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A*STAR's Institute of High Performance Computing, the Singapore Management University and Fujitsu are collaborating to develop these innovative new technologies, with the support of the Maritime and Port Authority of Singapore.

The Agency for Science, Technology and Research (A*STAR)'s Institute of High Performance Computing (IHPC), the Singapore Management University (SMU) and Fujitsu Limited (Fujitsu) announced their collaboration to develop innovative new technologies for vessel traffic management in the Port of Singapore, with the support of the Maritime and Port Authority of Singapore (MPA).

These new predictive technologies will leverage artificial intelligence (AI) and big data analytics and they will be validated using real-world data to improve the forecasting of congestion and potential collisions before they occur at sea, and identification of risk hotspots.

The research and development for these new maritime technologies has been conducted under the guidance of the Urban Computing and Engineering Centre of Excellence (UCE CoE), a public-private partnership consisting of A*STAR, SMU, and Fujitsu, that was established in 2014.

The Straits of Singapore and Malacca comprise one of the world's busiest sea lanes. According to the MPA, at any given moment there are about 1,000 vessels in the Singapore port, with a ship arriving to or leaving Singapore once every 2-3 minutes.

The partnership was formed with the goal of continuous enhancement of navigational safety in these crowded waters. The UCE CoE initiated research and development into technologies for maritime vessel traffic management in 2015. IHPC contributed its capabilities in modeling and simulation, as well as probabilistic modeling and machine learning techniques, while SMU provided its expertise in large-scale multi-agent optimisation models. Fujitsu Laboratories Ltd. leveraged its data analytics and artificial intelligence technologies to support the endeavour.

Under the agreement, MPA will provide data and information for further research and development and test-bedding of technologies developed by UCE CoE for application in the Singapore waters.

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Key technologies being developed include prediction models, such as a short-term trajectory prediction model that accurately predicts the trajectory of a vessel using machine learning and motion physics and a long-term traffic model that can forecast the traffic situation based on the traffic patterns of a large number of vessel types, derived from historical data.

A risk calculation model is being developed that can reliably quantify the near-miss risk of a pair of vessels, by integrating various risk models. A hotspot model would dynamically reveal changing risk hotspots through spatio-temporal data analysis.

Intelligent coordination models are being developed such as a spatial coordination model that seeks to re-route vessels to avoid near-miss and collision incidents and a temporal coordination model that coordinates the passage timing of vessels to reduce hotspots. Both of these coordination models will support real-time decision-making to mitigate predicted risks, while minimising disruptions and ensuring smooth navigation for the vessels.

These technologies will eventually be integrated and test-bedded for their potential to enhance navigational safety, such as the ability to detect and recognise a near-miss risk prior to the event (e.g. 10 minutes beforehand), by combining short-term trajectory prediction with risk calculation.

Another target is to forecast and mitigate dynamically changing hotspots before it is generated (e.g. 30 minutes beforehand) by integrating long-term traffic forecasts, hotspot calculation, and intelligent coordination models.

The outcomes of this research and development phase, as well as the practical knowledge and experience gained through the project trials, will also be integrated into Fujitsu's future maritime solutions.

"As Singapore develops future capabilities that will enhance our port operations, research and innovation will remain key to the maritime industry. As part of the recently launched Sea Transport Industry Transformation Map, MPA is supportive of collaborations among local Institutes of Higher Learning and technology companies to explore new technologies that will raise the standards of navigational safety within the Port of Singapore. We look forward to further testing the research outcomes at the MPA Living Lab," said Capt. M Segar, Assistant Chief Executive (Operations), MPA.

Prof Alfred Huan, Executive Director of A*STAR's IHPC, commented, "A*STAR is delighted to deepen our existing partnership with Fujitsu, SMU and MPA to solve challenges faced by Singapore and other maritime nations. Such a private-public partnership model leverages capabilities from both public institutions and industry players, strengthens our collaboration through a multi-disciplinary approach, and enhances our collective ability to develop innovative solutions that can meet future maritime needs."

Professor Lau Hoong Chuin, SMU's Lab Director and Lead Investigator of the UCE CoE talked about the extensive use of multi-agent technology [1] in coordinating the movements of unmanned aerial vehicles and unmanned ground vehicles.

He explained that in this project with MPA, SMU is proposing a next generation maritime traffic coordination technology that is similar to air traffic control, yet respects major differences between air and sea navigation.

"With the advent of autonomous ships, this technology can potentially disrupt vessel traffic management to reduce human errors and improve navigational safety," said Professor Lau Hoong Chuin.

"Enhancing navigational safety is an enormous challenge as there is no single right path for how to achieve it. That is why we value the collaboration with A*STAR and SMU to welcome bold ideas. We also appreciate the support by MPA to examine the applicability of the solutions, and this is a great

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match with Fujitsu's emphasis on "co-creation". We are pleased to not only contribute technologies, but also to have provided a platform to integrate and test the technologies by different parties," said Shoji Suzuki, Corporate Executive Advisor, Fujitsu Laboratories.

[1] Multi-agent systems consist of a network of software agents that interact to solve problems that are beyond the individual capacities or knowledge of each problem solver.