



**Putrajaya,  
Malaysia.**

# **2<sup>nd</sup> International Symposium on Systems Modelling and Simulation**



Organised By

<https://mysimsc.org/sms2026> 

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# About SMS 2026



The Malaysian Simulation Society (MSS) is a learned society established in 2017 with the aims to enhance knowledge, research and teaching in many aspects of modelling and simulation. MSS is affiliated in The Asia Simulation Federation (ASIASIM) together with simulation societies in Japan, China, South Korea and Singapore.

With the aims to enhance and disseminate frontier and latest knowledge in modelling and simulation, MSS is proud to organise the second International Symposium on Modelling and Simulation (SMS 2026). SMS 2026 focuses on important topics in Modelling and Simulation that are related to the current and emerging technologies. The applications of modelling and simulation to advanced systems such as robotics, smart manufacturing, intelligent systems and machine learning will be of interest. Moreover, SMS 2026 encourages articles that apply theoretical work into practice.

SMS 2026 is conducted in hybrid format to encourage many submissions from different regions of the world. This is also to ensure high-quality articles can be selected. For this hybrid symposium, online participation is available; however, we strongly encourage in-person attendance to enhance collaboration and build stronger professional relationships.. SMS 2026 is expected to provide researchers, academicians, industries and postgraduate students opportunities to share their latest scientific, engineering and technological research findings, which covers applications of Modelling and Simulation in various fields. For this year, three themes were chosen: (1) Emerging Trends in Engineering and Computing; (2) Modelling and Simulation for Digital Transformation; (3) Intelligent System and Applications. Articles within the focus area from all regions are welcomed.

The organizing committee has carefully selected technical papers for SMS 2026 by adopting best practices and peer-reviews. SMS 2026 received 56 submissions, and 25 papers were accepted with an acceptance rate of 43%. All the accepted and presented papers will be submitted for evaluation and publication in the Communications in Computer and Information Science (CCIS) series published by Springer. It is envisaged that the articles will be beneficial to many people in the area of modelling and simulation.

It is hoped that SMS 2026 will be a successful event, and will have more success in the future series of the symposium.

# Foreword Malaysian Simulation Society (MSS) Chair



On behalf of the Malaysian Simulation Society (MSS) organizing committee, I would like to extend my gratitude and warmly welcome all participants from around the world to the 2<sup>nd</sup> International Symposium on Systems Modelling and Simulation 2026 (SMS 2026). Your participation is what truly makes this Symposium special, whether you are an attendee, speaker, or panellist. For your reference, MSS is a scholarly organization founded in 2017, with the goal of advancing the teaching and research of modelling and simulation across various disciplines. MSS is also affiliated in the Federation of Asian Simulation (ASIASIM) together with several simulation societies in Asian including Japan, China, South Korea and Singapore.



**Prof. Ir. Dr. Norhaliza Abdul Wahab**  
*"Chair, Malaysian Simulation Society"*

Following the success of SMS 2024, the Malaysian Simulation Society is proud to organize SMS 2026, the second chapter of this symposium series which conducted in hybrid format. We encourage you to participate actively and make the most of the unique opportunities that our hybrid Symposium provides. Together, we explore new research, cutting-edge ideas, and actionable solutions that can drive the future forward.

I would like to take a moment to express my deepest gratitude to a few key individuals and groups who have made this second series of Symposium possible. Thank you to our organizing committee for their incredible hard work in ensuring every aspect of the event is a success. I would also like to extend my sincere appreciation to our Keynote Speaker and Presenters. Thank you for generously sharing your expertise with us. Your contributions are the heart of this event, and we are grateful for the knowledge and insights you will be providing. And finally, to you, our attendees: Thank you for your enthusiasm and willingness to embrace our second edition of Symposium, SMS 2026. Your participation is what truly makes this Symposium special. We are excited to share this experience with you and hope it leads to new ideas, partnerships, and opportunities.

# Foreword Malaysian Simulation Society (MSS) Chair



This Symposium is not just about listening to presentations, it is about collaboration. It is about sparking conversations, sharing ideas, and building connections that can lead our systems simulation to real-world impact.



**Prof. Ir. Dr. Norhaliza  
Abdul Wahab**

*"Chair, Malaysian Simulation Society"*

Finally, I would like to leave you with a thought: SMS 2026 is our second series of Symposium, and it will certainly not be the last. We are committed to continuing this journey of learning, connecting, and innovating. We are so glad to have you on this journey with us.

Enjoy the Symposium, stay engaged, and let's make this a memorable event.

Thank you.

Prof. Ir. Dr. Norhaliza Abdul Wahab  
Chair,  
Malaysian Simulation Society (MSS)

# Foreword SMS 2026 Chair



Opening Speech by the Chair:

On behalf of the organizing committee, it is my great pleasure and honour to warmly welcome all of you to the 2<sup>nd</sup> International Symposium on Systems Modelling and Simulation (SMS 2026). SMS 2026 is conducted in a hybrid format, integrating both physical and online participation. While virtual attendance is available, we strongly encourage participants to attend in person to foster deeper collaboration and strengthen professional relationships.

This symposium is proudly organised by the Malaysian Simulation Society (MSS), which is affiliated with the Asia Simulation Federation (ASIASIM), alongside simulation societies from Japan, China, South Korea, and Singapore. We are delighted to host such a diverse and distinguished community of participants.

The primary objective of this symposium is to provide an international platform for researchers, engineers, academicians, and industry professionals to present and exchange the latest findings and advancements in the field of systems modelling and simulation. We also hope that this event will foster meaningful networking opportunities and inspire future collaborations across disciplines and borders.

This year, we received a total of 54 paper submissions. Following a rigorous review process, 24 papers were selected for oral presentation, resulting in an acceptance rate of 44%. Of these, 15 papers are from Malaysia, while the remaining contributions come from Indonesia, Nigeria, Japan, France, Germany, Ecuador and USA. We are truly privileged to bring together such a rich diversity of perspectives and expertise. Accepted and presented papers will be published in the Communications in Computer and Information Science (CCIS) series by Springer prior to the symposium. The CCIS series is indexed and abstracted in major databases, including EI Compendex, DBLP, INSPEC, the Japanese Science and Technology Agency (JST), the Norwegian Register for Scientific Journals and Series, Google Scholar, zbMATH, SCImago, and Scopus.



**Assoc. Prof. Ts. Dr.  
Herman Wahid**

*"Chair, SMS 2026"*

# Foreword SMS 2026 Chair



Over the next two days, the symposium will explore three main tracks:

- (1) Trends in Engineering and Computing;
- (2) Modelling and Simulation for Digital Transformation; and
- (3) Intelligent Systems and Applications.



**Assoc. Prof. Ts. Dr.  
Herman Wahid**

*"Chair, SMS 2026"*

I would like to extend our sincere appreciation to our keynote speaker, Ts. Dr. Hairi bin Zamzuri, CEO of eMooVit Technology Sdn. Bhd., for graciously sharing his valuable insights and expertise with us. My heartfelt thanks also go to the organizing committee, whose dedication and hard work have been instrumental in making this symposium a reality.

As we begin this journey of knowledge sharing and collaboration, I encourage all participants to engage actively, exchange ideas openly, and build connections that extend well beyond this event.

Once again, welcome to SMS 2026. I wish you all a fruitful and inspiring symposium filled with engaging discussions and meaningful experiences.

Thank you.

Assoc. Prof. Ts. Dr. Herman Wahid  
Chair, SMS 2026

# Organising Committee



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# Keynote Speaker



Dr. Hairi bin Zamzuri is the Chief Executive Officer of eMooVit Technology Sdn. Bhd., a Malaysian technology company specializing in autonomous driving software solutions for smart mobility and urban transportation. He has more than 20 years of experience in the development, testing, and commercialization of autonomous and intelligent vehicle systems.

Dr. Hairi received his Bachelor's and Master's degrees in Electrical Engineering (Control Systems) from Universiti Teknologi Malaysia, and later obtained his Ph.D. in Artificial Intelligence and Control Design from Loughborough University.



**Ts. Dr. Hairi Zamzuri**

*"CEO of eMooVit Technology  
Sdn Bhd, Malaysia"*

Prior to his leadership in industry, he served as an academic and researcher, publishing over 100 scholarly works in areas related to vehicle dynamics, control systems, and active safety technologies. His research interests include integrated vehicle control, intelligent systems, and automotive safety, and he has led collaborative research initiatives with industry partners such as Proton.

At eMooVit, Dr. Hairi leads the development of autonomous mobility solutions, including driverless shuttles and electric buses for last-mile transportation. His work has contributed to Malaysia's early adoption of autonomous vehicle technologies, including pilot projects and public trials of self-driving buses.

In addition to his role as CEO, Dr. Hairi is actively involved as a speaker, consultant, and advisor in the fields of autonomous driving, smart mobility, and transportation policy, contributing to collaborations between academia, industry, and government agencies.

# Program Schedule Day 1 | 4 May 2026



Time	Event
08.00	Registration
08.30 - 09.00	Opening Ceremony at Putrajaya Hall, Level 8
09.00 - 10.00	Keynote Speech at Putrajaya Hall, Level 8 <i>Ts. Dr. Hairi Zamzuri from eMooVit</i>
10.00 - 10.30	Photo Session & Coffee Break
10.30 - 13.00	Technical Session 1 at Putrajaya Hall, Level 8
13.00 - 14.00	Lunch
14.00 - 15.20	Technical Session 2 at Putrajaya Hall, Level 8
15.20 - 15.40	Coffee Break
15.40 - 17.00	Technical Session 2 (CONTINUE) at Putrajaya Hall, Level 8
20:00 - 22:30	Symposium Dinner at Putrajaya Hall, Level 8

# Program Schedule Day 2 | 5 May 2026



Time	Event
08.30 - 10.10	Technical Session 3 (ONLINE) Physical Participants at Cheras Hall
10.10 - 10.30	Coffee Break
10.30 - 13.00	Technical Session 4 (ONLINE) Physical Participants at Cheras Hall
13.00 - 14.00	Lunch
	End of Symposium

# Presentation Schedule



4/5/2026 (MONDAY)	Technical Session 1: MODELLING AND SIMULATION FOR DIGITAL TRANSFORMATION SESSION CHAIR: DR. NOOR HANIS IZUDDIN MAT LAZIM	
	PAPER ID	TITLE
10:30	1571216509	Novel Cascade Model for Designing Tunable Filters with Cascaded Low-Order Sections
10:50	1571233142	Spare-Buffer Cell Rewiring for Efficient Timing Engineering Change Order
11:10	1571235737	Data-Driven Agent-Based Evacuation Simulation in a Campus Digital Twin
11:30	1571235739	A Unified ML Framework for Cross-Pillar Energy Optimization in 5G Self-Organizing Networks
11:50	1571242896	LLM-Based Simultaneous Waypoint Generation for Multi-Robot Planning in 2D Corridor Environments
12:10	1571244322	Modelling the Impact of Sugary Food Consumption on Diabetes Dynamics
12:30	1571244364	Effect of Hydrogen Bonding on Physicochemical Properties of Natural Deep Eutectic Solvents (NaDES)

# Presentation Schedule



4/5/2026 (MONDAY)	<b>Technical Session 2: EMERGING TRENDS IN ENGINEERING AND COMPUTING &amp; INTELLIGENT SYSTEM AND APPLICATION</b> <b>SESSION CHAIR: DR. MOHD SHAHRIZAL RUSLI</b>	
	PAPER ID	TITLE
14:00	1571216029	Simplified Rcone-Programming Scheme for Restraining Delay-Error Peaks in Variable-Delay Systems
14:20	1571252277	Boolean-Algebraic Modeling and Analysis of NOMA Schemes in Two-User Interference Channels
14:40	1571261681	An Extended Feedforward Neural Network for Solving Caputo-Fabrizio Fractional Differential Equations
15:00	1571235686	KPI-Adaptive DQN Framework for Handover Optimization in 5G Ultra-Dense Networks
15:20	COFFEE BREAK	
15:40	1571224595	Computational Performance Enhancement in Wind Energy Systems via AI-Based Predictive Analytics
16:00	1571243934	Machine Learning Predictive Analytics for Sustainable Consumer Data Management in Automotive Sector
16:20	1571252988	Design of Indoor Mobile Robot with Visual SLAM using Distributed Processing and Deep Learning

# Presentation Schedule



5/5/2026 (TUESDAY)	Technical Session 3: ONLINE SESSION CHAIR: ASSOC.PROF. DR. SOPHAN WAHYUDI NAWAWI	
	PAPER ID	TITLE
8:30	1571210622	Performance Evaluation of Fuzzy Logic and Nonlinear PID controllers for Antenna Positioning Systems
8:50	1571235266	LMI-based controller design for leaky-integrator MIMO systems
9:10	1571238453	Statistical Meta-Process Modeling for Fidelity Selection in Model-based Optimization
9:30	1571243688	Simulation of care processes to maximise operational efficiency under industry 5.0 paradigms
9:50	1571244471	Optimal Connected-Area Distribution for Multi-Agent Coverage Path Planning
10:10	COFFEE BREAK	

# Presentation Schedule



5/5/2026 (TUESDAY)	Technical Session 4: ONLINE SESSION CHAIR: TS. DR. HAZRIQ IZZUAN JAAFAR	
	PAPER ID	TITLE
10:30	1571244531	Optimal Trajectory Tracking based Improved SCA for Gantry Crane System
10:50	1571246877	A Data-driven Analysis of Backwash Interval on Ultrafiltration Membrane Performance
11:10	1571246935	Preliminary Study of Corrosion-Induced Ultrasonic Signal Changes in Reinforced Concrete
11:30	1571254073	Neuro-Evolutionary Heuristics for Euclidean Traveling Salesman: A Computational Intelligence Benchmark
11:50	1571254123	Adaptive Transformer-Based Tri-Modal Fusion of RGB, Thermal, and LiDAR Data for Robust Object Detect
12:10	1571244156	A Comparative Study of Single-Task and Multi-Task Learning for Sentiment and Emotion Classification on Reddit Text

# Technical Session



## Technical Session 1

## Modelling and Simulation for Digital Transformation

**Paper ID: 1571216509**

**Title: Novel Cascade Model for Designing Tunable Filters with Cascaded Low-Order Sections**

**Author: Tian-Bo Deng**

**Abstract** - The paper reveals a novel model (structure) for realizing a tunable digital filter (TDF) having tunable frequency bandwidths. This model is comprised of cascaded low-order sections that contain 2nd-order denominators, while their numerators can be higher orders. Since this cascade model consists of only low-order sections, the low-order sections can be utilized as fundamental building elements for implementing the entire cascade model. The cascade structure also features low implementation noise induced from coefficient quantization. Since the low-order sections have 2nd-order denominators, it is easy to guarantee the stability by exploiting an explicit stability condition. Based on the explicit stability condition, the paper also reveals a stability-ensuring scheme, which uses a uniquely defined function to represent the denominator parameters of the low-order sections. Representing the denominator parameters as the functions enables the stability condition to be definitely satisfied and thus keeps the whole cascade model stable during bandwidth tuning. This paper includes the simulation results of designing a highpass bandwidth-tunable filter for exemplifying the achieved high accuracy as well as the ensured stability. The simulations verify that exploiting the novel cascade model can obtain a highly accurate TDF with tunable highpass responses. The design results also demonstrate that the highpass TDF remains stable during frequency-bandwidth tuning.

**Paper ID: 1571233142**

**Title: Spare-Buffer Cell Rewiring for Efficient Timing Engineering Change Order**

**Authors: Nik Muhammad Afif Nik Rumzi, Mohd Shahrizal Rusli, Ab Al-Hadi Ab Rahman, Muhammad Nadzir Marsono, Haslina Md. Sarkan, Fakhru Zaman Rokhani**

**Abstract** - Timing closure during the Engineering Change Order (ECO) stage, remains a major challenge in advanced integrated circuit design as circuit complexity increases. Although pre-placed spare cells support post-layout fixes, many spare-cell ECO methods emphasize allocation policies rather than maximizing timing recovery using accurate net-delay impact. This paper presents an automated timing-driven spare-buffer rewiring ECO framework that tightly couples the static timing analysis stage with the physical design stage to perform localized, delay-optimized timing repair. The framework identifies the worst-slack nets along the data path, constructs path-specific bounding boxes to constrain candidate spare buffers, estimates source-to-spare and spare-to-sink delays using Manhattan-distance-based wire-delay models and applies a spare-locking mechanism to ensure conflict-free reuse across iterations. The approach is evaluated in 32 nm technology on five benchmark instances spanning a 4 by 4 DCT core, an FP64 unit, and a pipelined MAC design. Overall, spare-buffer rewiring reduces ECO-critical path violations substantially more than conventional gate sizing, achieving an average ECO-path resolution of about 73% across all benchmark instances, compared with about 59% for gate sizing. Consistent with these results, the proposed method delivers higher TNS gain defined as pre-ECO TNS minus post-ECO TNS and reduces runtime by up to about 26% versus gate sizing, while maintaining low overhead with total cell area increase below 0.15% and power overhead below 4%.

# Technical Session



**Paper ID: 1571235737**

**Title: Data-Driven Agent-Based Evacuation Simulation in a Campus Digital Twin**

**Authors: Ryo Kishimoto, Shady Salama, Valentinus Roby Hananto and Victor Kryssanov**

**Abstract** - This study introduces a data-driven agent-based evacuation framework implemented in a building digital-twin environment to analyze the performance of static and dynamic evacuation guidance strategies under varying congestion conditions. The first three floors of Building H at the Osaka Ibaraki Campus (OIC) of Ritsumeikan University are used as a real-world testbed and are reconstructed, using Blender and Unity. Human movements are simulated via NavMesh-based navigation, incorporating empirically grounded heterogeneity in reaction times and walking speeds, together with a lightweight mechanism that adaptively reduced speed, based on local density. Seven guidance strategies are evaluated under measured off-peak and peak occupancy conditions. Results show that strategy effectiveness depends strongly on the congestion level. In off-peak scenarios, the Dynamic-Individual strategy achieved the shortest evacuation time, demonstrating the benefit of individual-level rerouting when viable alternative paths exist. Under peak conditions, however, dynamic strategies deteriorated markedly, particularly Dynamic-Individual, and evacuation times increased by approximately 72%, as saturated exits and staircases constrained rerouting opportunities. In contrast, pre-balanced static strategies, particularly Static-Phased, exhibited greater robustness under heavy congestion. While Static-Naive enables rapid early evacuation, Static-Phased reduced extreme tail delays and shortened the maximum evacuation completion time by approximately 10% compared to baseline, Static-Naive. These findings clarify when the dynamic guidance is effective and when the static guidance is preferable, and they underscore the broader value of digital-twin-based simulation as a generalizable tool for evacuation analysis and building safety planning.

**Paper ID: 1571235739**

**Title: A Unified ML Framework for Cross-Pillar Energy Optimization in 5G Self-Organizing Networks**

**Authors: Sharmin Sharmin, Ismail Ahmedy, Bryan Raj Peter Jabaraj, Rafidah Md Noor and Muhammad Umair Munir**

**Abstract** - The exponential growth of mobile data traffic and the proliferation of connected devices have positioned energy efficiency as a critical challenge in fifth-generation (5G) networks. While significant research efforts have addressed individual energy-saving pillars—Advanced Sleep Modes (ASM), Dynamic Spectrum Management (DSM), Network Densification (ND), and Energy Harvesting (EH)—these approaches operate in isolation, leading to suboptimal energy utilization and potential conflicts between optimization objectives. This paper introduces a comprehensive framework that combines four energy-efficiency pillars into a single integrated machine learning-based Self-Organizing Network (SON) model. The proposed framework employs Multi-Agent Reinforcement Learning (MARL) in a hierarchical manner to cooperate at different scales, which allows flexible decisions with respect to whether to enter sleep mode, how to share spectrum resources, control cell density and use infrastructure. The framework fills an important gap in the related literature, which is dominated by positioning optimization within the context of a single pillar and fails to consider multi-pillar cooperation. This paper provides an awareness of six crucial pillar interdependencies, a four-tier coordinating architecture and the formal complexity analysis of the mechanisms proposed. In which future work will verify the framework through MATLAB simulation with actual network conditions.

**Paper ID: 1571242896**

**Title: LLM-Based Simultaneous Waypoint Generation for Multi-Robot Planning in 2D Corridor Environments**

**Authors: Marouane El Massine Lfella, Pei Ling Leow, Nurulaqilla Khamis**

**Abstract** - Multi-robot systems (MRS) require efficient path planning to navigate complex environments while avoiding collisions. While traditional heuristic algorithms and modern learning-based methods have made significant strides, they often face challenges with computational scalability, adaptability, or semantic reasoning in dynamic environments. This paper presents a novel framework that leverages a Large Language Model (LLM) for waypoint generation in a 2D corridor environment with two mobile robots. The environment consists of axis-aligned corridors, junctions, and obstacles, all encoded into a structured textual prompt. The LLM generates coordinate-based waypoints for both robots simultaneously, and a closed-loop feedback mechanism validates these waypoints against spacing, collision, and junction constraints. Invalid waypoints trigger iterative refinement until all constraints are satisfied. Experimental results demonstrate that the proposed approach achieves high waypoint generation success rates while maintaining path feasibility in complex scenarios

**Paper ID: 1571244322**

**Title: Modelling the Impact of Sugary Food Consumption on Diabetes Dynamics**

**Authors: Norazaliza Mohd Jamil, Chai Jian Tay, Nadirah Mohd Nasir, Balvinder Singh Gill, Sharmeen Izat Hassan and Salisu Ibrahim**

**Abstract** - The global prevalence of diabetes is increasing, partly due to lifestyle factors such as high sugar consumption. While mathematical models have often been used to study how diabetes develops, the direct effect of eating sugary foods on progression between disease stages has not been well studied. This study presents a compartmental ordinary differential equation model that characterizes transitions among susceptible, prediabetic, and diabetic populations, with sugar consumption intensity incorporated as a key driver of disease progression. The model is studied using equilibrium analysis, nullcline structure, and phase-plane dynamics within the prediabetes to diabetes state space. Analytical results identify threshold conditions that determine whether the system exhibits prediabetes dominant or diabetes-dominant equilibria. Increased sugar intake shifts the system toward persistent diabetes. Phase-plane simulations indicate that increased sugar consumption qualitatively modifies long-term system dynamics, leading to higher diabetes prevalence. The results underscore the significant influence of dietary behaviour on diabetes progression and establish a mathematical framework for evaluating the long-term effects of sugar-reduction interventions.

# Technical Session



**Paper ID: 1571244364**

**Title: Effect of Hydrogen Bonding on Physicochemical Properties of Natural Deep Eutectic Solvents (NADES)**

**Authors: Joanne Liew Xin Hui and Azizul Azri Mustaffa**

**Abstract** - Natural Deep Eutectic Solvents (NADES) are emerging as sustainable alternatives to conventional organic solvents and ionic liquids, with promising applications in extraction, biocatalysis, and pharmaceutical formulation. However, the rational design of these solvents remains challenging due to the complex role that hydrogen bonding plays in determining their physicochemical properties. This study uses molecular dynamics simulations to obtain and correlate hydrogen bonding metrics — total hydrogen count, donor-acceptor distance, and bond angle — with five key properties in Type V NADES: solubility, viscosity, density, melting point and boiling point. Seven thymol-menthol (Thy-Men) and menthol-lauric acid systems (Men-Lau) were simulated using GROMACS at various molar ratios. Results show that stronger hydrogen bonding increases solubility, density, and boiling point while depressing viscosity and melting point. Highest number of hydrogen bond, NHB were observed in the Men-Lau (0.5:1) and Thy-Men (2:1) systems, reaching 124.921 and 114.178, respectively. This work establishes hydrogen bonding as a predictive design parameter, enabling the tailored formulation of NADES for green chemistry applications.

# Technical Session



## Technical Session 2

2-1: Emerging Trends in Engineering and Computing  
2-2: Intelligent System and Applications

**Paper ID: 1571216029**

**Title: Simplified Rcone-Programming Scheme for Restraining Delay-Error Peaks in Variable-Delay Systems**

**Author: Tian-Bo Deng**

**Abstract** - The paper formulates a rotated-quadratic cone (Rcone) technique for producing a variable allpass-delay filter (AP-DF) while significantly containing the delay-error overshoots. After showing that both frequency-response (FR) error and delay-error have denominators and numerators being linear functions of the AP-DF parameters, the paper reveals a minimization scheme for designing a variable AP-DF. The design technique uses the Rcone-programming to minimize the FR-error peak while effectively containing the delay-error overshoots. Since the Rcone-programming design reduces to a convex minimization, performing the convex minimization yields a convergent AP-DF solution. The paper provides an AP-DF design example to exemplify the utility of the Rcone-programming formulation. As compared to other design techniques, this new scheme can reduce the design to a convex-programming problem, rendering it easy to solve. The design simulations also verify that this Rcone-programming formulation can further suppress the delay overshoots as compared with other design techniques. More precisely, the Rcone-programming design causes the smallest delay-error peak (0.002960) among all the designs.

**Paper ID: 1571252277**

**Title: Boolean-Algebraic Modeling and Analysis of NOMA Schemes in Two-User Interference Channels**

**Authors: Sock Theng Ooi, Marwan H. Azmi, and Razali Ngah**

**Abstract** - This paper introduces a novel analytical framework based on Boolean algebra for modeling and analyzing Non-Orthogonal Multiple Access (NOMA) systems. Departing from conventional signal-to-interference-plus-noise ratio (SINR) based models, the proposed approach conceptualizes the Successive Interference Cancellation (SIC) process in a two-user interference channel as a probabilistic system of logical events. The core contribution is a systematic procedure that transforms the SIC decoding problem into a Boolean model, subsequently simplified and analyzed using techniques such as Karnaugh maps. This framework is demonstrated for systems characterized by 2, 4, and 5 elements, showcasing its capability to capture the fundamental logical interdependencies of SIC. The Boolean approach provides a new, complementary perspective for NOMA analysis, offering a structured methodology to evaluate decoding performance and system complexity in interference-limited environments.

**Paper ID: 1571261681**

**Title: An Extended Feedforward Neural Network for Solving Caputo-Fabrizio Fractional Differential Equations**

**Authors: Mohd Rashid Admon, Norazak Senu, Noorehan Yaacob, Mohd Ariff Admon, Mohamad Shahiir Saidin, and Hanis Nasir**

**Abstract** - The contemporary application of artificial neural network (ANN) has transcended traditional computer science problems, making significant inroads into the field of mathematics. A notable variant, the feedforward neural network (FNN), has emerged as a powerful tool for approximating solutions to fractional differential equations (FDEs). However, researchers have often limited themselves to ANN with a single hidden layer. Recent advancements in various real-world applications have demonstrated the superior performance achieved by incorporating multiple hidden layers. This study focuses on investigating the accuracy of Caputo-Fabrizio FDEs (CFFDEs) by extending the hidden layers in feedforward ANN from one to two, resulting an extended feedforward neural network (EFNN). At first stage, the method formulation involving type of CFFDEs, construction of approximation solution and approximation of Caputo- Fabrizio derivative is derived. Then, the vectorization is implemented for forward propagation, approximate solution and error function. In the last stage, the learning solver that use Broyden-Fletcher-Goldfarb-Shanno (BFGS) algorithm is described. The effectiveness of the EFNN-BFGS approach is validated through several CFFDEs, including a practical application to tumor-immune dynamics. Numerical results demonstrate that the proposed scheme offers improved accuracy and outperforms existing methods.

**Paper ID: 1571235686**

**Title: KPI-Adaptive DQN Framework for Handover Optimization in 5G Ultra-Dense Networks**

**Authors: Muhammad Umair Munir, Ismail Ahmedy, Rafidah Md Noor, Saaidal Razalli Azzuhri, Sharmin Sharmin, Uzair Iqbal**

**Abstract** - Ultra-dense network (UDN) deployment in 5G or B5G systems creates significant handover management challenges due to frequent cell transitions and highly dynamic signal conditions. While existing deep reinforcement learning approaches optimize handover decisions based on signal quality, they treat all scenarios uniformly and focus on single objectives. This paper proposes a KPIAdaptive Deep Q-Network (DQN) framework that addresses these limitations through three key contributions. First, a multi-objective reward function with adaptive penalty weights is incorporated that follows multi-objective reinforcement learning principles and enable explicit balance between Radio Link Failure (RLF), handover frequency, and signal quality. Second, inside DQN, a phase-based curriculum learning mechanism with three distinct training stages is introduced that progressively shifts priorities from connection stability to balanced optimization. Third, a dynamic weight adaptation mechanism is implemented that automatically adjusts objective weights based on real-time KPI performance deviations from target values. Comprehensive simulation results in a 21-cell ultra-dense environment demonstrate that the proposed method achieves 13.2% RLF reduction compared to baseline 3GPP A3 approach and 5.4% improvement over plain DQN, while simultaneously reducing handover frequency by 1.8% and maintaining stable signal quality above 70 dB throughout 120 training episodes.

# Technical Session



**Paper ID: 1571224595**

**Title: Computational Performance Enhancement in Wind Energy Systems via AI-Based Predictive Analytics**

**Authors: Yean Shim Tan, Wei Seng Yeap, Angie See Tien Ng, Jay Jay Ngiam**

**Abstract** - The integration of Artificial Intelligence AI-driven predictive analytics into wind energy systems represents a major advancement in intelligent energy management. This paper presents a scalable diagnostic framework built with the Intel® AI Analytics Toolkit, designed to enable real-time fault detection and predictive maintenance across various wind turbine configurations. By optimizing machine learning workflows and leveraging heterogeneous compute acceleration, the framework can detect early signs of critical issues—such as gearbox wear, blade damage, generator faults, and sensor drift before they lead to disruption in operations. Information gathered from field deployment has shown tangible benefits, including a 40% reduction in unplanned downtime and a 25% decrease in maintenance costs. The use of Intel® oneAPI's unified programming model further improves system performance, delivering up to a 10× speedup in model training and inference. This acceleration improves responsiveness and scalability, allowing wind farms to quickly adapt to changing operating conditions. By enabling efficient data processing and real-time insights, the proposed framework supports the development of autonomous, self-optimizing wind farms. These capabilities not only improve reliability and energy output, but also contribute to broader sustainability and decarbonization goals. Overall, this work demonstrates the potential of unified AI toolchains in renewable energy, paving the way for smarter, more resilient energy systems and encouraging the adoption of Artificial Intelligence and Machine Learning across the clean energy sector.

**Paper ID: 1571243934**

**Title: Machine Learning Predictive Analytics For Sustainable Management Of Consumer Response Data In The Automotive Sector**

**Authors: Samud Jaidina and Nor Asmaa Alyaa and Wong Kuan Yew**

**Abstract** - Multi-robot systems (MRS) require efficient path planning to navigate complex environments while avoiding collisions. While traditional heuristic algorithms and modern learning-based methods have made significant strides, they often face challenges with computational scalability, adaptability, or semantic reasoning in dynamic environments. The LLM generates coordinate-based waypoints for both robots simultaneously, and a closed-loop feedback mechanism validates these waypoints against spacing, collision, and junction constraints. Invalid waypoints trigger iterative refinement until all constraints are satisfied. Experimental results demonstrate that the proposed approach achieves high waypoint generation success rates while maintaining path feasibility in complex scenarios.

# Technical Session



**Paper ID: 1571252988**

**Title: Design of Indoor Mobile Robot with Visual SLAM using Distributed Processing and Deep Learning**

**Authors: Liao Cheng, Sophan Wahyudi Nawawi and Sulaiman Sabikan**

**Abstract** - Indoor mobile robots have a wide range of application value, such as home cleaning, indoor exploration, etc. SLAM technology is usually used to solve its localization and mapping problems, with VSLAM (visual SLAM) being a key research focus. Traditional VSLAM robots mainly rely on processors on the vehicle body. This architecture of pure on-board processor leads to problems such as low battery endurance and high vehicle body cost. In addition, traditional VSLAM frameworks, such as ORB-SLAM3, tend to exhibit degraded performance in environments with dynamic objects. This research presents a novel approach to address these challenges by designing an indoor distributed VSLAM system that offloads computationally intensive tasks to an off-board station via advanced wireless communication technology (WIFI 6) and hardware-accelerated video encoding (H.264). Additionally, the system integrates deep learning-based image segmentation to filter dynamic objects, thereby improving tracking error. The research employs ORB-SLAM3 as the foundational VSLAM framework, combined with ROS 2 for distributed communication management. The implemented system demonstrates real-time communication performance with a Sense-Move delay of 64.9ms, network delay of 19.1ms, and network throughput of 0.5 MBps. The integration of YOLO-based semantic segmentation for dynamic object filtering substantially improves trajectory tracking accuracy, reducing RMSE from 0.669m to 0.015m in dataset evaluations. The integrated system achieves 10-15 fps on Jetson Orin Nano Super hardware. This distributed architecture successfully reduces the computational burden on indoor mobile robots while maintaining real-time operation, demonstrating the effectiveness of integrating advanced wireless technologies, hardware-accelerated video encoding, and deep learning.

# Technical Session



## Technical Session 3 Online Presentation

**Paper ID: 1571210622**

**Title: Performance Evaluation of Fuzzy Logic and Nonlinear PID controllers for Antenna Positioning Systems**

**Authors: Abdulganiyu Mukhtar, Muhammad Sani Gaya, Norhaliza Abdul Wahab, Sulaiman Muhammad Gana**

**Abstract** - Accurate alignment and efficient tracking of the satellite by an Earth station antenna to maintain the desired line of sight are critical for optimal power transfer and reliable signal reception. Incorrect alignment leads to instability and poor reception, which in turn increases operational costs. While conventional control strategies often fail to deliver the desired performance, many advanced control techniques are computationally expensive. This research presents a comparative performance analysis of a two-input Fuzzy Logic Controller (FLC) and a variable gain Nonlinear Proportional Integral Derivative (NPID) control strategy applied to an antenna azimuth positioning system. Simulations in MATLAB/Simulink evaluated both controllers under various scenarios, including fixed and variable reference signals, as well as external disturbances. The results show that the NPID controller provides a faster initial response of 0.1807s but with a significantly high overshoot of 33.22%. Conversely, the FLC demonstrates superior overall performance, characterized by minimal overshoot (2.4%), settling time (1.785s), enhanced disturbance attenuation, and more stable tracking. The findings confirm that the FLC is a more effective and robust control solution for ensuring precise antenna alignment and reliable operation amidst system nonlinearities and external disturbances..

**Paper ID: 1571235266**

**Title: LMI-Based Controller Design For Leaky-Integrator MIMO systems**

**Authors: Hao Deng, Cristina Stoica, Mohammed Chadli, and Daniel Ossmann**

**Abstract** - Leaky-integrator systems have attracted attention due to their capability of capturing the gradual loss of the system states. Thanks to the advantages of taking into consideration the leaky effect on gradual loss of systems states, leaky-integrator systems have been applied in biological modeling and electronic circuit design. However, robust control design conditions for such systems are insufficiently developed. In the existing literature, global asymptotic stability analysis has been conducted on leaky-integrator systems, however, such analysis neglects the effects of the inputs and is based solely on single-input single-output systems. The stability analysis for leaky-integrator multi-input multi-output (MIMO) systems is yet to be developed. This paper proposes a controller design method based on Linear Matrix Inequality (LMI) for a class of leaky-integrator MIMO systems. Compared to the existing literature, controllers that guarantee incremental input-to-state stability for leaky-integrator systems are established. In this paper, a set of linear matrix inequalities regarding the controller design conditions is derived based on the incremental input-to-state stability. An observer structure for the considered leaky-integrator MIMO systems is also presented, along with the observer design conditions. A numerical simulation example showcases the effectiveness of the proposed approach. The simulation results demonstrate that the developed LMI conditions are applicable for a class of leaky-integrator multi-input multi-output systems. With the proposed controller and observer design conditions, the leaky-integrator MIMO system can be stabilized and achieve the control goal of trajectory tracking.

# Technical Session



**Paper ID: 1571238453**

**Title: Statistical Meta-Process Modeling for Fidelity Selection in Model-based Optimization**

**Author: R. Sala**

**Abstract** - Model and simulation-based optimization has emerged as a powerful methodology in science, engineering, and industrial systems. A recurring fundamental challenge is selecting appropriate model fidelity that balances accuracy against computational cost and the resulting constraints on optimization iterations under limited resources. Contrasting and complementary to dynamic multi-fidelity approaches, this work focuses on selecting a single fidelity level per optimization run. This work presents a statistical meta-process modeling framework for analyzing accuracy-cost trade-offs to support offline a priori fidelity or budget selection in model-based optimization. The framework combines three components: a modeling error model that represents accuracy as a function of fidelity, a cost model that describes computational expense per evaluation, and an optimization error model that characterizes optimality-gap convergence across iterations. The corresponding model parameters can be estimated from empirical data obtained from previous experiments on representative problems. An open-source Python implementation is provided for numerical approximations of optimal-fidelity curves and budget-performance plots. Results from case studies demonstrate that the framework can serve as a practical tool for fit-for-purpose model selection in budget-aware optimization settings.

**Paper ID: 1571243688**

**Title: Simulation of Care Processes to Maximise Operational Efficiency Under Industry 5.0 Paradigms**

**Authors: Luis Nuela and John Reyes**

**Abstract** - This study presents a methodology that integrates discrete event simulation (DES) with design of experiments (DoE) to maximise operational efficiency, with a focus on sustainability and resilience in the context of industry 5.0. Thus, a DES model is developed in FlexSim 2025 that represents the areas of interest. In addition, to parameterise the process times, 60 observations are recorded to adjust the probability distributions with the Fitted Distribution tool. Thus, a DoE based on a  $2^3$  full factorial design with three factors is implemented: doctors, nurses and two-level triage. Here, 80 replicates per scenario are run in the Experimenter tool to evaluate two demands of 10 and 40 patients per day. In this context, two metrics are analysed to evaluate the operational performance: the total patient time in the system (TTS) and the waiting time to enter the medical consultation. Consequently, the results of the experiment determine that the medical consultation is the bottleneck. Therefore, it is validated that the number of doctors is the determining factor in operational performance management. Thus, increasing the number of doctors from one to two reduces TTS by 20% with low demand and by 28% with high demand, the impact of which is reflected in the waiting time to enter the medical consultation, which is reduced by 91% with low demand and by 56% with high demand. Finally, this study can serve as a guide for other healthcare centres to anticipate bottlenecks and validate changes virtually, thus ensuring improvements with a guaranteed impact

# Technical Session



**Paper ID: 1571244471**

**Title: Optimal Connected-Area Distribution for Multi-Agent Coverage Path Planning**

**Author: Rashad Abul Khayr, Muhammad Zakiyullah Romdlony, Md Abdus Samad Kamal, and Yamada Kou**

**Abstract** - Autonomous unmanned systems have numerous applications in a complex environment. One such application is coverage path planning to explore and cover a known or unknown area. The efficiency of such an application, especially for multi-agents, can be greatly increased by dividing the the active area into an exclusive connected area of operation beforehand. Finding an equal division for the coverage path planning can be crucial to the performance of such operation. Therefore, we proposed an optimized region distribution method using Particle Swarm Optimization (PSO) that was modified with repulsion field and inspired by A\* to find optimal base placement, and Spanning Tree Coverage (STC) with connectivity-conscious bidding to ensure equal distribution. The proposed method managed to achieve even distribution in an area with or without obstacle outperforming Rapidly Exploring Random Trees (RRT) and Centroid Veronoi Tessellation (CVT), and in an area with large amount of obstacle, managed to outpace both methods in term of iteration or average time.

# Technical Session



## Technical Session 4 Online Presentation

**Paper ID: 1571244531**

**Title: Optimal Trajectory Tracking based Improved SCA for Gantry Crane System**

**Author: Mohamed O. Elhabib, Herman Wahid, Zaharuddin Mohamed, and O.A. Elhabib**

**Abstract** - The precise manipulation of gantry cranes is inherently complicated by underactuated nonlinear dynamics, where a single input must simultaneously regulate trolley positioning and suppress multi-mode oscillations. Traditional Linear Quadratic Regulator (LQR) approaches often yield steady-state errors due to the absence of integral action, while parameter tuning via standard Sine Cosine Algorithms (SCA) is prone to premature convergence in high-dimensional search spaces. This work addresses these limitations by developing an Integral LQR (ILQR) controller tuned via an Improved Sine Cosine Algorithm (ISCA). Distinguished by a linear search path and empirical best-history retention, the ISCA mechanism balances exploration and exploitation to avoid local optima stagnation, ensuring precise gain optimization. Numerical validations confirm the superiority of the proposed ISCA-ILQR scheme, demonstrating a 12.5% reduction in payload sway compared to standard SCA-tuned counterparts in nominal operations. Moreover, the controller exhibits robust disturbance rejection; under combined parametric uncertainties involving significant cable extension (0.40 m) and payload mass variations (0.50 kg), the system effectively confines residual sway within  $\pm 1^\circ$  limits, ensuring operational safety in dynamic industrial environments.

**Paper ID: 1571246877**

**Title: A Data-driven Analysis of Backwash Interval on Ultrafiltration Membrane Performance**

**Authors: Mohamad Fikkri Sarif, Noorhazirah Sunar, Norhaliza Abdul Wahab, Anita Ahmad, Nurul Adilla Mohd Subha, Mashitah Che Razali and Alya Afiqah Shakhar**

**Abstract** - Membrane-based filtration systems, particularly ultrafiltration (UF), are widely adopted for water treatment because of their ability to remove pathogens from organic matter, and particulates. However, membrane fouling remains a persistent challenge that reduces efficiency, lowers permeating quality, and increases operating costs. This study evaluates a lab-scale UF membrane system under three conditions: continuous filtration without backwash, filtration with a 10-minute backwash interval, and filtration with a 20-minute backwash interval. River water was used as feed, and performance was monitored with real-time pressure, flow, and turbidity sensors integrated with LabVIEW. Continuous operation without backwash led to rapid flux decline and rising transmembrane pressure (TMP), with a strong negative Pearson correlation value 0.928 between flux and TMP. Both 10 and 20-minute intervals improved flux recovery, but the 10-minute interval provided more stable flux and controlled fouling buildup, while the 20-minute interval yielded higher shortterm recoveries but greater fluctuations. Absolute and relative flux recovery analyses highlight dynamic, non-linear backwash behavior, suggesting that fixed schedules are sub-optimal. Findings emphasize the importance of optimizing backwash frequency for operational stability, with implications for both small and large-scale water treatment systems.

# Technical Session



**Paper ID: 1571246935**

**Title: Preliminary Study of Corrosion-Induced Ultrasonic Signal Changes in Reinforced Concrete**

**Author: Musa Iskandar Shah, Anita Ahmad, Farah Aina Jamal Mohamad, and Noorhazirah Sunar**

**Abstract** - Corrosion of steel reinforcement in reinforced concrete (RC) structures is a major factor compromising structural integrity and service life. While non-destructive evaluation (NDE) techniques such as ultrasonic testing are commonly used to detect cracks and voids, corrosion-specific detection remains underexplored, and simulation-based investigations are limited. This study presents a preliminary simulation-based analysis of the effect of corrosion layer on the ultrasonic wave propagation in RC structures. A two-dimensional model was developed in COMSOL Multiphysics® to simulate ultrasonic pulse propagation in both healthy and corroded configurations under identical conditions. The corrosion defect was represented by a rust layer surrounding the steel, introducing acoustic impedance mismatches with the surrounding materials. A modulated Gaussian ultrasonic pulse was applied at the transducer, and time domain responses were analyzed to evaluate the effects of corrosion on wave amplitude. Simulation results indicate that the presence of corrosion significantly alters ultrasonic signal characteristics. The presence of the rust layer caused localized wave scattering and reflection, resulting in high-amplitude peaks and repeated defect-related features in the time-domain response. These changes demonstrate that ultrasonic waves are sensitive to corrosion-induced material degradation, suggesting potential for early detection of corrosion in RC structures.

**Paper ID: 1571254073**

**Title: Neuro-Evolutionary Heuristics for Euclidean Traveling Salesman: A Computational Intelligence Benchmark**

**Author: Mayank Jha**

**Abstract** - This paper studies the analysis of the Euclidean Traveling Salesman Problem (ETSP), a variant of the Traveling Salesman Problem (TSP), through application of computational intelligence techniques. The TSP is a classical NP-hard combinatorial optimization problem. The ETSP specifically considers cities as points in Euclidean space where distances satisfy the triangle inequality. Heuristic frameworks for algorithmic performance evaluation of genetic algorithm, greedy constructive method, local search operators using artificial intelligence on synthetic and real-life geographic data. The results demonstrate that neuroevolutionary strategies can yield tours that are close to optimal, particularly as the dimension of the problem increases. The balance between quality of solution, temporal complexity and scalability in an artificial intelligence optimisation framework are further explored. The open-source implementation serves as a consistent platform for advancing intelligent routing in automated logistics and spatial reasoning.

# Technical Session



**Paper ID: 1571254123**

**Title: Adaptive Transformer-Based Tri-Modal Fusion of RGB, Thermal, and LiDAR Data for Robust Object Detection in UAV Surveillance**

**Author: Mohamad Tamim Bakrou, Hazlina Selamat, and Anas Aburaya**

**Abstract** - Robust object detection in Unmanned Aerial Vehicle (UAV) surveillance is frequently compromised by dynamic environmental degradations such as low illumination, atmospheric obscurants (fog, smoke), and sensor failures. While multi-modal sensor fusion offers a potential solution by leveraging complementary data, existing approaches often rely on static integration rules that fail to adapt when specific sensors become unreliable. This rigidity can lead to "negative transfer," where the inclusion of noisy or degraded data reduces performance below that of the single best sensor. To address this, this paper presents FuseFormerNet, an adaptive tri-modal fusion framework that robustly integrates RGB, thermal, and LiDAR data. The proposed architecture introduces a novel mid-level fusion mechanism comprising two key components: (1) a context-conditioned reliability gating module that dynamically regresses modality importance weights to suppress degraded sensors before fusion, and (2) a transformer-based fusion block that utilizes multi-head selfattention to facilitate content-aware feature refinement across modalities. The approach is benchmarked on the challenging R-LiViT dataset using a rigorous "detector-fair" protocol to isolate fusion benefits. Experimental results demonstrate that FuseFormerNet achieves 67.14% mAP@0.5, outperforming static tri-modal fusion by 1.41% and the RGB-only baseline by 4.80%. Crucially, the system exhibits superior robustness, maintaining high recall in darkness and synthetic smoke where single-modality detectors fail.

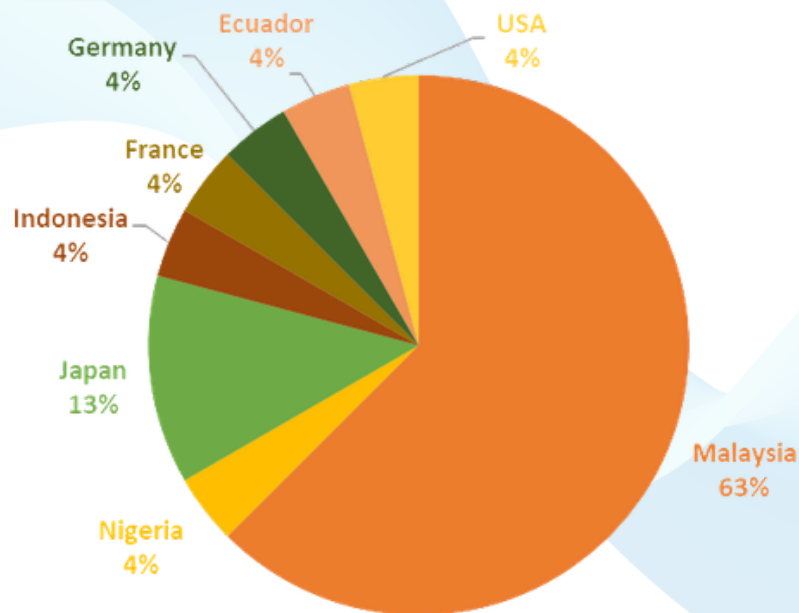
**Paper ID: 1571244156**

**Title: A Comparative Study of Single-Task and Multi-Task Learning for Sentiment and Emotion Classification on Reddit Text**

**Authors: Kai Xin Edwina Hon, Chuk Fong Ho and Chi Wee Tan**

**Abstract** - Social media crises, such as the Samsung Galaxy Note 7 recall, unfold rapidly and generate intense public reactions. To respond effectively, organizations require tools that go beyond sentiment detection to capture underlying emotional patterns. However, existing sentiment classification approaches often prioritize accuracy while struggling to adapt to domain-specific crisis contexts. This study proposed a Multitask Learning (MTL) framework for jointly classifying sentiment and emotion in Reddit-based crisis communication. Transformer-based models, including BERTweet and DistilRoBERTa, were fine-tuned under both Single-Task Learning (STL) and MTL configurations using benchmark datasets and evaluated on a curated Reddit corpus from the Note 7 crisis. To ensure robustness, performance was assessed using Macro-F1 as the primary evaluation metric, with standard deviation reported across five random seeds to capture performance robustness and stability. The results show that STL models consistently outperform MTL on general-domain benchmarks for emotion classification, whereas MTL offers modest improvements for sentiment classification in crisis-specific data. Emotion classification remains particularly challenging, with most models consistently achieving lower Macro-F1 scores. Overall, the findings highlight both the potential and limitations of MTL for crisis analysis and provide a foundation for developing more reliable and transparent artificial intelligence tools to support effective crisis communication.

# Participation by Country





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