# Erli Wang

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Dr. Erli Wang is a leading AI researcher and practitioner with a strong background in both academic and industrial applications. He has successfully led technology commercialization at NEC Corporation and spearheaded the development of decision-making solvers at the Australian National University and the University of Queensland.

He has a proven track record of translating AI/ML methodologies into practical solutions. His work spans a variety of industries, including the retail sector, where he delivered demand forecasting solutions to reduce food waste, and human capital management, where he employed causal analysis to identify key performance drivers. Additionally, he has contributed to predicting biomarkers for flavor preservation and developed novel planning algorithms for robotics under uncertainty. He has also lent his data science expertise to the urban food systems project, initiated by the Food and Agriculture Organization (FAO) of the United Nations.

His contributions have been recognized through numerous high-impact publications in top-tier conferences such as AAAI and ICAPS, and he is the first inventor on 10 patents. In 2021, he received the second-grade Contribution Award from NEC Corporation, and his causal analysis system was showcased at the prestigious 2023 Zhongguancun Forum.

## Skill

**Core Competencies**: Solution Architecture, Artificial Intelligence, Machine Learning, Data Science
**Programming**: Python, C/C++, Matlab, SQL, LaTeX
**Library**: Pandas, NumPy, scikit-learn, statsmodels, PyTorch
**Operating System**: Linux, Windows
**Professional Skills**: Stakeholder Engagement, Intellectual Property, Technology commercialization

## Education

**Ph.D.** in Mathematics and Computer Science, University of Queensland(UQ), Australia 04/2015 - 08/2019
Thesis: Decision Making in An Uncertain World.
Supervisors: Prof. Dirk P. Kroese and Prof. Hanna Kurniawati
**B.Sc.** in Applied Mathematics, Chengdu University of Information Technology, China 09/2008 - 06/2012

## Solution Innovation Experience

**Researcher** 07/2020 - 08/2024
Data Analysis Group, NEC Labs, China

- **Insight technology via causal analysis**. Except highly-engineered task, understand the basic mechanisms is key to behave optimally. Causal analysis is a technique used to uncover the underlying causes and effects ("why"). Its purpose is to discover the causal structure within complex systems, enabling explicit descriptions of the generative mechanisms and facilitating accident prevention through intervention.
  - `Technology Leadership`: As a major contributor, our causal analysis system offers a comprehensive set of functionalities. It involves determining the key driving factors to a given target, predicting future changes in the target, and automatically generating a strategy to achieve a predefined objective. Besides, our what-if function allows for new strategies simulation in an interpretable manner prior to execution.
  - `Solution Design and Implementation`: In digital HR, we often get the result like 'I don't know the reason, but it seems like this is how it is.' In that case, it's hard to connect the next action. Another technical difficult of this type problem is to improve rare and unsatisfied people, but with hundreds of monthly behavior data dimensions. Our causal-based solution is able to identify key drivers to unsatisfied people, and apply intervention operations to improve a better than as-is situations.
  - `Transform Technology to Business`: Spin-out from our research, NEC X, the innovation accelerator for NEC's emerging technologies, guided Inguo.io's entrepreneur-in-residence (EIR) participants through the steps of customer discovery and development, along with business model validation. Inguo.io, Inc. provides automated Causal Discovery and Causality Analysis tools — a first for the data science industry.
  - Award: We received a second-grade contribution award from NEC in 2021.
  - Patent filed: US20220414540A1, US20230153689A1
  - Programming languages: Python, Matlab
  - In NEC's AI lineup: https://www.nec.com/en/global/solutions/ai/analyze/index.html.

- **Sales Forecasting Architecture**. Description: According to the U.S. Department of Agriculture (USDA), between 30% and 40% of food is wasted in the U.S., with 31% of this occurring at the retail and consumer level. The mismatch between supply and demand is one of the main causes of food loss. Therefore, we expect to reduce the discards by accurately forecasting the next days of sales. A difficult in this case is that the real sale is often heavily skewed: a long runs of zero demand but with a sharp increase.
    - To alleviate this technical difficult, our comprehensive solution includes data quality control, item grouping/filterinng, statistical test for time lag identification, multi-step forecasting and model monitoring overtime. Collabroating with a large retailer, we are able to improve unnecessary waste to about 1.3% of total sales. As a reference, the EBITDA in the fiscal year of this retailer is 6%.
    - Patent filed: US20240070160A1
    - Programming languages: Python, Matlab
    - Link: https://vpdd.github.io/erliwang/solution_idea/forecast.html.
- **Sample Efficient Framework for Decision Making**. The shortage of sufficient interaction data challenged the practicality of decision making method.In reality. For example, medical data are often collected from different hospitals causing domain shift issues.There are also some examples that the training data are not known in advance such as the demand forecasting of new products to address this issue.
    - ACAMDA combines causal recovery with guided counterfactual data augmentation to realize sequential decision-making across heterogeneous environments in a data-driven manner, so that non-expert datasets can be used to disentangle the causal mechanism, leading to tremendous cost savings in collecting data from multiple sources. Experiments show that the new algorithm achieves comparable results to other leading model-based approaches in the stationary domains and shows a significant performance when the policy adapts to novel unseen scenarios with a 15% success rate improvement in some control tasks. This research result was published at AAAI-2024 main track [1].
    - Patent filed: US20230214694A1
    - Programming languages: Python, PyTorch
    - Website at AAAI-24: https://ojs.aaai.org/index.php/AAAI/article/view/29442.

**Research Fellow** 05/2019 - 06/2020

Research School of Computer Science, ANU, Australia

- **Inventory control with partially observable states**. Industrial investigations indicate that errors in inventory recordings are common and often unavoidable. Such errors result in dramatic wastes and cost to the industry. Inventory control in the presence of such errors is essentially a partially-observed decision-making problem. Although robust framework, such as the Partially Observable Markov Decision Processes (POMDPs) have been applied to inventory control, most work restrict to single commodity or assume independence between commodities, due to difficulties in solving large discrete action space problem.
    - This work applies our method, QBASE [4], to problems with multiple commodities whose demand levels are correlated. Numerical experiments on partially observed multi-commodity inventory control problems indicate that our proposed solution [2] can find less conservative inventory control strategies that yield 20% higher profits, compared to existing solutions.
    - Programming languages: C++, Python
    - Link: https://rdl.cecs.anu.edu.au/projects/po_inventory_control.
    - Media: https://reporter.anu.edu.au/all-stories/better-behaving-bots

**PhD Student** 04/2015 - 08/2019

ARC Centre of Excellence for Mathematical & Statistical Frontiers, UQ, Australia

- **Decision making in an uncertain world**. Making principled decisions in the presence of uncertainty is often facilitated by Partially Observable Markov Decision Processes (POMDPs). Despite tremendous advances in POMDP solvers, finding good policies with large action spaces remains difficult. This issue is regarded as one of key AI problems to breakthrough.
    - The multi-armed bandit problem is an important model for studying the exploration−exploitation tradeoff in sequential decision making. I developed a method called CEMAB [5] to study large-scale multi-armed bandit problem. It uses the Cross-Entropy method as a noisy optimizer to find the optimal arm without sweeping all arms at beginning, so as to scale up much better on problems with a large arm set.

      We introduce our efforts to scale-up the capability to solve large-scale problems. Similar to most online solvers, our QBASE[4] uses sampling to construct a belief tree. However, it uses a quantile-based approach, derived from the Cross-Entropy method for optimization, to adaptively construct a small subset of the action space, so as to avoid full enumeration of the action space without sacrificing the quality of the generated decision strategies. Experiments on four different robotics tasks on large-scale problems (states upto $10^{32}$, actions upto a million) indicate that our developed QBASE planner can generate substantially better strategies than a state-of-the-art method. For example, the new algorithm

only needs 5 seconds computing to achieve 97.7% success rate, whereas benchmark's number is 33.9%. This is work was published in ICAPS 2018.
- Programming languages: C++, Python
- Link: https://rdl.cecs.anu.edu.au/projects/pomdp_large_action_space.

## Teaching/Tutoring

**COMP3600/6361 Algorithm** 07/2019 - 02/2020
The Australian National University, Australia

**COMP3702/7702 Artificial Intelligence** 07/2018 - 11/2018
The University of Queensland, Australia

## Award

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| Second grade contribution award, NEC Corporation | 07/2021 |
| UQ candidate development award | 05/2018 |
| School of mathematics and physics student conference funding | 04/2018 |
| ICAPS student support | 04/2018 |
| UQ international scholarship (UQI tuition fees & living allowance) | 12/2014 |
| Second national award in CUMCM-2010 (mathematical contest in modeling in China) | 11/2010 |

## Selected Publication


[1] Yuewen Sun, Erli Wang*, Biwei Huang, Chaochao Lu, Lu Feng, Changyin Sun, Kun Zhang. ACAMDA: Improving Data Efficiency in Reinforcement Learning Through Guided Counterfactual Data Augmentation. *The 38th AAAI Conference on Artificial Intelligence (AAAI-24)* [paper].

[2] Erli Wang and Hanna Kurniawati and Dirk P. Kroese. Inventory Control With Partially Observable States. *The International Congress on Modelling and Simulation (MODSIM)*, 2019. [paper].

[3] Erli Wang. Decision Making In An Uncertain World. PhD thesis, *The University of Queensland*, 2019. [thesis].

[4] Erli Wang and Hanna Kurniawati and Dirk P. Kroese. An On-line Planner for POMDPs with Large Discrete Action Space: A Quantile-Based Approach. *Int. Conference on Automated Planning and Scheduling (ICAPS)*, 2018. [paper].

[5] Erli Wang and Hanna Kurniawati and Dirk P. Kroese. CEMAB: A Cross-Entropy-based method for large-scale multi-armed bandits. *Proc. Australasian Conference on Artificial Life and Computational Intelligence (ACALCI)*, 2017. [paper].

[6] Erli Wang and Hanna Kurniawati and Dirk P. Kroese. Cross-Entropy method for robot motion planning. *ITEE Technical Report No. 2015--01. School of Information Technology and Electrical Engineering, The University of Queensland, Brisbane, Australia.*.

[7] Dingping Wu, Qibin Duan, Erli Wang and Hang Zhao. The Split Feasibility Problem in Hilbert Space. *International Conference on Communication, Electronics and Automation Engineering*, 2013. [paper].

[8] Qibin Duan, Erli Wang, Dingping Wu and Xuping Xie. Ishikawa's Iterative Algorithm of Nonexpansive Mappings and Averaged Mappings. *International Conference on Communication, Electronics and Automation Engineering*, 2013. [paper].

[9] Erli Wang, Yongmin Chen and Zhixi Chen. Based on the optimal point of new strengthening buffer operator and its applications. *Journal of Statistics and Decision (in Chinese)*, 2012. [paper].

[10] Erli Wang, Dingping Wu, Qibin Duan and Hang Zhao. Strong Convergence Theorems for Lipschitzian Demi-contraction Semi-group in Banach Space. *International Conference on Business Computing and Global Informatization*, 2011. [paper].


**Patent Filed:**


[11] US-2024070160, Data processing method and electronic device. [link].

[12] US-2023214694, Data processing method and electronic device. [link].

[13] US-2023153689, Information processing method and electronic device. [link].

[14] US-2022414540, Method, device and medium for data processing. [link].