

# Research Statement

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## Background

What is impactful research? – A question I ask myself when I consider research questions I would like to work on. My prior working experience in the IT consulting industry allowed me to appreciate practical research solutions which bring value to people and organizations. Hence, I decided that my research shall focus on practical problems, where real-world problems shape the research questions and the scientific investigations from research yield evidence-based real-world solutions.

My research spans three main areas: (1) applied machine learning and analytics for healthcare and general well-being; (2) learning analytics and adaptive learning; and (3) optimization and decision analytics for sustainable supply chains. In my research work, the techniques applied include simulation, machine learning algorithms, and optimization. Being a practice-track faculty member, I enjoy the applied work with a balance in both research outcomes and practical applications. I hope my research outputs are not only scientific publications but also tangible outputs to create an impact either in the industry or in learning and teaching.

## Research Areas

### ***(1) Applied Machine Learning and Analytics for Healthcare and General Well-Being***

Service improvement in healthcare institutions is a meaningful problem as we are concerned about the well-being of people. Partnered with a healthcare institution for my PhD thesis, I worked on a variety of algorithms that involved information processing, staffing, and queue management issues to yield operational and patient quality of service improvements. Three pieces of work related to the Emergency Department (ED) were duly studied. One of these involved dynamic prioritizations of patients as a decision-support approach to help doctors decide the sequence of patients to see so that overall length-of-stay could be optimized [1]. Another work was a dynamic resource allocation algorithm based on arrival patterns for adjusting physician staffing requirements [2]. Putting both demand and supply considerations together, I proposed a consolidated framework with a symbiotic simulator for handling both dynamic patient flow and resource allocation in real-time [3].

Over the past five years, my collaboration with hospitals has shifted focus towards enhancing process optimization, refining operational scheduling, and tackling challenges to improve patient outcomes through data mining methodologies. One such project was a surgical duration prediction model. Many existing related studies used post-surgical data which we found to be impractical for implementation in a public hospital because certain key predictors were unavailable during surgery scheduling. Differing from the other studies, our work focused on resolving the research-to-practice gap by combining feature engineering and multiple prediction

models to bridge the gap. The resulting model was practice-feasible and can be used by the hospital to better schedule surgeries across thirty disciplines [4].

More recently, my research has moved toward the citizens' well-being and improving patients' outcomes. I worked on research questions that provide evidence-based analysis to understand behavioural patterns and needs of citizens in the city for a better quality of life. An example of a study involves the use of geolocational sensor data to infer the social participation performance of wheelchair users [5] to inform decision-makers on the provision of social support for a more inclusive society. Another work includes one which is related to understanding the mental wellness of the citizens in the city by using text and social analytics [6]. In our recent endeavours to enhance patient outcomes, we have delved into leveraging machine learning to address COVID-19 at a national level. This involves employing risk stratification prediction techniques to recommend suitable intervention measures [7].

## ***(2) Learning Analytics and Adaptive Learning***

I'm deeply passionate about teaching and am currently researching the impact of a dual-perspective feedback system on student learning. This innovative mechanism combines learner-centric reflection and instructor-centric learning analytics to guide personalized interventions for each student. My research introduces an automated text-mining approach to assess student understanding and pinpoint doubts, a novel concept distinct from previous methods relying on sentiment analysis and question identification [8].

In our extension, we further refine the doubt identification artificial intelligence (AI) model that leverages a hybrid approach using Doubt Sentic Pattern Detection (SPD) algorithm and a machine learning model [9]. An adaptive learning system was developed to deploy our doubt-identification model, along with an additional topic alignment model and personalized learning tool to enable students to benefit directly from the adaptive learning capabilities. A pilot study was done with a real class and learning effectiveness results were published in [10]. Expanding our research, we applied doubt-mining techniques to StackOverflow posts and comments. This approach helps predict which posts may require improved or revised answers. Additionally, we introduced new metrics on StackOverflow. We aim for our proposal to assist programming learners in discovering high-quality answers [11].

## ***(3) Optimization and Decision Analytics for Sustainable Supply Chain***

In the context of urbanization, optimizing natural resource usage and addressing urban congestion and pollution have become increasingly important. My previous projects focused on applying optimization and decision analytics within supply chain management. One example of a research project is the Ocean Freight Consolidation Optimization study for a large manufacturer of consumer products. The study approached sustainability by formulating an optimization model to minimize carbon emissions of ocean freight shipments [12, 13].

Another notable project related to sustainability involved the development of a framework (in collaboration with the Maritime Port Authority of Singapore (MPA)) to analyse and evaluate sustainability initiatives for maritime operations across four types of port terminals in Singapore: container, bulk cargo, oil, and cruise terminals.

This work served as guiding principles for governing the policies for energy consumption and efficiency in Singapore's Next Generation Port (NGP) 2030. The project garnered the Special Mention Award for being the Top-voted Policy Research in the Singapore Maritime Institute Research Project Showcase in April 2016 [14].

Through collaboration with the industry, I led a team at Green Transformation Lab (GTL) from 2013 to 2017 to develop and commercialize tools that helped organizations better visualize the carbon footprint of their end-to-end supply chain. A few to name which have been commercialized are The Carbon Dashboard and The Carbon Calculator [15]. Other data-driven analytical tools include a road freight calculator and an energy benchmarking tool for sustainable warehouses [16].

## Going forward

In the near future, I plan to sustain partnerships with healthcare institutions and government agencies to tackle healthcare and social well-being challenges through data-driven approaches. I'm excited about exploring learning analytics and adaptive learning further, aiming to collaborate with like-minded researchers to innovate teaching and learning tools and methodologies.

## Selected Publications and Outputs

- [1] Improving patient length-of-stay in emergency department through dynamic queue management, by Kar Way TAN, Hoong Chuin LAU, Francis Chun Yue LEE. Proceedings of the 2013 Winter Simulation Conference, Washington DC, Piscataway, NJ, 12/2013. (Published, Peer-Reviewed)
- [2] Improving patient length-of-stay in emergency department through dynamic resource allocation policies, by Kar Way TAN, Wei Hao TAN, and Hoong Chuin LAU. Proceedings of IEEE International Conference on Automation Science and Engineering, Madison, Wisconsin, 08/2013. (Published, Peer-Reviewed)
- [3] Improving patient flow in emergency department through dynamic priority queue, by Kar Way TAN, Chao WANG and Hoong Chuin LAU, Proceedings of IEEE International Conference on Automation Science and Engineering, Seoul, Korea, 08/2012. (Published, Peer-Reviewed)
- [4] Data-Driven Surgical Duration Prediction Model for Surgery Scheduling: A Case-Study for a Practice-Feasible Model in a Public Hospital, by Kar Way TAN; Francis Ngoc Hoang Long NGUYEN, Boon Yew ANG, Jerald Tang Chow GAN, Sean Shao Wei LAM. Proceedings of IEEE Conference of Automation Science and Engineering, Vancouver, 08/2019. (Published, Peer-Reviewed) -- **Best Healthcare Paper Finalist.**
- [5] Social Participation Performance of Wheelchair Users Using Clustering and Geolocational Sensor's Data, by Yukun YIN; Kar Way TAN. Proceedings of IEEE Conference of Automation Science and Engineering, Hong Kong, 08/2020. (Published, Peer-Reviewed)
- [6] Discovery of Mental Wellness Via Social Analytics for Liveability in an Urban City, by Kar Way TAN; Proceedings of IEEE Conference of Automation Science and Engineering, Lyon, France, 08/2021. (Published, Peer-Reviewed)
- [7] Combat COVID-19 at National Level Using Risk Stratification with Appropriate Intervention, by Xuan JIN, Kar Way TAN. Proceedings of IEEE Big Data, Italy, 12/2023. (Published, Peer-Reviewed)
- [8] Do my students understand? Automated identification of doubts from informal reflections, by Siaw Ling LO, Kar Way TAN, Eng Lieh OUH. Proceedings of the 27th International Conference on Computers in Education. Taiwan: Asia-Pacific Society for

Computers in Education, 2019. (Published, Peer-Reviewed) – **Overall Best Paper Finalist**

- [9] Automated doubt identification from informal reflections through hybrid sentic patterns and machine learning approach; by Siaw Ling LO, Kar Way TAN, Eng Lieh OUH; Research and Practice in Technology Enhanced Learning (RPTEL), Vol 16(1), pp 1-24, 2021. (Published, Peer-Reviewed)
- [10] AI-enabled adaptive learning using automated topic alignment and doubt detection, by Kar Way TAN, Siaw Ling LO, Eng Lieh OUH, Wei Leng NEO. Proceedings of the 2022 Annual Pacific Asia Conference on Information Systems (PACIS), 07/2022. (Published, Peer-Reviewed)
- [11] Machine-Learning Approach to Automated Doubt Identification on Stack Overflow Comments to Guide Programming Learners, by Tian Hao Chen, Eng Lieh OUH, Kar Way TAN, Siaw Ling LO. Proceedings of the 2023 Annual Pacific Asia Conference on Information Systems (PACIS), 07/2023. (Published, Peer-Reviewed)
- [12] Reducing carbon emission of ocean shipments by optimizing container size selection, by Edwin Lik Ming CHONG; Nang Laik MA; Kar Way TAN. Proceedings of IEEE International Conference on Automation Science and Engineering (CASE 2014), Taipei, Taiwan, 08/2014. (Published, Peer-Reviewed)
- [13] Improving Carbon Efficiency through Container Size Optimization and Shipment Consolidation, by Nang Laik MA; Kar Way TAN; Edwin Lik Ming CHONG, The 8th International Conference on Logistics and Transport, Singapore, 09/2016. (Published, Peer-Reviewed)
- [14] A Framework for Evaluating Energy Sustainability Efforts for Maritime Smart Port Operations, by Kar Way TAN, Michelle KAN, Pang Jin TAN and Stephan SCHABLINSKI, Proceedings of IEEE International Conference on ICT for Smart Society, 10/2018 (Published, Peer-Reviewed)
- [15] DHL GoGreen Carbon Dashboard and Carbon Calculator, DHL, website, <https://www.dhl.com/global-en/home/our-divisions/global-forwarding/special-expertise/gogreen-solutions.html>, last accessed on 24 December 2022.
- [16] A Data-Driven Approach for Benchmarking Energy Efficiency of Warehouse Buildings, by Wee Leong LEE; Kar Way TAN; Zui Young LIM, Proceedings of the 19th International Conference on Supply Chain and Logistics Engineering, 05/2017. (Published, Peer-Reviewed)