Periscope: A tool for centralised asset reliability assessment powered by NLP \(. ..\)](#) —



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Tyler Bikaun

PhD Student

### Theme 1

2022-06-03

- [Presentation - Semi-automated Estimation of Reliability Measures from Maintenance Work Order Records \(...\)](#) —



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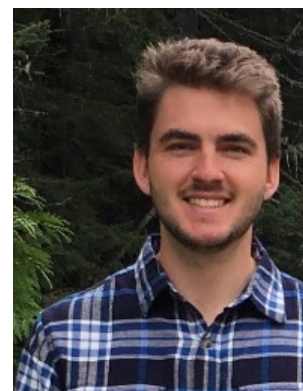
Tyler Bikaun

PhD Student

### Theme 1

2021-07-01

- [Presentation on Semi-automated Estimation of Reliability Measures from Maintenance Work Order Records \(...\)](#) —



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**Tyler Bikaun**

PhD Student

### **Theme 1**

2021-04-13

- [QUARRY: A Graph Model for Queryable Association Rules \(. ..\)](#) —



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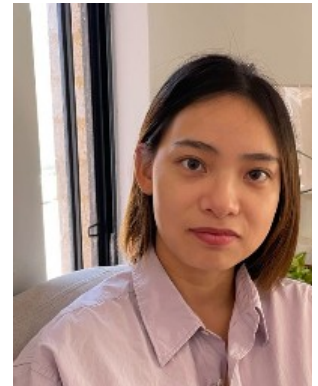
**Dr Michael Stewart**

Research Fellow

## Theme 1

2022-10-07

- [Question Answering over Temporal Knowledge Graphs \(. ..\)](#) —



Dr Sirui Li

Research Fellow

## Theme 1

2023-05-19

- [Questioning your maintenance data and get accurate answers \(...\)](#) —



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Ziyu Zhao

PhD Student

### Theme 1

2023-03-17

- [QuickGraph: A Rapid Annotation Tool for Knowledge Graph Extraction from Technical Text \(...\)](#) —



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Tyler Bikaun

PhD Student

### Theme 1

2022-05-27

- Reasoning about technical language for incomplete knowledge graphs using query embedding (...) —



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Chau Nguyen

PhD Student

### Theme 1

2022-04-08

- Redcoat: A Collaborative Annotation Tool Supporting Technical Language Processing Research (...) —



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Dr Michael Stewart

Research Fellow

### Theme 1

2021-04-13

- SConE: Simplified Cone Embeddings with Symbolic Operators for Complex Logical Queries poster presentation (...)



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Chau Nguyen

## PhD Student

### Theme 1

2023-07-12

- [Semantic Arts in US - Industrial Data Extraction and Use \(...\)](#) —



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**AUSTRALIA**

Prof Melinda  
Hodkiewicz

Chief Investigator

### Theme 1

2024-02-09

- [Simplified Cone Embeddings with Symbolic Operators for Complex Logical Queries poster presentation \(...\)](#) —



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**Chau Nguyen**

PhD Student

**Theme 1**

2023-09-05

- TBA (...) —



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**Prof Melinda  
Hodkiewicz**

Chief Investigator

## Theme 1

2019-06-19

- [The International Conference on Smart Computing & Communications \(ICSCC 2019\) \(...\)](#) —



**Prof Andrew Rohl**

Training Centre  
Director

## Directorate

2019-06-29

- [Towards a set of open reference ontologies for reasoning and text interoperability across the manufacturing domain \(...\)](#) —



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Prof Melinda  
Hodkiewicz

Chief Investigator

### Theme 1

2021-04-16

- [Tutorial at AJCAI 2022 \(...\)](#) —



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Dr Michael Stewart

Research Fellow

## Theme 1

2022-12-05

- [Tutorial at AJCAI 2022 - A Practical Guide to Knowledge Graph Construction from Technical Short Text \(...\)](#) —



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Dr Michael Stewart

Research Fellow

## Theme 1

2022-12-05

- [Unlocking knowledge buried within technical records \(...\)](#) —



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Dr Michael Stewart

Research Fellow

### Theme 1

2020-06-25

- [Unlocking knowledge in Maintenance Work Orders with Echidna and Redcoat \(...\)](#)
- 



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Dr Michael Stewart

## Research Fellow

### Theme 1

2021-04-13

- [Unlocking knowledge in Maintenance Workorders \(...\)](#)
- 



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Research Fellow

### Theme 1

2020-09-11

- [WA Mining Conference \(...\)](#) —



Prof Melinda  
Hodkiewicz

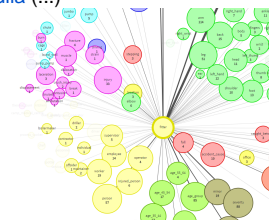
Chief Investigator

**Theme 1**  
2019-10-15

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## Tools

- [Aquila \(...\)](#) —

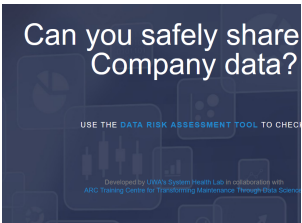


2020-01-31

An Interactive  
Web-based  
Toolset for  
Knowledge  
Discovery from  
Short Text Log  
Data

**Theme 1**

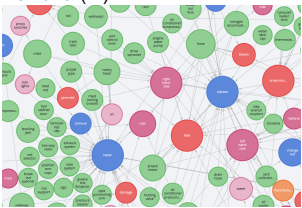
- [Data Risk Assessment Tool \(...\)](#)



2020-01-31  
Can you safely share your company data?

Theme 1 Theme 5

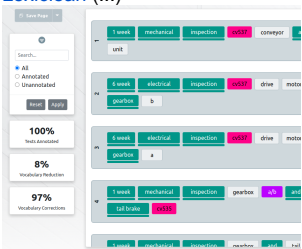
- [Echidna \(...\)](#) —



2020-01-31  
A Knowledge Graph for Maintenance

Theme 1

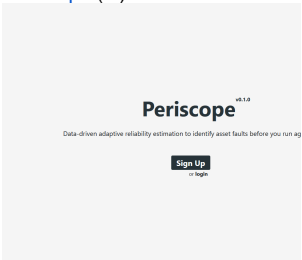
- [Lexiclean \(...\)](#) —



2020-01-31  
An annotation tool for rapid multi-task annotation of noisy corpora for the task of lexical normalisation

Theme 1

- [Periscope \(...\)](#) —

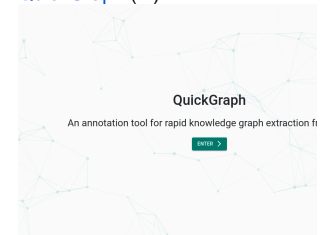


2020-01-31  
Data-driven adaptive reliability

estimation to  
identify asset  
faults before you  
run aground

## Theme 1 Theme 5

- QuickGraph (...) —

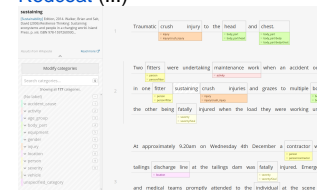


2020-01-31

A collaborative  
annotation tool for  
rapid multi-task  
information  
extraction for  
knowledge graph  
construction.

## Theme 1

- Redcoat (...) —

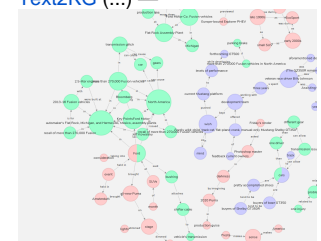


2020-01-31

A Collaborative  
Annotation Tool  
for Hierarchical  
Entity Typing

## Theme 1

- Text2KG (...) —



2020-01-31

An Automated  
Text to Knowledge  
Graph System

## Theme 1

The Team

Lead



- [A/Prof Wei Liu \(...\)](#) —  
[A/Prof Wei Liu](#)

Theme Lead

### Theme 1

Chief Investigators

- [A/Prof Timothy French \(...\)](#) —



[A/Prof Timothy French](#)

Chief Investigator

### Theme 1

- [Prof Melinda Hodkiewicz \(...\)](#) —



[Prof Melinda Hodkiewicz](#)

Chief Investigator

**Theme 1**

- [Prof Tele Tan \(...\)](#) —



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**Theme 1**

Partner Investigators

- [Dr Ulrich Engelke \(...\)](#) —



[Dr Ulrich Engelke](#)

Partner Investigator

### [Theme 1](#)

## Research Fellows

- [Dr Michael Stewart](#) (...) —



[Dr Michael Stewart](#)

Research Fellow

### [Theme 1](#)

- [Dr Sirui Li](#) (...) —



**Dr Sirui Li**

Research Fellow

**Theme 1**

**PhD Students**

- [Chau Nguyen \(...\)](#) —



**Chau Nguyen**

PhD Student

**Theme 1**

- [Tyler Bikaun \(...\)](#) —



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**AUSTRALIA**

[Tyler Bikaun](#)

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### Theme 1

- [Ziyu Zhao \(...\)](#) —



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### Theme 1